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Alumne (nom i cognoms):

Aida Ballester López

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Study for the production and commercialization of green cosmetics from Moringa Oleifera oil

Directora del TFM:

Beatriz Amante García

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Master Thesis
Master in Management Engineering

Study for the production and commercialization of green cosmetics from Moringa Oleifera oil

Final Report

AUTHOR:
Aida Ballester

TUTOR:
Beatriz Amante

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“Science knows no country,
because knowledge belongs to humanity,
and is the torch which illuminates the world.”

Louis Pasteur, 1876

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ABSTRACT

Hacia finales del siglo 20, problemas medioambientales como el desarrollo sostenible, el consumo ético y el uso de productos ecológicos abrió nuevos nichos de mercado en busca de políticas ambientales más eficientes como la química verde.
Por este motivo, este estudio se centró en la evaluación del aceite de Moringa Oleifera siendo una materia prima no tóxica con excelentes propiedades fisicoquímicas aun sin explotar para la producción de cosméticos naturales.
El estudio empezó con una revisión del estado del arte para la extracción del aceite de Moringa Oleifera, seguido de una propuesta de formulación para un jabón corporal que permitiera seleccionar los proveedores y evaluar los costes de la actividad. A continuación, se especificaron la calidad deseada, el personal requerido, las políticas de comunicación y se evaluaron los riesgos. Finalmente, se realizó una evaluación ambiental conforme a la ISO 14001, complementada con una evaluación financiera usando los criterios más comunes de inversión (payback, VAN y TIR) para verificar la sostenibilidad y rentabilidad del proceso global. Tanto la literatura revisada como la metodología aplicada destacan la extracción acuosa del aceite de Moringa Oleifera como el método más sostenible y rentable, con una reducción del impacto ambiental superior al 10% y un payback inferior a 5 años.

Palabras clave: Desarrollo sostenible, consumo ético, producto ecológico, química verde, cosmética natural, Moringa Oleifera, aceite vegetal, criterios de inversión, rentabilidad, impacto ambiental.

By the end of the 20th century, environmental concerns such as sustainable development, ethical consumerism and the use of eco-friendly products opened new market niches looking for more efficient environmental policies like green chemistry.
For this reason, this study focused on the evaluation of *Moringa Oleifera* oil as a non-toxic raw material with great physicochemical properties still untapped for the production of green cosmetics.
The study started with a review of the state of the art for the extraction of *Moringa Oleifera* oil, followed by a proposal for the formulation of a body soap in order to select the suppliers and evaluate the costs of the activity. Then, specifications were set for the desired quality, required personnel and communications policies, as well as a risk assessment. Finally, an environmental evaluation according to ISO 14001 approach is performed, complemented with a financial evaluation using the most common investment criteria (payback, NPV and IRR) to verify the sustainability and affordability of the overall process. Both revised literature and applied methodology highlight the aqueous extraction of *Moringa Oleifera* oil as the most sustainable and affordable method with a reduction of more than 10% of the environmental impact and a payback of less than 5 years.

Keywords: sustainable development, ethical consumerism, eco-friendly product, green chemistry, green cosmetics, Moringa Oleifera, vegetable oil, investment criteria, affordability, environmental impact.

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LIST OF ABBREVIATIONS

AC	Actual Cost
AE	Aqueous Extraction
AON	Activity On Node
BAC	Budget At Completion
BPEO	Best Practicable Environmental Option
CAB	Conformity Assessment Body
CPI	Cost Performance Index
CV	Cost Variance
DRS	Deposit-Refund System
EAC	Estimate At Completion
EBIT	Earnings Before Interest and Taxes
EBT	Earnings Before Taxes
EHS	Environmental, Health and Safety
EV	Earned Value
EVM	Earned Value Management
EWG	Environmental Working Group
FDA	Food and Drug Administration
FFA	Free fatty acid
GMP	Good Manufacturing Practices
HR	Human Resources
IMS	Integral Management System
IRR	Internal Rate of Return
ISO	International Organization for Standardization
IT	Information Technology
ITW	Illinois Tool Works
KPI	Key Process Indicator
LAM	Linear Averaging Method
MVP	Minimum Viable Product
NPV	Net Present Value
PDCA	Plan-Do-Check-Act
PE	Polyethylene
PU	Physical Unit
PV	Planned Value
QA	Quality Assurance
QC	Quality Control
R&D	Research & Development
SCCS	Scientific Committee on Customer Safety
SE	Soxhlet Extraction
SFE	Supercritical Fluid Extraction
SOP	Standard Operating Procedure
SPI	Schedule Performance Index
SV	Schedule Variance
TPM	Total Productive Maintenance
TQM	Total Quality Management
VOC	Volatile Organic Compounds
WBS	Work Breakdown Structure

1. Scope Management

1.1. Aim

This study intends to propose alternative disposals of the waste produced during the processing of the Moringa Oleifera (M. Oleifera from now onwards) tree, using this subproduct as raw material for the production of green cosmetics, in order to reduce the environmental impact associated to this activity and its resource and energy consumption.

Ultimately, this study consists in the analysis of the marketing and sales potential for the commercialization of the so-called green cosmetics coming from M. Oleifera oil.

1.2. Scope

The scope of this study includes the following main items:

- Perform a research of the state of the art for the extraction of M. Oleifera oil.
- Managing of the woodlots of M. Oleifera during all their lifecycle.
- Collection and supply of the different parts that compound the M. Oleifera trees to each treatment plant.
- Processing of the ingredients at each plant in order to produce the diverse green cosmetics to commercialize.
- Packaging and labelling of the final products.
- Storage previous to its final delivery.
- Transport and distribution of the final products to the end user.

Added to these items, other issues must be considered in relation with the waste disposal of the final product:

- Design and engineering of the products and the different processes involved in obtaining the cosmetics from M. Oleifera oil.
- The quality control (QC from now onwards) and assurance from each process unit.

The following items are considered to be outside of the scope of this study:

- The intermediate transports the final product may experience until its final consumption by the customer and until it arrives to the waste treatment plant.
- Whether the customer performs or not the correct disposal of the product after its whole consumption.
- The influence the M. Oleifera may have in the ecosystems where produced as an aggressive and invasive species [1].

1.3. Purpose and justification

It wasn't until the celebration of the *United Nations Conference on the Human Environment* [2] held in Stockholm in 1972 that environmental concerns (such as the climate change and sustainable development) started to play an important role in the European society and economy.
One year later, in 1973, the oil crisis [3] and the significant rise of oil prices definitely woke up the urgent need of renewable energies and promoted the investment in research for better environmental policies.

In 2000, concepts as green or sustainable brands [4], greenwashing [5] or ethical consumerism [6] became powerful marketing tools that serve companies nowadays to differentiate their products from the competence in order to stand out from the rest. So much so, it appeared a new trend in the chemical industry called *green chemistry* [7] which intends to significantly minimize the environmental impacts associated to this sector by using eco-friendly substances.

With this approach and taking into account the continuous increase of the negative consumer perception of most synthetic preservatives and drugs present in cosmetics and food [8], *Moringa Oleifera* tree (M. Oleifera from now onwards) is one of the raw materials that offers a wider range of opportunities to produce green chemicals from its constituents (see *Figure 1*). As very few parts of this tree are toxic [9], almost every part is edible like its flowers, fruits, leaves and roots. In particular, M. Oleifera offers a valuable source of oil from its seeds (19 to 47%), commercially known as Ben oil, with a high content of oleic acid (about 70%), that provides great resistance against oxidation resulting into great stability. Moreover, Ben oil confers a great medium where fragrances can be retained, reason for which M. Oleifera is even a better source of green chemicals within the perfume industry and in cosmetics in general, as it is also considered an excellent emollient commonly used in hair and skin care ([10] [11] [12]). In fact, cosmetic uses have been reported since 150 A.D. for Romans, Greeks and Egyptians in the preparation of skin lotions and ointments, but it wasn't until the 19th century that M. Oleifera oil started being exported to Europe from the West Indies and not until 1970s that nutritional and industrial research started to be formally conducted [13].

Up to now, several industries have taken profit from specific parts of M. Oleifera tree producing a portfolio of products in different presentations (dehydrated, powder, pulp, oil, etc.) depending on the final application (see *Figure 2*).

