



COMPETITIVE RISARALDA, GENERATING RESEARCH ALLIANCE FOR DEVELOPMENT

Compiladores

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MISIÓN DE LA MESA DE INVESTIGACIONES DE RISARALDA

La Mesa de investigaciones de Risaralda es un equipo de instituciones de la triada Universidad-Empresa-Estado vinculada a la Red de Universidades de Risaralda, dedicada a fomentar y socializar los procesos de investigación en CTel del departamento, dirigido a la comunidad académica y sociedad en general, con el propósito de generar conocimiento que contribuya a la solución de problemas impulsando así el desarrollo y competitividad en pro de mejorar la calidad de vida de la región.

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Al 2028, la Mesa de Investigaciones de la Red de Universidades de Risaralda será conocida nacional e internacionalmente por el posicionamiento de los grupos e investigadores que mediante investigaciones de alto impacto y su apropiación por parte de la sociedad han aportado al desarrollo y competitividad de la región.

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Vicerrectoría de Investigaciones, Innovación y Extensión
Universidad Tecnológica de Pereira
2020

Competitive Risaralda, generating research alliance for development / Compilado por Ana María López García y otros. – Pereira : Editorial Universidad Tecnológica de Pereira, 2020.
467 páginas. – (Colección Trabajos de investigación).

ISBN: 978-958-722-495-5

1. Risaralda – Desarrollo tecnológico 2. Risaralda - Desarrollo científico 3. Ciencias sociales – Investigaciones – Risaralda (Colombia) 4. Ciencias agrícolas – Investigaciones - Risaralda (Colombia) 5. Ciencias de la salud – Investigaciones - Risaralda (Colombia) 6. Competencia en educación – Colombia 7. Ciencias de la tecnología e información – Investigaciones - Risaralda (Colombia) 8. Bibliometría 9. Economía colombiana – Competitividad

CDD. 378.007

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eISBN: 978-958-722-495-5

Universidad Tecnológica de Pereira
Vicerrectoría de Investigaciones, Innovación y Extensión
Editorial Universidad Tecnológica de Pereira
Pereira, Colombia

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Prologue

The book “Competitive Risaralda, generating research alliance for development” is the result of the fifth meeting of researchers from the department of Risaralda held in November 2020.

This event presented the latest research carried out in different educational institutions of the department, who are part of the “Mesa de Investigación de Risaralda”; an exercise of great interest that yields research results in different areas such as Agricultural Sciences, Social Sciences, Health Sciences, Technology and Information Sciences.

A special thanks to the authors, who in each chapter shared the results of their research contributing to the scientific and technological development of our region. Thanks to their daily commitment to knowledge, they are the ones who set the guidelines to make research a process of learning, knowledge and analysis of realities for the continuous improvement in the fields of research and innovation.

In the same way, to thank the network of universities of Risaralda, institutions that allowed the development of the book as they are: Universidad Tecnológica de Pereira, Universidad Católica de Pereira, UNAD, UNIREMINGTON, UNISARC, Visión de las Americas, Universidad Cooperativa de Colombia, Universidad Libre Pereira, ESAP, Fundación Universitaria Comfamiliar, UNIMINUTO, SENA, Areandina, CIAF and the Empresa de Energía de Pereira . They contribute to this text with their commitment and responsibility. We hope that this work will be of your interest, demonstrating the commitment to the contribution of knowledge for the advancement and development of our country.

Carlos Santiago Arbeláez Cárdenas

*Member of Risaralda Research Board, Innovation Manager of
Empresa de Energía de Pereira*

Prólogo

El presente libro lleva como título “Risaralda competitiva, generando alianzas en investigación para el desarrollo”, resultado del V encuentro de investigadores del departamento de Risaralda realizado en el mes de noviembre del año 2020.

Evento en el cual se presentaron las últimas investigaciones realizadas en las diferentes instituciones educativas del departamento; quienes hacen parte de la Mesa de Investigaciones de Risaralda; ejercicio de gran interés que arroja resultados de investigaciones en diferentes áreas como son las Ciencias Agrícolas, Ciencias sociales, Ciencias de la salud, Ciencias de la tecnología y la información.

Agradecimientos especiales a los autores, quienes en cada capítulo compartieron los resultados de sus investigaciones aportando al desarrollo científico y tecnológico de nuestra región, gracias por el compromiso que tienen día a día con el conocimiento,

son ellos quienes marcan la pauta para hacer de la investigación un proceso de aprendizaje, conocimiento y análisis de realidades para la mejora continua en los ámbitos de la investigación y la innovación.

De la misma forma, dar las gracias a la Red de Universidades de Risaralda, instituciones que permitieron el desarrollo del libro como son: la Universidad Tecnológica de Pereira, Universidad Católica de Pereira, UNAD, UNIREMINGTON, UNISARC, Visión de las Américas, SENA, Universidad Libre Pereira, ESAP, Fundación Universitaria Comfamiliar, UNIMINUTO, Universidad Cooperativa de Colombia, Areandina, CIAF y la Empresa de Energía de Pereira, siendo posible gracias a su compromiso y responsabilidad. Esperamos que esta obra sea de su interés, demostrando el compromiso con el aporte de conocimiento para el avance y desarrollo de nuestro país.

Carlos Santiago Arbeláez Cárdenas
Integrante Mesa de investigación de Risaralda, Gestor de
innovación Empresa de Energía de Pereira

1

CHAPTER ONE Technologies and engineering

Evaluation of competences in critical
reading and scientific thinking
mathematics and statistics in the Saber
11 and Saber Pro 2016-2017 tests in two
engineering programs

*Evaluación de competencias en lectura
crítica y pensamiento científico en
matemáticas y estadística en las pruebas
Saber 11 y Saber Pro 2016-2017 en dos
programas de ingeniería*

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Abstract

The objective of this work is to evaluate the competences in critical reading and scientific mathematical and statistical thinking of students in the last semester of Financial Engineering and Commercial Engineering. In this context, the evaluation is considered as learning guiding process, through it, it is possible to obtain the necessary information to identify what was learned, what was not learned and take assertive decisions can be made in the teaching process and learning. Therefore, in this research, the results achieved by the students in the Saber 11 Tests applied by ICFES, and subsequently, the results obtained by the same students in the Saber Pro Tests, belonging to the programs in mention of the Universidad Libre.

This research is a study of evaluative design, non-experimental, of explanatory character that uses a methodology of complementarity between the qualitative and quantitative methods. The SPSS software was used as an instrument for data processing, through which the results generated in the Saber 11 Test and Saber Pro Test were evaluated. The sample was census in nature, made up of 187 university students belonging to the two programs object of study of the Faculty of Engineering that were active between 2016 and 2017.

As a result of the information processing, it was obtained that the students in the Saber 11 test reached a good rating scale and in the Saber Pro test these same students reached a regular rating scale, a phenomenon that places the latter in a position below the national average. Therefore, in front of this atypical behavior, the need to explain the causes of this phenomenon is generated, as well as to review the learning processes and the development of specific competences, with the pedagogical purpose of training more competent professionals and raising the performance in the Saber Pro tests.

Keywords: *Competences, Evaluation, Saber 11, Saber Pro, SPSS.*

Resumen

Este trabajo tiene como objetivo evaluar las competencias en lectura crítica y el pensamiento científico matemáticas y estadística de los estudiantes de último semestre de Ingeniería Financiera e Ingeniería Comercial. En este contexto, se considera la evaluación como un proceso orientador del aprendizaje, puesto que, a través de ella se logra obtener la información necesaria para identificar qué fue lo aprendido, lo no aprendido y se puedan tomar decisiones asertivas en el proceso de enseñanza y aprendizaje. Por lo anterior, en esta investigación, se realiza un seguimiento a los resultados alcanzados por los estudiantes en las Pruebas Saber 11 aplicadas por el ICFES y, posteriormente, a los resultados obtenidos por los mismos estudiantes en las Pruebas Saber Pro, pertenecientes a los programas en mención de la Universidad Libre.

Esta investigación es un estudio de diseño evaluativo, no experimental, de carácter explicativo que utiliza una metodología de complementariedad entre el método cualitativo y el cuantitativo. Como instrumento para el procesamiento de datos se empleó el software SPSS, por medio del cual se evaluaron los resultados generados en la Prueba Saber 11 y Prueba Saber Pro. La muestra fue de carácter censal conformada por 187 estudiantes universitarios pertenecientes a los dos programas objeto de estudio de la Facultad de Ingeniería que se encontraban activos entre los años 2016 y 2017.

Como resultado del procesamiento de la información, se obtuvo que los estudiantes en la Prueba Saber 11 alcanzaron una escala valorativa de bueno y en la Prueba Saber Pro estos mismos estudiantes alcanzaron una escala valorativa de regular, fenómeno que los ubica a estos últimos en una posición por debajo de la

media nacional. Por lo tanto, frente a este comportamiento atípico se genera la necesidad de explicar las causas de este fenómeno, así como también, revisar los procesos de aprendizaje y el desarrollo de las competencias específicas, con el propósito pedagógico de formar profesionales más competentes y elevar el desempeño en las pruebas Saber Pro.

Palabras clave: *Competencias, Evaluación, Saber 11, Saber Pro, SPSS.*

Introduction

The evaluation of the competences in critical reading and scientific thinking, mathematics and statistics has become a priority in the Faculty of Engineering of the Universidad Libre, reason why, from 2014 to 2018, tests were designed and applied diagnostic tests by means of which the competences in critical reading of expository and argumentative texts were evaluated in students who entered the different university programs for the first time. The results analyzed in the evaluated years, showed difficulties in inferential and critical reading in 63.63%, which determines the urgency of implementing pedagogical strategies that allow improving performance in the inferential analysis of academic texts, the development of critical thinking and students' logical reasoning.

Similarly, the activities and evaluations applied by teachers to students in the regular classroom show low results in activities such as: analysis of short sentences in physics and mathematics, poor interpretation in the application and conducting workshops, as well as, clearing up unknowns, solving problems, following instructions in disciplinary areas, applying theories for the analysis of results in laboratory practices, among others.

Therefore, the diagnosis made not only allows knowing the problematic variables, but also enables reflection on the teaching

and learning process, as well as attempts to respond to a complex situation that involves the institution, quality, evaluation and the development of relevant competencies for the performance of the future professional. According to Maldonado (2014) “evaluation is a central phase in a training process for the acquisition and development of skills. Understanding this stage is understanding that a competence is synonymous with evaluation and recognition of know-how” (p. 40).

In this sense, it is necessary to recognize the evaluation as a pedagogical action that allows to deepen and show in the results, the academic advances, as well as the degrees of difficulty and the skills not developed in the evaluated groups, with the intention of proposing the solution to the problem. According to the Dictionary of Educational Evaluation and Research (1985):

The term evaluation has a much broader meaning than the word measure. The latter is a quantitative description of the behaviors, while the evaluation comprises both the qualitative description and the quantitative description of the behaviors and a value judgment that affects their desirability. (p. 145)

Likewise, Schuman (1967) distinguishes the evolution of the term as a social process by which value judgments are produced and evaluative research as a set of procedures for the collection and analysis of data that increases the possibility of testing rather than of affirm. Additionally, López (2014) points out that “the evaluation for learning is an integral part of the teaching and learning process since it is an essential tool to determine where students are in their learning process, where they should be, and what they must do to improve” (p. 7).

On the other hand, According to the Ministry of National Education (MNE), with the issuance of Law 1324 of 2009, a regulatory framework was established that established the parameters and criteria that govern the organization and

operation of the education quality evaluation system. In this sense, the State exams operate as control instruments for the (MNE) whose function is to inspect and monitor the results of the tests and take decisions to improve the quality of education.

There are many changes that have been generated since the evaluation process began with the Saber 11 Test applied by ICFES, not only has the structure of the question been modified, but also the addition of new booklets or modules that respond to policies of quality or particular interests of the State, according to the Development Plan of the current government. To cite a few examples, the test was extended to the third grade of elementary school, to the ninth grade of secondary school and later, to higher education with the test called Saber Pro.

The Saber Pro test, entitled mathematical and statistical scientific thinking, was one of the last modules of specific competences evaluated by ICFES and since August 2014 it was accepted as final. The results have been made public as of March 2015, confirming what academics already sensed the difficulty of students to understand, analyze and front facing real or abstract situations with scientific rigor, a phenomenon that has been evidenced in the last four years.

On the other hand, critical reading has been a challenge in higher education institutions. In this regard, Parodi (2014) points out:

Active learning from what has been read requires from the reader a critical stance regarding the content of the text. This implies reflective thinking through which an inspection of the text is carried out and the ideas expressed in it are evaluated. In this sense, critical reading requires that the reader actively participate in the construction of the meanings of the text, and take a stance on what it says. This implies that the reader builds his own thoughts from what is said in the text and that he is able to evaluate what is said and decide whether he agrees with it or not. In this way, a critical and reflective reader, who seeks to learn from what he

reads, must evaluate the content of the text and identify his own beliefs and positions and distinguish them from the author of the text. (p. 150-151)

Therefore, the development of skills in critical reading allows the reader to establish an open dialogue with the author of the text, from their own theoretical references, their beliefs, their values and their position in relation to what is proposed by the author. Consequently, this act of the active reader's superior thinking involves deep reflection, self-resignification and a new discursive construction.

The underlying problem in the reading of inferential and critical transcendence is a problem studied in Colombia in the last 20 years, both in public and private universities. Cisneros et al. (2010) proved that only 17% of students apply inferential reasoning as a reading comprehension strategy, compared to an argumentative expository text.

According to Parodi and Peronard (2010), understanding a text is not an easy task, since this cognitive exercise involves detecting the theme, the issues developed, the main and secondary ideas, the overall idea of the text and the author's purpose; all this aspect conditioned to the nature of the text from higher to lower complexity.

Due to the above, this research aims to evaluate through the SPSS software the competencies in critical reading and scientific thinking, mathematics and statistics, in the Saber 11 and Saber Pro Tests, 2016-2017 in students of the Commercial Engineering and Financial Engineering of the Universidad Libre. In this sense, the results of this research allow orienting the way to be followed in the short and medium term, with the purpose of offering alternative solutions to the needs of students.

Materials and Methods

Design

This research is an evaluative design study, non-experimental, of character explanatory that uses a methodology of complementarity between the qualitative and quantitative methods. From the qualitative method, the relationship between variables and efficiency levels was measured through the SPSS, performing an analysis of contingency tables that estimates the comparative relationship of the tests, through the distribution of percentages. On the other hand, from the qualitative approach the interpretation of the data was carried out, taking into account the structural and situational contexts of the problem, generating a pedagogical proposal for both programs, in order to improve the performance levels of the students in the Tests Saber.

Participants

The population sample consisted of 187 students belonging to the Universidad Libre Seccional Pereira, divided as follows: 56 participants of the Financial Engineering program and 131 participants of the Commercial Engineering program who were active between 2016 and 2017, and who were studying the programs in the daytime and at night.

Instruments

The data analysis process was carried out through the SPSS Software, with the purpose of comparing the results of the Saber Pro Test and the Saber 11 Test, achieved by students of the Commercial Engineering and Financial Engineering programs in 2016 and 2017. It is important to clarify that, although the subjects evaluated by the ICFES in the Saber 11 Test and the Saber Pro Test are different, they have in common the evaluation of critical reading skills and scientific mathematical and statistical

thinking. In the Saber 11 Test, the areas that were considered for the evaluation by the affinity with the objectives of the study were: language and mathematics, and in the Saber Pro tests, critical reading and scientific thinking, mathematics and statistics were evaluated.

In this sense, the Saber 11 Test was downloaded through the interactive ICFES platform of the Colombian Government. Subsequently, it was necessary to convert the results from quartile to percentile since both tests present a different measurement. In this sense, the national average and the national standard deviation were considered for each of the competencies evaluated in the Saber 11 and Saber Pro tests, to apply the normal distribution formula.

With the above information, in the data view tab of the SPSS statistical software the numerical information was entered in decimal values corresponding to the results presented by each student in relation to the Saber 11 Test and the Saber Pro Test. It should be clarified that; it was necessary to configure the classification of the numerical variable.

Subsequently, the report of the contingency table used to analyze the relationship of one variable as a function of another was generated, through the distribution of percentages. To obtain the contingency table, it was necessary to use the analyze function of the SPSS software in descriptive statistics and cross tables, assigning the Saber 11 rating as a row and the Saber Pro rating as a column. Next, in the boxes tab, it was necessary to activate the options observed, column and round the cell count to be able to generate the table.

Procedures

For the development of the research, the competences in critical reading and scientific mathematical and statistical thinking were evaluated in the students of the programs under

study in the Saber 11 test and the relationship with the results of the Saber Pro test in the period 2016- 2017, through SPSS analysis, and the results were analyzed in light of the theory.

Results

The results of the Saber Pro Test and Saber Test 11 of the students under study in the Financial Engineering program are presented below, with their respective evaluation on a scale of 1 to 5, where 1 is the low performance score and 5 is the highest yield performance score.

Table 1. General behavior of the Saber Pro 2016 and 2017 Test, according to the results of the Saber 11 Test of the Financial Engineering program

			QUALIFICATION SABERPRO				Total
			1	2	3	5	
QUALIFICATION SABER11	2	Count	1	1	2	0	4
		% within RATING SABER11	25,0%	25,0%	50,0%	0,0%	100,0%
	3	Count	2	15	15	15	47
		% within RATING SABER11	4,3%	31,9%	31,9%	31,9%	100,0%
	5	Count	0	1	1	3	5
		% within RATING SABER11	0,0%	20,0%	20,0%	60,0%	100,0%
Total	Count	3	17	18	18	56	
	% within RATING SABER11	5,4%	30,4%	32,1%	32,1%	100,0%	

Table 1 shows that a total of 56 students were evaluated in the Financial Engineering program. Therefore, in category 2 of the Saber 11 Test, 4 students were found and when comparing with the Saber Pro Test, 1 student represented by 25% fell to category 1 (very low), likewise, another student corresponding 25% retained category 2 (low). On the other hand, 2 students, corresponding to 50%, rose to level 3 (regular), and no student reached category 5.

In category 3 of the Saber 11 Test, 47 students were evidenced and when comparing with the Saber Pro Test, 2 students corresponding to 4.3% passed to a lower level: category 1 (very low), 15 students represented by the 31.9% fell to category 2 (low), while 15 students, corresponding to 31.9%, retained category 3 (regular) and the remaining 31.9% represented by 15 students went up to category 5 (excellent).

Finally, in category 5 of the Saber 11 Test, 5 students were found and when comparing with the Saber Pro Test, 1 student represented by 20% fell to category 2 (low), another student corresponding to 20% fell to category 3 (regular) and 3 students belonging to 60% maintained category 5 (excellent).

Table 2.General results of the Financial Engineering Program

QUALIFICATION	1		2		3		5		Higher performance
	%	No. Students	%	No. Students	%	No. Students	%	No. Students	
SABER PRO	5,40%	3	30,40%	17	32,10%	18	32,10%	18	5
Critical reading	19,60%	11	25,00%	14	21,40%	12	33,90%	19	5
Scientific thought	25,00%	11	19,60%	11	30,40%	17	25,00%	14	3
mathematical	%	14	%	11	%	17	%	14	3

The partial results by competencies in the Financial Engineering program demonstrated that most of the Financial Engineering students who took the Saber Pro Test between 2016 and 2017 were classified in level 3 of the Saber 11 Test.

In this sense, the competencies of the students of the program with financial emphasis demonstrate a 33.90% grade 5 corresponding to the critical reading competency. On the other hand, the scientific thinking, mathematics and statistics competence presents 30.43% located in grade 3. Therefore, the need to implement an improvement plan is exalted that allows university students to enhance their competencies in: critical

reading and mathematical scientific thinking as a fundamental basis for cognitive and metacognitive development that enables the development of heuristic, flexible and creative thinking; as well as “unveiling the counter-hegemonic ideology, the recognition of the hegemonic ideology and the identification of professional interactions” (Díaz, Bar & Ortiz, 2015).

Table 3. General behavior of the Saber Pro 2016 and 2017 Test, according to the results of the Saber 11 Test of the Commercial Engineering program

		QUALIFICATION _SABERPRO					Total
		1	2	3	5		
QUALIFICATION_ SABER 11	2	Count	5	5	4	0	14
		% within RATING _SABER11	35,7%	35,7%	28,6%	0,0%	100,0 %
	3	Count	13	41	33	13	100
		% within RATING _SABER11	13,0%	41,0%	33,0%	13,0%	100,0 %
	5	Count	4	3	3	7	17
		% within RATING _SABER11	23,5%	17,6%	17,6%	41,2%	100,0 %
Total		Count	22	49	40	20	131
		% within RATING _SABER11	16,8%	37,4%	30,5%	15,3%	100,0 %

The previous results indicate that a total of 131 students were evaluated in the Commercial Engineering program. Therefore, in category 2 of the Saber 11 Test, 14 students were located and when comparing with the Saber Pro Test, 5 students represented by 35.7% fell to category 1 (very low), likewise, 5 students corresponding to 35.7% retained category 2 (low). On the other hand, 4 students, corresponding to 28.6%, went up to level 3 (regular), and no student reached category 5.

In category 3 of the Saber 11 Test, 100 students were evidenced and when comparing with the Saber Pro Test, 13 students corresponding to 13% passed to a lower level: category 1 (very low), 41 students represented by 41% they fell to category 2 (low), while 33 students corresponding to 33% retained category 3 (regular) and the remaining 13%, representing 13 students, rose to category 5 (excellent).

Finally, in category 5 of the Saber 11 Test, 17 students were found and when comparing with the Saber Pro Test, 4 students represented by 23.5% fell to category 1 (very low), 3 students corresponding to the 17.6% fell to category 2 (bad), likewise, 3 students referring to 17.6% fell to category 3 (regular) and 7 students, represented by 20%, retained category 5 (excellent).

Table 4. General results of the Commercial Engineering Program

QUALIFICATION	1		2		3		5		Higher performance
COMPETENCIAS	%	No. Students	%	No. Students	%	No. Students	%	No. Students	
SABER PRO	16,80%	22	37,40%	49	30,50%	40	15,30%	20	2
Critical reading	34,30%	45	18,30%	24	25,20%	33	22,20%	29	1
Scientific thought mathematical	33,60%	44	32,80%	43	16,00%	21	17,60%	23	3

The partial results by competencies in the Commercial Engineering Program demonstrated that 34.3% in critical reading was positioned in the lowest grade with 1, as well as 33.6% corresponding to the mathematical scientific thinking competence.

Discussion

The university student, when finding himself from his academic reality with the approach of various texts (literary, informative, scientific), must have the necessary capacities that allow him to establish a clear understanding of the contents and, what is more important, build his own Insights from reflective processes. In this sense, Freire (1989) maintains that “very few students reflect on what they perceive from the text and consequently, they do not generate new ideas, lack creativity and are not builders of their own knowledge” (p. 1). Likewise, the development of reading comprehension skills is linked to knowledge and perception of the world.

Reading comprehension as a transversal axis in the training processes must be an extension of each of the subjects that the student takes through a reading plan oriented from the micro-curricula, therefore, linguistic competence acquires a fundamental role in training comprehensive of professionals. Generally, students arrive at the university with great difficulties in reading and writing, in many cases they demonstrate a literal reading. When starting their university careers, students are faced with academic demands for which no one has trained them, since neither the school nor the university undertake the task of teaching to read inferential and critical ways different academic texts.

“Reading through the curriculum is a process in which it is proposed that the teachers of each subject take on the task of teaching reading following the arguments of each area of knowledge” (Carlino, 2013, p. 370). Many of the texts that are read in school are of the expository type, that is, they contain an absolute truth about the subject at hand, they are phonological texts.

In an argumentative reading, there are different positions on a defined topic, which leads the reader to assume a position or point of view; hence, argumentative skills also trigger critical thinking skills. Therefore there is great concern in higher education centers regarding the argumentation of students based on academic learning in textual production and its relationship with the high rates of university dropouts.

In this sense, Olave, Rojas and Cisneros (2013) examine the relationship between academic dropout and difficulties in understanding and producing academic texts at university; They also refer about the problems that teachers and students encounter in topics related to reading and writing and the importance of academic literacy:

Training in reading and writing at the university is not an easy task, to this is added that when students with previous deficiencies arrive, higher education institutions have to make a double effort: to level their skills and, from there, promote those that need to be mastered in the university environment to achieve better results in academic performance and in the fight against desertion. (Olave, Rojas and Cisneros, 2013, p. 24).

For their part, Uribe and Camargo (2011) emphasize the needs of the teaching and learning of reading and writing in the higher academic environment and the need to integrate various strategies to generate greater results in the understanding and production of academic texts. In the same way, Rojas (2014) points out that students do not have enough tools to fully understand the specialized texts that are part of their curricula. These texts are drastically far removed from the documents that are studied during basic and secondary education, with different objectives, recipients, styles, knowledge, and cognitive requirements (Rojas, 2014).

On the other hand, the development of competencies in mathematical and statistical scientific thinking is the fact of greatest interest to politicians, government officials, industrialists, technological developers, engineers, among others, in today's globalized and competitive world. In this sense, students and professionals are required to understand highly symbolic, specialized and scientific languages that are expressed in assertive, propositional, hypothetical, explanatory sentences, general principles, laws, definitions and theorems, associated with mathematical logic and quantitative statistical procedures that make it possible to measure, assess and evaluate all kinds of human processes and actions. In this regard, Pacheco and Gutiérrez (2011), refer to the scientific method and define it as “a set of steps to follow that, based on logic, mathematics and statistics, among other areas of knowledge, allows to explain phenomenological events and, when its results are used as a support for technology, control or modify nature” (p. 74).

Finally, the current era generates surprising volumes of information, in various theoretical fields and with different forms and graphic, numerical, and geometric representations that are also accompanied by arguments of character statistical and probabilistic. Therefore, it is urgent to develop logical mathematical thinking from early childhood and throughout academic life so that in professional interaction it can face numerical and logical challenges, with the purpose of capturing and understanding the information that is presented in mathematical terms, such as: graphs, diagrams or tables, by means of references to percentage increases or decreases (Cardoso & Cerecedo, 2008).

Conclusions

After the investigation, it can be concluded regarding the development of competences in critical reading and in scientific mathematical and statistical thinking that:

- If the students of the Commercial Engineering and Financial Engineering programs did not pass the results in the Saber Pro test with respect to the results, they achieved in the Saber 11 test in critical reading and in scientific thinking, mathematics and statistics, it can be inferred that, the university failed to develop superior thinking structures so that students could demonstrate their competencies in practice.
- The students were interested in achieving better results in the Saber 11 test since the entrance to the university depended on these results, on the other hand, the Saber Pro test represents only a requirement to graduate.
- According to the results obtained in the SPSS analysis, the students did not improve their academic performance in critical reading and in scientific thinking, mathematics and statistics, in relation to the Saber 11 test, in the last university semesters.

- The study shows, from the results of the evaluation carried out, information that can guide administrative decisions that impact the curriculum or guide academic intervention for the development of competencies in critical reading and in mathematical and statistical scientific thinking.

- It is suggested from the pedagogical reflection to work the PBL Problem-Based Learning method so that the student can analyze various events in the real world from statistical problems, mathematical problems and from a vision of scientific thinking, logical thinking, as well as, critical reflection, so that you can propose a viable solution to problems.

- It is necessary to form a discursive academic community to the extent that the teachers of the Commercial Engineering and Financial Engineering programs pedagogically socialize the practices and methodologies necessary so that students can approach critical reading and scientific mathematical and statistical thinking in this field of knowledge.

- Through academic literacy it is expected that teachers from their areas of specific knowledge can offer guidelines, strategies and recommendations so that students can assume scientific reading as a necessary activity for their academic performance in the program and in their future performance professional.

- It is necessary to recognize evaluation as a process linked to learning, therefore, a mathematical competence is linked to the cognitive development of being able to understand theories, concepts and to establish mathematical properties and relationships to create and do.

- Confronting the results of the SPSS analysis regarding the development of competencies in critical reading and in mathematical and statistical scientific thinking, taking as a reference the background of the diagnostic test applied by the institution between the years 2014 - 2018, and the research carried out by Cisneros, Olave & Rojas (2013) it can be concluded that the results obtained by these investigations are similar to studies carried out

in other Colombian and Latin American universities. Finally, it is urgent to work from the IEP Institutional Educational Project to impact the curriculum of these programs from the mathematical dimensions and design the strategy from competencies such as: formulate, represent and solve problems from logic and argumentation to develop scientific thinking.

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Exchange risk assessment, case of application to an importing company

Evaluación de riesgo de cambio, caso de aplicación en empresa importadora

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Abstract

This applied investigation had as objective to establish a short-term financial cover to control the impact of loss on profits due to the exchange rate risk on the COP/USD ratio, in a company dedicated to the import and marketing of tires in Colombia. For the above, it was necessary to carry out a quantitative analysis between the options and forward coverage, requiring the use of the Black Scholes technique for the calculation of the premium; Likewise, it was necessary to simulate through different forecasting methods

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to choose the lowest RMSE error, presented as a result the time series which was used to project the future behavior of the dollar through the Risk Simulator software. Finally, it was evident that a great part of the background for the present investigation is of a qualitative type, some of the existing quantitative origin are not focused on case studies; otherwise, the results obtained allowed to demonstrate that the best coverage is the purchase of the Call in The Money option because of the financial benefit generated.

Keywords: *Black Scholes, Forward, Options, RMSE, Risk Simulator*

Resumen

La presente investigación aplicada, tuvo como objetivo establecer una cobertura financiera de corto plazo que permitiera controlar el impacto de pérdida en las utilidades por el riesgo cambiario en la relación COP/USD, en una empresa dedicada a la importación y comercialización de llantas en Colombia. Para lo anterior, fue necesario realizar un análisis cuantitativo entre las coberturas opciones y forward, requiriendo emplear la técnica de Black Scholes para el cálculo de la prima; así mismo, fue necesario simular a través de diferentes métodos de pronóstico para elegir el de menor error RMSE, presentado como resultado la serie de tiempo el cual fue utilizado para proyectar el comportamiento futuro del dólar por medio del software Risk Simulator. Finalmente, exaltando las principales conclusiones se evidencio que gran parte de los antecedentes a fin con la presente investigación son de tipo cualitativo, algunos existentes de origen cuantitativo no se enfocan a casos de estudio; de otra forma los resultados obtenidos permitieron evidenciar que la mejor cobertura es la compra Call opción In The Money por el beneficio financiero que se generó.

Palabras clave: *Black Scholes, Forward, Opciones, RMSE, Risk Simulator*

Introduction

In Colombia, the evolution of banking penetration has been mainly linked to microcredit as a financing system for small businesses; however, little recognition was given to other financial services such as payments, fund transfers, savings and insurance (Tafur, 2009), and to the financial knowledge and skills needed to identify issues such as the relevance of savings, detect the product according to needs and plan the costs involved, and the operation and advantages of having insurance to address the risks that can impact finances (Dinero, 2019); as well as the appropriation of knowledge on investment issues in the capital market, risk management and profitability for the optimization of resources. It is necessary to exalt the importance of keeping in mind that:

There are very efficient and diligent companies in terms of developing their own business activity that, however, do not have comparative advantages that allow them to manage the risks associated with the volatility of variables exogenous to their reason for being, in a more efficient way than other market agents (Arango and Arroyave, 2011).

Volatility “measures the increase or decrease in the price of an asset over a given period of time” (Lizarzaburu Bolaños, Burneo, Galindo, & Berggrun, 2015). Otherwise, from a financial management the company in the management of exchange rate risks can be considerably affected in the cash flows and its potential in the operational and financial activity of the company (Vivel, 2010); in another condition an optimistic and opportunistic moment of high solvency, before the need to compete promotes the execution of projects that allow to overcome the local environment to belong to international environments with new business opportunities and strategic challenges in each area.

Exchange risk is the effect on local currency prices of the application of the exchange rate in foreign currency purchase and sale operations (Díaz y Redondo, 2019), which may be intensified for an exporting or importing business in a context of a flexible exchange rate regime, within which the value of the foreign currency in local currency fluctuates freely (Lizarzaburu and Berggrun, 2013), generating a devaluation or revaluation, impacting on emerging economies by the influx or outflow of external capital, which in turn is determined by the policies of their central banks; This is why the main Latin American economies seek at all costs to meet inflation targets, using the exchange rate as the nominal anchor (Rosas Rojas, 2016), in order to avoid contracting commercial activity and generating economic shocks; which on the contrary in industrialized countries can emerge from an exchange rate crisis without any damage (Ramírez, Romero and Lozano, 2007).

Otherwise, the exchange rate risk is considered “easily covered with the mechanisms available in the financial system but in the long term, which is the horizon in which direct investment operates” (Lizarzaburu and Berggrun, 2013), such as currency hedging instruments that reduce the volatility of returns through an efficient portfolio that benefits from market liquidity (Clavellina, 2018), limiting the risk by agreeing on a fixed price for the currency so that the fluctuations generated by the devaluation of the peso in the future do not affect money flows; However, it should be borne in mind that when incurring in futures contracts and other types of transactions even if a cost is paid for them, security is never complete (Chapoy, 2004).

The management of the exchange risk in the country during the last years has been in a constant evolution, not only because it is the most liquid market, but also due to the need to reduce the funding costs obtained when accessing the international market (Cardozo, Rassa y Rojas, 2014). Due to the constant relation between the peso and the dollar, the demand for coverage in

this country comes mainly from the importing companies, which can access to coverage and investment strategies offered by the financial system, such as forwards, options, cross-currency swaps and the currency tunnel; However, participants in the derivatives market implement forwards in their foreign trade operations, followed by options (Cardozo, Rassa and Rojas, 2014), as a more common way of protecting future cash flows against exchange rate risk (Salazar Garza, 2012), which will be the subject of this research, since hedging instruments such as Cross-Currency Swaps cover long-term exchange rate exposure and generally, at the end there is an exchange of interest to offset existing interest differentials between different currencies, which is costly for this type of market participant (García, Pérez and Tovar, 2016). Also, the currency tunnel is not widely used by importers in Colombia, since the price or position taken is exposed to the volatility curve in Colombia and would only serve to obtain profits in the face of expectations of an appreciation of the Colombian peso (Cardozo, Rassa and Rojas, 2014).

Some authors, to evaluate the exchange rate risk, from the perspective of an effect on the performance and permanence of the companies, the implementation or adoption of coverage to mitigate this type of risk, carry out research such as that carried out by Romero et al. (2019) applied to some SMEs in the municipality of Sincelejo with the objective of “establishing the current state of exchange rate risk management in several SMEs in the municipality of Sincelejo in Colombia. In general, there was a lack of knowledge among the SME entrepreneurs about the alternatives for managing foreign exchange risk”.

Likewise, multiple studies carried out by Vivel et al. (2012) have investigated the impact of the exchange rate risk in the locality of Spain showing that "Spanish companies maintain, in majority, an attitude of covering their exchange rate exposure, fundamentally, through the use of financial techniques such as derivatives and foreign currency debt"; Similarly, a qualitative

research was led in Mexicali, Baja California to "determine how currency risk affects the performance of commercial companies dedicated to the purchase and sale of women's clothing, derived mainly from the rise in the price of the dollar" (Carrillo et al, 2017), through the application of a questionnaire which was submitted to statistical tests through Cronbach's alpha to determine its reliability, concluding that businessmen faced with changes in the price of the dollar, increase their prices, without analyzing the market, reducing purchases and supplying themselves with products from the national market without making coverage to protect themselves against this type of economic event, a situation that affects their liquidity and puts their permanence at risk.

On the other hand, investigations such as "the strategy of exchange coverage by means of futures for a company that imports vehicle parts and accessories in Colombia", allowed contributing with significant experiences that exalt the importance of the knowledge and application of coverage contracts in companies dedicated to the negotiation with foreign currency, since in the results they showed that it is possible to diminish the risk associated to the exchange volatility when implementing futures contracts, assuring an expected profitability by the company (Ospina, Jiménez and Rojas, 2017).

The study "Hedges with futures and options to reduce the exchange risk in exporting companies in Colombia", could conclude that the hedge with futures granted benefits in the unit price with which the dollars are obtained by an upward trend; on the contrary, an option contract showed loss in the exchange value that the scenario without hedge (Jiménez, Acevedo and Rojas 2017).

Otherwise, it is worth highlighting, in addition to the investigative background, the importance of the theories that influence the investigation, such as exchange rate risk, which is known as the implication of the loss or gain in the exposure

derived from collections or payments in currency. foreign, is classified according to the type of exposure, which can be transactional, conversion, operational or economic and depends on the changes in value that may occur at the time of the transaction, conversion changes for the value of money over time, the implication of the market value of a company due to the change in the price of the currency, exposure in negotiations with international agents where they assume the ability to face exchange risk (Ogáyar Sanchiz, 2015).

In Colombia, these hedges can be carried out in two different markets, such as the over-the-counter or also known as OTC, and the stock market, managed by the Colombian Stock Exchange. These markets are different because in the first one there is a direct interaction between the two parties, where certain terms and conditions are established that can be agreed looking for a common interest in each position; these interests refer to the rates, the established time, the amount to negotiate, among others. In the stock market these terms are already pre-established, and there are respective regulatory entities in charge of providing guarantees to the system so that the procedure is carried out correctly, such as the clearinghouse, the central securities deposit and the Colombian Stock Exchange.

The most used instruments correspond to futures, belonging to a standardized market, forwards, options and swap to an over-the-counter market (OTC), which are described as follows:

Table 1. Characterization of OTC hedge contracts

INSTRUMENT	CHARACTERISTICS	VOLUME OF TRANSACTION - IMPORTS
FORWARD PESO-DOLLAR	<p>Lower cost, since they do not require the exchange of flows at the beginning of the contract.</p> <p>They are carried out in the short term, less than 30 days</p> <p>High Liquidity.</p> <p>No cash flow is compromised</p> <p>They imply a lower credit risk since they are usually agreed on short terms and can be compensated through a CRCC</p> <p>They have a clearer procedure for accounting</p> <p>They are less expensive in tax terms.</p>	High
OPTIONS PESO-DOLLAR	<p>The bookkeeping of these types of instruments is not clear, and their tax treatment makes them more expensive</p> <p>Generally its use is medium term, average of the operations is 90 days.</p> <p>Call's purchases are par excellence the busiest operations.</p> <p>They require the payment of a premium, therefore, they require the exchange of flows at the beginning of the contract.</p>	Medium
CROSS-CURRENCY EXCHANGES	<p>They agree on the exchange of interest flows in different currencies.</p> <p>They cannot be settled for differences, as the payment flows in the two currencies are different.</p> <p>Long-term use.</p> <p>Companies with high levels of foreign currency debt</p> <p>Higher Cost</p> <p>The largest participants in this market are the foreign agents,</p>	Low
CURRENCY TUNNEL	<p>It is mostly used by exporters.</p> <p>Establishes exchange rate fluctuation limits.</p> <p>It allows you to benefit from favorable exchange rate movements.</p> <p>It limits losses in exchange for unfavorable movements.</p>	Very Low

Source: Elaborated from:

* Cardozo Alvarado, N., Rassa Robayo, J. S., & Rojas Moreno, J. S. (2014). Characterization of the Exchange Derivatives Market in Colombia Drafts of economics. Obtained from Caracterización del mercado de derivados cambiarios en Colombia: https://www.banrep.gov.co/sites/default/files/publicaciones/archivos/be_860.pdf

*García Núñez, J., Pérez Fructuoso, M. J., & Tovar Jiménez, J. (2016). Corporate finance II. derivatives as a hedging instrument. Udimá.

Option contracts can be made on shares, interest rates, stock indicators and currencies. The latter allows reducing the uncertainty derived from the unfavorable variation in the exchange rate that can occur in the future, assuming a cost called premium (Díez de Castro, 2008).

The options are divided into purchase characterized by the name Call and sale by put, of which the premium is recognized for the first by C and the second by P, depending on the period, can be exercised in American or European type, the first option inferring that it can be executed before or during the expiration, on the contrary, the European only in the date of expiration of

the contract. The value gained or lost corresponds to the market price on the date minus the strike or exercise price minus the premium (Montserrat Casanovas, 2014).

In the Call option, future prices are expected to increase, so the buyer is prepared to pay a premium, which if the asset exceeds the strike price before maturity, will buy the asset at the strike price. The higher the price of the asset, the greater the profit for the buyer of the Call. Conversely, in an expectation that prices will fall, the scenario is to buy puts, since "the lower the market price with respect to the strike price, the greater the profit for the buyer of the put" (Baca Urbina & Marcelino Aranda, 2016).

The profit that would be obtained from an option if it is exercised is called the intrinsic value which is evaluated in the Call as the market value minus the exercise value ($S - E$); for the Put option, the exercise value minus the market ($E - S$); whose result can be a positive or negative differential value, which determines whether the contract is exercised, or the premium is paid. This decision is evaluated based on the criteria In The Money (ITM), AT The Money (ATM), Out The Money (OTM) for each option as shown below:

Table 2. *Assessment of the intrinsic value of Call and Put*

Description option	CALL	PUT
ITM	$S > E$ Exercise the option	$S < E$ Exercise the option and pay the premiums
ATM	$S = E$ Either exercise the option or pay the premiums	$S = E$ Either exercise the option or pay the premiums
OTM	$S < E$ It doesn't exercise the option and pay the premiums	$S > E$ It doesn't exercise the option and pay the premiums

Source: Prepared by the authors from Rona Azekeley, J. (2007). A practical guide to derivative financial instruments. Editorial Fund of the Pontificia Universidad Católica del Perú

The calculation of the option premium is done through the Black Scholes methodology, which "considers that the stock exchange follows a random trajectory, like the Brownian movement of particles suspended in the fluid" (Serrano García,

2014), which defines that “in their trajectories at no point do they have a derivative; that is, it is formed only by peaks and that is why we cannot talk about the speed of a possible Brownian movement trajectory” (Tresierra Tanaka & Carrasco Montero, 2016). This formulation considering its fulfillment to the expiration date, is represented by the following equation as it is sustained by the author Fernández (1997):

$$C = S N(x) - K r^{-t} N(x - \sigma\sqrt{t}) \quad [1]$$

Where:

$$x = \frac{\ln(S/Kr^t)}{\sigma\sqrt{t}} + \sigma\sqrt{t}/2 \quad [2]$$

C= Price of call option (T=0)

T= Period of validity of the call option

r= 1+ risk-free interest rate between T=0 and t.

σ = Annual asset volatility by one

K= Exercise price of the call option

S= Price of the asset in t=0

N(x)= Value of the cumulative probability function of a standard normal distribution

Otherwise, you must consider the option calculation; in which you must have the following variables: Forecast at the end of the period - market value, strike price, premium paid and profit/loss. The Forecast at the end of the period -Market value: Numerical values in which the representative rate of the market can be found at the end of the period, established in a speculative way by the work team.

Price of the year or strike: Price agreed by the company before the financial entity; this will be fixed.

Premium paid: Price established by the financial entity; this will be fixed.

Profit/Loss: Numerical value that expresses whether the operation yields a positive or negative economic result for the company.

A forward constitutes a private agreement between a seller and a buyer, where the seller agrees to deliver a specific real (products such as wheat, corn, gold, etc.) or financial (currencies, rates and interest, etc.) asset (called the underlying) to the buyer at a specified future date, and the buyer agrees to pay the seller an agreed price (the contract price) upon delivery (Pérez Barbeito, 2014).

Forward contracts are the oldest and most widely used foreign exchange risk management instrument in international trade, finance and investment. They can also be used as speculative instruments. Forwards belong to the OTC (over-the-counter) market, and the amount of a contract usually exceeds one million dollars. The contracting parties can be a bank and its client, or two banks (Kozikowski Zbigniew, 2013).

Historically, derivative markets were born as over-the-counter (OTC) markets, in that contracts are negotiated bilaterally, and the risk of default is assumed by both parties (Ramírez Celada, 2006).

According to Baca et al., (2016), this OTC contract is evaluated by applying the basic economic engineering formula to obtain the future price of the asset at maturity as presented in the following formula:

$$F = P (1 + i)^n \quad [3]$$

Where:

P = Present value of the COP/USD ratio

n = Number of working days of the period to be carried out based on the year.

i = Implicit devaluation rate of the COP-USD Forward contracts, given by the bank of the republic.

The quality of forecasts generated with a quantitative approach deteriorates as the variability of the data increases, therefore, it is necessary to consider the greater number of historical data, to improve the adjustment of the forecasts (Krajewski & Ritzman, 2000). Therefore, in the estimation processes of the forecast model of variables with high volatility as is presented in the subjacent

assets of the stock market or the macroeconomic variables, it is required to determine the formation of prices, expressed in the following formulation (Serrano García, 2014):

$$P_t = P_{t-1} * \exp(r_t) \quad [4]$$

Where:

P_{t-1} = At previous value of the asset

Exp (r_t) = Estimated current value yield

Being r_t :

$$r_t = \text{Ln} \left(\frac{P_t}{P_{t-1}} \right) \quad [5]$$

Ln = Neperian logarithm of current price over previous value of asset

Also, errors in the forecasts are necessary to estimate them, since this allows to identify the model that has less bias with the original values when compared with the estimated ones, these can be bias or random errors (Krajewski & Ritzman, 2000), Among the random errors, it is possible to identify the RMSE, which in itself is an inferential statistic and econometric concept, the difference between the real and the predicted values (Barreto & Howland, 2006), using the root equation of the mean square error (Kurková et al., 2018), as expressed below:

$$RMSE = \sqrt{\frac{(Y_t - \hat{Y}_t)^2}{n}} \quad [6]$$

Among the forecasting theory, there are different simulation models that allow determining the future values of the assets, among the most used is the Monte Carlo Simulation, a methodology initiated by Boyle in 1997, which allows the simulation of stochastic processes whose accuracy in the results depends on the number of scenarios that are projected (Prósper Lamothe & Somalo Pérez, 2006). The results of the process can be Gaussian taking negative values which for some forecasts is an undesirable result (Martínez & Villalón, 2013). Likewise, the Time Series allows to evaluate the data from the decomposition in four components like the tendency, a gradual movement of the data in the time that can be ascendent or descendent; the

seasonality, corresponding to the pattern of repetition of data of a period; the cycles, infer in the repetition of the data but after several years and random variation, data generated by chance or by unusual or not estimated incidents (Heizer & Render, 2004).

The Auto ARIMA methodology has the functionality to automate several permutations of the model specifications to project the one that fits best, through the dependent variable and multiple independent ones, without limiting the number of data to be forecasted if only the time variable Y is used; if X variables are considered the limitation is presented by the number of data periods of exogenous variables minus the data periods of the time series variable (Mun, 2016).

Stochastic Processes that consist of a mathematical equation that generates a series of results are not deterministic over time, allowing a simulation that originates several trajectories for prices, allowing a statistical sampling of the potential trajectories of the simulation, where the Brownian motion is a random walk (Mun, 2016), observed by botanist Robert Brown, who noticed that pollen grains in watery solution have an irregular motion trajectory; which gave rise to Bachelier's proposal that stock prices behave in a Brownian way, which means unpredictable due to the efficient market assumption that the next price depends only on the price at that time and not on its history of variation (Ramos et al., 2019).

Materials and methods

The objective of this applied quantitative research is to demonstrate the benefits that could be contracted to implement other non-standardized hedges in 2018, other non-standardized hedges such as options and/or forward contracts to reduce the exchange risk in the company under study dedicated to the import and marketing of tires, which to date was negotiating futures contracts.

The development of this research was determined by four phases, the first one was a test and modeling exercise concerning finding the method with less error value to forecast the TMR with the help of the Risk Simulator tool, later, the exchange rate volatility was evaluated and the TMR was projected 5 days, In the third phase, the premium calculation methodology was applied using the Black Scholes method, followed by the evaluation of the Call option coverage and finally the forward coverage was applied to analyze the results and to demonstrate the best coverage technique to be implemented in the company.

Results

The importing company of tires located, by October 3, 2018 had pending the payment of an invoice to its suppliers abroad in the amount of \$1,000,000 USD. On September 26, 2018, it decided to make an exchange coverage to fix the price of the dollar, to insure in pesos (COP) the cost of the invoice in the future date. The coverage evaluated to contemplate the one that generated the greatest benefit was between the Call option and the forward.

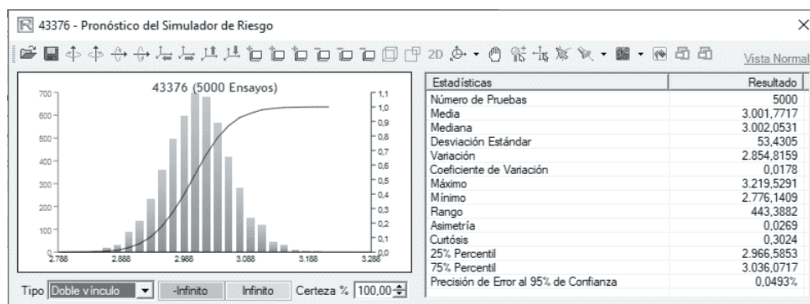
Buying a Call Option: Based on the value of the COP/USD of the underlying asset on September 26, 2018, which was \$ 3,001.88 and an estimated strike price of \$ 2,948.34. The value of the exercise of the option or the Strike, was considered from the proximity and level of confidence in the test evaluation with lower RMSE of the behavior of the TRM that was the Monte Carlo Simulation; therefore the K Sigma methodology was contemplated emphasized in the Lower Effectiveness Limit (LEI) that refers to the mean minus one deviation (Gómez and Tocino, 2004); in order to have the reference value to contract the option taking into account that it refers to the same methodology assigned to determine the expected results of the lower limit, average and upper limit of the exchange rate on October 3, 2018.

The strike was \$2,948.34 pesos, considering an average of \$3,001,7717 pesos and a deviation of \$53,4305 pesos. Initially a test sample was made with data from January 2, 2018 to September 20, 2018 in order to evaluate with the real data from September 20 to 26 of the year the RMSE error in the Monte Carlo Simulation, Time Series, Auto ARIMA forecast models, Stochastic Forecast with Exponential Brownian Movement, which would allow choosing the least error to estimate the TRM of 5 working days later which as short term coverage would be adjusted with a high probability in order to carry out the evaluation of the contracts for October 3, 2018.

When performing the Monte Carlo Simulation test with simple distribution fitting, it was presented that the historical data of the Nigerian logarithms of TRM were adjusted for a logistic distribution commonly used to describe growth, whose P-value was 91.02%,

To evaluate the simulation of the historical period from September 20, 2018 to October 26, 2018, then the RS Forecast Statistic (simulated TRM value; "average") was calculated, the result of the RMSE error for this method was \$9.24 cents, the time series with the double exponential smoothing \$9.39 cents, Auto ARIMA \$15.81 cents, Stochastic Forecasts with the exponential Brownian motion \$9.37 cents. The above concluded that the forecast to use was stochastic.

Finally, the estimated value for October 3, 2018 was \$ 3,001.77 pesos through the logistic distribution of historical data of the TRM in 2018 gave a P-value of 89.97% for the estimation of the Monte Carlo Simulation; the minimum expected value of the TRM for this day was \$2,981.83 pesos and maximum of \$ 3,021.72 pesos with a confidence level of 95%.

Figure 1. Mock test MRT from day 26th of September 2018

P.S: Prepared from the data of the Colombian Government Open Data Representative Exchange Rate and Risk Simulator.

Source: Government of Colombia. (2020). Open data. Obtained from Representative Exchange Rate or TRM (for Spanish): <https://www.datos.gov.co/Econom-a-y-Finanzas/Tasa-de-Cambio-Representativa-del-Mercado-Historic/mcec-87by>

Thus, the first coverage simulation was carried out, with the purchase of a Call option starting on October 26, 2018 for 5 days (Business Days) corresponding to October 3, which was agreed at a price of \$ 2,948.34 pesos with the corresponding financial entity. In accordance with these conditions, the entity establishes as business parameters a risk-free rate of 2.25% EA and a premium of \$ 53.54 COP per USD.

For the respective premium calculations, it was necessary to apply the Black-Scholes model, in which two variables of high impact on the results were highlighted: the risk-free rate and the volatility. The risk-free rate worked was 0.0062% (2.25%), corresponding to the daily percentage of the Federal Found Rate of September 26 (Bank rate, 2016) and the volatility was specified with the historical information of the TRM of the year elapsed or also called Year to date, since the exercise was agreed in that same period.

Once the historical information was obtained, we proceeded to calculate the volatility with the Nepalese logarithms of the series and the sample standard deviation of the same, which corresponded to a volatility of 0.724%.

With the above, the Black Scholes model was made, considering the market price variables of September 26, corresponding to \$3,001,88 pesos, the value of the exercise that was previously determined by 2,948,34 pesos, the estimated volatility, the risk-free rate and the time factor of 0.0137, which gave rise to a Call of \$53.54 pesos per dollar.

To classify the options in relation to the strike price of the option and the price of the underlying, an expected forecast was made for October 3, 2018 of \$3,001.77 pesos; a lower limit of \$2,981.83 pesos and an upper limit of \$3,021.72 pesos with a 95% probability.

Table 3. *Assessment of the option in function of the Call*

Price of the exercise (E) \$ 2948,34 COP		
Market Price (S)	Option Call	
	Type of option	Interpretation
\$2.981,83	ITM (in the money)	
\$3.001,77	ITM (in the money)	
\$3.021,72	ITM (in the money)	It will produce benefits to the buyer. Market Price (S) > Price of the exercise(E)

Using the forecast series of the underlying, the following results were given:

Table 4. *Practical exercise, buy Call.*

DESCRIPTION PRICE OF THE MARKET	Inferior Limit	Media	Superior Limit
MARKET PRICE	\$2.981,83	\$3.001,77	\$3.021,72
PRICE OF THE EXERCISE OR STRIKE	\$2.948,34	\$2.948,34	\$2.948,34
ASSESSMENT OF CALL	\$33,49	\$53,43	\$73,38
PREMIUMS PAY X DÓLAR	\$53,54	\$53,54	\$53,54
PARTIAL PROFIT OR LOSS	-\$20,05	-\$0,11	\$19,84
EARNINGS FUNCTION	\$-20.050.000	\$-110.000	\$19.840.000

The maximum loss is limited to the value of the premium, which for this year is \$53.54 per dollar, or \$53,540,000, while the gain is unlimited. If the dollar reached the upper limit of \$3,021.72, the net profit would be \$19,840,000.

Forward Contract: According to Baca et al., (2016), this OTC contract is evaluated by applying the basic economic engineering formula to obtain the future price of the asset at maturity as presented in the following formula: $F = P (1 + i)^n$ from where:

$P = \$3.001,88$.- present value of the COP/USD ratio.

$n = 5/365$ - number of working days of period to be carried out based on the year.

$i = 1.26\%$ (Term 3 to 14 days - September 2018) - Implicit devaluation rate of the Forward COP-USD contracts of Banco de la República de Colombia (Colombian Republic Bank).

Therefore, the future value for this exercise would be as follows:

$$F = 3.001,88 (1+0,0126)^{0,0137}$$

$$F = 3.002,39$$

To determine the profit or loss generated by the forward contract, the price of the dollar on the day the debt was contracted (initial spot) is taken and multiplied by the amount, this result is subtracted from the price of the dollar on the day the invoice is due (final spot) and the amount, if the result of the subtraction is positive it means that the company is saving money, but if the result of the subtraction is negative it means that the company is incurring a loss.

-Starting spot: \$3,001.88 Value that had a dollar the day the company acquired the debt.

-Final spot: \$3,002.39 Estimated future value.

-Amount: \$1,000,000 Amount owed by the company

Chart 5. Exercise Contract Forward

CONTRACT FORWARD						
AMOUNT USD	INITIAL SPOT	FINAL SPOT	DIFFERENCE	PAYMENT IF THE PRICE IS STABLE	PAYMENT WITH CONTRACT FORWARD	EARNINGS / LOSSES
\$1.000.000	\$3.001.88	\$3.002.39	-\$0,51	\$3.001.880.000	\$3.002.394.940	-\$514.000

The result obtained showed that, if the company paid the bill without contracting any type of coverage, it would have to pay \$514.000 pesos more than it had budgeted to pay on the day it

contracted the debt, this overpayment corresponds to increase of the price at future.

Table 6. Coverage comparison

INITIAL CONDITION						
AMOUNT USD	MARKET PRICE (PRICE TODAY)	MARKET PRICE (PRICE TODAY)		PAYMENT IF THE PRICE WAS STABLE		
\$1.000.000	\$3.001,88			\$3.001.880.000		
BUY CALL IN THE MONEY						
MARKET DESCRIPTION	MARKET PRICE	STRIKE	DIFFERENCE	PREMIUMS	PARTIAL EARNINGS OR LOSSES	EARNINGS FUNCTION
Lower limit	\$2.981,83	\$2.948,34	\$33,49	\$53,54	-\$20,05	-\$20.050.000,00
Media	\$3.001,77	\$2.948,34	\$53,43	\$53,54	-\$0,11	-\$110.000,00
Upper limit	\$3.021,72	\$2.948,34	\$73,38	\$53,54	\$19,84	\$19.840.000,00
CONTRACT FORWARD						
AMOUNT USD	INITIAL SPOT	FINAL SPOT	DIFFERENCE	PAYMENT IF THE PRICE WAS STABLE	PAYMENT WITH CONTRACT FORWARD	EARNINGS /LOSSES
\$1.000.000	\$3.001,88	\$3.002,39	-\$0,51	\$3.001.880.000	\$3.002.394.940	-\$514.000

When analyzing the results that were presented of the different types of coverage, it was determined that the coverage that generated more benefit for the importing company was the purchase of Call with a Strike of \$2,948.54 pesos, a profit of \$19,840,000 pesos, in a scenario where the price could oscillate by \$19.84 pesos above the market price, in this case the company benefited because the value paid for the premium, was the maximum loss that could have when exercising the option; therefore, any upward movement would be a profit scenario for the company.

In conclusion, if a company needs to generate profit with a hedge, it is necessary to set the strike price based on analysis that determines the smallest error in the expected forecast of the initial spot rate or also called market price. Likewise, the purchase of Call must be contracted, since it is a flexible hedge that allows

you to have profits both when the spot rate rises and maintaining the value of the dollar budgeted strike price, which allows you to maintain the financial stability of the company.

Conclusions

It was evident in the background study that most of the recognition research in indexed journals is of a descriptive and qualitative type, where the evaluation of exchange risk is focused on the application of a diagnostic instrument and in a smaller proportion quantitative studies applied to case studies were found.

The hedge that offers more flexibility and greater possibilities of obtaining benefits both to the rise of the price of the dollar and to the fall, is the hedge that is contracted with options.

Risk Simulator is a complete and efficient tool when projecting the values of the variables that were used to structure the hedges, since the results they give are reliable and allow to have an approximation to the values that are going to be presented in real life, estimating different scenarios in time.

Investors should not negotiate with certain foreign currencies expecting the peso to revalue against that currency, on the contrary, they should contract hedges and seek to obtain benefits in any situation, establishing optimistic, moderate and pessimistic scenarios.

Before implementing a financial hedge, it is important to estimate the trend and possible values of the asset at which the risk is required to be managed due to the effect of uncertainty, since these would allow a more objective analysis to be made in accordance with expected expectations.

Structuring the possible future results of the variables, will not always be security to make the investment, since there are many macroeconomic factors that may influence the values they take and make them have a different volatility than the one believed.

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Application of a competitiveness model for permanent free trade zones in Colombia

Aplicación de un modelo de competitividad para las zonas francas permanentes en Colombia

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Abstract

This article aims to show the importance of determining the level of competitiveness of the Permanent Free Trade Zones (PFTZ) in Colombia, from the applicability of a business competitiveness model that seeks to analyze their competitive potential and establish strategies for the optimal development in this sector.

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A diagnosis of the permanent free trade zones in Colombia was carried out, in which aspects such as: the subsectors in which the free trade zones are focused, percentage of participation, number of industrial users of goods or services, promotion of free trade zones through electronic means, types of certifications they have, among others; Immediately afterwards, the Business Competitiveness Model of Manuel Humberto Jiménez was applied to 10 PFTZ of Colombia, which allowed determining the level of competitiveness of these, it should be noted that for the application of the model, a questionnaire of 22 questions was designed that were applied to some of the senior managers of the free trade zones and were complemented with information obtained from the web pages, public information of the Association of Free Trade Zones of the Americas (AFTZA) with a specific focus on the Colombian case and the National Association of Foreign Trade (ANALDEX).

It was found that the most critical factor of the Special Permanent Free Trade Zones (PFTZ) and that produces delays in the development of their competitiveness is related to the factors: financial management, science and technology; Regarding the first, most of the PFTZ s present low profitability, and regarding the second factor, it is necessary to intensify the implementation of science and technology projects that promote development and competitiveness in the regions where they are installed.

This research made it possible to carry out a diagnosis of 10 PFTZs in Colombia, identifying the critical factors in these areas, among which promotional activities by electronic means are highlighted, having a Colombian seal of sustainable construction, outsourcing of processes, the number of foreign companies installed and financial factors. However, efficient criteria were identified such as constant growth in sales, having different certifications both in the logistics chain and with quality standards, little customs transit time of the merchandise, the use of inventory systematization programs and frequent participation in international events.

On the other hand, through the implementation of the Business Competitiveness Model of Manuel Humberto Jimenez, it was possible to show that the PFTZs are not competitive from the point of view of the model, these regimes in Colombia have a decline in their competitiveness in the market, which it should serve as an alert for government institutions to carry out projects to improve competitiveness in this sector.

Keywords: *Colombia, Diagnosis, Competitiveness Model, Permanent Free Trade Zones*

Resumen

En el presente artículo se pretende mostrar la importancia de determinar el nivel de competitividad de las Zonas Francas Permanentes (ZFP) en Colombia a partir de la aplicabilidad de un modelo de competitividad empresarial que busca analizar el potencial competitivo de las mismas y establecer estrategias para el óptimo desarrollo en este sector.

Se realizó un diagnóstico de las zonas francas permanentes en Colombia, en el cual se analizaron aspectos como: los subsectores en los que se enfocan las zonas francas, porcentaje de participación, número de usuarios industriales de bienes o servicios, promoción de las zonas francas a través de medios electrónicos, tipos de certificaciones con las que cuentan, entre otros; acto seguido se aplicó el Modelo de Competitividad empresarial de Manuel Humberto Jiménez a 10 ZFP de Colombia, que permitió determinar el nivel de competitividad de estas; cabe resaltar que para la aplicación del modelo se diseñó un cuestionario de 22 preguntas que se le realizaron a algunos de los altos directivos de las zonas francas y se complementaron con información obtenida de las páginas web, información pública de la Asociación de Zonas Francas de las Américas (AZFA) con enfoque específico en el caso Colombiano y de la Asociación Nacional de Comercio Exterior (ANALDEX).

Se encontró que el factor más crítico de las Zonas Francas Permanentes Especiales (ZFP), que produce retrasos en el desarrollo de su competitividad, está relacionado con los factores: gestión financiera, ciencia y tecnología; en cuanto al primero las ZFP en su mayoría presentan una baja rentabilidad, y en cuanto al segundo factor hace falta intensificar la implementación de proyectos en ciencia y tecnología que promuevan el desarrollo y competitividad en las regiones donde se encuentran instaladas.

Esta investigación permitió realizar un diagnóstico de 10 ZFP en Colombia, identificando los factores críticos de estas zonas, dentro de los cuales se resaltan las actividades de promoción por medios electrónicos, contar con sello colombiano de construcciones sostenibles, la subcontratación de procesos, el número de empresas extranjeras instaladas y factores financieros. No obstante se identificaron criterios eficientes como el constante crecimiento en ventas, contar con diferentes certificaciones tanto en la cadena logística y con estándares de calidad, poco tiempo de tránsito aduanero de la mercancía, el uso de programas de sistematización de inventarios y la frecuente participación en eventos internacionales.

De otro lado, a través de la implementación del Modelo de Competitividad empresarial de Manuel Humberto Jiménez, se pudo evidenciar que las ZFP no son competitivas desde el punto de vista del modelo, estos regímenes en Colombia tienen un declive de su competitividad en el mercado, lo que debe servir como alerta para que desde las instituciones gubernamentales se realicen proyectos tendientes a mejorar la competitividad en este sector.

Palabras clave: *Colombia, Diagnóstico, Modelo de Competitividad, Zonas Francas Permanentes*

Introduction

At present, competitiveness is a determining concept both for the development of the regions and for the country, since when referring to competitiveness it can be said that it is the ability to innovate, design, produce and develop strategies with the same resources of the most efficient way and standing out from other competitors present in the environment. According to the National Competitiveness Report 2018-2019 (Consejo Privado de Competitividad, 2019):

Colombia must accelerate the pace to achieve structural changes and thus greater competitiveness, and this is demonstrated in the Global Competitiveness Index of the World Economic Forum where Colombia went from position 57 among 135 countries to 60 among 140 countries, as well as in the Yearbook of Competitiveness World Bank of the Institute for Management Development, the country fell from position 51 in 2015 to 58 in 2018 and in the Doing Business ranking of the World Bank, from position 51 to 59 in the same period.

These measurements were able to identify that the country must advance as a priority on three fronts: improving the enabling conditions that allow increasing productivity, optimizing the functioning of markets and betting on business innovation, which includes greater investment in science, technology and innovation (STI).

Considering the above, Free Trade Zones are a development element that allow to enhance the competitiveness of a country. Some studies developed such as: “The characteristics of small and medium-sized enterprises in the Batam free trade zone” (Hendrawan, 2012), “An evaluation of the port free trade zone in Taiwan” (Chiu, Lirn, Li, Lu, & Shang, 2011), “Combining industrial free trade zones and regional free trade agreements: lessons from the Mexican experience” (Matthews & Sargent, 2001), “Free Trade: treaties and the new order” (Sánchez, 2016); allow to show

that the implementation of a free trade zone can impact several aspects, allowing to improve environmental variables so that the region is more competitive and productive, however not all territories have the facility for its implementation or do not have a strategic geographic location that exalt the potentials of these zones and allow them to fulfill the objectives for which they were created.

The establishment of Free Trade Zones in Colombia had a great reception since 1956 when they were potentiated as drivers of the economy, which generated the creation of these in several cities of the country. However, according to the “Technical Bulletin for foreign trade and movement of goods Free Trade Zones (PFTZ), Colombia has 106 free trade zones divided into 38 Permanent Free Trade Zones (PFTZ) and 68 Special Permanent Free Trade Zones (SPFTZ)” (DANE, 2020); leading the sector to an unstable economy, since all of these are not operating in their entirety, nor are they generating the expected development in terms of social impact, industry development, technology transfer, infrastructure, among other aspects.

"Many of the Free Trade Zones have managed to meet the investment goal by 140%, however they have presented a deficit of 48% in job creation" (Portafolio, 2014), this being one of the main factors that delays the full development of free trade zones, a figure that has a negative impact considering that these covers 60% of the national territory, which means that this sector does not generate the desired competitiveness.

For these reasons, this study seeks to answer the question: What is the level of competitiveness of the Permanent Free Trade Zones in Colombia?

To this end, the purpose of this study consisted in determining the level of Competitiveness of Permanent Free Trade Zones in Colombia, for which two specific objectives were developed,

the first related to the diagnosis of the PFTZ under study and the second corresponding to the application of a Business Competitiveness Model designed by the author Manuel Humberto Jiménez, which analyzes competitiveness based on six factors: Managerial Management (MM), Commercial Management (CM), Production Management (PM), Internationalization (I), Science and Technology (ST), Financial Management (FM).

This study will help identify those Permanent Free Trade Zones that take better advantage of the factors that allow them to develop greater competitive advantages. Likewise, the results of this study offer operator users to focus on factors that allow them to perform and optimize the quality of their processes and improve the effectiveness of planning, generating strategies to attract new markets.

Materials and methods

The development of this study was carried out on 10 Permanent Free Trade Zones (PFTZ) in 2017, “as of 2019 there were 38 PFTZ in Colombia” (DANE, 2020); However, when collecting the information, it was only possible to obtain information on 10 of these.

