Cycle of Knowledge in the Management of the Supply Chain of Corn for Human Consumption

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Abstract

The objective of this study is to characterize the cycle of knowledge in the supply chain of the industry of corn for human consumption. White corn is cultivated almost exclusively for human consumption and it has a significant value in the food supply in countries whose diet has a high proportion of this variety of corn, such as: Venezuela, México and Colombia in America, and the Republic of South Africa and Sahel countries in Africa. Corn is produced in Venezuela, under rainfed conditions and in a highly mechanized production system.

The cycle of knowledge is defined as a progressive spiral in which knowledge is created, stored, transferred, applied and preserved, in order to increase the competitiveness and sustainability of organizations and companies in the food supply chain.

This non-experimental and cross-sectional research is of a descriptive type. It was conducted in Venezuela during the second semester of 2009 in the supply chain of white corn, specifically, at the level of first tier producers (primary sector). The population is constituted by 1,754 producers of corn in the most important producing regions of the country. The representative sample was selected by the stratified sampling technique with proportional allocation: by association of corn producers and according to the grain yield. A questionnaire was designed and conducted according to the structured survey method. Its validity was verified by discriminant tests of items and its reliability through Bartlett's test, variance factorial analysis, Kaiser-Meyer-Olkin and Cronbach Alpha, achieving the last one a value of 0.9276.

The production units have an average area of 67.17 ha, with 1.97 permanent workers and 4.06 temporary workers. They obtained a physical productivity of 4,210.45 $kg.ha^{-1.}$ The Knowledge Index (KI) achieved a value of 69.78% and the Perception Index of the results (PI) was 76.06%. The Pearson correlation among these indices was positive and significant with a value of 0.51. The factorial analysis for principal components with rotated factors allows obtaining four factors from the five dimensions originally considered. These factors are: (1) knowledge creation, (2) knowledge storage, (3) knowledge transfer and application, and (4) preservation of knowledge.

The results allow us to conclude that the cycle of knowledge is managed in four stages in an intuitive and predominantly tacit manner which is the reason why those practices related to explicit knowledge become the agents of differentiation. Moreover, the existence of a positive correlation between the Knowledge Index and the Perception Index of the positive results by the producer was also proven.

Keywords: *Knowledge Cycle, Industry of White Corn, Food Supply Chain*

1 Introduction

The food industry and its production and supply chain is considered a traditional industry. At a global level it consists of millions of small farms, small and medium traditional food industries and conventional type food businesses which are predominantly owned and exploited by family units, using rudimentary and empirical management systems. They do not participate in the global food market and in their production process they do not use or have a low rate of utilization of information and communication technologies (ICT).

These productive organizations have not identified knowledge as an important source of competitiveness and sustainability. This is the case of corn production in Venezuela that is the primary input of the most important food industry in this country (precooked corn meal).

The objective of this article is to present the results of a study to characterize the cycle of knowledge in the supply chain of corn for human consumption, focusing specifically in the primary production.
The research was conducted through the following stages:

1. The description of the population of corn producers and the most important aspects in their manner to manage knowledge.
2. The identification of the main determinant factors of the cycle of knowledge in the production of corn.
3. The realization of a correlation analysis of the Knowledge Index with the Perception Index of results and performance.

2 Theoretical Framework

2.1 The Industry of White Corn

The global supply of white corn is about 100 million metric tons (Mt) per year, which is relatively low compared with the 700 Mt of yellow corn produced annually. However, and quite differently from yellow corn, white corn is grown almost exclusively for human consumption and it has a significant value for the nutrition of the population in countries where corn represents a high proportion of the diet. Such is the case of countries like Venezuela, México and Colombia in Latin America and the Republic of South Africa, and the countries to the South of the Sahara desert in Africa.

In Venezuela, the white corn supply chain is of the utmost importance for its security and food supply, representing about 15% of the daily calorie intake per person, 7% of the total agricultural production, over 13% of the vegetal production and about 25% of the cultivated agricultural land. At the industry level, it is classified in the milling products branch which represents about 20% of the Venezuelan food industry and within this branch the industry of precooked corn meal contributes with a value between 35% and 45% of the activity.