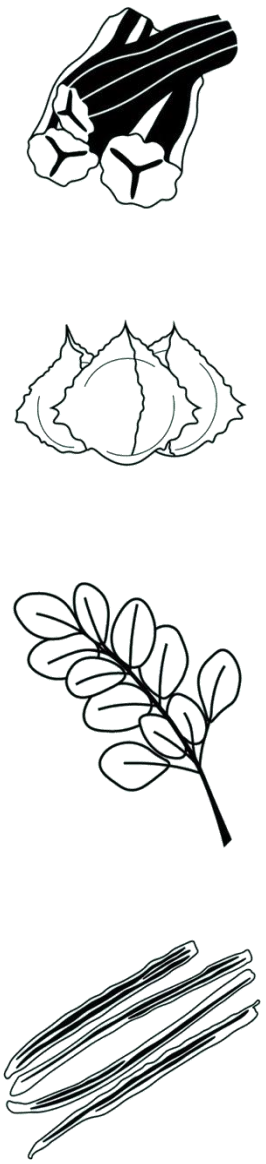


Figure 1 Plant parts from M. Oleifera: fruits, seeds, leaves and pods (up to down). Credit: https://www.bonappetit.com/story/moringa-plant-wellness-superfood

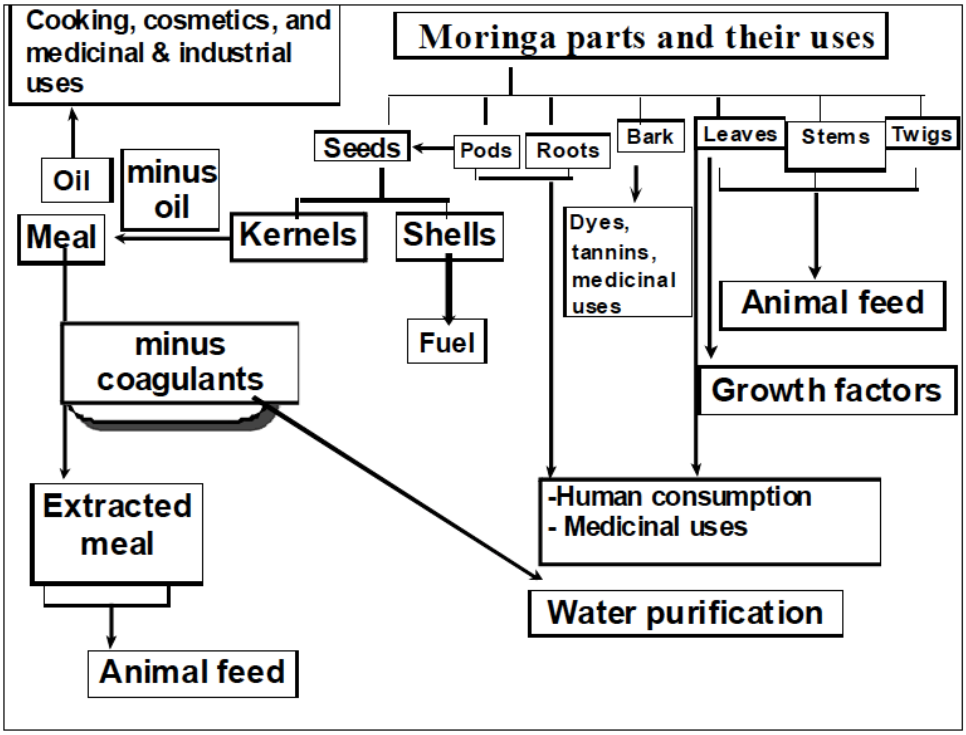


Figure 2 Uses of different parts of M. Oleifera [9].

The large scale cultivation of M. Oleifera and its relative species due to the increasing popularity natural products all over the world claims for an urgent need to find a sustainable processing and waste disposal of the residues derived from the commercial exploitation of this tree [9].

This study consists in the analysis of the marketing and sales potential for the commercialization of the so-called green cosmetics coming from M. Oleifera oil, as a high added value product still untapped. In turn, the study is based in a strong environmental approach that claims for a better performance when compared to present processes.

To determine the affordability of the proposed alternatives, a financial report is issued ultimately as a final step of this study.

1.4. Requirements and specifications

The initial requirements that must be fulfilled in this study are:

- The conception, design and commercialization of the final products must be according to the environmental policy in which is based this study.
- The proposed alternatives for the extraction of M. Oleifera oil must be technically feasible.
- Any outsourcing (if needed) must be supervised as an extension of the whole activity, with the same policy as the main defined process units.
- A market research has to be done previous to determine the affordability of the alternatives proposed in this study, in order to quantify the minimum viable product (MVP from now onwards [14]) that will cover the fixed costs of the activity.

Moreover, the initial specifications for this study are the following ones:

- Guarantee an MVP that covers at least a 95% of the fixed costs based on the results of the market research.
- Achieve the quality standards set for each product and process by using six sigma techniques [15].
- The actual costs (AC from now onwards) of the study must not be greater than those established in the estimated budget. Otherwise, the proposal will be considered as unfeasible.
- Reach a better environmental performance or best practicable environmental option (BPEO from now onwards) by comparison with current process data (see *Table 31* for specific objectives).

2. Time Management

2.1. Work Breakdown Structure (WBS)

The table below shows the hierarchical decomposition of the different tasks that must be done until the completion of this study:

Level 1		Level 2		Level 3		Level 4	
1	Study for the production and commercialization of green cosmetics from M. Oleifera oil	1.1	Study Charter	1.1.1	Study Charter approval.	1.1.1.1	Drafting of the Study Charter.
		1.2	Time Management Plan	1.2.1	Time Management Plan approval.	1.2.1.1	Making of the WBS and the activity list.
						1.2.1.2	Making of the PERT Chart.
						1.2.1.3	Making of the Gantt Chart.
		1.3	State-of-the-art Report	1.3.1	Revision of the State-of-the-art Report.	1.3.1.1	Document techniques for the extraction of M. Oleifera oil.
		1.4	Market Research Report	1.4.1	Revision of the Market Research Report.	1.4.1.1	Document the Market Research for the commercialization of green cosmetics from M. Oleifera oil.
						1.4.1.2	Analysis of potential customers.
						1.4.1.3	Analysis of potential competitors.
		1.5	Economic Feasibility Report	1.5.1	Economic Feasibility Report approval.	1.5.1.1	Drafting of the initial budget.
						1.5.1.2	Repayment evaluation.
						1.5.1.3	Determination of the balance sheet.
		1.6	Green Cosmetics Design Report	1.6.1	Design phase approval.	1.6.1.1	Brainstorming for the design of green cosmetics.
						1.6.1.2	Definition of the technical specifications of the green cosmetics.
				1.6.2	Simulation phase approval.	1.6.2.1	Production process simulation.
						1.6.2.2	Production process design optimization.
		1.7	Regulatory Report	1.7.1	Regulatory Report approval.	1.7.1.1	Revision of the applicable and voluntary legal requirements.
		1.8	Pilot Tests Report	1.8.1	Pilot Tests Report approval.	1.8.1.1	Formulation of green cosmetics from M. Oleifera.
						1.8.1.2	Quality tests of the green cosmetics from M. Oleifera.

Level 1	Level 2		Level 3		Level 4	
		1.9	Minimum Viable Product Report	1.9.1	Minimum Viable Product Report approval.	1.9.1.1	Raw materials selection.
						1.9.1.2	Materials suppliers' selection.
						1.9.1.3	Quality tests of the MVP.
		1.10	Final Product Certificate	1.10.1	Final Product Certification achievement.	1.10.1.1	Certification documents hand-out.
						1.10.1.2	External audit from a Conformity Assessment Body (CAB).
		1.11	Final Report	1.11.1	Administrative closure of the study.	1.11.1.1	Completion of the final report.

Table 1 ***Work Breakdown Structure.***

2.2. Activity list

The levels described in the activity list are assigned according to the following classification:

- **Level 1:** refers to the study as a whole.
- **Level 2:** refers to a major deliverable like the study charter, a report or a plan.
- **Level 3:** refers to a control account that must be done in order to continue with the following tasks, such as a report approval or a revision of a plan.
- **Level 4:** refers to each of the work packages that compound a major deliverable. This level includes already the description of the work to be done.

Table 2 shows the dictionary of the WBS.

Level	ID	Activity	Description of Work
1	1	Study for the production and commercialization of green cosmetics from M. Oleifera oil	Study that intends to find feasible and affordable green cosmetics from M. Oleifera oil.
2	1.1	Study Charter	Document that sets the fundamentals for the development of the study.
3	1.1.1	Study Charter approval.	Approval of the initial document from the sponsor top management.
4	1.1.1.1	Drafting of the Study Charter.	-
2	1.2	Time Management Plan	Document that includes the WBS, PERT and Gantt charts until the completion of the study.
3	1.2.1	Time Management Plan approval.	Approval from the sponsor top management of the planning document for all the activities of the study.
4	1.2.1.1	Making of the WBS and the activity list.	-
4	1.2.1.2	Making of the PERT Chart.	-
4	1.2.1.3	Making of the Gantt Chart.	-
2	1.3	State-of-the-art Report	Document with the research of the current techniques for the extraction of M. Oleifera oil.
3	1.3.1	Revision of the State-of-the-art Report.	Revision from the sponsor top management of the technical feasibility of the current techniques for the extraction of M. Oleifera oil.
4	1.3.1.1	Document techniques for the extraction of M. Oleifera oil.	-
2	1.4	Market Research Report	Document that reflects the potential supply and demand of cosmetics with M. Oleifera oil and the market competitors.
3	1.4.1	Revision of the Market Research Report.	Revision from the sponsor top management of the commercial feasibility of the production of green cosmetics from M. Oleifera oil.
4	1.4.1.1	Document the Market Research for the commercialization of green cosmetics from M. Oleifera oil.	-
4	1.4.1.2	Analysis of potential customers.	-
4	1.4.1.3	Analysis of potential competitors.	-
2	1.5	Economic Feasibility Report	Document that analyses the economic feasibility of the cosmetics with M. Oleifera oil.
3	1.5.1	Economic Feasibility Report approval.	Approval from the sponsor top management of the analysis of the economic viability of the cosmetics with M. Oleifera oil.
4	1.5.1.1	Drafting of the initial budget.	-
4	1.5.1.2	Repayment evaluation.	-
4	1.5.1.3	Determination of the balance sheet.	-
2	1.6	Green Cosmetics Design Report	Document that sets the final design of the final products to be commercialized.