Decree 383 of 2007 establishes three types of free trade zones: permanent, permanent special and transitory. Permanent or multi-user Free Trade Zones are considered as a defined geographical area within the national territory with special regulations and where industrial or commercial activities of goods and services are developed. In addition, for this type of Free Trade Zones, minimum amounts of investment and job creation are established. (Moscoso & Castellanos, 2018)

To determine the most competitive Permanent Free Trade Zone in Colombia, a descriptive study based on the deductive method is carried out, where it is intended to identify elements of

a common company, such as: the organizational structure, type of customer with which it operates, marketing channel, pricing policy, supply, demand, among others. For this purpose, in the first phase of the investigation, a questionnaire of 22 questions is applied to some of the managers of these free trade zones, likewise additional information is obtained from the web pages of these zones and public information from the Association of Free Trade Zones of the Americas (AFTZA) with a specific focus on the Colombian case and the National Foreign Trade Association (ANALDEX) in order to explore the problem and determine the variables that influence the competitiveness of the Permanent Free Trade Zones in Colombia. As a second phase, the business competitiveness model proposed by Manuel Humberto Jiménez was applied.

The following table shows the phases of the investigation, the models used, and the variables analyzed:

Table 1. *Phases, models and study variables.*

Investigation phase	Model used	Variables analyzed
1. Permanent Free Trade Zones Diagnosis	Structured questionnaire according to the methodology of Hernandez, Fernandez and Baptista which indicate that “the most logical process to create an instrument is to move from the variable to its dimensions, then to the indicators and finally to the items” (Hernández, Fernández, & Baptista, 2010)	<ul style="list-style-type: none"> • Subsectors in which the PFTZ focuses • Determination of the prices of the PFTZ • Visualization of the sales of the PFTZ • Percentage of market share • Number of industrial users of goods and / or services they have • Promotion of PFTZs through electronic means • Type of certifications that it has • Means of access to the free trade zone (land, air, sea) • It has a Colombian seal of sustainable constructions • Depreciation of equipment used • Subcontracting of the latest technology or higher capacity equipment • Percentage of participation of outsourced processes • Number of direct jobs • Number of foreign companies installed • Agility in customs transit processes of merchandise for the different users of the PFTZ • Participation of the PFTZs in international events

- Projects developed by the PFTZs in the regions where they are installed
- Use of inventory systematization programs
- Educational level of managers
- Year of experience of managers in the sector
- Number of languages that managers speak
- Types of decision-makers used in decision-making
- Profitability of the PFTZ
- Level of indebtedness
- Liquidity
- Cash flow
- Credit quota
- Return on Investment (ROI)

	<p>Definition of the model: $COMP = MM (GC + GF + GP + CT + I)$</p>
<p>2. Application of the Business Competitiveness Model</p>	<p>Where: COMP = Competitiveness, MM = Managerial Management, CM = Commercial Management, FM = Financial Management, PM = Production Management, ST = Science and Technology, I = Internationalization</p> <ul style="list-style-type: none"> • Managerial Management • Commercial Management • Financial Management • Production Management • Science and Technology • Internationalization <p>Each factor is scored with a maximum score as follows: MM = Between 0 and 1 CM = 30 points FM = 20 points PM = 20 points ST = 10 points I = 20 points</p> <p>With a maximum score of 100 points (p.) And the rating scale will be: Between 0-69 p. = Not competitive Between 70-79 p. = Low competitiveness Between 80-89 p. = Competitive Between 90-100 p. = Very competitive (Jiménez Ramírez, 2006)</p>

Results and discussion

- Diagnosis of 10 Permanent Free Trade Zones in Colombia

For the presentation of these results, the variables were divided according to the 6 factors established in the Business Competitiveness model: Commercial Management (CM), Production Management (PM), Internationalization (I), Science

and Technology (ST), Managerial Management (MM), Financial Management (FM). The following tables show the main results obtained from the diagnosis:

Table 2. Results of the diagnosis of Permanent Free Trade Zones (PFTZ)

Variable	Most representative answer	%
Commercial Management		
Subsectors in which free zones are focused	Manufacturing, Automotive, Agroindustry, Building Materials, logistics and storage	51%
Determination of PFTZ prices	Business objectives	60%
Visualization of sales of products and services	Constant growth	90%
Percentage of participation of the PFTZ	Greater than 10%	40%
Number of users of goods and / or services	Between 1-30 users	60%
Promotion of PFTZs through electronic means	Does not respond / does not know	80%
Types of certification available to the PFTZ	BASC certification, ISO 9001	90%
Means of access to the Free Trade Zone	Land access	70%
Colombian seal of sustainable constructions	Does not have	50%
Production Management		
Depreciation of PFTZ equipment	5-year maximum depreciation	80%
Subcontracting of latest technology equipment or greater capacity	Yes	80%
Percentage of contracting of outsourced processes	Less than 1%	40%
Number of direct jobs	10,000 jobs approximately	70%
Internationalization		
Number of foreign companies installed in PFTZ	Between 4-7 companies	60%
Customs transit process of the merchandise	Between 1 -3 days	80%
Participation of the PFTZ in international events	Attend frequently	70%
Science and Technology		
Projects developed by the PFTZs in the region in the last 5 years	Yes	50%
Use of inventory systematization programs	Yes	80%
Managerial Management		
Free trade zone managers educational level	Specialization, Master	70%
Years of experience of managers	Between 8-11 years	30%
Other languages that managers speak	English	50%
Decision-maker types	Decision maker 1: Presents a conservative attitude with aversion to risk	50%
Financial Management		
Cost effectiveness	Between 1 - 20%	50%
Debt level	Greater than 50%	40%
Liquidity	<= \$ 100,000,000	70%
Acid test	Between 1 - 5	71%
Cash flow	<= 100,000,000	50%
Credit limit	Greater than 50%	80%
Return on Investment (ROI)	Between 1 - 20%	70%

Regarding the diagnosis of the Permanent Free Trade Zones analyzed, it was possible to show in the Commercial management factors that 51% focus on five specific subsectors: manufacturing, automotive, agro-industry and construction materials, logistics and storage; 60% determine prices taking into account business objectives, which shows that these are the main axis of the Free Trade Zones, since this factor is above the other variables that are normally used to establish prices such as its costs and competition. 90% say that sales are in constant growth and 40% have a market share greater than 10%, which proves that the sector is on the rise. Regarding the number of industrial users of goods and / or services, 60% state that they have between 1 and 30 users, which is good for these areas, since in a few words it is related to the companies installed in the Free Trade Zone that produce, transform or they assemble goods or companies that offer logistics, communication and transportation services, among others, that have tax, customs and foreign trade benefits, but which, due to these same characteristics, give dynamism to the PFTZs. Likewise, regarding the promotion of these areas through electronic means, 80% did not respond, which was a limitation to conclude this question, however it can be indicated that in this factor the companies do not have priority and only they limit themselves to having a web page with general information about the free trade zone and its services.

90% have implemented some type of certification, standing out the BASC standard for its control and security standards in the logistics chain and the ISO 9001 standard for its quality standards, which generates a comparative advantage for free trade zones, turning this into a benefit for them. Regarding the means of access to the PFTZ, it is evident that 70% have good land accesses, which is logical if one considers that by law, they have the obligation to build or fix the roads that lead to the port more nearby. Furthermore, it is evident that very few have air or sea access, which becomes a competitive advantage for those that offer various accesses to the area. Finally, in the commercial aspect,

it is identified that 50% do not have sustainable construction stamps, only a small proportion is aware of the importance of having these stamps and contributing to the environment.

Regarding the production management factor, this sector has state-of-the-art machinery, this being a priority, since this is a variable that drives their development and in turn generates a comparative advantage for them, which is evidenced by the fact that 80% of the PFTZs use machinery that depreciates over 5 years and is in constant renewal. On the other hand, there is a high trend in the sector (80%) for the subcontracting of equipment, giving priority to this activity before buying, in the same way this allows determining the interest of the companies in the sector under study in having cutting edge technology; Regarding the percentage of participation of outsourced processes, it is an unreliable option, since it is evident that only 40% do so and at levels less than 1%, in turn meaning that companies do not have total trust in companies external, having greater preference in that they themselves carry out their operations. 70% of the studied Permanent Free Trade Zones generate around 10,000 direct jobs, this being a positive factor, since they indicate that they are generating development in the regions where they are installed.

When studying the internationalization factor of Permanent Free Trade Zones in Colombia, it is known that 60% have an average between 4 - 7 foreign companies installed within the free territory, it is also important to highlight that a large part of these are supported by agreements with the ports and with the National Tax and Customs Directorate (DIAN), facilitating the customs transit of the merchandise for the different industrial users of goods and / or services, taking an average of 1-3 days to carry out the procedures, making these agile processes in 80% of the PFTZs. On the other hand, 70% of these free trade zones participate in international events.

Regarding the Science and Technology factor, only 50 % carry out development projects for the region and for itself such as Data Center construction, software development, implementation of joint Social Responsibility actions with business groups located in the region. free trade zone, among others; On the other hand, the use of inventory systematization programs is used by 80 % of the free trade zones, which allows greater optimization in the processes.

The management factor of Permanent Free Trade Zones in Colombia indicates that 70 % of managers have a high educational level, as well as 50 % of a second language, 30 % of them have an average experience in the sector between 8 - 11 years, this being a positive variable; on the other hand, it is evident that 50 % are inclined towards a type of conservative decision-maker, leaving aside the preference for taking risks.

Finally, in the analysis of the financial management of the PFTZs, it is determined that 50 % have a profitability between 1-20 %, it should be noted that only one has a profitability higher than this value and the rest have a negative profitability which indicates that the decisions taken in the commercial, production, science and technology and internationalization factors have not been significant, therefore causing the loss of new investors. Regarding the level of indebtedness, 40 % have an indebtedness greater than 50%, which indicates that the participation of creditors in their pecuniary provision is representative.

On the other hand, with respect to liquidity, 70 % of the Free Trade Zones have a liquidity of less than \$ 100 000 000, which can be worrying when complying with their obligations; On the other hand, in the study of the acid test, it is evidenced that 71% have a good short-term payment capacity without the need to liquidate or sell their inventories, which generates a go-ahead for

managers; However, the cash flow trend shows that 50 % have a good capacity to generate cash flows both in their inflows and outflows of capital, in parallel 70% of the free trade zones claim to have an ROI between 1-20% , which shows a low indicator of financial gains for this sector according to the effort they must make in the development of their operations.

- Level of Business Competitiveness of the ZFPs

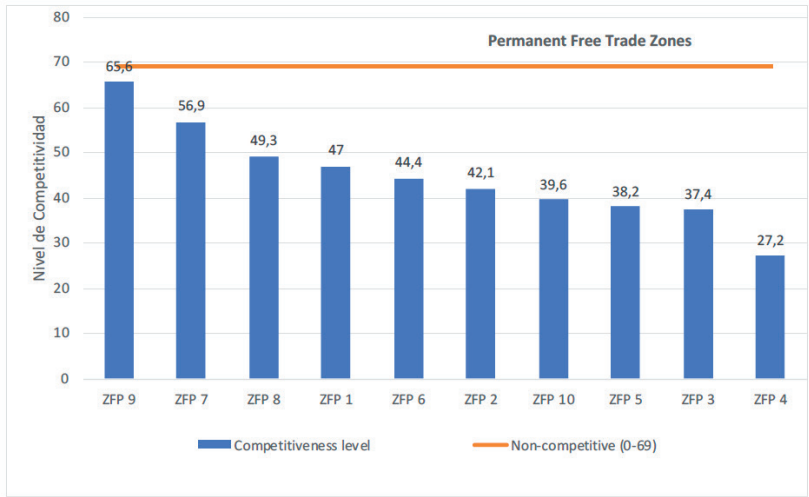
For the development of this chapter, we proceeded to establish qualification and scoring criteria for each of the variables and factors of competitiveness: Commercial Management, Production Management, Internationalization, Science and technology, Managerial Management, Financial Management, followed immediately by the rating of each of the PFTZ under study.

Table 3. *PFTZ Business Competitiveness Level by Management*

Ratings obtained by factor in each PFTZ										
Factor	PFTZ 1: Zona Franca del Pacífico S.A	PFTZ 2: Zona Franca Parque Central	PFTZ 3: Zona Franca Bogotá	PFTZ 4: Zona Franca Palermo	PFTZ 5: Zona Franca Occidente	PFTZ 6: Zona Franca Internacion al del Atlántico	PFTZ 7: Zona Franca Brisa S.A	PFTZ 8: Zona Franca Internacional de Pereira	PFTZ 9: Zona Franca de Ibagué	PFTZ 10: Zona Franca Valle de Aburrá
Managerial Management	0,75	0,75	0,53	0,48	0,65	0,75	0,85	0,8	0,85	0,75
Commercial management	22,32	21,32	25,31	17,16	20,99	20,82	25,98	24,15	23,65	17,49
Financial management	3	2,5	2	8,5	2,5	4	2	2,5	12,5	1
Production Management	15	7	18	14	15	14	14	13	16	12
Science and Technology	5	10	10	5	5	5	5	10	5	5
Internationalization	17,32	15,32	15,32	11,99	15,32	15,32	19,98	11,99	19,98	17,32
Competitiveness level	47,0	42,1	37,4	27,2	38,2	44,4	56,9	49,3	65,6	39,6

The following figure shows the level of competitiveness of the PFTZs analyzed:

Figure 1. *General Competitiveness Level PFTZ year 2017*



From the point of view of the Business Competitiveness Model of Manuel Humberto Jimenez, the Permanent Free Trade Zones analyzed for 2017 are not competitive, because of this, it is evident that the most critical factor of the Permanent Free Trade Zones is found in financial management, this is due to the fact that the vast majority have a low profitability, taking into account that this factor is also related to the level of indebtedness, liquidity and cash flow. However, the Ibagué and Brisa Free Trade Zone located in the department of La Guajira were the best rated in this regard as they presented outstanding returns, however in their other financial indicators they are not the best, thus affecting the final score for this factor.

Similarly, it is evident that another of the critical factors is science and technology, where 50% of the Permanent Free Trade Zones under study have not implemented in the last 5 years, according to the information collected, representative projects in this aspect that promote a greater boost in competitiveness in these regions, therefore it is a worrying factor since this is one of the objectives of these Permanent Free Trade Zones.

However, the Ibagué Free Trade Zones and the Brisa Free Trade Zones are the most developed ones that show that they have the procedures that the model evaluates, although they are not competitive. The Ibagué Free Trade Zone stood out for having a sustainable construction seal, which guarantees a balance between industry and the environment, it is strategically located near the main cities of the country, it has access to the main land routes of the country and excellent land access roads that connect to the port of Buenaventura, one of the main multipurpose ports in Colombia; All this means that the commercial aspect is qualified in a representative manner, however there is evidence of a lack of dynamics in sales due to the small number of users installed in the PFTZ; Furthermore, according to the information collected, it has not been able to generate enough jobs or the investments required in the region, which produces little dynamism and is a critical variable that can affect it in the long term.

Of the Brisa Free Trade Zone, it stands out that it is one of the largest complexes of the free regime in the country, it also has a single multipurpose port specialized in bulk and liquid products that allows the development of industrial, logistics and cargo handling activities, which gives it an advantage over the others; In addition to the ease of access it has to the seaport, which allows it to have a good qualification in commercial management, in addition to the internationalization factor, it stands out for the number of companies installed, the agility in customs transit processes and its presence at events and constant training for its collaborators in the free regime.

Conclusions

Regarding the diagnosis of the Permanent Free Trade Zones, it was concluded that among the factors analyzed, these have criteria in critical condition where no type of importance is given to activities such as promotion through electronic media, having the Colombian seal of sustainable constructions, the

outsourcing of processes, the number of foreign companies and the projects in Science and technology that they carry out in the region and even one of the most worrying criteria is presented in the financial part.

On the other hand, it is concluded that among the factors there are also efficient criteria for the PFTZs, such as the constant growth in sales, having different certifications both in the logistics chain and in quality standards, having equipment with a depreciation less than five years, also the short time of customs transit of the merchandise, the frequency of participation in international events and the use of inventory systematization programs. Consequently, said diagnosis makes it possible to highlight the criteria that make the performance not as expected, in such a way that the areas where the gaps are evident can be analyzed in detail compared to the other criteria of the other free trade zones.

Regarding the level of Competitiveness for the year 2017 and according to the application of the Manuel Humberto Jiménez model, it is evident that the sector of the Permanent Free Trade Zones of Colombia is not competitive, despite being a figure that seeks to boost the economy and the development of the regions where they are installed, this regime shows a decline in its competitiveness in the market, it is necessary for the government to generate strategies that seek to better optimize financial factors and science and technology in this sector.

On the other hand, the purpose for which these projects are created is to boost the economy, competitiveness, job creation, planning and implementation of projects in the regions where they are installed. With the development of this research, it was observed that contracting is a positive criterion, since this is in accordance with the commitments acquired for the creation of the free trade zone. However, once installed, it is evident that it is difficult for them to maintain themselves.

Finally, the model, proposed by Manuel Humberto Jiménez, could be applied to the Permanent Free Trade Zones sector and allowed a comparative analysis, evaluating various organizational areas, which allowed us to understand that there is a synergy between all the components of the organization, and that thus The managerial factor is properly managed by a manager with all the competencies and capacities to do so, if the rest of the areas of the organization do not work properly, the results will be inefficient, therefore, properly manage all organizational areas and maintaining control over them will contribute to making the right decisions and generating a competitive advantage.

Acknowledgement

The authors thank the Universidad Libre Seccional Pereira for their support in conducting the research, as well as students Sebastián Londoño Hoyos and Jhonier Gálvez Cardona for their contribution and participation in the project.

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Mechanical characterization of re-used vulcanized rubber

Caracterización mecánica del caucho vulcanizado reciclado

Juan Fernando López¹

Abstract

Rubber is an important material in factory for manufacturing vehicles parts and electric industry components. There are thousands of tons of vulcanized rubber waste due to cars' tires, shoes, electric components, o- rings, rubber seals, etc. which every day are disposed in landfills causing a severe environmental damage. In specialized literature there are many alternatives to rubber recycling, some of them mechanical, other chemicals. However, most of them expensive because the process of rubber recycling is very difficult, and there is not an effective and industrial recycling technique. This paper shows the mechanical characterization of rubber re-vulcanized test pieces, using several

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compositions mixing raw and vulcanized crumb rubber. This study shows the increase of tensile modulus when homogenization is achieved.

Keywords: Crumb rubber, Mechanical characterization

Resumen

El caucho es un material importante en la fabricación de autopartes y componentes de la industria eléctrica. En la actualidad existen miles de toneladas de desechos de caucho vulcanizado debido a las llantas de los automóviles, suelas de zapatos, componentes eléctricos, empaquetaduras, sellos de caucho, etc. que todos los días son desechados en vertederos provocando un severo daño ambiental. En la literatura especializada existen muchas alternativas para el reciclaje del caucho, algunas mecánicas, otras químicas. Sin embargo, la mayoría de ellas son costosas porque el proceso de reciclaje del caucho es muy difícil y no existe una técnica de reciclaje industrial eficaz. Este trabajo muestra la caracterización mecánica de piezas de caucho re-vulcanizado, utilizando varias composiciones que mezclan caucho virgen y caucho vulcanizado triturado. Este estudio muestra el incremento del módulo de elasticidad cuando se logra la homogeneización.

Palabras Clave: Caucho vulcanizado, Caracterización mecánica

Introduction

Natural Rubber comes from the rubber tree as a white latex and after vulcanization It has many industrial applications such as o-rings, shoes, electric components, flexible piping, tires, etc. However, every industrial process in rubber transformation brings some amount of waste. The most visible problem with rubber is the tire production. Every tire is made from a mixture

of natural and synthetic rubber with more than 100 different chemical components. The previous scenario shows a problem of general pollution and waste disposal.

In the city of Pereira, Colombia, in 2015, is estimated that 448.879 tires were discarded. 249.887 were converted into special solid waste, numbers tending to increase, due to the growth in the automotive fleet in recent years. The city cleaning company cannot handle tires accord to legislatives that does not include tires in the characterization of ordinary waste in Pereira, added to the complexity involved in its handling, recycling and decomposition. Most of this recycling is accomplished transforming the vulcanized rubber in Asphalt concrete (black-top, bitumen or rolled asphalt) or shredding to small parts for synthetic soccer fields.

There are several strategies for vulcanized rubber reusing, as can be seen in the works of Ciesielski (2009), Martin (2014) and Sadhan (2005), who established chemical methods to recover the vulcanized rubber and desulfurize the material. The specialized literature in materials (Ashby, 2014), (Kalpakjian, 2008), (Smith, 2006), specifies how rubber changes its molecular structure when vulcanized and this is the main challenge to overcome in a system of rubber reuse. The other approach to this reuse is the mechanical transformation of the waste in other industrial design products (Ashby, 2014) using different manufacturing processes or binders to carry out processes for shaping the rubber chip or pellets. Recent studies show how to obtain a crumb rubber with a particle size of 100 to 150 micrometers using ultrasonic grinding (Dobrotă & Dobrotă, 2018) this rubber granulate can be treated as a raw material for composites, polymers (Sienkiewicz et al., 2017) (Cazan et al., 2019) concrete aggregates (Saberian & Li, 2018), asphalt or chip seal (Gheni et al., 2017), (Gheni et al., 2018), etc.

Besides this research in the field of rubber reusing, there is not much information concerning the rubber re-vulcanization with granulated aggregate and its mechanical properties. This paper shows the mechanical properties of crumb rubber mixed with natural rubber for revulcanization. Two different granulate sizes are used and hardness, compression and tension tests are achieved.

Materials and methods

Test pieces

Several test pieces were fabricated with different composition of natural and vulcanized rubber. For this purpose, natural rubber 65 is mixed with rubber burr and crumb rubber. The configurations considered for specimen's construction are specified in Table 1.

Table 1. Test pieces compositions

Piece Number	Code	Natural Rubber (% in weighth)	Vulcanized Rubber (%in weighth)	Observations
1	100VU	0	100	
2	20VR80VU	20	80	Vulcanized Rubber: Burr from pieces of natural rubber
3	40VR60VU	40	60	
4	60VR40VU	60	40	
5	80VR20VU	80	20	
6	40VR60VULL	40	60	Vulcanized Rubber:
7	60VR40VULL	60	40	Crumb Rubber

Source: Authors

The specimens were made by means of transformation of the virgin rubber and recycled rubber mixtures, through a vulcanization process, based on special characteristics according to the ASTM test standards for determination of mechanical properties. The specimens for tensile test have a double bell

shape (Figure 2) with $L = 30$ mm and the specimens used for hardness and compression tests have a standard cylindrical shape (Figure 2) with diameter $d = 29 \pm 0,5$ mm and height $h = 12.5 \pm 0.5$ mm. For each configuration, 3 specimens were obtained to be subjected to traction and 3 for compression tests.

Figure 1.

Tensile test piece. (IS, 2012), Source: Authors

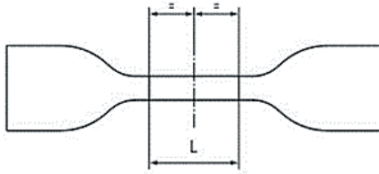
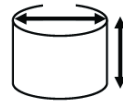


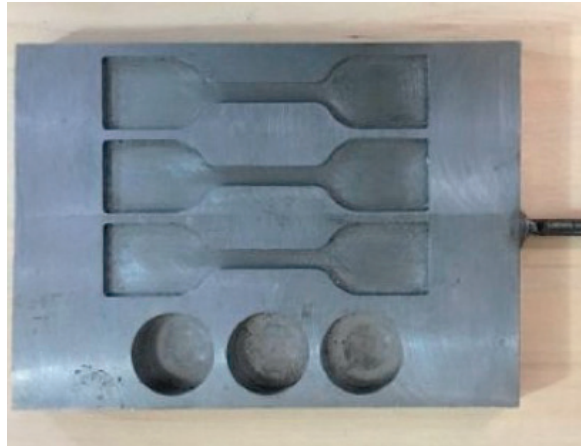
Figure 1.

Hardness and compression test piece. Source: Authors



For creation of specimens, a mold in AISI-SAE 1020 steel is fabricated (Figure 3), which is installed in the press for the transformation of the rubber mixtures through traditional vulcanization process.

Figure 2. *Mold for test pieces manufacturing Source: Authors*



Methods

Material tests: To determine the mechanical properties of rubber mixtures, the mechanical tests achieved on the rubber specimens will serve as a basis for characterizing the behavior of the material when it is subjected to mechanical stress. The conditions for each of the tests accomplished on the manufactured specimens are shown in Table 2.

Table 2. *Standards used for testing rubber samples*

Test	Standard	Number of pieces	Description
Hardness	DIN 53505	3	Shore Hardness A. This test is implemented in compression piece. A 1kg mass is used in the test.
Compression	ISO7743:2017	3	Constant speed load is applied at 10 mm/min until 25% deformation is reached. The piece is released at the same speed. The cycle is repeated 4 times.
Tensile	IS3400:2012	3	0.1MPa preload. Constant speed load is implemented of 200 mm/min until specimen crash.

The Shore A hardness test was carried out under standard DIN 53505 at 20 ° C, one week after vulcanization of the test specimens. For each of them, at least 3 marks were made at different points on the surface, separated at least 5 mm from each other and from the edges. When making the measurements, the apparatus exerted an approximate load of 1 kg (9.81 N) on the surface of the test pieces. Each reading was made after 3 seconds of load execution. The experimental setup of the test is shown in Figure 4.

Figure 4

Shore A hardness test set up. Source: Authors



Figure 5

Compression test set up. Source: Authors



Hardness, compression and tensile tests were achieved in materials resistance laboratory in Universidad Tecnológica de Pereira, for compression test is used a universal test machine according to standard specification. For tensile test, a Mark 10 Force Test Stand is applied as shows figures 5 and 6

Figure 6. *Tensile test set up. Source: Authors*



Results and discussion

According to the standard, three specimens were tested, and the overall mean is presented in this paper. Table 3 shows results for 100% natural virgin rubber. Table 4 summarizes the hardness mean value and variance results for each material combination.

Table 3. *Hardness results for 100% natural rubber test piece*

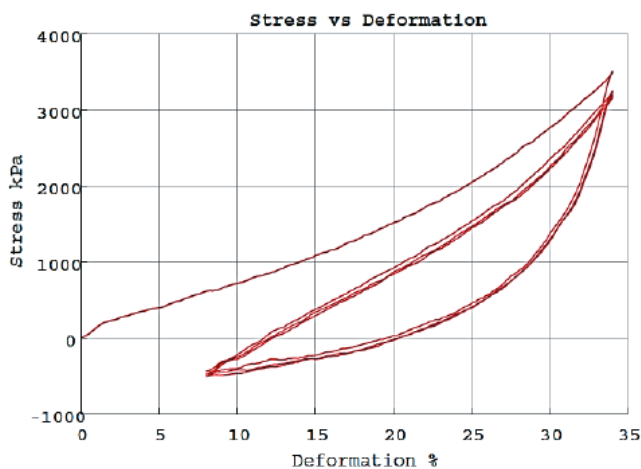
	Hardness 1	Hardness 2	Hardness 3	Mean
specimen 1a	55.5	57.5	57.0	56.7
specimen 1b	59.0	58.5	59.0	58.8
specimen 1c	57.5	58.0	56.0	57.2
Shore A Hardness (Test piece 1 – 100VR)				57.6

Table 4. *Hardness test results*

Test piece / Shore A Hardness	Hardness mean value	Results Variance
Piece 1 – 100VR	57.6	
Piece 2 – 80VR20VU	58.4	
Piece 3 – 60VR40VU	51.7	
Piece 4 – 40VR60VU	54.4	
Piece 5 – 20VR80VU	57.6	
Piece 6 – 40VR60VULL	52.6	
Piece 7 – 60VR40VULL	50.2	

Compression results

In compression test, the Young Modulus was calculated from 4 load cycles. Figure 7 shows stress vs deformation graph. Most of the rubber application are in the scope of compression forces therefore this test is important for practical applications.

Figure 7. *Stress vs Strain curve for compression test in test piece 1.*

From this curve is possible to calculate a Young modulus in compression. The machine test actually measures force and deformation, the stress and proportional deformation are calculated with eq 1 y eq 2.

$$\sigma = \frac{F}{A_0} \tag{1}$$

Since σ is the stress calculated, A_0 is the transversal specimen area and F is the force measured in the Universal test machine.

$$\varepsilon = \frac{\Delta L}{L_0} * 100 \tag{2}$$

Since ε is the strain calculated, ΔL is the specimen length variation and L_0 is the initial length of the test piece.

Table 5 shows the unitary deformation ε , the maximum stress σ_{max} and the Young's Modulus in compression.

Table 5. Compression test results

Test piece	ε	σ_{max} (kPa)	E(MPa)
Piece 1 – 100VR	0.3406	3009.86	12.2658
Piece 2 – 80VR20VU	0.34084	2130.67	6.2653
Piece 3 – 60VR40VU	0.34037	2188.83	8.9886
Piece 4 – 40VR60VU	0.34064	1859.83	5.4646
Piece 5 – 20VR80VU	0.34059	897.81	2.6332
Piece 6 – 40VR60VULL	0.3399	2065.44	6.0885
Piece 7 – 60VR40VULL	0.33866	2191.58	6.43

Source: Authors

3.2. Tensile test results.

The principal result of tensile test is the Young Modulus which permits the comparison of this material with others, also, this result gives a clue in the possible application of the mixture vulcanized rubber.

Figure 8 shows the stress strain curve for all test pieces in different color with a typical characteristic curve for rubber materials.

Figure 8. *Stress vs Strain for tensile test.*

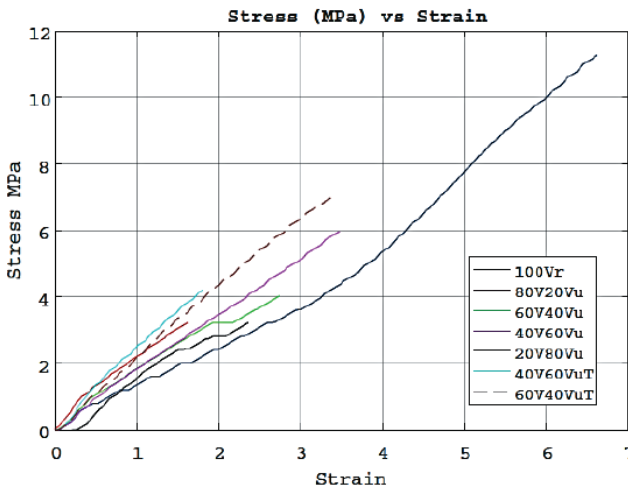


Table 6 summarizes the tensile test results for different test pieces. The table shows the unitary deformation ϵ , the maximum stress σ_{max} and the Young's Modulus E.

Table 6. *Tensile test results*

Test piece	ϵ	σ_{max} (kPa)	E(MPa)
Piece 1 – 100VR	0.661	11.27	1.70
Piece 2 – 80VR20VU	0.320	6.83	1.79
Piece 3 – 60VR40VU	0.359	5.24	1.46
Piece 4 – 40VR60VU	0.346	5.96	1.72
Piece 5 – 20VR80VU	0.215	3.22	1.49
Piece 6 – 40VR60VULL	0.180	4.21	2.33
Piece 7 – 60VR40VULL	0.529	9.79	1.85

Source: Authors

Discussion

The principal characterization of rubber for practical applications is the hardness number, even you can find several charts that localize de rubber products according to Shore number. In the focus of this research the Rubber used in the

factory CADELI, is mainly applied in electrical elements, o-rings and automotive parts. With the Shore A test a Hardness between 50 and 58 was found in the overall material tested. Having a decrease in hardness in the mixture with the crumb rubber, compared with the 100% virgin rubber. From application point of view those test pieces are between medium soft and medium hard rubber. This means that harder ones (test piece 1 and

2) works for applications in tires and automotive parts. Piece 5 is medium hard, but in the test piece It is not possible to obtain a homogenous mix between virgin and vulcanized rubber, also, due to the size of the granulated waste rubber, the hardness test often shows the characteristic of only this part of the mixture.

Conclusions

It is found that the crumb rubber allows a better homogenization with the virgin rubber meanwhile decrease the compound hardness.

In general, the mechanical properties of Rubber decrease with the amount of chopped rubber and crumb rubber added. From tables 5 and 6 it can be shown that chopped waste rubber maintains better the compression strength and crumb rubber maintain better the tensile compound strength.

From this, in applications as floors, shock absorbers and compression parts, it should be used chopped rubber mixed with virgin rubber. And for application such as elastic bands, and tensile parts, the crumb rubber should be better. However, each application of this recycled material should be tested before to avoid problems with product quality.

Acknowledgment

The Authors acknowledge the factory CADELI, who opened the doors to this research, to Universidad Católica de Pereira that financed the research, and Universidad Tecnológica de Pereira which allowed the resistance tests in its laboratories.

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Bibliometric review of the research overview on green concrets

Revisión bibliométrica del panorama investigativo en concretos verdes

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Abstract

The manufacture and use of concrete are significant environmental pollutants due to its high CO₂ emissions. Contrary to the current postulates of sustainable development and global pacts for the reduction of greenhouse gases, which

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is why during the last 20 Years have been developing new techniques and use of alternative materials, as raw material for the manufacture of concrete, with satisfactory results in terms of durability and resistance. The search was advanced in the Scopus database, using the search equation “green concretes”, filtering by title. Using bibliometric and network visualization tools, such as RStudio and VOSviewer, the information corresponding to 201 documents was processed and evaluated. The most significant findings indicate that China and India are leading the research on new technologies to use recyclable raw materials in the manufacture of green concrete, causing the global environmental impact in the construction sector to decrease. Additionally, it was found that the most relevant sources are the *Journal of cleaner production* with 20 published articles corresponding to 9.9% and *Construction and building materials* with 15 articles, of the total distribution of publications.

Keywords: bibliometric indicators, CO2 emissions, collaboration networks, concrete industry, scientific mapping, environmental protection.

Resumen

La fabricación y uso del concreto es uno de los mayores contaminantes ambientales debido a sus altas emisiones de CO₂, en contravía de los actuales postulados del desarrollo sostenible y pactos globales por la disminución de los gases efecto invernadero, razón por la cual durante los últimos 20 años se han venido desarrollando nuevas técnicas y aprovechamiento de materiales alternativos, como materia prima para la fabricación de concretos, con resultados satisfactorios en cuanto a la durabilidad y resistencia. Se adelantó la búsqueda en la base de datos Scopus, mediante la ecuación de búsqueda “green concretes”, filtrando por título. Mediante el uso de herramientas bibliométricas y de visualización de redes, como RStudio y VOSviewer, se procesó y evaluó la información correspondiente a 201 documentos.

Los hallazgos más significativos indican que China e India lideran las investigaciones de nuevas tecnologías para el uso de materias primas reciclables en la fabricación de concretos verdes, propiciando que el impacto ambiental a nivel mundial en el sector de la construcción disminuya. Adicionalmente, se encontró que las fuentes más relevantes son el *Journal of cleaner production* con 20 artículos publicados correspondiendo al 9.9% y *Construction and building materials* con 15 artículos, de la distribución total de publicaciones.

Palabras claves: emisiones de CO₂, indicadores bibliométricos, industria del hormigón, mapeo científico, protección del medio ambiente, redes de colaboración.

Introduction

In recent decades, the emission of carbon dioxide (CO₂) through human and natural processes and human activities in eliminating waste materials and natural resources consumption (Sanyal, Kodgire, Desai, Saxena, Singh, & Dasgupta, 2020; Shukla, Gupta, Goel, & Kumar, 2020) is considered the most important cause of climate change. In the construction industry, cement production (Nguyen, Chang, Lee, & Shih, 2020) is one of the main contributors to the increase in CO₂ emissions in the world (Azarsa & Gupta, 2020^a; Azarsa & Gupta, 2020^b). Khalil & Al Obeidy (2020); Saadoon (2019); Turuallo & Mallisa (2019) concluded that concrete is an essential material for the construction of many infrastructures (residential, bridges, roads) and civilizations around the world. Also, every year concrete production exceeds 120,000 million tons. Among those are cement with approximately 1,600 million tons, 1,000 million tons of aggregates, and 1,000 million tons of water.

Authors Zhao, Gao, and Yang (2020) explained that the production of a quantity of cement generates almost the same quantity of CO₂ gas that causes ecological damage, indicating

that the manufacture of concrete has a considerable influence the environment and health (Haza, Shulhan, & Kadis, 2020). Likewise, Hamada et al. (2020) investigated that cement consumption in 2010 was 3.27 billion metric tons and is expected to rise to 4.83 billion metric tons in 2030, possibly causing climate change. The conservation and protection of the environment had become a problem of global context, for which since the world summit of the earth in 1997 in Kyoto Japan the need to reduce CO₂ emissions on a large scale was created (objective before 2010 was to reduce by approximately 21%) to avoid a global catastrophe, large industries and countries around the world agreed to formulate a regulation that dreams of emissions of protection and preservation of the environment (Suhendro, 2014)

O'Reilly et al. (2010) indicate that the optimal management of concrete technologies must be considered concerning the built works' useful life. In addition to the conventional aspects that have marked their management until today, it is necessary to consider the aspects of the environment and the ecological impacts that occur. From the same premise Saadoon (2019), Suhendro (2014), Palanisamy (2020), Al-Mansour (2019) ensure that the raw materials of concrete are mining at very high temperatures 1,500 C. Also, Oyebisi (2020) mentions that concrete releases a tremendous amount of carbon dioxide CO₂. The reported rate in global emissions in 2004 was 7%. Katiyar & Pal-Singh (2019) and Azarsa & Gupta (2020b) stated that large amounts of different types of plastic and glass waste are created worldwide. These wastes are buried in landfills because plastic and glass do not degrade quickly. This method seriously damages the environment. The researcher Al-Mansour et al. (2019) describes the importance of human beings finding new solutions to preserve the environment. The alternatives are to reuse, recycle, and reduce this waste (plastic and glass). The glass is a transparent material made by mixing SiO₂, CaCO₃ at high temperatures and it is a material that takes thousands of years to degrade. Tang (2020), Nursyamsi et al. (2019) describe that plastic is a polymer formed by organic nature

chains. It can be classified into three categories, thermoplastic, elastomer, and thermoset. Worldwide, plastic material increased from 204 million tons in 2002 to 299 million tons in 2013.

Parihar & Pastariya (2020), Zhao et al. (2020) highlight that the production of cement as a construction material is not sustainable since it consumes large amounts of natural materials, 1.5 tons of raw materials are needed to produce each ton of cement, which is the main material in the production of concrete, in the same way, the author Tang (2020) writes that the manufacture of cement is producing the emission of CO₂ that leads to global warming and climate change. In parallel, Oyebisi et al. (2020) provides a solution for manufacturing and proposes to develop cementitious materials, a product of industrial waste (Muhamad, Zainol, Yahya, Noor, Hashim, & Shahrazi, 2020), and thus consume less energy in production and reduce the content of cement to be used in the production of concrete. Besides, the use of these materials can give additional benefits and improve specific properties such as strength, workability, and durability of concrete (Turuallo & Mallisa 2019, Nagarkar 2017).

Palanisamy (2020), Tang (2020) describes the concept of green concrete as a drift of saving various natural resources without compromising the needs of the future generation, durability, low cost, recycling, and reuse of waste materials (Thiruvekitam, Pandian, Santra, & Subramanian, 2020) without losing space, time, and money at your disposal. The engineer Saadoon (2019) clarifies that green concrete is made from 90% recycled materials, so the cost of doing this will be less than cement when it is manufactured in bulk. It also has a production process that does not lead to the destruction of the environment, has high performance and life cycle sustainability. Green concrete technology becomes a historical revolution in the concrete industry. The first green concrete manufactured was made by Dr. WG. in Denmark in 1998 (Saadoon 2019). Al-Mansour (2019) and Nuralinah (2019) ensure that green concrete incorporates

materials that have been used before in industries. However, the development of green concrete does not stop at the utilization of by-products but instead advances through more advanced approaches to investigate material systems to achieve sustainability.

Ali Zidan and Al-Eliwi (2020) state that sustainable construction can be achieved; green concrete technology can be adopted (Bosro, Samad, Mohamad, Goh, & Tambichik, 2020; Bunnori, Alani, Noaman, Johari, & Majid, 2020; Azad, Saeedian, Mousavi, Karami, Farzin, & Singh, 2020). This technology provides savings in natural materials, pollution, and time using waste materials. Today, fly ash is used throughout the world for the construction of buildings. It is a significant by-product of coal combustion. Oyebisi et al. (2020) say that fly ash is mainly used to replace cement, decrease environmental pollution, improve durability, and decrease shrinkage and hydration.

Zhao et al. (2020), Maryoto & Heri Sudibyo (2019) said that the number of researchers interested in new, environmentally friendly building materials increases (Mohammadhosseini, Alyousef, Lim, Tahir, Alabduljabbar, Mohamed, & Samadi, 2020). Traditional Portland cement-based concrete is expected to be replaced by geopolymer concrete due to reducing carbon dioxide emissions. Shanmugavel et al. (2020) say that the Ordinary Portland Cement product releases a focus six times greater than that of CO₂ compared to geopolymer-based concrete. Cornelis et al. (2019) believe that a lot of construction waste is generated every second worldwide, which is not used effectively. Many of them are willing to make new land; at the same time, they also cause pollution of construction waste.

This descriptive article aims to provide an overview of the main characteristics of publications in green concretes based on bibliometric analysis. The information presented in this document provides a clear picture of the research progress achieved in research in green concretes (Sadowski, Nikoo, Shariq, Joker, & Czarnecki,

2019; Rehman, Rashid, Zafar, Alqahtani, & Khan, 2020) and can help researchers and practitioners identify the fundamental influences of authors, journals, countries, institutions, references, and research topics.

Materials and methods

For the bibliometric analysis development, the search equation "green concrete" was used by title in the Scopus database, allowing to develop of broad searches and the filters that the researcher defines (Burnham, 2006; Boyle, & Sherman, 2006). The results were filtered by type of document, including only research articles, conference papers, and review articles, and they were considered every year. The search yielded a total of 201 articles, from which the scientometric and bibliometric analysis was developed, using the open-source tool bibliometrix, through the import of bibliographic data from Scopus (Aria & Cuccurullo, 2017). For the bibliometric network analysis and the visualization of scientific information structures, the VOSviewer software (Van Eck & Waltman, 2010), developed at Leiden University, was used. Such action included co-authorship between countries and authors, analysis of co-citation between sources, and the co-occurrence of keywords.

Results and discussion

According to Table 1, of the 201 documents obtained, 54.23% correspond to articles, 39.30% correspond to conference documents, and 6.47% correspond to review articles. It is essential to highlight that, of the articles evaluated, 1,353 keywords are reported, and 573 authors presented them. The primary sources are journals and books with a participation of 56.71%, and 43.29% come from other sources. Just as the average years of publication correspond to 5.53 and the average citations per document are 15.33, which indicates that the average

annual citations per document are 2.496. In addition to the 201 documents, 54.23% are from articles, 39.30% correspond to conference documents, and 6.47% correspond to review.

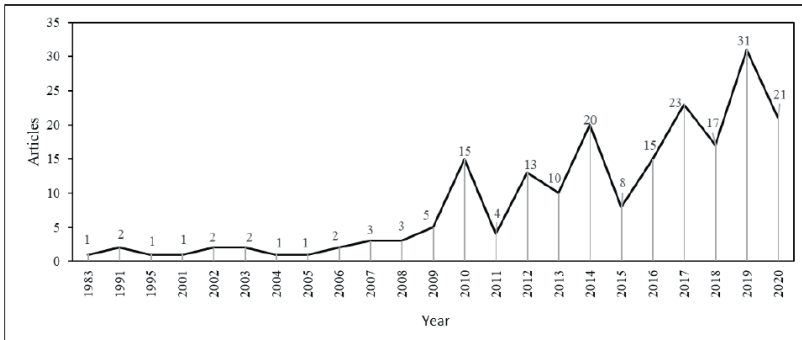
Table 1. *Main information*

Description	Results
Documents	201
Sources (Journals, Books, etc.)	114
Keywords Plus (ID)	1353
Period	1983 - 2020
Authors	573
Document types	
Article	109 (54,23%)
Conference Paper	79 (39,3%)
Review	13 (6,47%)

Annual Scientific Production

The evolution over time and trends of the annual scientific production, in terms of thematic scientific publications, are summarized in Figure 1. Where the first publication on the subject was registered in 1983, and during the following 22 years, the publications were intermittent, showing that publications were, on average, 0.5% per year. From 2006 to 2020, research on green concrete generated its development in the 2000s due to the increase in concrete consumption, which generated environmental impacts that led to the need to use renewable raw materials to manufacture concrete. In the last 37 years, 201 articles were published, and in 2019 it had its greatest boom with 31 articles, corresponding to 15.42% of all publications.

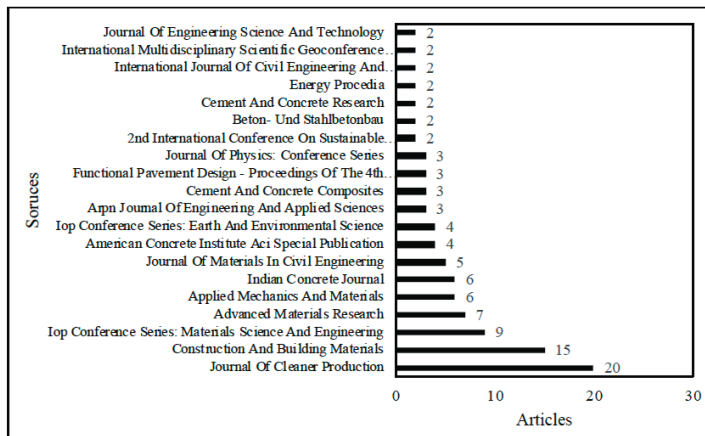
Figure 1. Annual scientific production



Top 20 most productive journals

Taking a total of 201 articles as a reference, Figure 2 shows the top 20 of the most relevant journals. The *Journal of Cleaner Production* has historically been the affiliation with the highest scientific productivity in this field, with a production of 20 articles. Then there is *Construction and Building Materials* with 15 articles and *IOP Conference Series: Materials Science and Engineering* with nine articles. It is evidenced that 95.52% of the journals have only published up to a maximum of 3 articles on green concretes.

Figure 2 Top 20 most productive journals



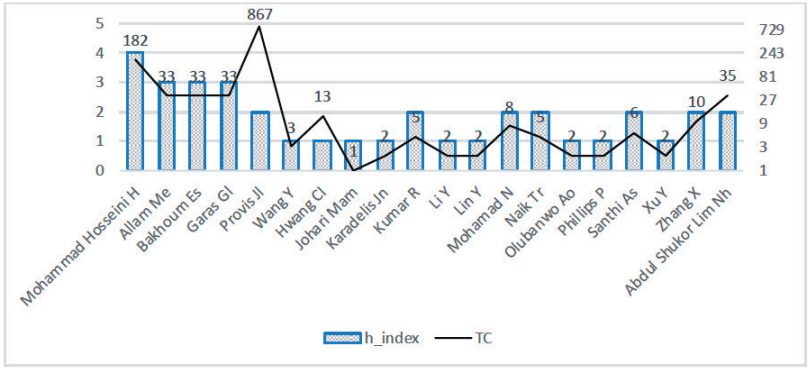
Author's productivity in terms of h-index, g-index, m-index, Total Citations (TC), and Total Publications (TP)

Of the 201 published documents, they were prepared by 573 authors, of which 86.56% are multiple authorship, and 13.43% are a single author. The following indicators can be obtained from the results presented in Table 2, and Figure 3: 0.35 corresponds to the number of documents per author; 2.87 is the value of the number of authors per document, and 3.13 represents the index of collaboration between authors. Additionally, it is evidenced that the five most relevant authors are the professor of the department of mechanical engineering of the University of Hormozgan, Mohammad Hosseini H, with five articles of which 4 have no co-authorship and correspond to 1.99% of the total articles published. Allam Me, an associate professor at the Egyptian National Research Center of the civil engineering department with four articles of which three are not co-authored, corresponding to 1.49% of the total published articles. Bakhoum is a civil research engineer at the University of Nile and Egypt with four articles, of which three are not co-authored.

Table 2. *Authors' productivity in terms of h-index, g-index, m-index, Total Citations (TC) and Total Publications (TP)*

Author	h index	g index	m index	TC	NP
Mohammad Hosseini H	4	5	0.8	182	5
Allam Me	3	4	0.429	33	4
Bakhoum Es	3	4	0.429	33	4
Garas Gl	3	4	0.429	33	4
Provis Jl	2	4	0.143	867	4
Wang Y	1	1	1	3	2
Hwang Cl	1	3	0.1	13	3
Johari Mam	1	1	0.5	1	3
Karadelis Jn	1	1	0.2	2	3
Kumar R	2	2	0.286	5	3
Li Y	1	1	0.091	2	3
Lin Y	1	1	0.2	2	3
Mohamad N	2	2	0.667	8	3
Naik Tr	2	2	0.286	5	3
Olubanwo Ao	1	1	0.2	2	3
Phillips P	1	1	0.2	2	3
Santhi As	2	2	0.25	6	3
Xu Y	1	1	0.2	2	3
Zhang X	2	3	0.182	10	3
Abdul Shukor Lim Nh	2	2	0.667	35	2

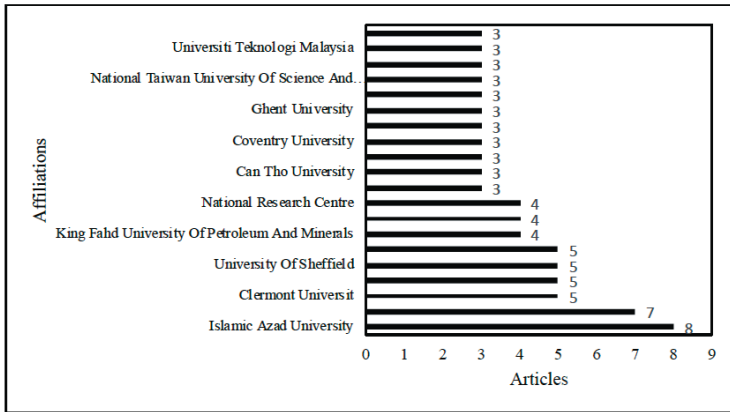
Figure 3. Relation *h*-index vs *T_c* results of the 20 most relevant authors



Most relevant affiliations

A total of 358 data on affiliations can be seen in Figure 4, the top 20 of the most relevant affiliations by the number of documents. The Islamic Azad University is the sixth-largest university in the world. It was founded in 1982 and had a faculty of engineering | civil society where modern laboratories and workshops have historically been affiliated with the highest scientific productivity in this field, with eight articles. In second place is the University Sains Malaysia. It is the second public university in Malaysia and was founded in 1969. It is one of the oldest universities in northern Malaysia and has 12 schools applied to technology where engineering is found civil. It is a university with many technological advances and resources for which it has seven articles. In third place on the subject is the "Clermont University" is a private university located in California, founded in 1925 and private, specializing in graduate research. They have five articles. The analysis indicates that of the top 20, there are only two North American universities, which indicates that the Asian continent is the one that investigates the issue of green concrete the most.

Figure 4. Most relevant affiliations



Top 20 countries with the most publications

Figure 5 shows the twenty countries with the highest number of publications. India and China lead according to the number of documents closely followed by the United States. The presence of countries like Iran and Malaysia that double the production of world powers stands out. The presence of Colombia as the only Latin American country and Nigeria and Egypt as African representatives is highlighted. Also, European countries' low participation is notorious, specifically the low presence of Scandinavian countries, only Denmark, whose policies are aimed at sustainable development.

Figure 5. Most relevant countries



The ten most cited publications

Table 3 shows the ten most cited documents worldwide, with their respective author and total citations. In the first place, we find the most cited the article entitled "The role of inorganic polymer technology in the development of green concrete" by Duxson, published in *Cement and Concrete Research*, in 2007, with 841 citations and a count per year of approximately 60 citations. In the second position is the article entitled "Environmental impact and life cycle assessment (LCA) of traditional and green concretes: literature review and theoretical calculations" by the author Van Den Heede, published in *Cement and Concrete Composites*, in 2012, with 256 citations and a count per year of approximately 29 citations.

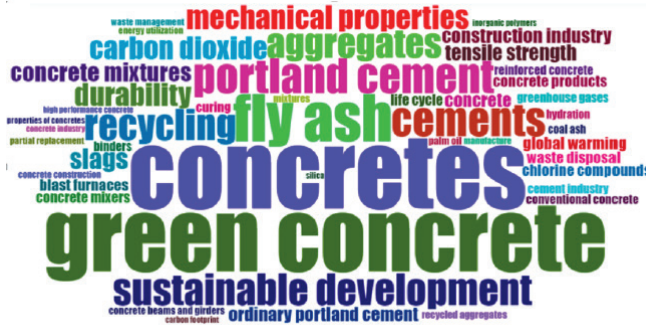
Table 3. Top 10 most cited publications

Document	Author	Journal	Year	Global citation
The role of inorganic polymer technology in the development of 'green concrete	Duxson Peter	Cement and concrete research	2007	841
Environmental impact and life cycle assessment (LCA) of traditional and 'green' concretes: literature review and theoretical calculations	Van Den Heede Philip	Cement and concrete composites	2012	256
Engineering and transport properties of high-strength green concrete containing high volume of ultrafine palm oil fuel ash	Megat Johari	Construction and building materials	2012	145
Design of green concrete made of plant-derived aggregates and a pumice-lime binder	Nozahic Vicent	Cement and concrete composites	2012	82
Environmental evaluation of green concretes versus conventional concrete by means of LCA	Turk Janez	Waste management	2015	79
A life-cycle approach to environmental, mechanical, and durability properties of "green" concrete mixes with rice husk ash	Gursel Aysegul Petek	Journal of cleaner production	2016	76
Toward green concrete for better sustainable environment	Suhendro Bambang	Procedia engineering	2014	68
Green concrete partially comprised of farming waste residues: a review	Kim Hung Mo	Journal of cleaner production	2016	67
Green concrete production incorporating waste carpet fiber and palm oil fuel ash	Abdul Awal	Journal of cleaner production	2016	67
Properties of green concrete containing quarry rock dust and marble sludge powder as fine aggregate	Shahul Hameed	Journal of engineering and applied sciences	2009	64

Keywords

In Figure 4, a cloud of the most used keywords is presented. It is important to note that "Concretes" presents the highest frequency (95). According to the figure, the font size and the centrality of each word displayed indicate each topic's relevance. Besides allows visualize, as a whole, the evolution and relevance of each of the topics addressed throughout the publications. The terms "Concretes," "Green Concrete," "Fly Ash" represent 22% of the use of all keywords used by authors.

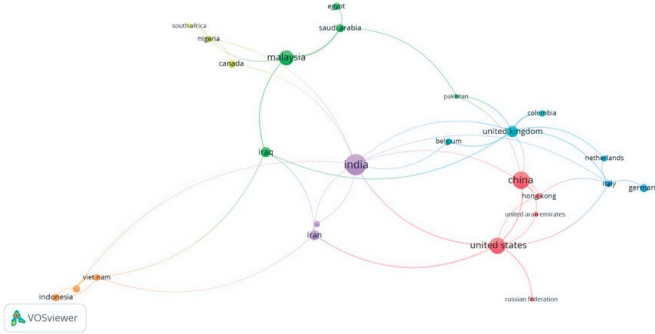
Figure 6. *Cloud of keywords*



Structural Analysis and Visualization in research publications Co-authorship (countries) in publications

As a result of the search equation, the countries with the highest growth in co-authorship are India, China, the United States, Malaysia, and the United Kingdom. Figure 7 shows that the publications between countries mostly come from Asian countries, with India being the central axis of collaboration and disseminating the studies to other latitudes. China is the main collaborator between the United States and the United Kingdom, leaving the latter as the primary node of Europe, Africa, and South America, extending its ties to the South American continent with a country like Colombia; Malaysia is the link country to the African continent.

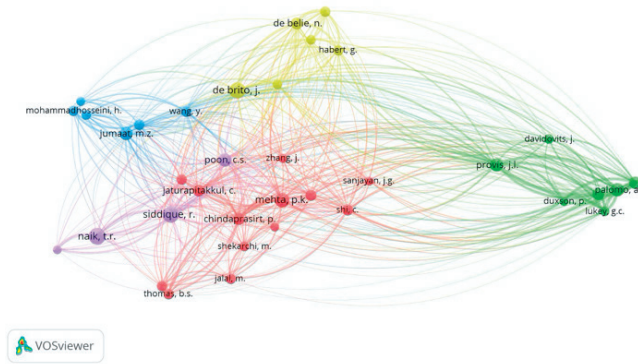
Figure 7. *Co-authorship (countries) on publications*



Co-authorship analysis

There is a collaborative dynamic between co-authors who develop investigative processes at a global level, generating as a result of the search equation significant support networks for the advancement of new production technologies, expansion of knowledge, and innovative alternatives for the protection of the environment and sustainable development. It is evident in Figure 8 that collaborative networks are concentrated in five main aspects, which in turn interact widely with each other, consolidating large dynamic and diverse sources of information. Those with the most significant collaboration are the researchers from the red side, which generate different links with the other nodes, and the researchers from the yellow nodes that establish extensive collaborative networks. The green nodes are the side with the most significant collaboration between yes, but they do not generate many links with researchers from different latitudes.

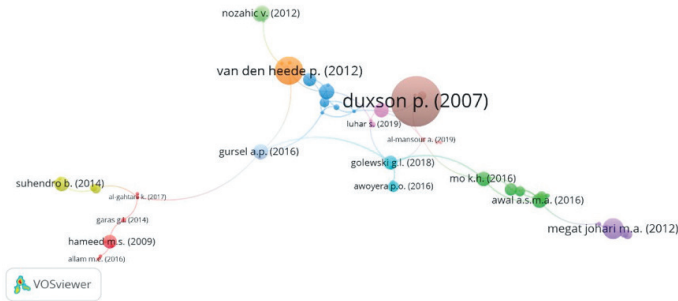
Figure 8. *Co-authoring network*



Citation analysis (documents)

It is of great relevance to know the authors' dynamics, evolution, and relationship over time to identify the years and the author of the most significant scientific interest on the subject in question. Figure 9 identifies the networks between authors and their evolution. For example, the author Van Den Heede has eight networks, which indicates that he is the author who has more relationships with other researchers. It can also be observed that the blue nodes' networks have approximately six links that make the relationship between them notorious. It is also observed that the authors of the red links are American and that although the engineer Peter Duxson has the largest node, it is the one with the least links.

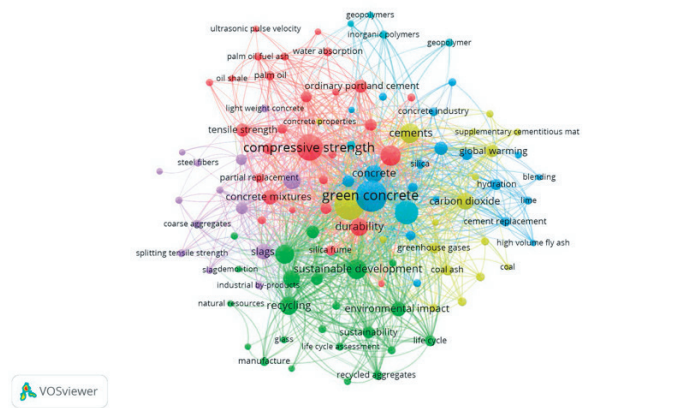
Figure 9. Document citations analysis



Keyword Co-occurrence Analysis

It can be seen in Figure 10 that the red slope is based on the mechanical and chemical properties of concrete, the blue links are focused on polymers, and the green slope is the environmental impact that the manufacture of concrete can generate. It should be noted that the word "concretes" has an occurrence of 99 with 848 links, but the essential keyword, "green concrete," has 111 occurrences and 817 links. It is noted that "green concrete" is the word with the highest occurrence, but it has fewer links than "concretes," which indicates that the two words named above are the most used in all the documents found.

Figure 10. Keyword co-occurrence



Conclusions

The first publication on the subject was recorded in 1983, and from then until 2006, its annual growth was relatively slow. As of 2007, and henceforth until 2020, research on green concrete had considerable growth, expressed in more excellent scientific production, since 188 articles were published, corresponding to 93.5% of the total scientific production.

The most relevant source is the Journal of Cleaner Production, with 20 published articles corresponding to 9.9% of the publications' total distribution. Second, the Construction and Building Materials source appears with 15 articles. It is notable that 15 journals are European and have 82 published articles that correspond to 40.8% of total publications.

With the most extended validity in time, the author is Li Y since his publication record has been maintained between 2009-2020, highlighting that in 2009 he had 29 citations. In 2010, the total number of citations was 2, respectively.

The authors Mohammad Hosseini H, with five (5) publications and an h-index of four (4) and Allam Me, with four (4) publications and an h-index of three (3), are the most internationally recognized authors and those with the highest scientific production about green concrete.

The keyword "concrete" is most often referred to by authors in their articles on green concretes. The keyword "green concrete" followed by "compressive strength" appears in the next degree of importance. Additionally, the words are divided into three main aspects that stand out for their chemical and mechanical properties, polymers, and environmental impacts.

Developed and developing countries produce the highest amount of CO₂ due to their urban growth and polluting materials such as concrete. For this reason, researchers from countries such as India, China, the United States, the United Kingdom, and Malaysia lead the investigations of new technologies and recyclable raw materials such as polymers. They are generating that their investigations are regularly consulted by interested parties and researchers from other latitudes.

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**Bibliometric analysis of the advances in
the area of engineering and materials on
rural roads**

*Análisis bibliométrico de los avances
en el área de ingeniería y materiales en
carreteras rurales*

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Abstract

The term rural roads refer to the road network that is not part of urban environments, characterized by low traffic, by interconnecting communities located in towns and villages, allow access to the agricultural market and the design speed is less than higher-ranking routes. Rural roads are extremely important infrastructure for the social and economic development of rural communities, often located in mountainous or semi-desert places, where access to basic health and education services is very complex. In this paper, a bibliometric analysis has been applied to the theme of rural roads to identify the most important trends and influences, facilitating an organized view of the peculiarities and developments in their field of research. Consequently, a total of 433 publications made between 1968 and 2020 related to the term rural roads in Scopus were identified. The 433 publications contain 878 authors, 176 journals, 41 countries or territories, and 321 institutions. From the analysis completed, four main research areas related to the rural roads research topic stand out; factors that generate risk of accidents in rural roads, technology of rural road construction materials, technological advances in vehicles for rural roads and level of environmental, social and economic impact of rural road infrastructure. In the publications, it was determined that the most relevant journals are Accident Analysis and Prevention (UK) and Transportation Research Record (USA), the most important publications are by Bella (2008) and Misaghi (2005). Additionally, the countries that produce the most research related to rural roads are China, the United States and India. Also, it can be inferred that research collaboration between authors about rural roads is high, especially between the continents America, Europe and Asia.

Keywords: *Bibliometric analysis, rural road, accidents, speed, automobile drivers, risk analysis, geometric design of roads.*

Resumen

El término carreteras rurales hace referencia a la red de carreteras que no hace parte de los entornos urbanos, caracterizándose por su bajo tráfico, por interconectar comunidades localizadas en pueblos y villas, permiten el acceso al mercado agropecuario y su velocidad de diseño es menor a las vías de mayor jerarquía. Los caminos rurales son infraestructura de extrema importancia para el desarrollo social y económico de las comunidades rurales, muchas veces localizadas en sitios montañosos o semidesérticos, en los que el acceso a los servicios básicos de salud y educación es muy complejo. En este artículo, se ha aplicado un análisis bibliométrico a la temática de las carreteras rurales para identificar las tendencias e influencias más importantes, permitiendo una visión organizada de las peculiaridades y los desarrollos en su campo de investigación. Por consiguiente, se identificaron en total 433 publicaciones realizadas entre los años 1968 y 2020 afines al término carreteras rurales en Scopus. Las 433 publicaciones contienen 878 autores, 176 revistas, 41 países o territorios y 321 instituciones. Del análisis efectuado sobresalen cuatro áreas de investigación principales dentro de la temática de investigación relacionada con carreteras rurales; factores que generan riesgo de accidentalidad en las vías rurales, tecnología de materiales de construcción de carreteras rurales, avances tecnológicos en vehículos para carreteras rurales y nivel de impacto ambiental, social y económico de la infraestructura vial rural. Dentro de las publicaciones se determinó que las revistas más relevantes son Accident Analysis and Prevention (UK) y Transportation Research Record (USA), las publicaciones clave son de Bella (2008) y Misaghi (2005). Adicionalmente, los países que más producen investigaciones relacionadas con carreteras rurales son China, Estados Unidos e India, y se puede inferir que la colaboración investigativa entre autores en torno a la temática de las carreteras rurales es alta, sobre todo entre los continentes América, Europa y Asia.

Palabras clave: *Bibliometric analysis, rural road, accidents, speed, automobile drivers, risk analysis, geometric design of roads.*

Introduction

According to Ardanuy (2012), the purpose of science as an intellectual activity is to respond logically and systematically to questions that are regularly associated with contextual problems and that manifest themselves in adverse effects on communities, objects, or systems. This situation raises the growing challenge of systematizing, evaluating, and qualifying, from different perspectives, scientific production in all fields and applications. The first bibliometric studies were published by Cole & Eales (1917), Wyndham (1923), and Gross & Gross (1927), addressing issues of anatomy and distribution of the animal kingdom, history of science, and assessment of the impact of scientific journals related to the chemistry, respectively. In today's world scientific production, bibliometrics is gaining special interest since scientific mapping is contributing to the growth and strengthening of currents and networks of research and scientific support (Aria, & Cuccurullo 2017), in addition to contributing to the quantitative study of scientific production (Morales, 1995; Gauthier, 1998; Spinak, 2001). However, the complexity of the treatment and processing of large volumes of information requires tools that allow the flow, organization, and statistical treatment of information to be functional, reliable, and agile. According to Aria & Cuccurullo (2017), open-source tools such as bibliometrix become powerful instruments for carrying out scientific mappings. As it is programmed in R, its flexibility and possible update allow it to be integrated with other statistical R packages.

The process of identifying and evaluating trends, advances, and scientific development that has had the issue of "roads / rural roads" worldwide involves a broad scientific mapping in databases of recognized trajectory and reliability. In effect, a search for scientific articles was carried out in the Scopus bibliographic

database portal, with the search equation by topic "Rural Roads," and using the engineering and materials science thematic filter. "Rural Roads" produced 433 related articles, and according to the annual scientific production, its trend is growing and of broad scientific interest.

When mentioning rural roads, reference is made to the road network that is not part of urban environments. Their low traffic characterizes them; by interconnecting communities located in towns and villages, they allow access to the agricultural market. Their design speed is lower than that of higher-ranking roads. In general, its management, maintenance, and operation are the responsibility of the local authorities. Rural roads are critical infrastructure for rural communities' social and economic development, often located in mountainous or semi-desert places. Access to essential health and education services is very complex (Keller, & Sherar, 2004). Unquestionably, the development of rural roads accounts for the comparative advantages that a region can have, as Zhou (2020) suggests when he suggests that in the evaluation of rural roads, essential aspects such as construction, management, maintenance, and operation, as this results in its functionality and safety.