This important industry is based on a supply chain constituted by a network of small farmers, producers' organizations, small and medium industries for processing grain, marketing systems, wholesale and retail distribution, and a conglomerate of small restaurants and fast food businesses. These independent or semi-autonomous organizations are responsible for the production, conditioning, processing, marketing and consumption of precooked corn meal and of its most relevant product that is the *Arepa*.

The complex network of relations and processes mentioned in the preceding paragraphs is supported by a productive and gastronomical culture, which can be analyzed and optimized through the Knowledge Cycle approach.

2.2 The Knowledge Cycle

As a reference for the present study the theory of organizations as knowledge systems has been used (Holzner and Marx, 1979).

This theory consists of four knowledge processes that sequentially or simultaneously occur in productive organizations. These processes are: the creation and/or acquisition of knowledge, its storage and recovery, its transfer and exchange, and its implementation and integration. The model, despite having been originated in the 1970s, is still considered as a valid reference and a starting point in the analysis of knowledge and its management.

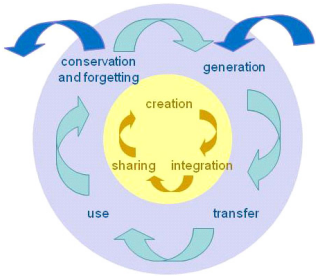

Figure 1. Cycle of Organisational Knowledge.
Double-Layered Knowledge Life Cycle
(Source: Müller-Prothmann 2006, p. 51)

For this research authors have incorporated in this theory the protection process and the preservation of knowledge. In the case of corn producers, the concept of preservation of knowledge, which will be described later, is considered to be more relevant.

Some brief definitions of the processes that conform the cycle of knowledge for the purpose of this study are presented below:

Creation or Acquisition of Knowledge:
Knowledge creation is the process of generation of internal knowledge and/or its acquisition from external sources in productive organisations. The work of Nonaka and Takeuchi (1995) is considered to be fundamental in indicating that an organisation is not a machine but a living organism, whose function is not to 'process' objective information, but rather to take the set of ideas, intuitions and creativity of the employees and to encourage its use by the organisation.

However, production organisations also have the option to acquire or to adopt knowledge generated in their environment. This process implies the use of mechanisms such as identification, location, acquisition and assimilation of knowledge (Zack, 1999). Therefore, the interaction with agents such as customers, suppliers and public and private institutions, or its direct purchase in the marketplace may be absolutely necessary activities (Nielsen and Lundvall, 2003).

Storage and Recovery of Knowledge:
The storage and recovery of knowledge is concerned with the processes of the organization, the collection and location of knowledge in order to make it formal and accessible in a timely manner.

Included as components of this concept are a number of knowledge repositories (with different contents), among which we find written documents, the information structured and stored in electronic databases, the human knowledge encoded in expert systems, organisational processes and procedures (manuals) and the tacit knowledge acquired by individuals which is accumulated in intangible elements such as the functional and organisational culture or structure.

Transfer and Distribution of Knowledge
The transfer of knowledge is the process through which an organisational unit is influenced by the experience of another one and it is manifested through changes in the way of doing things and the results achieved by the former organisation (Argote and Ingram, 2000).
The difficulty of this process is evident when the various factors which may influence it are considered, such as the specific characteristics of the knowledge to be transferred, its ontological dimension, the transfer channels and the motivational factors, among others.

The Application and Integration of Knowledge
The application of knowledge is defined as the process of knowledge incorporation that adds value to products, services and management practices of an organization.

The application and integration of knowledge is closely related to the nature of companies and organisations dedicated to production (Grant, 1996). Besides, the integration of knowledge consists, at least, in the following actions: the development of rules and directives, sequencing, organizational routines, solutions to problems and group decision making.

The Protection and Preservation of Knowledge
The protection of knowledge represents the maintenance of the competitive advantage of a company, organisation or conglomerate of producers (Liebeskind, 1996). Grant (2002) indicates that the potential for obtaining rents which originate in the use of organisational knowledge is based primarily on the regime of appropriation. This term is referred to the value in the form of profit that a company, organisation or conglomerate of producers will perceive from its innovative activities relative to other actors such as customers, suppliers and imitators. The fundamental difficulty for the organization is when the conditions of appropriation of the results are unfavorable, or otherwise, when a problem of imperfect appropriation is presented (Levin et al., 1987).