Level	ID	Activity	Description of Work
3	1.6.1	Design phase approval.	Approval from the sponsor top management of the design proposal before starting the simulation phase.
3	1.6.2	Simulation phase approval.	Approval from the sponsor top management of the simulation of the production of the final cosmetics.
4	1.6.1.1	Brainstorming for the design of green cosmetics.	-
4	1.6.1.2	Definition of the technical specifications of the green cosmetics.	-
4	1.6.2.1	Production process simulation.	-
4	1.6.2.2	Production process design optimization.	-
2	1.7	Regulatory Report	Document that considers any legal and voluntary requirements that the final product must fulfil.
3	1.7.1	Regulatory Report approval.	Approval from the sponsor top management of the compulsory and voluntary legislation that applies to the final product.
4	1.7.1.1	Revision of the applicable and voluntary legal requirements.	-
2	1.8	Pilot Tests Report	Document that summarizes the pilot tests performed to the final product and its satisfactory results.
3	1.8.1	Pilot Tests Report approval.	Approval from the sponsor top management of the tests and results obtained in the Pilot Tests Report.
4	1.8.1.1	Formulation of green cosmetics from M. Oleifera.	-
4	1.8.1.2	Quality tests of the green cosmetics from M. Oleifera.	-
2	1.9	Minimum Viable Product Report	Document that sets the minimum quantity to be produced in order to guarantee the maximum profitability.
3	1.9.1	Minimum Viable Product Report approval.	Approval from the sponsor top management of the minimum production proposed in the MVP Report.
4	1.9.1.1	Raw materials selection.	-
4	1.9.1.2	Materials suppliers 'selection.	-
4	1.9.1.3	Quality tests of the MVP.	-
2	1.10	Final Product Certification	Certificate that declares the conformity of the product according to all the regulatory requirements to fulfil.
3	1.10.1	Final Product Certification achievement.	Achieve the resulting quality and regulatory certification of the final product from a CAB.
4	1.10.1.1	Certification documents hand-out.	-
4	1.10.1.2	External audit from a CAB.	-

Level	ID	Activity	Description of Work
2	1.11	Final Report	Document with all the relevant data from the study until its completion.
3	1.11.1	Administrative closure of the study.	Revision of the present study and its conclusions and setting of future work to be done.
4	1.11.1.1	Completion of the final report.	-

Table 2 ***WBS dictionary.***

2.3. Planning

Once the study has been structured and the work packages have been defined, it must be set the duration of each activity (*Table 3*) and the order of precedence (*Table 4*) for all the WBS so the delivery time is accomplished.

Level 2		Level 3		Level 4		Duration (weeks)		
						Level 2	Level 3	Level 4
1.1	Study Charter	1.1.1	Study Charter approval.	1.1.1.1	Drafting of the Study Charter.	2	2	2
1.2	Time Management Plan	1.2.1	Time Management Plan approval.	1.2.1.1	Making of the WBS and the activity list.	1	3	3
				1.2.1.2	Making of the PERT Chart.	1		
				1.2.1.3	Making of the Gantt Chart.	1		
1.3	State-of-the-art Report	1.3.1	Revision of the State-of-the-art Report.	1.3.1.1	Document techniques for the extraction of M. Oleifera oil.	2	2	2
1.4	Market Research Report	1.4.1	Revision of the Market Research Report.	1.4.1.1	Document the Market Research for the commercialization of green cosmetics from M. Oleifera oil.	4	8	8
				1.4.1.2	Analysis of potential customers.	2		
				1.4.1.3	Analysis of potential competitors.	2		
1.5	Economic Feasibility Report	1.5.1	Economic Feasibility Report approval.	1.5.1.1	Drafting of the initial budget.	2	4	4
				1.5.1.2	Repayment evaluation.	1		

Level 2		Level 3		Level 4		Duration (weeks)		
						Level 2	Level 3	Level 4
				1.5.1.3	Determination of the balance sheet.	1		
1.6	Green Cosmetics Design Report	1.6.1	Design phase approval.	1.6.1.1	Brainstorming for the design of green cosmetics.	1	3	15
				1.6.1.2	Definition of the technical specifications of the green cosmetics.	2		
		1.6.2	Simulation phase approval.	1.6.2.1	Production process simulation.	8	12	
				1.6.2.2	Production process design optimization.	4		
1.7	Regulatory Report	1.7.1	Regulatory Report approval.	1.7.1.1	Revision of the applicable and voluntary legal requirements.	2	2	2
1.8	Pilot Tests Report	1.8.1	Pilot Tests Report approval.	1.8.1.1	Formulation of green cosmetics from M. Oleifera.	4	8	8
				1.8.1.2	Quality tests of the green cosmetics from M. Oleifera.	4		
1.9	Minimum Viable Product Report	1.9.1	Minimum Viable Product Report approval.	1.9.1.1	Raw materials selection.	4	12	12
				1.9.1.2	Materials suppliers' selection.	2		
				1.9.1.3	Quality tests of the MVP.	6		
1.10	Final Product Certificate	1.10.1	Final Product Certification achievement.	1.10.1.1	Certification documents hand-out.	12	13	13
				1.10.1.2	External audit from a CAB.	1		
1.11	Final Report	1.11.1	Administrative closure of the study.	1.11.1.1	Completion of the final report.	2	2	2

Table 3 ***Duration of the activities.***

Name	Task	Duration (weeks)	Predecessors
A	1.1 Study Charter	2	-
B	1.2 Time Management Plan	3	A
C	1.3 State-of-the-art Report	2	A
D	1.4 Market Research Report	8	A
E	1.5 Economic Feasibility Report	4	D
F	1.6 Green Cosmetics Design Report	15	B, C, D
G	1.7 Regulatory Report	2	D, F
H	1.8 Pilot Tests Report	8	E, F, G
I	1.9 Minimum Viable Product Report	12	F, H
J	1.10 Final Product Certificate	13	G, H, I
K	1.11 Final Report	2	I, J

Table 4 ***Order of precedence.***

2.3.1. PERT Chart

With the information from *Table 3* and *Table 4* and using the Microsoft Project software the PERT chart can be obtained as shown in *Figure 3* using the Activity On Node (AON from now onwards) method.

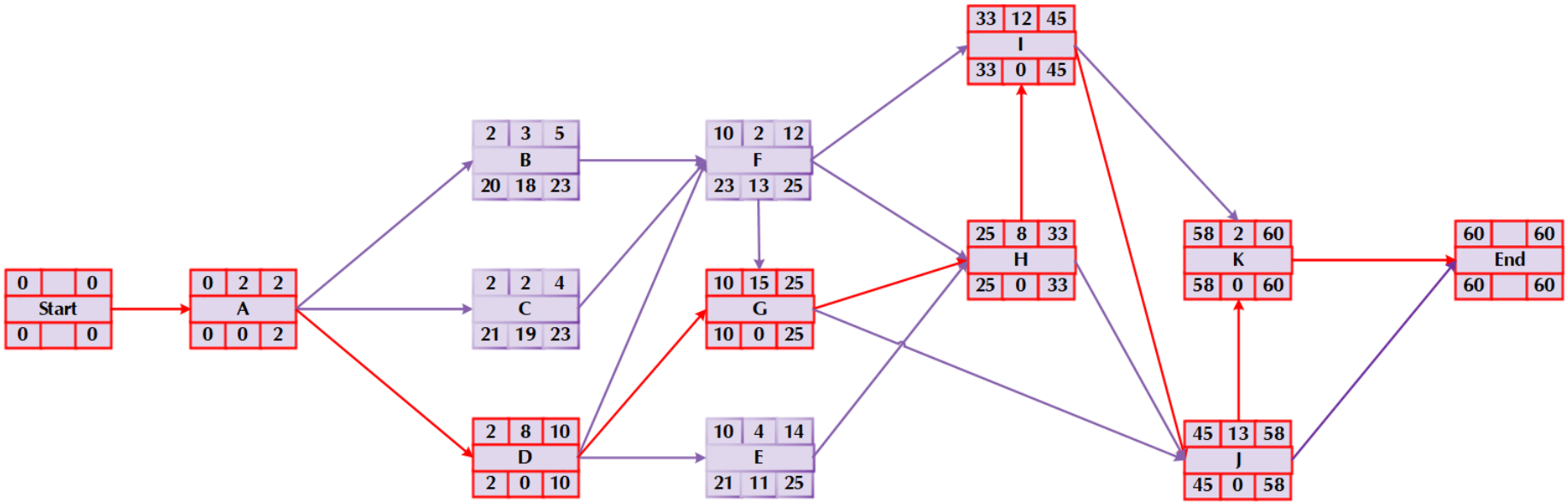


Figure 3 PERT chart.