In this sense, it is crucial to consider those rural roads present a great diversity and can be categorized by design, appearance, and function (Weller, Schlag, Friedel, & Rammin, 2008). Bella (2008) and Bella (2013) emphasize their attention on speed (Liu, Huang, Wang, & Xu, 2011) and its effects on traffic, as a risk factor, through simulations. Goldenbeld & van Schgen (2005) state that the danger generated by speeding on roads, both main and rural, for people and other vehicles (Llorca, Angel-Domenech, Agustin-Gomez, & Garcia, 2017), is the same anywhere in the world, and that one of the most efficient ways to mitigate speeding violations (Martens, Compte, & Kaptein, 1997), continues to be fined for violators. This affirmation is confirmed and complemented by the studies by Kashani & Mohaymany (2011), finding that commonly

traffic accidents on the roads, as well as the severity of the effects on the occupants of the vehicles involved worldwide, are more frequent on rural roads, due to the tendency of users to exceed speed limits. However, this concept is differentiated according to risk perception (Starkey & Charlton, 2020) and each of the drivers (Goldenbeld & van Schgen, 2005). Their behavior obeys what the speed limit represents for them.

Although, the speed factor is an excellent generator of risk on rural roads, it is not the only one. The influence of rural road maintenance (Mathew, & Isaac, 2014), lane design (Russo, Busiello, & Dell, 2016), traffic and pedestrian flow (Tulu, Washington, Haque, & King, 2015), roughness (Sandamal, & Pasindu, 2020) and climatic conditions (Pokorny, Jensen, Gross, & Pitera, 2020) also play an important role when analyzing the exposure and increase in accidents on rural roads. Environmental conditions can directly affect the mechanical behavior of vehicles and the reaction capacity of drivers traveling on the roads (Drosu, Cofaru, & Popescu, 2020), in addition to technological distractors, as is the case with the use in full conduction of smartphones (Yannis, Laiou, Papantoniou, & Christoforou, 2014).

Another variable that directly influences road safety on rural roads is lighting conditions. It is vitally important to ensure that drivers can circulate in safe conditions since the road's lighting directly affects their visual capacity. Anarkooli & Hosseinlou (2016) highlighted the importance of installing lights along the route and near intersections on rural roads since the severity of injuries increases considerably when collisions occur at these points in dark conditions. Additionally, road geometry is an essential factor (Gooch, Gayah, & Donnell, 2016) and measuring the consistency of the horizontal design (Misaghi, & Hassan, 2005), in contrast to the operating speed and expected accidents. (Laam, Choueiri, Hayward, & Paluri, 1998). It is clear then that the level of safety of a road does not depend exclusively on the behavior of users in terms of compliance with traffic regulations, but also on the state

and design configuration of the rural road (Lamm, Psarianos, & Cafiso, 2002) and the signaling processes that are implemented (Loose, Franke, & Stiller, 2009). It is therefore clear that the behavior of drivers plays a transcendental role in road safety, as determined by Lehtonen, Lappi, & Summala (2012) when they suggest the importance of understanding the visualization pattern of drivers when taking curves in a rural road, as this will result in the optimization and improvement of its geometric design.

From another dimension, rural roads projects, due to the topographic characteristics and territories that they interconnect, cannot ignore the environmental, social, and economic impacts (Abd et al., 2020) that they generate since such benefits cannot be the excuse to generate effects adverse effects on the natural environment. In fact, the social and economic benefits of rural roads (Osorio-Lird, Chamorro, & González, 2020) have no discussion, as is well stated by Abhishek, van Steenberg, Fajardo Vera, Borgia, & Manjur (2020), in addition to the improvement of quality of life and gender inclusion, as the authors well argue.

Regarding the technologies of materials used in the construction of roads, there are significant advances such as those proposed by Basu, Roy, Bhattacharyya & Ghosh (2009). They realize that the materials used in the construction of rural pavements have evolved notoriously in recent years through the use not only of compacted granular materials (Jiménez, Ayuso, Galvín, López & Agrela, 2012), chloride additions (Osorio-Lird, Chamorro, & González, 2020). Also, through the use of geotextiles that help to increase the bearing capacity of pavements on rural roads. Likewise, Kumar & Singh (2008) suggest using granular materials, considered as waste, to solve the problems of shortages of some raw materials.

Materials and methods

The process of identifying and evaluating trends, advances, and scientific development that has had the topic of "rural roads/roads" worldwide involves a broad scientific mapping in databases of recognized track record and reliability. For this purpose, a search for scientific articles was carried out on the Scopus bibliographic database portal. The search equation by topic "Rural Roads," using the thematic filter engineering and materials science. The search provided a total of 433 articles, from which the scientometric and bibliometric analysis was developed using the open-source tool bibliometrix (Aria & Cuccurullo, 2017). For the analysis of bibliometric network data and data visualization, the VOSviewer software was used (Van Eck & Waltman, 2010). This action included analysis of co-authorship between countries, co-citation of authors, and co-occurrence between words.

Results and discussion

Table 1 summarizes the totality, type, and percentage distribution of the articles corresponding to the period 1968-2020, finding that 65% of them correspond to research articles. This value indicates the enormous and growing interest that the subject has had in the scientific world and denotes the current concern for the design, operation, safety, and innovation in new materials that rural roads have throughout the world. To a lesser extent, papers for conferences (30.6%), review articles (3.0%), and articles in book chapters (1.4%) appear.

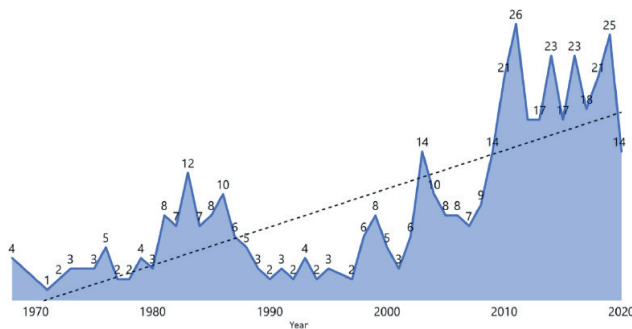
Table 1 *Types of documents and percentage distribution*

Type	Results	Distribution %
Article	282	65
Article; book chapter	6	1,4
Conference paper	132	30,6
Review	13	3,0
Total	433	100

Annual Production

In terms of annual scientific production, the most productive year was 2011, with 26 articles published on the subject, while the least productive year was 1970, with only 1 article published. Additionally, there can be evidence of an increasing trend in the publication of Rural Roads from 2007 to 2020. It is necessary to bear in mind that the search was carried out before the end of 2020, and for that reason, the number of articles from 2020 could increase. The dotted line shows a growing linear trend in the publication of articles on the subject.

Figure 1. Annual production



Most relevant countries

The scientific production by country is presented below. It can be seen that the countries with the highest number of scientific articles are China with 97, the United States, with 86, India with 56, and Spain with 35. Figure 2 a growing trend of scientific production in Europe, Asia, and South America. North. Likewise, there is deficient production on the subject in Latin America and Africa. The production of the United States is 9.55 times higher than the scientific production of the first country in Latin America, which is Chile with nine articles.

Figure 2. *Most relevant countries*

Most relevant authors

The ten most relevant authors can be seen in Table 1. Cafiso S, Russo F, Bella F, Perco P, and Garca A are among the leading authors on the subject. With more articles on the subject, the author is Garca A with eight articles, followed by Cafiso S and Russo F with five. The highest registered H index is five for Cafiso S, followed by Russo F, Bella P, and Perco P with four. Goldenbeld, having only three documents, is the second author with the most citations, only below Bella F.

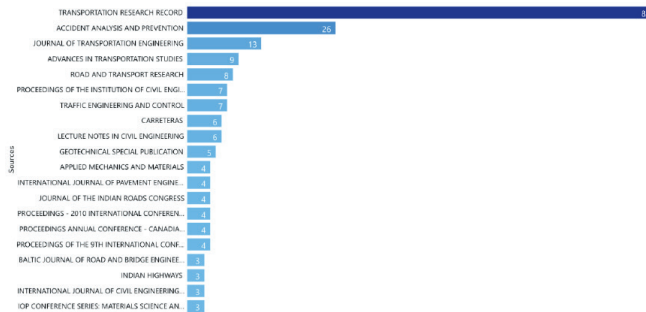
Table 2. *Most relevant authors*

Author	h index	g index	m index	TC	NP	PY
Cafiso S	5	5	0,263	86	5	2002
Russo F	4	5	0,500	62	5	2013
Bella F	4	4	0,308	259	4	2008
Perco P	4	4	0,267	40	4	2006
Garca A	3	6	0,375	40	8	2013
Donnell E	3	4	0,600	38	4	2016
Gayah V	3	4	0,600	38	4	2016
Berloco N	3	3	1,000	31	3	2018
Colonna P	3	3	1,000	31	3	2018
Goldenbeld C	3	3	0,188	166	3	2005

Most relevant sources

In Figure 3, the 20 journals with the highest number of publications are presented. 18.9% of the publications are published in the *Transportation Research Record*. The journal has some thematic areas focused on the policies, administration, economics, financing, operation, construction, safety, and designs of all transport modes. This journal triples in several articles to *Accident Analysis and Prevention*, which ranks second. There are no Latin American or African journals on the list.

Figure 3. *Most relevant sources*



Most cited documents

Table 3 shows the ten most cited documents. In the first place is Bella F. "Driving simulator for speed research on two-lane rural roads" with 176 citations and its publication date is 2008 in the journal *Accident Analysis and Prevention*. The second most cited article is "Modeling operating speed, and speed differential on two-lane rural roads" by Misaghi P. and Hassan Y. with 129 citations is from 2005 in the *Journal of Transportation Engineering*. Four authors have two articles among the most cited.

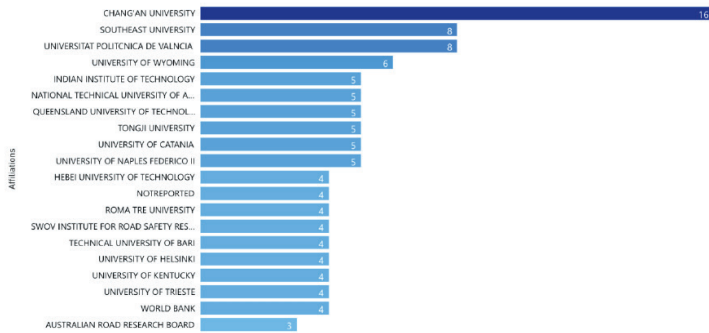
Table 3. Most cited documents

Paper	Authors	Source	Year	Total citations
Driving simulator for speed research on two-lane rural roads	Bella F	Accident Analysis And Prevention Journal Of Transportation Engineering	2008	176
Modeling operating speed and speed differential on two-lane rural roads	Misaghi P;Hassan Y	Accident Analysis And Prevention	2005	129
Asnalysis of the traffic injury severity on two-lane, two-way rural roads based on classification tree models	Kashani At;Mohaymany As	Safety Science	2011	103
Safety evaluation process for two-lane rural roads: a 10-year review	Lamm R;Psarianos B;Cafiso S	Transportation Research Record	1988	87
The credibility of speed limits on 80 km/h rural roads: the effects of road and person(ality) characteristics	Goldenbeld C;Van Schagen	Accident Analysis And Prevention	2007	85
The effects of speed enforcement with mobile radar on speed and accidents: an evaluation study on rural roads in the dutch province friesland	Goldenbeld C;Van Schagen	Accident Analysis And Prevention	2005	70
Driver perception of roadside configurations on two-lane rural roads: effects on speed and lateral placement	Bella F	Accident Analysis And Prevention	2013	64
Drivers' speed behaviour on rural road curves	Kanellaidis G;Golias J;Efstathiadis S	Traffic Engineering And Control	1990	59
Kaiman particle filter for lane recognition on rural roads	Loose H;Franke U;Stiller C Zuriaga	Ieee Intelligent Vehicles Symposium, Proceedings	2009	56
Modeling operating speed and deceleration on two-lane rural roads with global positioning system data	Amp;Garca Ag;Torregrosa Fjc;D'attoma P	Transportation Research Record	2010	53

Most relevant affiliations

The organizations that publish the most about Rural Roads can be shown in Figure 4. First, there are 16 articles Changan University located in the city of Xi'an in China. In second place is eight articles, Southeast University, located in Nanjing, China. Additionally, in third place is the Polytechnic University of Valencia with eight articles, and it is in Valencia, Spain. However, it can be seen in the table that no organization or university from Latin America is present in the top 20.

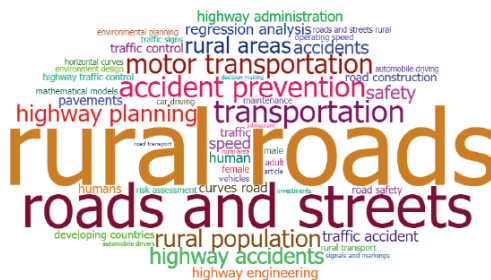
Figure 4. *Most relevant affiliations*



Keywords

In Figure 5, the most relevant words within the research topic are observed. Words such as Rural Roads, Operating speed, Road Safety, and evaluation appear. The minimum number of frequency of these keywords was 3. The most frequent words denote some research trends in recent years towards reducing accidents and the planning of roads as a motor of development in some populations.

Figure 5. *Wordcloud*

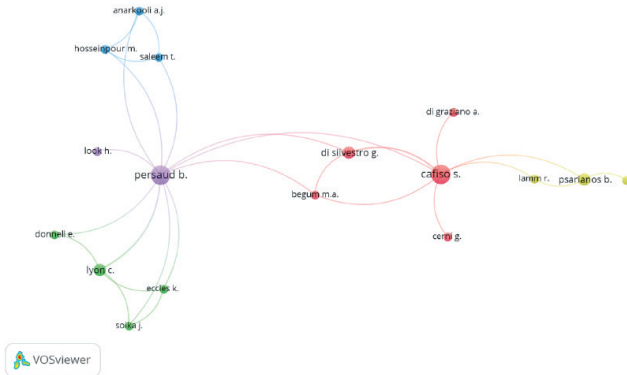


Co-authorship analysis

Figure 6 shows the relationships and co-authorship networks found among researchers. The name of Salvatore Cafiso stands out, visible as a researcher since 2002, because apart from being

the author with the best h-index (5), the second in publications (5), and one of the most cited (86), he is perhaps the author with greater relationships, after Bhagwant Persaud, a civil engineer whose areas of research interest are road safety, geometric design, and traffic engineering. One of his five publications entitled "Microscopic accident potential models for two-lane rural roads," published in 1995 in the journal *Transportation Research Record*, has been cited 22 times. However, because it lacks DOI, its visibility and recognition as a researcher are very low. He is one of the authors with the most extended validity since his publications have been registered from 1995 to 2019, explaining that his collaboration network is the widest of all. It is striking that authors like Russo F; Bella F; Perco P; Garcia A; Donnell ET and Gayah VV, being some of the most recognized authors, do not present collaboration networks, either because of their relatively recent appearance in the research world or because their research does not have co-authorship that allows greater visibility.

Figure 6. Co-atorship networks

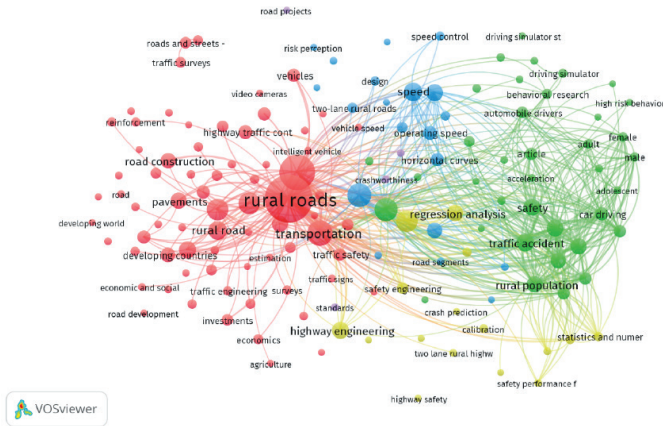


Keyword co-occurrence analysis

Figure 7 highlights the relationships and strength of those relationships between keywords. The word "rural roads," which represents the cluster of most significant importance and density,

presents a total of 234 occurrences, 146 connections, and a link strength value of 1583, which is why it is the node with the highest visibility and associated searches. The words "roads and streets" and "transportation", with 131 links and 127 occurrences and 123 links and 67 occurrences, respectively, make up nodes of lower density since their linking forces are much lower than rural roads. Likewise, Figure 7 refers to the presence of 5 main clusters. Each one of them represents a field of particular interest in rural roads, such as safety and accidents, speed, and road operation, among the most important.

Figure 7. *Co-occurrence of keywords*



Conclusions

The first publications about rural roads date from 1968 and 1971. From then on, the annual scientific production grew, reaching figures of 26 articles in 2011, the year with the highest production, according to the cut made. It is necessary to make the exception that by 2020 there is a growing trend, although the bibliographic production data is not yet officially reported.

The countries with more publications on the subject are China with 97, the United States with 86, India with 56, and Spain with 35. Europe, Asia, and North America emerge in this field of scientific production. At the same time, Latin America and Africa continue to lag, despite presenting rural and territorial conditions with a high demand for rural roads.

The most cited article corresponded to the one entitled "Driving simulator for speed research on two-lane rural roads," by the author Francesco Bella (2008), affiliated with Roma TRE University, Department of Sciences of Civil Engineering.

Concerning the authors with the most significant prominence on the subject, Garca A, Kumar P, Llopis-Castell D, Cafiso S, and Camacho-Torregrosa are among the most recognized. Complementarily, the most prominent publication on the subject is the journal *Transportation Research Record*, with a record of more than 50 years. This publication focuses its interests on the policies, administration, economics, financing, operation, construction, safety, and designs of all transportation modes. According to Scimago, it has an H-index of 107 and is categorized in Q2.

With the analysis of collaboration networks, it was confirmed that these are incipient. Most of the efforts are local, isolated, and without the expected articulation between organizations and countries. The effort to generate networks between authors is highlighted.

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Building Information Modeling from a bibliometric analysis

Modelado de Información de Construcción desde un análisis bibliométrico

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Abstract

Bibliometry is responsible for applying mathematical and statistical methods to scientific research; this discipline is responsible for measuring scientific studies by applying quantitative variables to articles or texts produced by a scientific

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nature. A bibliometric analysis was carried out where the term "BIM" was consulted, which is the acronym for Building Information Modeling. The search was carried out in the scientific research portal Web of Science, obtaining 684 journal articles related to civil engineering and construction technology. Additionally, the bibliometric analysis software (Bibliometrix) was implemented with which analysis of co-occurrence, co-citation, and co-authorship was carried out, which allowed the study carried out to be better visualized in graphic form. The results of the research show growth in Building Information Modeling research in recent years, noting that the countries with the highest contributions are China, the United States, and the United Kingdom in the scientific field on this subject. Finally, it is essential to emphasize that BIM development and research must continue to grow since this methodology and other innovations in construction will revolutionize the field of civil engineering and construction processes towards more effective and efficient solutions, considering counts the life cycle of construction projects.

Keywords: *Bibliometric analysis, BIM, scientific production, Building Information Modeling.*

Resumen

La bibliometría se encarga de aplicar métodos matemáticos y estadísticos a lo que es cuantificable en la producción y en el consumo de la información científica. Esta disciplina se encarga de medir los estudios científicos aplicando variables cuantitativas a los diferentes artículos o textos producidos de carácter científico. Se realizó un análisis bibliométrico donde se consultó el término "BIM", el cual, es el acrónimo de Building Information Modeling. La búsqueda se realizó en el portal de investigación científica Web of Science, obteniendo un resultado de 684 artículos de revista relacionados con ingeniería civil y tecnología de la construcción. Adicionalmente, se implementó el software de

análisis bibliométrico (Bibliometrix) con el que se realizaron análisis de co-ocurrencia, co-citacion y co-autoría que permitió visualizar de mejor forma el estudio realizado en forma gráfica. Los resultados de la investigación evidencian un crecimiento en las investigaciones de Building Information Modeling en los últimos años, notando que las potencias (China, Estados Unidos y Reino Unido) son las que más aportan al desarrollo científico sobre este tema. Así mismo, los autores más destacados son Wang X. y Cheng JCP, ya que son los que mayor cantidad de aportes han realizado. Finalmente, es importante que el desarrollo sobre BIM siga en aumento ya que la utilización de este sistema revolucionará el campo de la ingeniería y los procesos constructivos hacia soluciones más eficaces y eficientes.

Palabras clave: *Análisis bibliométrico, BIM, producción científica, Bibliometrix, Building Information Modeling.*

Introduction

Years ago, bibliometrics stood out for being a statistical bibliography tool with functions related to the analysis of library activities, theory, processes, and regularities of the scientific documentation archived in the physical document repositories. On the other hand, bibliometrics has evolved in the digital age as a metric discipline whose objective, based on exact sciences, is to assess the behavior of the advance of scientific processes linked to social phenomena, and, consequently, to extract making the most of the literary heritage (Morales Morejón, 1995).

For his part, Spinak (2001) highlights in bibliometrics the benefit of the quantitative characteristics of mathematics and statistical techniques in the process of knowledge of trends and advances in scientific topics. On the other hand, the term "bibliometrics" coined by Alan Pritchard at the end of the '60s, refers to the part of Scientometrics that applies mathematical and statistical methods to scientific literature (Bellis, 2009). Initially,

this science was introduced by Eugene Garfield in the middle of the 20th century, and since then, it has become widespread in scientific research in the revision of knowledge in recent years (Abad-Segura et al., 2020). In bibliometric studies on BIM, there are two main objectives, the first is to analyze the background of all the work published in relation to BIM as bibliometric maps of this subject, and to see which groupings of the scientific field are common among them, and the second objective is to identify the improvements and barriers in the implementation, given the importance that BIM has in the improvements of the value chain and sustainability in construction (Mehdi et al. 2019).

This research aims to identify and examine trends, particularities, and scientific bibliographic progress in the BIM field worldwide through a bibliometric analysis, in addition to highlighting some main characteristics of the BIM process and its importance to increase the added value of construction (Osorio-Gómez et al. 2020). It should be said that Building Information Modeling is not a methodology of the future, but is already a reality in many countries, and it can also become a competitive advantage and a guarantee of permanence for companies in the construction market. It is a comprehensive and diverse concept since it does not only encompass project modeling (Brugarolas et al., 2016).

Building Information Modeling (BIM) is a collaborative work methodology for the creation and management of a construction project. Its objective is to centralize all project information in a digital information model created by all its agents (Loyola, 2014). On the other hand, (Pacheco, 2017) defines BIM as a process focused on the development and use of a digital information model of a civil works project, for the design, construction, and operation of a portfolio of facilities that comprise the entire project. This methodology has slowly become popular in recent years in Colombia and Latin America

in general, although in various parts of the world, it is already implemented with defined standards, countries such as Singapore, Spain, the United Kingdom, among others.

The BIM concept was suggested by Eastman and later used by Van Nederveen and Tolman (Rojas-Sola & Aguilera-García, 2020), and it has been implemented since the early 2000s, since then its methodology has contributed to the development of innovative techniques for the construction industry today BIM has revolutionized construction technology and has become a tool that allows achieving more efficient projects (Rojas-Sola & Aguilera-García, 2020). This methodology arises in response to a series of needs and deficiencies in the construction industry to improve its processes and utilities (Granados, 2018), but their implementation has not had a very rapid evolution due to different cultural aspects of the necessary infrastructure, assuming the limitations of the context in which they are executed in terms of the availability of financing and the possible supplies of resources according to the strategies developed, with the level of integration that functional structures and organizations allow (Guere Oussouboure, 2017). Worldwide, technology changes with accelerated speeds; for this reason, the BIM methodology must be adopted and managed in the right way (Cerón & Liévano Ramos, 2017).

The purpose of this study is to carry out a detailed bibliometric analysis of the scientific production of BIM in one of the most central databases such as Web of Science, and to submit them to different bibliometric indexes where they are identified: the authors, prominent universities, number of articles and citations, documents per author, the average number of citations per documents, keywords, co-authorship networks, among others. The results of the analysis made it possible to show that in recent years the scientific production on BIM has had notable growth, the average number of citations per year, the most relevant sources,

the most relevant authors, the impact of the authors, is presented in this article the most relevant *words and the co-occurrence*.

Materials and methods

A search was carried out in the Web of Science (WoS), which is one of the most recognized portals in the world for scientific research. After analyzing various equations, the end was reached. TI = ("BIM"), the word BIM was filtered by title, and the quotation marks denote that it must be an exact search for the word. In this search, conference articles and early Access were excluded, thus leaving only journal articles. The search was carried out in April 2020. With this search, you can find a relationship with the sources that publish the most on the subject and their distribution in the selected period. Also, an exclusion was made of other topics where the word BIM usually appears, these being mainly areas such as Biology and molecular chemistry.

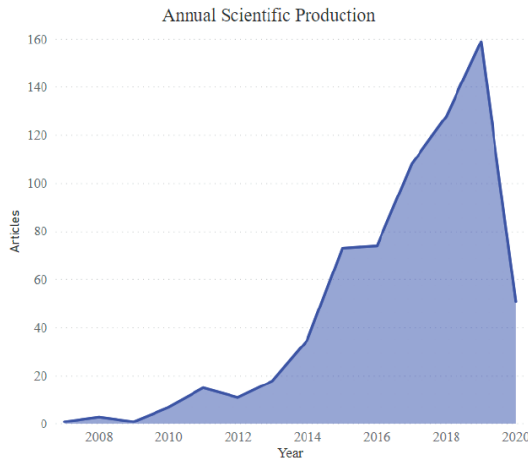
A TXT file was exported with the information from the search, later with said file. A bibliometric analysis was performed in an R-studio program (Bibliometrix) that has been used in multiple bibliometric analyzes. For this analysis, the emphasis was placed on the bibliometric indicator H index (H Index), or Hirsh index, which is an indicator that allows evaluating scientific production per researcher, measuring its quality and quantity, thus being able to identify the most prominent authors in this area of knowledge (Castro Forero et al., 2020).

In this way, several analyzes were obtained, such as co-occurrence, co-citation, co-authorship; that allowed to visualize better the data obtained from the WoS search. This type of analysis is recommended to understand how research on the subject has gained relevance in recent times. Finally, an analysis of the data and graphs obtained through the free program VOSviewer was carried out (Jan van Eck & Waltman, 2010).

Results and discussion

The Figure 1 allows to chronologically identify the annual scientific production; it could be said that the search for BIM in the field of civil engineering and construction has been increasing over the years, thanks to its efficiency in the processes and the improvements in productivity. In 2007, almost until 2011, an increase of around 20 articles was discovered, allowing more information to be found on the net; however, until 2015, the number of publications rises in a higher percentage since the concept went viral in the sector and at the same time, they were finding their most significant potential, determining their highest peak in 2019 with more than 150 articles published.

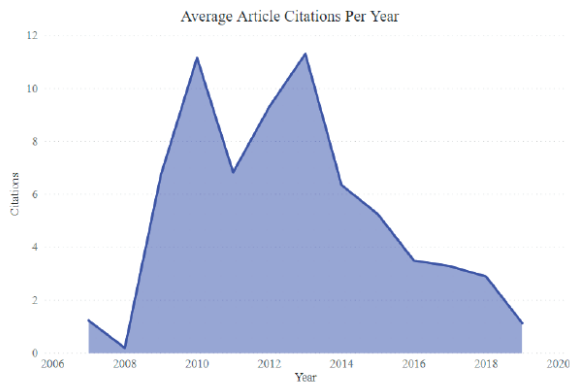
Figure 1. *Annual scientific production*



The average number of citations per year in Figure 2 indicates that it increases between 2009 and 2010, where the first publications on the subject are mostly found; that is, the increase in publications are focused on these years since the authors collect information that is already found on the Internet. From there, they build their own articles citing the authors. In 2011 the number of

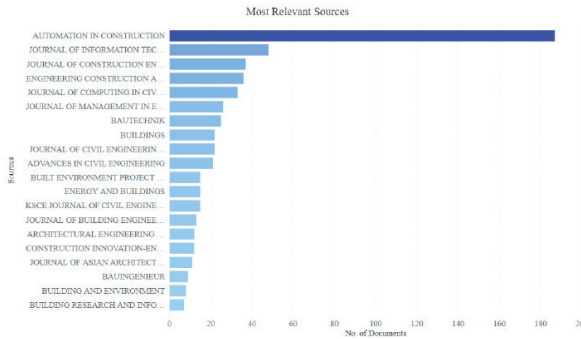
citations decreased and again reached its peak in 2013. However, from then until 2019, this number decreases as the volume of articles about BIM increases, then the average of citations of articles per year is decreasing because the amount of bibliography for consultation is more. Besides, many new authors generate their content since BIM has become a relevant topic in industry and academia; therefore, it has led to an increase in published research on the subject. BIM has stood out most for its key and innovative approach to construction and civil engineering, and these new studies cover various areas, including various technical and non-technical issues.

Figure 2. *Average citations per year*



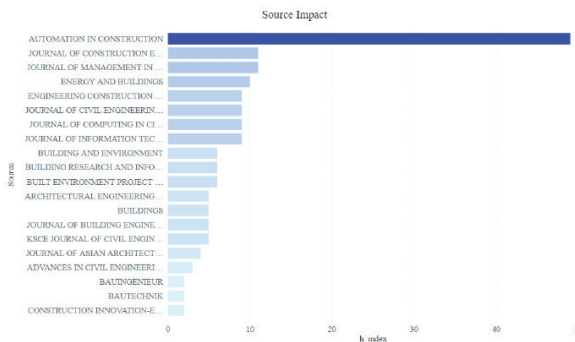
In the Figure 3 it is identified that the magazine *Automation in Construction* dramatically exceeds the number of documents compared to the other sources, which has more than 150, taking into account that the following magazine *Information Technology in Construction* "is made up of a little less than 50 documents and from then on the percentages are reduced. The main aspects towards which the sources are inclined were identified, becoming bibliometric indicators; thus, they allow the analysis of various features of scientific activity, linked to both the production and consumption of information (Ardanuy, 2012).

Figure 3. Most relevant sources



The impact of a source is classified from the h index, which is defined as the h-index of a researcher R is defined by Hirsch as the unique number h such that R has h publications that received h or more citations and all R's other publications received at most h citations (Bar-Ilan, 2008). That is, this becomes a quality classifier element, the measurement is carried out approximately from 0 to 50 according to the implemented sources, in the Figure 4, Automation in Construction magazine reaches almost 50 of the h index, surpassing all the others, from then on, the journals decrease from the value 10 to approximately 2 of the h index.

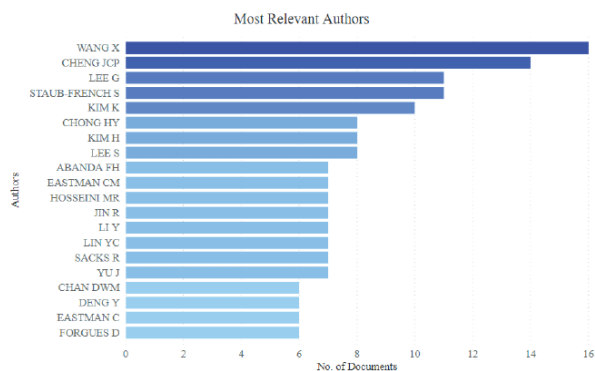
Figure 4. Impact of sources



The most relevant authors are identified from the number of documents they have, in the Figure 5. They are classified in a range of approximately 0 to 15; the most relevant author or the one with

a greater number of documents is Wang X with a little more than 15, in second place is Cheng JCP with around 14, both top the list. From then on, the number decreases, although all of them exceed five documents.

Figure 5. Most relevant authors



According to Figure 6, the author who generates the greatest impact according to the h index is Cheng JCP. In the second place, there is Wang X with a difference of one point. Point 5 of the h index is where the largest number of authors are located, made up of 11 authors, their level of impact, a little more than half of all authors. The impact range is from 4 to 8 h index.

Figure 6. Impact of the authors

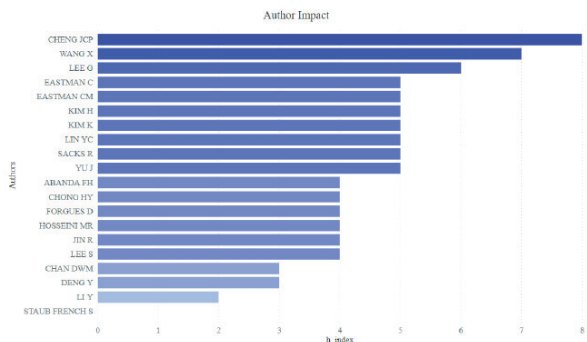
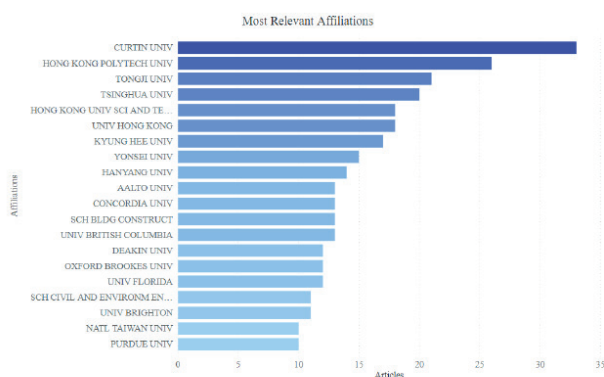


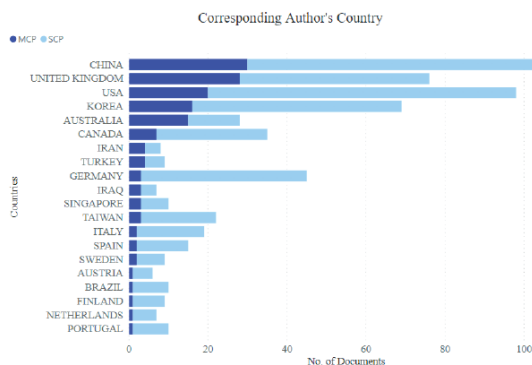
Figure 7, according to the number of documents in a range from 0 to 30, the most relevant universities are classified, in which Curtin University ranks with more than 30 documents, in second place, Hong Kong Polytech University accompanies it very closely with 26 documents. The other universities have more than ten units, and they are progressively decreasing from Tongji University to Purdue University.

Figure 7. *Most relevant universities*



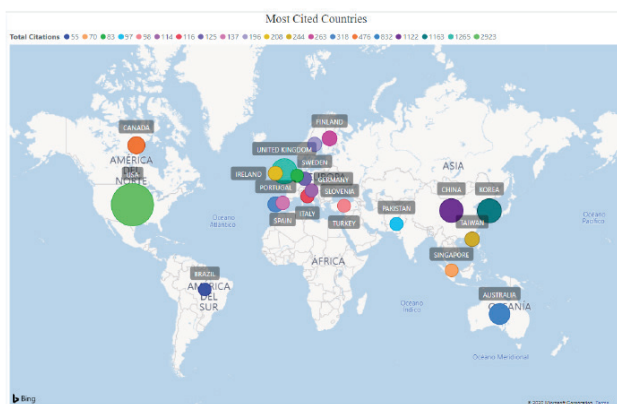
In Figure 8, the figures of the collaborations of some countries are identified from the creation of documents in a range of 0 to 100. Initially, in the national collaboration (SCP), the country that has a more significant number in China with a little more than 100. However, very close to the United States in second place and from there, the graph decreases, with Austria with the lowest percentage, only four countries exceed 50 documents (China, United States, United Kingdom, and Korea). In the MCP international collaboration index, only two countries exceed 25 documents, firstly China and secondly the United Kingdom. The graph falls in a large proportion compared to the SCP.

Figure 8. *Country of the corresponding author*



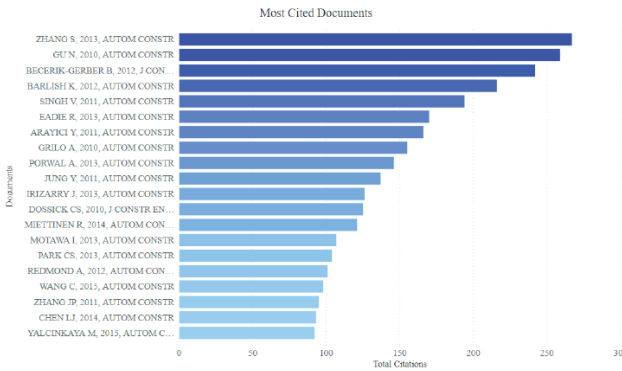
Regarding the most cited countries as expressed in Figure 9, The United States is the most productive country, although with a relative impact factor more generous than the average due to the dispersion of its publications in medium and low impact journals (RojasSola & Aguilera-García, 2020). The United States tops the list with a significant advantage, with its number of citations approaching nearly 3,000; Only three more countries exceed a thousand citations, the other countries are well below this margin, the graph is decreasing, leaving Brazil in the last place.

Figure 9. *Most cited countries*



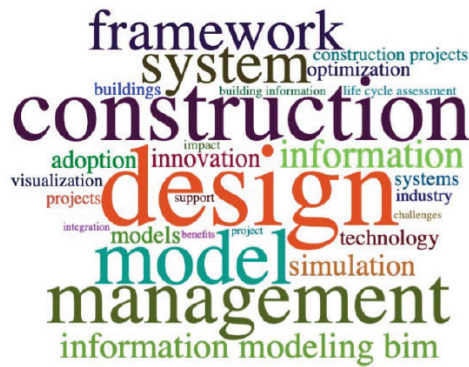
Regarding the most cited documents shown in Figure 10, only four articles do not exceed 100 citations, but are very close to overcoming this barrier. Also, only 4 exceed 200 citations; among these is Zhang, 2013, Automation Construction, which occupies the number one position in its totality of citations. It should be noted that the date it has is not a determining variable, however, if it is within a 5-year margin (2010-2015). From this analysis of citations, the impact indicators are evaluated, that is, one of its variables, where growth elements could be analyzed.

Figure 10. *Most cited documents*



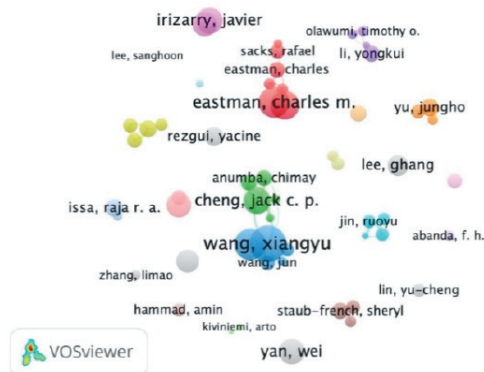
In the Figure 11, cloud of keywords is obtained, that is, the most mentioned in the keywords of the documents that are being analyzed. This classification is made from the size of the words; without a doubt, one of the words that stands out the most is a design, and it is mentioned in both graphs in the same dimension. Some of the words that were found, it could be said that they are in second place, but they continue to be very striking are Model, Management, Construction are common in the same way in both word clouds. From there, two more classifications in size were delimited, around 30 classified words are calculated.

Figure 11. *Word cloud*



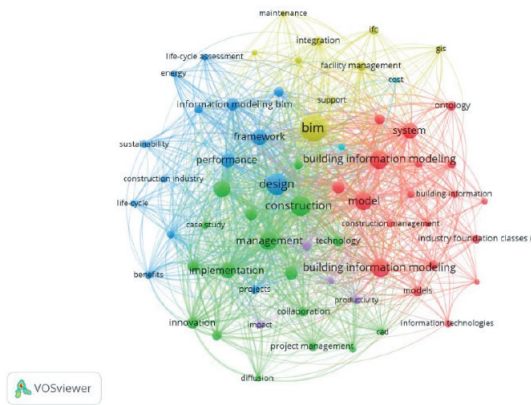
From the networks raised in Figure 12, connection nodes between authors were identified from the development of common themes and authors who are expanding their subject by themselves; no doubt in the graph, two extensive node connections were identified. In the first place, the Eastman C and Sacks R nodes which come together to display information around the same common purpose or theme. There is also the case of Cheng J and Anumba X, in addition to Wang X and Wang J, in which the same dynamics mentioned above happens. New nodes develop around them, some with fewer connections than others.

Figure 12. *Co-authorship*



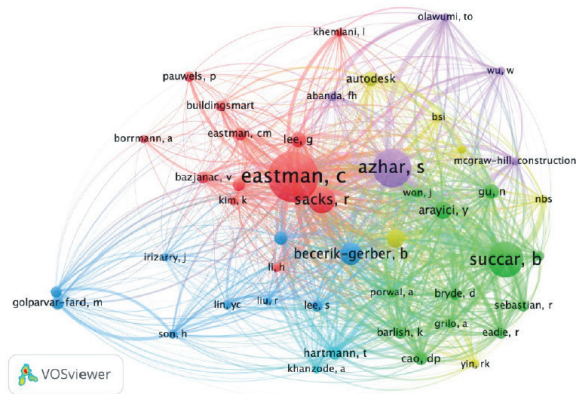
In the Figure 13, it is visualized in a network all of the connections of the key terms around taking into account their frequency; in some central nodes, the words with the highest occurrence are identified and from which most of the terms are derived, identifying the number of times that are mentioned, little by little they are joining each other. In the center, there is evidence of BIM, Design, Construction, Model, Building Information Modeling, which are divided into colors that facilitate analyzing the classification and union between the nodes. Those that are closer to the limits are those that do not have as many occurrences, reducing the size of their node.

Figure 13. Co-occurrence



The co-citation network is embodied in Figure 14, which reflects the way in which the authors mention each other and generate new knowledge content. It is possible to show a cluster where reciprocal citations are made. The primary node from which the most extensive connections are deployed is from the author Eastman C; that has connections with smaller nodes where authors like Sacks R and others are located. Finally, there are other large clusters headed by Azhar S and Succar B.

Figure 14. *Co-citation.*



4. Conclusions

Bibliometry is a tool that helps us quantify information through graphs and tables. That allows interpreting the data much more comfortably and more dynamic (Ardanuy & Rey Vázquez, 2009). In this research, it can be seen that scientific production on BIM has increased in recent years, and this is reflected in the development of this methodology and becomes more relevant for the development of large, medium, and small projects; thus obtaining an increase in productivity, efficiency, value, quality and sustainability in projects (Doumbouya, Gao, & Guan, 2016). Likewise, these investigations will be the basis for future developments in BIM investigations, not only in pioneer countries but also in countries that are beginning to learn about this methodology. Industry 4.0 (I4.0) is a facilitator of cutting-edge technology developed in major countries, which calls for the digital revolution in industries (Ramos-Sanz, 2019). The compound annual growth rate worldwide should total 17.3% for BIM products and services over the eight-year period, Pike Research predicted; This figure includes both revenues from BIM software and revenue from related BIM services, such as training, support, management, and collaboration on the project. (D'Paola

Punche, 2014). Consequently, companies and construction companies can obtain significant benefits in the value chain by implementing this methodology (Osorio-Gómez et al. 2019).

One of the most critical challenges in current construction is the research and implementation of the BIM methodology; However, BIM adoption is much slower than anticipated (Fischer & Kunz, 2004). Since it is necessary to standardize the BIM process and define its implementation (Azhar et al., 2007), those who contribute the most are countries such as China, South Korea, the United States, and the United Kingdom; in the latter, the use of BIM in public works is mandatory (Smith, 2014). While in Latin American countries, this methodology has an immature implementation in general and in some isolated cases, that is why these countries should be encouraged to make more contributions and promote the implementation and research on Building Information Modeling.

From these data, it could be defined if it is related to geographic areas. The AngloSaxon area leads to the set of innovations that support BIM adoption (Fernández-Tamases & Zamarrón-Mieza, 2018). Regarding the practical contribution, many conclusions made by the bibliometric approach have been verified, such as that the legal system and standards in each country are different, which leads to an international project with BIM that can be efficiently conducted with contradictory information and risk of information loss, affecting the result of the project (Tsenguun, Heap-Yih, & Liao, 2018). Future BIM-related problems would be about how to perform construction works in different places that have different BIM standards. Different BIM constructs could demonstrate how to standardize modeling methods between different groups or countries and how to precise international information with BIM (Tsenguun, Heap-Yih, & Liao, 2018). The most relevant authors in BIM research are Eastman C, Sack R, Wang X. and Cheng JCP since they are the ones who have made the most significant

amount of contributions. The most used words in articles about BIM are Design and Construction since they are concepts closely related to civil engineering and architecture.

The construction industry has a significant impact on the environment; different studies showed the high contribution of the construction industry on energy consumption, the use of raw materials, and CO₂ emissions; due to this high negative impact on the environment and the growing awareness of environmental protection, there is a sense of urgency for the construction industry to be more sustainable in its projects and work processes (van Eldik et al., 2020). However, there is no doubt that the implementation of this new methodology worldwide in engineering will reduce the environmental impact framed in the generation of gases and the misuse of raw materials in waste and residues. In turn, this methodology will help achieve greater efficiency in construction processes (Jiménez-Roberto et al., 2017), avoiding reprocessing and downtime on-site, having total control of the project from its design, construction, and throughout its life cycle.

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Transformation of a combustion vehicle to electric

Transformación de un vehículo de combustión a eléctrico

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Juan Felipe Arroyave Londoño²

Abstract

Colombia, like other developing countries, has been incorporating various electric vehicles in its automotive park, motivated by an emerging policy of incentives, a concern for the environment and health, and a high cost of fuel; however, these types of vehicles remain relatively expensive. The transformation of thermal vehicles (combustion engine) to electric vehicles becomes an interesting option, due to its low cost compared to new commercial electric vehicles and the positive environmental

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impact which represents. The present work illustrates the technological steps that have been required in the transformation from a traditional internal combustion vehicle to an electric one (sprint vehicle), showing the economic benefit and the impact on the attenuation of greenhouse gases. The analysis of the traction dynamics and validation with various laboratory and field (road) tests, have shown the viability of a transformed vehicle, which satisfies the power demands under different load conditions, typical of high slopes on Latin American roads. A synthesis of the experience has been published in https://www.youtube.com/watch?v=a7DY8p7J1_Q&feature=youtu.be.

Keywords: electric vehicles, contamination, sustainable mobility.

Resumen

Colombia, al igual que otros países en desarrollo, viene incorporando en su parque automotor diversos vehículos eléctricos, motivado por una emergente política de incentivos, una preocupación por el medio ambiente y la salud y un alto costo del combustible; sin embargo, este tipo de vehículos continúa siendo relativamente costosos. La transformación de vehículos térmicos (motor de combustión) a vehículos eléctricos se convierte en una opción interesante, debido a su bajo costo comparado con los vehículos eléctricos comerciales nuevos y el impacto ambiental positivo que representa. El presente trabajo ilustra las etapas tecnológicas que se han requerido en la transformación de un vehículo tradicional de combustión interna a eléctrico (vehículo sprint), mostrando el beneficio económico y el impacto en la atenuación de gases de efecto invernadero. El análisis de la dinámica de tracción y validación con diversas pruebas de laboratorio y de campo (carretera), han mostrado la viabilidad que posee un vehículo transformado, que satisface las demandas de potencia bajo diferentes condiciones de carga, propias de las elevadas pendientes que se encuentran en las carreteras latinoamericanas.

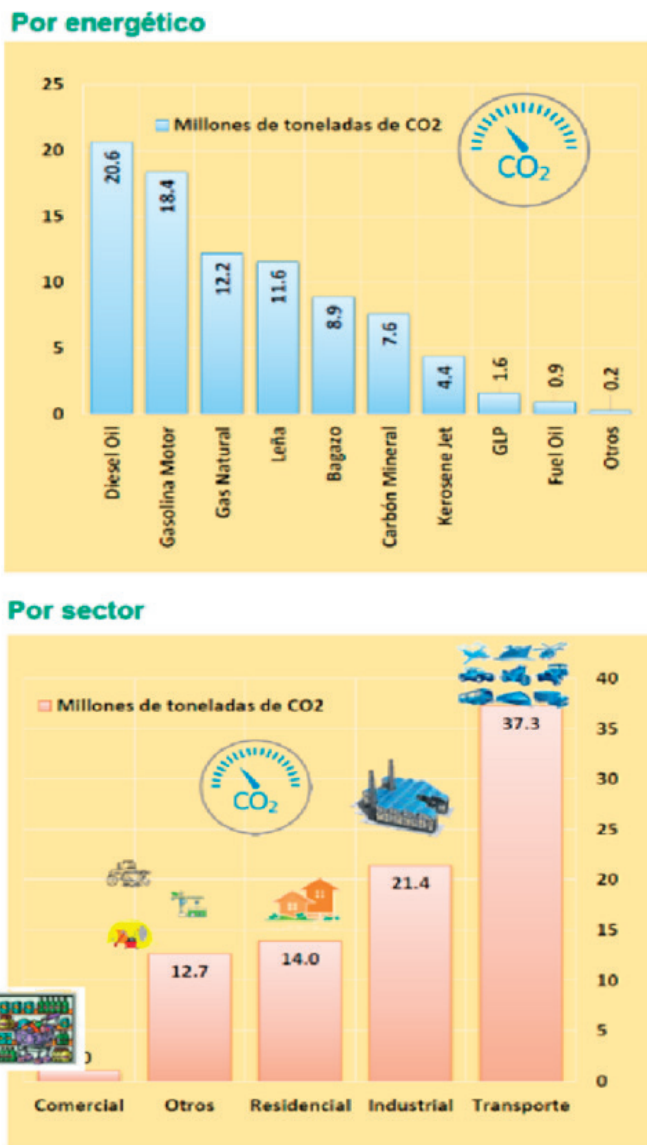
Una síntesis de la experiencia ha sido publicada en https://www.youtube.com/watch?v=a7DY8p7J1_Q&feature=youtu.be.

Palabras Clave: vehículos eléctricos; contaminación; movilidad sostenible.

1. Introduction

Traditional transportation (based on combustion) has had, in recent years, an increasingly harmful effect on the environment and human health. Recently, a study published by the Lancet commission (Landrigan, 2018) states “For decades, pollution and its harmful effects on people’s health, the environment, and the planet have been neglected both by Governments and the international development agenda. Yet, pollution is the largest environmental cause of disease and death in the world today, responsible for an estimated 9 million premature deaths”. Nine million represent 16% of all premature deaths in the world today. Furthermore, the costs due to pollution represent 4.6 trillion dollars per year to the global economy, equivalent to 6.2% of global economic output. Transportation not only affects human health but is also the main source of greenhouse gases. Recent reports from the Mining and Energy Planning Unit UPME (2019) (Figure 1) show transportation as the sector of the economy with the highest CO₂ emissions in the country with contributions of 37.3 million tons per year. On the other hand, transport becomes the main source of pollution components such as particulate matter (PM₁₀) and Nitrogen Oxide. Other studies (Vidal, 2016) have shown how the growth of cities and therefore the number of vehicles and the industrial sector, have increased the problem of pollution and public health. The mandatory quarantine that humanity is currently experiencing due to the pandemic, has allowed us to appreciate the positive effects on the environment derived from the non-overcrowding of vehicles on the roads, allowing the enjoyment of a cleaner environment and the observation of mountains and snow-capped mountains. that were previously not perceived due to pollution.

Figure 1. CO2 emissions by type of fuel and sector (UPME)



Electric mobility therefore represents an interesting alternative to mitigate this problem, even more so when it involves saving costs for fuel, which is growing progressively in countries like Colombia. The transformation of combustion vehicles to electric vehicles has been implemented in various Latin American countries (Mexico, Peru, Ecuador and Venezuela), but generally they do not carry out a theoretical analysis and experimental tests that fully validate the performance of the transformed vehicle. There are studies that have made some interesting analyzes, such as Rodríguez (2015), which studies the behavior of various electric vehicles on the topology of Medellín; González (2010) describes the methodology used to convert a thermal vehicle to an electric vehicle without analyzing the behavior of the system. Other studies (Duque, et al., 2018) analyze different standardized ways to measure the autonomy of a vehicle, but do not incorporate the analysis of traction power. Other investigations (Asimakopoulos, 2010) analyze the conversion of a conventional vehicle to a hybrid, however, there are no studies that involve theoretical analysis and experimental tests for the full validation of the behavior of the traction dynamics and the electronic system of a transformed electric vehicle . In Latin America, electric vehicles still have a high cost for an end user, mainly influenced by the original factory price and the import costs involved. An example of this, the Nissan Leaf (24 kWh model) costs € 16,607 in Japan, € 29,460 in Spain, but in Colombia the cost amounts to € 34,300 (equivalent to \$ 120,000,000 COP). Therefore, converting a vehicle with a combustion engine to an electric vehicle is an interesting and economically motivating option.

Materials and methods.

Below are the stages used in the vehicle conversion process.

2.1 Choosing of vehicle and traction dynamics analysis

After analyzing several alternatives, a Chevrolet Sprint vehicle (Suzuki Swift in the United States) was selected for the conversion, due to its low weight and its large space in the front cavity.

Figure 2. *Vehicle to transformation*



Technical characteristics: Tare: 675 kg

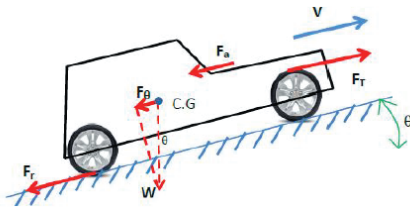
Power: 46.8 kW.

Weight/power ratio: 14.43. Displacement: 993 cm³.

The vehicle's traction dynamics has been analyzed to establish the power requirements based on the different parameters, including the slope θ (figure 3), normally high in Latin America. Equation (1) determines the power required for a vehicle involving the components slope θ , rolling F_r , aerodynamic effect F_a and acceleration [Jazar, 2016; Gillespie, 1992].

$$\dot{W} = \underbrace{W \sin \theta}_{F_\theta} + \underbrace{C_r W \cos \theta}_{F_r} + \underbrace{\frac{1}{2} \rho S K_a V^2}_{F_a} + \underbrace{ma}_{accel} \quad (1)$$

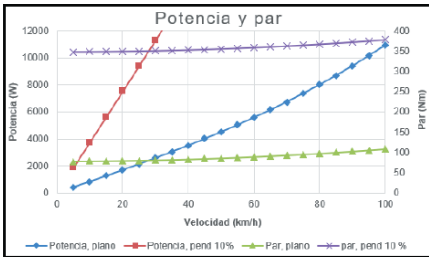
Figure 3. Fuerzas restrictivas al movimiento de un vehículo



W (weight), θ (road slope), C_r (rolling coefficient), ρ (air density), S (vehicle cross section), K_a (drag coefficient), m (mass), a (acceleration), V (velocity).

Figure 4 shows the behavior of power as a function of vehicle speed.

Figure 4 . Power and torque as a function of speed on flat terrain and 10% slope.



Taken values:

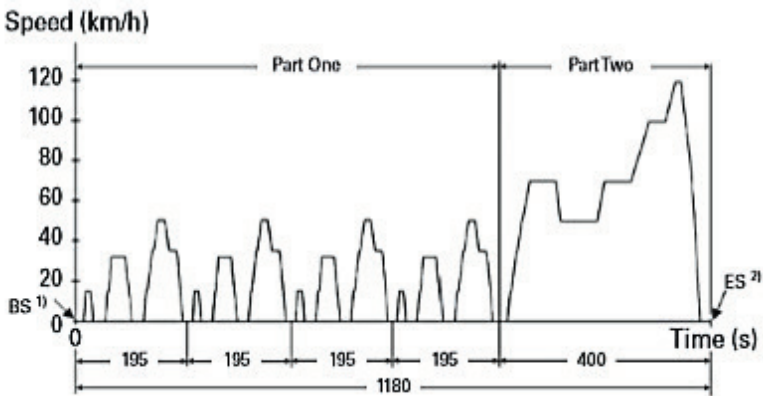
$m = 1025$ kg (675 vehicle + 5 passengers/70 kg)
 $C_r = 0.01$, $\rho = 1.2$ kg/m³, $K_a = 0.2$, $a = 0$
 (constant speed), $S = 1,3$ m², $\theta = 0$ and 10%
 (flat terrain and high slope).

Speeds of 70 km/h are expected in favorable conditions (flat terrain). A 10 HP (7.5 kW) electric motor can satisfy these conditions (figure 4). However, with a slope of 10%, this engine will move the vehicle at 20 km/h. On Colombian highways (Latin America average) it is necessary to have a gearbox to deliver the required torque under demanding load conditions. As can be seen in figure 3, on a 10% slope the required torque amounts to 350 Nm. The characteristics of an electric motor do not allow to satisfy this level of torque, requiring a transmission box that amplifies the original torque of the motor.

2.2 Preliminary tests to combustion vehicle.

Combustion tests are important to determine how much pollution the vehicle emits into the atmosphere. For this, dynamic tests were developed based on the NEDC (New European driving Cycle) protocol (figure 5) to evaluate fuel consumption and polluting emissions. Measurements were taken of the vehicle on rollers (from the E20 dynamic test laboratory of the Technological University of Pereira).

Figure 5 . Driving cycle: NEDC

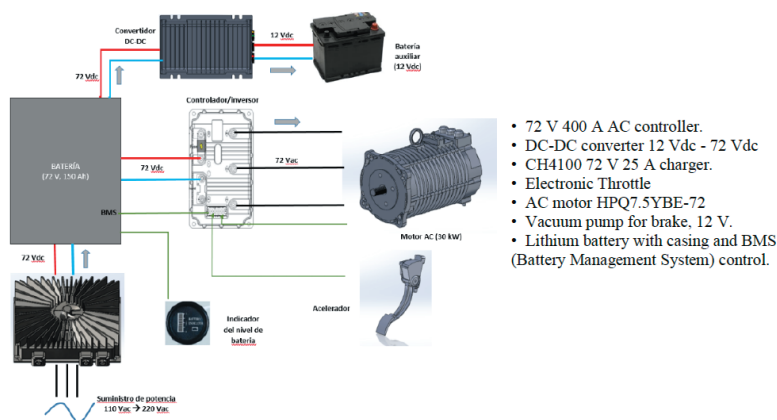


During testing, the average fuel consumption was 57.78 km/gallon (6.54 L/100 km). The combustion gases obtained were CO: 1.808 g/km, THC + NOx: 0.652 g/km. These values exceed the established international limits, which for this type of vehicle and according to the standards (Euro 4) are: CO: 1.0 g/km and HC + NOx: 0.3 g/km. In Colombia, vehicles are evaluated based on the Euro 2 protocol (resolution 910 of 2008), which establishes limits such as CO: 2.20 g/km and HC + NOx: 0.50 g/km. Taking into account the emission results, the selected vehicle is highly conducive to conversion.

2.3 Selection of the electrical kit.

The electric motor required according to the analysis of the traction dynamics (Figure 4) is 10 HP (7.5 kW). A motor of this capacity requires a 72 V electrical system. Figure 6 shows a basic connection diagram and the necessary components.

Figure 6. General electrical connection diagram and required components



The main battery must be connected to the auxiliary 12 VDC battery (can be used from the original vehicle) through the DC/DC converters to charge it continuously, replacing the alternator function. The battery employs a BMS (Battery Management System) that requires to be connected to the controller to achieve feedback from the system. The electrical current demanded by the motor in the no-load tests registered peaks of 40 A (72 Vac) representing a consumption of 2880 W, with a motor rotation speed of 3000 RPM. The initial tests allowed to identify connectors, cables, necessary protections and range of work of the accelerator. Battery load tests were carried out by connecting to a 120 VAC electrical network (local network in Colombia), presenting consumptions of 14 A (1700 W).

2.4 Replacement of the combustion engine.

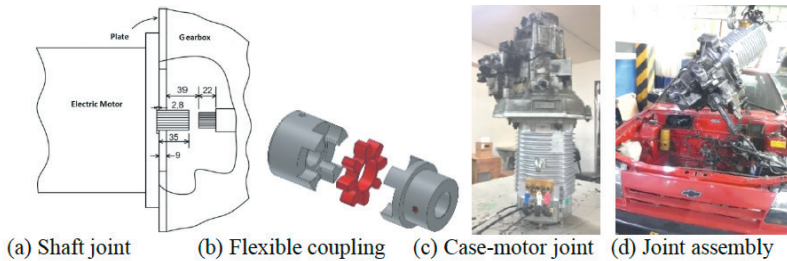
The images in Figures 7 and 8 show different stages of the process.

Figure 7. *Stages of engine replacement*



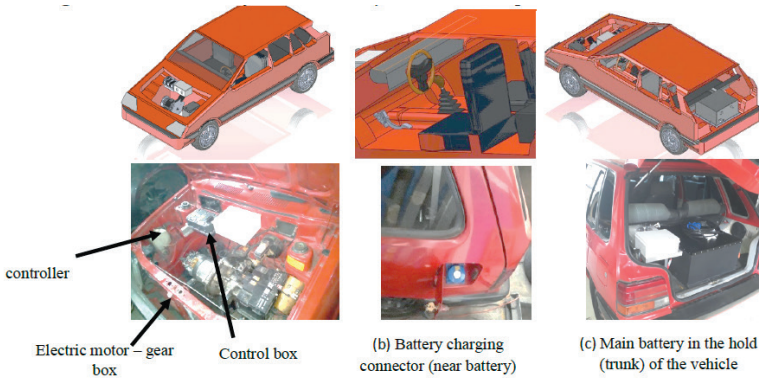
On the left side you can see the combustion engine, which is removed together with the gearbox. This box is disassembled and coupled to the electric motor through a flexible coupling (preventing possible misalignments), to which grooved holes are made to firmly couple with the shafts of the box and the motor.

Figure 8. *Assembling and mounting of coupled electric motor and box*



The box-engine assembly is coupled to the vehicle, using the supports of the original combustion engine. For the assembly projection, considering dimensions and optimization of the system, 3D modeling tools were used. The battery and charger are in the trunk of the vehicle, considering the dimensions and weights and the proximity of the charging connector, provided in the same place as the (original) fuel inlet. Figure 9 presents 3D projection and component location images.

Figure 9. Design 3D and location of lithium battery and other components



The control box (figure 9, left image) has been designed to implement overcurrent and voltage protections and incorporate a relay (or relay) to provide signal access to the system with activation of the vehicle's main switch signal. Figure 10 presents a diagram of the circuit used, keeping the location of components in the vehicle (top view).

2.5 Mass Balance

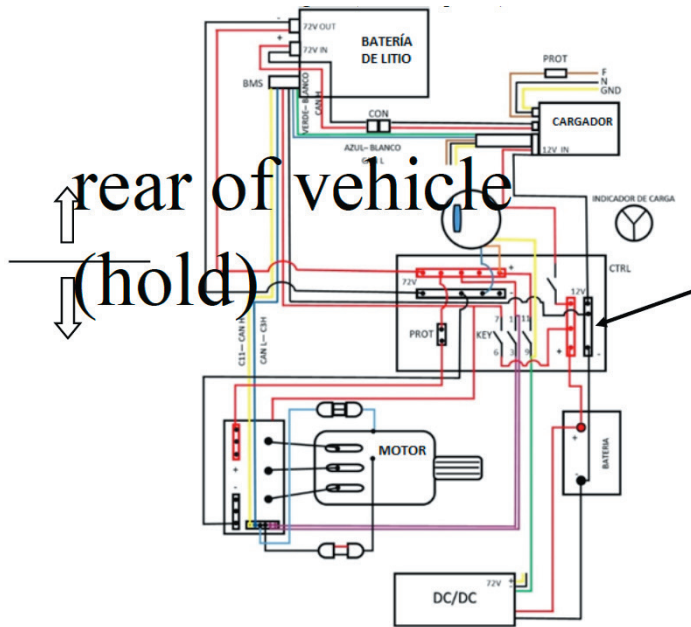
The total mass comparison of the vehicle was made before (combustion) and after transformation (electric). Weights of the different components were taken in each of the systems, Table 1 presents the results.

Table 1. Component Weight Comparison

Electric System		Combustion Motor	
Component	mass (kg)	Component	mass (kg)
Electric motor	40	Combustion motor	150
Lithium Battery	90	Combustible tank (full)	30
Controller	6	Radiator	5
Charger	5	Exhaust pipe	6
DC-DC Converter	1	Filters and pipes	5
Total	142	Total	196

The transformation of the vehicle into electric represents a weight reduction of around 30%, allowing the power demanded to be less for the same load conditions.

Figure 10. *Electrical Vehicle connection diagram (vehicle top view)*



2.6 Experimental testes

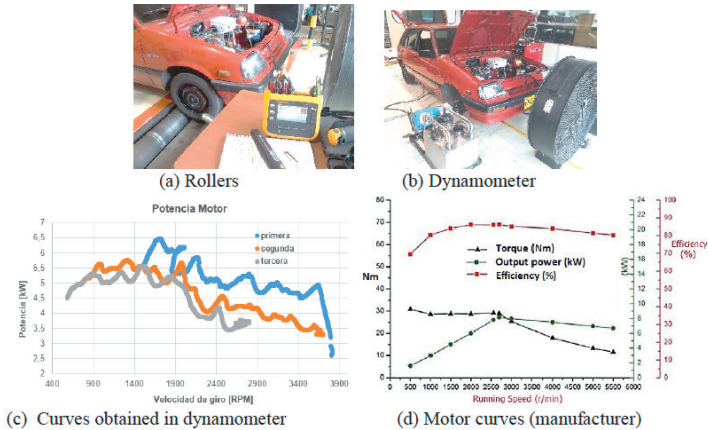
At this stage, as a central contribution of this work, some results of tests of the system, carried out in the laboratory (dynamometer and roller) and in different road conditions will be presented.

2.6.1 Laboratory testes

Effective power measurement tests on the output shaft (traction) were carried out in the dynamic test laboratory of the Technological University of Pereira, using a cube dynamometer

equipment (Dynapack). In the same way, autonomy tests were performed on rollers, following standard NEDC profiles (figure 5). Figure 11 presents images of the assembly and results.

Figure 11. Roller and dynamometer mounting, power results and engine manufacturer curves

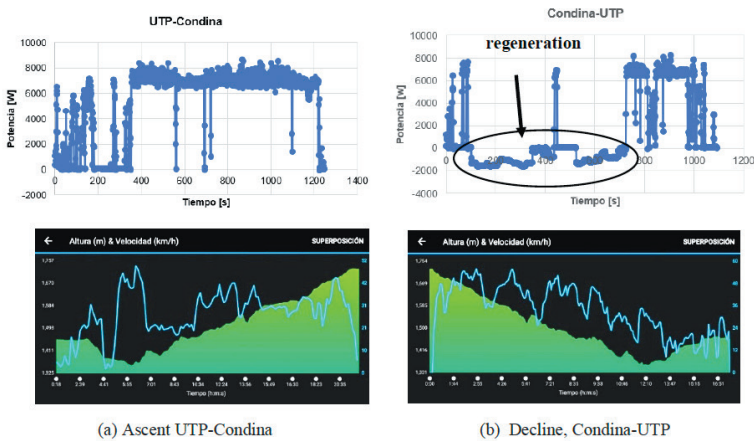


The output powers were measured using the 1st, 2nd and 3rd gears with registers between 5 and 6.5 kW due to the loss represented by the transmission and efficiency of the engine itself. Comparing with the original engine manufacturer curves, a certain similarity in the behavior of the engine power is obtained, maintaining its value at low RPM and gradually falling after approximately 2000 RPM. The differences are presented by the power losses and dynamic variations, derived from the gearbox (the original motor curves are built with load analysis on the isolated motor, without transmission box). In rollers, following NEDC profiles), autonomy values (complete battery discharge) equivalent to 250 km were found. Comparing with a heat engine, a full tank (8 gallons) has a range of 320 km but with a cost of \$ 72,000 higher than the cost of electricity demanded by the electric vehicle for the same journey, equivalent to \$ 6000.

2.6.2 Road tests

Initially, preliminary tests were carried out with all passengers, on the road with short distances, to subject the system to real load conditions and validate the traction model and the performance of the regenerative brake. Figure 13 shows the typical curves generated in a path, in this case short path UTP-Condina-UTP (UTP: Technological University of Pereira).