The Knowledge Cycle as an Integration Process
Finally, a reference must be made to the overall effect that the cycle of knowledge process can cause in the results of a company or conglomerate of producers. In this sense, it is indubitable that the more coherent development of these processes will generate a positive response greater than that of their individual and segmented application (Donate and Guadilla, 2007).
In this sense Grant (1996) notes that the integration, application and generation of knowledge cannot be considered in isolation. Moreover, some empirical studies have

attempted to show its effect in the results, through the development of different typologies, although without reaching a clear consensus about the dimensions that this concept should compound (Bierly and Chakrabarti, 1996; Hanse, Nonaka and Tierney, 1999; Schulz and Jobe, 2001).

It is due precisely to this last consideration that the present study has been made. The cycle of knowledge is defined as a progressive spiral in which knowledge is generated, stored, transferred, applied and preserved, in order to increase the competitiveness and sustainability of the organisations or companies that manage knowledge in an intuitive or in a planned manner.

3 Research Methodology

This research is descriptive and non-experimental, cross-sectional and of field design, since it was performed with primary information sources. (Bavaresco Prieto, 2006; Chávez, 1994; Hernández, et al., 1998; Hurtado Barrera, 2000; Tamayo y Tamayo, 2006).

3.1 Description of the Study Area

The study was done in Venezuela, in the West Central region, which is the main corn producing area and where all the necessary production support services are available. The field work was carried out in the second semester of 2009 and focused on the corn industry supply chain, specifically on first tier suppliers or primary producers. The predominant climate in the area is tropical savanna, with an average annual temperature of 28 º C and rainfall ranging between 1,400 and 1,800 mm.year^{-1}.

In this region of flat and fertile land, corn is grown under rainfed conditions. The cultivation cycle is about 120 days and sowing takes place in the months of May or June. Both sowing and harvesting are mechanized; certified hybrid and varieties seeds are used and 600 kg.ha^{-1} of fertilizers are applied. Likewise, the necessary sanitary practices for the control of weeds, plagues and crop illnesses are implemented.

3.2 Population and Sample

The study population consisted in 1,754 corn producers associated or affiliated with the largest organizations in the country. The sample size was calculated for both qualitative and quantitative variables. In the case of qualitative variables the procedure followed for calculating the sample size (Chávez, 1994; González, 2001, Martínez, 1999; Smith, 2005a) was based on the formula:

$$n_0 = \frac{(Z)^2 * N * p * q}{(E)^2 * (N-1) + (Z)^2 * p * q}$$

Where:
N = Size population (1,754 producers)
p = probability of being selected (0.5)
q = probability of not being selected (0.5)
E = sampling error (0.0549%)
Z = confidence level=95% (1.96)

For the determination of the sample size for the quantitative variable (Buendía et al., 1998; González, 2001), the following formula was applied:

$$n_0 = \frac{(Z)^2 * N * \sigma^2}{(E)^2 * (N) + (Z)^2 * \sigma^2}$$

Where:
N = population size (1,754 producers)
s^2 = standard deviation of the performance of corn production of the population (1,356.36)
E = sampling error (3.073% = 132.4146 Kg)
Z = confidence level=95% (1.96)

Since the sample size is larger than 10% of the population, a correction factor for the sample size can be applied according to the following expression (González, 2001; Parra, 2003) for both the qualitative and quantitative variables:

$$n = \frac{n_0 * N}{n_0 + (N-1)}$$

Where:
N = population size (1,754 producers).
n_0 = sample size (269.8345 and 269.9535).

Based on these results, the sample which was used in this research was 234 producers (13.34% of the population of 1,754 producers). The sampling realized is highly stratified with proportional allocation (Chávez, 1994; Lawley, et al., 2007; Namakforoosh, 2006; Parra, 2003) for corn producer associations and according to the yield of corn produced.

3.3 Variable, Dimensions and Operationalization

The variable or construct under study is the *Knowledge Cycle* and its dimensions are: the origin, storage, transfer or distribution, application and protection of knowledge. For the "*Knowledge Cycle"* variable an index, denominated "Knowledge Index" (KI), was designed. This index is calculated based on a 100-point scale, transforming the 1 to 5 Likert scale of each indicator through a conversion factor. The same transformation was made in the calculation of the Perception Index of results (PI) variable.