For each node from the PERT chart, the fields include the information as presented in the figure below:

Early Start	Duration	Early Finish
Task Name		
Late Start	Slack	Late Finish

Figure 4 Description of the fields included in the nodes from PERT chart.

Observing the PERT chart it can be stated that the duration of the study is 60 weeks and that the critical path (nodes in red) goes through activities A, D, G, H, I, J and K, giving to them special attention in section **9 Risk Management** in order to manage effectively the work progress of these activities.

2.3.2. Gantt Chart

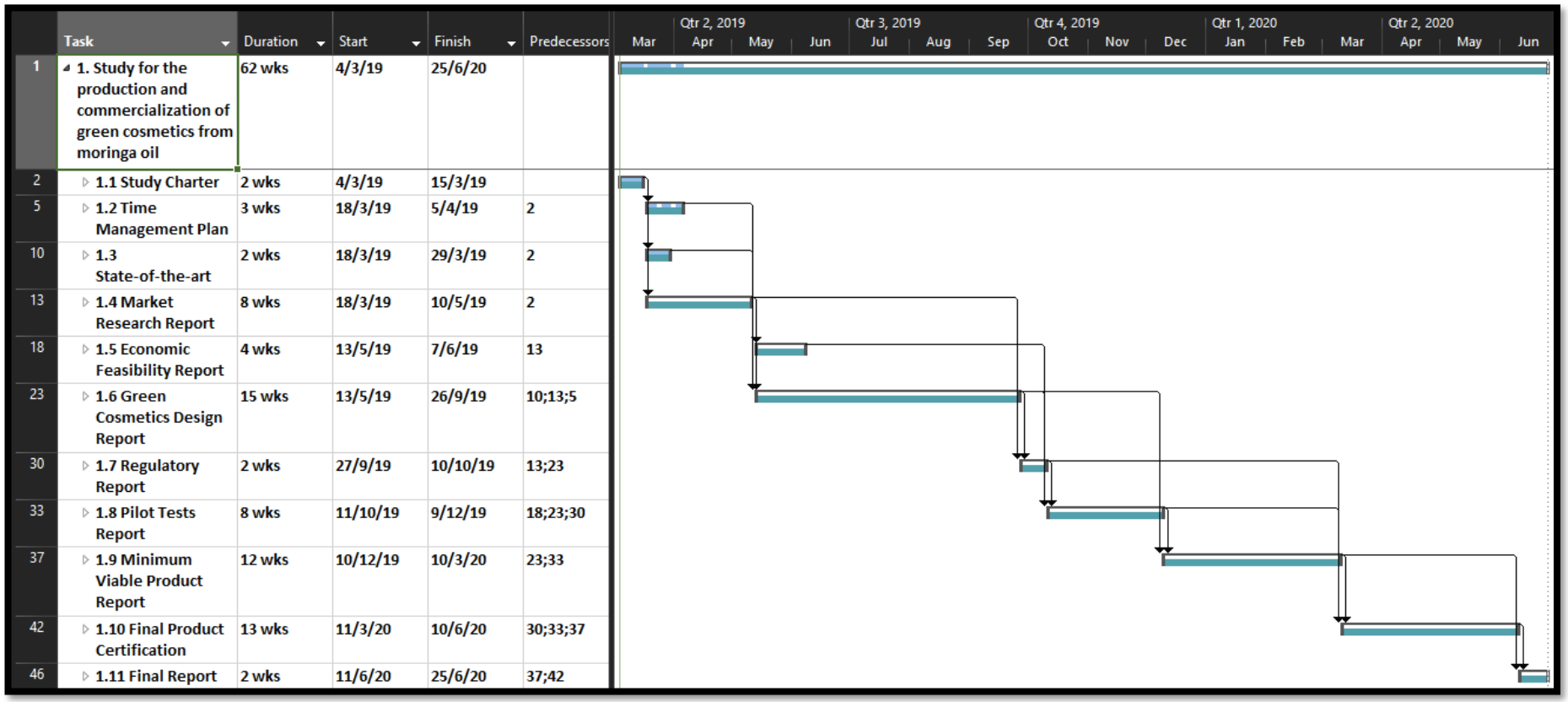
The Gantt chart (*Figure 6*), is obtained by using the software Microsoft Project applying the following restrictions:

- Working days from Monday to Friday.
- Working hours from 8:00 to 17:00 with one-hour break for lunch.
- Each month includes 20 business days.
- The next dates (see *Figure 5*) are excluded from business days as holiday periods:

Exceptions | Work Weeks

	Name	Start	Finish
1	Saint John's Eve	24/6/2019	24/6/2019
2	Summer Holidays	1/8/2019	31/8/2019
3	Catalonia's Day	11/9/2019	11/9/2019
4	Spain Nationals'Day	1/11/2019	1/11/2019
5	Constitution's Day	6/12/2019	6/12/2019
6	Christmas Holidays	25/12/2019	1/1/2020
7	International Workers'Day	1/5/2020	1/5/2020
8	Saint John's Eve	24/6/2020	24/6/2020

Figure 5 Holiday periods within the duration of the study.



	Task	Duration	Start	Finish	Predecessors
1	1. Study for the production and commercialization of green cosmetics from moringa oil	62 wks	4/3/19	25/6/20	
2	1.1 Study Charter	2 wks	4/3/19	15/3/19	
5	1.2 Time Management Plan	3 wks	18/3/19	5/4/19	2
10	1.3 State-of-the-art	2 wks	18/3/19	29/3/19	2
13	1.4 Market Research Report	8 wks	18/3/19	10/5/19	2
18	1.5 Economic Feasibility Report	4 wks	13/5/19	7/6/19	13
23	1.6 Green Cosmetics Design Report	15 wks	13/5/19	26/9/19	10;13;5
30	1.7 Regulatory Report	2 wks	27/9/19	10/10/19	13;23
33	1.8 Pilot Tests Report	8 wks	11/10/19	9/12/19	18;23;30
37	1.9 Minimum Viable Product Report	12 wks	10/12/19	10/3/20	23;33
42	1.10 Final Product Certification	13 wks	11/3/20	10/6/20	30;33;37
46	1.11 Final Report	2 wks	11/6/20	25/6/20	37;42

Figure 6 ***Gantt chart.***

Looking at *Figure 6*, it can be obtained that the lead time until the completion of the study is of 62 weeks, which differs slightly from the result in PERT chart due to the inclusion of holiday periods, adding 2 more weeks to the total time.

3. Research of the state of the art

3.1. Research background

Given the different parts (fruits, seeds, leaves, pods, etc.) and appearances (raw, powder, capsules, dried, dissolved, etc.) in which M. Oleifera can be used, it is necessary to narrow the research of this study to effectively target its main purpose.

Since M. Oleifera offers a valuable source of oil from its seeds (19 to 47%), with a high content of oleic acid (about 70%), which acts as a great medium where fragrances can be retained and it provides great stability and high resistance against oxidation, it is determined to go further into looking for the different methodologies for the extraction of M. Oleifera oil ([10] [11] [12]).

In the other hand, M. Oleifera oil represents the ingredient with the highest foresight of benefits due to its versatility as a basic ingredient in a wide variety of product presentations.

3.2. Key factors affecting oil yield and quality

Regardless of the method employed in the extraction of M. Oleifera oil, there are preliminary constraints that will determine the final yield and quality in oil such as ([10], [16]):

- Growing, environmental and climatic conditions at the plantation.
- Plant variety: literature reveals 13 different species within the family *Moringaceae* [13].
- Season and time of harvest.
- Ripening stage.
- Type and conditions during the pre-treatment of seeds and initial presence of moisture.

3.2.1. Planting and collection conditions

Prior to collection and processing of the seeds, even though M. Oleifera tree can grow in locations up to 1000 m above sea level and needs really low input of soil nutrients and annual rainfall, it is important to set the optimum planting conditions. After revising the latest research, it can be stated that a planting density of 1 million trees per hectare with an average of 10x10 cm section for each tree should be adequate on a sandy, well drained and fertile soil. The density of trees must also have into account that plants will be competing for sunlight during all their lifespan, and that, after cuttings, trees with slower growing rhythms or smaller sizes will slow down even more their rate of growing decreasing the total productivity of the whole plantation. Being aware of these restrictions, a total of 9 cuttings per year is the recommended parameter for productivity by ensuring an adequate regime of fertilization and irrigation. Also, the requirements of minerals by fertilization should be periodically revised in order to maintain productivity at its best [9].