Figure 12. UTP-Condina-UTP road tests. Top: electrical power demand, bottom: altimetry curves (green) and speed (blue)



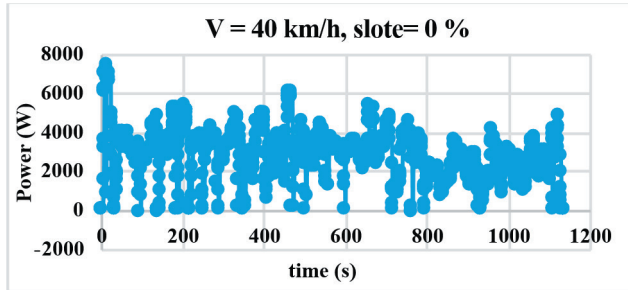
The average slope in the UTP-Condina ascent is 6%, the recorded energy consumed was 1858 Wh with a voltage reduction from 76.4 V to 75 V. It is to be noted, as is reasonable, that the highest speed in This route was presented on the descents, with very low power demands and, on the contrary, maximum powers are demanded on the ascents. In the Condina-UTP descent, the inertia reached was used to activate the regenerative brake, reaching powers in favor of 2 kW. The net demanded energy consumption recorded was 402 Wh with a voltage loss of only 0,5 V.

On the uphill, more demanding slope conditions place higher demands on power and torque, which roughly match the calculated traction dynamics. The nominal battery voltage is 72 Vdc, however, it can be charged up to 82 V (full load) and discharged up to 62 Vdc. This voltage reduction is generated with an energy discharge of 11 kWh. In ascent conditions, the vehicle traveled 9.89 km with an energy expenditure of 1,858 Wh, equivalent to 187 Wh/km. This means that maintaining similar conditions of slope and speed, the vehicle would have a range of 60 km if we have a full energy available of 10,800 Wh (150 Ah at 72 V). On the contrary, in favorable conditions (descents), even with higher speeds, the autonomy would be 267 km with the regeneration possible on the steepest descents.

2.6.3 Autonomy tests

Other tests were carried out to measure the autonomy on the road, to compare with the tests carried out on the roller (laboratory). Journeys were made in a section of approximately 20 km flat, maintaining a constant speed of 40 km / h and taking the vehicle from full battery charge (82 Vdc) to a total discharge of 62 Vdc, reaching 12 journeys. This represents an autonomy of 240 km under standard conditions (constant speed and flat terrain), very similar to the autonomy achieved in the laboratory. Figure 13 shows the power demanded; the transient peaks represent the power required at the start of the test where acceleration occurs. The total energy measured (area under the Power-time curve) was 11 kWh, as previously measured and estimated. This test defines a relative consumption of 46 Wh/km.

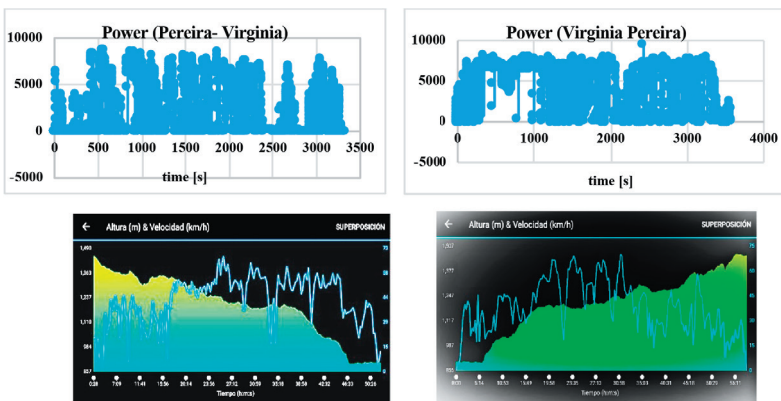
Figure 13. Power measurement over a 240 km route under favorable conditions (constant speed and flat terrain)



2.6.4 Long-distance tests

Longer journeys were also made between cities. The lack of charging stations on the road, force to limit the routes of the tests. With total passengers it traveled between the cities of Pereira and Virginia with a total distance of 100 km. Figure 15 shows the behavior of the power demanded by the engine, vehicle speed and travel altimetry.

Figure 14. Power measurement over 240 km in favorable conditions (Constant speed and flat terrain)

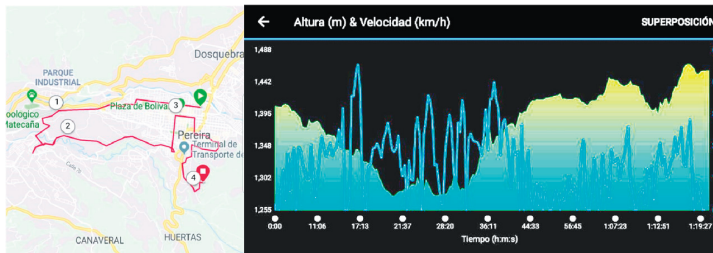


The energy consumption (area under the curve Power vs time of figure 15) in descent was 4085 Wh with an average consumption of 82 Wh / km, while in ascent it was 7932 Wh / km with an average consumption of 160 Wh / km . It is notable that in both routes the maximum power (8 kW) was demanded with greater constancy in the ascent. The average slope of this route (according to the altimetry profile) is 2%. The speed curves over time allow the estimation of accelerations, reaching in this case up to 0.8 m / s² (example: increase from 20 to 30 km / h in 10 s). With this acceleration and the recorded slope, the model of the proposed traction dynamics (equation 1) is validated in a very successful way. It has been proven both in the traction model and experimentally that acceleration is the factor that most affects the power demanded.

Tests were also carried out on trips to more distant cities, with a certain recharge in the destination city, necessary for the return. Steep slopes were also made to observe the behavior and temperature of the engine reached.

2.6.5 Urban tests

In order to evaluate in a more real way the performance of the vehicle in conditions of greater use, as it is within the urban area, tours of the city of Pereira were made for 7 hours (from 12 to 7 pm), facing conditions associated with stops and starts continuous (typical of current traffic in a main city). Figure 15 presents the profiles of the route, altimetry and speeds reached.

Figure 15. Route profile, altimetry and speed, urban area

(a) Profile of the route (downtown and periphery) (b) Altimetry (green) and speed profile (blue) during a section of the area and periphery route

The average slope recorded was 5%, with variations between 1270 and 1450 m.a.s.l. Distance recorded throughout the entire route was 108.5 km with an average speed of 16 km/h (considering all the stopping times). The total power consumption was 4230 Wh, corresponding to less than half the battery's full charge (10800 Wh). It is notable that speeds are maximum (50 km/h) in areas with negative slopes and with little traffic (outskirts of the city). In the routes of the downtown area logically the speeds are minimum with many continuous stops, being increased in the peak hours. In this scenario, the engine, despite having continuous accelerations, works with less demand on power. The power and torque curve of an electric motor shows that at low revs it can deliver maximum torque with low power demands. This was reflected in this type of route, where the engine temperature increased very slightly unlike the increase on the road. With the measured energy demand, a total journey of 14 hours through the city can be projected with a full battery charge, as long as the driving regime is regulated at low accelerations.

3. Results and discussion

Table 2 summarizes some of the tests carried out on the road, routes with different conditions of slope and speed.

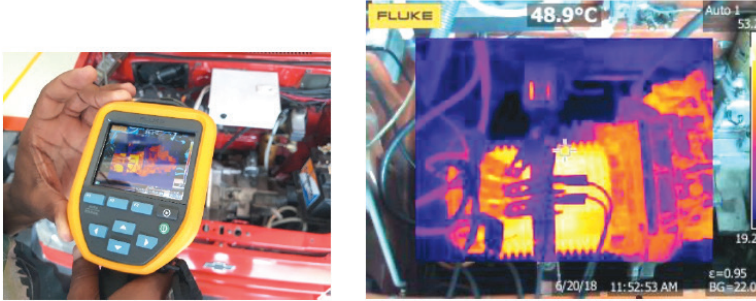
Table 2. *Tests of different routes**Tests of different routes*

Route	Distance km	Average slope	Consumption energy (Wh)	Aver. Veloc. (km/h)	Time test (min)	Wh/km	Projected autonomy (km)
UTP -> Condina	9,89	+ 5,12 %	1858,2	27,6	21,3	188	58,5
Condina -> UTP	9,81	- 5,12 %	403,3	32,8	17,5	41,11	267
UTP->La Virginia	49,49	- 2 %	4085	38	52,57	82	132
La Virginia -> UTP	49,49	+ 2 %	7932	33,6	59,57	160	68
UTP->Santa Rosa	14,46	+ 10 %	2553,1	18	52,57	176,6	62,3
Santa Rosa -> UTP	14,45	- 10 %	897,16	28	32	62,08	177,2
UTP -> La Paila	87,37	- 1 %	7135	50,1	104	81,66	134,7
La Paila -> UTP	80,74	+ 1 %	9192	46	105	113,8	96,7
Recorrido Pereira	108,5	+/- 5 %	4230	16	420	134	277

According to the tests carried out (table 2), autonomy depends on multiple factors, as predicted by the traction model (equation 1) for some parameters. Variables such as grade, acceleration, speed, road conditions, vehicle weight (passengers), ambient temperature, travel (run time), stops and starts, and driving mode have some influence on autonomy (or average consumption Wh / km). Interestingly, the widest autonomy was found in the city, where there are more stops and starts, with a relatively low average speed. This operation at low revolutions makes the motor work in areas of high torque and low power (figure 12), making the energy level consumed relatively low over time. On the road, the level of power demanded is maximum since the speed reached is high and greater accelerations are required (in passing vehicles for example). In constant high power curves and a warm environment (such as Virginia for example), it causes the temperature of the battery to increase, reducing its efficiency, reaching consumptions of 160 Wh / km. Likewise, high slopes (10%) demand high consumption (177 Wh / km), projecting a range of only 62 km. Even for high demands, the motor's thermal release fins keep it at suitable temperature levels.

Figure 16 presents thermographic images of the engine, after the test on a steep road, registering a maximum value of 48.9 oC.

Figure 16. *Maximum temperature in high demand test
(road with 10% gradient)*

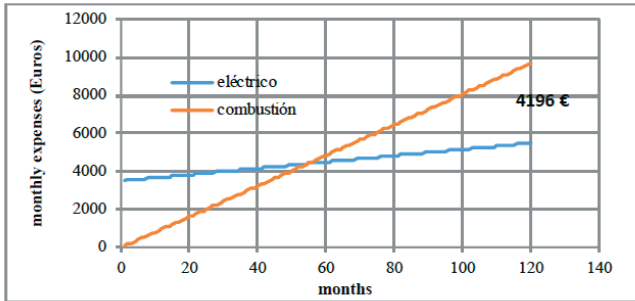


A basic analysis of return on investment has been carried out considering not only initial investment, but also maintenance expenses and necessary mobility costs (monthly). This analysis includes the conversion price which includes the cost of the electrical kit and labor in the conversion. The maintenance required for an electric vehicle is zero or almost zero, without requiring periodic visits to the dealer. In terms of maintenance, some costs associated with a combustion vehicle are: oil change every 5000 km, gearbox and transmission oil change every 50,000 km, synchronization costs that must be done every 12,000 km. In addition to this, it requires a technical-mechanical inspection certificate at a cost of € 50, while an electrician does not require certification and only demands a revision of lights and peripherals (€ 6). Figure 18 presents the comparative costs between a combustion vehicle (before transformation) and an electric vehicle (transformed). It is also worth mentioning that there is a slight return on the sale of spare parts derived from the disassembly of the combustion system. Consumptions are taken under similar standard conditions.

The comparative analysis is carried out per month, assuming a journey of 1000 km (which corresponds to an average standard annual journey of 12000 km). The maintenance costs required for

a combustion vehicle (deferred monthly) have been involved. Tax and soat (required) costs are considered equal. Figure 17 shows the respective graph highlighting the crossover point of the behavior of the expenses of each vehicle option.

Figure 17. *Projection of monthly expenses (accumulated) considering investment for transformation*



The crossover point shows that the return on investment is in month 55 (4 years, 7 months) if the monetary factor is analyzed exclusively, however, it can highlight the fact of the profit from future savings, which amounts to 4196 € in year 10 (120 months). Increases in changing costs over time (such as gasoline or electricity) due to inflation, which could reduce the return time, have not been considered. In addition, electric vehicles enjoy exemption from restrictions for their mobility in the main cities of the country. Expenses generated by this restriction in combustion vehicles are not considered in this analysis.

4. Conclusions.

Experimental tests have shown that the power depends on the established load conditions, validating the proposed model (equation 1), figure 4. On flat terrain (slope 0) the vehicle (with all its occupants) has reached speeds of 80 km / h with a full power of 8 kW (constant speed). The battery has been discharged under different charging conditions showing different autonomy

values. In the most favorable conditions, the vehicle has reached autonomy values of 240 km (in the laboratory) and close to 200 km on the road (10,800 Wh, 82 to 62 Vdc). However, in urban areas (even with traffic) it could exceed these values, since the engine works mainly in low-rev areas, with high torques but at low power.

Tests carried out on the combustion vehicle (before conversion) showed that the fuel consumption was 6.54 L per 100 km, showing high levels of contamination (CO: 1.808 g / km, THC + NOx: 0.652 g / km), exceeding the admissible international limits, generating a high impact on the carbon footprint.

Comparative mass analysis showed that the transformation of a combustion vehicle to electric can have a reduction of the total mass of almost 30% and therefore the load demanded.

The economic factor represents an important reason to carry out this type of conversions, mainly in the Latin American context. In Colombia, for example, the total cost of the electrical system oscillates around € 3,500 (15,000,000 COP approx.). A new electric vehicle costs about 100,000,000 COP (23,800 €), excessive costs, with transformation being a feasible option.

Economic analyzes have shown that the return on investment can be achieved in 4.5 years, considering the savings due to the expenses derived from fuel and maintenance required in combustion vehicles. In 10 years, savings of \$ 17,600,000 (€ 4,200) can be achieved, which can be used to purchase a new battery and a new conversion or installation of a charging station.

Regarding the mitigation of greenhouse gases, with an electric vehicle, 21.7 kg of CO, 7.8 kg of NOx - THC and 1.8 Tons of CO₂ are no longer sent into the atmosphere annually (taking emission of 150 g CO₂ / km and 12,000 km per year).

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Importance of computational thinking in the training of engineers based on theories and learning models

Importancia del pensamiento computacional en la formación de ingenieros a partir de teorías y modelos de aprendizaje

Omar Iván Trejos Buriticá, PhD¹

Abstract

The target of this research was to propose, implement and bring to the classroom a model that would facilitate the learning of imperative programming in Systems Engineering and Computing based on the theory of meaningful learning (Dr. David Paul Ausubel), Discovery learning (Dr. Jemore Seymour Bruner) and the 4Q model of thinking preferences (Dr. William Herrmann). From the perspective of these three models, it was sought that, in this learning process, the meaning of programming would be simplified,

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spaces would be opened for the student to discover solutions based on their own logic, students would be outlined and they would be aware of their profile and, in general, computational thinking will be assimilated as a basis for decision making. The adopted method was quantitative with written evaluations and valued in the range of 1 to 5 and qualitative from observation, dialogue and interaction between students and the research teacher. The results show that, both quantitatively and qualitatively, the proposed model is favorable to the learning process of imperative programming. It is concluded that in a learning process of these characteristics, it is worthwhile for the teacher to document himself about learning theories so that his work is rewarded with what the student learns regardless of the assessment that exists in between.

Keywords. Computational thinking, Computer programming, Learning models, Learning theories, Systems Engineering

Resumen

El propósito de la presente investigación era el de plantear, implementar y llevar al aula un modelo que facilitara el aprendizaje de la programación imperativa en Ingeniería de Sistemas y Computación basado en la teoría del aprendizaje significativo (Dr. David Paul Ausubel), teoría del aprendizaje por descubrimiento (Dr. Jemore Seymour Bruner) y el modelo 4Q de preferencias de pensamiento (Dr. William Herrmann). Desde la perspectiva de estos tres modelos se buscaba que, en dicho proceso de aprendizaje, se simplificara el significado de la programación, se abrieran espacios para que el estudiante descubriera soluciones a partir de su propia lógica, se perfilaran los estudiantes y éstos fueran conscientes de su perfil y, en general, se asimilara el pensamiento computacional como base para la toma de decisiones. El método adoptado fue cuantitativo con evaluaciones escritas y valoradas en el rango de 1 a 5 y cualitativo a partir de la observación, el diálogo y la interacción entre estudiantes y el docente investigador. Los resultados advierten que, tanto en lo cuantitativo como en lo cualitativo, el modelo planteado es favorable

al proceso de aprendizaje de la programación imperativa. Se concluye que en un proceso de aprendizaje de estas características, vale la pena que el docente se documente acerca de teorías de aprendizaje de manera que su labor se vea recompensada con lo que el estudiante aprenda allende la valoración que exista de por medio.

Palabras Clave. Ingeniería de sistemas, Modelos de aprendizaje, Pensamiento computacional, Programación de computadores, Teorías de aprendizaje.

1. Introduction.

One of the great difficulties that arise in university training is the preparation that, regarding models and learning theories, have engineering teachers who were trained as engineers but who work as teachers (Trejos Buriticá, 2012), which establishes The need for them to strengthen their purely disciplinary knowledge since engineering is the subject of their work as teachers but also to appropriate and apply learning models and theories, given that the environment where said engineering knowledge is applied is in the teaching context and Therefore, the convenience lies in the fact that all the strategies and actions adopted to improve learning will be favorable in addition to the awareness that engineering teachers have of the need to be strong on both edges (Annanth, 2016).

The tendency for engineers to form part of the teaching staff of higher education institutions, and especially systems engineers, is increasing every year (Nacional, 2016), which invites the establishment of forecasts for the engineering teacher to see his knowledge from engineering but his work from teaching and that, between one and another, he can count on the most appropriate tools to develop the specified task.

The research project that inspires this presentation seeks to make a proposal through which a methodological model can be proposed that enables the learning of programming from the adoption of actions and strategies derived from the theory of

meaningful learning, discovery learning theory and the 4Q model of thinking preferences. The presentation seeks to stage, in a systematic and organized way, the criteria that justify the specific importance of computational thinking in the training process of engineers, and particularly of systems engineers, based on the aforementioned theories and models.

The research problem of the 6-16-13 project lies in the enormous need to strengthen in engineering teachers both the disciplinary knowledge of engineering, whatever the branch of their specialization, and the theory that underlies teaching as a path through which the student transforms, updates or questions his cognitive base based on a new knowledge acquired. The novelty of this presentation is that it seeks to highlight computational thinking as an articulating element between the theories and learning models with the knowledge of systems engineering so that, together, they strengthen what the student can learn in their training cycle.

The research is justified, among other reasons, from three specific reasons: a) the high need for engineers in today's world, b) the inclination of engineers towards teaching as a job option, c) the new areas of knowledge that are strengthening different engineering programs. The presentation is based on a slightly more specific justification: a) the promotion of computational thinking as a basis for decision-making, b) the need to train critical thinking, the use of technologies and the algorithmization of solutions to problems emerging, c) the need to appropriate and apply theories and learning models from an engineering perspective.

According to the statistical information published in the Statistical Compendium of National Education of Colombia updated to 2016, if the trend of incursion of engineers in the teaching field in higher education continues, it could be expected by 2030 that half of the teachers University students may be engineers or from some area related to engineering. This makes it necessary to highlight the importance of the subject since, to the extent that it is done, a culture of deepening in engineering and training in teaching is created, so that the students are the beneficiaries.

The presentation presents some conceptual elements for reflection around the need to incorporate computational thinking, to understand and assimilate it by teaching engineers and to promote it in their classes, to relate it to different learning strategies and to articulate it with theories and models that they strengthen it, make it possible and make the path to the results established from the curricular point more expeditious. Although the 6-16-13 project has a rigorous statistical support that allows comparing the results obtained in parallel from two courses, one of study and the other of reference, this presentation raises from the theoretical the foundations to highlight what has been said previously.

Theory

In the first place, we will refer to Computational Thinking, which consists of the simplification of deliberative human logic to approach computational logic (Denning & Tedré, 2019), that is, to bring as many ways of solving a problem to the way it can be solved when modern technology serves as a means of solution based on a transformation of logic. Computational Thinking consists of three concepts that constitute it in its fundamental part:

Critical thinking. In its simplest definition, critical thinking is defined as the ability to perform analysis and evaluations of reasoning that comes from a specific topic and that is part of a defined context (Wing, 2006). Different paths enable critical thinking such as the scientific method, the accumulation of information, experience, observation and interaction with the context in question. Critical thinking always requires a situation, a set of rules, and a context in which those rules are valid. The situation may or may not be problematic, that is, it may require a solution but it may not necessarily be solvable. The set of rules can be defined by a method of representation or they can be the product of a tradition, myth or belief. The context can be defined by the variables and their behaviors and also by the way they intervene in the conditioning of the

rules. Confronting the rules with the situation and reviewing the possible relationships between them and the context from an analytical perspective is what constitutes, in its simplest essence, critical thinking.

The use of technology. The penetration of screens in today's world is such that at all times we have one of them at a very short distance. The characteristic of these times is not in the physical penetration of these screens but in the great influence that their content exerts and in the immense possibilities that are opened to the members of today's society both for the human and for the profane, to access information, to publish information, to raise concerns and to resolve them (Eady & Lockyer, 2013). Screens are the front-end of a world full of virtual options that make it necessary to adopt other positions and visions about life, human beings, the relationship between them and society in general. Being trained to live in today's world means understanding the ways in which new information and communication technologies can be used to the maximum for the advancement of knowledge, human wellbeing, information and access to data and of the future prospects of the society in which we live (Johnson & Wetmore, 2008).

The resolution and algorithmization of problems. Solving problems is one of the most necessary characteristics in these times, since in the society of the 21st century new scenarios appear with new forms of interaction, relationship and conflict (Trejos Buriticá, Imperative Programming with Language C, 2017). One way that technology provides is the algorithmization of the solutions that may arise, when it is seen that these problems are computable. It must be admitted that more and more problems are becoming computable thanks to the advancement of theories such as artificial intelligence, machine learning and data analysis. With the algorithmization of the problems, it is achieved that they are not seen from the perspective of human deliberative logic but from computational

logic to take advantage of the processing speed, the handling of large volumes of data, the large storage capacities and the high speeds in generating responses (Brown & Wilson, 2018).

For its part, meaningful learning, a theory developed and formulated by Dr. David Paul Ausubel, gives priority in learning to the meaning of knowledge and what the student already knows (Ausubel, 2010). The meaning of knowledge is the search for its meaning, that is, it answers the question, what is the use of what is learned? According to this theory, if the student (also known as an apprentice) finds a relationship between the new knowledge they receive and the context with which they relate on a daily basis, be it a theoretical, practical or experiential context, the knowledge acquires a different presence and , therefore, it begins to occupy memory spaces in the medium and long term as opposed to the instantaneity of the short term.

In this way, meaningful learning theory is based on three elements: a) prior knowledge that corresponds to the set of knowledge, specific, systematic, informal, academic, theoretical, practical or experiential, which occupies a space in the memory of the learner either in the short, medium or long term, b) the new knowledge that corresponds to that which is new, by definition, that is to say that it has recently appeared within a specific context as part of its related knowledge or that to which the learner he had not yet had the form or ability to access and that, for his brain, it is also new and c) the student's attitude that, basically, can be divided into two parts: the student's motivation to learn and the ability to establish relationships between their previous knowledge and their new knowledge (Ausubel, *The Acquisition and Retention of Knowledge*, 2012).

According to the theory of meaningful learning, the most relevant thing in a learning process is what the student already knows, which is why three reflections are reached: a) the contexts in which the learner operates influence their learning and correspond to the classroom context, institutional context and extra-institutional

or external context, the classroom context being the least influential for their learning and training, b) the student's ability to establish connections between prior knowledge and new knowledge depends on the motivation to learn and, to a large extent, that will depend (in turn) on the strategies that the teacher adopts to enable the creation of this ability in the student and c) the goal is that knowledge corresponds to a set of knowledge that are available in the medium and long term so that it can be used in situations similar to those from which it comes (which is known as skill) or in situ Actions that, being different, can be resolved with the same knowledge (which is known as competition).

Learning by discovery enables the student to "discover" the elements of the knowledge that he wants to acquire every time the teacher has adopted the strategies and actions that allow him to have a knowledge base from which he can fulfill his purpose as learning objective. It starts from the fact that knowledge is more durable and persistent when it comes from an autonomous discovery process by the learner (Bruner, 2006).

This theory was formulated by Dr. Jerome Seymour Bruner who considered that for the human being the maximum meaning of knowledge could be found in what he discovered by his own means and from the previous knowledge he already had.

In the light of this theory, knowledge is received, transformed and evaluated. It is received through the senses in a way that is carried to the brain. Subsequently, it is transformed into useful or not useful information or, also, it is left waiting to be classified (Bruner, *Acts of Meaning*, 2009). At a given moment, when it has been classified as useful information (that is, knowledge as such), it is evaluated to verify its validity when it is put into practice and applied in situations dissimilar to the nature that produces it or similar to the context of the which is derived.

The 4Q model of thinking preferences is a model formulated by Dr. William Herrmann that proposes the preference of a specific approach to see the world and interact with it (Herrmann, 2015), from four possible approaches, each one located in a different quadrant of the human being.

Quadrant A, also known as Logical, is the preferred one for those people who always want to know the reason for things, their genesis and their evolution in order to assimilate them more easily.

Quadrant B, known as Sequential, is the preferred quadrant of those people who simply comply very well with an order when it has been delivered in orderly and sequential steps so that there is no doubt in its execution. People in this quadrant do not question the provenance or root of a procedure. They simply do it step by step as indicated.

Quadrant C, social, is the quadrant of people who need to interact with others to feed back their knowledge, to make their points of view known and to find new and better ways that can solve certain problem situations. In the light of this quadrant, there is no questioning about the origin of knowledge, nor the sequentiality in the performance of actions.

Quadrant D or imaginative, is the quadrant of people who can go further, supported by their imagination, creativity and inventiveness, than other people can reach. They are idealists and often become so far removed from reality that, suddenly, they can find themselves alone looking for the most ingenious way to solve a problem, a way that they often cannot find but are convinced that it exists (Lumsdaine & Lumsdaine, 2005).

Below, Table 1 presents some observations about the contribution of these three theories to both the research and this presentation:

Tabla 1. Therorie's contributions

Theory / Model	Contribution to Proj	Contribution to presentation
	6-16-13	
Thought Computational	It enables the appropriation of computational logic from a purely practical perspective	It is the main topic of discussion and inquiry among the engineering teachers selected for the study.
Meaningful Learning	Provides tools to provide the student with criteria and adopt strategies that enable the meaning of programming, its logic and its associated thinking	It is one of the two theories that serves as a basis to be able to raise reasons that highlight the importance of logical thinking
Learning By Discovery	Provides tools for the teacher to visualize a path through which the student can be guided in the "discovery" of the knowledge required	It is one of the two theories that serves as a basis to be able to raise reasons that highlight the importance of logical thinking
Model 4Q of Preferences Thought	With its adoption, it allows students to profile themselves and, in this way, facilitates the approach of certain topics on their own terms and from their personal preferred approach.	It is the model that has been adopted to have elements of judgment that facilitate observations about the contribution of logical thinking in a programming course

Fuente: Self preparation

Materials And Methods.

For the development of the study that inspires this presentation, 30 computer programming teachers with undergraduate training in Systems Engineering and with experience of more than two years in computer programming subjects were selected. These teachers were contacted electronically through their directors and in the Valle del Cauca, Tolima and Eje Cafetero region in public universities that had engineering programs or associated or derivative programs within their academic offerings.

Contact with these teachers revolved around the questions of an instrument that, for the purpose of the investigation that is exposed, was designed. Open questions were answered that were sent by email after the first contact and that the answers were received by that same means. The instrument contained the following questions:

1. Years of experience teaching computer programming in Systems Engineering
2. Years of experience as a programmer
3. Do you know what computational thinking is?
4. Do you know what meaningful learning is?
5. Do you know what discovery learning is?
6. Do you know what the 4Q model consists of?
7. Do you use any of these models in the planning and development of your programming subjects?
8. If yes, explain how you do it and which model you use.
9. Are you a programming logic, programming or programming language teacher?
10. Do you consider it important for a programming engineer teacher to know about theories and models of learning and of thinking preferences?
11. Age and Sex

Questions 1 and 2 are completely closed since your answer refers to a specific value. From question 3 to question 6, although the answer could be a simple YES or NO, the teacher is invited to briefly expand it in the introduction of the instrument. In this way it is possible to try to detect if the teacher really knows the theory for which she is asking or not.

Question 7 is a closed question whose answer refers to a YES or a No. Question 8 opens a space where the teacher has the option to explain, as broad as he or she needs or as brief as he considers it. Question 9 raises the teacher the concern about her classification as a programming teacher, if what she has written so far is coherent and truthful, she will find it very easy to answer this question. If it is not, you will see yourself in tight tights to do it. Question 10 reveals,

in a very simple way, the relevance that an engineering teacher in programming areas gives to education science training and its derived models and theories.

The information collected was grouped and tabulated according to the responses collected. It must be accepted that this quantitative inquiry does not correspond to a detailed study but to a preliminary inquiry that, due to the randomness of the selected sample of teachers, could shed some light on the conception that engineering teachers have of programming subjects in engineering programs of public university systems and in similar or derived programs, on the relevance that these confer to computational thinking and the need to know models and learning theories with the aim that their efforts as teachers are more effective both in terms of learning as in relation to the time used for it.

Results And Discussion

The results obtained in this investigation are summarized in Table 2.

Table 2. Results

Prg	Enunciado	Respuestas	
1	Years of experience teaching computer programming in systems engineering	< 5	≥ 5
		22	8
2	Years of experience as a programmer	< 5	≥ 5
		25	3
3	Do you know what computational thinking is?	Yes	No
		2	28
4	Do you know what meaningful learning is?	Yes	No
		1	29
5	Do you know what discovery learning is?	Yes	No
		3	27
6	Do you know what the 4Q model consists of?	Yes	No
		1	29

	1	29		
Do you use any of these models in the planning and development of your programming subjects? 2 28				
8	How do you do it and what model do you use?			(See table 3)
Are you a teacher of programming logic, programming or programming languages?				
	LogPrg	Prog	LangPrg	9
	4	9	17	
Do you consider it important for a programming engineer teacher to know about theories and models of learning and preferences?				
10	Yes	No		
	8	22		
11 Average Age and Sex Age				
	Avg	M	F	
	26	19	11	

Fuente: Self elaboration

Table 3. Model's use

Ans	Description
1	I try to find a relationship between the experiences of the students and the statements that are raised so that they can be solved with programming. I understand that this is what they call meaning. For example, students build a program that allows them to register the ticket on the bus and say how the returns should be delivered.
2	For two semesters I tried to place the students in the preferred quadrants to get to know them a little better. I suppose that to study programming a Logical preferred quadrant is required, although after this period I began to think about the benefits that sequential, social and imaginative students had as part of the work groups.

Despite the fact that the present investigation is not an exhaustive study, in any case due to the randomness of the sample and geographic distribution, the information collected allows us to raise some reflections in this regard that are worth considering.

Question 1 shows an overwhelming majority of teachers who have less than 5 years of experience as professors of programming in systems engineering and in question 2 it is observed that the

experience as programmers is also the majority, which is less than 5 years. If the average age of question 11 is taken into account, which corresponds to 26 years, it can be concluded that they are recently graduated systems engineers whose knowledge revolves around purely disciplinary knowledge but who, in the absence of experience, have not yet had enough time to assess the importance of other knowledge in the case of teaching in a field such as programming in systems engineering.

Questions 3, 4, 5 and 6 that inquire respectively about computational thinking, meaningful learning, discovery learning and the 4Q model, support what has been said in the previous paragraph since the majority answer is NO when asked if they know some of the these theories and / or models. The average of negative responses is 28.25, which, taken to a percentage level, corresponds to 94.1% and, therefore, it can be thought that only an approximate 6%, of the selected sample of teachers, could attest to your knowledge or at least a brief understanding around the theories and models mentioned. Indeed, the affirmative answer corresponds to an average of 1.75, which, as a percentage, is 5.83% of the teachers who filled out the form.

This leads us to think a) that the randomly selected teachers are mostly so young or so recently graduated that they have not yet been able to assess the need for other knowledge that complements disciplinary knowledge in teaching work, b) that the Theories and learning models are not a topic that interests programming engineering teachers, c) that they may know other theories and learning models but that, exactly, they do not know about those that are asked in the instrument, d) that they are possibly making enormous efforts to change the cognitive base of their students when trying to teach programming and that, one might think, these efforts could become more effective if they were based on the theories that were selected as well as the sense of training by competencies that requires the learning of modern programming, of the need for the student to relate disciplinary knowledge to real life as suggests the theory of meaningful learning, that the student may have tools that

allow him to discover knowledge relevant to programming to be able to practice it later, that a preferred profile of the 4Q model could be more convenient in the selection of students for a program such as systems engineering and that computational thinking can be the basis for programming, and knowledge of other areas, to acquire a much more applicative meaning in today's society.

As expected, the use of the specified models and theories is conspicuous by its absence in the academic scene of the selected teachers, since question 7 presents some results where it attests that only 2 teachers use these models in the planning and development of their programming subjects and that 28 teachers do not, which can be explained by the reasons stated in the immediately preceding paragraphs.

In question 8, Table 2 presents the way in which teachers have used theories and learning models. The only two teachers who use them, one of them has thought about the concept of meaning (as proposed by the theory of significant learning) when wanting to relate programming to the needs of the students' everyday world and the other has considered it important to outline to students with the conviction that those who have a Logical preferred quadrant can be more productive in terms of programming logic and therefore in terms of programmable solutions that can be implemented on a computer.

In both cases, there is evidence of a relationship, albeit timid, of the teachers from their own knowledge of systems engineering with two of the theories raised in this inquiry. It would be convenient, in a more exhaustive study, to know the results obtained by the teachers who answered YES and to make a comparison with the results of other courses where, the same teacher teaching the same subject, had not adopted the changes mentioned in their answers.

Question 9 embodies a trap door that consists of knowing if teachers really know the difference between being a professor of programming logic, programming or programming languages. The

majority answer is that teachers define themselves as programming language professors, which is hardly natural among recently graduated engineers who consider programming simply as the way to learn to handle programming languages, ignorance of the importance of the mathematical foundations that they teach. Underlie (as derived from programming logic) or programming paradigms from a perspective of their theoretical conception (as can be inferred from programming as such).

This indicates the great need to appropriate, assimilate, apply, feed back and evaluate computational thinking as a way to develop solutions that have a scientific foundation (logic), that can be located with good theoretical bases within a paradigm (programming) and that is also seen working on a computer (programming languages).

Question 10 has an answer that could be considered consistent with what has been said so far, because of the 30 randomly selected teachers in different regions and different public universities, only 8 consider it important for an engineering teacher to know about the learning models and theories and apply them in your subject. The vast majority, that is, 22 teachers (73%) do not see the relevance of these theories and models as a complement to facilitate, simplify and make their work more effective as teachers of programming in systems engineering.

4. Conclusions

Bearing in mind that the objective of the unfunded research project that inspired this presentation consisted in the Development of a methodological model for learning programming in systems engineering based on meaningful learning, discovery learning and the 4Q model of student preferences. Thinking, and that the objective of this presentation was to stage, in a systematic and organized way, the criteria that justify the specific importance of computational thinking in the process of training engineers, and particularly of systems engineers, taking As a basis for the aforementioned theories

and models, and taking into account the electronic interaction carried out with the students selected for the inquiry that supports this presentation, the following conclusions can be drawn:

Teaching is part of one of the possible occupational profiles of engineers since it is not far from their job expectations. Teaching engineers require that they be made aware of the importance of appropriating and applying theories and learning models so that their teaching work becomes more effective and efficient.

Computational thinking corresponds to the strongest conceptual edge that must be taken into account within the processes of the formation of the logic required to assimilate and apply computer programming and its associated subjects. Theories such as meaningful learning and discovery learning and models such as 4Q of thinking preferences, pave the way for teaching computer programming.

Carrying out a study with a larger sample may reveal the current state of perception of computer programming engineering teachers in systems engineering in relation to computational thinking, meaningful learning, discovery learning and the 4Q model. , the way they can take advantage of it for the development of their classes and the potential that these can awaken in the teacher in the teaching and learning process with the respective students

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2

CHAPTER TWO

Economic, administrative
and accounting sciences

Bioeconomics: a bibliometric analysis in Latin America and the Caribbean

Bioeconomía: análisis bibliométrico en América Latina y el Caribe

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Abstract

This article offers a vision of how Latin America and the Caribbean (LAC) have adopted the principles of the bioeconomy in the last two decades with different levels of socio-economic impact. The analysis was carried out with 706 publications obtained from the SCOPUS database between 2003-2020. The results allowed us to identify that in LAC, there are capacities for the development of the bioeconomy; however, these potentialities are disparate at the

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country level. It was identified that the three countries that most promote the development of this issue are Brazil, Argentina, and Mexico. The structural analysis of the bioeconomy work showed a high rate of cooperation between LAC institutions with institutions in North America, Asia, and Europe. The relevance of the bioeconomy in LAC is highlighted as an alternative for growth with emissions decoupling, contributing to productive diversification, especially in the agricultural and agro-industrial sectors. The potential of (agro) biodiversity resources, the capacity to produce biomass for various uses, in addition to food, and the availability of agricultural and agro-industrial waste are highlighted. This research aimed to analyze the bioeconomy in LAC from a bibliometrics perspective to explore scientific studies related to the concept.

Keywords: *Bioeconomy, Latin America and the Caribbean, Bibliometric analysis*

Resumen

Este artículo ofrece una visión sobre cómo América Latina y el Caribe (LAC) ha adoptado los principios de la bioeconomía en las últimas dos décadas con diferentes niveles de impacto socioeconómico. El análisis se realizó con 706 publicaciones obtenidas de la base de datos SCOPUS entre 2003-2020. Los resultados permitieron identificar que en LAC existen capacidades para el desarrollo de la bioeconomía, sin embargo, estas potencialidades son dispares a nivel de los países. Se identificó que los tres países que más impulsan el desarrollo de este tema son Brasil, Argentina, y México. El análisis estructural del trabajo en bioeconomía mostró que existe una alta tasa de cooperación entre instituciones de LAC con instituciones en Norte América, Asia y Europa. Se destaca la pertinencia de la bioeconomía en LAC, como alternativa para un crecimiento con desacople de emisiones, que contribuya a la diversificación productiva, especialmente en los sectores agrícola y agroindustrial. Se subraya el potencial de los recursos de la (agro) biodiversidad, la capacidad para producir biomasa para diversos usos, además de alimentos, y la disponibilidad de desechos agrícolas

y agroindustriales. Esta investigación tuvo como objetivo el análisis de la bioeconomía en LAC desde una visión de la bibliometría con la exploración de los estudios científicos relacionados con el concepto.

Palabras clave: *Bioeconomía, América latina y el Caribe, Análisis bibliométrico.*

1. Introduction

The European Commission coined the term Knowledge-Based Bioeconomy (KBBE) to transform knowledge of the life sciences into new, sustainable, eco-efficient, and competitive products (Aguilar, Bochereau, & Matthiessen, 2009). In other words, these processes must produce "more with less," thanks to the performance of living beings. Thus, the use of biomass to produce biofuels in "biorefineries" or of microbial enzymes in various food and textile industries or value chains that include, in addition to useful products, the recycling of waste and by-products, are examples of bioeconomy that are based on new advances in the biological sciences. LAC has abundant fossil, mineral, and biological resources, which have shaped its economy for centuries. In turn, the demographic challenges of the 21st century and industrial transformation generate new value chains and economic models that have driven initiatives for bioeconomic solutions in the region. The term "bioeconomy" encompasses the traditional economy, all industrial and economic sectors that produce and manage biological resources and related services. However, it performs exploitation differently by establishing the production processes of new chains of value sustainably. The more excellent knowledge in life sciences has resulted in promoting the substitution of fossil fuels and materials derived from fossils by materials derived from biodiversity, thus minimizing environmental impact and recycling waste towards more sustainable development. In this sense, the Latin American bioeconomy has focused on aspects such as:

- Achieve the sustainable use of biodiversity.
- Achieve the eco-intensification of agriculture,
- Implement biotechnology applications in the mining industry,

- Establish biotechnological applications applied to the food and beverage industries,
- Implement biorefineries for the use of agricultural by-products,
- Establish a bioeconomy that is aware of ecosystem services.

On the subject of sustainable uses of biodiversity, plant products play an essential role in health systems. For example, medicines extracted from plants represent around 25% of the prescriptions filled in the US. The World Health Organization estimates that around 80% of the world's inhabitants still depend on traditional medicine, including plant extracts and phytochemicals, for primary health care (2002). LAC has excellent plant biological diversity and has depended on plant-based medicine for centuries. In this sense, the best-documented initiatives correspond to work carried out by INBio (National Institute of Biodiversity of Costa Rica), whose strategy has been to develop agreements for bioprospecting, training, and capacity building with different companies and countries. The other important example is the collaboration between Peru and South Korea: the agreement was signed between KRIBB (Korea Research Institute of Bioscience & BioTechnology) and the Peruvian Council of Science and Technology (CONCYTEC), aimed at the evaluation of 450 medicinal plants from the Amazon rainforest. Other initiatives in the region have not delivered on their promise, mainly due to the lack of applicable legislation and stakeholder reward schemes (Sasson & Malpica, 2018). Regarding the issue of eointensification of agriculture, an example to highlight is the organization of Argentine agriculture and livestock, which have gradually evolved to a point where both the rural company and the sector as a whole have become very different from what they were a few decades before. Production and innovation groups were formed, and relationships were established beyond commercial exchanges governed solely by prices. The groups mentioned above have promoted the development of technical and organizational capacities that depend not only on individual productivity but also on the exchange links between the various actors involved in the activities (Bisang, 2008). Argentina, in this sense, is making rapid

progress on issues aimed at this achievement, such as work on genetically modified crops, collaborative work between farmers and companies in the agricultural sector, and the development of new strategies for working the land to improve their productivity (Sasson & Malpica, 2018). For its part, Brazil through EMBRAPA (Empresa Brasileira de Pesquisas Agropecuarias, Portuguese acronym for the Brazilian Agricultural Research Corporation), has developed varieties of transgenic crops, which not only meet the needs of its farmers but also lead to a strong economy in the production and trade of commodities.

Finally, another tool that is worth mentioning, which contributes to the real bioeconomy, is digital agriculture, which corresponds to the use of a variety of technologies, for example, drones or near and remote sensors, use of Internet technologies from Things (IoT) to make decisions on when to start harvesting crops, remote disease management, changing weather conditions, in this way digital agriculture can make a real contribution to the development of an effective bioeconomy. Environmental biotechnology, also called "white biotechnology", includes all biotic processes aimed at controlling pollution, e.g. Eg treatment of wastewater, industrial effluents, and solid waste. This environmental biotechnology contributes to a green economy and, indirectly, to a bioeconomy, through the reuse and recycling waste. A good example in Latin America is the outstanding effort made by Chile (the world's third-largest copper producer) in the application of bioleaching (or biometallurgy) to extract copper. Nutraceuticals, also called the functional food sector, is a relevant area for the development of the bioeconomy in LAC. The Andean countries and that include Amazonian ecosystems offer numerous examples of plant and wild species which are and could be exploited as functional foods if clinical tests are carried out on the use of their relevant organs (roots, fruits, seeds, and leaves) and if they are they can be grown on a commercial scale, once, for those with possibility, their nutraceutical value has been scientifically proven. First-generation biofuels or agrofuels, such as ethanol from corn (starch) and sugarcane (sucrose), and biodiesel from vegetable oils (palm oil and rapeseed), are now established in many countries,

often encouraged by generous subsidies and supporting regulations (Parker, 2011).

Brazil, the world's second-largest ethanol producer, behind the United States, and the leading exporter, produces its fuel mainly from the fermentation of sugar cane. Processing plants can go back and forth between ethanol and crystallized sugar, depending on prices. They can even be converted into "biorefineries" where fuel or sugar is produced and other types of products, using bagasse as an energy source for these refineries. Likewise, since 2006, Clayuca Corporation (<http://www.clayuca.org/sitio/index.php/procesamiento/produccion-de-ettanol>), has developed an exciting example of how to leave monoculture for the production of bioethanol, in which several Latin American countries participate, using cassava, sweet potato, and sweet sorghum as raw materials. Ecosystem functions are the chemical, physical and biological processes that contribute to the self-maintenance of the ecosystem. Some examples of ecosystem functions are the provision of habitat for wildlife, the carbon cycle, or the capture of nutrients. Thus, ecosystems, such as wetlands, forests, or estuaries, can be characterized by the processes that occur within them. Some examples of ecosystem services support the food chain, sustainable collection of animals or plants, and the provision of clean water or exceptional landscapes. These can be calculated in the form of natural capital variation in forests, land, and water and their potential benefits, how they are produced, and what social development growth objective they support can also be calculated (<https://seea.un.org/>). Understanding the importance of ecosystem services and taking them into account when building new value chains is critical to bioeconomy initiatives' success.

To conclude this document, this document's objective is to present a current bibliometric analysis of research work on the bioeconomy issue at the LAC level and thus establish a baseline of trends in this area at the local level.

2. Materials and methods

The previous research is part of a retrospective, and descriptive study carried out through Scopus (<https://www.scopus.com/home.uri>), a database that provides information on citations for more than 25,000 active titles, such as journals, conference proceedings, and books. It was considered to use this database and not Web of Science (WoS) (<https://mjl.clarivate.com/>) despite being considered one of the most complete, since Scopus showed a more significant number of documents than (Wos). The search was carried out on July 29, 2020, by providing the keyword "Bioeconomy" with an enabled time interval of "Every year". An article on bioeconomy was considered to be from LAC when at least one of the affiliated authors belonged to one of the following countries: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guyana French, Grenada, Guatemala, Guiana, Haiti, Honduras,

Jamaica, Mexico Nicaragua, Paraguay, Panama, Peru, Puerto Rico, Dominican Republic, Suriname, Uruguay, Venezuela. For this, the filter option (country/territory) of the database was used. With this search strategy, the database provided different types of documents since 2003, and everything published in progress for the year 2020, as shown in Table 1.

Table 1. *Types of documents analyzed and percentage distribution in the period 2003-2020*

Types of documents	Number	%
Article	494	69,97
Book	1	0,14
Book Chapter	66	9,35
Conference Paper	19	2,69
Editorial	6	0,85
Erratum	1	0,14
Note	2	0,28
Review	115	16,29
Short Survey	2	0,28
Total	706	100

Analysis programs

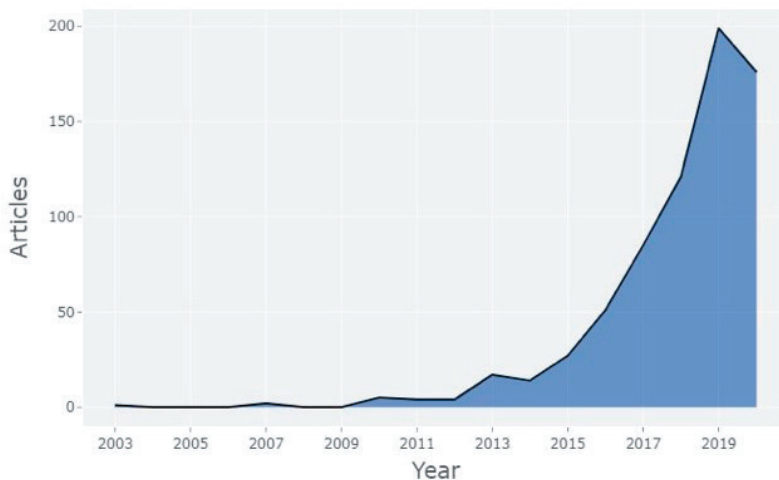
The bibliometrix R package (<http://www.bibliometrix.org>) provides a set of tools for quantitative research in bibliometrics and scientometrics. This program is written in the R language, which is an open-source environment and ecosystem. The existence of powerful and effective statistical algorithms, access to high-quality numerical routines, and integrated data visualization tools are perhaps essential qualities that distinguish R from other languages for scientific computing (Aria & Cuccurullo, 2017). The data retrieved from Scopus was analyzed using R studio v.1.1.456, R v.3.5.1 (2018-07-02), and bibliometrix R-package (<http://www.bibliometrix.org>) (Aria & Cuccurullo, 2019). The generation of graphics was carried out using the biblioshiny application. Additionally, data mapping was carried out according to the study theme, using the VOS (Visualization of Similarity) visualization program (Van Eck and Waltman 2010, 2014b; www.vosviewer.com), to demonstrate the scientific panorama, especially complex geometric scientific relationships such as co-citation and cword occurrence analyzes in Bioeconomy research.

3. Results and discussion

Annual Scientific Production

The annual trends of scientific production in terms of publications are represented in Figure 1. The production results reported in the Scopus database used are shown, from 2003 to July 29, 2020. The number of publications' growth was not very noticeable in the years from the start date of the study to 2012. However, as of 2013, there is a considerable increase in the number of publications, from 17 to 189 in 2019, and in what analyzed in 2020, 176 documents were found.

Figure 1. *Annual Scientific Production of bioeconomy in LAC*

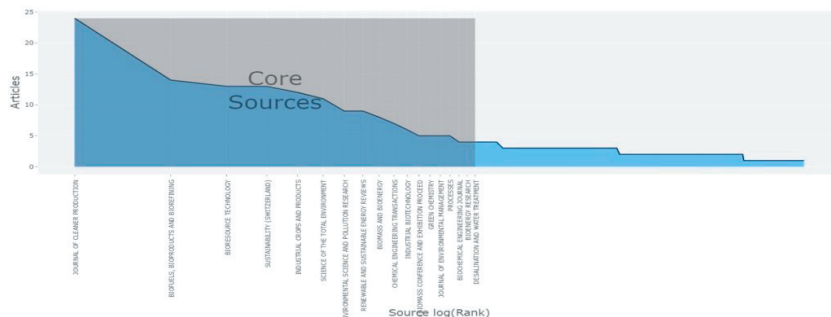


The analysis in the established period showed an annual growth rate equivalent to 53.86%. It is possible to affirm that the growth in the production of this topic is related to the interests that countries have presented in recent years to promote the bio-economy (Konstantinis, Rozakis, Maria, & Shu, 2018)

The 25 most productive journals showcased with publications

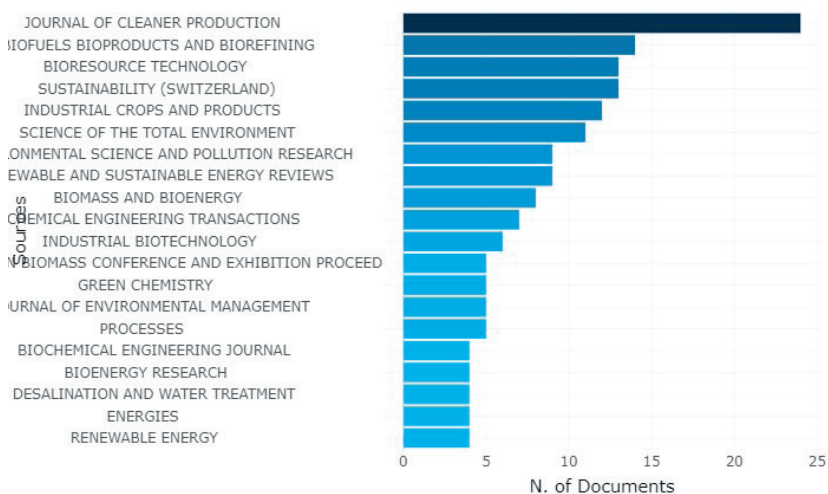
Figure 2 shows the journals that consolidate the core of knowledge, with the highest number of publications, on the subject of Bioeconomy as established by Bradford's Law. This shows an unequal distribution, that is; that most of the articles are concentrated in a small group of journals, while another portion of articles is dispersed in a high number of these (Urbizagástegui Alvarado, 2016).

Figure 2. Representation of Bradford's law for the term Bioeconomy, for Latin America, concerning the bibliographic sources with the highest number of publications



It was found that the Journal of Cleaner Production with a Q1 rating stands out for being the journal with the highest number of publications with a total of 24. It is followed by the journal Biofuels Bioproducts and Biorefining with 14 publications and is also located in the quartile Q1 (Figure 3).

Figure 3. The 25 most productive sources displayed with publications



Author productivity in terms of h-index, g-index, Total Citations (TC), and Total Publications (TP)

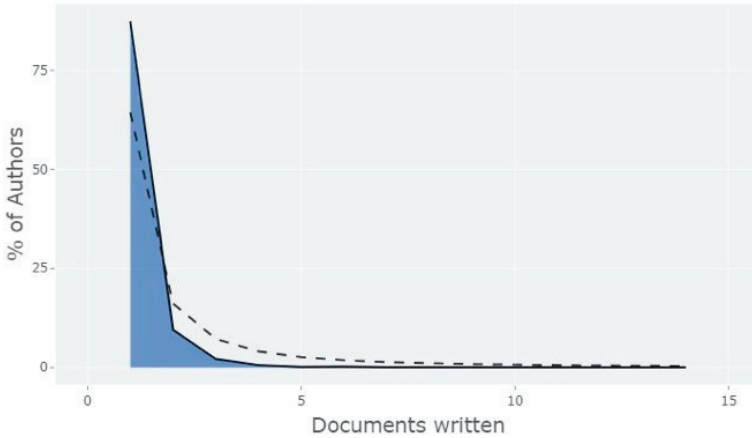
The h index is an author-level matrix that defines the number of documents that have been cited by a given number. This index is a reliable and authentic tool for mapping the scientific contribution achieved by an individual author (Hirsch, 2005). For its part, the g index is also calculated from the distribution of citations received by a specific researcher's publications. It is similar to the h-index, more involved in its calculation, but being more extensive and more variable allows us to distinguish between authors with a similar h-index (Egghe, 2006). Table 2 shows the 20 principal authors and their level of productivity based on the following parameters: total number of publications (NP), the total number of citations (TC), H and G indices in bioeconomy research at the level of LAC and the relationship between the number of authors and the number of publications generated on the subject. It should be noted that the authors with the highest h and g index values are Maciel Filho, Rodríguez, Carrilho and Labuto assigned to institutions in Brazil and Argentina: School of Chemical Engineering, University of Campinas (UNICAMP), Campinas, Brazil; Department of Chemistry, Universidade Federal de São Paulo (Unifesp), Diadema, Brazil; Institute of Biodiversity, Experimental and Applied Biology, University of Buenos Aires, Argentina; Department of Science of Nature, Mathematics and Education, Universidade Federal de São Carlos, Araras, Brazil respectively.

Table 2. *The 20 authors with the highest bioeconomy productivity in Latin America*

Author	h_index	g_index	TC	NP
Jacob Lopes E	x3	5	33	14
Zepka Lq	3	5	30	12
Chandel Ak	3	9	101	9
Dos Santos Am	2	4	24	6
Klingen I	2	4	19	8
Maciel Filho R	5	8	110	8
Mussatto Si	4	8	107	8
Rodrguez Em	6	7	55	8
Freire Dmg	4	7	71	7
Venus J	3	5	30	7
Canosa Is	4	6	39	6
Carrilho Envm	5	6	36	6
Costa J	3	6	39	6
Da Silva Ss	4	6	131	6
Depr Mc	2	4	20	6
Farinas Cs	4	6	38	6
Fernando Al	3	6	39	6
Labuto G	5	6	36	6
Severo Ia	2	4	20	6
Arancibia F	3	5	57	5

Figure 4 shows that of Lotka's law, which describes the frequency of the authors' publications on the subject (Lotka, 1926). For the specific topic of bioeconomy in Latin America, it was found that most authors have few publications (4560 authors with 1 article each), and there is a lower percentage of authors with a higher level of production on the topic (1 an author with 14 articles).

Figure 4. Relationship between the number of authors and written documents (Lotka's Law) for authors publishing in Bioeconomy, in Latin America



Most cited country, article citations, and average citations obtained in bioeconomy publications

Table 3 shows the Latin American countries with the highest number of citations on the subject of bioeconomy. It can be seen that the Latin American countries that have the most citations are Brazil, Mexico, Argentina, Chile, and Colombia. In the first place is Brazil, with 1,445 citations (7.6 on average per article). Mexico has a total of 339 citations (6.11 on average per article). Another Latin American country with a presence in the publications on the Bioeconomy is Argentina, which up to the date of the study, had 236 citations with an average of 7.8 citations per article. Chile has publications on the subject with 156 citations in total, equivalent to an average number of citations per article of 11.14. In the last place, Colombia, with 55 citations and an average of 2.03 citations for each article. The results allow identifying that LAC has significant potential for the development of the bioeconomy worldwide. However, some countries in the region have extensive experience in applied research in biotechnology and innovative agricultural production techniques.

In contrast, others reflect a deficient scientific-technological development level, insufficient to maximize opportunities for research the emerging bioeconomy. These innovative experiences in leading countries in the region are supported by a solid base of biotechnological research applied to agro-livestock. A study financed by the Inter-American Development Bank (IDB) reflects strong growth in investment in regional research in agribusiness in the last decade, but with an intense concentration in Argentina, Brazil, and Mexico (Stads, Beintema, & Flaherty, 2016). Similarly, a study by the Inter-American Institute for Cooperation on Agriculture (IICA) reveals the dominance of various advanced biotechnology techniques in the region, such as in vitro cultivation of plant cells and tissues, in vitro reproduction, and cloning of animals. , plant transgenesis, genome sequencing, and bioinformatics, in this case, Argentina, Brazil, Colombia, and Mexico, show a degree of advance significantly higher than the average (Hodson, 2014).

Table 3. *The Latin American countries most cited in bioeconomy*

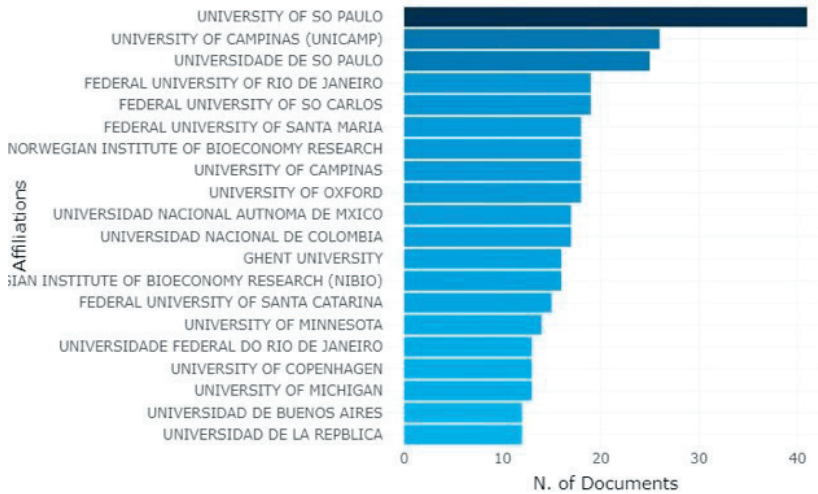
Country	Total Citations	Average Citations per Article
Brazil	1445	7,605
México	339	6,164
Argentina	236	7,867
Chile	156	11,143
Colombia	55	2,037
Guatemala	9	4,5
Costa Rica	8	8
Uruguay	7	1,75
Venezuela	7	7

Most relevant affiliation related to publications

The University of Sao Paulo is the university with the highest number of publications on the subject (32), followed by the University of Campiñas and the Federal University of Santa María (21 and 18 respectively), the three Brazilian institutions which supports the previous analysis about the Latin American country that has the highest productivity on the subject. Similarly, the graph shows the

University of Buenos Aires in Argentina, the National Autonomous University of Mexico, and the University of the Andes in Colombia among the most significant production on the subject. See Figure 5.

Figure 5. *The 20 most relevant institutions in the field of bioeconomy in Latin America*



Top 20 Authors' Countries

Table 4 presents the list of the leading Latin American countries of affiliation of the authors with the total number of articles, number of publications by a single country (SCP), the number of publications with the participation of multiple countries (MCP), and the relation between the number of publications with multiple countries and the total number of publications, (MCP_Ratio).

Table 4. *The main countries of the Latin American authors*

Country	Article	Frequency	SCP	MCP	MCP_Ratio
Brazil	190	0,42222	132	58	0,305
Mexico	55	0,12222	40	15	0,273
Argentina	30	0,06667	24	6	0,2
Colombia	27	0,06	20	7	0,259
Chile	14	0,03111	3	11	0,786
Uruguay	4	0,00889	3	1	0,25
Ecuador	3	0,00667	2	1	0,333
Guatemala	2	0,00444	2	0	0
Costa Rica	1	0,00222	0	1	1
Peru	1	0,00222	1	0	0
Venezuela	1	0,00222	1	0	0

According to the search criteria, the Latin American country with the highest number of publications on the subject is Brazil, with 27%, followed by Mexico with 8%, Argentina, and Colombia with 4%. When analyzing how publications are made, it is found that Brazil, as the leading Latin American country, has a total of 190 articles, of which 132 were developed only by Brazilian authors and 58 with authors from other countries. The preceding allows us to conclude that only 16% of Brazil's total articles were made in collaboration with other countries. In the second place, there is Mexico with 55 publications, of which only 15 were made in collaboration with authors from other countries. Argentina ranks third with a total of 30 publications, of which Argentine authors made 24. The previous shows that in these countries, there is no evident culture around collaborative work. Chile, contrary to the countries previously analyzed, despite having only 14 publications, is the Latin American country with the highest rate of collaboration, with 78.5% of the articles published.

The 20 most cited publications

Table 5 shows the list of the 20 most cited publications with their respective authors, year of publications, and journals in which they were published. For example, the publication was written by Jayasiri Sc entitled "The Faces of Fungi database: fungal names

linked with morphology, phylogeny and human impacts" published in the journal *Fungal Diversity* in 2015, obtained the maximum of 361 citations in the period analyzed with a dating count of 60.1 per year. The participation of two Latin American authors linked to the Federal University in Viçosa, Viçosa, Brazil, and the University of Buenos Aires Argentina stands out. In the second position, we find the document published by Santos Jcsd entitled "Importance of the Support Properties for Immobilization or Purification of Enzymes" in 2015 with a count of citations equal to 45.8 per year. Colombian authors belonging to the following institutions, Universidad del Tolima and Universidad Industrial de Santander, participate in this document through their chemistry and microbiology programs, respectively.

Table 5. *The 20 most cited publications*

<u>Paper</u>	<u>Total Citations</u>	<u>TC per Year</u>
Jayasiri Sc, 2015, <i>Fungal Diversity</i>	361	60,167
Santos Jcsd, 2015, <i>Chemcatchem</i>	275	45,833
Roy He, 2016, <i>Biol Invasions</i>	150	30
Niederwieser D, 2016, <i>Bone Marrow Transplant</i>	140	28
Bender Rr, 2013, <i>Agron J</i>	133	16,625
Jacobs S, 2016, <i>Ecosyst Serv</i>	131	26,2
Buschmann Ah, 2017, <i>Eur J Phycol</i>	109	27,25
Arevalo-Gallegos A, 2017, <i>Int J Biol Macromol</i>	103	25,75
Brodin M, 2017, <i>J Clean Prod</i>	86	21,5
Chandel Ak, 2018, <i>Bioresour Technol</i>	85	28,333
Crago Cl, 2010, <i>Energy Policy</i>	79	7,182
Gupta Vk, 2016, <i>Trends Biochem Sci</i>	77	15,4
Carneiro Mlnm, 2017, <i>Renewable Sustainable Energy Rev</i>	72	18
Vaglio Laurin G, 2016, <i>Remote Sens Environ</i>	70	14
Blschl G, 2019, <i>Hydrol Sci J</i>	68	34
Ciriminna R, 2015, <i>Biofuel Bioprod Biorefining</i>	68	11,333
Nascimento Dm, 2018, <i>Green Chem</i>	63	21
Lupi L, 2015, <i>Sci Total Environ</i>	60	10
Pinho Adr, 2017, <i>Fuel</i>	58	14,5
Bilal M, 2018, <i>Sci Total Environ</i>	52	17,333

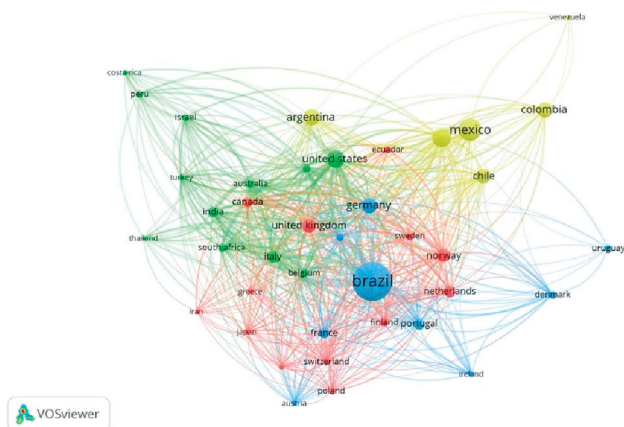
Structural Analysis and Visualization in Research Publications in Bioeconomics

Co-authorship analysis based on the countries that publish on the topic of bioeconomy in LAC

The LAC co-authorship network has been created using VOSviewer software (see figures 6 and 7). In the figures, a node symbolizes a country, while the node's size represents the country's activity. The curved line between the two nations shows the publication collaboration relationship between them. Finally, the thickness of the line shows the degree of collaboration between the respective countries. For this analysis, criteria were established, taking only for the study of those with at least 5 publications and 0 citations. The program analyzed manually defined criteria, and of the 82 countries, 40 reached the previously defined threshold. For each of the 82 countries, the total strength of the co-authorship link with other countries was also calculated. The maximum number of connected and forming groups was 40, 4 clusters were constituted with 603 cooperation links with a total link force of 2383.

Figure 6 shows the network of co-authors between Latin American countries with countries of other regions. It can be observed, according to the size of the nodes, that Brazil is the country with the highest number of articles and co-authorship. The vast majority of her co-authorship is established with European countries (France, Germany, Denmark, Ireland, Portugal, Austria), Asians (China), and in America (Uruguay). It is followed by Mexico, Chile, Argentina, and Colombia, with a total liaison force of 130, 120, 111, and 67. These countries in the figure constitute cluster number 4 in yellow. For their part, Venezuela, Costa Rica, Uruguay, Ecuador, and Peru are the Latin American countries with the least number of relationships from other regions.

Figure 6. *Co-authorship between LAC countries with the rest of the world and LAC with each other on the bioeconomy issue*



Finally, the graph shows good relationships established between the countries, in terms of co-authorship, given that when analyzing the connecting lines, most are of the same thickness. Additionally, the countries are currently strengthening their policies for the development of the bioeconomy.

Co-authorship analysis based on the institutions that publish on the subject of bioeconomy

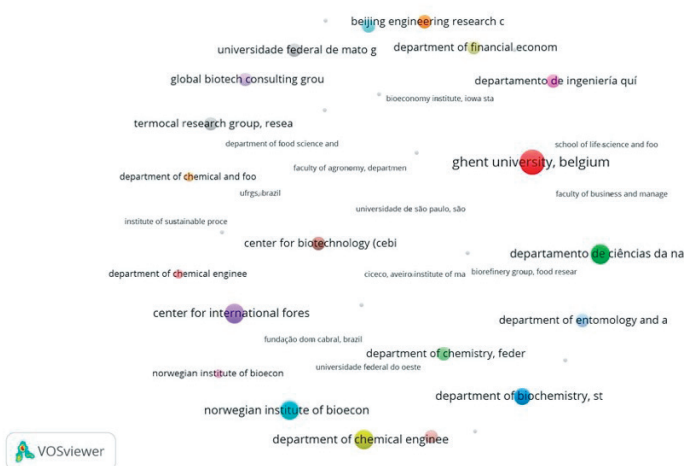
Scientific collaboration between institutions refers to any process involving the work of several individuals to achieve a common goal. The increase in scientific collaboration has several causes, among them are complex difficulties whose solution requires an inter and multidisciplinary approach, financing policies that stimulate the formation of working groups, regional cooperation agreements; and information technologies that facilitate remote work. Table 6 shows the network of co-authorship relationships between institutions on the subject of bioeconomy at the LAC level. The Universities of Ghent University, Belgium; Institute of agricultural and fisheries research (ilvo), Belgium; Ithaka institute for carbon strategies, arbaz, Switzerland; Nutrient management institute nmi, Netherlands;

They are characterized by presenting the highest total link strength of the ten selected institutions. The link strength is an indicator of connection within the network. Figure 7 shows the network of co-authorship relationships between institutions on the subject of bioeconomy, 2163 organizations were identified, a maximum number of 2 documents per organization, and a minimum number of citations for each organization of 0, with this criterion, 71 organizations were identified. There are no relationships between the institutions, due to the degree of dispersion of the institutions and the information.