3.4 Measuring Instrument (Design and validation)

The measuring instrument used was a questionnaire composed of two sections. The first one is integrated by a section of identification and description variables for a total of 17 items. The second one consists in five sub-sections and 19 items that were evaluated by respondents based on a Likert scale with five values, being 1 the value which represents total disagreement with the propositions formulated and 5 the value which represents total agreement.
The validation was performed through three different methodologies. The first one is the judgment of five experts. The second one is the Delphi method which was implemented with the technical personnel working in the corn producers' associations. Finally, the third one

applied a methodology based on two pilot surveys processed by statistical means, such as the test of discriminant validity of items and reliability through the test of Cronbach's alpha, factorial analysis and polychoric correlation, Bartlett's and Kaiser-Meyer-Olkin. The sample selected reached the adequate values of reliability and validity. It should be noted that the value of 0.96 reached by the Cronbach alpha and the variance of 69.24 show the high degree of reliability and validity of the measuring instrument.

Table 1. Analysis of reliability and analysis of factors of the items that constitute the sub-dimensions of the methods to manage knowledge.

METHODS TO MANAGE THE KNOWLEDGE	Number of items	Bartlett* test	KMO	Factors	Total variation	Cronbach's alpha
1.- Origin	4	378.75	0.7109	1	61.511	0,748
2..- Storage	3	425.81	0.6852	1	80.463	0,877
3.- Transference	5	737.30	0.8265	1	69.703	0,884
4.- Application	3	362.31	0.6936	1	78.942	0,866
5.- Protection	4	316.97	0.7113	1	61.140	0,780
Total	19	3176.40	0.9028	4	69.36	0,927

* Significance = 0,000

Source: Authors

3.5 Application and quality control

The technique applied for the questionnaire was the structured and/or semi-structured personal interview. The information and written responses in the questionnaires were transcribed to an Excel spreadsheet under a rigorous system of quality control of the data.

3.6 Data analysis

The recorded data in an Excel spreadsheet from Windows were selected and then a descriptive analysis was performed with a SAS version 9.0 software. The following procedures were used: PROC SORT, PROC UNIVARAITE NORMAL PLOT, PROC SURVEYSELECT METHOD SRS = N STRATA, PROC FREQ with the following options: TABLE, PROC TABULATE, PROC MEANS MEAN STD N MIN MAX, and in order to calculate the polychoric correlations, the PROC FREQ procedure with the PLCOR option was used (Bilenas, et al., 2007; Flora and Curran , 2004; Rigdon and Ferguson, 1991; SAS, 2006; SAS, 1988; Siller and Tompkins, 2005; Suhr, 2009).

The SPSS statistical package was also used to test the validity with the discriminate analysis of items (Chávez, 1994), and the calculation of reliability with Cronbach's alpha and factorial analysis (Pérez, 2005; Roofe and Kroeck, 2008; Visauta and Martori, 2005).

4 Results

4.1 Description of the population of corn producers and the more relevant aspects in the way how knowledge is managed

<u>The population</u>

The indicators which describe the population analysed (Table 2) are related to the producer or to the manager of the production unit, to the farm, to the services that this farm receives and to the results of the management implemented.

The predominant educational level of corn producers and managers was concluded primary education with 40.78%, followed by secondary education with 35.08%, for a total of 75.86% of interviewed producers who have completed at least their primary education. The average age of respondents achieved a value of 51.04 years out of which they have dedicated an average of 22.24 years to the commercial production of corn.

The average harvested area was 67.17 ha. The corn farms have electricity supply in 55.00% of the cases and mobile phone coverage in 66.51% of the cases. 80.45% of the respondents do not have access to Internet and of the rest only 10.88% used it for productive o technical management purposes.

The production units have an average of 1.97 permanent workers and 4.06 temporary workers, indicating that units of production of corn are mainly small and micro family enterprises. On the other hand, the production of corn in the area is highly mechanized and the trend is towards the widespread and intensive use of agricultural machinery and implements, which drastically reduces staffing for sowing and harvesting.

The surveyed farmers in the sample reached a grain yield of 4,210.45 $kg.ha^{-1}$. The knowledge index (KI) was calculated using the methodology described above and it reached an average value of 69.78 %.

The Perception Index of the results (PI), which represents a way to measure the results achieved by the production unit from the standpoint of perception of the respondents, reached an average value of 76.06%.