When cutting, a maximum lead time of 8 to 10 days is recommended for the processing of the M. Oleifera seeds as they suffer microbial spoilage if stored under ordinary conditions after this period [17].

3.2.2. Seeds pre-treatment

Before proceeding to the extraction of M. Oleifera oil, literature suggests that seeds must be pre-treated according to the following steps [18]:

- Raw seeds are cleaned to remove major impurities like leaves, earth, stones, etc.
- Seed shells are removed manually.
- Seeds are introduced into a ball mill (see *Figure 7* Working principle of a ball mill. Credit: https://www.sherlocks.com.au/the-working-principle-of-a-ball-mill/) and crushed into powder.
- Resulting powder is sieved with a suitable mesh size.
- Meshed powder is dried and desiccated in appropriate conditions.

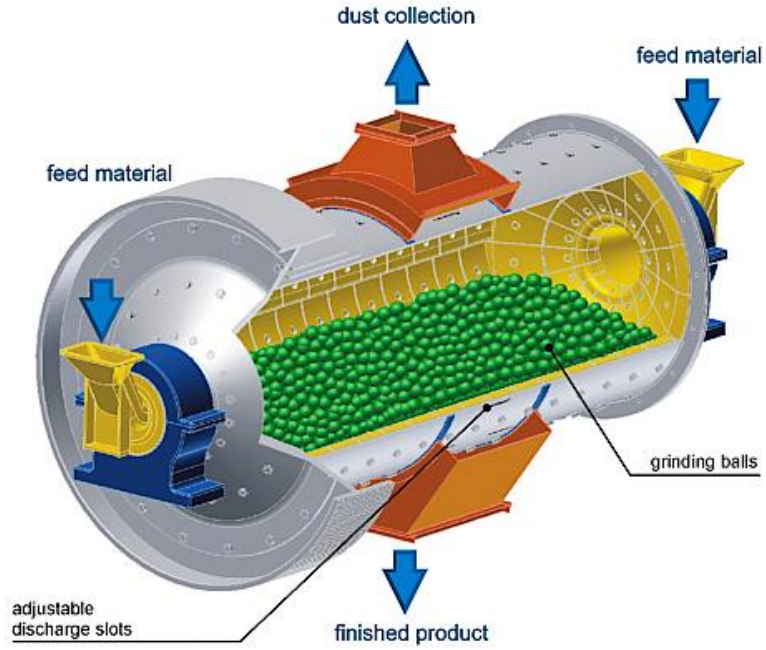


Figure 7 ***Working principle of a ball mill.***
Credit: https://www.sherlocks.com.au/the-working-principle-of-a-ball-mill/

3.3. Methods for the extraction of M. Oleifera oil

Here below are presented the most important methods to extract oil from M. Oleifera. Each of them has major advantages and disadvantages that should be taken into account along with cost and sustainable studies in order to choose the most suitable method for each application [18].

3.3.1. Soxhlet Extraction with organic solvents (SE)

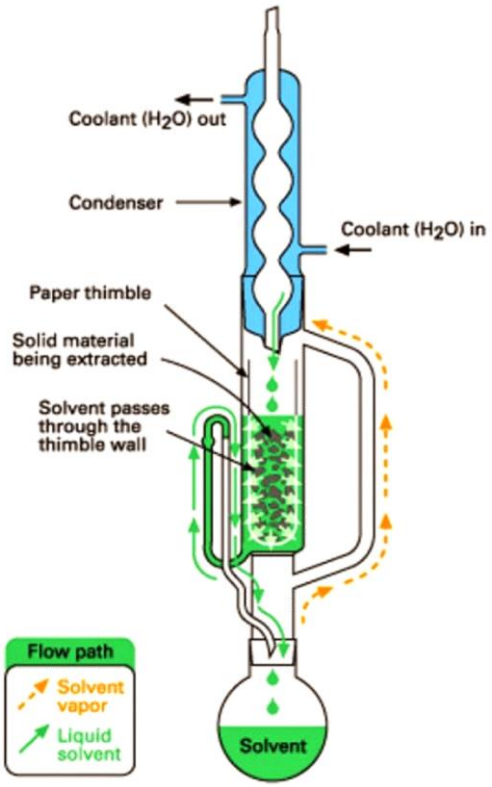


Figure 8 ***Soxhlet apparatus and scheme.***
Credit:
http://3.bp.blogspot.com/-HEDzTxG1gq4/VPRoijwtk-I/AAAAAAAAES8/JHZUlTfpmXQ/s1600/soxlet-scheme.jpg

This method is by far the most used and oldest procedure to obtain oil from vegetables and it is performed following 3 main stages which are [12]:

I. **Soxhlet extraction (SE from now onwards):** at a laboratory scale, it consists in the removal of solid impurities by its retention on a paper thimble when heated oil is passed through a distillation column as shown in *Figure 8*.
II. Filtration.
II. Concentration of crude oil with a rotary evaporator.

The following ones are the most popular organic solvents used in the extraction of M. Oleifera oil from its seeds [12]:

- **Hexane:** it is the cheapest solvent from all of them, even though it implies several environmental problems and safety issues concerns due to its toxicity. Added to this, it is a hazardous solvent with a difficult waste disposal after its use [16].
- Chloroform.
- Methanol.
- Petroleum ether.
- **Ethanol:** this solvent yields better oil recovery than hexane [18].
- **Acetone:** this solvent provides lower extraction times with larger particle size of seeds if compared to hexane but has a higher price [17].
- **Combinations of solvents:** revised literature reports experiments using mixtures of the previous solvents at different ratios, providing similar performance as using only hexane. Depending on the type of solvent(s) employed during oil extraction, ratios between solvents and the ratio between solvent(s) and the solid phase, different oil yields may be acquired [12]. A higher ratio between solvent(s) and the solid phase increases oil recovery due to a better mass transfer [19]. Also, polarity represents a key property to play with, as the combination of polar with non-polar solvents have reported better yield than the obtained with a single solvent [12].

3.3.2. Aqueous Extraction enhanced with enzymes (AE)

It consists in the hydrolyzation of the cell walls by means of enzymes that break the chemical structure of the cells in order to maximize the oil yield. Mainly, this method can be divided in two stages:

I. Enzymatic pre-treatment of seeds.
II. Oil extraction process.

As the extraction is performed, the aqueous phase retains the present phospholipids from the cells and avoids the following phase of degumming. Also, the aqueous residual phase represents a valuable source of edible protein that may be used as an additive in beverages or food commodities, so the environmental impact can be even more reduced.

As this method is not as aggressive as the SE, the oil composition remains unaltered and only few by-products and pigments are extracted during the operation and bleaching is no needed too. However, the desired quality and yield will depend on the concentration of enzymes and the incubation time and these will rely on the overall process cost. Related to this, depending on the amount and combination of enzymes added, different adjustments of pH range must be done, affecting the lead time and cost of the whole process.

This method can be improved by using different combinations of enzymes that attack specific parts of the cell, so a better degradation can be achieved with the obtained synergy between enzymes of different natures [11].

3.3.3. Supercritical Fluid Extraction (SFE)

This is the most recent method and is performed by using an optimum flow rate of CO_2 through the crude oil. Its main stages are [18]:

I. **Static extraction**: crude oil is in contact with CO_2 without renewal of the extracting fluid.
II. **Dynamic extraction:** a second step is performed with a continuous flow rate in order to remove impurities removed during the first stage.

3.3.4. Comparison of the main methods for the extraction of M. Oleifera oil

A brief summary of the advantages and disadvantages for the main extraction methods revised from the existent literature ([11], [16], [18]) is included in *Table 5*:

Extraction Method	Advantages	Disadvantages
SE	• Maximum yield. • Faster. • Higher economic profit.	• Requires high operation temperature that affect quantity and composition of oil recovered and its oxidation stability. • Yields a high color intensity in oil that must be bleached after extraction. • Final oil presents traces of the organic solvent(s) used during extraction. • High expenditure of energy to recover and recycle the organic solvent(s).

Extraction Method	Advantages	Disadvantages
AE	• Mild operating conditions. • Low color intensity in the final oil. • No need of degumming nor bleaching. • Safer process as used reagents are non-hazardous.	• Longer reaction time. • More expensive than SE. • Requires pH to be adjusted for each enzyme or combination of enzymes used. • Lower oil yield than the obtained with SE.
SFE	• Obtained crude oil is the cleanest from the 3 methods. • Sustainable process.	• Needs to develop a kinetic curve for an estimation of fabrication costs. • Facility with high processing costs. • Large-scale manufacturing development still not performed for this method.