Table 6. *Main institutions in co-authorship activities on the subject of bioeconomy*

Main institutions	Documents	Citations	Total Link Strength
Ghent University, Belgium	2	0	7
Institute Of Agricultural And Fisheries	2	0	7
Ithaka Institute for Carbon Strategies, Arbaz,	2	0	7
Nutrient Management Institute Nmi,	2	0	7
Center for International Forestry Research	2	12	4
Departamento De Ciências Da Natureza,	2	15	4
Departamento De Ciências Da Natureza.	2	15	4
Departamento De Química, Universidad	2	15	4
Departamento Of Chemical Engineering And	2	1	4
Institute of Geography, Soil Science/Soil	2	12	4

Figure 7. *Institutions in co-authorship activities about bioeconomy*



Co-citation / Cited Sources / Fractional Count

When two sources or authors are cited in the reference list of a document, they form a joint citation or co-citation relationship. The program analyzed the cited sources used in bioeconomy research. This analysis constitutes a potential method to assess any topic's general structural horizon and its related sources. At least 20 citations from a source were selected, identifying 323 out of 18,118 sources that met the established limit. The data were grouped into 6 clusters with a total link strength of 603,189. Table 7 shows the ten principal sources of the bioeconomy with their number of citations and total link strength. It was identified that the journal with the highest number of citations was the journal *Bioresour Technol* with several citations of 1071 and a total link strength of 72644. However, this was not the journal with the highest productivity, since as stated in figure 2, the journal with the highest number of articles is the *Journal of Cleaner Production*.

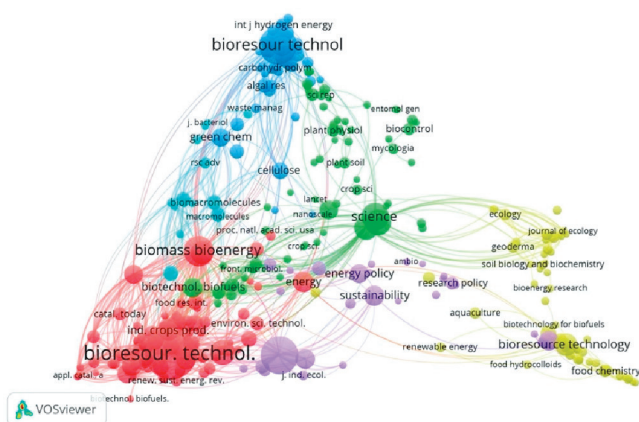
Table 7. *Top ten sources cited, number of citations, and total link strength*

Sources	Citations	Link strength
Bioresour. Technol.	1071	72644
Bioresour Technol	581	34425
Biomass Bioenergy	370	26963
J. Clean. Prod.	579	19747
Fuel	218	17806
Energy Fuels	153	17377
Plos One	246	16089
Ind. Eng. Chem. Res.	154	15102
Biotechnol. Biofuels	161	14528
Renew. Sustain. Energy Rev.	255	14184

Figure 8 shows the density network of sources cited in the bioeconomy research, sources with a higher binding force are denser than those with a lower binding force. We use the Cocitation type of analysis to emphasize the importance and dominance of the

technological factor within the framework of the bioeconomy. As shown in the figure, the essential sources in terms of bioeconomy are related to natural science. Those related to social sciences are less dense (purple cluster), in the lower central part of the density network; This confirms the earlier claim of a technology-oriented bioeconomy.

Figure 8. Citation density analysis of sources cited in bioeconomy publications



Keyword concurrency analysis

Keyword matching analyzes the research access point in a discipline and studies research trends in a defined domain. To build the bioeconomy scientific literature network, we used the coincidence analysis type, the full count method, and the keywords present in the title and abstract as the analysis unit. A total of 18,566 terms were identified in the database; it was established as a minimum criterion of occurrence of the term, 10 words. When making this selection, 520 terms were identified that met the established limit; Vosviewer suggests an additional selection by evaluating 60% of the most relevant terms, corresponding to 312 words. Table 8 lists the 10 most frequently used keywords in bioeconomy research in LAC. For each of the 312 keywords, the total link strength was calculated; Words

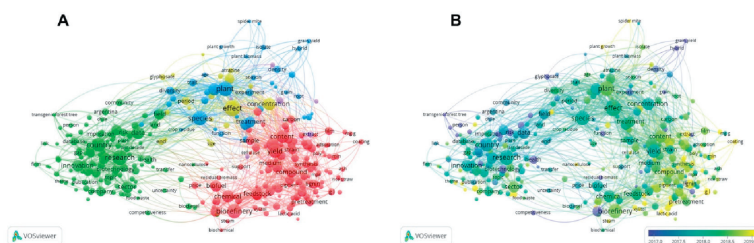
were grouped into 5 clusters, cluster 1 with 128 elements, cluster 2 with 118, cluster 3 with 39, cluster 4 with 21, and cluster 5 with 6 constituent elements.

Table 8. *The 10 most common keywords used in bioeconomy research in LAC*

Keywords	Cluster	Occurrence	Total Link Strength
Effect	4	216	3838
Plant	3	189	3292
Research	2	188	3278
Species	3	176	3220
Biorefinery	1	162	2414
Country	2	152	2542
Yields	1	142	2447
Concentration	4	132	2775
Property	1	130	2008
Content	1	129	2247

Concerning the distribution cloud of the topics, two larger groups are constituted in red and green colors. The red cluster mainly groups the terms related to research lines from the biological and chemical sciences. In contrast, the green cluster groups are related mainly to social and political sciences (Figure 9A). In figure 9B, the network map of the trend issues is presented. The appearance of key concepts in the bioeconomy literature is evidenced in recent years, such as lignin, extracts, valorization, lactic acid, and Gay Lussac. This type of term allows us to identify that a trend towards recognizing natural resources as a source of wealth is consolidating.

Figure 9. *Keyword co-occurrence analysis in bioeconomy research. Coverage display*



LAC is a heterogeneous region in terms of R&I systems in agriculture in many aspects, which represent challenges and opportunities given the strengths and capacities of each of them, having an extraordinary diversity of natural resources, but with a very low capacity to appreciate/guard it and take advantage of it. On the other hand, there is awareness throughout the region that it is necessary to have more monetary funds and increase the infrastructure and training of qualified personnel. To consolidate the R&I processes, it is necessary to increase and consolidate the critical mass and develop novel processes/techniques to go beyond just being technology adopters. The entire region must transition towards a bioeconomy strategy that offers the possibility of transcending the dichotomous agriculture/industry vision so widespread in the region.

The emerging bioeconomy provides new options for the creation of quality jobs associated with renewable natural resources, opens opportunities for agriculture beyond food, by implementing new production methods that take advantage of biomass for multiple uses as well as the elaboration of bio-inputs for agriculture and facilitates the creation of knowledge-based startups, inserted in new value chains associated with the use of biomass. However, there are several obstacles that LAC countries must work on to take full advantage of the opportunities offered by the bioeconomy, including i) the lack of adequate regulatory frameworks, especially in areas of the rapid advance of biotechnological applications; ii) disjointed regulatory frameworks and incentive policies; iii) insufficient coordination of existing scientific and technological capacities; iv) restriction of the entry of SMEs into a concentrated biotechnology market; and v) lack of financing for the creation of innovative bioeconomy companies (ECLAC, 2017). In particular, despite the clear competitive advantages of several countries in the region, dedicated bioeconomy strategies have not yet been consolidated, limiting the development of a strategic vision on the bioeconomy and reducing existing initiative's effectiveness.

Additionally, the research volume in the region is relatively low compared to other developed or developing countries, such as China and India. This is reflected in a small number of patents and published articles, and therefore, the capacity for innovation continues to depend on external supplies from developed countries. LAC does not need to be self-sufficient per se, but local technology products must be competitive in the global market. In turn, there is ample potential for intraregional collaboration, such as the Argentine-Brazilian Center for Biotechnology (CABBIO), which promotes interaction between scientific centers and the productive sector of both countries-, the Brazil International Cooperation Program- FAO, which offers technical cooperation in agriculture and food to less developed countries in the region-, or the project "Towards a bioeconomy based on knowledge in LAC in partnership with Europe" within the framework of the Community of Latin American and Caribbean States (CELAC), however, its work has been scarce and disjointed. It is for this reason that the leadership of public agencies, entrepreneurs, and research institutes in countries such as Mexico, Argentina, Brazil, Chile and Colombia can serve to consolidate a regional platform, which helps reduce the gap between the countries of the region and promotes economies of scale, efficient and synergistic. Furthermore, it is of interest to explore the value of the bioeconomy to develop regional value chains, for example, between MERCOSUR and the Pacific Alliance.

4. Conclusions

The bioeconomy in LAC is an ongoing process that, in part, reflects the trend of what is happening in other parts of the world, but, above all, it has comparative advantages and potentialities that suggest strong growth of the same in the region during the next years. It is identified that the transition towards a knowledge-based bioeconomy also depends mostly on the level of applicability of new technology developments in specific sectors of the economy. The expected socio-economic impact can be very high in countries and sectors where value chains are well established, such as Brazil

and Argentina. Consequently, for LAC, the knowledge-based bioeconomy will require a significant transformation effort in terms of policies and institutions for its promotion.

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Polycentrism and Metropolization in the Administrative and Planning Regions of the Coffee Belt

Policentrismo y metropolización en la Región Administrativa y de Planificación Eje Cafetero

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Abstract

This chapter presents the results of a research exercise that addressed the characterization of the Coffee Belt APR, from a morphological and functional perspective, and the study of the existing metropolization relations based on the observed demographic dynamics. Regarding the results, the APR is

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configured as a polycentric region with four main nuclei, the departmental capitals and the municipality of La Dorada, capitals that exercise a prima facie condition in their departments and that from their hierarchy have promoted metropolitan processes around them.

Keywords: Polycentrism, Metropolization, Urban Hierarchies, Region, Regionalization.

Resumen

En este capítulo se presentan los resultados de un ejercicio de investigación que abordó la caracterización de la RAP Eje cafetero, desde una perspectiva morfológica y funcional, y el estudio de las relaciones de metropolización existentes con base en las dinámicas demográficas observadas. En cuanto a los resultados, se evidenció que la RAP se configura como una región policéntrica con cuatro núcleos principales, las capitales departamentales y el municipio de La Dorada, capitales que ejercen una condición primacial en sus departamentos y a partir su jerarquía han impulsado procesos metropolitanos a su alrededor.

Palabras Clave: Policentrismo, Metropolización, Jerarquías Urbanas, Región, regionalización.

1. Introduction

Since the promulgation of the Organic Law of Territorial Ordering (OLTO), in Colombia, the Administrative and Planning Regions (APR) from the Caribbean, Pacific, Coffee Belt as well as the Central Region Special APR (S-APR) have been formed. In this context of integration, it was considered fundamental to advance in studies that help the characterization of the Coffee Belt APR, exploring its centralities and urban hierarchies, as elements that affect the territorial cohesion and serve the strategies of territorial ordering that is configured.

On the other hand, in the Coffee Region APR, a series of urban agglomeration processes are taking place with a wide dynamic of metropolization (Gaviria, 2018), a term that alludes to a type of socio-spatial interrelation of a main city with the urban centers and the surrounding rural area, in which the main city establishes strong relations of interdependence with its surroundings, even before its physical fusion, to the point that a wider socio-spatial unit is configured that exceeds the political-administrative limits. This reality makes it necessary to study these spatial phenomena, especially because it is desirable that the formalization of metropolitan areas that is being promoted in the region should correspond to the processes of metropolization experienced by territorial entities.

This chapter presents the results of a research exercise that addressed the characterization of the Coffee Belt APR, from a morphological and functional perspective, and the study of the existing metropolization relations based on the observed demographic dynamics. Regarding the results, the APR is configured as a polycentric region with four main nuclei, the departmental capitals and the municipality of La Dorada, capitals that exercise a *prima facie* condition in their departments and that from their hierarchy have promoted metropolitan processes around them.

2. Methodology and Sources

The process of characterization of the Coffee Belt APR was based on the methodological developments of quantitative geography for spatial analysis, which considers morphological and functional approaches; the first one, associated to a static vision and form directs its look to the distribution of the population masses on the space and defines as centers those parts of the urban system with greater occupation threshold in number of inhabitants. The second, in a more dynamic perspective that has its origin in the Central Place Theory (CPT), starts from a criterion of functionality

and considers the centers as the units with the greatest order in that system, characterized by providing the highest level of goods and services and performing the main functions in the urban hierarchy. The relevance of these approaches derives especially from their use in geography as an analytical tool for identifying urban centers and sub-centers, in a study agenda that, although still fragmented and dispersed, is considered a research program around polycentrism (Boix & Trullén, 2011).

In this way, the identification of the centers of the Coffee Belt APR was done based on population thresholds and functionality levels of the municipalities. For the former, information from the 1985 to 2018 population census, carried out by the National Administrative Department of Statistics (DANE in Spanish), was used. Likewise, to demonstrate conditions of inequality in the weight and size of the population among the municipalities, the indexes of inequality in the size of the cities (q) were estimated and obtained from the principle of "range-size" (Pumain & Saint-Julien, 2014), and of urban primacy (UPFCI) ⁴.

For the functional categorization of the municipalities of the APR, a function scale was constructed, which had as a reference a list of 70 functions and the classification proposed for the study of the Coffee Belt Ecoregion (Corporación Alma Mater, et al., 2002), using the data on the presence of functions provided by the planning offices of the municipalities. With this information the weighted index of centrality was calculated, which considers the relative weights of the functions found⁵.

Finally, the observation of the processes of metropolization present in the APR was done through the Metropolitan Intensity Index (MII), which provides evidence on these phenomena

4 Urban Primacy Four-City Index, which establishes the relationship between the population of the first municipality and the population of the three following municipalities in size.

5 P_i : function weight "i"; F_i : frequency of function "i" in the system, N : combined value of centrality, a constant that is assumed to be equal to 100; then, $C_j = \frac{P_i F_i}{N}$. The city's centrality index (C) "j" is defined as: $C_j = \sum_i P_i F_i$; con P_i : function i with presence in the city j.

and allows identifying their evolution in the established time horizon (León & Ruiz, 2016). In this sense, the MII explains the transition between urbanization and metropolization, and its construction considers "the relationship between the population of the metropolitan area [MA] (inhabitants of the metropolitan municipalities [M] and the core city [N]) and the population of the core city [N]" (Ruiz, 2015, p. 83). The index was calculated using the 1985-2005, 2018-2020 and 2005-2017 population projections produced by DANE.

3. Data analysis and results

In its evolution, the MII reflects 3 phases of the metropolization process. An MII with values greater than or equal to 2 and a negative slope of the curve that describes it reveals a phase of consolidation of urban concentration, in which the core city grows at a higher rate than the rest of the metropolized municipalities; values between 1 and 2 and a negative slope show a stage of transition to metropolization, in which some municipalities other than the core show changes in the dynamics of growth; finally, values greater than 1 and a positive slope highlight a phase of initiation and subsequent metropolitan consolidation ($MII > 2$), in which the population of the metropolized municipalities begins to grow at a faster rate than the core city.

3.1. Regionalization in Colombia and in the Coffee Belt.

The term region describes spatial phenomena at various scales of supranational and subnational order (Soya, 2014). The social sciences assign full relevance to it given its role as a frame of reference for the analysis and action in territories, although it is a category that does not offer a conceptual unit that favors its understanding; however, its more general definition alludes to a

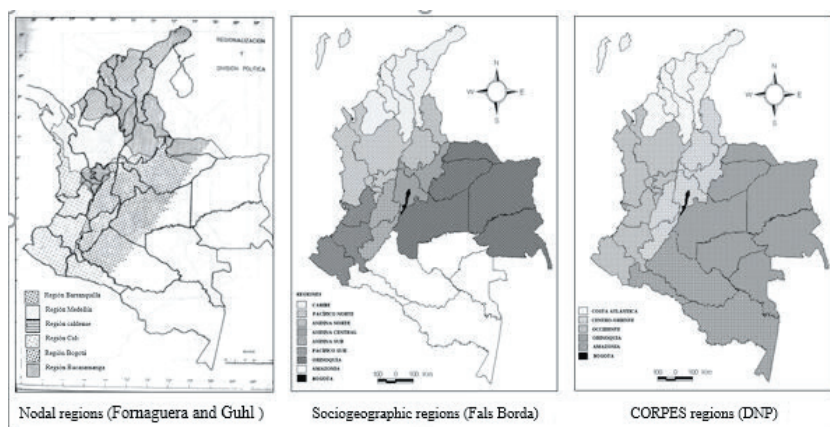
geographic space that has similar characteristics associated with shared identity, environmental, social, cultural, historical and/or economic features⁶.

Under these considerations, regionalization, understood as the classification of geographic spaces based on previously defined differentiation criteria, is important for the description, analysis and understanding of the socioeconomic phenomena that occur in space, as well as for the formulation of development policies, inasmuch as "it is unquestionable that human, social, cultural and economic phenomena are ordered in geographic space, leave their marks on it, and are intimately related to the physical and biological ordering that occurs in that same space" (Fornaguera and Guhl, 1969, p.11).

In Colombia, in addition to the political-administrative division into two levels (which until the end of the last century considered the departments, councils and police stations on one side and the municipalities on the other, and which today is simplified to departments and municipalities), there have been different regionalization exercises as a product of this conceptual diversity, among which the pioneering proposal developed by Fornaguera and Guhl (1969) stands out, which adopted "urban epicentrism" as a criterion and considered the areas of influence of the main urban centers; the work of Fals Borda (1996) who adopted a sociogeographic perspective based on local history and culture; and the various regionalization exercises led by the National Planning Department, which served as the basis for the formation of the CORPES planning regions (Chamorro, 1997) through Law 76 of 1985 (Figure 1).

⁶ Other studies (Czerny, 2008; Figueras, Capello & Moncarz, 2009; Tomadoni, 2016, Vázquez & Propín, 2001) share the same conclusion.

Figure 1. *Colombia. Regionalization proposals*



Source: Fornaguera and Guhl (1969), Barón (2002).

The CORPES constitute the most immediate reference of the APRs, in the sense of its configuration from departments with geographical continuity and with purposes of joint regional development. The APRs are organized on the basis of territorial associations, whose normative reference is basically contained in the National Constitution, Articles 86 and 306, which define territorial autonomy and guide their formation; Law 136 of 1994, which allows territorial entities to jointly organize the provision of services and the execution of works of a local nature; Law 489 of 1998, which opens up the possibility for public entities to become members through inter-administrative agreements; and Law 1454 of 2011, the Organic Law on Territorial Ordering (OLTO), which establishes as a guiding principle of territorial planning, associativity for the generation of synergies, competitive alliances and economies of scale, conceiving the territory as a dynamic process of social construction.

There are four APRs in Colombia, the first of which was the Central Region S-APR comprising the departments of Boyacá, Cundinamarca, Meta, Tolima and Bogotá. The remaining are the Pacific APR, which associates the departments of Chocó, Valle del

Cauca, Cauca and Nariño; the Caribbean APR, which includes the departments of the Atlantic coast, and the Coffee Belt APR, composed by the departments of Caldas, Quindío and Risaralda, whose geographical position and spatial, cultural and productive proximity allowed them to generate development axes around the production and commercialization of coffee (Valencia, Cortázar, & López, 2013).

The purposes of regional integration in the Coffee Belt were expressed in different previous associative efforts, among which stand out the public-private alliances of a supramunicipal nature (Rodríguez and Arango, 2004) for the regional management of solid waste, the development of the forestry sector -Pacofor-, the sustainable management of the guadua and the Natural National Park Los Nevados -NNPLN-, the regional mitigation of seismic risk, and the Innovation -EJE INNOVA-, among others; the Territorial Pact for Employment, which in 2010 brought together the three capital cities around this problem (Candia, Riffo, Sandoval and Williner, 2015); the initiatives for the creation of the Ecoregion of the Coffee Belt and the conformation of metropolitan areas in the conglomerates of cities around Manizales and Armenia; the management for the declaration of the Coffee Cultural Landscape before the UNESCO.

The Coffee Belt Administrative Planning Region (APR) is an opportunity to consolidate these efforts. It constitutes an associative figure that institutionally strengthens the region in the management of its development, by promoting the coherence and articulation of planning among the departmental entities that make it up, through the design and execution of programs and projects of mutual interest; at the same time it favors its configuration as a territory based on the strengthening of the territorial identity of its population.

A territory is structured and organized on the basis of the relationships established by human beings, among themselves and with the space that is occupied and possessed. In this respect, in a recent approach to the daily experience of social actors with different roles and municipalities of residence (Gaviria, 2020), it became evident that the spatial dimension that they adopt and with which they identify themselves in relation to the "others" is the Coffee Belt; which stands as the primary socio-spatial reference of belonging, from which the existence of a "we" is perceived and for which an image of the future is shared in which the preservation of natural wealth, green and coffee culture stand out as central elements.

The Coffee Belt is evoked by social actors as a historical region whose characteristic landscape, cultural and economic features act as common repertoires of pride; its name reveals a necessary condition, coffee as a cultural framework of a social and spatial construction. In addition, in the collective imagination of the actors, this region appears as the primary notion of what was Gran Caldas, and it is kept alive in the evidence of the maps produced by their mental elaborations. Furthermore, they come to it as a traditional reference space in a sustained way.

In this way, the conformation of the Coffee Belt APR responds to the territorialities present in it. In the task of strengthening territorial cohesion that gives a missionary sense to the process of territorial association undertaken, it is essential to appeal, among other fundamental references, to the culture of coffee, which was identified as another essential symbol in the definition of "we" (Gaviria, 2020).

The dynamic observed received a fundamental boost with the issuance of the Law of Regions (Law 1962 of June 28, 2019), which ratifies the State's intention to develop its functions using the figure of the regions to plan, organize and execute its activities; it sets the organic standards for the strengthening of the APRs and

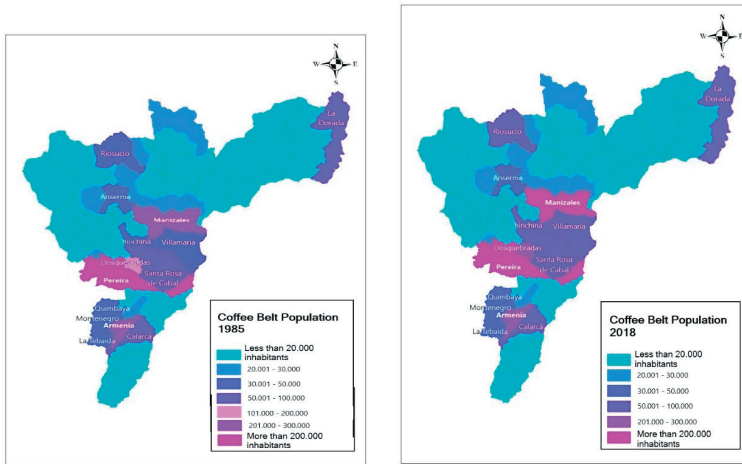
defines the conditions and procedures for their conversion into regions of territorial entities (RTE), with their own authorities, the possibility of access to resources and participation in the national budget, in addition to greater interference in planning. In this way the Coffee Belt will be strengthened in its task of promoting competitiveness, idiosyncrasy and regional facts.

3.2. The Urban Hierarchy in the Coffee Region APR

The morphological perspective focuses its attention on the distribution of the population, considering as main regional centers those territorial entities with the greatest number of inhabitants (Figure 2). From this perspective, a regional urban system is evident in which the capital cities Pereira and Manizales stand out as the main centers, while Armenia shares with the municipality of Dosquebradas a condition closer to that of a subregional center, the latter thanks to its recent population dynamics.

The works of Zambrano and Bernard (1993), Cuervo and González (1997) and Pachón (2013) reveal the historical process of the formation of the system of cities in the Coffee Belt and describe the consolidation of the three capitals as the main cities of the western section of the central mountain range, through a process associated with the dynamics of industrial expansion, coffee production and the development of road infrastructure; cities from which an urban network has been strengthened, taking advantage of the spatial proximity and the historical and economic closeness. This suggests reviewing other approaches to identify the centers of a region with historical and economic roots, such as the Coffee Belt APR

Figure 2. *Coffee Belt APR, evolution of population mass distribution according to intervals, 1985-2018*



Source: DANE, census and projected population. Made by authors.

In the functional approach, municipalities were categorized according to the number and specialization of the commercial functions and services they provide. For this exercise the list of functions and the scale defined in the study of the Ecoregion was used (Alma Mater Corporation, et al., 2002); derived from this the three capital cities observed a character of main centers at the regional level, a condition that is also reached by the municipality of La Dorada (Table 1). In the opposite situation, the municipalities that are conurbated to the capitals, such as Dosquebradas, Villamaría and Calarcá observe a low functionality that only allows them to be classified as urban centers, the first one, or intermediate sub-regional centers, the others.

Table 1. *Coffee Belt APR, functional order of urban units, 2018*

<i>Functional order</i>	<i>Function range</i>	<i>Municipalities in spatial formation</i>
<i>Main Regional Centers</i>	58 or more	Manizales, Pereira, Armenia, La Dorada.
<i>Major Sub-Regional Centers</i>	from 50 to 57	
<i>Intermediate Sub-Regional Centers</i>	from 43 to 49	Santa Rosa de Cabal, Riosucio, Salamina, Calarcá, Anserma, Supia, Villamaría
<i>Urban Centers</i>	from 36 to 42	Neira, Montenegro, San José, Manzanares, Risaralda, Aguadas, Palestina, Quimbaya, Chinchiná, Marquetalia, La Tebaida, Marulanda, Dosquebradas, Mammato, Pensilvania
<i>Rural Service Centers</i>	from 30 to 35	Apía, Salento, Filadelfia, Circasia, Filandia, Guática, Belén de Umbria
<i>Rural Centers</i>	less de 30	Victoria, Pijao, Pácora, Marsella, Belalcazar, Pueblo Rico, Norcasia, Génova, Balboa, Buenavista, Córdoba, Aranzazu, Santuario, La Virginia, La Merced, Quinchia, Mistrató, La Celia, Samaná, Viterbo.

Source: By authors based on information provided by the planning offices of the municipalities of the Coffee Belt APR in November, 2018.

The above shows a functional configuration close to that proposed by the Central Place Theory, which based on the assumption of isotropic surfaces considers that settlements with lower functional orders are distributed more uniformly in the regional space and with greater proximity to the main centers; therefore these municipalities are highly dependent on the services and functions of medium and high complexity offered by their capital city. On the contrary, and close to that normative idea, La Dorada, a municipality more distant from the main urban agglomerations of the region, observes a widely superior functional centrality.

A more integral perspective for qualifying the functional hierarchy of municipalities is the weighted index of centrality. This index allows for the measurement of functional complexity in terms not only of the number of functions in a site, but also of their frequency of occurrence. That is, for its calculation, the functions are assigned a weight in inverse proportion to the frequency with which they are present in the cities of the system, so that the higher the index, the greater the functional complexity of that city

(Table 2). This new index confirms that the municipalities with the highest level of centrality in the Coffee Belt APR are the capital cities (Pereira, Armenia and Manizales), while the municipality of La Dorada continues to stand out as a regional center in the east of the department of Caldas.

Table 2. *Coffee Belt APR, weighted index centrality index, first nine municipalities.*

<i>Municipality</i>	<i>Centrality index (2018)</i>	<i>Position by population size (2018)</i>
<i>Pereira</i>	579,95	1
<i>Armenia</i>	467,83	3
<i>Manizales</i>	418,84	2
<i>La Dorada</i>	344,49	6
<i>Villamaría</i>	182,43	9
<i>Calarcá</i>	180,57	5
<i>Dosquebradas</i>	169,22	4
<i>Supía</i>	168,80	20
<i>Riosucio</i>	164,20	8

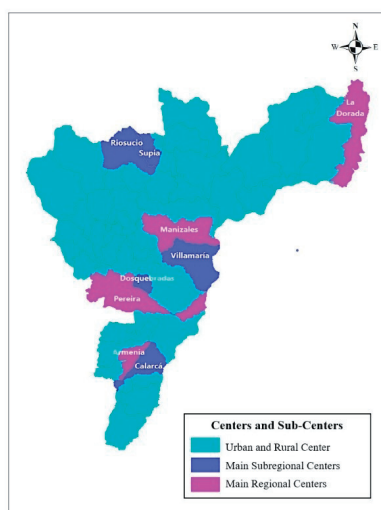
Source: By authors based on information of the planning offices of the municipalities.

Then, in a more dynamic perspective, offered by the functional approach, the three capitals Pereira, Manizales and Armenia stand out as main regional centers. Although La Dorada does not have one of the largest populations in the region, the broad functional performance allows this municipality to qualify as a major regional center in its eastern zone. In a different sense, although Dosquebradas is the fourth municipality in population and an important economic activity is concentrated there, the low number of functions that it houses only allows to qualify it as a sub-regional center; a condition that, by combining morphological and functional criteria, it shares with its similar Calarcá, Villamaría, Riosucio and Supía.

Figure 3 shows the regional and sub-regional centers defined on the basis of the functional criterion. These are largely concentrated in the urban agglomerations around the capital cities; however, in the department of Caldas there is evidence

of a better spatial distribution of these urban hierarchies, a condition that benefits the populations of the northwestern and northeastern areas of the region. In any case, as shown in the figure, the distribution of the central places of first and second order in the RAP Eje Cafetero favors the accessibility of all the inhabitants for the attention of their diverse needs.

Figure 3. Coffee Belt APR, regional centers and sub-centers, morphological and functional perspectives.



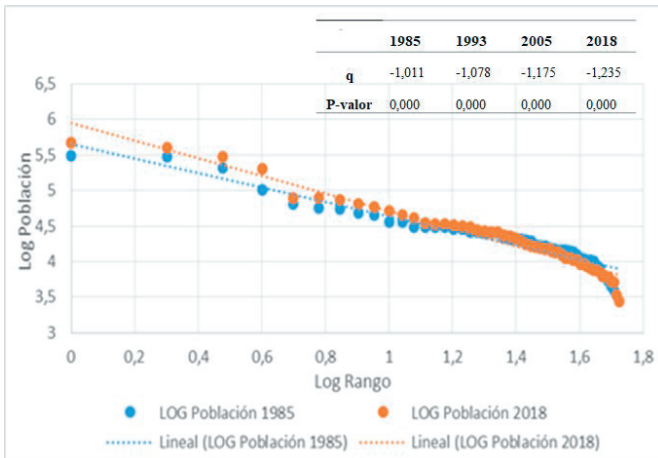
Source: By authors

To observe urban hierarchies, the index of inequality in the size of cities (q) was estimated from the rank-size principle, which reveals the conditions of distribution of the population of the APR (Pumain & Saint-Julien, 2014). The results show an increasingly unequal distribution of this population among the municipalities ($q > |1|$), which warns of the presence of primary conditions in the region; however, this parameter is located in the average of contemporary urban systems, which according to Pumain & Saint-Julien fluctuates between $|0.7|$ and $|1.3|$ (Figure 4).

The Urban Primacy Four-City Index (UPFCI) was calculated at the level of the departments and the RAP, taking in the latter case Pereira as the main city (Figure 5). In general, the primary conditions of the three capitals are higher than those of Bogotá at the national level, but significantly lower than those of other cities such as Cali and Medellín in their territorial entities (Gaviria 2017). On the regional scale, although Pereira's primacy index is very low and lower than that of cities such as Bogotá and Cali in the Central and Pacific RAPEs respectively (Rubiano-Bríñez, & Eligio-Triana, 2019), it has observed a growing trend during the study period.

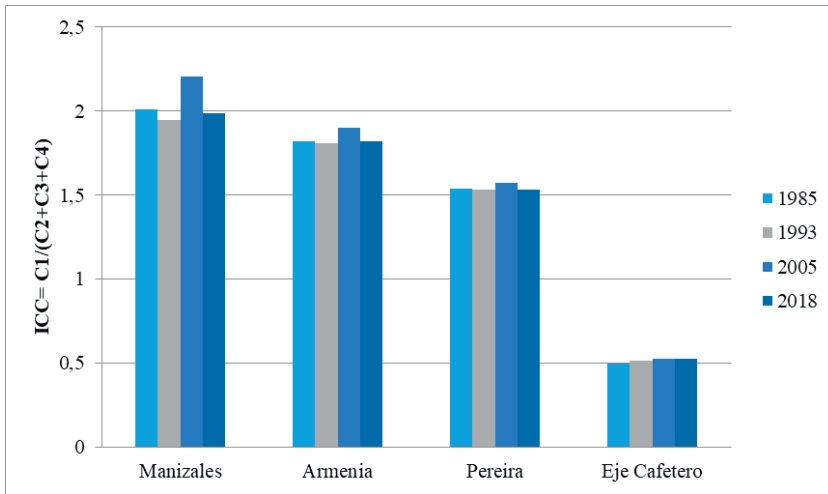
Then, from the urban hierarchies, this last one shows, on the one hand, that the Coffee Belt APR is configured as a polycentric region with the presence of three primary cities, the three department capitals; and on the other hand, in spite of that shared primacy, the marked hierarchical ascendancy of the city of Pereira, whose population grows at higher rates than those exhibited by the cities of Armenia and Manizales, could lead to configure it in the medium term as the primary city of the RAP Eje Cafetero.

Figure 4. Coffee Belt APR, range-size ratio, 1985-2018



Source: DANE, calculations made by authors.

Figure 5. *Coffee Belt APR, Urban primacy indexes, 1985-2018*



Source: DANE, calculations made by authors.

3.3. *Metropolization Dynamics of the Coffee Belt APR*

The urbanization of the planet is a millennial history that has known important variations in space and time and that began to harmonize globally in the 15th century, when the European conquest of the world was accompanied by the foundation of cities and ports that established the first structure of a world urban network linked by exchanges of people, goods and information. The industrial revolution altered this network from the 19th century onwards by introducing new production and transport systems that triggered a rural exodus to the city (Monnet, 2009). As a result, the urbanization process and the formation of metropolitan areas is one of the most representative phenomena of the 20th century.

In the era of globalization, the new pattern of territorial dispersion offers a wide range of possibilities for incorporating small cities and rural peripheries into the direct influence of a major city. Moura (2009) interprets this spatial and urban

phenomenon as metropolization, a process of urban expansion that, although expressed in agglomerated morphologies, is also a phenomenon through which society and urban life penetrate the immediate regional space and disseminate a way of life that involves systems of objects and systems of values.

On the Coffee Belt, authors such as Alfonso (2012, 2017) and Gaviria (2018) argue from different perspectives about the existence of three processes of metropolization in the region; which have as a nucleus the departmental capitals, to which the nearby municipalities are articulated through relationships of economic, social and cultural order. Alfonso considered the long-term population movements or "lifetime migrations", captured by the 2005 population census in the changes of residence, from which he calculated a metropolization index that compares the proportion of immigrants from the main nucleus to the metropolized municipality with respect to the total number of residents in the latter, with a similar proportion but referring to the total of the metropolitan area; on the other hand, Gaviria observed the short-term, or daily, flows as evidence of spatial interaction between the municipalities, through the daily passenger traffic of 2013.

Table 3. *Coffee Belt, metropolitan areas*

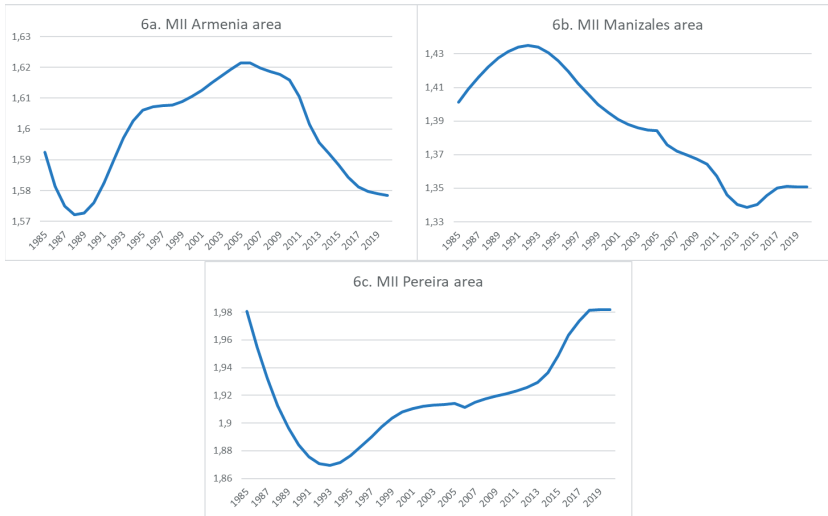
<i>Metropolitan nucleus</i>	<i>metropolitan municipalities</i>	<i>Population 2018*</i>		
		<i>Metropolitan nucleus</i>	<i>Metropolitan municipalities</i>	<i>Total</i>
<i>Pereira</i>	Dosquebradas, La Virginia, Santa Rosa de Cabal y Cartago	467.269	458.668	925.937
<i>Manizales</i>	Chinchiná, Neira, Palestina y Villamaría	434.403	152.502	586.905
<i>Armenia</i>	Calarcá, La Tebaida, Circasia y Montenegro	295.208	171.147	466.355

Source: DANE, made by authors based on Alfonso (2012, 2017) y Gaviria (2018).

As a complement to the previous observations, the Metropolitan Intensity Index (MII) provides new evidence on the phenomena of metropolization present in the region and allows for

the identification of the evolution of the process in the established time horizon (León & Ruiz, 2016). In this sense, the MII explains the transition between urbanization and metropolization, and it is structured as the relationship between the population of the metropolitan area [MA] (inhabitants of the metropolitan municipalities [M] and the core city [N]) and the population of the core city [N] (Ruiz, 2015). Using census data and population projections from DANE, the MII was constructed for the three metropolitan areas of the Coffee Belt APR for the period 1985 to 2020. The results are presented in Figure 6.

Figure 6. Coffee Belt APR, MII of its metropolitan areas, 1985-2020



Source: DANE, calculations made by authors.

Metropolization processes in core areas in Armenia and Manizales (Figure 6a and 6b) have shown little regularity. In the first case, although an accelerated transition to metropolization was observed between the end of the 1980s and the beginning of the 1990s, given the high convexity of the curve in that period, the process slowed down in the second half of the 1990s and did not manage to consolidate, while, before the MII reached values

close to 2, it began a decline that reflected a new dynamic of urban concentration, in which the core city grew again at a higher rate than the rest of the municipalities, and in net terms there were no significant migratory processes towards the peripheral municipalities. The end of the period analyzed marks a turning point that makes one foresee a reactivation of the metropolization process.

The rising curve at the end of the 1980s of the MII for the metropolitan area with a core in Manizales (Figure 6b) shows a phase of beginning of the dynamic of metropolization, which is interrupted prematurely in the 1990s and gives way to a new process of urban concentration in the core city. Similar to the previous case, in the last years of the period analyzed there is a point of inflection and the MII curve acquires a convexity that shows a reactivation of the metropolization process, with the presence of population migration from the capital to its nearby municipalities⁷.

According to the behavior of its MII (Figure 6c), in the metropolitan area whose nucleus is Pereira there has been a clearer transition from a process of urban consolidation to one of metropolization with a tendency towards consolidation; a dynamic in which some metropolized municipalities, such as Dosquebradas, are beginning to grow their population at a faster rate than the nucleus. The convexity of the MII curve shows a greater speed of the metropolitan process in the nineties, while in the course of this century it has been slower, but with values close to 2 that trace a path towards the consolidation of this urban phenomenon.

In summary, the results obtained in the MII of the three metropolitan areas of the Coffee Belt APR show the existence of a clear metropolitan process around Pereira, while metropolitan

⁷ According to the DANE (2019b), in the five years prior to the 2018 census, Manizales presented a net migration of 4554 inhabitants to the metropolitan municipalities.

dynamics are interrupted in the areas of Armenia and Manizales. In none of the analyzed areas has the MII reached a level higher than 2, which rules out phenomena of population deconcentration in the region that could significantly alter the existing primatial structure.

4. Conclusions

The Coffee Belt APR shows characteristics that make it possible to see in it a territory that advances in its construction. This region, repeated in the collective imagination of its population as a primary notion of what was the Gran Caldas, is still alive as evidenced by the maps that are the product of the mental elaborations of its inhabitants, who in a sustained way come to it as a traditional reference space.

This Coffee Belt APR is organized as a polycentric region with four main nuclei, among which the city of Pereira increases its population size compared to the cities of Manizales and Armenia and the municipality of La Dorada is configured as a relevant population center in the emerging territory.

This polycentric condition of the Coffee Region APR is mainly related to coalescence processes by fusion, in which the capital cities have extended their functionality to the surrounding municipalities and fulfill a role of main centers with clear interrelations, based on their historical, geographical and cultural proximity and their economic and institutional links.

The capital cities of the APR exercise a *prima facie* condition in their departments and from their hierarchical condition metropolitan processes have developed around them, a situation that has resulted in the continuous growth of the resident population in the municipalities subject to metropolization. According to what has been observed through the metropolitan intensity index (MII), these processes have emerged since

before 1985 and have developed with greater continuity in the metropolitan area with a nucleus in Pereira; in the cases of Manizales and Armenia, although these cities exercise primacy in their departments and are configured as metropolitan nuclei, a still incipient and discontinuous process is observed.

One of the strategic axes in the configuration of the Coffee Belt APR is the organization and territorial foresight (Government of Caldas, Government of Quindío, Government of Risaralda, 2018), which is the basis for an adequate and coherent territorial management. As a contribution to this task of planning and foresight, the study offers evidence on the distribution of the most important centers in the system of cities in the region, warns about the dynamics observed in the urban hierarchy and sheds light on the processes of expansion and the formation of new urban morphologies through the phenomena of metropolization that have the capital cities as their nucleus.

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Coffee-farmers' empowerment in municipalities of Risaralda and Caldas through information technologies: A survey.

Empoderamiento de los caficultores en los municipios de Risaralda y Caldas a través de las tecnologías de la información: una encuesta.

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Abstract

Coffee cultivation is one of the mainstays for Colombian economy since it is known at international level due to its superb quality. In order to cultivate coffee, it is needed the existence of people and processes that allow them to obtain a top-notch product by using best practices. Also, it is necessary to talk about the empowerment that coffee-farmers have in order to improve, somewhat, the processes for their economic benefits to be greater, and how technology can contribute to this empowerment so that it grows and better results are achieved. The specialized literature in South America is limited in regard to the use of agriculture; however, some research in the south of Asia was found in the field of technology application in agriculture, and how the foregoing might support people's empowerment towards their crops. This job aims for acknowledging the level of coffee-farmers' empowerment that use information technologies in some municipalities of Risaralda and Caldas in Colombia. In order to fulfill that, some empowerment models of coffee-farmers were studied through technology, which were found in the academic literature. Then, the strongest model was selected and adjusted to the country's reality. The data were collected from a topographic survey, and the analysis was carried out by linear regressions in the statistical package STATA. The results were that the general farmers' empowerment was boosted with the age and education level of individuals. Besides, there is evidence of the presence of scale effects from different empowerment subtypes; for example, economic, social and familiar, as well as of knowledge and psychology.

Keywords: Agriculture, Empowerment, Information Technology.

1. Introduction

Colombia is a country that belongs to the third world. This means that it has a big competitive disadvantage in regard with developed countries, and this leads poverty to be demonstrated more significantly in an important part of the population. Coffee cultivation becomes an important economic option for several coffee-farmers inasmuch as the product quality is recognized worldwide. In order to fulfill the materialization of crop benefits, it is necessary to reach high efficiency levels. For this to happen, it is convenient to technify and implement technological tools in the productive processes (Blandón-Andrade, RamírezAristizábal, and Bedoya-Cadauid, 2020).

So as to achieve such technification and implementation levels of technological tools, it is necessary that the coffee-farmer owns a great level of empowerment. With the foregoing, the coffee-farmer seeks, somewhat, processes for their economic benefits to be enhanced as time goes by. In order to get to an optimum empowerment, technology can be used as a source of new knowledge, and it can become a relevant tool that, through scientific method, can turn empirical knowledge into viable and functional solutions for the farmers (Brooks, 1994). Thus, this becomes a means of enhancing their productive processes and therefore their life quality.

Thanks to technological progress, populations have more access to knowledge, thus developing their daily activities with greater agility and efficiency. The foregoing optimizes their time and resources. It is therefore a challenge for governments to further technological use in their settlers. It is necessary to analyze and comprehend how to measure the coffee farmers empowerment in some municipalities of Risaralda and Caldas through the information technologies considering the impact that these tools generate in the reinforcement of their duties and improvement in their life quality.

The upcoming paper is organized as it follows: the conceptual framework is introduced on the thematic axes in which the research is based on. Then, in the materials and methods part, the methodology used, data collection, and analysis techniques used are explained. Lastly, the obtained results, discussion and conclusions are introduced.

1.1. Conceptual Framework

Down below, a revision of the main three thematic axes from the current research is carried out: coffee cultivation, technology and empowerment.

Coffee cultivation

Coffee cultivation plays an important role in the Colombian economy. It is one of the responsible why the country has a strong presence in international markets, and it is internationally known due to the quality's product (Blandón-Andrade et al, 2020). Likewise, the foregoing is constituted in one of the most attractive productive alternatives for many farmer families because it gives an extra value to their lands (Federación Nacional de Cafeteros, 2017a).

It is crucial to highlight, at this point, that the coffee is a flagship product of the Colombian economy, from which 555.692 Colombian families get their livelihood

(Federación Nacional de Cafeteros, 2017b). This means that any effort research, in this strategic sector of the national economy, shall redound in benefits for the population. Moreover, the departments studied, Caldas and Risaralda, in this research, are alongside with Quindío those departments that compose the coffee region.

A concept that has gained momentum over the last years in coffee cultivation and other agricultural products has to deal with the Good Agricultural Practices (GAP) in accordance with Páez et al., (2012):

It has been demonstrated that it is possible to reduce the use of pesticides by means of the accurate implementation of the BPA due to the fact that they are a strategy for agricultural production that guarantees sustainability and competitiveness. The aforementioned aims for producing agricultural goods, environmentally friendly taking into account the worker's health as well as the people who consume them. Producers and other factors from the agri-food chain must understand the importance to adapt them to the crops for expanding trade opportunities in the international field.

Finally, it is relevant to mention the concept of specialty coffees as one part of the cultivators that participated in the survey are specialty-coffees producers. This brings them economic benefits as additional premiums over production price, yet they have additional requirements in terms of their crops' technification and administration. The specialty coffees can be defined as:

The consumer acknowledges quite particular characteristics by which he is willing to pay a higher price. These particularities can be related to organoleptic qualities of the infusion (highest quality coffee or special degree) with its unique source and constant quality (gourmet coffee), or with strict cultivation and/or marketing standards (sustainable coffee). (Castro, Contreras, Laca, & Nakamatsu, 2004)

It is also important to highlight the concept of bio-business. This approach might favor farmers' empowerment since it promotes economic and social impact as well as sustainable environmental practices. Molano cited by Albán, Pulido and Molano (2017) defines Bio-business as:

The economic process led to value's increase, tangible and intangible, by which the offeror and plaintiff of knowledge (public and private) are identified, interrelated and interacted, and from related products with biodiversity as well as biotechnology, in the frame of individual applications, entities and productive significative chains for a country.

Technology

It is important for human beings to enhance their life conditions. Because of that, they must evolve every day on how different activities are performed and through which they seek to meet their needs. Technology has currently become an indispensable tool because it counts with different devices and innovative systems that greatly contribute so as to facilitate many production processes or basic needs.

Information and Communication Technologies (ICT) are those technologies that are needed for management and transformation of the information. They are also particularly required in the use of computers and programs that permit to create, modify, collect, protect and recover that information. [...] Particularly, a social sense underlies the use of technology as long as it is associated with communication, human job in which inevitably social relationships are embedded. (Sanchez, 2008)

Bhatnagar and Schware (2000) mention that technology can be used for accelerating the development process since it contributes understanding, which was missed, or it speeds up fabrication processes. In other words, technology is one of the keys for optimizing resources and implementing efficient and quality programs. The foregoing is connected with the importance of emphasizing in production speed in order to be more competitive (Chakravarty, 2000). Technology contributes a type of cheaper and faster communication which represents an economic benefit,

thereby improving agricultural work and of marketing. This generates development for the country, and it is an efficient way to attack poverty (Aker & Mbiti, 2010).

Information and communications technologies (ICT) have within several concepts such as information systems, mobile devices, mobile applications, among others. An information system can be technically defined as a group of interrelated components that collect, feedback, process, store as well as distribute information as to support decision making, coordination, and control. Furthermore, information systems can even analyze problems caused by administrators and operators, visualize complex issues, and create brandnew products (Laudon & Laudon, 2014).

Mobile devices have evolved into the first personal computers, thus combining computational capacity with mobility and personalization. Unlike desk computers or even laptops, cell phones are always with their respective users, and they (cell phones) are ready to be used anytime (Jarvenpaa & Lang, 2005).

Mobile applications or apps are defined as “a software or an informatic program that is designed to function in smartphones, tablets and other mobile devices” (Martín, Fernández, & Yurrita, 2014, p.2). They are informatic tools that allow the user to perform different daily tasks through programs designed for being dynamic with the user in a fast and easy way, thus storing all the processed information in the devices and the cloud. The foregoing provides security and confidence in the new technologies.

Mobile applications might come already in the mobile devices, or they can be downloaded by the users in app mobile stores or the Internet. Furthermore, applications usually help users either connect with other Internet services commonly used in desk computers, or facilitate Internet use in their mobile devices (Wang, Liao, & Yang, 2013).

Empowerment

The empowerment implies a certain type of community intervention, and of social change. This is based on the strengths, competencies, skills, and social support systems that promote transformation in the communities. Part of its appeal as a concept comes from the emphasis on the positive aspects of human behavior such as the identification and capacities' promotion as well as the well-being promotion rather than problem solution or identification of risk factors. [...] In this way, the community becomes an active participant in the process of its own development (Perkins & Zimmerman, 1995)

Empowerment is understood then as the one in charge of fostering every human being dimensions, evaluating its capacities by providing a standard of living with greater sustainability. Each individual is willing to change, and a constant struggle for taking their life's control.

For analyzing empowerment, some models exist in the literature due to the fact that the concept changes according to the sociocultural context. Canval (1999) proposes that in order to determine the community empowerment, the following should be taken into account "to emphasize in the participation, attention, sharing, and responsibility. An empowered community is the one in which individuals as well as organizations gather abilities and resources in a collective effort so as to meet their needs".

Abdolmaleky's research (2012) proposes a sample of 330 farmers, who were randomly selected through sampling technique in diverse groups based on the characteristics of land use. Research design was carried out by a survey's design, which was divided into two sections. The first one was designed to collect personal data of every participant including the gender, the age, the income, time of work experience, level of education, etc. The second one

was designed to identify the satisfaction degree on their farm operations. The survey considered aspects such as: i) the size and kind of operations performed on the farms; ii) participation; iii) importance of the income that do not come from the farms; iv) the use of information technology; v) the perception regarding different statements; vi) marketing practices and research, and vii) the degree and need of education. The author sought the factors that affect the well-performance of the farmer's operations, and whether the technological use, as an empowerment strategy, helped increase productivity, which was indeed confirmed.

Ginige and Richards (2012) show another empowerment model, which was used for evaluating the farmers. They were empowered through technology, especially, with an agricultural system that facilitated farmer's operations. To conclude, farmers needed personalized information so that it can be useful for every user, and, through the empowerment presented model, activities are established to empower participants.

In another model, Rashig, Haque and Islam (2016) mention that the following variables should be taken into account: i) the change in economic empowerment that consists of the residual obtained income, money saving, investment, available loans, and consumable purchase; ii) the change in familiar and social empowerment that is considered by the contact evolution measures with the establishments, the partnerships that have with development departments, team spirit, leadership quality, group awareness for solving problems; and iii) the change in political empowerment, which is measured by the social activities participation, membership in social organizations, free expression and conflict management; iv) the change of knowledge empowerment, measured by team management, agricultural equipment, and BPA's implementation; v) the change in psychological empowerment, measured by motivation increase for agriculture, self-esteem, taking risk ability, decision making

capacity and confidence. Lastly, the current study suggests that agricultural technology has an impact on farmer empowerment in Bangladesh (Southeast Asia).

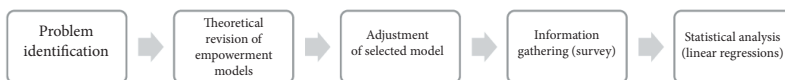
From the empowerment analyzed models, the current research takes the approach proposed by Rashid et al., (2016) as it includes categories that allow it to relate the technology development and use along with farmers empowerment; the aforementioned is at the same time a parsimonious model.

2. Materials and methods

2.1. Research Approach

The current research has a quantitative approach, which is the most appropriate to test theories (Hernández Sampieri, 2014). Within this approach, a topographic descriptive survey was carried out. The foregoing is oriented to understand the importance of such phenomenon and describe the distribution per se within a population (Forza, 2002). Its primary focus is not a theory development; however, through described facts, useful clues were found in theory construction and refining (Malhotra & Grover, 1998). Hence, the analysis of the collected data permitted to describe the relation between different empowerment types and the general farmers' empowerment. In figure 1, the research model used is shown.

Figure 1. *Estimation for social and familiar empowerment*



Problem identification – Theoretical revision of empowerment models – Adjustment of selected model – Information gathering (survey) – Statistical analysis (linear regressions).

The construction of farmer's empowerment is supported in four empowerment subtypes: economic empowerment; social and familiar empowerment; knowledge empowerment; and psychological empowerment, in which case the effects of the characteristics are observed on each of the empowerment previously mentioned. Thus, the general farmer empowerment is calculated by the following equation:

$$FE = EE + SFE + KE + PE$$

Where:

FE = Farmer's empowerment

EE = Economic empowerment

SFE = Social and familiar empowerment

KE = Knowledge empowerment

PE = Psychological empowerment

In agreement with the aforementioned, economic empowerment is calculated as the linear sum of the observed variables and graded from zero to five; therefore, the minimum value is zero, and the maximum value is twenty five in this category. The social and familiar empowerment is calculated as the linear sum of the components in a scale from one to five between each component, thereby the maximum number per individual is twenty. The knowledge empowerment is constructed by four components and a linear sum, so the lowest observed numbers per individual are zero, and the maximum ones would be fifteen. Finally, the psychological empowerment is calculated by three components and a linear aggregation of the observed results per individual whose values range between zero and fifteen.

Likewise, the observed characteristics of the 43 surveyed individuals will be taken as the independent variables in the estimated models of the different empowerment types. The following variables; age, education, land size, agriculture uses,

participation in organizations, cosmopolitanism, and agricultural availability, explain mean deviations from the different empowerment through five estimations.

Particularly in the sample, the education variable takes two different values; zero for illiterate people, and one for people with some primary school education. The size of the surveyed lands is 5,23 hectares and a maximum value of 32. Agricultural empowerment varies between 17 and 54 along the sample with a mean of 36,41. Economic empowerment varies between 0 and 16, with a mean of 7,67. Social and familiar empowerment varies between 2 and 12 with a mean of 7,79. Knowledge empowerment varies between 5 and 14 with a mean of 10,44. Lastly, Psychological empowerment varies between 5 and 15 with a mean of 10,51.

2.2. Data collection

Data collection was carried out through a survey. For this, an already valid document was adopted from the academic literature for the thematic axes previously mentioned (Rashid, 2014; Rashid et al., 2016). It is important to highlight that some adjustments were carried out since the instrument application was developed in Bangladesh. Notwithstanding that Colombian farmer conditions matched with some points from southern farmers, some sociocultural conditions were necessary to be adapted for Colombian farmers.

The main adjustment that was carried out in regard to the research of Rashid et al., (2014) was that the political empowerment was not included within the analyzed empowerment types. This was done in order to avoid any kind of controversy considering that the military conflict in the country has affected mainly the rural sector. Furthermore, in some empowerment categories, a few proposed variables were removed in the original instrument inasmuch as they did not apply for Colombian context. The adjusted instrument can be seen in the appendix 1.

The surveys were manually analyzed by one of the researchers so as to ensure that all the farmers had understood each one of the questions. The municipalities where the information was collected were Apia and Santa Rosa (Risaralda) as well as Viterbo (Caldas). It is crucial to highlight that despite the fact that the information was gathered in these geographic places, some of the participants belonged to other municipalities of the two departments previously mentioned. Considering cultural, economic and social similarities between the departments of the Colombian coffee region, that did not whatsoever affect the results obtained in the survey. In total, 50 responses were obtained; however, only 43 responses were actually used. The other 7 were discarded due to the lack of some data.

It is also relevant to mention that, although the people involved were not asked to sign an informed consent, they were told, before asking the respective questions, that their participation was voluntary, and the information would only be used for academic purposes.

2.3. Data analysis

For the collected data analysis, five linear regressions were carried out on the four empowerment subtypes: (1) economic, (2) social and familiar, (3), knowledge and (4) psychological. The fifth regression was performed on the influence of the observed characteristics on the general farmers' empowerment level. In order to carry out these regressions, the statistical STATA package was used.

3. Results and discussion

The relation between the independent variables and agricultural empowerment is expected to cause a significantly statistical-linear-regression model that capture the expected effects of the independent variables on the empowerment results. With

a partial correlation analysis, a priori, the following factors; age; education; listening to radio programs about agriculture; watching TV programs about agriculture; attitude towards electronic agriculture; and participation in organizations are expected to have positive effects on farmer empowerment. However, other factors such as localization and the type of land are expected to have negative effects as observed variables present a higher value.

In the framework of economic empowerment, positive correlations with age; education, land size; listening to agricultural radio programs; looking up information in the Internet about agriculture; attitude towards electronic agriculture; electronic agriculture availability; and other empowerment types such as the economic and the psychological one are evidenced. However, there is a negative correlation towards the land type and cosmopolitanism level.

For social and economic empowerment, a high positive correlation with land type, watching television programs about agriculture, attitude towards electronic agriculture, participation in organizations, and other empowerment types as the ones of knowledge and psychological is observed. Nonetheless, a negative high correlation exists towards localization; land size; use of technology; and electronic agricultural availability.

On the other hand, in knowledge empowerment a positive correlation was obtained towards education; land size; use of the cell phone in agricultural jobs; watching television programs about agriculture; attitude towards electronic agriculture; participation in organizations and other empowerment types as the economic; social, familiar and psychological. A negative correlation was obtained in regard to age; localization; land type and Internet consultation of agricultural information.

Lastly, in psychological empowerment a positive correlation is observed in relation with the use of technology; attitude towards

electronic agriculture; participation in organizations; and other empowerment types such as the economic; social, familiar and of knowledge.

3.1. Estimations

The dependent variable is taken as the empowerment indicator that is explained by the observed agricultural characteristics. That is to say, 5 linear regression models are made in order to capture partial effects of the observed individual characteristics towards the agricultural empowerment level, the 4 subtypes, economic empowerment level, social and familiar empowerment level, knowledge empowerment level as well as psychological empowerment level5. The results for the farmer empowerment are shown in figure 2.

Figure 2. *Farmer's empowerment estimation*

Source	SS	df	MS	Number of obs	=	43
Model	952.348739	6	158.72479	F(6, 36)	=	3.86
Residual	1482.11638	36	41.1698994	Prob > F	=	0.0045
				R-squared	=	0.3912
				Adj R-squared	=	0.2897
Total	2434.46512	42	57.9634551	Root MSE	=	6.4164

ea	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
edad2	-.0022944	.0014403	-1.59	0.120	-.0052155 .0006266
localización	-7.597792	3.184091	-2.39	0.022	-14.05543 -1.140157
tipopredio	-2.822658	1.741999	-1.62	0.114	-6.355596 .7102804
K	3.282772	1.845222	1.78	0.084	-.4595105 7.025055
M	5.442908	1.635831	3.33	0.002	2.125288 8.760527
eedd	.2357446	.1226923	1.92	0.063	-.0130869 .484576
_cons	26.27395	6.967424	3.77	0.001	12.14335 40.40454

Edad2: age2

Localización: location

Tipo predio: land-type

It can be inferred that farmer's empowerment has a direct relation with listening radio programs about agriculture, K variable, and watching television programs about agriculture, variable M. On the other hand, the education product along with

the age, variable eedd, evidences that there is a booster effect in education population as the individual is getting older. On the contrary, as the individual shares the property or the crop shows a less empowerment degree, which strengthens the idea of a reinforced individualism with low willingness levels to the cooperation. In the table 1, the estimate summary is shown for each one of the empowerment subtypes, and in the appendix 2, estimates results are shown in detail.

Table 5. *Estimates summary for each empowerment subtype*

<i>Estimaciones empoderamiento económico</i>						
var. dep.	edad	edad2	K	ec	dispon. ea	constante
coeficiente	0,560092	-0,0044	1,936893	0,594993	1,089852	-19,6095
p-valor> t	0,024	0,067	0,022	0,021	0,003	0,003
R ²	0,4862					
p-valor> F	0,0001					

<i>Estimaciones empoderamiento social y familiar</i>						
var. dep.	eedd	tamaño	tipopredio	L	ee	constante
coeficiente	-0,03806	-0,17988	1,381141	-0,71528	0,314556	5,967995
p-valor> t	0,202	0,038	0,031	0,14	0,004	0,039
R ²	0,3736					
p-valor> F	0,0030					

<i>Estimaciones empoderamiento de conocimiento</i>								
var. dep.	eedd	tamaño	tipopredio	usoea	N	esf	edad	constante
coeficiente	0,055521	0,138559	-1,15545	1,659761	-1,0572	0,431557	-0,08836	9,593876
p-valor> t	0,055	0,022	0,006	0,047	0,003	0,000	0,010	0,000
R ²	0,5732							
p-valor> F	0,0000							

<i>Estimaciones empoderamiento psicológico</i>			
var. dep.	M	ec	constante
coeficiente	1,272826	0,379488	4,358626
p-valor> t	0,006	0,009	0,004
R ²	0,3772		
p-valor> F	0,0001		

Economic empowerment estimation

var. dep: dependent variable (dep var); age; age 2; K; ec; dispon.ea (availability fe), constant

Social and familiar empowerment estimation

Var. dep: dependent variable (dep var); eedd; size, land type, ee, constant.

Knowledge empowerment estimation

Var. dep: dependent variable (dep var); eedd; size, land type; usoea (use of FE); esf; age; constant

Psychological empowerment estimation

Dep.var; M;ec; constant

5 . From the test for heteroscedasticity, Breush-Pagan, null hypothesis rejection for Heteroscedasticity in all estimated models is evidenced. Also, those variables that do not contribute to explain average behavior of the dependent variable through T-test of individual significance are discarded.

Economic empowerment increases as the following factors take place; the individual gets older⁶, listens to radio programs about agriculture, and has a higher willingness at the use and acquisition of electronic resources for agricultural activities, see table 1 and figure 3 from the appendix.

In the social and familiar empowerment, there is evidence that the farmers have less empowerment levels as their land becomes bigger. Nonetheless, social and familiar empowerment increases when it cooperates, or has shared ownership from the land or the harvest. On the other hand, there is no sufficient evidence on the real effect of the cell phone use and education product along with the age in empowerment social and familiar level. That can be appreciated in table 1 and the figure 4 from appendix 2.

Knowledge empowerment is expected to increase its average value when the land increases its size, people are more educated as they get older, and use technology. On the other hand, the knowledge empowerment reduces Internet consultation, and it shares the property of the land or the harvest and with the age. That can be appreciated in table 1 and figure 5 from appendix 2.

Finally, psychological empowerment increases as farmers use their cell phones in agricultural activities. This is evidenced since the variable partially explains average variations in psychological empowerment, see table 1 and figure 6 in the appendix 2. There is no sufficient statistical evidence to infer the presence or absence of other observed socioeconomical characteristics on the psychological empowerment level.

Furthermore, there is a positive relation between the four categories of empowerment. If one category is developed, the expectation is that the other categories are increased, too. In this way, the economic empowerment is boosted by knowledge empowerment. Social and familiar empowerment has positive

⁶ Nonetheless, the increase will be decreasing as years go by.

effects of increases in the economic empowerment. Knowledge empowerment has a direct and positive relation with the social and familiar empowerment, and psychological empowerment has positive effects of the increases in knowledge empowerment.

4. Conclusions

In the general farmer's empowerment, the momentum is reinforced on the multimedia content in order to increase the empowerment level of the coffee producers. The boosting education effect with the age requires the public policies rout on education of the adult and valid population, from the theories of the human capital, the early education with long-term effects.

In economic empowerment, further studies are expected to ensure the relation between financial capacity and economic empowerment, thereby understanding the capacity as the finance knowledge and the access to financial services from the development perspective.

On the other hand, the increase in the land size has a negative relation with the social and familiar empowerment level, whereas such relation is positive with knowledge empowerment. This situation can indicate that bigger land's administration requires more qualification and thus might induce social isolation as it requires more work and dedication.

Considering psychological empowerment, the values of the associated coefficients with the cell phone use and knowledge empowerment, which explain psychological empowerment, are positive and promote to deepen in the direction of causality among these variables. Hence, farmer's motivation and fulfillment, through agricultural work, can be in favor to technological information access and communication as a means of cultural, social and productive linkages as was pointed out by Aker and Mbiti (2010), Ginige and Richards (2012).

By considering the average age of the surveyed farmers, 50 years old, the proposal consists in harnessing the generational replacement with incentives to the construction and maintenance of agricultural empowerment. Thus and through this study, the needs are identified in the community that address public policy; for instance, the use of TIC in agricultural activities that promote motivation and fulfillment of young farmers, access to technical information through media, education strategies that enable autonomous learning and access to financial services.

Finally, the positive relations between the different empowerment categories are established, but it is not possible to establish causality relations among the aforementioned. There should be required to explore the connection between the categories that can understand scale effects or positive externalities for targeting resources, in terms of public policy, efficiently in the development of a categories subset. Also, there is a recommendation in future research to carry out bio-business plans with the farmers, as mentioned in the theoretical framework, this approach can favor the empowerment since it promotes social impact and environmental conservation.

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3

CHAPTER THREE Health and sports sciences

Experiences of relatives of women
deprived of liberty that participate in the
“Laboratory of affection”

Vivencias de familiares de mujeres
privadas de la libertad que participan en
el “Laboratorio del afecto”

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Abstract

To identify and know the experiences of the families of women deprived of liberty that participated in the strategy “laboratory of affection at the detention center for women in the city of Pereira in 2019. Qualitative-phenomenological study in which the participants’ points of view will be considered in regard to the experiences, feelings, emotions and strategies of coping in light of stressful events such as the deprivation of liberty of a loved one, the experiences of each family were taken into account, that is to say, the essence of the experiences that each of them have lived when facing the loss of liberty of their relative, this through the recollection of information with a sample of 2 families of women deprived of liberty, guaranteeing a saturation of information, said information will be compiled through the snowball sampling according to the penitentiary population registered in June 2019-2 that participated in the laboratory of affection, lastly the recollection and analysis of the information will be carried out through in-depth interviews to the relatives of the WDL of the detention center La Badea- Dosquebradas/Pereira which will be transcribed and analyzed by the researchers. This research showed that feelings of sadness, anguish, nostalgia and loneliness are demonstrated in the totality of the sample, besides of presenting changes in the family dynamic such as the displacement of the family to other departments, children care, change in the care role of elder parents and dreams frustration, in addition to this, major economic changes were presented because the imprisonment was reported as a new expense for the relatives. An important find refers to the change in children’s behavior such as the regression in their development and defiance in their behavior. Finally, coping strategies used by the families to carry out the process of imprisonment were demonstrated, such as leisure activities and seeking out for social help. In the identified experiences of women deprived of liberty’s families, feelings of sadness, anguish, nostalgia, desperation and loneliness were observed, as well as feeling their absence which affects their mental health which could

be highlighted by the crying and voice-breaking then speaking to them. In the same way, economical changes were demonstrated because, when their relative got detained, a member was added to the sustaining expenses, and one was subtracted from contributing to home economics. Added to this, changes in family dynamics were observed, where displacements from their homes to other departments of the country were perceived, as well as leaving their families to accomplish the role that their relative used to develop, leaving their plans for their lives in such places and frustrating their dreams and goals for the future. Finally, major changes were remarked in the behavior of children such as the regression in their development stages and *the enuresis in one of the children and defiance in others*.