Table 2. Description of the corn producing units from The Knowledge Cycle perspective

Variable	Level reached
At least completed primary education	75.86 %
Age of respondents	51.04 years
Time producing corn	22.24 years
Harvested area	67.17 ha
Electrical Service Coverage	55.00 %
Coverage of mobile telephone service	66.51 %
Internet access service	19.55 %
Permanent workers	1.97 workers
Casual workers	4.06 workers
Grain yield	4,210.45 $kg.ha^{-1}$
Knowledge Index (KI)	69.78 %.
Perception Results (PI)	76.06 %.

Ways to manage knowledge

The knowledge cycle was identified in this study on the basis of a set of items included in the dimensions: creation, storage, transfer, application and preservation of knowledge. Only those items in each dimension which were valid and reliable according to the methodology followed in this research were selected.

Table 3 indicates the magnitude reached by the items in the different dimensions of the Knowledge Cycle in terms of average, mode and frequency. For example, in the first dimension which corresponds to the creation, exploration and acquisition of knowledge, it can be observed that the valid and reliable sources of exploration of knowledge are related to

the mass media specialized in agricultural themes and specifically in the production of corn. The items consulted to the respondents reached a mode of 4 and in the case of participation or attendance to the *Field Days* (formal meetings in the fields to share best practices), a mode of 5 was achieved. However, when these items are discussed in relation to the frequency analysis, it appears that none of them reached a 40% frequency of response, which shows the great variability in the perceptions of those individuals who were interviewed on the subject.

Table 3. Valid and reliable indicators of the Knowledge Cycle in the productive management of corn

Knowledge Cycle	Average	Mode	Frequency (%)
Creation, exploration or acquisition of knowledge			
Mass Media	3.10	4	26.50
Agricultural publications	3.47	4	36.32
Pamphlets and primers about corn	3.76	4	37.18
Field Days	3.17	5	34.21
Storage of knowledge			
Organised physical file	3.19	4	30.34
Organised digital files	2.63	1	36.75
Databases in servers	2.47	1	41.03
Transfer of knowledge			
Staff turnover	3.2	5	28.21
Training of apprentices	3.48	4	33.76
Sharing experiences informally	3.91	5	44.87
Coming to an "expert"	4.26	5	58.55
Technical support from producers' association	4.39	5	72.65
Application of knowledge			
In sequence according to the farming cycle	4.04	5	47.44
Progressively and maturing	3.89	5	39.74
Scheduling and communicating	4.15	5	53.42
Protection of knowledge			
Prestige associated with a name	3.26	3	27.35
Prestige of superior quality	3.55	5	29.06
Difficult to imitate terms and conditions	3.12	3	31.62
Recognition of the productive regions	3.86	4	38.46

Source: Authors

4.2 Determinant factors of the knowledge cycle in corn production

A factorial analysis was conducted using the method of principal components with varimax orthogonal rotation and Kaiser normalisation applied to each of the specified dimensions (multi-item). The factorial analysis was done using a polychoric correlation matrix, which is used when the scale of items are based on categories (e.g. Likert scales), but when there is no multi-co-linearity among the items that make up the factors. This means that the regression variables are not correlated and, therefore, the multivariate analysis is valid. The internal consistency and reliability of the measurement instruments of the cycle of knowledge was also verified through the calculation of Cronbach's α for each scale or dimension obtaining a total value for $\alpha = 0.9206$. Having met all the methodological requirements, a factorial

analysis was performed which enabled the identification of 4 factors derived from the five dimensions originally considered by the researchers, as can be seen in Table 4.

In this sense, the integration of two dimensions, transfer of knowledge and application of knowledge into a single factor could be observed, while the original dimensions of storage and protection of knowledge also reached the category of factors. Therefore, it is possible to infer that the factor analysis confirmed the hypothesis formulated by researchers in relation to the size of the Knowledge Cycle in corn production. This means that the construct (Knowledge Cycle) consists of five dimensions, transformed into four factors through the integration into a single factor of the transfer of knowledge and application of knowledge dimensions, although maintaining the multi-item scale developed in the methodology and reflected in the measurement instrument (survey).