Table 5 Comparison chart for the main extraction methods of M. Oleifera oil.

The 3 methods compared above, are affected by the following variables in different terms:

- Residence or reaction time and the consequent accumulation of undesired by-products: as long as the extraction process takes place, more oil can be recovered but also more impurities are extracted and get accumulated in the crude oil.
- Shaking speed: an excessive stirring may result into oil emulsified, affecting its recovery yield and quality.
- Temperature and pressure: a higher temperature may increase oil yield by raising solubility and diffusivity [12] as the extraction process is endothermic [19], but too much temperature could break antioxidant molecules affecting the final quality of oil. These two variables depend strongly on the chosen method and organic solvent, as temperature will be limited to the boiling point of the solvent in order to avoid oil losses by dragging [17].
- Seed particle size: smaller particles ease oil recovery but also require more time on pre-treatment to reduce size.

3.3.5. Other methods

3.3.5.1. Organic solvent extraction with sonication

It is a similar procedure as the Soxhlet extraction but enhanced with a sonicator that applies sound energy in order to agitate particles in the sample [10].

3.3.5.2. Distillation

Consists in a traditional distillation using steam, water, a combination of these or organic solvents in order to separate the oil by differences in boiling points within the compounds. Distillation with steam or solvents has a main disadvantage due to an unavoidable loss of diverse volatile compounds and the generation of undesired by-products in the condensed product.

When performing a distillation with water it receives the name of *hydrodistillation* and presents the advantage of a significant reduction of undesired by-products that are formed during extraction, given the high solubility potential of water which enables an easy recovery of oil [8].

3.3.5.3. Microwave assisted extraction

Like the extraction with sonication, this method uses a microwave oven in order to improve oil yield during the extraction with an organic solvent or with water [17].

3.4. M. Oleifera oil refining process

After extraction of oil, undesired impurities have to be removed from the crude oil by a refining process in order to transform oil into a clear, odorless and oxidation resistant substance. This process consists in 4 stages:

I. **Neutralization:** crude oil is treated with a strong base (e.g. sodium hydroxide, NaOH) in order to diminish the acidity and peroxide index in oil, resulting into better stability and higher resistance to oxidation.
II. **Degumming:** this operation reduces the amount of gums, phospholipids and proteins present in crude oil that may act as emulsifiers, forming a colloidal suspension [20] of oil in water and not a single phase solution.
III. **Bleaching:** it serves to remove biochemical compounds that give color to crude oil such as carotenes, tocopherol and other pigments by treating oil with activated carbon.
IV. **Vacuum deodorizing:** final stage intends to remove any odor or taste that crude oil may have at the beginning of the refining process.

At the end of the refining process, obtained oil is not significantly affected and storage features get highly improved as shelf life of M. Oleifera oil is increased with a better oxidative stability [10].

3.5. Decision of the extraction method to be used

After doing a thorough revision of the related research for the extraction of oil from M. Oleifera seeds and given the inherent sustainable approach of this study, the AE method is the most suitable as it would provide the minimum environmental impact from methods compared in *Table 5* along with an optimal profitability for the commercialized products. For this reason, following sections will be developed applying the AE method.

3.6. Parameters of analysis for the extracted oil

After revising the literature ([11], [16], [12], [18], [19]) the following parameters are considered the basics for determining the suitability of extracted oil for further processing and treatment:

- Color.
- Density.
- Peroxide and saponification values.
- Ash content and unsaponifiable matter: for quantifying impurities.
- Refractive index: for determination of content or purity.
- Viscosity.
- Acidity
- Free Fatty Acids (FFA from now onwards) content: mainly oleic, palmitic and stearic acids.

4. Procurement Management

Due to the multiple compositions of green chemicals that can be obtained using M. Oleifera oil, it is necessary to set and limit the ingredients to be used in order to fit the scope of this study.

With that in mind, a body soap formulation will be developed from now onwards as differences in compositions with other green chemicals from M. Oleifera oil may be subtle and the information displayed in this study will serve as a starting point.

4.1. Identification of required materials

On a preliminary basis for the proposed body soap formulation, the following ingredients taken from an already commercialized product [21] are evaluated according to information obtained from Environmental Working Group (EWG from now onwards) Cosmetics Database [22]:

Ingredient Description	Function(s)	EWG Score (1-10)	Quality of Available Data	Required (Y/N)
Water	Solvent	1	Robust	Y
Moringa Oleifera seed oil	Emollient, skin conditioner	1	Limited	Y
Citric acid	Chelating agent, fragrance, pH adjuster	2	Good	Y
Coconut acid (oil)	Surfactant	1	Limited	Y
Etidronic acid	Chelating agent	2	Fair	Y
Glycerin	Emollient, humectant	2	Good	Y
Sodium chloride	Viscosity increaser	1	Robust	Y
Sodium sulphate	Viscosity increaser	1	Fair	Y
Sorbitol	Humectant, tableting aid	1	Fair	Y
Tetrasodium EDTA	Chelating agent	2	Fair	Y
Tocopherol	Antioxidant, fragrance, skin conditioner	1	Fair	Y
Sodium palmate	Surfactant, cleansing agent, viscosity controller	1	None	N
Sodium palm kernelate	Surfactant, cleansing agent, viscosity controller	1	None	N
Triethanolamine	pH adjuster, fragrance	5	Good	N
Linalool	Fragrance	5	Fair	N
Glycine soja oil	Antioxidant, fragrance, skin-conditioner, emollient	1	Fair	N
Hexyl cinnamal	Fragrance	5	Limited	N

Ingredient Description	Function(s)	EWG Score (1-10)	Quality of Available Data	Required (Y/N)
Lilial	Fragrance	7	Fair	N
Benzyl salicylate	Fragrance, UV absorber	7	Limited	N
Geraniol	Fragrance, tonic	7	Fair	N
CI 77891 (Titanium dioxide)	Colorant, opacifying agent, sunscreen agent, UV light absorber	1-3	Good	N
CI 19140 (Tartrazine)	Colorant	5	Limited	N
CI 15510 (Acid orange 7)	Colorant	2-4	Fair	N

Table 6 ***Preliminary evaluation of ingredients for producing soap with M. Oleifera oil.***

The required ingredients indicated in *Table 6* are obtained after excluding some of them in accordance with the following restrictions, ordered by priority:

a. Only ingredients with a low hazard classification (EWG Score from 1 to 2) are chosen as suitable ingredients. Ingredients with moderate (EWG Score from 3 to 6) or high (EWG Score from 7 to 10) hazard classification are excluded if possible (function dispensable).
b. Ingredients synthesized from palm oil are excluded due to its major role in deforestation [23].
c. Ingredients with fragrance or colorant function are excluded as non-essential.
d. Other oils apart from M. Oleifera seed oil are excluded.

Thus, a final composition of 11 ingredients is set for the formulation of a body soap with M. Oleifera oil:

1- Water.
2- Moringa Oleifera seed oil.
3- Glycerin.
4- Sorbitol.
5- Etidronic acid.
6- Tetrasodium EDTA.
7- Tocopherol.
8- Sodium chloride.
9- Sodium sulphate.
10- Citric acid.
11- Coconut acid (coconut oil).

It must be noted that water is going to be treated at the manufacturing plant prior to start the production and is not a required material from an external supplier. In a similar way, Moringa Oleifera seed oil is going to be obtained in situ by extracting oil from raw seeds. However, for the selection and evaluation of seeds there are many variables in origin that affect oil in terms of quality and yield (see **3.2 Key factors affecting oil yield and quality** for further details) and should be properly evaluated in the lab to determine which source has best performance and affordability.

Apart from the compounds for the formulation, other laboratory reagents will be needed for the quality control during the analysis of pilot tests depending on the methods applied for the determination of each parameter (see **6.7 Quality Control approach and design of the Key Process Indicators** for further details). In order to fully optimize the procurement management, both formulation ingredients and laboratory reagents are going to be acquired from the same supplier as this ensures a minimum number of requests and deliveries.

Likewise, a series of laboratory equipment and consumables are also needed for the elaboration of pilot tests such as general laboratory glassware, stirrers, heaters, balances, paper filters, thermometers, pHmeters, etc. In addition, other storage equipment is also necessary for an adequate preservation of in-process and finished batches like a fridge, security cabinets, a fume hood, drying ovens, muffle furnaces, etc.

Finally, end-consumer products must be properly packaged after production and kept during an equivalent time to the shelf life of the product in order to perform stability studies and detect possible shortcomings to be solved during the testing phase. Therefore, a packaging material supplier must be also selected.

4.2. Source selection criteria

The selection criteria and weights for the selection of the chemical compounds needed for the formulation and other laboratory reagents is shown in *Table 7*:

Criteria	Weight (%)
Price (€/kg)	40
Availability (working days until shipment)	30
Proximity (km)	15
Quality (ISO certifications)	10
Capacity (products in stock)	5
TOTAL	100

Table 7 Selection criteria descriptions and weights for chemical suppliers.