Keywords: *psychological adaptation, family relations, women, female prisoner*

Resumen

Identificar y conocer las vivencias de las familias de mujeres privadas de la libertad que participaron en la estrategia “laboratorio del afecto en el centro de reclusión de mujeres de la ciudad de Pereira en el 2019. Estudio cualitativo-fenomenológico en el cual se considerará el punto de vista de los participantes referente a las vivencias, sentimientos, emociones y estrategias de afrontamiento ante eventos estresantes como la privación de la libertad de un ser querido, se tuvo en cuenta las vivencias de cada una de las familias, es decir la esencia de las experiencias que han vivido cada una de ellas a la hora de afrontar la pérdida de libertad por parte de su familiar, esto a través de recolección de información con una muestra de 2 familias de mujeres privadas de la libertad, garantizando una saturación de la información, dicha información se recopilará a través de un muestreo por bola de nieve de acuerdo con la población carcelaria registrada en junio 2019-2 que participó en el laboratorio del afecto, por último la recolección y análisis de la información se realizara a

través de entrevistas a profundidad a los familiares de las MPL del reclusorio La Badea Dosquebradas /Pereira, las cuales serán transcritas y analizadas por los investigadores. Esta investigación arrojó que en la totalidad de la muestra se evidencian sentimientos de tristeza, angustia, nostalgia y soledad, además de presentar cambios en la dinámica familiar como desplazamiento de la familia de otros departamentos, cuidado de los hijos, cambio en el rol del cuidado de los padres ancianos y frustración de sueños, adicional a esto, se presentaron cambios económicos importantes ya que el encarcelamiento se presentó como un gasto más para los familiares. Un hallazgo muy importante es el cambio en el comportamiento de los hijos como la regresión en su desarrollo y la rebeldía de en su comportamiento. Finalmente, se evidenciaron estrategias de afrontamiento que las familias utilizaban para sobrellevar el proceso de encarcelamiento, tales como realizar actividades de ocio y buscar ayuda social. En las vivencias identificadas en las familias de las mujeres privadas de la libertad, se observaron sentimientos de tristeza, angustia, nostalgia, desesperación, soledad y sentir su ausencia lo cual afecta la salud mental lo cual pudo ser evidenciado por el lloro y quebrantamiento de voz al hablar con ellos. Asimismo, se evidenciaron cambios a nivel económico ya que, al entrar su familiar a la reclusión, se sumaba un miembro más para el sostenimiento y un miembro menos para el aporte de la economía del hogar. Adicional a esto, se evidenciaron cambios en la dinámica familiar, donde se evidenciaron desplazamientos de sus hogares en otros departamentos del país dejando a sus familias para cumplir con el rol que su familiar desempeñaba, dejando sus planes de vidas en aquellos lugares y frustrando sus sueños y metas a futuro. Finalmente, se evidenciaron cambios importantes en el comportamiento de los hijos como la regresión en sus etapas de desarrollo como la enuresis en uno de los hijos y la rebeldía en otros de ellos.

Palabras Clave: *Adaptación psicológica, relaciones familiares, mujer, prisionera.*

1. Introduction

This research is oriented to getting to know the experiences of the families of women deprived of liberty who participated in the strategy “Laboratory of Affection” from the nursing program of the Universidad Libre sectional Pereira, which searches to strengthen the self-concept of women that have been deprived of their liberty; this strategy allows their resocialization process to be more efficient because during the encounters, topics such as autonomy, assertive communication, family functionality, among others are treated, which allows the strengthen of interpersonal relationships with their families since it was been shown through circumstantial talks during the approaches to the detention center that imprisonment generates a negative impact in the relationship of the woman deprived of liberty and her family, apart from the everyday life, the social environment and the family functionality. For this, it was highlighted the importance of coping for the families for these transformations that are lived during the process of imprisonment by means of the structuration of objectives that allow us to identify the family’s coping mechanisms in these situations.

This research was done in the women’s prison in Dosquebradas/ La Badea, which holds a total of 346 inmates to the moment. The objective in this research was to get to know the experiences of the families of women deprived of liberty, taking as a base Callista Roy’s theory.

Female detention centers in Colombia have increased their number of inmates, from 1.500 in 1991 to 7.944 women deprived of liberty in June 2018, a very high number for the Colombian population. (Ortigosa, 2019).

On a regional level, Pereira’s detention center has a real capacity for 237 inmates (“Rm Pereira - INPEC”, 2019), however for January 2017 it had a record of 323 inmates in total (Ramirez

Aragon and Riaño Vargas, 2017). 1 of the previous is translated to 7.944 families in Colombia that have lived crisis in their homes for the imprisonment of one of their members.

The family is considered as the basic social unit since it is where bare necessities are satisfied, the human being is developed emotionally, psychologically and physically, values and principles are formed, culture is transmitted and good habits for social coexisting are taught. In the same way, in the family, each of its members fulfills a specific function, for example, the providing role and normative function is attributed to the father, the mother is granted the role of care and parenting, besides of the role of affection and comprehension, children are given the care role for their parents when they enter old age and the compliance of home tasks, but what happens when a home member gets detained?

To begin with, we found that prisons were designed with the objective of re-socializing an individual from its criminal conduct, and with it, reeducate them with the purpose of integrating them to society in a way they can be useful in it. But it is difficult to think of a resocialization process for these individuals when observing the conditions in which they live in the prison, through which a plethora of limitations are detected to have a proximity to the principal support net as the family.

The effects produced by the imprisonment process in families is traced back to the fact that prisons have been designed for men (Hurtado, 2015) for the fact that women have been less imprisoned, obstructing the visualization of female needs in light of different established public policies.

Besides, the impact generated in detention-conceived children is observed since they are separated from their mothers when they turn 3 years old, this is perceived by the mother as one of the most difficult separations (Ordoñez Vargas, 2005) because it creates in her the uncertainty of handing over their child to their

family to be taken care of, or in the worst case scenario, they are handed over to the Instituto Colombiano de Bienestar Familiar (ICBF), besides, the feeling of guilt and impotence is created for losing the accompaniment during the raising and parenting of their child (Ordoñez Vargas, 2005). In the same way, during the stay of their child in the detention center, it is considered that they are treated as if they had been condemned in the same way as their mother, generating psychological and behavioral disorders that affect the child's normal development (2019).

In addition to this, when children that weren't conceived during the detention are taken to visit their relatives, they have the obligation of being joined by an overage person (Jurídico, 2017) preventing them from having an intimate space with their relative in which they are allowed to express their feelings in a freeway. This is added up to a number of conditions that limit the accompaniment of the prisoner to its children, such as the fact that visits frequency is interrupted, creating a shame feeling for the felony committed by the prisoner in relation to their kinship (Garcia Vita, 2015) due to the social discrimination they live, with leads to denying their kinship, hiding it in social media and even facing the necessity of changing their support net, which ends up breaking family relationships.

Also, referring to couple relationships, it is seen that conjugal visits are presented with a series of restrictions that are more numerous than the ones for men (Ordoñez Vargas, 2005) weakening the sustaining of sentimental relationships and maintaining family functionality, since the lack of a couple at home gives place to the seeking of a new one, deconstructing the family's structure.

Due to the absence that represents the inmate in the family group, a modification of the roles is introduced (Agudelo Hernandez et al., 2016) that can lead to the undiscussable family disintegration and dysfunctionality when is not achieved.

By presenting these conditions, families suffer a series of internal transformations that contribute to the familiar function and structuration deterioration, preventing the resocialization of inmates and their reinsertion in society.

Considering this, we ask ourselves, how are the experiences of the families of women deprived of liberty in the female prison in Dosquebradas/ La Badea?

2. Materials and methods

It is a qualitative-phenomenological study in which the participants' points of view will be considered in regard to the experiences, feelings, emotions and strategies of coping in light of stressful events such as the deprivation of liberty of a loved one, the experiences of each family were taken into account, that is to say, the essence of the experiences that each of them have lived when facing the loss of liberty of their relative, this through the recollection of information with a sample of 2 families of women deprived of liberty, guaranteeing a saturation of information, said information will be compiled through the snowball sampling according to the penitentiary population registered in June 2019-2 that participated in the laboratory of affection, lastly the recollection and analysis of the information will be carried out through in-depth interviews to the relatives of the WDL of the detention center La Badea Dosquebradas/Pereira which will be transcribed and analyzed by the researchers.

A snowball sampling was made through which, during the circumstantial talks, a potential subject was identified to participate in the research because they fulfilled the inclusion and exclusion criteria and, through this, we made contact with another participating family, wherewith we managed the saturation of data, who accepted to be a part of the study and to respond to the in-depth interviews in their homes.

Recollection of the information:

In relation to the recollection of information, in-depth interviews were done to the relatives of women deprived of liberty that fulfilled the criteria of inclusion: being an overage relative, that their relative had been an active participant of the laboratory of affection and that both parts had accepted to participate in this investigation (the woman deprived of liberty and the interviewed relative), finally, having disposition to respond to the interview.

An informed consent form was filled with a previous explanation, followed by a questionnaire whose questions were related to the planed objectives and gave an answer to the investigation question, subsequently the interview was made; these were carried our during the period of September to November of 2019, they were developed in an individual way and with the presence of third parties, the place was arranged with the interviewees, given it would help the spontaneity of their answers, a audio recorder was used with a duration between 20 to 25 minutes, according to the opening and verbal extension of each interviewed person, the final sample was composed by 2 participants who corresponded to relatives with first kinship of the first degree of consanguinity (sisters) in both interviews.

For the posterior analysis the interviews were transcribed in their totality, without omitting phrases or expressions within their context, each of them was assigned a code, and subsequently, each line was read, and the following categories were extracted. Sadness feelings, economic issues, changes in family functionality, children's psychological affectations, coping strategies, contributions of the laboratory of affection to the coping process of imprisonment. A chart for the analysis of information of said categories was used.

Ethical and bioethical aspects

This proposal of investigation is directed under the ethical principles of the Belmont report, whose guidelines are related to the respect for people; the women deprived of liberty and their families are treated as autonomous agents and in the case that their autonomy is reduced, their right to be respected is protected, this proposition is also backed in the declaration 8430 of 1993, where the respect, dignity, protection, rights and well-being of participants prevails.

This study is considered to be of minimal risk because the relatives interviewed are not intervened nor physically or psychologically, it is only about participating in the analysis of the experiences after finding out about the deprivation of liberty of their relative expressed in the in-depth interview.

Rigor criteria

Coherence or credibility: The validation was made through:

- Verification of the participants. After each interview a feedback was made with the participants to validate the integrity of the information and verify the fidelity of the data.

- Validity of the information. It is present due to the repetition of the interviews to the participants to confront the recollected information.

- The credibility of the analysis and interpretation was observed in the quotes of the interviews contained in the topics and subtopics that back up the results of this investigation and that were discussed among the group researchers.

Auditability

For the evaluation of the research, the methodological rigor was accomplished during the whole process of the research, in the same way the fidelity of the descriptions and the validation of the contents by the participants give faith for other researchers to confirm the finds in this research.

Neutrality: The results of this research are not biased by motivations, interests or perspective of the researcher.

Transferability: The possibility to expand the results to other population exists.

3. RESULTS AND DISCUSSION

The purpose of this study was to describe the experiences of the relatives of the women deprived of liberty who participated in the socio-educative strategy of the laboratory of affection 2019-2, which was done in the detention center for women Dosquebradas /La Badea.

The analysis corresponds to the information found in the interviews, which showed the following data referring to the sociodemographic characteristics. (**table 1**)

The studied population showed that 50% do not have children and the resting 50% had 2 children.

The type of family that conforms their home is 50% an extensive family, in which 2 sisters live with their respective families and the resting family is a mixed family formed by the sister of the WDL and her nieces.

A study made in 2014 in Peru by Rojas, Cavanzo, Benkelfat, Perefán and Mora relates to our study because the interviewed families of the women deprived of liberty belonged to extensive families (Rojas Cavanzo et al., 2015).

The participation of the relatives of the women deprived from liberty shows emotions, feelings, gestures that are discovered in different topics with relevance from their voices.

Regarding to the dimension of the feelings, the relatives of the women deprived of liberty refer to feelings of sadness from the beginning of the deprivation of the liberty of their relatives.

“SADNESS WILL ALWAYS BE THERE”

LM01: “The truth, it invades us at once, the sadness, the nostalgia”

LM01: “When they came for her at home, and, well, it’s a desperation to not able to do anything”

LM01: “sadness and anguish to see her there and not know when she can really get out”

YP02: “Every time I go visit her it makes me so sad to see her there”

The consequences of imprisonment are not limited to incarcerated people, but the custodial penalty also has a generally serious impact on the families of these individuals (GarcíaBores, et al., 2006). Previous studies in Colombia, such as that conducted by Sanchez, show that imprisonment becomes an unexpected stressful event that, depending of the circumstances, tends to be kept occult and become part of family secrets that modify family interaction, affecting the mental health of its members (Rojas Cavanzo et al., 2015).. In addition to this, a study made in Cajamarca in 2014 by the author Baez Fernandez shows the emotional changes in families that live the situation of imprisonment expressed in disagreements, anxiety, sadness, loneliness and generating confrontations between family members, arriving to our study in which it is shown by the participants’ voices who feel sad, anxious and anguished, observing the affectations to its mental health. (Baez Fernandez, 2014)

“ONE MORE EXPENSE”

LM01: *“The expenses augmented, really. Yes, because by obligation you have to bring her toilet implements every month, clothes and whatever she needs, you have to deposit whatever money 20 or 30 thousand pesos.”*

YP02: *“We are here carrying a burden, to say it like that, the girls and her”.*

YP02: *“I was super stressed, because that man has annoying me about the rent money and no”*

According to Massa, Lopez, Maldonado, Rodriguez, Raggi, Villeta and Vdovdov in a study made in 2016 in Argentina, it is explained that the relatives of women deprived of liberty were forced to work double working days because in this cases it could be even presented an extra task, considering that as well as ensuring the daily livelihood for the family group, they have to ensure the livelihood for who is deprived of its liberty. In the same way, their concern was observed because the money could not satisfy the basic necessities of the family and be able to sustain a quality of decent life for the family group (Vdovsov et al., 2016). Additionally, an economist called Ronald Balza adds that, without mattering the socioeconomical stratum of the family, they have to get more income in an alternative way because there are more expenses (Leon, 2014). Finally, a study developed in Peru in 2015 by Olarte and Vázquez, describes that the economical level is also affected, because they do not count with the income that the mother used to provide to the home, and they have more expenses because they have to support her in prison, reinforcing a vicious circle of precarity and necessities (Farrow & Baker, 2015).

“FAMILY CHANGES”

LM01: *“As I used to like over there, we didn’t communicate a lot before, yes, that’s the true, and now well, we’re like more united”*

When an even of family-level detention is presented, a change in the home of one of the relatives was produced, which, without thinking, resulted in an approach that was not there before, nor physically or emotionally, but that despite the feelings generated by the separation of the home, ironically strengthened family union, at least for the interviewee with the inmate.

YP02: *“Yes, it is a change, being in charge of house, I hadn’t been alone an aware then, it’s like one says, is a task very big for example for me that I don’t have children yet”*

YP02: *“Because I was the one that was working, then I was the one that helped my parents and I also helped my sister here”*

YP02: *“Well it changed a lot, because I had thought about living in Medellin and taking my parents there... Then in my thoughts it was, let’s say, this year, I was going to work in July but no, as all of that happened, then I couldn’t, let’s say that my studies are stalled because I was also going to start the university”*

Taking care of the obligations that the woman deprived of liberty used to have in her daily life, conditions directly the projects of the other people or relatives that surround her, and that support her directly, for Gaviria, Hernandez and Osorio (2015) the family is the one in charge of assuming and paying the account and taking care of those obligations because “As the family is the active subject, it presents changes that modify its dynamic, situations as the absence, abandonment, loss of liberty, among others, can generate changes in the roles that are exercised each member of the family” (Gaviria Malagon et al., 2015). In this way, the changes generated in the interviewed families, modified, to the moment of the interview their plans, and life projects, which is translated in an engagement of great caliber to try to overcome the burden generated by the absence of a family member due to the loss of liberty, but also in a burden that generated anxiety and stress.

“HER MOM BEING THERE MADE HIM CHANGE”

LM01: “He changed a lot, really, he, he thinks he’s independent, he thinks he directs himself”

LM01: “He became even more rebellious, he became very rebellious, he doesn’t listen, he basically directs himself”

LM01: “Because with my sister (the inmate) he didn’t do what he does now”

When interviewing one of the relatives of women deprived of their liberty, they expressed the negative changes in the behavior of one of the children of an inmate in the detention center, on their behalf, Baez, Fernandez (2014) in a study made in the penitentiary center Huacariz Cajamarca in Peru, it is mentioned that

as the family is unable to guarantee emotional support, a series of maladjustments in children are presented, even more if they are during the adolescence stage, generating a rebellion that’s characteristic of them, showing feelings of anger, and lack of respect for family norms. (Baez Fernandez, 2020)

YP02: “The girls on hand keep crying a lot, so it is very hard to see the girls crying because their mom is there”

YP02: “She’s peeing in bed every night (she laughs) and that’s something she didn’t do with her mom and she’s too big to be doing that”

It is notorious that the impact of the detention produces important changes in minors, that affect the normal development of their childhood, reaching the point of producing regressions. For Robertson (2007) “some children become introverted or start to reflect even more health issues and regressive behaviors like wetting the bed” (Robertson, 2007).

“IT MAKES US FORGET FOR A WHILE”

LM01: *“Putting on music, listening to the music she used to like, looking at pictures in Facebook, all that”*

YP02: *“I also listen to music to get distracted”*

LM01: *“As hard as the situation is, trying to control de situation and asking help by more means to avoid mistakes”*

YP02: *“I keep speaking to my mom over videocall and with my dad, well he doesn’t have a phone there to see him so I keep calling him at night and in the day I speak to my mom and also with my other siblings”*

Within the identified coping strategies by the participant’s voices, it is found the association of coping strategies presented by Ordóñez (2009) where it is referred to the RELAXING DISTRACTIONS AND TENSION REDUCTION which consist in developing leisure activities that produce pleasure such as listening to music, reading, scrolling through social media, among others, as well as the SOCIAL SUPPORT SEAKING in which the problem is shared with other people like the family, friends or significant other to seek help in them (Gaviria Malagon et al., 2015).

“IT HELPS THEM CHANGE THEIR SPIRIT”

LM01: *“The activities, that make them reflect”*

LM01: *“That helps them a lot to overcome everything they have in mind, to be calmer, to overcome everything more easily”*

LM01: *“It helps them a lot to stop thinking that they are there for a moment”*

YP02: *“She now feels calmer”*

4. Conclusions

The families of women deprived of their liberty presented a similar sociodemographic characterization, in the sense that both families belonged to level medium to low socioeconomic stratum, being the stratum 1 and 2 that prevailed constantly, also both

families had a relative with at least a year in a detention center and both families earned less than a minimum wage when the interview was made. Moreover, the educational studies of the interviewees were characterized for being basic, even technologists, but not professional, being linked directly to the few opportunities they had to access superior education, and thereby to the well-paid work environment, which explains why unsatisfied basic needs turn into motives to commit crimes and end up being deprived of liberty. Also, both families were living in the urban quartier, not rural, when the interview was made, however, with one interviewee there were no children, meanwhile with the other there were 2 underage children.

The feelings experienced by the families during the imprisonment process were usually sadness, anguish, nostalgia, desperation, loneliness and feeling their absence, as well as impotence for having a relative within a detention center as well as for not knowing what situations could be presented during the passing of days that could be observed in the crying and voice-breaking when speaking to them.

On the other hand, there was an approaching in most of the relatives when the event of the imprisonment was presented, since they started to have more communication more frequently and even some of the family members moved into different homes to assume the care over their inmate relative. The coping strategies that were identified in the families of the women deprived of liberty include occupying their mind in leisure activities such as listening to music, scrolling through social media and making video calls and telephonic calls to their family since this produces relaxation and the decreasing of tension. In the same way, it was observed that this situation of imprisonment caused a significant learning in which they think of not making the same mistakes as their relatives seeking for help in their social environment.

According to the results, it is necessary to make programs for mental health promotion extensive for the families of the women deprived of their liberty to help with the coping of this phenomenon.

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Acute Effects of Dynamic Tape® Application on Vertical Jump Performance: A Case Report

Efectos Agudos de la Aplicación del Dynamic Tape® sobre el Rendimiento de Salto Vertical: un Estudio de Caso

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Abstract

Introduction: Different types of neuromuscular tapes have led to no consensus about its benefits on muscle performance. Unlike kinesiology and rigid tapes, Dynamic Tape® has different composition and properties with unknown effects on performance. The aim of this exploratory-type case study was to report the acute effects of dynamic tape® application on vertical jump performance. *Material and methods:* Using a test-retest methodology, a case study was carried out in two 21-year-old, healthy and physically active women. Flight time, jump height and muscle power were evaluated by squat jump and countermovement jump tests using a contact mat, before and after the application of dynamic tape® on quadriceps and gastrocnemius muscles. Single and double taping were also used in different combinations. *Results:* Improvements of up to 10.8% on flight time, 22.6% on jump height and 8.9% on muscle power were observed for squat jump after the application of dynamic tape®. *Conclusions:* This preliminary and exploratory case study showed that using dynamic tape® might improve vertical jump performance; however, further research is necessary in this relatively novel type of tape.

Keywords: Athletic tape, functional performance, elastic bandages, sports performance

Resumen

Introducción: Actualmente, no existe un consenso sobre los beneficios de los diferentes tipos de cintas neuromusculares sobre el rendimiento muscular. A diferencia del vendaje neuromuscular y las cintas rígidas, el Dynamic Tape® tiene una composición y propiedades diferentes con efectos desconocidos sobre el rendimiento. El objetivo de este estudio fue reportar los efectos agudos del tape dinámico® sobre el rendimiento del salto vertical. *Materiales y métodos:* Utilizando una metodología test-retest, se realizó un estudio de caso con dos mujeres de 21 años, saludables y

físicamente activas. Se evaluó el tiempo de vuelo, la altura del salto y la potencia muscular a través de salto desde sentadilla y salto con contra movimiento en plataforma de contacto, antes y después de la aplicación del tape dinámico® en cuádriceps y en gastrocnemios. *Resultados:* Se encontraron mejoras en el salto desde sentadilla de hasta 10.8% en el tiempo de vuelo, 22.6% en la altura del salto y 8.9% en la potencia muscular después de la aplicación del tape dinámico®. *Conclusiones:* Este estudio preliminar y exploratorio mostró que la utilización del tape dinámico® podría mejorar el rendimiento del salto vertical; sin embargo, se necesitan más investigaciones sobre este tipo de vendaje.

Palabras Clave: Vendaje atlético, rendimiento funcional, vendajes elásticos, rendimiento deportivo

1. Introduction

In recent years, the implementation of neuromuscular tape has increased considerably. The term neuromuscular taping refers to bandages of different composition with longitudinal stretch characteristics that reach between 120 to 140% of elongation, with regards to its initial state, and that shorten when the tape is attached to the skin (Reneker et al., 2018) (McNeill & Pedersen, 2016). This taping is used with the aim of supporting muscle function during the rehabilitation/readaptation of injuries or in cases where muscle function is restricted by processes of overuse or muscle damage (Vinken, 2015). The possible mechanisms of neuromuscular tape application for rehabilitation and prevention of sports injuries are the improvement of muscle function, blood flow, lymphatic flow, sensory perception and fascia function (Drouin et al., 2013). Furthermore, neuromuscular taping can also be used to prevent, correct exercise technique or even improve athletic performance (Wilson et al., 2016), but this last is still controversial. In fact, Reneker et al., (2018) concluded, in a recent systematic review of 15 studies, that there is no definitive evidence

about the effectiveness of the neuromuscular tape Kinesio Tape® on sports performance. Notwithstanding, the lack of consensus regarding the effectiveness of the neuromuscular tape application might be associated with differences of tape materials and variation of methodologies and procedures used among the studies (Huang et al., 2011).

Recently, a relatively novel tape called Dynamic Tape (DT) has being introduced to the market with alleged better outcomes due to the simulated viscoelastic behavior of the connective tissue of its components (Nylon/Lycra or Recyled PET/Lycra), that allow moving in four directions and a longitudinal stretching capacity greater than 200% with respect to its initial state (McNeill & Pedersen, 2016). These features would suppose a mechanical help when the subject is performing vertical jumps, offering accumulation of additional elastic energy to the musculature and providing an improvement in the jump performance, especially starting from positions where elastic energy cannot be taken advantage. Based on the above information, the objective of this exploratory-type case study was to report the acute effects of DT on jump performance in two young adult women that used this kind of neuromuscular tape.

2. Materials and methods

Using a test-retest methodology a case study was carried out in an university laboratory

2.1. Patient

Two 21-year-old, healthy and physically active women, who practice regularly resistance training and basketball, participated in a research project at the Human Movement Laboratory at the Universidad Tecnológica de Pereira (Pereira, Colombia) and called the attention of the researchers due to their morpho-functional

characteristics. In their medical questionnaire, the women reported no history indicating cardiac pathology, any ongoing pathologies or pain at upper limbs, lower limbs and trunk during the last six months.

In Case 1, a 21-year-old woman (height = 172.2 cm; body mass = 62.1 kg; BMI = 20.94kg·m⁻²). University student of sports sciences, physically active, occasional weightlifting practitioner, without skeletal muscle pathologies during the last six months.

Case 2 involved another 21-year-old woman (height = 162.3 cm; body mass = 56.2 kg; BMI = 21.33 kg·m⁻²). University student of sports sciences, physically active, occasional basketball practitioner, without skeletal muscle pathologies during the last six months. After volunteering and signing the informed consent in accordance to the ethical guidelines of the World Medical Association Declaration of Helsinki (2013), the women participated in a case study with test-retest methodology.

2.2. Intervention

Each subject performed three squat jumps (SJ) and three countermovement jumps (CMJ) after instructions on proper jump execution based on previous recommendations (Bosco & Riu, 1994) on a contact mat (Globus Ergo Tester, Codognè, Italy) with no tape (NT) application. Briefly, to perform the SJ the subject positioned himself with hands fixed to the hips, in a squat with knees flexed at 120°, remaining in this static position for five seconds in order to produce loss of elastic jump performance, and then the subject executed the maximum jump. Any countermovement was avoided. For the CMJ, the subject stood with knees in 180°, hands on the hips. Then, every subject performed the countermovement technique, which consists of a rapid stretching-shortening cycle, where there was a simultaneous knee, hip and ankle flexion followed by an extension of the knees seeking to push the body in a vertical position in order to

reach the maximum height. For both jumps, it was required that knees remained in extension during the jump, and the interval between one trial and another was 10 seconds. Absolute power was calculated for every jump test according to Sayers equation (Sayers, Harackiewicz, Harman, Frykman & Rosenstein, 1999).

Table 1. Equations used for calculating interest variables

Variable	Equation	Reference
Jump height (cm)	$ft^2 * (g/8)$	(Bosco & Riu, 1994)
Absolute power for SJ (W)	$(60.7 * \text{height SJ (cm)}) + (45.3 * \text{BM}) - 2055$	(Sayers et al., 1999)
Absolute power for CMJ (W)	$(51.9 * \text{height CMJ (cm)}) + (48.9 * \text{BM}) - 2007$	(Sayers et al., 1999)

ft = flight time; g = gravity (9.8 m·s⁻²); BM = body mass (kg)

Same jump protocols were performed under different conditions of DT (Official manufacture under the direction of Ryan Kendrick). Tape was placed in a layer from the upper and anterior region of the thigh to the anterior half of the tibia with the knee in extension, applying a tension such that a deceleration was generated towards flexion (quadriceps; 1Q). The same procedure was performed but with the application of a double layer of DT or power band, to enhance the described effect (2Q). The application on gastrocnemius (1G) corresponded to a single layer of DT applied from the plantar region to the superior and posterior aspect of the tibia with the ankle in plantar flexion, until reaching with the tape a tension such that it produced a deceleration towards the dorsiflexion. The application called (2G) consisted of the same procedure described as before but with a double administration of DT or power band, to enhance the described effect. Four series of three SJ and three CMJ with five minutes rest between series and ten seconds rest between jumps were performed in the following

conditions 1Q, 2Q, 2Q+1G and 2Q+2G. The tape was placed by a certified and expert physical therapist. Three data sets were registered from each condition and the best record was chosen for each subject in each condition. Afterwards, the mean of the best records of both subjects was determined at each condition. Jump height, flight time and absolute power were analyzed contrasting by percentage differences the performance in each of the jumps.

3. Results

Table 2 presents the comparison of the means obtained before and after the application of DT. Improvements on jump height were seen for SJ after dynamic taping on 1Q, 2Q, 2Q+1G and 2Q+2G (9.6%, 9.9%, 16.9% and 22.6%, respectively). Regarding CMJ, improvements on jump height were observed after DT application on 1Q, 2Q+1G and 2Q+2G (1.8%, 4.9% and 8.8%, respectively); however, a negative behavior of 4.2% was shown for the 2Q condition.

There was an improvement on flight time in SJ after application of DT on 1Q, 2Q, 2Q+1G and 2Q+2G (4.2%, 4.8%, 8.0% and 10.8%, respectively). In contrast, an increase on flight time was observed in CMJ for 1Q, 2Q+1G and 2Q+2G (0.8%, 2.2% and 4.3%, respectively), but a diminishment was seen after DT application on 2Q (2.1%). Absolute power showed also increased values in SJ (2.1%, 0.3%, 2.1% and 8.9%) and CMJ (9.4%, 5.0%, 6.6% and 12.5%) for 1Q, 2Q, 2Q+1G and 2Q+2G, respectively.

Table 2. Comparison of the jump height between CMJ and SJ in each of the moments evaluated.

	SJ			CMJ		
	Flight time	Jump height	Power	Flight time	Jump height	Power
	(s)	(cm)	(W)	(s)	(cm)	(W)
NT	0.500	30.8	2484	0.523	33.6	2622
1Q	0.521	33.7	2663	0.527	34.2	2653
2Q	0.524	33.8	2669	0.512	32.2	2549
2Q+1G	0.540	36.0	2800	0.535	35.3	2708
2Q+2G	0.554	37.7	2906	0.546	36.6	2775

squat jump; CMJ = countermovement jump; NT = no tape; Q = quadriceps; G = gastrocnemius.

Finally, comparing the jump height performance between SJ versus CMJ, an improvement of 9.27% and 1.48% in favor of the CMJ in NT and 1Q condition, while an improvement of 4.73%, 1.95% and 3.05% was observed in favor of the SJ in condition 2Q, 2Q1G and 2Q2G respectively, indicating that the dynamic tape attenuates the characteristic loss of elastic performance of the SJ condition.

4. Discussion

One of the main exploratory findings of this study was that the use of DT produces positive changes on jump height, flight time and absolute power, possibly due to optimization of quadriceps and triceps surae function during the execution of vertical jumps. To our knowledge, no previous research has evaluated DT as an element that can modify vertical jump performance. Thus, this is the first scientific approach to evaluate the effects on muscle performance. Conversely, Kinesio Tape®, a kind of neuromuscular tape, has not shown significant improvements on vertical jump performance

when applying on both quadriceps and gastrocnemius (Drouin et al., 2013; Reneker et al., 2018). Our findings do not agree with these reports, possibly due to the mechanical differences attributed to the DT, which seems to offer possibilities of elastic energy recovery and might favor the mechanical properties of muscle tissue. Both women of this case study experienced an improvement on jump performance after application of DT on the facilitated muscles. These data demonstrate in a preliminary and exploratory fashion the potential improvement of jump performance based on the mechanical advantages of DT composition.

The possible positive effects of this tape could be related to support structures directly involved in the transmission of muscle tension, as the elastic component in series and parallel, which would allow an immediate increase in effective force during explosive gestures, such as vertical jumps (Vinken, 2015; Wilson et al., 2016). Among the most representative results of this exploratory study were the improvements obtained in the SJ, position in which the elastic energy accumulated by the muscle tissue cannot be effectively transferred to the mechanical gesture (Cavagna, Dusman, & Margaria, 1968; Hortobagyi, Hill, Houmard, Fraser, Lambert & Israel, 1985). Initially, the improvement of jump performance may be attributed to the mechanical and viscoelastic properties of DT, which simulates the viscoelastic behavior of the connective tissue (McNeill & Pedersen, 2016). These properties could compensate the energy eliminated as heat (Bolstad & Erslund, 1978; Edwards et al., 1975) during the five isometric seconds prior to SJ execution. The jump height performance reached by the SJ supports the previous hypothesis, showing an increasing behavior of the elastic capacity of the facilitated muscles, getting the point where the SJ surpasses the CMJ. Possibly, the high recruitment of motor units during the isometric action of the SJ plus the mechanical facilitation offered by the DT would favor the gain of the elastic component after the isometric action. It is to emphasize that the performance on jump height would favor CMJ, considering the expression of the

elastic capacity of the muscle tissue; however, when applying the DT bandages, the SJ exceeds the elastic capabilities of the CMJ. This compensation of elastic energy propitiated by DT would have important implications on the mechanical behavior of muscles subjected to fatigue states, which would prevent the possible appearance of injuries during intense exercise situations, such as those experienced by athletes in various sport disciplines.

The compensation offered by DT would be useful during sports rehabilitation processes, in which mechanical facilitation of injured muscles is required. This would shorten the time of rehabilitation/readaptation and would provide safety and support during the processes.

5. Didactic contributions

Although the effects of Kinesio Tape® on vertical jump performance are still inconsistent in the short or medium term (Nakajima & Baldrige, 2013; Nunes et al., 2013; Schiffer et al., 2014; Vinken, 2015), the results of this exploratory study suggest that other types of tape with better viscoelastic properties, such as DT, might improve jump performance. Particularly, the application of DT on quadriceps and gastrocnemius might improve vertical jump performance, especially in SJ, possibly because of the mechanical support provided by the tape in positions where the elastic energy cannot be used efficiently.

Acknowledgment

The authors would like to thank the participants for their invaluable contribution in this study and the Human Movement Laboratory from Universidad Tecnológica de Pereira.

Note: This project has not received funding or grant. We also declare that the project has not been presented before.

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4

CHAPTER FOUR Agricultural sciences

Socio-economic and productive reality of blackberry no thorn farmers in the state of Risaralda

Realidad socioeconómica y productiva de agricultores de mora sin espina en el departamento de Risaralda

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Abstract

The participatory research with farmers was carried out in order to know the socioeconomic and productive reality of blackberry farmers no thorn (*Rubus glaucus Benth*) from seven cities in the state of Risaralda, taking into account the technological

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demands of the crop. It was carried out with 328 producers, grouped into 40 subgroups, participatory methodologies were used such as Participatory Rural Diagnosis, appraisals, direct and participant observation, interviews and semistructured dialogues, group discussions and analysis, information output matrices, ideas for group reflection, talking maps, analysis of qualifications and scores, comparison of opinion groups, workshops, semi-structured interviews, field days, participatory research plots and field transects, from an on-demand research scheme. It was found that the cultivation of blackberry no thorn in Risaralda is 90% of peasant agriculture, it is carried out in plots of between 0,5 to 1 hectare, under the modalities of ownership, sharecropping and leasing, 30% are tenants, hand the work is family-oriented and the tasks are classified by gender and age; one hectare produces 8.5 t / year and generates 2,5 minimum wages. 27 variables were analyzed that allowed to identify the strengths, limitations, opportunities and risks of the crop in the technical, economic, social, cultural, environmental and commercial components. The strengths identified were quality of the seed and the product, cultural work and GAP, adequate use of protection kits and permitted chemical inputs, family labor, revolving fund and savings and land tenure. The main limitations were pests and diseases, inappropriate use of pesticides and infrastructure in terms of cold rooms; The opportunities described had to do with access to training and implementation of GAP, technical support and support from the Ministry of agriculture, processing, post-harvest management, product transformation, certifications, crop records, integrations between partners and the family, support from institutions and better living conditions for producers and their families; access to education, decent housing, social security and health; The risks identified were climatic factors, low prices in commercialization, high costs of inputs and low sales prices. Planting and the establishment of a tutored system are the most important cultural tasks for blackberry producers, in the same way they mention 35 important insects during the entire production cycle and the diseases Crespera, Anthracnose, Downy mildew and gray

mold as the most limiting. Participatory research with farmers turned out to be a useful and versatile strategy for conducting research on demand. The exchange and collaboration with the farmers allowed not only to know the reality of the cultivation of blackberry without thorn in its different dimensions, but also to carry out field trials with research plots

Keywords: *Rubus glaucus*, Participatory research, Participatory Rural Diagnosis

Resumen

La investigación participativa con agricultores (IPA) se hizo con el fin de conocer la realidad socioeconómica y productiva de agricultores de mora sin tuna (*Rubus glaucus Benth*) de siete municipios del departamento de Risaralda, teniendo en cuenta las demandas tecnológicas del cultivo. Se realizó con 328 productores, agrupados en 40 núcleos o subgrupos, se utilizaron metodologías participativas como Diagnóstico Rural Participativo (DRP), avalúos, observación directa y participante, entrevistas y diálogos semi-estructurados, discusiones y análisis grupales, matrices de salida de información, ideas para la reflexión grupal, mapas parlantes, análisis de calificaciones y puntajes, comparación de grupos de opinión, talleres, entrevistas semiestructuradas, días de campo, parcelas de investigación participativa y transectos en campo, desde un esquema de investigación por demanda. Se encontró que el cultivo de mora sin espina en Risaralda es un 90% de agricultura campesina, se realiza en predios de entre 0,5 a 1 hectárea, bajo las modalidades de propiedad, aparcería y arrendamiento, el 30% son arrendatarios, la mano de obra es familiar y las labores se clasifican por género y edad; una hectárea produce 8,5 t/año y genera 2,5 salarios mínimos. Se analizaron 27 variables que permitieron identificar las fortalezas, limitaciones, oportunidades y riesgos del cultivo en los componentes técnico, económico, social, cultural, ambiental y comercial. Las fortalezas identificadas fueron calidad de la semilla y el producto, labores

culturales y BPA, utilización adecuada de los kits de protección e insumos químicos permitidos, mano de obra familiar, fondo rotatorio y de ahorro y tenencia de la tierra. Las principales limitaciones fueron plagas y enfermedades, uso inadecuado de agrotóxicos e infraestructura en cuanto a cuartos fríos; las oportunidades descritas tuvieron que ver con acceso a capacitaciones e implementación de BPA, acompañamiento técnico y apoyo del MADR, procesamiento, manejo post-cosecha, transformación del producto, certificaciones, registros del cultivo, integraciones entre socios y la familia, apoyo de instituciones y mejores condiciones de vida para los productores y sus familias; acceso a educación, vivienda digna, seguridad social y salud; los riesgos identificados fueron factores climáticos, bajos precios en la comercialización, altos costos de los insumos y bajos precios de venta. La siembra y el establecimiento de sistema de tutorados son las labores culturales más importantes para los productores de mora, de igual manera mencionan 35 insectos de importancia durante todo el ciclo de producción y las enfermedades Crespeta, Antracnosis, Mildew veloso y moho gris como las más limitantes. La investigación participativa con agricultores resultó ser una estrategia útil y versátil para realizar investigación por demanda. El intercambio y colaboración con los agricultores permitió no solo conocer la realidad del cultivo de mora sin espina en sus diferentes dimensiones, sino también, llevar a cabo ensayos en campo con parcelas de investigación.

Palabras Clave: *Rubus glaucus*, Investigación participativa, Diagnóstico Rural Participativo.

1. Introduction

Participatory Research is a collaborative work model between researchers and farmers whose purpose is, among others, the transfer and / or adoption of technology that allows farmers to take the role of researchers: testing, collecting data, analyzing and determining information. It is a tool that is used, among other

reasons, to quickly prioritize the problems of a community, with its use it is possible for producers to solve the technological problems that limit their agricultural production, according to their points of view (Roa *et al.*, 2002).

It allows farmers to observe, test, apply, adopt and participate in the information analysis and feedback processes; and to the institutions, manage to articulate their experience, the daily contact with the crops and their ability to experiment and innovate to enrich the reports of the field work, the transfer and innovation processes, the diffusion of technologies and the results of a research project and technology transfer.

It is part of the innovative methodologies of collaborative work between producers and researchers where there is a combination of research, education, learning and action (Geilfus, 2001; Falabella, 2002; Pérez *et al.*, 2002; Hellin *et al.*, 2006; Cárdenas *et al.*, 2010).

The experiences of CIAT, CORPOICA, the National Federation of Coffee Growers and CENICAFE are recognized at the national level; Pontificia Universidad Javeriana, the Center for Research on Sustainable Agricultural Production Systems (CIPAV), the CIER Rural Research and Extension Center of the Faculty of Agronomy of the National University of Colombia, the Corporation for the Participative and Sustainable Development of Small Farmers and UNISARC.

At the international level, the experiences of IICA (Inter-American Institute for Cooperation on Agriculture), GTZ (German Agency for Cooperation), SWISSAID (Swiss Cooperation Agency), FAO (UN), IUCN (International Union for the Conservation of Nature and Natural Resources), IDRC (International Development Research Center), the Universidad Mayor de San

Simón (AGRUCO), the Four Worlds International Institute for Indigenous Sciences, CATIE, Zamorano (Honduras), USAID (Agency of the United States for International Development), Regional Fund for Agricultural Technology FONTAGRO, Andean Program for Technological Innovation PAITEC - Andean Community, among others.

The participatory research project with farmers of blackberry no thorn (*Rubus glaucus* Benth) in the state of Risaralda used participatory research (PI) in order to know the socioeconomic and productive reality of blackberry no thorn (*Rubus glaucus* Benth) farmers from seven cities in the state of Risaralda and update the technological package of the crop (pests, diseases, pruning, tutored, soils, nutrition, climate), taking as a starting point the demands of the producers.

The importance of the study lay in the participation of the producers in the adjustment to the technological package of the crop through the management of participatory methodologies, which led to processes of adoption of hybrid agronomic practices, obtained from the experience of the producers and the knowledge of teachers and students, with a view to improving crop productivity; The dialogue of knowledge between producers and the academy allowed obtaining hybrid knowledge related to the cultivation very useful in the adoption of the adjustment of the technological package of the crop.

2. Materials And Methods.

Type of study

A descriptive and interpretive study that used participatory research with farmers and applied experimental research.

It was carried out in five stages: 1. Motivation, organization and agreements with the farmer researchers; 2. Establishment,

accompaniment and monitoring of the plots of experimentation and technological adjustment; 3. Situation Analysis through participatory characterization; 4. Monitoring the research plots; 5. Socialization of results.

The participatory research techniques used were: Participatory Rural Diagnosis (PRA), appraisals, direct and participant observation, interviews and semi-structured dialogues, group discussions and analysis, information output matrices, ideas for group reflection, talking maps, analysis of qualifications and scores, comparison of focus groups, workshops, semi-structured interviews, field days, participatory research plots and transects, from a research on demand scheme.

Population

328 farmers participated in the study, grouped into 40 subgroups, (which were formed in order to make teamwork by cities more viable): 8 in the city of Apia, 9 in Belen de Umbria, 6 in Guatica, 1 in Pereira, 7 in Quinchia, 6 in Santa Rosa de Cabal and 3 in Santuario.

Sampling technique

The selection of the sample was intentional for convenience, the selection criterion of the farmers was their connection to 11 associations of producers of the state of Risaralda (Table 1), of which 328 were selected and distributed as follows:

Table 1. *Producers by associations of farmers of the state of Risaralda*

Associations	City	Number of farmers
AMOROSA	Santuario	50
HORFRUBELLA	Pereira	14
AMORQUIN	Quinchia	82
COPAC - ASOMORIGUA	Guatica	68
ASMOBEL	Belen de Umbria	45
FRUTIMORA - ASOMORALCA - APROMAC - PROMERALDA	Apia	22
MUSA	Santa Rosa de Cabal	47
Total		328

Stages of The participatory research with farmers

Stage 1. Motivation, organization and agreements with farmers-researchers

In this first stage, the project was socialized with the producers, agreements were reached about the activities to be developed and visits were made to the farms where the research plots were established.

The foundations were laid for conducting research, collaborative exchange and collective construction of knowledge.

Stages 2. Situational analysis through participatory characterization

The situational analysis is presented in table 2

Table 2. Situational Analysis Tools

Participatory workshops	Workshop development	Workshop activities	Exit protocols or training products
- Strengths - Limitations - Opportunities - Risks	- Installation - Registry - Presentation - Feedback - Induction to the theme - Workshop closure - Exit protocols or training products	- Characterization of production systems - Matrix recognition - Prioritization of problems - Proposal of solutions	- Talking maps - Identification sheet of strengths, limitations, opportunities and risks of the crop by nucleus - Limitations weighting matrix. - Record of the approach to solutions suggested by farmers.

The situational analysis of blackberry production in the state of Risaralda was carried out through the characterization of the crop, from three types of participatory workshops:

- A. Situational analysis workshops through participatory characterization
- B. Workshops of Identification of cultural tasks for the blackberry crop

C. Workshops on Identification of pests and diseases vs Phenology of the blackberry crop

a. Situational analysis workshops through participatory characterization

In these workshops three activities were addressed: a) characterization of the production system, b) recognition of crop and c) prioritization of problems. For the identification of the Strengths, Limitations, Opportunities and Risks of the crop, the matrix (Table 3) and the protocols or output matrices were used in order to systematize the information:

Table 3. *Matrix: Strengths, limitations, opportunities and risks of blackberry crops in the state of Risaralda*

City	Strengths, Limitations, Opportunities, Risks				
	<i>Cultural</i>	<i>Social</i>	<i>Comercial</i>	<i>Environmental</i>	<i>Technical</i>
Apia					
Belen de					
Umbria					
Guatica					
Pereira					
Quinchia					
Santa Rosa					
de Cabal					
Santuario					

For the analysis and grouping of the Strengths, Limitations, Opportunities, Risks of the crop, a weighting matrix was used (Table 4), by means of which the producers rated each aspect according to a scale from 0 to 3, where 0 is no incidence value and 3 the tallest.

Table 4. *Strengths, Limitations, Opportunities, Risks weighting matrix*

Incidence	Value	Description
None	0	It has no impact on blackberry production system
Low	1	It has a low impact on the blackberry production system
Half	2	It has a medium impact on the blackberry production system
High	3	It has a high impact on the blackberry production system

b. Workshops of Identification of cultural tasks for the blackberry crop

Three activities were addressed in these workshops: a) feedback of the results of workshop as input behavior, b) identification of cultural tasks and c) relationship of cultural tasks with phenological stages and phytosanitary aspects (pest insects and diseases). For the identification of the cultural tasks, the identification form of cultural tasks was used for the cultivation of blackberry without thorn (Table 5).

Table 5. *Matrix of identification of cultural tasks*

Cultural work	Objective of cultural work	Tool or product used

Once the cultural tasks had been identified, the farmers related them to the phenological stages of the crop and the phytosanitary aspects (pest insects and diseases), for this the relationship matrix of cultural tasks with phenological stages and phytosanitary aspects of the crop was used (Table 6)

Table 6. *Matrix of cultural tasks vs phenological stage vs phytosanitary aspects*

Cultural work	Phenological stage in which the work is done	Time of realization	Insect or disease that appears when doing the work

The group discussion and analysis technique was used by each nucleus of producers in order to evaluate the cultural tasks, their usefulness and the tools or activities carried out.

c. Workshops on Identification of pests and diseases vs Phenology of the blackberry crop

For the identification of the pests and diseases of the crop, the environmental offer, the phenological cycle, the phytosanitary problems and their influence on the development of the plant were taken into account, as well as the climatic periods of greater prevalence and the phenology of the crop. To record the information, the identification sheet for pests and diseases and their relationship with the phenological stage (Table 7) was used.

Table 7. *Matrix of relation of insect pests and diseases with phenological stages*

Phenological stages	Pest insect	Diseases
<p>Phenological Stage I: Sowing from seed to final site: 24 to 35 days</p>		
<p>Phenological Stage II: Definitive site at the beginning of flowering: 180 to 210 days</p>		
<p>Phenological Stage III: Start of flowering to beginning of harvest: 90 days</p>		
<p>Phenological Stage IV. Start of harvest until the end of the cycle.</p>		

The nucleus of farmers established relationships between cultural tasks, phenological stages and phytosanitary aspects (pest insects or diseases); For this, they used the relationship matrix of cultural tasks with phenological stages and phytosanitary aspects (Table 8).

Table 8. *Matrix of relation of cultural tasks with phenological stages and phytosanitary aspects*

Cultural work	Phenological stage in which the work is done	Time of realization	Insect or disease that appears when doing the work
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Finally, relationships were established between climatic changes and activities that favor the appearance of pests and diseases. The registration of the information was carried out by means of the identification card of the climatic changes and / or activities that favor the appearance of pests and diseases in the no thorn blackberry crop is presented in Table 9.

Table 9. *Matrix of relation of pest insect and diseases with cultivation activities and climate change.*

Climate change.	Activity in the crop	Pest Insects	Disease
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Stages 3 and 4. Establishment, accompaniment and monitoring of the plots of experimentation and technological adjustment

8 demonstration plots were installed in 8 properties of blackberry farmers located in:

Quinchia, Guatica, Belen de Umbria, Santa Rosa de Cabal, Pereira, Apia and Santuario.

Stage 5: Socialization of results

The socialization of the results, both from the demonstration plots and the situational analysis of the crop, was carried out using methods such as field days and training events.

3. Results And Discussion

Stage 1: Motivation, organization and agreements with farmer-researchers

Meetings were held with the boards of directors of each one of the associations to organize the research process and the areas where they would be carried out, in the same way, the minutes of commitment between the institution and the co-investigating farmers were signed.

Stage 2. Situational analysis through participatory characterization

Social Cartography - Talking Maps

The first method used to characterize blackberry culture in Risaralda was Social Cartography. The producers made talking maps of their farms where they drew the productive system, the other crops and areas of the producing farms. From the analysis with social cartography, it was found that the no thorn of blackberry crop in Risaralda is 90% of peasant agriculture, it is carried out on plots of between 0.5 to 1 hectare, under the modalities of ownership, sharecropping and leasing, the 30% are tenants, the labor force is family and the tasks are classified by gender and age; one hectare produces 8.5 t / year and generates 2.5 minimum wages.

Situational Analysis Workshops through participatory characterization

For the situational analysis and characterization of the blackberry cultivation in Risaralda, 24 workshops were carried out in which 27 variables that gave rise to 63 matrices or exit protocols were analyzed. In these workshops, 19 variables were addressed in four activities: 1. Characterization of the productive systems,

2. Recognition of the Strengths, Limitations, Opportunities, Risks in the crop, 3. Prioritization of problems and 4. Proposal of solutions.

The variables addressed by the producers were:

1. Environmental offer
2. Roads of communication
3. Producer associations
4. Management of the technological package (varieties, planting distances, propagation systems, cultivation practices, pruning, tie-downs or tutored, fertilizers, pest and disease management, harvest, post-harvest)
5. Technical assistance and training
6. Commitment of associates
7. Means of transport
8. Refrigeration in the sidewalks or collection sites of the associations
9. Sustainability in price
10. Land tenure for cultivation
11. Consumer demand at the industrial and household level
12. Value to the product
13. Productive areas
14. Promising fruit 1
15. Costs in the establishment
16. Pests and diseases
17. Biosecurity
18. Planting distance
19. Tutoring systems

Identification of the strengths, limitations, opportunities and risks of the crop

The strengths, limitations, opportunities and risks of blackberry cultivation in the department of Risaralda were cataloged and analyzed based on the technical, economic, social, cultural, environmental and commercial components, thus obtaining a comprehensive analysis of all cultivated areas.

Once the strengths, limitations, opportunities and risks were grouped for each producing municipality, they were classified and analyzed taking into account the factors, resulting in a comprehensive analysis of the entire crop for the department of Risaralda:

Strengths of no thorn of blackberry crop in Risaralda

The blackberry farmers of the state of Risaralda identified and prioritized 19 strengths for the crop, the scores placed as main those related to the technical economic factor: quality of the seed and the product, cultural work and GAP, adequate use of protection kits and permitted chemical inputs, family labor, savings and revolving fund, and land tenure.

The following are those that were prioritized in the 40 nuclei of the 7 municipalities (Table 9):

Table 9. Main strengths of no thorn of blackberry crop in the department of Risaralda

Factors	Strengths
Cultural	Experience and knowledge of the crop, Family support
Social	Associations, Good organization, Commitment and sense of belonging
Commercial	Access and communication routes, Good merchandising and marketing, Packaging and packaging presentation
Economic	Family labor, Revolving and savings fund, Stable price and timely payments, Land tenure.
Environmental	Good location of the properties, adequate environmental offer for cultivation, accessibility of water and protection of water sources.
Technical-productive	Quality of the seed and the product, Cultural tasks and GAP, Proper use of permitted pesticides and use of protective equipment, Live guardians and polyculture.

Limitations in the no thorn of blackberry crop in Risaralda

The blackberry farmers in Risaralda described an average of 17 limitations for cultivation for each of the producing municipalities.

Using a quantitative scale, the percentages of the main limitations were calculated and taking into account the frequencies and weighted averages, the three main limitations were determined, namely: 1) pests and diseases, 2) inappropriate use of pesticides, and 3) infrastructure as regards to cold rooms, homes and septic tanks, these limitations are highlighted in Apía, Quinchía, Belén de Umbría and Santa Rosa de Cabal.

Some farmers expressed the opinion that: "the problem that most afflicts us and that limits us are pests and diseases, more than all the Crespers caused by the *Oidium* fungus"; "We get confused because they tell us to use this, apply this, this is forbidden and others come and tell us otherwise, then one becomes that he does not know what to believe" and "people are getting very sick from toxins"

Blackberry crop opportunities in Risaralda

The most relevant opportunities were described around the technical - productive factor in what has to do with: access to training and implementation of GAP, technical support - MADR support, processing, post-harvest management, product transformation, certifications, records cultivation, integrations between partners and the family, support from institutions and better living conditions for producers and their families; access to education, decent housing, social security and health (Table 10):

Table 10. *Opportunities for no thorn of blackberry crop in the producing areas of the department of Risaralda*

Factors	Opportunities
Cultural	Acquire better knowledge, rural opportunities and tourism.
Social	Integrations between partners and the family in cultivation, Support from different entities and institutions, Better living conditions.
Commercial	New markets and commercial alliances, Product transformation, Obtaining a good price.
Economic	Access to bank loans and aid, Strengthen the revolving and savings fund, Added value of the product.
Environmental	Improvement of water sources and environmental conservation, Diversification and reforestation.
Technical-productive	Access training and implementation of GAP, technical support and support from the MADR, processing, postharvest handling and transformation of blackberries, certifications and records for cultivation.

Risks in the blackberry crops in Risaralda

The main risks identified by farmers in Risaralda were: climatic factors that affect the crop and cause losses, low prices in marketing, high input costs and low sales prices.

In this regard, Jainer Bedoya, president of ASMOBEL stated that "to produce a kilo of blackberry they spend \$ 1,200 pesos and Postobon buys it for \$ 2,000 so their earnings are very low."

Workshops of identification of cultural tasks for the blackberry crop

Table 11 shows the cultural tasks identified by the blackberry farmers in the seven producing cities. With 100% of frequency the sowing and the establishment of tutored systems are presented, that is to say, all the farmers consider these tasks essential for the development of the crop; with 94% edaphic and foliar fertilization and with 90% the work of preparing the land, tracing and drowning.

Seed selection and post-harvest management were only taken into account as cultural tasks in less than 10% of the farmers. The producers stated using tools such as: machetes, *palín*, hoe, fiber, wood (tutored), pruning shears, agro-inputs such as fertilizers, herbicides, fungicides, insecticides and baskets for harvesting.

Table 11. *Cultural activities identified for blackberry farmers in the producing areas of the state of Risaralda*

Work	Percentages (%)
Sowing the seed	100
Tutored	100
Fertilization	94
Batch preparation	90
Lot plot	90
Drowned out of the lot	90
Fumigation with fungicides	89
Maintenance pruning	88,6
Formation pruning	77
Insecticide spraying	77
Harvest	77
Weed control	74
Determine the batch	56
Plateo	37
Soil disinfection	13
Post-harvest	9
Seed selection	3

The producers indicated that there are tasks that are carried out only once in the crop cycle, such as: the selection of the land, the layout and the drowning. Others, on the contrary, must be carried out repeatedly: fertilization, weed control, fumigations, pruning and harvesting; the time and number of times that the work must be carried out depends on the conditions of the crop, climate and the producer's decision.

Workshops on the identification of pests and diseases vs phenology of the blackberry crop

The blackberry farmers in the state of Risaralda reported 35 insects associated with the different phenological stages of the crop, this indicates a risk due to the increase in production costs, given the amount of controls they must carry out, in addition to the losses of the product and ignorance of the type of handling.

In general, the borers, with a high incidence in the crop, occupied the highest levels reported by the farmers for the phenological stages. It should be clarified that when referring to the borers, both the stem and the neck of the plant are covered; According to Betancourt *et al.*, (2014), these insects involve severe damage since they pierce and penetrate the plant organ leaving excrement in its wake, as it progresses, wilting and subsequent drying is observed from the apex towards the base of affected branches.

Regarding the climatic period, the farmers reported that 22 of the 35 pests appear in warm periods with percentages equal to or greater than 50% in all phenological stages; they are: red spider mite, mites, prodiplosis, rooks, mosquito and yellow mosquito with a 100% prevalence.

In the rainy season, 6 pests are reported (slugs, virgin's burrita, foliage eaters, fruit flies, weevils and chrysomelids) with perceptions of the farmers higher than 50%. It was found that there are seven pests in all climatic periods, of these, chizas, suckers, choppers, whiteflies and parrots with a reference of 100% of the blackberry producers of the department.

The farmers mention that they control 83% of the pests using insecticides, however, they alternate with other methods such as: cultural work, soil treatments, weed management, biological baits,

among others; For the rest of the pests, baits (slugs), acaricides (mites and spider mites), scarecrows (parrots), cultural tasks (chrysomelids) are used in 100%.

Diseases vs Crop phenology

The blackberry farmers in the state of Risaralda identify 18 diseases in the different phenological stages of the crop, however, Crespers, Antracnosis, Peronospora and Botrytis are mentioned as the most common and with the highest incidence in all the phenological stages of the crop; With the exception of Botrytis, since this disease begins its appearance in flowering. Other diseases reported by the producers were: Fusarium, Phythoptora, Nematodes, Gray spot, Virosis, hereditary malformations, Descending death, Rust, Verticillium, Alternaria and Rosellinia, with appreciations lower than 20% of the producers.

The farmers stated that 3 of the 18 reported diseases occur in all climatic periods, 15 are reported by more than 50% of the producers in the rainy period: *Fusarium*, fungal complex, sores, gray spot, mildew, descending death and *Verticillium*, therefore, the control or management is carried out in these stages.

Farmers reported that they use fungicides to control 13 of the 18 diseases reported for the crop, of these 57% (8 diseases) are alternated with other management such as pruning, timely collection of fruit and weed management, among other tasks. For the control of nematodes, 100% of the producers use nematicides, in the same way, 100% of them mention that they control Virosis and eliminate the plant to control descending death.

Conclusions.

Participatory research with farmers turned out to be a useful and versatile strategy for conducting research on demand. The exchange and collaboration with the farmers allowed not only to

know the reality of the blackberry crops in its different dimensions, but also to carry out field trials with research plots.

The knowledge of the farmers about the cultivation of blackberry allowed them to be the ones who characterized it and realized how they are managing it with its strengths and weaknesses; An account of this was also the identification of the main cultural tasks, pests and diseases of the blackberry and its relationship with the phenological stages and climatic period.

The participatory research tools are multiple and varied, as are the participation scales; In this case, the participation was functional and for incentives, as the producers not only participated in the workshops, but also assumed functions in the plots with responsibilities in aspects related to the installation of the same, the appropriate propagation methods, maintenance , the data collection and the socialization of the results; This led to a high degree of interest from producers in the process, which led to the adoption of new elements of the technological package of no thorn blackberry crops in the state of Risaralda.

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Chili pepper (*capsicum annum* l. var. cayenne) as feed additive for rabbits

Ají (*capsicum annum* l.var. cayenne) como aditivo alimentario para conejos

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Abstract

Chili is used as a substitute for growth promoting antibiotics in animal production. The objective of this work was to evaluate the effect of supplementation with Chili Powder (*Capsicum annum* L. var. Cayenne) on fattening rabbits consuming commercial concentrate during the fattening phase on productive performance, carcass, digestive system size and digestibility of the diet. We used 10 rabbits of the New Zealand White breed with 30 d of age that were randomly distributed in the treatments according to a completely Randomized Experimental Design. The treatments consisted of two diets: a control in which concentrate was supplied

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without Chili and another in which the concentrate of the control treatment was mixed with Chili Powder (20 g kg⁻¹ of concentrate). Feed Chili Powder did not affect live weight ($P>0.05$), feed intake ($P=0.6076$), feed conversion rate ($P=0.4849$), diet digestibility ($P>0.05$), weight carcass ($P=0.5396$), weight of different portions of the digestive system ($P>0.05$), and the length of the small intestine ($P=0.6132$). Rabbits receiving Chili presented a liver with a lower relative weight (g kg⁻¹ of live weight) compared to control, but not the relative weight of the carcass ($P=0.4399$) and the other portions of the digestive system ($P>0.05$). It is concluded that under the conditions of the experiment, the Chili cannot be considered as a growth promoter in rabbits, but a lower relative weight of liver should be considered in future researches.

Key words. Growth promoting antibiotics, phytogetic feed additive.

Resumen

El Ají se utiliza como sustituto de los antibióticos promotores del crecimiento en la producción animal. El objetivo de este trabajo fue evaluar el efecto de la suplementación con harina de Ají (*Capsicum annum* L.var. Cayenne) en conejos de engorde que consumieron concentrado comercial durante la fase de engorde sobre el rendimiento productivo, canal, tamaño del sistema digestivo y digestibilidad de la dieta. Se utilizaron 10 conejos de raza Blanca de Nueva Zelanda con 30 d de edad que se distribuyeron aleatoriamente en los tratamientos según un Diseño Experimental Completamente al Azar. Los tratamientos consistieron en dos dietas: una control en la que se suministró concentrado sin Ají y otra en la que el concentrado del tratamiento control se mezcló con chile en polvo (20 g kg⁻¹ de concentrado). La harina de ají no afectó el peso vivo ($P> 0.05$), la ingesta de alimento ($P=0.6076$), la tasa de conversión de alimento ($P=0.4849$), la digestibilidad de la dieta ($P> 0.05$), el peso de la canal ($P=0.5396$), el peso de diferentes porciones del sistema digestivo ($P>0.05$) y la longitud

del intestino delgado ($P=0.6132$). Los conejos que recibieron Ají presentaron un hígado con un peso relativo menor (g kg^{-1} de peso vivo) en comparación con el control, pero no el peso relativo de la canal ($P=0.4399$) y las otras porciones del sistema digestivo ($P>0.05$). Se concluye que bajo las condiciones del experimento, el Ají no puede ser considerado como un promotor del crecimiento en conejos, pero se debe considerar un menor peso relativo de hígado en futuras investigaciones.

Palabras clave: Antibióticos promotores de crecimiento, aditivos alimenticios fitogenéticos

1. Introduction

The antibiotic growth promoters (**AGP**) improves the production performances of rabbits (Falcão et al., 2007), but its residue in animal products gradually created antibiotic resistant microbes (Thiamhirunsopit et al., 2014). The limited use of **AGP** as the feed supplement has stimulated investigations on alternative feed additives in animal nutrition (Corduk et al., 2013), like natural substances (Thiamhirunsopit et al., 2014) called phytogetic compounds (Mountzouris et al., 2011). Phytogetic feed additives are plant-derived products used in animal feeding to improve the performance of agricultural livestock and are discussed possibly to add to the set of nonantibiotic growth promoters (Windisch et al., 2008).

Peppers from *Capsicum* species are native to the tropical and humid zones of Central and South America. They are commonly used as a spice or food and also for a broad variety of therapeutic applications. Capsaicin, the main representative of the pungent components, is a lipophilic alkaloid and has been used in clinical practice (Zimmer et al., 2012) with antimicrobial activities (Al-Kassie et al., 2011; Zimmer et al., 2012) against pathogenic bacteria, such as *Escherichia coli*, *Clostridium perfringens*, and *Salmonella enteritidis* (Corduk et al., 2013). Chili has been used

as a substitute for antibiotics (Thiamhirunsopit et al., 2014) and has been evaluated in broilers (Al-Kassie et al., 2011, Atapattu and Belpagodagamage, 2011, Thiamhirunsopit et al., 2014), laying hens (Lokaewmanee et al., 2013) and pigs (Manzanilla et al., 2006). We didn't find any studies in which Chili was used in rabbit feeding.

The small producers of rabbits usually supply the commercial concentrate with various plant materials in order to make the diet more efficient and improve the animal health. The aim of this work was to evaluate the effect of supplementing with Chili Powder (*Capsicum annum* L. var Cayenne) to rabbits that consume commercial concentrate during the fattening phase on the productive performance, the carcass and the digestibility of the diet.

2. Materials and Methods

Location

This experiment was performed in an experimental farm “El Jazmín” of Unisarc University, located in Santa Rosa de Cabal (Risaralda, Colombia) at 4°52'07” N, 75°37'22” W and 1701 masl. Average temperature of 18.6 °C and average yearly precipitation is 2620 mm yr⁻¹. This experiment was carried out between April and May 2015.

Duration and treatments

The experiment lasted 35 d (7 d of adjustment to the metabolic cages, and a collection period of 28 d). The treatments consisted of two diets supplied to rabbits during the fattening phase that were differentiated according to the inclusion of Chili Powder: a control where commercial concentrate was supplied without Chili Powder and another in which the concentrate of the control treatment was mixed with Chili Powder (20 g kg⁻¹ of concentrate).

The Chili Powder was prepared by grinding dried chili (60°C/36 h) through 2 mm diameter sieve blender. Chemical composition of concentrate and Chili Powder used for the experiment are presented in Table 1.

Table 1. *Chemical composition concentrate and Chili meal used for the experiment*

Component	Concentrate	Chili
Dry matter (DM), g kg ⁻¹	868.5	876.0
Crude protein (CP), g kg ⁻¹ DM	172.9	90.2
Neutral detergent fiber (NDF), g kg ⁻¹ DM	319.8	382.8
Acid detergent fiber (ADF), g kg ⁻¹ DM	170.2	382.8
Non-fibrous carbohydrates (NFC) ³ , g kg ⁻¹ DM	338.6	429.4
Acid detergent lignin, g kg ⁻¹ DM	26.8	ND ²
Ether extract (EE), g kg ⁻¹ DM	71.6	37.8
Ash, g kg ⁻¹ DM	97.1	59.8
Gross energy ³ , kcal kg ⁻¹ DM	4382	4236

Note. ¹NFC = 100 – (CP + EE + Ash + NDF) (Omer et al., 2013). ²Not determined. ³Gross energy was calculated by multiplying the nutrient concentrations by their heats of combustion (each g of CP, EE, carbohydrates -NFC+NDF- produces 5.65, 9.40 and 4.15, respectively) (Omer et al., 2013).