Table 4. Factorial analysis by principal components with varimax rotated factors

Knowledge Cycle /Factors	1	2	3	4	Commonalities
1.- Origin					
Mass Media	0.23	**0.68**	0.29	0.06	0.60
Agricultural publications	0.20	**0.81**	0.28	0.15	0.80
Pamphlet and primers about corn production	0.26	**0.82**	0.14	0.14	0.78
Field days	0.07	**0.48**	0.03	0.16	0.26
2..- Storage					
Organized physical file	0.37	0.46	**0.62**	0.05	0.74
Organized digital files	0.17	0.26	**0.84**	0.20	0.84
Databases in servers	0.09	0.24	**0.82**	0.26	0.81
3.- Transfer					
Staff turnover inside of the farm	**0.60**	0.10	0.37	0.09	0.52
Training apprentices	**0.68**	0.06	0.47	0.04	0.69
Sharing experiences informally	**0.80**	0.27	0.21	0.15	0.77
Coming to an "expert"	**0.84**	0.19	0.08	0.26	0.82
Technical support of the organization of producers	**0.86**	0.16	-0.02	0.18	0.79
4.- Application					
In sequence according to the cycle of farming	**0.81**	0.22	0.13	0.24	0.78
Progressively and mature	**0.73**	0.18	0.14	0.24	0.65
Scheduling and communicating	**0.79**	0.19	0.05	0.27	0.74
5.- Protection					
Prestige associated with a name	0.25	0.23	0.17	**0.73**	0.68
Prestige of superior quality	0.29	0.38	0.16	**0.72**	0.77
Difficult terms and conditions to imitate	0.13	-0.08	0.37	**0.58**	0.50
Recognition of the productive regions	0.35	0.24	0.00	**0.69**	0.65
Variance	**28.18**	**15.23**	**13.55**	**12.40**	**69.36**

Source: Authors

In terms of commonalities, all items were valued at about 0.5 which explains why most of the variance of each variable is produced as an effect by common factors, and only for the item *Field Days*, the figure is less than 0.5. However, this case showed a similar behaviour in the analysis as the other items of this factor (source of knowledge).

In summary, the key factors in the Knowledge Cycle are the following: creation, storage, transfer and application and finally, the preservation of knowledge.

4.3 Knowledge Cycle Relations

In order to explore the relationships that the Knowledge Index has with other major indicators a Pearson correlation analysis was performed (Table 5) with the most relevant responses about production management, selecting for that purpose the grain yield and the Perceptions Index of results (PI). It was found that there is a direct and significant relationship between the KI and the PI, that is, respondents who have higher KI results perceive that their productive management tends to be better.

In the case of the correlation of KI with the grain yield, although it reaches the minimum level of significance(<0.05), it does not present a clear and positive trend although the correlation is positive.

Table 5. Correlations for KI and response to the productive management indicators

Indicators*	**Knowledge Index (%)**	**Grain yield ($kg.ha^{-1}$)**	**Perception Index of Results (%)**
Knowledge Index	1.00	0.04*	**0.51***
Grain yield ($kg.ha^{-1}$)	0.04*	1.00	0.15*
Perception Index of Results	**0.51***	0.15*	1.00

***** All these values are significant (p<0.05)
Source: Authors.

5 Conclusions and Recommendations

1. Corn production in Venezuela takes place in small organisations of family nature, in relatively large plots of land, with rudimentary management systems and a very limited implementation of information and communication technologies.
2. The development of a Knowledge Cycle that is managed intuitively in a tacit way was identified and validated. There are four main factors involved: the creation and acquisition of knowledge, the storage of knowledge, the transfer and application of knowledge, and the preservation of knowledge, in agreement with similar studies in other economic activities.
3. Positive and direct relationships between the knowledge index (KI) and the Perception Index of results (PI) have been established. Therefore, there is evidence of a positive impact of the KI in the performance of the corn producing organizations.
4. The Knowledge Cycle reached an acceptable index enhanced by tacit knowledge, achieving favourable results both in qualitative and quantitative terms.

6 Future Lines of Research

Researchers responsible for this project are in the process of expanding this study to the remaining links in the supply chain of the corn industry in Venezuela. In particular, the next steps will be focused in the processing sector, in trade transactions, and in the services associated with this supply chain.

Having identified the key factors and indicators of the Knowledge Cycle in the supply chain of the corn industry in Venezuela, a Knowledge Management model will be developed in order to increase the levels of quality, competitiveness and sustainability of this sector.

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