For the purchasing of lab and storage equipment, selection criteria from *Table 8* are used:

Criteria	Weight (%)
Capacity (products in catalogue)	30
Proximity (km)	30
Sales growing rate (€ turnover)	20
Technical service availability (Y=1/N=0)	10
Quality (ISO certifications)	10
TOTAL	100

Table 8 Selection criteria descriptions and weights for lab and storage equipment suppliers.

The supplier for packaging material is selected according to criteria from *Table 9*:

Criteria	Weight (%)
Proximity (km)	40
Sales growing rate (€ turnover)	25
Product development experience (years established)	15
Ratio of recycled packaging (%)	10
Quality (ISO certifications)	10
TOTAL	100

Table 9 Selection criteria descriptions and weights for packaging material suppliers.

For the criteria stated above, the following trends are promoted:

- **Price:** lower acquisition cost per kilogram of raw material.
- **Availability:** it is preferable a supplier that already has product in stock in order to avoid a previous lead time of production until shipment.
- **Proximity:** fewer kilometers of transport constitute a better environmental policy. Proximity is calculated from the manufacturing facility to Terrassa (Spain) by using Google Maps public tool.
- **Quality:** the presence of International Organization for Standardization (ISO from now onwards) certifications are indicators of a well-performing and compromised enterprise. Only current certifications at the manufacturing facility of origin are taken into account.
- **Capacity:** when references in the portfolio and available stock are higher, response time may be faster.
- **Sales growing rate:** a company with increasing sales is preferred for a long-term procurement. For the comparison, data of increased sales turnover during 2017 period is taken into account.
- **Technical service availability:** if the supplier itself can provide technical support; possible complaints may be managed faster.
- **Product development experience:** as packaging must be tailored to each final product, more years of experience are valuable as needed solution may be already within supplier's portfolio.
- **Ratio of recycled packaging:** a higher percentage of recycled material is preferred.

4.3. Selection of suppliers

4.3.1. Group and description of suppliers

Hereunder are the group of suppliers to be evaluated for each category of required materials followed by a brief description of the companies (see *Table 10*).

Code	Laboratory Reagents	Code	Lab & Storage Equipment	Code	Packaging Material
A	Sigma-Aldrich Inc. (Merck Group)	E	Thermo Fisher Scientific Inc.	I	Saica SL
B	Alfa Aesar (Thermo Fisher Scientific)	F	Omnilab-Laborzentrum GmbH & Co KG	J	DS Smith PLC
C	PanReac AppliChem (ITW Reagents Division)	G	Scharlab SL	K	SelfPackaging (Jmg Garrofe Disseny SL)
D	Honeywell Research Chemicals	H	JP Selecta SA	L	Vegabaja Packaging SL (Hinojosa Packaging SL)

Table 10 Group of suppliers by category to be evaluated.

- **Sigma-Aldrich Inc.:** recently merged into the Merck Group, it belongs now to the oldest chemical company operating since 1668. It offers around 30,000 different chemical products in a wide range of qualities and formats. It provides service to 66 countries and 60 manufacturing facilities around the world [24].
- **Alfa Aesar:** as the chemical manufacturer and supplier of the Thermo Fisher Scientific group, it offers around 38,000 different research chemicals since 1989. With global distributors all over the world it outstands for having a broad range of products in stock for same-day shipment [25].
- **ITW Reagents:** under the management of Illinois Tool Works (ITW from now onwards), it operates worldwide with more than 75 years of experience serving to more than 80 countries. Its 2 main manufacturing facilities represent around 15,000 m^2 of production areas coordinated with 3 warehouses with more than 10,000 m^2 of stocks [26].
- **Honeywell Research Chemicals:** founded in 1814 by Johan Daniel Riedel, it is part of Honeywell International Inc. providing almost 2,000 different chemical products under their self-branding in diverse presentations [27].
- **Thermo Fisher Scientific Inc.:** employing around 70,000 people worldwide and exceeding a profit of more than $24 billion, it offers laboratory "instruments, equipment, software, services and consumables" with a portfolio continuously growing and providing its own technical assistance [28].
- **Omnilab-Laborzentrum GmbH & Co KG:** with a constant stock of more than 100,000 references and order processing times of less than 24 hours, it constitutes a flexible and agile German supplier employing 160 professionals with a technical support division [29].
- **Scharlab SL:** its main markets are within the chemical, microbiology, chromatography and glassware sectors, providing customers in more than 100 countries with approximately 200 employees and 60 years of experience with its headquarters based in Sentmenat (Spain) [30].
- **JP Selecta SA:** established more than 60 years ago, it manufactures and distributes today its own equipment to more than 100 countries from its more than 20,000 m^2 factory in Abrera (Spain). Its main strength is the design and making of its own technical documentation with technical assistance during all the lifespan of their equipment [31].
- **Saica SL:** founded in 1943 with over 70 years of experience, it was the first company to introduce a cogeneration plant in Spain and the first machine capable to produce paper with a weight of 75 g/m^2. Nowadays it recycles paper and polyethylene (PE from now onwards) since 2015 employing about 10,000 people in 9 countries [32].

- **DS Smith PLC:** established in London in 1940, it operates now in 37 countries with more than 32,000 employees producing corrugated and plastic packaging. Its key strategy is to assist its customers to "reduce waste, cost and complexity from their supply chains" [33].
- **SelfPackaging:** based in Barcelona, this packaging design agency has received already more than 300 awards since 1992 as it provides tailored designs both to companies and particulars, with a "do-it-yourself" touch and using recycled cardboard [P15].
- **Vegabaja Packaging SL:** founded in 1976 in Alicante (Spain), it has now 120 employees and is part of the Hinojosa Packaging group operating at a European level. Its production capacity exceeds 120 MM m^2 per year with 50,000 m^2 production facilities and 80,000 m^2 storage surface [P16].

4.3.2. Description of the selection procedure

For each supplier, data is going to be obtained and treated as follows:

a. The initial values displayed are obtained from the supplier's official website as public information.
b. Initial values are normalized into a scale from 0 to 1 (see 14.2.1 Formulas used for the selection of suppliers).
c. The Linear Averaging Method (LAM from now onwards) is applied, known as *Valor Técnico Ponderado* or VTP in Spanish (see 14.2.1 Formulas used for the selection of suppliers).
d. The supplier with the greatest LAM value is the selected one.

4.3.3. Selection of the laboratory reagents supplier

Given the high amount of compounds needed for the formulation of M. Oleifera oil soap, only prices, availabilities and stocks from Citric acid anhydrous with purity ≥99.5% (CAS Number*: 77-92-9) are included in the comparison for laboratory reagents suppliers (see *Table 11*) in order to simplify data and calculations.

	Supplier code for lab reagents			
Selection criteria	A [36]	B [37]	C [38]	D [39]
Price (€/kg)	173	64,8	69,8	47,55
Availability (working days until shipment)	10	1	10	10
Proximity (km)	655	1.196	16	1.702
Quality (ISO certifications)	1 (France)	2 (United Kingdom)	2 (Spain)	2 (Germany)
Capacity (products in stock)	0	2	6	0

Table 11 Initial values for the selection of the laboratory reagents supplier.

* The CAS number is a "unique numeric identifier" associated to only one chemical substance intended to provide a global nomenclature for all stakeholders [64].

Observing *Table 39*, it can be seen that the selected supplier for purchasing the formulation compounds and other laboratory reagents is Alfa Aesar with supplier code B.

4.3.4. Selection of the lab & storage equipment supplier

	Supplier code for lab & storage equipment			
Selection criteria	E [40]	F [41]	G [42]	H [43]
Capacity (products in catalogue)	1.060	3.070	2.930	1.369
Proximity (km)	608	1.674	25	19
Sales growing rate (% turnover increase)	14	16,4	6,9	5,3
Technical service availability (Y=1/N=0)	1	1	0	1
Quality (ISO certifications)	1 (Spain)	1	2	1

Table 12 Initial values for the selection of the lab & storage equipment supplier.

The selected supplier of lab & storage equipment is Scharlab SL with supplier code G (see *Table 12*).

4.3.5. Selection of the packaging material supplier

	Supplier code for packaging material			
Selection criteria	I [44]	J [45]	K [46]	L [47]
Proximity (km)	38	217	28	556
Sales growing rate (€ turnover)	11,8	6	1,54	13,1
Product development experience (years established)	76	79	27	43
Ratio of recycled packaging (%)	100	63,4	100	50
Quality (ISO certifications)	2	3	0	1

Table 13 Initial values for the selection of the packaging material supplier.

The selected supplier of packaging material is Saica SL with supplier code I (see *Table 13*).

5. Cost Management

5.1. Implementation of a cost control method

In order to measure and control cost management performance, an Earned Value Management (EVM from now onwards) system is applied over the course of this study displaying a "time-phased view of the cost baseline" by means of an S-curve (due to its shape) [48].