Animals and management

A total number of 10 male New Zealand White rabbits aged 30 d with an average body weight of 833±189 g (Ave±SD), were randomly allocated into two treatment groups with 5 replicates per treatment. Rabbits was individually kept in digestibility cages (35 x 50 x 35 cm; width x length x height). The cages were equipped with a feeder that avoid contamination of the feed by feces or urine and allowing recording individual feed intake for each rabbit; a drinker steel nipple with drainage system that avoids contamination of the feces with water; and a collection system allows quick escape of urine and individual collection of feces, urine and waste. the experimental diets and drinking water were supplied *ad libitum*. In order to ensure *ad libitum* consumption,

a quantity of concentrate equivalent to the consumption of the previous day plus 20% was supplied, which was divided into two doses: the first at 7:00 h and the second at 13:00 h.

The rabbits were weighed at 30, 37 and 65 d of age (at weaning, at start of the collection period and at slaughter, respectively); the weighing was carried out at 7:00 h prior to the supply of food. The slaughtering of rabbits was made as described by Castaño and Cardona (2015) on day 35 of the experiment, when they were 65 d old. Once the animals were sacrificed, the carcass, stomach, small intestine (with and without content), caecum, colon+rectum, and liver were weighed; additionally, the length of the small intestine was measured. The digestibility test was performed for 7 d, prior to sacrifice.

Collection samples

To determine the feed intake, the waste of the previous day was weighed (at 7:00 h) it was stored at -20° C and sent to the laboratory to determine the dry matter (**DM**) concentration and correct the **DM** intake.

On day 32, 500 g of concentrate and Chili were collected. During the digestibility test the feces were collected every 2 h and stored at -20 °C in a plastic container per cage; the total excretion of feces was dehydrated at 60°C for 48 h, it was macerated manually and passed through a strainer to remove the hairs coming from the rabbits. The samples of concentrate, chili and feces were ground through a Cyclone Sample Mill (Udy®) with 1 mm sieve and subsequently analyzed in the laboratory.

Chemical analysis

Concentrate, Chili and feces were analyzed to determine concentration of **DM** and ash (procedures AOAC-930.15 y AOAC-942.05, respectively; AOAC, 2010); crude protein (**CP**)

according to Kjeldahl method (Thiex et al., 2002); ether extract (**EE**) according to Soxhlet method (procedure 920.39 AOAC, 2010); neutral detergent fiber (**NDF**), acid detergent fiber (**ADF**) and acid detergent lignin (**ADL**) were determined according to the method of Van Soest et al. (1991), using heat stable amylase. Non-fibrous carbohydrates (**NFC**) were estimated according Omer et al. (2013) using the following equation: $\text{NFC} = 100 - (\text{CP} + \text{EE} + \text{Ash} + \text{NDF})$. Gross energy (Kcal kg^{-1} **DM**) was calculated by multiplying the nutrient concentrations by their heats of combustion (each g of **CP**, **EE**, carbohydrates produces 5.65, 9.40, 4.15 kcal; Omer et al., 2013).

Calculations

Feed conversion rates (**FCR**) were calculated as described by Castaño and Cardona (2015) and apparent digestibility according to Perez et al. (1995).

Statistical analysis

All data in this study were statistically analyzed by one-way analysis of variance (ANOVA) using the software Statistix (version 8.0, Copyright© 1985-2003 Analytical Software). Significance was declared at $P < 0.05$.

3. Results and Discussion

The Chili Powder did not affect live weight (**LW**) at 65 d ($P=0.3044$), weight gain ($P > 0.05$), feed intake ($P=0.6076$), and **FCR** ($P=0.2105$) (**Table 2**).

Table 2. *Effect of Chilli Powder (Capsicum annum L. var. Cayenne) dietary incorporation on growth performance in growing rabbits New Zealand White (37 and 65 d of age)*

Ítem	Treatment ¹		SEM ²	P-value
	Control	Chilli Meal		
Live weight, g at 65 d	1969	2087	129	0.5396
Weight gain				
Total, g	1022	900	163	0.6127
Daily, g	36	32	6	0.6127
Relative ³	1143	783	207	0.2540
Feed intake, g	3178	3346	222	0.6076
Feed conversion rate⁴	3.44	2.85	0.30	0.2105

Note. 1 Diets supplied to rabbits: a Control where commercial concentrate was supplied without Chili Meal and another in which the concentrate of the control treatment was mixed with Chilli Meal (20 g kg⁻¹ of concentrate). 2 Standard error of a mean. 3g of weight gain per kg of weight at starting the experimental diet. 4g of feed intake per g weight gain.

The addition of Chili Powder did not affect the weight carcass (P=0.5396), the weight of different portions of the digestive system (P>0.05), and the length of the small intestine (P=0.6132). The Chili Powder in the diet affected the relative weight of the liver (g kg⁻¹ live weight, P=0.0198), but not the relative weight of the carcass (P = 0.4399) and the other portions of the digestive system (P>0.05). The rabbits that received Chili had a liver with a lower relative weight compared to the control (42 and 35 g kg⁻¹ of live weight for the control and Chili Powder treatment, respectively) (Table 3).

Table 3. *Effect of Chilli Powder (Capsicum annum L. var. Cayenne) dietary incorporation on carcass and the size of different portions of the digestive system in growing rabbits New Zealand White (37 and 65 d of age)*

Ítem	Treatment ¹		SEM ²	P-value
	Control	Chilli Meal		
Carcass weight, g	1040	1129	86	0.4849
Weight digestive system, g				
Stomach	98	91	5	0.3170
Small intestine + content	63	67	5	0.6292
Small intestine	55	60	6	0.6502
Caecum	91	111	10	0.1837
Colon + rectum	47	56	6	0.3588
Liver	83	73	5	0.2239
Small intestine length, cm	257	235	30	0.6132
Relative weight, g kg⁻¹ Live Weight				
Canal	526	540	12	0.4399
Stomach	50	44	3	0.2112
Small intestine + content	32	32	1	0.9058
Small intestine	28	29	2	0.6955
Caecum	46	53	3	0.1532
Colon + rectum	25	27	4	0.6791
Liver	42	35	2	0.0198

Note. 1 Diets supplied to rabbits: a Control where commercial concentrate was supplied without Chili Meal and another in which the concentrate of the control treatment was mixed with Chilli Meal (20 g kg⁻¹ of concentrate). 2 Standard error of a mean.

The supply of chili pepper did not affect the digestibility of the DM (P=1.0000), OM (P=0.9433), CP (P=0.5375), EE (P=0.9429), carbohydrates (P=0.7546), and gross energy (P=0.9747) (Table 4).

Table 4. *Effect of Chilli Powder (Capsicum annum L. var. Cayenne) dietary incorporation on apparent digestibility¹ of diet in growing rabbits New Zealand White (37 and 65 d of age)*

Feed fraction	Treatment ²		SEM ³	P-value
	Control	Chilli Meal		
Dry matter	698.3	698.3	9.3	1.0000
Organic matter	716.3	717.3	9.5	0.9433
Crude protein	785.8	771.0	16.0	0.5375
Ether extract	789.0	792.3	30.8	0.9429
Carbohydrate ⁴	690.3	695.0	10.3	0.7546
Gross energy	727.0	726.5	10.7	0.9747

Note. 1 g of feed fraction digested per kg of feed fraction consumed. 2Diets supplied to rabbits: a Control where commercial concentrate was supplied without Chili Meal and another in which the concentrate of the control treatment was mixed with Chilli Meal (20 g kg⁻¹ of concentrate). 3Standard error of a mean. 4Carbohydrates = 100 - (CP + EE + Ash)

The use of **AGP** improves the productive performance of the animals and the efficiency of the diet; but its use is currently restricted due to a negative effect on human health. The additives used as alternatives to **AGP** have been studied mainly in pigs and chickens, and due to the particular characteristics of rabbit digestive physiology, it can be dangerous to extrapolate conclusions from other such species (Falcão et al., 2007).

The Chili has a variety of therapeutic applications in traditional medicine, due to the fact that it has phytochemical components with antioxidant properties such as carotenoids, capsaicinoids and phenolic compounds, particularly flavonoids, quercetin and luteolin. Capsaicin is the main pungent component, it is a lipophilic alkaloid and has anti-inflammatory and analgesic activity (Zimmer et al., 2012). The Chili has been used as alternative for **AGP** in broilers (Thiamhirunsopit et al., 2014), laying hens (Lokaewmanee et al., 2013) and pigs (Manzanilla et al., 2006), due to its antibacterial effect. The present work hoped to document

the effect of supplementing with Chili Powder (*Capsicum annum* L. var. Cayenne) to fattening rabbits that consume commercial concentrate during the fattening phase on the productive performance, the carcass and the digestibility of the diet.

Weight live at 65 d (2028g) was slightly lower than that reported by Castaño and Cardona (2015; 2169g). These results suggest that our concentrate and our handling under experimental conditions were suitable for fattening rabbits. However, and different from what was expected, the addition of chili pepper to the diet did not affect live weight at slaughter. It has been suggested that **AGP** are counterproductive for species that have a large part of their digestion with microbes, due to their antimicrobial nature (Falcão et al., 2007); but our results, do not show a negative effect on weight.

The **AGP** has been shown to improve performance in rabbits (Falcão et al., 2007), but we did not find this effect in our work. The adequate handling conditions in the experiment and the absence of an immunological challenge could explain these results; because germ-free animals do not respond to **AGP**, and they are more efficient when environmental conditions are sub-optimal (Falcão et al., 2007). Another explanation could be the level of inclusion, as will be discussed later, the levels used in this experiment could be so very low and not affect the digestibility of the diet, and therefore, not affect the productive performance.

We did not find effect of Chilli dietary incorporation on carcass and the size of different portions of the digestive system; but relative weight of liver (g kg^{-1} live weight) was lower when rabbits consumed chilli. We did not find works with similar results, or an explanation for them. But, due to the fundamental role of the liver on the metabolism of nutrients, it is important to deepen and take these results into account in future research.

Our results of diet digestibility for control treatment (698.3, 716.3, 785.8, 789.0, and 727.0 g kg⁻¹ for **DM**, **OM**, **CP**, **EE** and **GE**, respectively) were similar to reported for control diet by others researchers for (**DM**, g kg⁻¹: 700.3 -Omer et al., 2013- and 684.0 -Dorbane et al., 2019-; **OM**, g kg⁻¹: 676.6 -Omer et al.,2013- and 678.0 -Dorbane et al., 2019-; **CP**, g kg⁻¹: 775.3 -Omer et al., 2013- and 803.0 -Dorbane et al., 2019-; **EE**, g kg⁻¹: 773.4 -Omer et al., 2013- and 759 -Celia et al., 2010); but higher than others research (**DM**, g kg⁻¹: 602 -Casado et al., 2010- and 499 -Celia et al., 2010; **OM**, g kg⁻¹: 612 -Casado et al., 2010- and 505 -Celia et al., 2010-; **CP**, g kg⁻¹: 712 -Casado et al., 2010- and 719 -Celia et al., 2010-; **EE**, g kg⁻¹: 623.0 -Casado et al., 2010-; **GE**, g kg⁻¹: 591 -Casado et al., 2010- and 666.0 -Dorbane et al., 2019-); these results suggest that our concentrate had adequate digestibility for fattening rabbits. We did not find effect of Chili Powder on digestibility, although there were reports about benefits of capsaicin that it could digestive stimulant action (Platel and Srinivasan, 2004). Thiamhirunsopit et al. (2014) did not found effect of Chili Powder on apparent ileal nutrient digestibility coefficients in broilers, and they concluded that capsaicin at the level of 20–30 mg kg⁻¹ of feed (11.6-17.4 g of Chili Powder kg⁻¹ of diet) had no effect on digestibility, and they indicated further investigation with higher concentration of capsaicin should be implemented. We use a similar inclusion of Chili Powder (20 g⁻¹ kg) than Thiamhirunsopit et al. (2014), therefore, we too suggest further research with greater inclusion or Chili Powder.

4. Conclusions

The addition of Chili Meal did not affect the live weight, the feed intake, the digestibility of the diet; indicating that under the conditions of this experiment, the Chili can not be considered as a growth promoter in rabbits. The rabbits that received chili pepper had a liver with a lower relative weight, which should be considered in future researches.

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Intestinal integrity in broilers fed with ramie silage (*boehmeria nivea*) mixed with cassava bran (*manihot esculenta*)

Integridad intestinal en pollos de engorde alimentados con ensilaje de ramio (*boehmeria nivea*) mezclado con afrecho de yuca (*manihot esculenta*)

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Abstract

Bird's intestinal health is determinant because of its connotation on disease control, but also because it is the source of utilization of nutrients that results in successful production. Conventional raw material used for the fabrication of concentrate is expensive and has low availability, for these reasons, food

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alternatives with indigenous resources such as forage, have been sought out. In this way, *B. nivea* stands out as an alternative for feeding birds. The goal of this study was to determine the effect of using silage from *B. nivea* mixed with cassava bran (*Manihot esculenta*) on the intestinal integrity of fed broilers. 60 male broilers of the Ross 308 line were located in 12 pens, to each of which a completely randomized experimental treatment design was given. The treatments consisted in two types of diets provided to the birds, a control group that was only given concentrate and another group, that additional to the concentrate used in the control group, was given *B. nivea* silage mixed with cassava bran. The results of this study indicate that the silage from *B. nivea* leaves was able to be used as an alternative to increase the height, width and depth of villi resulting in a greater digestion and absorption surface for nutrients.

Key words: tropical forage; Ramie; Intestinal health; Broilers

Resumen

La salud intestinal en las aves es determinante debido a su connotación en el control de enfermedades, pero también porque es la fuente de aprovechamiento de nutrientes que deriva en una producción exitosa. Las materias primas convencionales utilizadas en la fabricación de concentrados son costosas y de baja disponibilidad, por ello se han buscado alternativas de alimentación con recursos autóctonos como forrajes. De esta manera, el *B. nivea* se destaca como alternativa en la alimentación para aves. El objetivo de este trabajo fue determinar el efecto de la utilización de ensilaje de *B. nivea* mezclado con afrecho de yuca (*Manihot esculenta*) en la alimentación de pollo de engorde sobre la integridad intestinal. Se utilizaron 60 machos de engorde de la línea Ross 308 que fueron alojados en 12 corrales, a cada uno de los cuales fue asignado en un tratamiento según un diseño experimental Completamente al Azar. Los tratamientos consistieron en dos dietas suministradas a las aves, un control en

donde recibieron sólo concentrado y otra donde se suministró el concentrado del tratamiento control y adicionalmente se ofreció ensilaje de *B. nivea* mezclado con afrecho de yuca. Los resultados de este trabajo indican que el ensilaje de las hojas de *B. nivea* se puede utilizar como alternativa para aumentar la altura, ancho y profundidad de las vellosidades dando como resultado una mejor superficie para la digestión y absorción de los nutrientes.

1. Introduction

The importance of a good intestinal health in birds is determinant, not only because of its clinical connotation on disease control but also because digestion processes are complemented in the small intestine, in which epithelial cell linings absorb products from digestion (Pacheco et al., 2008). Intestinal villi are in charge of providing a large internal surface, increasing the area of intestinal absorption and digestion. The size, length and width can vary throughout the small intestine because of the specific function of each portion (Boleli et al., 2002). For this reason, intestinal integrity is the source of utilization of nutrients that results in successful production. In this sense, animal nutrition has been a productive pillar with a wide investigation field, seeking to improve digestibility of raw materials available through ingredient processing or complete balanced meals (Mahagna *et al*, 1995; Sell, 1996).

Taking into account that conventional raw materials used in the fabrication of balanced meals are expensive and have little availability, food alternatives with indigenous resources such as forage, have been sought out., which represent an important source of nutrients for animals. Different studies have demonstrated that supplementation with lead flour in aviculture, decreases production costs and improves profit margin (Betancourt et al., 2017). For these reasons, preservation and conservation of these raw materials with different practices such as silage, haymaking, and pelleting, is recommended (Ledesma, *et al*, 2002).

The Ramie (*Boehmeria nivea*) has different uses, of which animal feeding stands out because it accumulates as much N in its leaves as is found in legumes, it has rapid growth and results appetizing for poultry, cattle and pork (Moranet et al., 2012). Although *B. nivea* has low non-fibrous carbohydrate content, the cassava bran mix (*Manihot esculenta*), that has a great NFC but little protein results of great utility to compensate the deficit of NFC of the forage and of the bran protein, generating an adequate nutritional balance of this meal (Betancourt et al., 2017).

For the reasons stated above and taking into account physiologic studies that have demonstrated that, birds adapt their intestinal tract's function to maximize food digestion and nutrient absorption according to the characteristics of the digestive content (Mateos et al., 2002), it is necessary to have knowledge on the effect that, meals with forage rich on fiber, have on the internal intestinal conformation and the absorption of nutrients. The goal of this study was to determine the effect of using silage from *B. nivea* mixed with cassava bran (*Manihot esculenta*) on the intestinal integrity of fed broilers evaluating the height, width and depth of intestinal villi.

2. Materials and Methods

Location.

The investigation took place in the Cattle Farm of the University Corporation Santa Rosa de Cabal, UNISARC. El Jazmín University Campus, located at 4°52'07" LN and 75°37'22" LO, Kilometer 4 via Santa Rosa de Cabal- Chinchiná (Caldas), located at 1640 meters above sea level, with an average temperature of 18.6°C, annual rainfall of 2620 mm and a relative humidity of 72%.

The experiment was carried out in the period between April and July 2017.

Experimental period and treatments.

The experiment lasted 42 days (all the birds were received on their first day of life and had the same management, weight evaluation and uniformity until sacrifice). The treatments consisted of two diets (T2) commercial concentrate and treatment (T1) consisting of Ramie silage (*Boehmeria nivea*) mixed with cassava bran (*Manihot esculenta*). It was given at a 70:30 ratio and administered at will between 5:00 p.m. and 7:00 a.m. of the following day, during this time the concentrate was removed to stimulate the consumption of forage. Table (1).

Table 1. *Chemical composition of the silage and concentrate used in the experiment.*

Chemical composition	Concentrate	Ramie silage + cassava
Dry Matter (DM) g/kg	880.9	317.8
Raw Protein (RP) g/kg	216.2	141.7
NDF, g/kg MS	96.7	201.9
FDA, g/kg MS	51.2	137.3
NSC ¹ , g/kg MS	-	524.5
Lignin g/kg	17	81.5
Ethereal extract, % MS	-	8.1
Ashes, % MS	64.7	123.8

Animals and treatment.

60 male broilers of the Ross 308 line (1 day of age), were used, and were located in 12 pens. The experimental unit consists of cages of 5 animals, finishing the experiment with 4 birds/m². 1 m² cement floor cages were used, they had a bed of chips and brick walls equipped with two Nipple-type trough and a hopper-type birdfeeder. Each pen was assigned to the treatments, according to a completely randomized experimental design of 2 treatments with 6 repetitions. Gas brooders (1 brooder / 6 pens) were used

to control the temperature of the shed during the first 21 days (adjusting the temperature to 30°C during the first 2 days until reaching 23°C on day 27). The animals were vaccinated against Newcastle La Sota (on day 6 and 14; ocular) and Gumboro (on day 17; orally). A 23 h light regime was handled during the first 7 d and 18 h until sacrifice. The sacrifice was made by cervical dislocation and all the processes and procedures of the experiment were approved by the Bioethics Committee of the University Corporation Santa Rosa de Cabal-Unisarç.

Elaboration of the diet with Ramie silage (Boehmeria nivea).

The silage was elaborated with Ramie leaves. To make the silo, the tree branches were cut off at 10:00 a.m., stripped by hand and left in the sun until 4:00 p.m. to reduce humidity. The leaves were chopped (approximately 2.5 cm) in a pickaxe (Trapp® TRF-300), 20% of the material to be ensiled was deposited (20 kg), it was stepped on to eliminate the air and the additive was added (1 L); This process was repeated 5 times until the silage was completed, at which time the forage was covered with plastic and enough sand was deposited on it to allow the lid to close and avoid air chambers in the silo. Cane molasses mixed with fermented juice of epiphytic flora (ratio 4:1; w/v) was used as an additive. The fermented juice was prepared by adapting the description by Bureenok *et al.* (2006) as follows: 200 g of fresh forage were macerated in 1 L of H₂O d with a blender, the macerated material was filtered through two layers of gauze, the juice was mixed with cane sugar (30 g of L-1 sugar), it was deposited in an amber glass bottle avoiding air chambers, it was shaken and left to rest for 18 h at room temperature.

Collection of intestinal samples for laboratory

After evisceration, the components of the digestive system were separated to weigh the duodenum (from the pylorus to the distal portion of the duodenal turn), the jejunum (from the

duodenum to Meckel's diverticulum) and the ileum (from the jejunum to the beginning of the cecum); additionally, the length of the duodenum, the jejunum and the ileum were measured. For the histological analysis, a 3 cm segment of the terminal portion of the duodenum, the jejunum and the ileum were sectioned and washed with saline solution. Tissue samples were deposited in 10% buffered formalin for 18 h, a ratio of 1:10 (sample: formalin), washed 3 times in H₂O dd, placed in 70%(v/v) ethanol and then the tissues were subjected to histological routine with the inclusion of paraffin material. With the use of a microtome, 8 cuts of 7 µm of thickness marked with hematoxylin and eosin were made; In these cuts and with the help of an optical microscope coupled to an image analysis system, the height (distance between the beginning of the basal area coinciding with the upper portion of the crypt to the apex) and width of the villi were measured, as well as the depth of the crypts and the thickness of the muscular layer in the different segments of the intestine. Twenty measurements were made for each collective tissue.

Chemical and microbiological analysis

The concentration of moisture, ash and ethereal extract was determined in the concentrate and silage (with and without cassava bran by gravimetry (AOAC 200.18 and AOAC 9942.5 methods, respectively). Raw protein (RP) was determined by the Kjeldahl method (Thiex et al., 2002), neutral detergent fiber (NDF), and FDA acid detergent fiber (Van Soest et al., 1991) were also determined. Non-structural carbohydrates (NSC) were estimated according to NRC (1998). A microbiological examination was also carried out for the silage (See Annex E). In addition to this, ileum and cloaca swabs were performed in order to determine the health of the lot before the beginning of the treatments and they did not report pathogenic bacteria, also a water analysis presented compliance according to the established parameters.

Histological analysis of intestinal samples

The sample was fixed for 18 hours in 10% buffered formalin to protect it from the environment, a 3 cm sample was taken, then it was passed to a hydration machine, the histological tissue processes were carried out and later it was mounted in paraffin, to be taken to the Leica RM 2135 microtome cutter and later stained with hematoxylin-eosin; The plate is mounted, placed on a sheet and analyzed in the Laser LASEZ- Leica equipment with an ICC50 HD camera for visualization and software for measuring height, width and depth, with a 40, 45 and 100x lens.

Statistical analysis

With the data obtained in the field, a database was built in the Excel program, which was exported to the statistical program S.A.S (Statistical Analysis System) v. 8.0 (Copyright © 1985-2003A test was carried out to check the assumption of normality of the data, through the statistic Shapiro Wilk at 5%, finding that in all the variables and tissues the assumption of normality was violated; due to the above, the data was analyzed by Non-Parametric Statistics using the Kruskal Wallis test.

3. Results and discussion

Table (2) shows the effect that T1 and T2 has in each section of the small intestine comparing the size of its villi and its degree of significance where:

Tabla 2. *Intestinal integrity in broilers fed with Ramie silage (Boehmeria nivea) mixed with cassava bran (Manihot esculenta)*

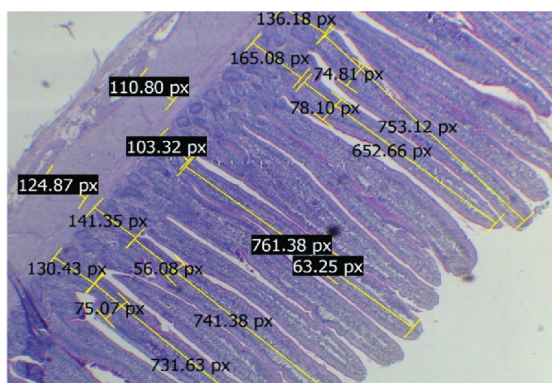
SECTION	TREATMENT	HEIGHT	WIDTH	CRYPT
DUODENUM	Silage	1004.92 ± 249.81	71.09 ± 9.67	310.25 ± 83.07
	Control	918.39 ± 126.65	66.55 ± 19.92	205.03 ± 63.23
	Kruskal Wallis	0.9135	0.7218	6.4962
	Significance	0.3300 NS	0.3956 NS	0.0108 *
JEJUNUM	Silage	594.72 ± 75.58	65.19 ± 21.39	157.62 ± 59.96
	Control	743.01 ± 144.53	77.40 ± 22.63	166.70 ± 49.10
	Kruskal Wallis	9.2084	1.8191	1.3272
	Significance	0.0024 **	0.1774 NS	0.2493 NS
ILEUM	Silage	1020.16 ± 1234.84	79.28 ± 24.61	158.95 ± 48.80
	Control	581.24 ± 77.79	66.77 ± 27.08	127.25 ± 21.52
	Kruskal Wallis	7.7368	3.5013	4.8496
	Significance	0.0054 **	0.0613 NS	0.0277 *

NS = No significant difference ($P > 0.05$), (*) = There is a significant difference ($P < 0.05$),

(**) = There is a highly significant difference ($P < 0.01$).

In the duodenum, between the treatments, no significant differences were found in the height and width of the villi ($P > 0.05$); in the crypt there was a significant difference of 0.0108 presenting itself better in the T1 of the experiment (Figure 1).

Figure 1. Duodenum of broilers fed with Ramie silage (*Boehmeria nivea*) mixed with cassava bran (*Manihot esculenta*)



The orange line indicates the height of the villi, the red line indicates the width of the villi and the green line indicates the depth of the crypt. 4x magnification.

According to Giannenas *et al.*, 2012; Salim *et al.*, 2013 y Yu *et al.*, 2011, the height of intestinal villi increased and the depth of the crypts rapidly decreased after the hatching, this increased the absorption surface of nutrients. The birds fed with a baseline diet presented deeper and wider crypts, this implies a greater requirement because of the high cell turnover to maintain this tissue.

It has been suggested that villi of greater height make for a better digestion and absorption surface for nutrients (Gómez *et al.*, 2018). The data obtained from this study shows higher villi in the jejunum section in T1, resulting in a better surface. Intestinal villi are the structures found at the level of the intestinal mucosa that serve as a reference to determine the efficiency in the absorption of nutrients.

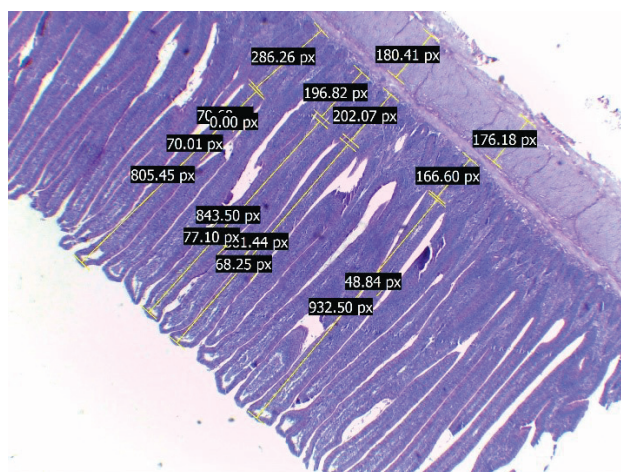
Compact and well heighted villi are indicative of better available nutrient absorption (Caspary, 1992 cited by Cao, 2013) and is associated with active cellular mitosis (Samanya y Yamauchi, 2002 cited by Disaji *et al.*, 2013). The comparisons made between established treatments, showed that there was a significantly higher difference in the height of the jejunum villi compared to the control group in 0.0024.

This concept is supported with the result obtained by comparing the measurement of villi height of the control group with the group who received silage and concentrate at the same time, where significant differences were found with averages of between 1 and 5. The increase in the depth of the crypts translated in the increase of cell rotation, resulting in a rapid renovation of the villi that could be necessary during the increase of pathogenic load (Awad *et al.*, 2009). When analyzing between treatments,

an increase in the depth of the duodenum and ileum crypts were observed, showing significant differences compared to the jejunum.

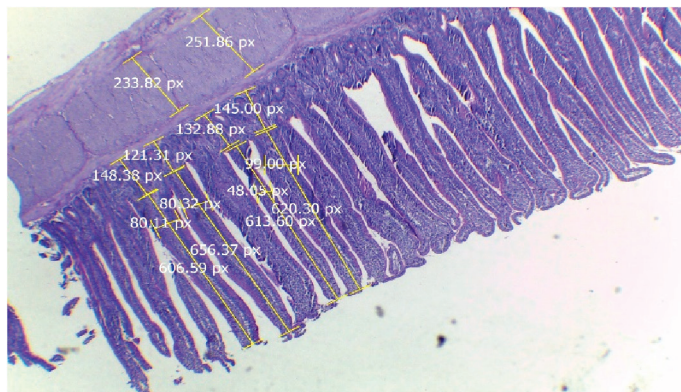
The jejunum shows no significant differences, between treatments, for the width and depth of the crypt ($P>0.05$); as for the height, it presents highly significant differences in 0.0024 corresponding to ($P<0.001$), in T1 compared to the control (Figure 2).

Figura 2. *Jejunum of broilers fed with Ramie silage (Boehmeria nivea) mixed with cassava bran (Manihot esculenta)*



The ileum does not present significant differences in the width of the villi between treatments ($P>0.05$); as for height, it presents a highly significant difference for T1 compared to T2 ($P<0.001$) and the crypt present significant differences for T1 ($P<0.05$) (Figure 3).

Figure 3. Ileum of broilers fed with Ramie silage (*Boehmeria nivea*) mixed with cassava bran (*Manihot esculenta*)



The analysis of variance shows that there were highly significant differences in villi height and crypt depth in the duodenum, jejunum and ileum, among the treatments. In the Kruskal Wallis test it was found that silage consumption showed statistical differences in the duodenum and ileum; The control treatment presented greater height of jejunum villi.

There is a close correlation between crypt depth and epithelial cell proliferation rates. In addition, the number of proliferations and epithelial cell turnover have a great impact on protein and energy requirements of the small intestine mucosa (Yasar *et al*, 1999;Hampson *et al*, 1986). The above correlates with the results obtained in this study because T1 has a significant difference between ($P<0.05$) in the depth of the duodenum and ileum crypts and a significantly high difference ($P<0.001$) in the height of jejunum and ileum villi compared to T2. Between the villi, structures called crypts of Lieberkühn, are observed where there are also Paneth cells, characterized for their pyramidal shape and whose function are protein synthesis. (Khalid *et al*, 2012). Birds have an efficient digestive capacity because they use 60 to 70% of the nutrients contained in the diet (Antillón *et al*, 1987). The percentage is consistent with each ingredient of the meal (Mack, 1986).

4. Conclusions

The results of this study indicate that silage from *B. nivea* leaves can be used as an alternative to increase the height and width of villi in the jejunum and duodenum section respectively, resulting in a better surface for digestion and absorption of nutrients.

The consumption of silage from *B. nivea* leaves, increased the size of villi and the height and depth of the crypt in the duodenum, jejunum and ileum portions, favoring the efficient digestive capacity of the birds that already use around 70% of the nutrients contained in the diet.

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Molecular techniques used for the detection of babesia spp. in cattle: systematic review

Técnicas moleculares empleadas para la detección de babesia spp. en bovinos: revisión sistemática

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Abstract

Bovine babesiosis is one of the most important parasitic diseases in the world, it is caused by protozoa of Babesia genus and generates anemia, anorexia, weight loss, jaundice and hemoglobinuria generating loss in production and even the death of the animal. Serological tests are relatively inexpensive and efficient to detect the parasite, but the results depend on factors

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inherent to the animal and the state of infection. Molecular markers are more precise tools to detect the parasite. The aim of the current systematic review was to review original studies, published between 2010 and 2018, in which molecular techniques were implemented to detect the parasite. The research was carried out using PubMed, LILACS, SciELO and Science Direct databases. 196 records were identified according to the research criteria and only 47 were analyzed. The main molecular techniques reported include Polymerase chain reaction (PCR), nested PCR (nPCR) and semi nested PCR, Real time PCR (qPCR), Reverse Line Hybridization (RLB), Cloning, Sequencing and Amplification isothermal nucleic acid (LAMP). The main molecular targets include the AMA-1 region, the 18s rRNA genes, the RAP-1 marker, the ITS region, SBP-2 and 4 proteins, VESA-1 and MSA. From the information obtained, the high impact of the disease, the efforts of different countries to study it and to investigate its causal agent is evident. The need to increase research in aspects in which molecular techniques are useful, such as the knowledge of the parasite genome and its dynamics with the host, in order to advance in the development of control and/or eradication strategies is also fundamental.

Keywords: Babesiosis, Diagnosis, Hemoparasites, Molecular marker

Resumen

La babesiosis bovina es una de las enfermedades parasitarias más importantes en el mundo, es ocasionada por protozoos del género *Babesia* y genera signos como fiebre, anemia, anorexia, pérdida de peso, ictericia y hemoglobinuria, con las consecuentes pérdidas en producción, e incluso la muerte del animal. Para la detección del parásito, se usan pruebas serológicas, relativamente económicas y eficientes, cuyos resultados dependen de factores inherentes al animal y al estado de la infección. Las técnicas moleculares constituyen herramientas más precisas para la

detección del material genético del parásito. Con el objetivo de evaluar los estudios en los cuales se implementaron técnicas moleculares para la detección de parásitos del género *Babesia*, se realizó una revisión sistemática de investigaciones realizadas entre los años 2010 y 2018, en las bases de datos PubMed, LILACS, SciELO y ScienceDirect. De 196 registros identificados solo 47 cumplieron con todos los criterios. Las principales técnicas moleculares empleadas comprenden la Reacción en cadena de la polimerasa de punto final (PCR), PCR anidada (nPCR) y semi anidada, PCR en tiempo real (qPCR), Hibridación en línea inversa (RLB), Clonación, Secuenciación y Amplificación isotérmica de ácidos nucleicos (LAMP). Los principales blancos moleculares incluyen la región AMA-1, los genes 18s rRNA, el marcador RAP-1, la región ITS, proteínas SBP-2 y 4, VESA-1 y MSA. Se evidencia el gran impacto de la enfermedad, los esfuerzos en diferentes países por estudiarla y conocer su agente causal, así como la necesidad de ampliar la investigación en aspectos en los que las técnicas moleculares son de gran utilidad, como el conocimiento del genoma del parásito y su dinámica con el hospedador, a fin de avanzar en el desarrollo de estrategias de control y/o erradicación.

Palabras clave: Babesiosis, Hemoparasitos, Diagnóstico, Marcador molecular

1. Introduction

Babesia spp. is one of the most problematic hemoparasites affecting tropical and subtropical livestock. It causes Bovine Babesiosis, a disease that together with anaplasmosis forms the Bovine Parasitic Sadness Complex (Blanco *et al.*, 2016). The parasite infects red blood cells causing clinical signs such as fever, anorexia, weight loss, decreased milk production, tachypnea, jaundice, hemoglobinuria and can end in the death of the animal (Zhou *et al.*, 2016; Bock *et al.*, 2004; Kocan *et al.*, 2010).

Disease control in many parts of the world is limited to chemotherapeutic treatment and control of the tick population with acaricide agents, but there are no control programs based on herd immunity studies, comprehensive control of the tick and the diseases it transmits, or commercially available babesiosis vaccines (Mosqueda *et al.*, 2012). Early diagnosis is the most effective tool for disease control, however, serological tests that have been used in many epidemiological studies to assess prevalence, despite being relatively inexpensive and efficient, fail to detect early infection (pre-seroconversion) (Ramos *et al.*, 2010) and their results depend on factors inherent to the animal and the infection status. In the last decade, many molecular markers have been developed, these are precise tools with an increasing specificity and sensitivity, that allow the detection and identification of parasites that were previously difficult to diagnose with conventional techniques (Tavares *et al.*, 2011). In this systematic review, the molecular methods and the regions of the genome of the microorganism used for the detection of *Babesia* sp in cattle, addressed in researches conducted during the years of 2010-2018 were analyzed. This information will be key to facilitate the conduction of studies focused on the search of more efficient control and possible eradication measures.

2. Materials and Methods

A systematic search was conducted for studies that met the following inclusion criteria: original studies, quantitative, completed, in Spanish, English and Portuguese and published between 2010 and 2018, in which the detection of hemoparasites belonging to the genus *Babesia* was carried out. Search criteria: The search was carried out in the PubMed, LILACS, SciELO and ScienceDirect databases, using the following terms: (tw:(Babesia)) and (tw:(Cattle)) and (tw:(POLYMERASE CHAIN REACTION)) or (tw:(REAL TIME POLYMERASE CHAIN REACTION)) or (tw:(REVERSE TRANSCRIPTASE POLYMERASE CHAIN

REACTION)) or (tw:(WESTERN BLOTTING)) o r (tw:(MOLECULAR DIAGNOSTIC TECHNIQUES)) or(tw:(MICROARRAY ANALYSIS)). For the selection of the studies we worked using the PRISMA flowchart (Moher *et al.*, 2009). The collection and synthesis of the results was done through Excel tabulation.

3. Results and Discussion

Out of 196 records found, 167 articles whose abstracts were relevant to the topic were selected, of which only 47 met *all* the criteria.

Distribution of the studies found

Of the selected studies, 25 were carried out between 2015 and 2017, being 2017 the most productive year with 10 published studies. According to the geographical distribution, 17 studies published in ten countries of the Asian continent stood out, mainly in the Philippines and Sri Lanka; 14 researches were reported in eight African countries, 12 in the American continent, published in countries like Colombia, Mexico, Argentina, Costa Rica and Brazil (country with the biggest production of the region), and finally three European countries with four studies.

Characteristics of the evaluated population

Only 14 studies specified the type of cattle evaluated (seven on crossbreed cattle, five on native or creole breeds and the remaining studies in Senepol, Braford, Angus and Holstein cattle). According to the productive stage of the animals, 22 studies did not specify this criteria, 19 sampled cattle of different ages, four limited the sample to calves, one limited to steer and only one study was based solely on adult cattle. The size of the used sample in approximately half of the studies (53.19%) was composed of

around 100 and 400 individuals, 19,15% of approximately 400 and 500, 14,9% between 50 and 100 and 6,38%, of each case used more than 700 or less than 50 individuals.

Molecular techniques used

The molecular techniques reported in the analyzed studies include End Point Polymerase Chain Reaction (PCR), Nested (nPCR) and Semi Nested PCR, Real Time PCR (qPCR), Reverse Line Hybridization (RLB), Cloning, Sequencing and Nucleic Acid Isothermal Amplification (LAMP).

According to Bolivar (2013), PCR is a diagnostic technique with a high degree of specificity and sensitivity, lacking the diagnostic interference that is usually implied when other methods are applied, including conventional parasitological and/or serological methods. A widely used variant of PCR is real-time PCR (qPCR), which offers the possibility of quantifying the amount of DNA or RNA present in the sample (Guevara *et al*, 2011), however, Giglioti *et al* (2017) evaluated the repeatability and correlation between the number of copies of a fragment of the genes that code for bovine cytochrome B (NC mt-cyB) and the antibody titre as a possible indicator of susceptibility/resistance of Angus cattle to the parasite, finding low values of repeatability and correlation between both indicators, so they infer that such tests cannot be used to determine resistant or susceptible phenotype to the parasite.

Nested PCR (nPCR) has two rounds of amplification where the product of the first reaction serves as a template for the second one, this way the parasitic genome can be routinely detected and the reproducibility and sensitivity depend on the amount and nature of the initial DNA mold (Snounou y Singh., 2002). Bath *et al.*, 2014 evaluated the effectiveness of PCR and nPCR in detecting *B bigemina* in a sample of 204 cattles, finding that the positive value of 7.35% found by primary PCR, increased to 30.39% with

nPCR, assuming that the amplification had already been achieved with primary PCR, although it could only be visualized in all samples by nPCR.

Hosary (2017) in a test carried out with 75 bovines from different localities of Asiut Governorate (Egypt), found a sensibility of 100% for the detection of *B bovis* through nPCR in the gene BV5650, compared to 65% obtained by PCR in the same gene. The lowest sensibility (30%) was obtained using blood smear and Giemsa staining, that is why for detection of bovines under field conditions and for epidemiological studies they recommend the first two methods.

Other studies have compared the effectiveness of molecular versus serological testing. Cao *et al* (2012), found a lower prevalence of *B bovis* and *B bigemina* using nPCR, possibly because the DNA of these parasites might have not been detected in cattle with chronic infections due to low parasitaemia. The persistence of antibodies in circulation even after the elimination of the parasites can explain such discrepancy, so in subclinically infected animals or animals with early infections nPCR can be applied for its detection, without the influence of the synchronization between the presence of the parasite and the antibody response, as well as the state of the infection (Cao *et al.*, 2012).

A technique mentioned in the studies analyzed is Reverse Line Hybridization (RLB), which involves covalent bonding of specific capture oligonucleotide probes to a membrane, followed by hybridization and detection of PCR products using streptavidinlabeled peroxidase and a chemiluminescent substrate. After use, the membrane can be dismantled and reused at least 20 times (Kong y Gilbert, 2007). Its main advantage is that with some variants, it allows the simultaneous identification of different genus of bovine hemoparasites in a large number of samples, possibly making it an essential tool for epidemiological studies (Paolettaa *et al.*, 2018).

Other tools such as the analysis of microarrays are useful for evaluating the gene expression involved in virulence and its possible post genomic modifications. Pedroni *et al* (2013) evaluated the profile of the virulent and attenuated *B bovis* transcriptome, finding a differential expression of 61 genes (41% and 59% expressed in the virulent and attenuated strains, respectively), highlighting regions such as SmORFs (genes that encode for small open reading frames for proteins), hypothetical genes (sequences that contain an open reading frame and that have been assigned a locus with its corresponding access number in the gene bank, without having been proven, experimentally or functionally, to actually code) (Pérez *et al.*, 2012) and VESA₁ (erythrocyte surface antigen variants), highlighting the role of the latter, involved in the cytoadherence of infected cells to endothelial cells and whose differential expression in the attenuated strain suggests a gene-specific activation, in addition to the activation of *sbp-2* genes, which may play a role in the attenuated phenotype. Procedures such as fragment cloning are very useful to obtain the recombinant expression, in bacterial systems, of genes that encode membrane and organelle proteins involved in target cell invasion processes (Cruz *et al.*, 2016), in the search for efficient vaccines.

According to Foxman *et al* (2005), there is no single molecular test that can fully satisfy the requirements that need to be known for all epidemiological and diagnostic applications, such as sensitivity, specificity, discriminatory power, cost, response time, reproducibility, ease of development and interpretation. However, the sensitivity of PCRbased methods can facilitate the analysis of vaccines and their ability to induce or prevent carrier status. In addition, they can be used to test the efficacy of antiparasitic drugs and in transmission and epidemiology studies (Adham *et al.*, 2009).

Addressed genome regions

The studies that analyze the presence of *B bovis*, report the use of 9 different molecular targets, for the detection of *B bigemina* 6 and only one study detected *B ovata* by amplifying the AMA-1 region. The 18s rRNA genes are the most widely chosen for detecting the genus, as well as for searching for *B bigemin*, and to a lesser extent for *B bovis*.

The marker RAP-1 was frequently used for the detection of *B Bovis* and *B bigemina*. For the detection of this last one, besides the other two regions, the region AMA-1 and in less extent the region ITS are also used, a putative gene for Babesipsine, a non-described aspartic protease present in *B bovis* and *B bigemina* (Florin *et al.*, 2002), and a hypothetical protein on which there is no precise information. Regarding *B bovis*, sbp-4 and in less extent MtCyB, VESA-1, MSA 2C markers are relevant, and similar to *B bigemina*, Babesipsine and ITS markers are relevant in lower proportion.

18sRNA

The 18S small subunit ribosomal RNA (rRNA 18S) genes, for being highly conserved, have been used for evolutionary and taxonomic studies (Aktas *et al.*, 2007; Luo *et al.*, 2005). Its abundance is 50% higher than the chromosomal DNA in the cell and its sequence has been proposed as a possible target for developing diagnostic tests for babesiosis. The information coming from this region is recommended for the molecular analysis and the reconstruction of the evolutionary history of the organisms, because by having a slow evolutionary rhythm, it allows the recognition of changes in place and time (Ríos y Ríos, 2011).

Using this region, Buling *et al* (2007) compared *B bigemina* sequences from different regions, finding a greater similitude between samples coming from America (Argentina, Mexico [obtained in the GenBank]) or Europe (Spain, Portugal) than

samples from other continents. Adham *et al.*, (2009) compared Egyptian strains of *B bovis* with Mexican strains, finding a high grade of similitude, so they recommend the PCR based method because it is highly sensible and widely applicable to parasite strains from different geographic regions.

The partial sequencing of the V4 region of the 18s ARNr gene in different species has demonstrated a significantly higher sensibility and specificity compared to microscopy, promising to be a very powerful tool for detecting lower rates of parasitemia and for discriminating species and coinfections (M'ghirbi *et al.*, 2008).

Spherical body protein (SBP) gene

It is a compliment of different proteins (SBP1 and SBP4), secreted by the spherical body, an organelle attached to the membrane, located in the apical complex and exclusive of *Babesia* and *Theileria* spp. (Guo *et al.*, 2018). SBP -2 and SBP -4 are part of the genes related to parasite infection and to immunogenicity (Simas *et al.*, 2020). Once characterized in *B bovis*, it is assumed that this gene can contribute to intracellular survival, growth and development of this parasite, as well as the generation of erythrocyte membrane alterations (AbouLaila *et al.*, 2010; Lobo *et al.*, 2012). The SBP-4 protein is secreted by the parasite during its intra-erythrocytic phase (Cruz *et al.*, 2016) and is distributed in the cytoplasm of the erythrocyte, this suggests that its importance lies in this part of the life cycle (Alaa *et al.*, 2011). Given that by bioinformatics in *B bigemina* a homologous protein to SBP-4 has been found, it is expected that the production of this recombinant protein will allow the evaluation of a potential diagnosis and vaccine (Cruz *et al.*, 2016).

Apical membrane antigen (AMA-1)

The apical membrane antigen is a protein apically located in many apicomplex organisms and its role lies in the invasion process of the host's erythrocytes (Torina *et al.*, 2010). It has been found that AMA-1 genes are highly conserved, at least those isolated from *B bigemina* found in Argentina, Italy and Australia (Sivakumar *et al.*, 2012). Barreda *et al.* (2019) studied peptides that contained B cell epitopes exposed and conserved from the AMA-1 extracellular region of *B bovis*, finding the presence of antibodies in bovine serum from endemic areas that attached to the identified peptides, with which they concluded that the epitopes are involved in the immune response under natural conditions, however, a greater characterization of the humoral immune response provoked by these peptides is needed.

Merozoite surface antigens (MSA)

Multigenic family present in *B bovis*, formed by five members located in two different genomic loci: MSA-1 y MSA-2, that codify for a group of proteins that have been studied for the development of vaccines due to their antigenic properties (Mosqueda *et al.*, 2002), because they codify for 42 y 44 kDa glycoproteins, respectively, exposed in the surface of the merozoite and that are involved in the erythrocyte invasion (Florin *et al.*, 2002; Wilkowski *et al.*, 2003; Genis *et al.*, 2008). Both proteins come from sole copy genes with a hypervariable region associated to related immunogenicity and antibody neutralization characteristics. This indicates that this region is under great selective pressure and could be considered an excellent pathogenicity attenuation indicator (Simas *et al.*, 2020).

For the isolation, cloning, sequencing and diagnostic analysis of the parasite, the MSA-2 gene is recommended, because according to Borgonio *et al.*, (2008), previous studies on MSA-1 have evidenced allelic variation of antigens isolated from *B bovis* of similar endemic regions, and from isolates from different

geographical regions of the world. However, studies on MSA-2c, have demonstrated that this antigen is widely conserved in isolates from different geographical regions. This gene is involved in the survival of the parasite and its product is candidate for inclusion in a possible vaccine because it contains highly immunogenic and conserved epitopes that cause neutralization of sensitive antibodies in cattle (Wilkowski *et al.*, 2003; Mosqueda *et al.*, 2012).

Variants of the erythrocyte surface antigen (ESA)

B bovis establishes a chronic infection in cattle, in part through a rapid variation of the VESA1 polymorphic and heterodimeric protein. Its components, which are synthesized by the merozoite and are transported to the surface of the infected erythrocytes, are involved in the cytoadhesive function of the parasite. (Allred *et al.*, 2000; O'Connor *et al.*, 1997). Its rapid antigenic variation can be related to the evasion of the immune response and the cytoadhesion of the infected erythrocytes, this causes the sequestration of the infected erythrocytes in the brain capillaries and can lead to a much severe form of the disease (Pérez de la Rosa *et al.*, 2012).

The complex is formed by a 128 kDa (VESA1 α) protein and a 113 kDa (VESA1 β) protein. The first one is located over the parasitized erythrocyte's extracellular phase of the plasmatic membrane, at the level of the protuberances called "knobs" (Figueroa y Alvarez., 2003). Babesia genomes are widely conserved in other aspects, but the evolution of VESA1 genes presents a constant change, which may reflect the challenges of host-parasite interactions that occurred over millions of years (Jackson *et al.*, 2014).

Internal rRNA transcribed spacers (ITS)

Formed by the internal transcribed spacer 1 (ITS1), the rRNA gene 5.8S and the internal transcribed spacer 2 (ITS2), which because they are subject to higher evolutionary rates leading to greater variability in both nucleotide sequences and length (Hillis and Dixon, 1991), are valuable in the phylogenetic separation of closely related species, for the definition of species, subspecies and/or strains (Aktas *et al.*, 2007; Jirapatharasate *et al.*, 2017).

Liu *et al* (2012) implemented the LAMP (loop-mediated isothermal amplification platform) methodology directed towards specific sequences of the ITS region to detect and distinguish between species in experimentally and naturally infected cattle in China. With a greater sensibility compared to classic PCR for the detection of *B bovis* and *B bigemina*, they highlight the potential of the technique for the detection and differentiation of species, especially in countries where the disease is endemic.

Protein genes associated with roptrias (RAP)

Family of proteins related to the invasión of the parasite and its development in the interior of the host, secreted by the roptrias, bulb-based organelles present in the parasite.

The genetic organization of the RAP-1 locus in most *Babesia* species seems very complex, with at least four different RAP 1A genes in *B bigemina*. The expression of multiple RAP-1A genes containing polymorphic regions and additional genes in the RAP1 family, such as RAP-1B and RAP-1C, result in the production of diverse proteins which can carry out functions that may be identical, different or redundant. In contrast, *B bovis* only has two RAP-1A genes arranged in tandem, so it is assumed that the mechanisms employed for variation in RAP-1A genes and the evolution and organization of the RAP-1 locus may not be the similar in all *Babesia* species (Suarez *et al.*, 1998).

Although some studies have genetically characterized and compared sequences of *B bovis* sbp-4 and *B bigemina* RAP-1 isolates, it is considered that by being highly conserved regions that present homology between different geographical areas, they are useful as specific targets for the detection of the parasite by molecular techniques (Jirapattharasate *et al.*, 2017; Roy *et al.*, 2018). In *B bovis*, 58 Kda RAP-1 has conserved epitopes and is immunogenic for T and B cells (Mcelwain *et al.*, 1987, 1991; Rodriguez *et al.*, 1996). It is considered a specific species marker with a greater percentage of identity for *B bovis* of different geographic regions, than for *B bigemina* (Ríos y Ríos, 2011).

In addition to the molecular targets already mentioned, Hosary, 2017 performed the molecular detection of *B bovis* through the amplification of the BV5650 gene, which encodes for a membrane protein, which is different from other proteins of the apical complex, such as RAP-1, which are preserved among different species of *Babesia*. Its use in the diagnosis of *B bovis* infection can increase the specificity and sensitivity of the PCR (AbouLaila *et al.*, 2010).

In general, the study of the species of the genus *Babesia* allows the discovery of genes related to other organisms of the Phylum Apicomplexa, which includes a large number of endoparasites that attack animals. Through comparisons of EST (expressed sequence markers) between *B bovis*, *T gondii* and *P falciparum*, homologous sequences with known genes have been found, increasing their importance for comparative analysis (Sivakumar *et al.*, 2014; Pérez de la Rosa *et al.*, 2012).

Reports of prevalence, management practices, vectors and risk conditions

26 of the selected studies analyzed prevalence and all of them were carried out on a local level. With very heterogeneous values, ranging from 0.2% to 62.2% in groups between 76 and

2880 individuals from different categories. Concerning the susceptibility by age groups, there are contrasting results, some studies report that young cattle, between 1 and 2.5 years old, are more affected than cattle older than 2.5 years (Rahman *et al.*, 2015), mainly if they are raised under intensive systems; and that crossbreed animals are more affected than animals of Friesian and native breeds (Rizk *et al.*, 2017; Jaimes, Triana y Mejía., 2017). In contrast, Roy *et al.*, (2018), found that young cattle (less than 2 years old) had lower positive rates of *B bovis* and *B bigemina* compared to older cattle. According to them, this difference could be caused by the greater innate immune response at a young age, a similar conclusion to the one reached by Souza *et al.*, (2013), who, considering age, found no statistically significant differences between the seroprevalences of *B bovis*, *B bigemina* and *A marginale*, suggesting that the animals sampled had been infected mainly before reaching one year of age, when they tended to be more resistant to hemoparasites.

The main vectors for *B bovis* are *Rhipicephalus microplus*, *R. annulatus* y *R. geigy*, while *B bigemina* can be transmitted by *R. microplus*, *R. annulatus*, *R. decoloratus*, *R. geigy* and *R. evertsi* (OIE, 2008) and *B divergensis* usually transmitted by *Ixodes ricinus* (Guswanto *et al.*, 2017). The identification and characterization of protective antigens against ticks has been a growing area of research since the early 1990s; the ability to control infestations through host immunization has been proved using recombinant proteins, however, a limiting step continues to be the identification and characterization of protective antigens (Almazan *et al.*, 2005), because its design has been hindered by extensive polymorphisms in some of the parasite's proteins, particularly those expressed on its surface (Torina *et al.*, 2010).

Ecology, management practices, presence of ticks, age, race and place of origin are potential risk factors for the presence of the parasite. Even animals raised in intensive systems have higher infection rates and there is more diversity of parasites in areas

where there are not tick management practices (Santos *et al.*, 2017; Rizk *et al.*, 2017). In addition, in many studies co-infections are more common than single *Babesia* infections (Zerihun *et al.*, 2017), which could have implications because of the potential interaction between pathogens and clinical symptom patterns (Paoletta *et al.*, 2018; Jirapattarasate *et al.*, 2017).

In some countries, like Nigeria, the deficit in veterinary services, causes an indiscriminated use of medications by the producers which leads to problems with antibiotic resistance (Rizk *et al.*, 2017). In other countries, like Vietnam, the prevalence of the disease is influenced by the importation of infected livestock that can promote the introduction of new strains, possibly compromising the development of anti *Babesia* immune control strategies, making evaluations prior to importation necessary (Sivakumar *et al.*, 2018).

Kubelová *et al* (2012) propose as basic measures to reduce economic losses in livestock production: extensive epidemiological studies using both serology and molecular genetic methods, the monitoring of vector distribution, availability of vaccination programs and traceability of animal transport.

4. Conclusion

The volume of studies found and the systematized information regarding the characteristics of the populations evaluated, the mentioned antecedents, the molecular techniques used and the regions of the genome evaluated in the parasite, show the wide distribution of the disease and the variability of factors that influence its presentation. However, it is evident the need to extend the research in aspects in which the molecular techniques turn out to be very useful tools, such as the particularities in the parasite's genome, the functioning of its genes and its interaction with other parasites and with the host, in order to advance in the development of control and/or eradication strategies.

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Tabla 1. Blancos moleculares empleados para la detección de *Babesia* spp. y autores que refieren su aplicación en los estudios seleccionados (2010-2018)

Parasite	Molecular target	References
<i>Babesia</i> spp.	18sRNA	Ayodele <i>et al.</i> , 2018; Kubelová <i>et al.</i> , 2012; Lempereur <i>et al.</i> , 2012; Paolettaa <i>et al.</i> , 2018; Roy <i>et al.</i> , 2018; Byaruhanga <i>et al.</i> , 2016; Simuunza <i>et al.</i> , 2011
	18sRNA	Paolettaa <i>et al.</i> , 2018; Roy <i>et al.</i> , 2018; Byaruhanga <i>et al.</i> , 2016; SouzaI <i>et al.</i> , 2013; Shebish <i>et al.</i> , 2012; Simuunza <i>et al.</i> , 2011; Hosary (2017)
<i>B bovis</i>	RAP-1 Rhoptry-associated protein 1a (BbiRAP-1a)	Santos <i>et al.</i> , 2017; Rizk <i>et al.</i> , 2017; Sivakumar <i>et al.</i> , 2012; Ybañez <i>et al.</i> , 2013
	Spherical Body Protein 2 gen (SBP-2)	Herrera <i>et al.</i> , 2017; Cao <i>et al.</i> , 2012; Jirapatharasate <i>et al.</i> , 2017
	Spherical Body Protein 4 gen (SBP-4)	Guswanto <i>et al.</i> , 2017; Terkawi <i>et al.</i> , 2012
	Gen BV5650	Hosary (2017)
	Cytochrome B gene (mt-cytB)	Giglioti <i>et al.</i> , 2017
	Putative gene of babesipin	Martins <i>et al.</i> , 2010
	Variant erythrocyte surface antigens (VESA1)	Rahman <i>et al.</i> , 2015
	Internal transcribed spacers (ITS)	Liu <i>et al.</i> , 2012
	Merozoite surface antigens (MSA)	Ramos <i>et al.</i> , 2010
	<i>B bigemina</i>	18sRNA
RAP-1 rhoptry-associated protein 1a (BbiRAP-1a)		Santos <i>et al.</i> , 2017; Herrera <i>et al.</i> , 2017; Jirapatharasate <i>et al.</i> , 2017; Guswanto <i>et al.</i> , 2017; Zhou <i>et al.</i> , 2016; Terkawi <i>et al.</i> , 2012; Cao <i>et al.</i> , 2012
Apical membrane antigen (AMA-1)		Rizk <i>et al.</i> , 2017; Musingzi <i>et al.</i> , 2016; Ybañez <i>et al.</i> , 2013; Sivakumar <i>et al.</i> , 2012
Putative gene of babesipin		Martins <i>et al.</i> , 2010
Internal transcribed spacers (ITS)		Liu <i>et al.</i> , 2012
<i>B ovata</i>	Apical membrane antigen (AMA-1)	Sivakumar <i>et al.</i> , 2012

**Presence of *podisus congrex* (stål 1862)
(hemiptera: pentatomidae) in relation to
weed management in the avocado crop of
Risaralda**

**Presencia de *podisus congrex* (stål 1862)
(hemiptera: pentatomidae) en relación
al manejo de arvenses en el cultivo de
aguacate en Risaralda**

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*Beatriz Elena García Vallejo*²

Abstract

In the last decade, Colombia has been growing in the production of avocado, making itself a production line of major interest in the country and therefore incentivizing the search of ecological alternatives for plague and disease control. This is why this investigation's goal is to determine the presence of the

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generalist predator *Podisus congrex* (Stål 1862) and its relationship with the frequency of weed management in the avocado crop of Risaralda department. For this, a weekly sampling was carried out throughout the months of March to September 2018, in four avocado crops (each one located in the municipalities of Apia, Belén de Umbría, Pereira and Santa Rosa de Cabal) by observation and collection of *P. congrex* specimens in 5% of the avocado trees. A total of 96 individuals of *P. congrex* were collected, whose presence by the type of weed management:

Mechanical-Semesterly, Mechanical-Quarterly, Chemical-Bimonthly Synthesis and Chemical Semesterly Synthesis, was 59.4%, 15.6%, 16.7% and 8.3%, respectively. The farm that used Mechanical-Semesterly had a greater presence of the predator compared with the farms that used a more frequent management or that applied pesticides. This suggests the advantages of increasing the diversity of the agricultural landscape through adequate weed management.

Keywords: Biological control, *Podisus congrex*, *Persea americana*, asopinae, weed management.

Resumen

En la última década Colombia está creciendo en la producción de aguacate, volviéndose una de las líneas de producción con mayor interés en el país y por tanto incentivando la búsqueda de alternativas más ecológicas para el control de plagas y enfermedades. Es por ello, que esta investigación tiene como objetivo determinar la presencia del depredador generalista *Podisus congrex* (Stål 1862) y su relación con la frecuencia del manejo de arvenses en el cultivo de aguacate del departamento de Risaralda. Para ello, se realizó un muestreo semanal, en cuatro cultivos de aguacate (cada uno ubicado en los municipios de Apia, Belén de Umbría, Pereira y Santa Rosa de Cabal) durante los meses de marzo a septiembre de 2018, mediante observación y colecta de especímenes de *P. congrex* en el 5% de los árboles de aguacate. Se recolectó un total

de 96 individuos de *P. congreg* cuya presencia por tipo de manejo de arvenses: Mecánico-Semestral, Mecánico-Trimestral, Síntesis Química-Bimensual y Síntesis Química-Semestral, fue 59,4%, 15,6%, 16,7% y 8,3%, respectivamente, presentándose una mayor presencia en la finca con manejo Mecánico-Semestral, que en los predios con manejo más frecuente o con aplicación de herbicidas; sugiriendo las ventajas de aumentar la diversidad del paisaje agrícola mediante el adecuado manejo de arvenses.

Palabras Clave: Control biológico, *Podisus congreg*, *Persea americana*, asopinæ, manejo de arvenses.

1. Introduction

The development of avocado crops reflects on the per capita consumption in Colombia that had an increase of 70% in the last five years from 6,1 to 12,3 kg/person/year (Ministry of Agriculture and Rural Development, 2019). This crop is also of economic importance because of its possibilities to satisfy the internal and export market, where they demand that the production is innocuous and without chemical residues; generating a growing interest in the study and management of plagues and diseases associated with this crop (Grisales, Rodríguez, Correa & Tamayo, 2019; Betancourt et al., 2017; Bernal et al., 2014; Kondo et al., 2011). There is a current and renewed interest in biological control as an alternative for conservation and augmentation of natural enemies (Bernal et al. 2014; Cotes, 2018; Barbosa, 1998; Gurr et al., 2000; Pickett & Bugg, 1998). Therefore, maintaining the abundance and diversity of natural enemies, including the manipulation of crop habitats in favor of these, allowing their spatial and temporal persistence is recommended because these allow a natural control of plagues in the agroecosystem (De Bortoli, Otuka, Vacari, Martins & Volpe, 2011; Straub et al., 2007; Barbosa, 1998).

It's estimated that 65% of all families in the suborder Heteroptera are partially or completely composed of predator species (Henry & Froeschner, 1988; Cohen, 2000) and many of them have the potential to biologically control arthropod plagues. Members of the subfamily Asopinae feed mainly on phytophagous larvae that belong to the orders Lepidoptera, Coleoptera and Hymenoptera, and in fact, several species of the families Anthocoridae, Miridae, Lygaeidae, Nabidae, Reduviidae and Pentatomidae (subfamily Asopinae) have been or are being used in augmentative biological control programs in various agro-ecosystems, however, only about 10% of the 300 known species have been studied in detail. The economically important species belong to the genus *Podisus*, *Picromerus*, *Arma* y *Perillus* (De Clercq, Coudron, & Riddick, 2014; Zanuncio et al., 2014; Grazia et al., 2015; LeRoux, 1960; López, Ridgwa & Pinnell, 1976; Khloptseva, 1991; Aldrich, Kochansky, Lusby & Borges, 1991; De Clercq, 2000).

In particular, species of the genus *Podisus* are generalist predators and some species have received attention as potential biological control agents for agricultural pests (Drummond, James, Casagrande & Faubert, 1984, Stamopoulos & Chloridis, 1994; De Clercq, 2000). Thus, associated with the avocado production system in Risaralda, the presence of *P. congrex* (Stål 1862) has been observed, a species reported for forestry in Colombia as a potential biological controller (Madriral, 2019; Pulgarín et al., 2019).

Only two species of the genus *Podisus*, *Podisus maculiventris* (Say) and *Podisus nigrispinus* (Dallas), have been widely studied because they show a great potential to control populations of phytophagous insects (Saini, 1995; De Clercq, 2000). *P. maculiventris* is the only Asopinae commercially available for augmentative biological control (De Clercq, 2008). However, these generalist predators can and should also be included in classic conservation biological control programs (Bernal et al.,

2014; Cotes, 2018). There is a currently renewed interest in this type of biological control that tends to maintain the abundance and diversity of natural enemies, including the manipulation of crop habitats in favor of these, allowing their spatial and temporal persistence because these allow a natural control of plagues in the agroecosystem (De Bortoli et al., 2011; Straub et al., 2008; Barbosa, 1998). This habitat manipulation includes all those strategies that increase the diversity of the agricultural landscape, among which are the adequate management of weeds. Nowadays, it is considered that the presence of different species of weeds within the crops, has a deep impact in the composition and interactions of the entomofauna of the crop, to such an extent that the predators and parasitoids are more effective in the complex habitats (Blanco & Leyva, 2007) as beneficial insects are more likely to find alternative prey, shelter, breeding sites and sleeping shelters (Zamora et al., 2008). These strategies are part of the Ecological Pest Management, key in the development of Agroecology to allow farmers to be less input-dependent while producing less contaminated food.

This is why this investigation's goal is to determine the presence of the generalist predator *Podisus congrex* (Stål 1862) and its relationship with the frequency of weed management in the avocado crop of Risaralda department.

2. Materials and Methods

Area of Study. The study was carried out in four farms located in different municipalities of the Department of Risaralda, and with avocado crops that were in a productive state (flowering and/or fruiting) and with tree ages between four and six years. In order to know details about the management of weeds, an interview was conducted with each farmer and it was established that the management of weeds was chemical (with chemical synthesis products) or mechanical (with scythe) and with variable frequencies (Table 1).

Table 1. Characteristics of four farms cultivated with avocado (*P. americana* M.) and selected for the sampling of *Podisus congrex* (Stål 1862) (Hemiptera: Pentatomidae) in Risaralda

Municipality	Altitude (msnm)	Variety	Type and frequency of management of weeds
Apia	1723	Hass	Mechanical-Semesterly
Belén de Umbria	1258	Papelillo/Santana	Mechanical-Quarterly
Pereira	1417	Hass	Chemical-Bimonthly Synthesis
Santa Rosa de Cabal	1716	Santana/Papelillo	Chemical-Semesterly Synthesis

Field sampling of *Podisus congrex* (Stål 1862) in avocado crops. In each of the four selected sites, a (weekly) sampling was carried out throughout the months of March to September 2018 for a total of 32 visits, and 5% of the trees per lot were randomly sampled. Each tree selected for sampling was (imaginatively) divided into four quadrants, in which plant structures (stem, branches, and leaves) in the middle and lower parts of the tree were checked for individuals of *P. congrex* (eggs, nymphs, and adults) (based on and modified from Vaissiere et al., 2011). Afterwards, the collected specimens were taken to the Entomology Laboratory of the Santa Rosa de Cabal University Corporation - UNISARC, for their identification.

Statistical analysis. For the evaluation of the field presence of *P. congrex*, the following formula was used:

$$\% \text{ Presence (relative)} = \frac{\text{No. of individuals of } P. \text{ congrex by frequency of management} \times 100}{\text{No. TOTAL of individuals of } P. \text{ congrex in the frequencies of management}}$$

In addition, descriptive statistics using the Excel® program were used.

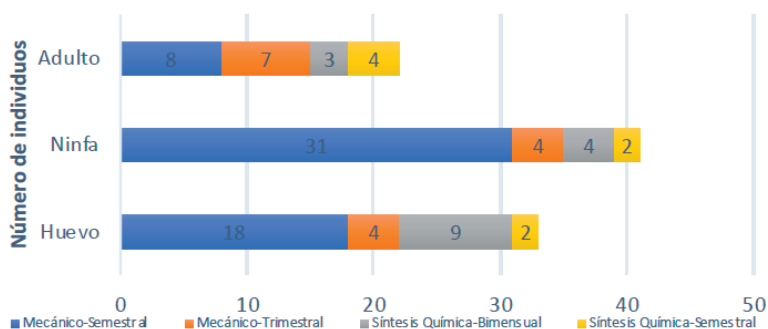
3. Results and Discussion

The collected specimens correspond to the generalist predator *Podisus congrex* (Stål 1862), species that, in Colombia, has only been reported by Madrigal (2019) and Pulgarín et al.

(2019) in forestry as a potential biological controller of *Gonipterus platensis* Marrelli (Coleoptera: Curculionidae).

A total of 96 *P. congrex* individuals were collected from the four sampled sites. This predatory bug was found throughout the avocado production period (from flowering to fruiting) in the four sampled plots, and when differentiated by developmental stages, 33 eggs, 41 nymphs and 22 adults were found (Figure 1).

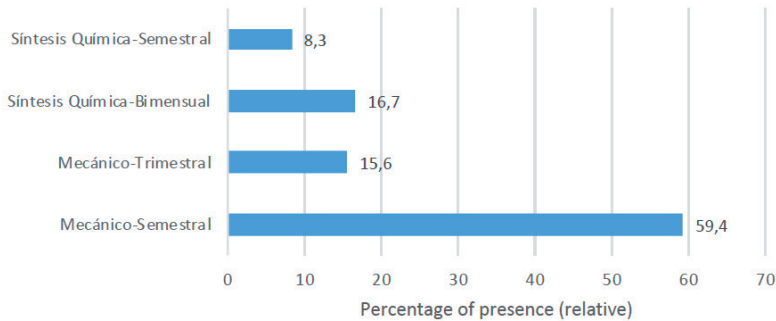
Figure 1. Number of individuals by developmental stage of *Podisus congrex* (Stål 1862) (Hemiptera: Pentatomidae) in avocado (*P. americana* M.) crops in four farms of Risaralda with differential weed management. (March to September 2018).



The relative presence of *P. congrex* was higher in the property with Mechanical-Semesterly weed management (59.4%), while it was much lower in the properties with more frequent management (Mechanical-Quarterly), or with herbicide application (Chemical-Bimonthly Synthesis and Chemical-Semesterly Synthesis) (Figure 2), suggesting that herbicide application may be affecting the presence of this predatory bug in the avocado agroecosystem. Regarding this, De Cock et al. (1996) indicate that predators can be indirectly affected by consuming contaminated water. However, it should also be taken into account that agroecosystems present different stochastic events, which include, in addition to the application of agrochemicals, the type of crop and the harvest,

and these can affect the presence of generalist predator species that, even if they are well adapted to the transitory environments created by the crops, can be temporarily affected by such events on a local scale (Symondson et al., 2002).

Figure 2. Relative presence of *Podisus congrex* (Stål 1862) (Hemiptera: Pentatomidae) in avocado crops (*P. americana* M.) in four farms of Risaralda with differential weed management. (March to September 2018).

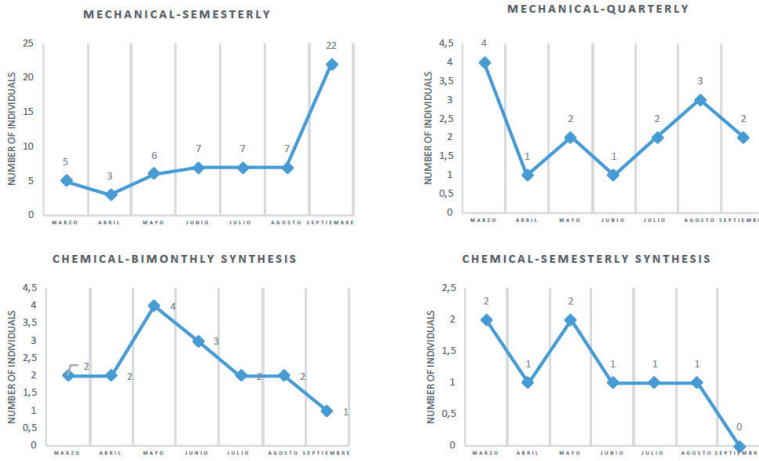


The property with mechanical-semesterly management presented a maximum of 22 individuals collected the last month, making this the type of management with the highest number of individuals collected (Figure 3). This indicates that the presence of weeds is of great value because these habitats are important as alternate sites for hibernation and refuge for some natural enemies, as well as areas with food resources such as pollen or nectar for parasites and predators (Altieri & Nicholls, 2004; 2007).

Sustainability in a production system is due to the adequate combination of agronomic practices carried out on the crop (Rodríguez et al., 2011); This allows weed groups to be considered in the agroecosystem as biological corridors, this means they constitute a natural biodiversity where beneficial insects find shelter and alternative food, and exercise their dominion by attacking the insect pests (Nicholls, 2008; Ryszkowski & Karg, 2007), which indicates

a direct trophic interaction (Norris & Kogan, 2000). Since the survival and activity of many natural enemies depend on resources offered by the vegetation adjacent to the field, this natural vegetation can be manipulated to promote biological control for conservation (Fry, 1995; Van Emden, 1965).

Figure 3. Population of *Podisus congrex* Stål in avocado crops (*P. americana* M.) in four farms of Risaralda with differential weed management. (March to September 2018).



The biological control for conservation, is recommended as a strategy that begins by overcoming the paradigm of prioritizing the use of specialized natural enemies (parasitoids) and considering the fundamental importance of the complex of predators as a complementary mechanism of control (Symondson et al., 2002); because of this it is necessary to sustain and increase the presence of *P. congrex* in the avocado crops of the region. In fact, some studies have shown that, in certain cultivation systems, the control exercised by predators is more important than the action of the parasites (Debach & Rosen, 1991; Safarzoda, Bahlai, Fox & Landis, 2014), this is justified by the fact that diversification of the avocado agroecosystem with a wide variety of plant

arrangements (cultivation with weeds, cover crops, biological corridors, among others) is an alternative that generally results in increased environmental opportunities for natural enemies (Altieri, 1994; Altieri & Nicholls, 2004).

4. Conclusions

The first report of the presence of *Podisus congrax* (Stål 1862) in avocado cultivation for the Department of Risaralda is made.

Podisus congrax had a greater presence on the farm with Mechanical-Semesterly management than on farms with more frequent management or herbicide application.

The relative presence of *Podisus congrax* (Stål 1862) by type of pest management: Mechanical-Semesterly, Mechanical-Quarterly, Chemical-Bimonthly Synthesis and ChemicalSemesterly Synthesis, was 59.4%, 15.6%, 16.7% and 8.3%, respectively.

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Evaluation of macroscopic lesions of different lung lobes in swine using a percentage classification model

Evaluación de lesiones macroscópicas de los diferentes lóbulos pulmonares en la especie porcina usando un modelo de clasificación porcentual

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Abstract

Respiratory diseases in pigs have a great economic impact, considering it is one of the main problems in intensive swine production. The objective of this study was to macroscopically evaluate the different pulmonary lobes in a processing plant located center-west of Risaralda, using a percentage qualification model. Through a descriptive study, 358 lungs were evaluated during the evisceration phase, the specimens came from 9 lots of different farms. Data was collected according to the degree of macroscopic lesion observed for each of the pulmonary lobes in percentages. With this data, averages were taken for each of the lobes and compared between the total of samples observed and for each of the lots. In addition, more specific lesions were evaluated on a scale of 0-5 as indicators of pleurisy and scarring. The analysis of the macroscopic observations showed that the majority of the lungs, presented some degree of lesion with an 85% (305/358) while only 15% (53/358) showed no type of lesion. 13% (43/358) presented lesions indicative of pleurisy and 71% (253/358) showed scarring. The comparison of the lesion averages between the different pulmonary lobes showed that the most affected was the right cardiac lobe with an average value of 2.10% while the least affected was the accessory lobe with an average value of 0.97%. In this study it was found that the right and left cardiac lobes were the most affected out of the totality of lungs evaluated, these results can be related to the respiratory signs, the health status and the productive parameters of the different batches in the farm, helping to determine a presumptive or final etiological diagnosis. This shows that the percentage evaluation method could be a quick and effective tool for the study of postmortem lesions in processing plants.

Keywords: macroscopic lesions, respiratory diseases, pulmonary lobes, slaughterhouses.

Resumen

Las enfermedades respiratorias en porcinos tienen un gran impacto económico, considerándose uno de los principales problemas en la producción intensiva porcina. El objetivo de este estudio fue evaluar macroscópicamente los diferentes lóbulos pulmonares en una planta de beneficio del centro-occidente de Risaralda, usando un modelo de calificación porcentual. Mediante un estudio descriptivo, se evaluaron 358 pulmones durante la fase de eviscerado, provenientes de 9 lotes de diferentes granjas; se recolectaron datos porcentuales según el grado de lesión macroscópica observada para cada uno de los lóbulos pulmonares. Con estos datos se calcularon los promedios para cada uno de los lóbulos y se compararon entre el total de muestras observadas y para cada uno de los lotes. El análisis de las observaciones macroscópicas permitió establecer una prevalencia de lesiones pulmonares del 85% (305/358), mientras que el 15% (53/358) no evidenciaron ningún tipo de lesión. El 13% (43/358) presentaron lesiones indicativas de pleuritis y el 71% (253/358) de cicatrización. La comparación de los promedios de lesión entre los diferentes lóbulos pulmonares mostró que el más afectado fue el cardiaco derecho, con un valor promedio de 2,1%, mientras que el menos afectado fue el accesorio con un valor promedio de 0,97%. En este estudio se encontró que los lóbulos cardíacos derecho e izquierdo fueron los más afectados del total de pulmones evaluados, estos resultados se pueden relacionar con los signos respiratorios, el estado sanitario y los parámetros productivos de los diferentes lotes en la granja, lo que contribuye a establecer, junto con otras pruebas complementarias un diagnóstico presuntivo en el caso de afecciones respiratorias. Mostrando que el método de evaluación porcentual podría ser una herramienta rápida y eficaz de estudio de lesiones postmortem en plantas de beneficio.

Palabras clave: lesiones macroscópicas, enfermedades respiratorias, lóbulos pulmonares, mataderos.

1. Introduction

Respiratory diseases in swine are highly prevalent and generate a great economic impact represented by a reduction in feed conversion, weight gain and feed intake (Garcia-Morante *et al.*, 2016). There are multiple determinant factors that influence the emergence of these type of conditions, such as, intensive production, breed, exposure to adverse environmental conditions for this species, the bad housing conditions they are exposed to, the microbial load they are in contact with, the deficient waste disposal and inadequate sanitary management, etc. This can lead to a greater predisposition for respiratory tract infections, which, at the same time, affects the profitability of the productive system and causes economic losses due to the confiscation of lots in addition to unnecessary costs of veterinary care (Espinoza y Martínez, 2008; Martín *et al.*, 2017).

The situation exposed above states the necessity to stablish methodologies that allow the prevalence of respiratory conditions in swine under intensive breeding to be calculated and therefore quantify the problem to stablish strategies to mitigate it, as well as to find the association between the risk factors and respiratory conditions. For this purpose, it is important to stablish and validate a macroscopic observation technique that allows the detection and quantification of pulmonary lesions of swine lots in an objective matter (Spillane, 2016). These observations are of great use to articulate the results of the inspections with the improvement of the sanitary plans, the biosafety programs of the farm, in addition to the application of good management practices.

The goal of the present study is to obtain percentage results of the macroscopic pulmonary lesions found in processing plants and therefore to generate information that can be associated to the respiratory disease state in each of the evaluated productions.

2. Materials and methods

A transversal cohort study took place with convenience sampling. 358 swine lungs were evaluated; they were sacrificed in a processing plant located in Risaralda – Colombia (central occident of the Andina region). A systematic 30-day sampling was carried out.

Macroscopic evaluation

Percentage data of the most representative macroscopic lesions were recollected during the postmortem inspection of the swine lungs selected at convenience. The pigs weighed around 115 to 140 kilograms, the most affected parts were photographed with a digital camera (Sony, DSC H9, Japan) to obtain a data log for posterior analysis of the observed lesions.

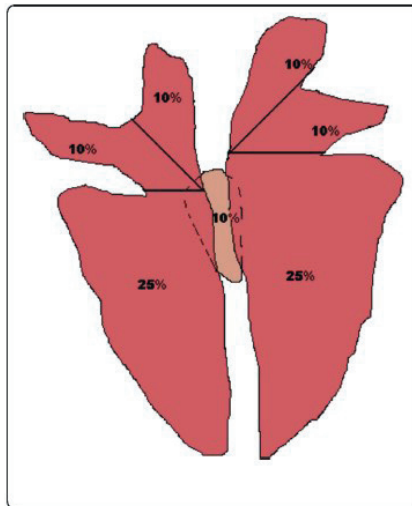
The size of the sample was taken according to the size of the animals that entered the farms that authorized the sampling, during a 4-week period. The inspected lots came from different farms, with the exception of one farm from which animals were received on two occasions, therefore, it had a second inspection, this situation is reflected in the results and is named as the second moment (sixth farm). The data recollected during the inspection were registered in an Excel table and were analyzed on the Infostat software.

Pulmonary tissue inspection

The pulmonary lesion patterns possibly responsible for the respiratory diseases were evaluated to homogenize the measurements made by both and to therefore minimize the observer bias, in addition to making an objective evaluation of the lesions. Even though the farm selection was made through convenience, the sample of each lot was randomized according to the order of arrival at the processing plant.

The inspection was conducted through macroscopic visualization of the different pulmonary lobes and the information was systematically registered like this: left apical lobe, left cardiac lobe and left diaphragmatic lobe. Afterwards, the same observations were made on the right side and lastly the accessory lobe was evaluated. A percentage according to what was observed, was assigned to each of these lobes following what was proposed by Steinmann *et al* (2014), as is shown on figure 1. In addition to the above, a log of the lungs with pleuritic and scarring suggestive conditions was made, with which a percentage of organ affectation was established.

Figure 1. Simplified pulmonary scheme (posterior view) standardized evaluation of the base for pulmonary lesions (“Rule of the tens”). Taken from Steinmann (2014).



3. Results and discussion

The data analyzed corresponds to the inspection of 358 animal lungs from different pig farms, which were macroscopically evaluated to determine the degree of lesion using a percentage classification model that appears reflected on table 1.

Table 1. Percentage of lesions found on each evaluated farm

Number of evaluated animals*		16	30	25	19	39	55	57	37	80
Variable		G1 %	G2 %	G3 %	G4 %	G5 %	G6a %	G6b %	G7 %	G8 %
Lobe	Side									
Apical	Left	1,25	0,33	2,12	0,84	0,13	1,47	1,40	0,92	1,06
Cardiac	Left	4,38	3,10	1,36	1,37	0,69	1,85	1,86	2,78	1,96
Diaphragmatic	Left	1,31	0,77	1,04	1,79	0,21	1,76	1,25	1,27	1,49
Apical	Right	2,56	1,53	1,68	2,26	0,725	2,09	2,32	2,08	1,46
Cardiac	Right	4,31	2,13	1,68	1,42	0,59	2,45	2,26	2,73	2,03
Diaphragmatic	Right	2,63	1,00	1,08	2,79	0,26	1,96	1,33	1,65	1,79
Accessory		2,19	1,33	0,88	1,05	0,31	1,04	0,65	1,19	1,00
Total		18,63	10,20	9,84	11,53	2,90	12,64	11,07	12,62	10,79
Scar		1,13	0,73	1,64	1,42	1,00	1,11	1,74	2,05	0,90
Pleurisy		0,31	0,17	0,28	0,00	0,10	0,09	0,13	0,11	0,31

G: farm

G6a: farm 6 first measurement

G6b: farm 6 second measurement

*Number of animals: expressed in absolute value

It was possible to establish that 85% (305/358) of the totality of lungs inspected evidenced some degree of macroscopic lesion observable as is seen on figure 2; in relation to the presence of pleurisy a 13% (46/358) prevalence was determined, figure 3; additionally, scarring processes were observed in 71% (253/358) of the animals, figure 4.

Figure 2. Prevalence of pulmonary lesions

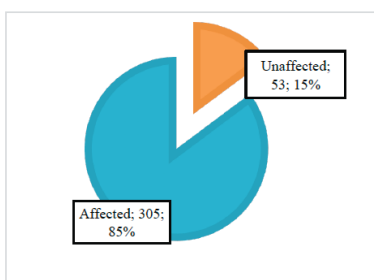


Figure 3. Presence of pleurisy lesions

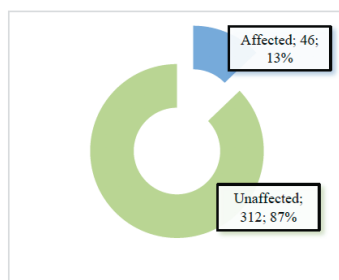
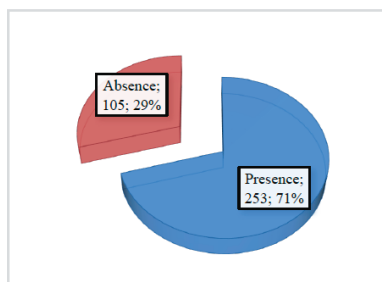


Figure 4. Presence of scars in the lungs

In the inspection of red viscera in swine livestock, it is frequent to find a high degree of pulmonary lesion, as was evidenced in the present study and is reported in studies carried out by authors such as Guzmán *et al* (2008) and Staaveren *et al* (2016). They reported 78,18% and 85% of apparent pulmonary tissue lesions respectively. In studies done by Merialdi *et al* (2012) and Meyns *et al* (2011) prevalence of 46,4% and 23,85% of macroscopic pulmonary lesions were observed respectively, this difference could be due to the size of the sample. The distribution of the lesions of the present study are shown on table 2.

Table 2. Degrees of lesion of the totality of pulmonary lobes

Lobe	Side	n	mean	D.E.	Var (n-1)	Var (n)	Min	Max	Median
Apical	Left	358	1,07	1,87	3,49	3,48	0,00	9,00	0,00
Cardiac	Left	358	2,01	2,29	5,22	5,21	0,00	9,00	1,00
Diaphragmatic	Left	358	1,25	2,32	5,40	5,38	0,00	15,0	0,00
Apical	Right	358	1,79	2,13	4,55	4,54	0,00	9,00	1,00
Cardiac	Right	358	2,10	2,26	5,09	5,07	0,00	9,00	2,00
diaphragmatic	Right	358	1,54	2,87	8,23	8,20	0,00	18,0	0,00
Accessory		358	0,97	1,87	3,51	3,50	0,00	9,00	0,00
Total		358	10,72	11,88	141,06	140,67	0,00	71,0	7,00

The findings showed a greater affectation of the right side of the lung, these results match the reported by Martín *et al* (2017), Guzmán *et al* (2008) and Steinmann *et al* (2014) who observed that the greatest degrees of macroscopic lesion were found on the apical, cardiac and diaphragmatic lobes of the right lung; although it is important to mention that in the study of Martín *et al* (2017) and in the study of Guzmán *et al* (2008) different percentage classification models were used. These findings could be explained

by what König *et al.* (2008) described, which is that the right lung is bigger than the left lung and this could favor the presentation of lesions of the right lung.

With regard to the observed lesions suggestive of pleurisy, it was found in 13% of the lungs evaluated, which is consistent with what was found by Fraile *et al* (2014) with a prevalence of 13.4% and similar to Alawneh *et al* (2018) who reported 22% of pleurisy; it should be noted that the latter work was done with a much larger sample (11,292 lungs).

In the present study, adhesions associated to pleurisy were not observed, this is consistent with the study of Staaveren *et al* (2016) who referenced a low frequency of pulmonary adhesions to the thoracic wall associated with pleurisy. Similarly, Andreasen *et al* (2000) affirms that it is common to find chronic pleural lesions in processing plants, because medical resolution of pleurisy can last three or more months; although in this study the evolution time of pleurisy was not determined, it is possible to presume that the result obtained may be due to the presence of chronic processes and not active infections.

On the other hand, the evaluation method proposed in this study has some limitations because the observations were made in very short times, due to the slaughter process being usually too quick, for this reason no incisional cuts were made, which would have allowed to check the depth of the injuries. Steinmann *et al.* (2014) considered that the limitations in this type of study could be directly related to its nature, which means that an observation or a two-dimensional photograph does not represent the pulmonary lesions with great exactitude as would a threedimensional evaluation. According to Hill *et al* (1992) and Davies *et al* (1995), the imprecision range between both methods results negligible due to the purpose to develop a pulmonary lesion scheme in the animal processing plants. Even though the proposed model in this study allowed to establish a simple and fast percentage rating of the

lesions, it is suggested to include lobe cuts in the methodology of future studies that may improve the observation of the different lesions, in addition to increasing the size of the sample and the spectrum of the evaluated farms and to try to evaluate the risk factors associated to these lesions in the productive systems.

4. Conclusion

This study revealed that the right and left cardiac lobes were the most affected, presenting the highest prevalence of pulmonary lesion. Additionally, it was possible to establish that the pulmonary percentage evaluation method used in the processing plant could be considered a practical and effective tool when monitoring the sanitary state of animals to be slaughtered, facilitating the analysis and association of these macroscopic findings with the different production parameters that are associated with profitability on farms and that allow the producer to make informed decisions about health plans, biosecurity measures and management practices to be implemented or reinforced to mitigate the presence of pathogens. It could also complement studies that correlate clinical signs, histopathological, bacteriological and virological studies focused on a definitive diagnosis of the diseases of respiratory origin.

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5

CHAPTER FIVE Arts, humanities and social sciences

**Education in social sciences and history:
the case of the faculty of educational
sciences of the Universidad Tecnológica
De Pereira (1970-2017)**

**La formación en ciencias sociales e
historia: el caso de la facultad de ciencias
de la educación de la Universidad
Tecnológica de Pereira (1970-2017)**

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Natalia Agudelo Castañeda²*

Abstract

This article outlines different stages of education in social sciences at the Faculty of Education of the Universidad Tecnológica de Pereira, articulated with the national and international context. We adhere to the conception of Jaime Jaramillo Uribe on the

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history of education as cultural and political history, to analyze the double perspective of internal history, which accounts for the different relationships between the field of knowledge and disputes of a curricular nature; besides, external history, represented in the contexts of each era in the reforms emanating from the State that generated contradictions in the academic communities, which resulted in ideological conflicts within the university between political sectors, and in the recurring tensions between modernization and autonomy.

It is about to analyze historically the relationships between the teacher education at the School of Social Sciences of the UTP and the curricular restructuring that were deciding in the search for interdisciplinarity, in the regulatory adjustments to the 1991 Constitution and Law 115 / 94, in addition to the tensions between the local and the global, neoliberalism, interculturalism, defense of the environment. This research was carried out under the historical-critical method, based on the approach of oral sources and institutional archives.

Keywords: Teacher Education; School of Social Sciences; Education History; Teaching of History; Faculty of Educational Sciences; Universidad Tecnológica de Pereira.

Resumen

Este Artículo esboza diferentes etapas de la formación en ciencias sociales en la Facultad de Educación de la Universidad Tecnológica de Pereira, articuladas con el contexto nacional e internacional. Nos adherimos a la concepción de Jaime Jaramillo Uribe sobre la historia de la educación como historia cultural y política, para analizar en la doble perspectiva de historia interna, que da cuenta de las distintas relaciones entre el campo del saber y las disputas de índole curricular; y de otro lado, la historia externa, representada en los contextos de cada época, en las

reformas emanadas por el Estado que generaron contradicciones en las comunidades académicas, lo que se tradujo en conflictos ideológicos dentro de la universidad entre sectores políticos, y en las tensiones recurrentes entre modernización y autonomía.

Se trata de analizar históricamente las relaciones entre la formación de docentes en la Escuela de Ciencias Sociales de la UTP y las reestructuraciones curriculares que se iban decantando en medio de la búsqueda de interdisciplinarietà, en los ajustes normativos a la Constitución de 1991 y la Ley 115/94, además de las tensiones entre lo local y lo global, neoliberalismo, interculturalidad, defensa del medio ambiente. Esta investigación se realizó bajo el método histórico-crítico, fundamentado en el abordaje de fuentes orales y archivo institucional.

Palabras Clave: Formación Docente; Escuela de Ciencias Sociales; Historia de la Educación; Enseñanza de la Historia; Facultad de Ciencias de la Educación; Universidad Tecnológica de Pereira.

1. Introduction

The Universidad Tecnológica de Pereira (UTP) and the graduate education (1961-1967).

The UTP was created by Law 41 of December 15th 1958, within the framework of what María Teresa Uribe and other scholars on the subject have identified as the massification and modernization of higher education in Colombia, a time that has been understood since the 1960s of the 20th century in which the need to expand the coverage of Higher Education through the creation of new universities in the regions, to contribute to economic and industrial development and to launch decentralized

educational projects³. This university started its academic offering in 1961 under the administration of its founder and first rector, Dr. Jorge Roa Martínez, with the collegiate programs of Electrical, Mechanical, and Industrial Engineering (Acevedo, Rodríguez and Giraldo, 2009, p. 290-291).

Four years later, Dr. Roa Martínez argued that the institution should not stop in its development and, consequently, should extend its teaching to other fields of science (Act 90/1965, of November 12th, of the Superior Council of the Universidad Tecnológica de Pereira). There, they began to talk about the creation of a Faculty of Educational Sciences at the UTP, a fact that was specified in 1965 in a session of the Board of Directors (Act 90/1965, of October 19th, of the Board of Directors of the Universidad Tecnológica de Pereira) in which it was approved that this new academic unit would begin its operation in the year 1967 (Act 10/1967, of May 19th, of the Directive Council of the Universidad Tecnológica de Pereira)⁴. The creation of this new Faculty also found justification in the recommendation of the Colombian Association of Universities (ASCÚN) to create a faculty of education in each university in the country (Act 90/1965, of the Board of Directors of the UTP), consolidating what in the History of Education has been cataloged as the second generation of Educational Sciences Faculties (Correa, Agudelo and Niño, 2018, p. 65-67)⁵, heirs of the first generation undergraduate programs

3 María Teresa Uribe, coord., *Universidad de Antioquia: historia y presencia* (Medellín: Editorial Universidad de Antioquia, 1998); Yvon Le Bot, *Educación e ideología en Colombia* (Bogotá: Editorial La Carreta, 1979); Carlos Alberto Molina, *FUN-ASCÚN en la historia del sistema universitario colombiano, 1958-1968* (Bucaramanga: Ediciones UIS, 2013); Fernán E. González, *Educación y Estado en la historia de Colombia* (Bogotá: Editorial Presencia, Centro de Investigaciones de Educación Popular (CINEP), 1979); Ricardo Lucio y Mariana Serrano, *La educación superior: Tendencias y políticas estatales* (Bogotá: Universidad Nacional de Colombia, 1992).

4 The Physics and Mathematics Bachelor program began academic work in the second semester of 1967 with twenty-three students. 5 The second generation of Faculties of Educational Sciences is composed by the faculties created between the decades of the sixties and seventies of the twentieth century in the following Colombian universities: Universidad Nacional Sede Bogotá (1959), Universidad del Atlántico (1961), Universidad del Valle (1962), Universidad del Quindío (1962), Universidad de Nariño (1962), Universidad del Tolima (1967), Universidad Tecnológica de Pereira (1967), Universidad de Córdoba (1968), Universidad del Cauca (1972) and Universidad de de Caldas (1973).

(Ríos Beltrán, 2007) and of the Escuela Normal Superior itself, but who distanced themselves due to the tensions between the pedagogical and disciplinary components, as will be explained later (See: Ríos Beltrán, 2007).

Thus, the Faculty of Educational Sciences of the UTP (FCE-UTP) began its academic work in 1967 with a Bachelor's Degree in Physics and Mathematics (Correa, Agudelo and Niño, 2018, p.72-76)⁵. In 1969 some budgetary problems became evident in the Faculty, which led its dean, Dr. Roberto Valencia Patiño, to propose the aperture of extracurricular programs to solve the said deficit. Given this, the Board of Directors issued a favorable decision, and the courses of Child Psychology, General Didactics, History of Culture, and Contemporary Poetry were opened, all with an intensity of 45 semester hours and with an enrollment of fifteen students (Act 23 / 1969, of July 2nd, of the Board of Directors of the Universidad Tecnológica de Pereira). These courses were the gateway to the Faculty of Educational Sciences for basic education teachers who had a normal school degree with more humanistic concerns and who at the same time were seeking to advance in their professional training, since to date in Risaralda there were only approximately ten professors with a Bachelor's degree (Mario Vélez García, interview, November 18th, 2015), which made the need for the Faculty to offer an alternative for professionalization to the department's teachers imperative; this was what made the creation of new Bachelor programs possible in subsequent years.

As stated in the Memorandum OP-078-A of February 4th, 1970 sent by the Planning Office to the Rectory of the University, the Faculty had structured a project to create three new areas: Social, Psychology and Educational Administration, and Biological and Chemistry (Memorandum OP-078-A of February 4th, 1970. Annex to Act 02/1970, of February 5th, of the Superior Council of the Universidad Tecnológica de Pereira). These areas would have

⁵ This Degree was modified on several occasions, being subsequently offered as a Degree in Mathematics and Physics, which was transferred to the Faculty of Basic Sciences of the UTP in 1985.

a duration of four academic semesters and would grant the title of Expert, in compliance with the provisions issued by Decree 1964 of 1969, by which higher education establishments are authorized to organize short and medium duration academic programs in educational sciences. Of the three, the functioning of the Social and Psychology and Educational Administration areas were approved, which were consolidated between 1970 and 1971 as the Bachelor of Social Sciences and the Bachelor of Psychopedagogy and Audiovisual Techniques, respectively (Memorandum OP-078- A of February 4th, 1970).

1.1 The first years of education in social sciences at the FCE-UTP (1970-1984).

The School of Social Sciences of the FCE-UTP was created through Resolution 0017 of July 27th, 1970. In the second semester of the same year, Luz Ángela Gómez de Lizcano was hired, who was the teacher in charge of guiding the first courses in this School and, therefore, to develop the study plan for the Bachelor of Social Sciences, which was approved by Agreement 10 of 1971 of the Academic Council of the UTP.

As Carlos Ramiro Bravo states, this study plan is related to the one of the Universidad Pedagógica Nacional, which is coherent if it is taken into account that Professor Luz Ángela Gómez graduated from that institution (Bravo Molina, 2003, p. 669). However, this program inherited the tradition of historical-geographical studies of the Faculty of Educational Sciences of the Universidad Nacional from the early 1930s, of the historical-ethnological program of the Escuela Normal Superior, and the programs in Social Sciences of the Universidad Pedagógica y Tecnológica de Colombia, and the University of Lomonosov and Patricio Lumumba of the Soviet Union. This means that the Bachelor of Social Sciences of the UTP had a historical-geographical component of German influence, at the same time that it was nourished by the experience of the with the Escuela Normal Superior, with the scientific contributions of the French ethnology represented in Paul

Rivet and the German Justus W. Schottelius, and of the German pedagogy embodied in Julius Sieber (*ibid.*, P. 671). Besides, some references and approaches from the New History, from Marxist-Engelsian historiography and the School of Annals were already being appropriated, while in the anthropological and geographical components were studied the contributions of the functional-structural approach of the American anthropologist Melville Herskovits and the French anthropologist Claude Lévi-Strauss, as well as Ernesto Guehl's approach to continental geographies and regional geography, respectively (*ibid.*, P. 672).

During the decade of the seventies, more professors came to make up the teaching staff of the Faculty of Education Sciences, which also contains information on the first students of the Bachelor of Social Sciences -, and specifically of the School of Social Sciences, a fact that coincided with a national panorama that was characterized by strong social mobilization and political-ideological radicalization in opposition to secrecy and the exclusionary and antidemocratic character that was perceived within the scheme of the National Front (1958-1974). This opposition was also exerted against the interventionism of the United States in the economic and educational policies of Latin American countries - specifically Colombia - and in particular with the launch of the Alliance for Progress, as a way to slow down the advance of communist ideas in the region and the country. It should be noted here that the movements, groups, and leaders of the left-wing in Colombia had been the visible target of persecution and stigmatization, to the extent of being associated with the guerrilla groups that had emerged in the sixties (Correa and Niño, 2018: 59-60).

In this context, the teaching of the social sciences was part of an option for an emancipatory critical formative project that would respond to the demands posed by a time of profound social, cultural, and political transformation. Hence, as proposed by Carlos Ramiro Bravo, the academic aims of the education of

social sciences teachers were conceived based on an "ideologizing" trend or, as he calls it, a "left-wing student" trend that lasted during throughout the decade of the seventies until well into the eighties (Bravo Molina, 2003, p. 60-64)⁶. Bravo managed to show that the School of Social Sciences, and to a great extent the FCE of the UTP, oriented their academic work in a close relationship with the political struggles and demands that characterized social movements at that time and particularly the actions of the left-wing, an aspect that was also evident in the faculties of other universities in the country that offered careers related to the social sciences. All these configured formative scenarios in social sciences in which epistemological reflections on:

(...) the various forms of expression of the Latin American reality, rethinking the methods, practices, and theoretical models of positivism by new critical-social paradigms, which at the time were considered the most elaborate and scientific, consequently not being alien to certain dogmatisms and over-ideologizations, which obviously had their repercussions on the progress of the Social Sciences. (Bravo Molina, 2000, p. 127)⁷

The said "ideologizing" tendency in the education of social science teachers was not unrelated to the educational policies that at the national level came to regulate how social sciences should be taught in basic education institutions. Indeed, the development of didactic-pedagogical tendencies and conceptions of instructional behaviorism and educational technology between 1960 and 1980 (Bravo Molina, 2003, p. 60-64), led the Colombian State to change its place and its strategy of control

6 As well, it should not be forgotten, that a large part of the professors at the FCE-UTP School of Social Sciences belonged to the Communist Party, which means that this "ideologizing" tendency may make more sense when it comes to understanding how the training of graduates in was given in this academic unit.

7 It should be noted here that the vast majority of the professors at the FCE-UTP School of Social Sciences were affiliated with the Communist Party. Besides, they approached the study of history and in general the social sciences from the postulates of historical materialism, the critical theories of the Frankfurt School and approaches to critical and liberating education.

over the teaching of history, directing and deciding on content and methodologies, “(...) through the formulation of study plans or general schemes, increasingly seeking to have control over the teacher's work; [sharing] the inspection on school texts with the Colombian Academy of History” (González Lara, 2012, p. 68). In this way, the teaching of history went through a kind of epistemological transition “(...) from anecdotal, jingoistic, descriptive and memoristic history to a history of economic, political, social, ideological, structural, explanatory, holistic and dialectical content, both in the faculties and in the schools” (Bravo Molina, 2000, p. 128).

The education in the Bachelor of Social Sciences of the FCE-UTP thus had a first stage between the seventies and eighties of the twentieth century, which was motivated towards the development of critical judgment and constructive thinking that led to a true interpretation of the human being versus space and time, and that it sought to promote a defined conscience about national problems, creating at the same time the will to serve and the desire to contribute to the search for correct solutions in society (Act 50/1971, of December 9th, of the Board of Directors of the Universidad Tecnológica de Pereira). This educational purpose was not substantially transformed in the following years, even though the Bachelor's Degree underwent a curricular restructuring as a result of the new educational policies issued by the Ministry of National Education.

1.1.1 A curricular restructuring: integrated social sciences (1984-1994).

In 1984, a new regulation was issued for preschool, basic and secondary education in the country: Decree 1002, which establishes the curriculum for preschool, basic (primary and secondary), and vocational secondary education in formal Colombian education. With that, the school social sciences (history and geography) were grouped into the same area: Social

sciences, a fact that meant a curricular restructuring in university education programs for graduates in this field. It is necessary to clarify that this new regulation was the product of the suggestions that the historians Jaime Jaramillo Uribe and Jorge Orlando Melo made to the Ministry of National Education in the 1970s in the report "Claves para la enseñanza de la Historia", in which they argued that History and geography were two school disciplines that had to be approached simultaneously in the teaching processes in basic education, while the knowledge of each is closely related to each other (Melo, Claves para la enseñanza de la Historia). This new epistemological conception of the teaching of the social sciences introduced a trend concerning academic purposes in the education of graduates between 1980 and 1990, which consisted of a scientific approach to the structures of school disciplines, that is, in a different way of relating and interconnecting the disciplinary components in the educational process. However, paradoxically, this is the same time in which the study plans of the licenses in the faculties of educational sciences were retracted again towards the unidisciplinary model of history or geography (Bravo Molina, 2003, p. 60-64).

Under this view, the Academic Council of the Universidad Tecnológica de Pereira approved the modifications to the study plan of the Bachelor of Social Sciences. In general terms, this restructuring of the curriculum showed a blurring of the components of other disciplines of the social sciences, specifically anthropology, which became part of the subject programs of the historical discipline. Furthermore, it is relevant to emphasize the presence of two new subjects in the 1984 curriculum dedicated to social research, which grouped the disciplinary seminars in sociology, history, and geography that were oriented in the previous curriculum. This explains why it has gone from a foundational curriculum that placed its emphasis on the theoretical field, towards a modified curriculum that began to focus its attention on the professional investigative component materialized in the completion of degree work (2000, 129 -130).

Finally, it draws attention to the fact that disciplinary subjects in history kept a thematic or temporal- specificity in the new 1984 curriculum: the history of primitive societies, slave societies, societies in transition, feudal societies, capitalist societies, and history of contemporary problems in Asia and Africa, in addition to those that already existed in the History of Colombia and America. This is especially revealing, insofar as Jaramillo Uribe and Melo's suggestions went in another way:

The teacher of History and Social Sciences must handle a set of concepts, such as slavery, feudalism, socialism, bourgeoisie, proletariat, democracy, etc. The good connoisseur of history knows that these types of concepts should not be taken as abstractions that help to characterize an era or a society, but which also acquire particular nuances and forms in peoples and nations, in times and periods. Also, that several of these ways of presenting cultural life, social or political life can coincide in any era or town. For instance, in a country like Colombia, forms of capitalist organization (modern city industry) and semi-feudal forms of agricultural life may coincide (peasants in debt through land leasing, who therefore lose their mobility and are practically linked to the property of the landowner). Modern democracy takes many forms and manifestations. It may be highly developed in England, but it is imperfect and hardly constitutes an ideal in many countries of the world, especially in today's so-called third world or a world of underdevelopment.

There is an old European bourgeoisie, with a very precise culture and way of life (for example in France), but the bourgeoisie in other countries (in the case of Latin America) is barely developing, is relatively young, and has many features cultural and psychological characteristics of these countries, of their tradition and their specific culture (Melo, Keys for the Teaching of History).

This plausible contradiction in the curricular restructuring of the Bachelor of Social Sciences, within the framework of the guidelines of Decree 1002 of 1984 and the suggestions made by these two historians, could be the reflection of a generalized situation in the other faculties of education of the country, of the non-appropriation of the “interdisciplinary” integrationist policy that the reform of the Ministry of Education proposed. According to Carlos Ramiro Bravo, this policy “(...) did not mean a transcendental step due to the exclusion of teachers and the educational faculties themselves” (Bravo Molina, 2000, p.134). Besides, and as several historians have stated today, Decree 1002 of 1984 did not generate substantial changes in the way history was being taught in basic education institutions, since teaching based on counts and chronological sequences prevailed more than on Historical concepts and problems, without dialogues between basic education teachers and professional historians:

Although it was intended to change the relationship between the educational system and producers of historical and social knowledge, the curricular structures remained unchanged in the approaches to political history, partially incorporating the proposals of professional historians (Acevedo and Samacá, 2012, p 233).

In general terms, the Bachelor of Social Sciences of the Universidad Tecnológica de Pereira continued its academic work from its creation in 1971 until the eighties without major trauma, except in some situations such as the National University Strike of 1971 and the National Civic Strike of 1977, in which the connection between professional training and the political actions of students and teachers was seen much more explicitly. It is also worth saying that both students and teachers were fundamental actors in the transformation of the cultural and political scene in the city of Pereira, since their academic contributions and political struggles laid the foundations for new projects and processes. This is the case of the creation of the House of Women and the Family

in 1983 by Professor Stella Brand de Prado; the emergence and consolidation of the Afro-Colombian Movement “Cimarrón” by the graduates Américo Portocarrero and later Iván Vergara; the creation and edition of the journal Cuadernos de Ciencias Sociales by Professor Luz Ángela Gómez between 1985 and 1992; and countless academic meetings and seminars that were promoted from within the School of Social Sciences (Bravo Molina, 2003, p. 673).

From this first stage of the School, it can be concluded that, despite the curricular renewal that took place in 1984, the disciplinary component of history continued in the curriculum without substantial changes in terms of the curricular contents and teaching methods. For its part, the research approach in social sciences was strengthened with the inclusion of Social Research seminars as support for the preparation of the degree work to qualify for the professional title. However, weaknesses continued to be evidenced in strengthening the line of local histories (2000, p. 134) and in general in scientific research from the School, since the efforts continued to fall on teachers individually, an aspect that also accounts for of the profound weaknesses in the conformation of academic communities that not only the School of Social Sciences but the Faculty of Education Sciences has had (p. 134).

1.1.2 The School of Social Sciences is transformed: from social sciences to ethnoeducation and community development (1995).

By 1995, the Bachelor of Social Sciences of the Faculty of Education Sciences of the UTP already had more than twenty years of experience. Nevertheless, some difficulties were already becoming evident with the offer and enrollment of this academic program, to the point that for the first semester of 1995 no enrollments had been received. This fact led to the fact that on April 20th of the same year, the Dean of the Faculty at that time, Professor Víctor Zuluaga Gómez, submitted a request to the

Academic Council of the UTP to temporarily suspend registrations for the Bachelor's Degree, covered by the announcement of the Secretariats Departmental and Municipal Education that there was an oversupply of Graduates in Social Sciences and Spanish and Audiovisual Communication (Correa, Agudelo and Niño, 2018, p. 144). Indeed, until the second semester of 1994, a total of 858 Graduates in Social Sciences had graduated, a figure equivalent to 39.74% of the 2,159 graduates of all undergraduates from the FCE-UTP, and barely followed by 35.57% that corresponded to the Graduates in Spanish and Audiovisual Communication, which was the other undergraduate program that was still offered in the faculty at the beginning of the nineties⁸.

The resolution to indefinitely close the academic offer for the Bachelor of Social Sciences coincided with the startup of a new undergraduate degree at the FCE-UTP: the Bachelor of Ethnoeducation and Community Development, whose project had been prepared by the professors of the School of Social Sciences Morelia Pabón, Carlos Arturo Escobar, Carlos Ramiro Bravo, and Gildardo Rivera (p. 146-147)⁹, and that had been approved by the Academic Council of the UTP.

Before proposing an interpretation regarding the curriculum of this program, it is worth noting that the rise of a Bachelor's Degree in Ethnoeducation and Community Development at the FCE-UTP in the mid-nineties is linked to a national panorama in which gradually the debates on ethnicity were entering the

8 Information developed with the Institutional Intelligence Tool of the Universidad Tecnológica de Pereira: Statistics and Indicators, Planning Office, «Historical Graduate», access on June 05, 2019, http://reportes.utp.edu.co/xmlpserver/publico/Planeacion/Boletin_estadistico/Graduados_Historico/. It should be noted that this tool counts a total of only 1819 graduates as graduates of the Faculty of Education Sciences in the period between 1966-I and 1994II. Nevertheless, the total number of graduates in this period would be 2,159, counting the 252 graduates of the Bachelor of Mathematics and Physics and the 88 of the Bachelor of Physics and Mathematics, who are counted in the figures for the Faculty of Basic Sciences. These last two figures correspond to the period between 1966-I and 1985-II, the year in which, as mentioned in footnote N ° 12 in this document, the Bachelor of Mathematics and Physics was transferred from the Faculty of Sciences from Education to the Faculty of Basic Sciences.

9 Later, professors Víctor Zuluaga, Luz Ángela Gómez, Gustavo Guarín, Alberto Berón and Olga Lucía Bedoya joined the program.

scene: the Ethnoeducation Program of the Ministry of National Education, approved in 1984; the declaration made with the 1991 Political Constitution that Colombia was a multi-ethnic and multicultural country; the issuance of Law 70 of 1993, which recognized the black communities of the Pacific and their right to collective ownership of the land; and Decree 804 of 1995, which came to regulate the provisions of Law 115 of 1994 -or General Law of Education- in the area of educational care for ethnic groups. (p. 145-146).

Having made this remark, we can affirm that this degree was designed for the preparation of graduates capable of guiding the training processes with ethnic communities and with the less favored social sectors, rather than to generate a differential higher education offers for ethnic communities (p. 172-176)¹⁰. In this way, it advocated the recognition of the sociocultural, economic and educational contexts in which there was a presence of ethnic groups and migrant population -generally from rural areas to the city-, along with knowledge of the processes of construction of the Nation-state in Colombia and the historical configuration of the population that inhabited the region of influence of the Faculty.

Likewise, the conjugation of the social sciences in the curriculum is to some extent evident, an aspect that could adduce to an interdisciplinary approach in the training of graduates, but which rather meant a new blurring of the disciplinary specificities of the social sciences within of the School of Social Sciences of the FCE-UTP, to the extent that, having distanced itself from the objectives of ethnoeducation enshrined in the regulations in

¹⁰ It should be clarified that in 1997 an expansion line of the Degree in Ethnoeducation and Community Development began to be offered, designed to prepare as graduates the teachers of the Purembará Indigenous Reservation Boarding School, located between the municipalities of Pueblo Rico and Mistrató, Risaralda. This line of expansion was consolidated as the Bachelor of Indigenous Education, which had a single cohort that ended in 2006 with a total of twenty-one (21) graduates, all teachers belonging to the Emberá Chamí indigenous community. Although this experience was derived from the Degree in Ethnoeducation and Community Development, only the Bachelor in Indigenous Education can be understood based on a differential higher education offers for ethnic groups.

force up to now in this matter (Valencia, 2016)¹¹, The Bachelor's Degree in Ethnoeducation and Community Development did not contribute –and to date is still indebted to it– pedagogical and epistemological reflections around issues such as self-education, interculturality, and ethnoeducation. This is not only a symptom of the low academic production and participation of students and teachers in settings typical of this field of studies but also of the loss of the particularities of the disciplines of social sciences in the curriculum, which has led to the professional profile of the graduates of this academic program is unclear, as stated by the peer evaluators of the Bachelor's Degree in their voluntary accreditation process in 2011 (Correa, Agudelo and Niño, 2018, p. 150-152).

Moreover, the disciplinary component of History did continue to be present in the academic work of the School of Social Sciences, no longer in terms of undergraduate degrees, but in postgraduate training, as we will see below.

1.1.3 A recent commitment to postgraduate training in History.

The Faculty of Educational Sciences of the UTP has had two postgraduate experiences in the field of history throughout its 52 years at the School of Social Sciences¹. The first was the Specialization in Contemporary History of Colombia and Regional Developments and the second the Master in History.

¹¹ Article 6 of Decree 804 of 1995 issued the following guidelines for the education of ethno-educators: a) Generate and appropriate the different elements that allow them to strengthen and stimulate the global life project in the communities of ethnic groups; b) Identify, design, and carry out research and promote tools that contribute to respect and develop the identity of the ethnic groups where they provide their services, within the framework of national diversity; c) Intensify the identification of their pedagogical forms and develop them through daily educational practice; d) Establish the permanent knowledge and use of the vernacular of the communities with their linguistic traditions, where they are going to perform; e) Acquire and assess the criteria, instruments, and means that allow to lead the construction and evaluation of the educational projects in the institutions where they will provide their services. Decree 804/1995, of May 18th, which regulates educational care for ethnic groups (Official Gazette No. 41853 of May 18th, 1995). For a better understanding of the distancing of the Degree in Ethnoeducation and Community Development of the UTP from these normative orientations..

The first program arose as a result of the need detected by FCE professors:

They identified at the beginning of the decade [of the nineties] that it was necessary to rethink the issue of the training of practicing teachers in the region, based on an academic offer that would provide them with a high-quality qualification and not only from the field of professionalization but also under the figure of specialization in specific areas and components of professional training and the promotion of investigative work (p. 153-154).

Such concern was in correspondence with what was stated in Law 30 of 1992, which considered specializations as a form of improvement in undergraduate training, and Masters and Doctorates as scenarios for the production of knowledge through research activities (Law 30/1992, of December 28). Thus, the Specialization was approved through Agreement No. 016 of May 18th, 1995 (Agreement 016/1995, of May 18, Of the UTP Superior Council, by which a Postgraduate Training program is approved. AUTP) with an emphasis on History Teaching and with a duration of 3 academic semesters.

The emphasis that the Specialization placed on the Teaching of History was complemented with a Marxist approach, since, as Professor Víctor Zuluaga comments, the study plan was designed under the scientific postulates of historical materialism, which was an of contemporary historiographic currents in vogue of the time (Correa, Agudelo and Niño, 2018, p. 156).

Some of the teachers who were part of this training process were: Víctor Zuluaga, Gustavo Guarín, Carlos Arnulfo Escobar, Morelia Pabón, Gildardo Rivera and Luz Ángela Gómez. Another important aspect worth mentioning are the areas that made up its curricular structure, which during its career was supported by external researchers such as Mauricio Archila, Albeiro Valencia Llano, Álvaro Fayad and César Augusto Ayala Diago.

The Specialization had a five-year existence at the UTP, which began in 1997 and ended in 2003. In that period, it managed to graduate two promotions with a total of 32 Specialists. In its last years, the program had severe administrative difficulties, which resulted in its definitive closure.

Six years later, at the initiative of Gustavo Guarín, Álvaro Acevedo Tarazona, Miguel Ángel Gómez, and Fernando Romero, the Master's Degree in History emerged intending to resume professional studies in this discipline, and as a response to an academic and research need in the field regional history, which has sought to fill the void in the historiographic production in the coffee region under the theoretical and methodological assumptions that the study of History implies at a professional and postgraduate level. This master's degree acquired administrative life with the promulgation of Agreement 68 of December 15th, 2009, of the Superior Council of the UTP, and obtained its qualified registration in 2010¹², starting its first cohort in 2011 with 15 students enrolled.

The master's in history began its academic work with the research modality. This emphasis carries a theoretical and historiographical base that groups in the curriculum the seminars of Memory and Nation, Nation and Region, Theories of History I and II, National, Regional, Urban and Environmental Historiography; a research base, which involves the seminars of the Office of the Historian and Research Project I, II and III in which students carry out their graduate work projects; and finally, a base of electives made up of History of Institutions and Sociabilities, Business History and Regional Elites, Cinema as a Didactic Tool in the Teaching of History, History on the Web: Museums, Libraries, and Documentary Sources, Microhistory and Daily Life, Historical Debates on Patronage and Violence in Colombia, Cultural Landscape in the Historical Perspective, Education, Conflict and Social Movements, Memory, Education

¹² External Norm issued by the Ministry of National Education Resolution 5226 of June 25th, 2010.

and School Textbooks in Social Sciences («Proyecto Educativo del Programa» Maestría en Historia, Universidad Tecnológica de Pereira).

Those who have completed the Master's studies have focused their undergraduate work on the lines of research on the history of education, urban history, regional history and on the line of history and memory, all of them making important use of documentary sources such as the press and institutional archives.

The Master's degree final projects show a renewal in the local and regional historiography, a product of the academic effort of the Master's Degree, which acknowledges the investigation of issues specific to the city of Pereira or the Department of Risaralda, ranging from founding myths to the resignification of the role of women or ethnic communities, in the different spheres that make up society seen from a historical perspective.

Furthermore, since 2016, the Master in History has been offering the modality of deepening in Didactics of Social Sciences and History, which is based on the agreements developed with the Ministry of National Education -within the framework of the programs of Scholarships for Teaching Excellence- with the Secretary of Education of the Department of Caldas and other agreements with the Secretary of Municipal Education of the Mayor's Office of Pereira. Hence, those who enter this emphasis, for the most part, are practicing teachers who have as their base training degrees that are not necessarily located in the field of history or social sciences. This input issue favors interdisciplinary dialogue, which requires the faculty of the Master's degree to make an effort to qualify the reflection of learning in the specific field of the social sciences and history. Given this, a permanent monitoring strategy has been developed for the classroom projects of these teachers, which goes from the beginning of their training process to its culmination.

The curricular structure of this modality it is formed by the same theoretical and historiographic base of the emphasis on research, and a pedagogical research base that corresponds to the following classroom project seminars: Didactics of History, Didactics of Social Sciences and Pedagogy, and Classroom I and II Project («Proyecto Educativo del Programa» Maestría en Historia, Universidad Tecnológica de Pereira).

This viewing of the course of the Master's Degree in History in its two modalities invites us to think about the role of disciplinary education in History and Social Sciences at a postgraduate level in two ways: the first, concerning the investigative processes in said field, and the second, in the training of practicing teachers in the field of social and human sciences. This second element poses different challenges, among them, considering the teaching of history within Integrated Social Sciences in basic and secondary education¹³, which implies not only disciplinary training but also interdisciplinary training, in this regard we join Alcira Aguilera who proposes that:

It is not about a dispute between disciplinarity and interdisciplinarity, but about disciplinary training to think and act interdisciplinary when teaching and approaching social sciences. (Aguilera Morales, 2017, p. 15-27)

This idea leads to directly raise the need for curricular interaction between pedagogy and didactics, based on the disciplinary preparation of teachers to carry out both the teaching-learning process and the investigative processes that may arise in the classroom at any level of education.

Finally, all the educational processes of the Master's in History have been headed by its director, Dr. Jhon Jaime Correa

¹³ It is worth mentioning that this aspect has been the subject of debates at the national level, in which several elements were exposed, among them, the problem of the contents to be addressed in this subject, the methodologies and specific didactics of the school discipline, and the social function of historical knowledge in school.

Ramírez, and the Curricular Committee integrated by Dr. Sebastián Martínez Botero, Dr. Alberto Berón Ospina and Mg. Carlos Alfonso Victoria Mena, and has had in recent years the visit of professors from national and international universities such as Luis Ervin Prado (Universidad del Cauca), Andrés Castañeda (Universidad del Valle), Enrique Rodríguez

Caporali (ICESI), Albeiro Valencia Llano (Universidad de Caldas), Jefferson Jaramillo Marín (Pontificia Universidad Javeriana), Alexander Betancourt Mendieta (Universidad Autónoma de San Luis de Potosí), among others.

2. Conclusions

A little more than five decades have passed since the opening of the Faculty of Educational Sciences that enlightened the first bachelor's in social sciences in the city. In this path, both the Universidad Tecnológica de Pereira and the FCE have been transformed in various aspects ranging from their physical infrastructure to the training stakes that have been mediated by contextual needs. In this way, it can be read in this brief section on the history of the School of Social Sciences, that the curricula and content addressed in the training of graduates in social sciences went through a process of transition from national and anecdotal histories to plural stories, to the history-problem, in which the emphasis was no longer placed on the great feats of independence and the figures of the great men -the heroes-, but on the processes of nation-building, as well as on the discovery of subordinate actors who undoubtedly constitute other visions of history and the understanding of the present. Doubtless, this transition was also characterized in part by the dogmatic positions held by some teachers - and students - of the School linked to the discourses of the left-wing politics, but this also made it possible to bet on the formation of critical thinking committed to social transformation.

Still, although within the School of Social Sciences there have been professors such as Víctor Zuluaga, Carlos Ramiro Bravo, Luis Gildardo Rivera, interested in studying and working with the ethnic groups that are present in the department, no an academic tradition in this field has been consolidated. Research efforts have been individual, they have not had continuity over time, and they have not contributed to the consolidation of academic communities and, therefore, of a school that forges a specific field of study, a matter that is linked to the interactions between peers as well as –and necessarily– in its dissemination through pedagogical practice, in actions that put knowledge in circulation and renewal. Taking into account that knowledge is dynamic, not immobile or trapped, such interactions reveal an active process that is the foundation of an academic community. Instead, what has happened in the School of Social Sciences, except for some cases, is the construction of individual or intermittent initiatives: half academic communities.

Now, to refer to the most recent years and the field of history and its teaching at the FCE, we bring up the proposals of Alcira Aguilera, for whom history is constituted as the structuring axis of school social sciences, to the extent that other disciplines, methods and languages of other social sciences converge in it:

Given that history mobilizes knowledge from all areas, this discipline becomes the pedagogical axis par excellence for comprehensive training in social sciences, provided that teachers have sufficient flexibility to integrate the different analytical and historical dimensions of the various fields of the social sciences. (Aguilera, 2017, p. 19)

In this sense, the Master's Degree in History has demonstrated the capacity that exists from this disciplinary field to make interdisciplinary transits, based on the degree work of its students and the exercise of its graduates; besides, it has generated a training scenario that has begun to be a cultural project with

its offer in terms of the dissemination of disciplinary research in History, in different spaces of the city and the region such as colloquia, symposia, and other academic conferences. Likewise, the creation of the “Colección Editorial de la Maestría en Historia” and the journal *Ciencia Nueva*, and the gestation of the Graduate Networks of the postgrade, are aspects that have begun to consolidate as a joint strategy for communication between the union and the dissemination of the work of students, teachers, graduates and research groups attached to the academic program, which will necessarily translate into a commitment to the renewal of local and regional historiography.

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Mario Vélez García, interview, November 18th 2015.

Cratylus: a study about language in Plato's works. Doctoral Thesis

Cratílo: un estudio sobre el lenguaje en platón. Tesis doctoral

Juan Manuel López¹

Abstract

This paper gives an overview of what was a long doctoral thesis process. Its results, implications and consequences arising from the academic exercise carried out over more than 7 years make up the centerpiece of this text. The results contain different exercises of writing and they are the central focus of the text. In the same process the results are evident at the level of directed theses, creation and participation in academic events as well as other products. These aspects are undoubtedly constitutive of the academic philosophy's work and that, therefore, help to the

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institution (Technological University of Perira) in different ways such as the Graduate Program in Philosophy and the Master Program to establish itself as a leading program with its research group in Ancient Philosophy.

Keywords: Writing, events, projects.

Resumen

El presente texto hace un balance general de lo que fue un largo proceso de tesis doctoral. Sus resultados, implicaciones y las consecuencias que se desprenden del ejercicio académico llevado a cabo a lo largo de más de 7 años constituyen el eje central del texto. Los resultados contienen diferentes ejercicios de escritura y ellos son el punto central de este texto. En el mismo proceso se evidencian los resultados a nivel de tesis dirigidas, creación y participación en eventos académicos así como de otros productos. Estos aspectos que sin duda son constitutivos del quehacer académico de la filosofía y que, por ende, ayudan a que una institución como el programa de Licenciatura en Filosofía de la Universidad Tecnológica se afianza como un programa líder con su grupo de investigación en Filosofía Antigua.

Palabras Clave: Escritura, eventos, proyectos.

1. Introduction

The issue of this work, as the title of the project announces, was the problem of language in Plato. Plato, as is well known, is the first cornerstone of philosophy and also, therefore, of writing. While there are testimonies of some of the thinkers before Plato, such thinkers are known precisely by the work of the Greek philosopher. However, the central point of this project was necessarily its conception of dialectics, which was interpreted into a scriptural component unlike the verbal component in which the different critics of philosophy have commonly done so. This

searching exercise on the grounds of philosophy at the level of the depth of what demands a doctoral thesis in a classical way (review of different sources in different languages, knowledge of history and the Greek language) opened and enabled the creation of different products, study groups, strengthening of research groups, which are the mainstay not only of one of the undergraduate programs of the Technological University of Pereira, but also from his Master's program in philosophy. In advance, we will look at some of the results that the project yielded beyond the understanding of the topic of dialectics and writing in the Greek world, that was the one that was initially sought, and which has been concretized in some articles and, of course, in the doctoral thesis which has the name of Cratilo, a dialectical practice in and with names.

2. Materials and methods

The methodology used is hermeneutic. In this way, the working material used is always a bibliographic material, which can be found in detail in the References of the project. That's why, it was necessary to have training in different languages in order to review many texts in their original language. It can be consulted in my CvLac². The method of work can be described as follows: Gadamer's work, especially in his *Gesammelte Werke* (Complete Works) Volumes II (1985) and III (1991) shape and framework of interpretation. This work, also, takes from Havelock (1994) the strong importance of writing as a technology of thought. This same methodology is applied by the great master Emilio Lledó (1984, 1994, 1999, 2000) for the Spanish language. In this direction what has been sought is the work related to the state of current art, and this in relation to the forms of classical approach to the Hellenic world.

² https://scienti.minciencias.gov.co/cvylac/visualizador/generarCurriculoCv.do?cod_rh=0000983128 (Research's date october 9, 2020)

3. Results and discussion

As usually happens with works that start with mere hypotheses or initial assumptions, typical of the humanities labor, the following work goes beyond the objectives initially proposed. Although at one point the work had an eminently theoretical objective, it is true that in practice we were able to achieve some results that are quite good. The results are described below in the following categories: business products (1), informative texts (3), texts research results (3), directed theses (undergraduate) (7), organization of events (13), legal documents (2), participation in events (11), courses designed for master’s program (5), social communication of knowledge (2).

The following outputs are described³:

<i>Name</i>	<i>Category</i>
Paideia Educational and Cultural Association	Business products - Process innovations

Publications

<i>Name</i>	<i>Informative texts</i>
Notes on translation, or the importance of polyglossy in the formation of citizens	Social communication of knowledge
Dialogue and Comedy in Plato’s Works, An Approach to the Problem of the Genre	Articles published in Journals B, C or D
The relationship between men and animals	Social communication of knowledge

<i>Name</i>	<i>Books resulting from research work</i>
Cratilo, a dialectical practice in and with names	Book resulting from research work
Greek II. Third declension. Theory and exercises	Textbook
What is dialectics? an inquiry to the <i>Cratylus</i>	Research article

<i>Name</i>	<i>Undergraduate degree work</i>
Say/show, escape route to Wittgensteinian bisegmentation?	Undergraduate degree work
Cinema, a didactic tool for teaching philosophy	Undergraduate degree work
Epicurus, a critique of the Greek paideia	Undergraduate degree work
Ethics of Conscience, Ernst Tugendhat and the Debate for a Plausible Justification of Moral Judgments	Undergraduate degree work
Distance in Time for Gadamer's Hermeneutic Understanding, Applied to Warhol's Campbell's Soup Cans	Undergraduate degree work
Parquesofico as a didactic resource for teaching and learning philosophy	Undergraduate degree work
Recognition Without Ethics	Undergraduate degree work

<i>Name</i>	<i>Events organisation</i>
Balances and Challenges of the JEP (Organizer. Social appropriation of knowledge)	Scientific or technological event organisation
Conversation space for the German language (Organizer. Social appropriation of knowledge)	Scientific or technological event organisation
Practice space for the English language (Organizer. Social appropriation of knowledge)	Scientific or technological event organisation
Practice area for the Portuguese language (Organizer. Social appropriation of knowledge)	Scientific or technological event organisation
Space for the practice of the French language (Organizer. Social appropriation of knowledge)	Scientific or technological event organisation
Philosophy of Law and the Generality of Politics (Organizer. Social appropriation of knowledge)	Scientific or technological event organisation
First Conference of Advances in Research Faculty of Fine Arts and Humanities (Organizer. Social appropriation of knowledge)	Scientific or technological event organisation
III Interinstitutional Forum of Students and Professors of Philosophy (Organizer. Social appropriation of knowledge)	Scientific or technological event organisation
First Conference of Advances in Research (Organizer. Social appropriation of knowledge)	Scientific or technological event organisation
Second Conference of Advances in Research Faculty of Fine Arts and Humanities: Friendship in Aristotle (Organizer. Social appropriation of knowledge)	Scientific or technological event organisation

Second Conference of Advances in Research Faculty of Fine Arts and Humanities: Enhancing political subjectivity from an experience of education for peace (Organizer. Social appropriation of knowledge)	Scientific or technological event organisation
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Second Conference of Advances in Research (Organizer. Social appropriation of knowledge)	Scientific or technological event organisation
IV Interinstitutional Forum of Students and Professors of Philosophy (Organizer. Social appropriation of knowledge)	Scientific or technological event organisation

<i>Name</i>	<i>Legal agreements</i>
Specific Agreement UNAD UTP	Pedagogical strategies for the promotion of CT and I
Framework cooperation agreement between UNAD and UTP	Pedagogical strategies for the promotion of CT and I

Participation in events

<i>Name</i>
Forum Aesthetics, Philosophy and Literature
III International Congress on Politics and Globalization
IV Regional Forum of Philosophy Students
IV Regional Forum of Philosophy Students, Universidad del Quindío - Universidad Tecnológica de Pereira. September 2015
IX Forum of Professors of Philosophy. Universidad del Quindío
IX Teachers' Forum Universidad del Quindío
Why Plato? an apology of the classical subjects in philosophy. Inaugural lesson
V Interinstitutional Forum of Students and Professors of Philosophy (Social appropriation of knowledge)
VII Forum of Professors of Philosophy. May 2015
VII Forum of Professors of Philosophy Universidad del Quindío
VIII Philosophy Teachers Forum. May 2016

Course Designed for Master's Programs

<i>Name</i>
Context Seminar I
Context Seminar II
Context Seminar III
Foundation Seminar I
Foundation Seminar III

Social Communication of Knowledge

Social Communication of Knowledge

<i>Name</i>	<i>Category</i>
2. Facebook page (CTL) of the Research group on education in Greece in partnership with UNAD (National Open and Distance University)	Social Communication of Knowledge
Facebook page (CTL) V Interinstitutional Forum of Students and Professors of Philosophy in association with the UNAD (National Open and Distance University) in it participate several professors of Philosophy and Social Sciences of the country and the region	Social Communication of Knowledge

4. Conclusions

The results of this research are numerous and important, but do not show anything decisive. From this project the important practice of writing was fostered through the research group, anchored to its seedbed. This work helped to consolidate the union between the Technological University of Pereira and the National Open and Distance University. These universities are currently working on the formulation of other projects and even on the design of a virtual national master's degree program, taking like point of depart the Master in Philosophy of the Technological University of Pereira. In addition, teamwork has been made

possible in a collaborative way around outreach and extension events that contribute to make the role of the humanities in Colombia much more visible.

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The book “Competitive Risaralda, generating research alliance for development” is the result of the fifth meeting of researchers from the department of Risaralda held in November 2020.

This event presented the latest research carried out in different educational institutions of the department, who are part of the “Mesa de Investigación de Risaralda”; an exercise of great interest that yields research results in different areas such as Agricultural Sciences, Social Sciences, Health Sciences, Technology and Information Sciences.

A special thanks to the authors, who in each chapter shared the results of their research contributing to the scientific and technological development of our region. Thanks to their daily commitment to knowledge, they are the ones who set the guidelines to make research a process of learning, knowledge and analysis of realities for the continuous improvement in the fields of research and innovation.

In the same way, to thank the network of universities of Risaralda, institutions that allowed the development of the book as they are: Universidad Tecnológica de Pereira, Universidad Católica de Pereira, UNAD, UNIREMINGTON, UNISARC, Visión de las Americas, Universidad Coperativa de Colombia, Universidad Libre Pereira, ESAP, Fundación Universitaria Comfamiliar, UNIMINUTO, SENA, Areandina, CIAF and the Empresa de Energía de Pereira . They contribute to this text with their commitment and responsibility. We hope that this work will be of your interest, demonstrating the commitment to the contribution of knowledge for the advancement and development of our country.

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eISBN 978-958-722-495-5