EVM rules can be summarized as follows:

I. Costs are estimated for each task in the WBS depending on its requirements of resources.
II. Estimated budget for each activity is distributed along time according to its WBS schedule.
III. Deviations from the initial budget are measured and controlled during the realization of the study until its completion, in order to offset them and end as planned.
IV. To detect deviations, a cost baseline or reference is represented as an S-curve chart showing the accumulated costs versus time.

5.2. Cost estimation and budgeting

5.2.1. Cost estimation

The estimated costs for this study are detailed in the Study Budget (see separate document) and summarized in *Figure 9*:

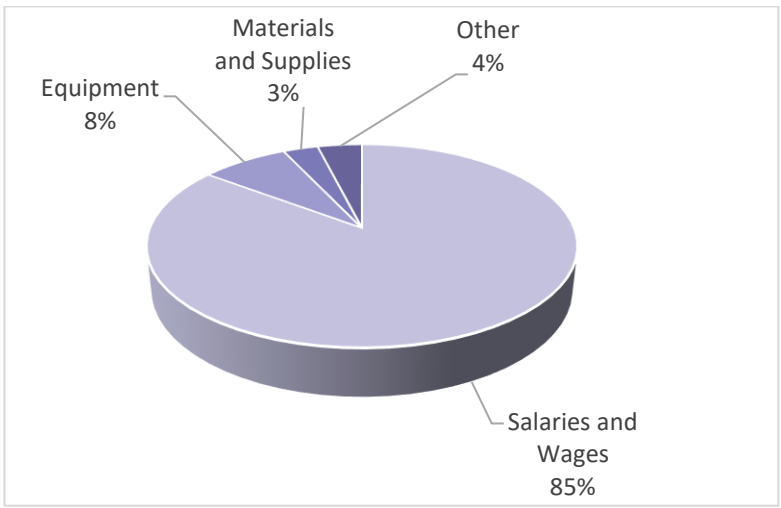


Figure 9 ***Pie chart with the estimated budget breakdown.***

As seen above, major costs are from personnel, due to the high requirements of research and development (R&D from now onwards) in this study.

5.2.2. Cost budgeting

Prior to determine the Planned Value (PV from now onwards), costs have to be distributed along the duration of the study until its completion.
Taking into account that the study takes about 300 hours of work and assuming full working days of 8 hours per day, with 5 working days per week (from Monday to Friday), this results into a total duration of approximately 8 weeks.

5.2.2.1. Personnel costs

For the distribution of personnel costs per week and person, the following data is taken into account (see 14.2.2 Formulas and calculations used for making the cost management plan for more details):

- Weekly internal personnel cost is 562,5 € per week.
- The total amount for external personnel cost is included in week 2 for the research of the state of the art after the initiation of the study.

The total cost for personnel is of 5.500,00 € until the completion of the study.

5.2.2.2. Additional costs

The distribution of additional costs per week is done according to the need for each item along the making of this study. In this sense:

- Additional costs for equipment are input on week 1 as they are needed from the beginning of the study.
- Additional costs due to office supplies are input proportionally for all weeks since they are necessary during the whole study.
- Additional costs from the purchase of ACS membership and ISO 14001:2015 are input on weeks 3 and 4 respectively, as they are not required until performing the research of the state-of-the-art and the environmental evaluation.

The total additional costs are 954 € until the completion of the study.

5.2.2.3. Planned value

With all the information obtained in previous sections, the distribution of the PV for each week is displayed below:

Week	Personnel cost	Additional costs	Total	Cumulative Value
1	562,50 €	525,00 €	1.087,50 €	1.087,50 €
2	1.562,50 €	25,00 €	1.587,50 €	2.675,00 €
3	562,50 €	185,00 €	747,50 €	3.422,50 €
4	562,50 €	119,00 €	681,50 €	4.104,00 €
5	562,50 €	25,00 €	587,50 €	4.691,50 €
6	562,50 €	25,00 €	587,50 €	5.279,00 €
7	562,50 €	25,00 €	587,50 €	5.866,50 €
8	562,50 €	25,00 €	587,50 €	6.454,00 €

Table 14 Planned Value for each week over the course of the study.

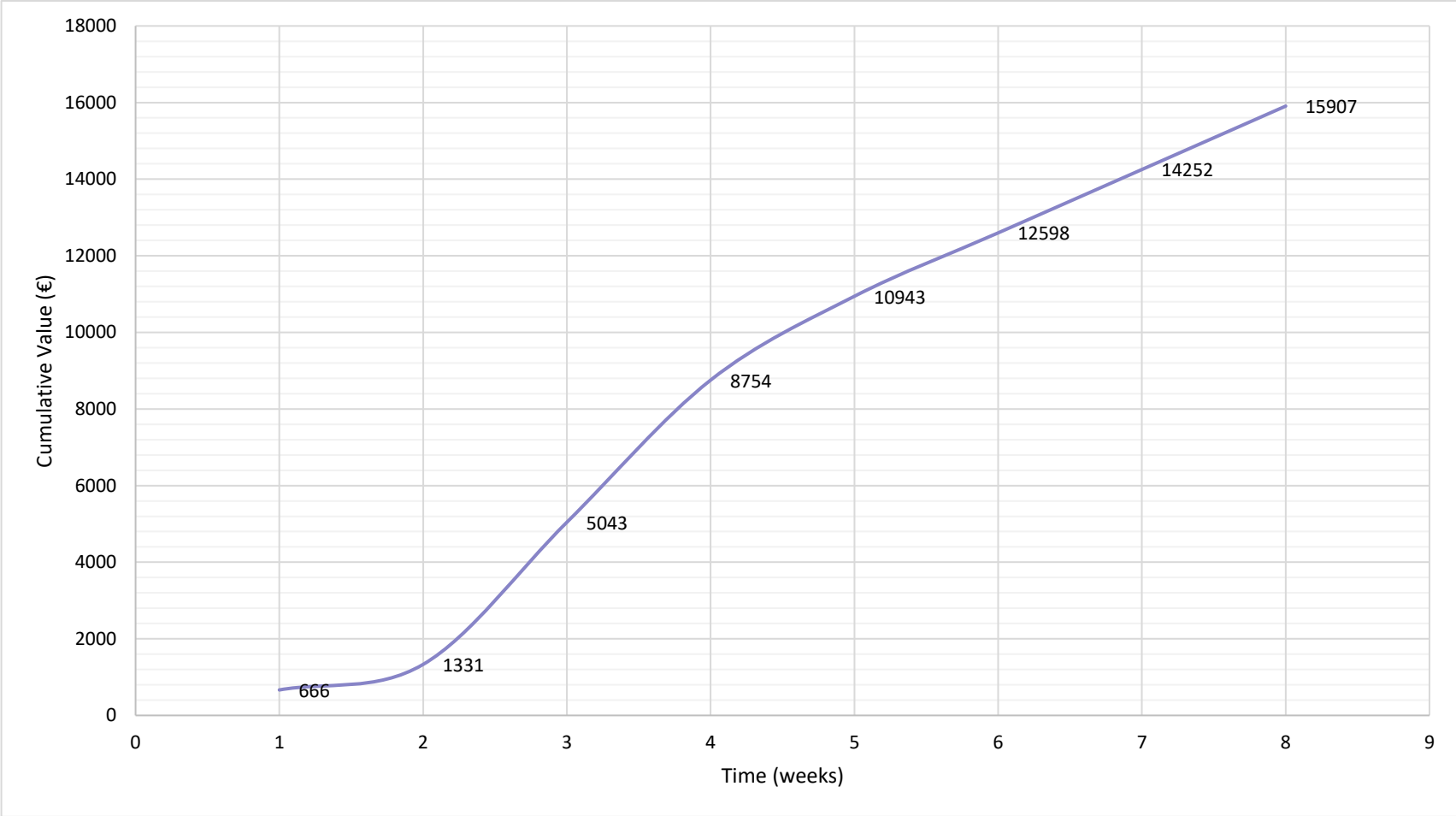


Figure 10 ***S-Curve with cumulative value during the study.***

5.3. Cost control

So as to control work performance during the development of this study, variance analysis is applied (see 14.2.2 Formulas and calculations used for making the cost management plan for more details).

Control threshold for Cost Performance Index and Schedule Performance Index (CPI and SPI from now onwards) is ± 5% of variance respect from ideal situation. Values out from control threshold will be treated as deviations and managed to finish the study within planned values.

5.4. Cost forecasts

Estimate At Completion (EAC from now onwards) forecast methodology is applied in order to manage deviations with regard to estimated Budget At Completion (BAC from now onwards).

This methodology quantifies current performance, assumes committed deviations until the moment and continues with the original planning for the rest of the study (see **14.2.2 Formulas and calculations used for making the cost management plan** for more details in calculations).

6. Quality Management

6.1. Scope of the quality management system

The scope of the quality management system includes all methods and procedures detailed in section **1.2 Scope**. In turn, Key Process Indicators (KPI from now onwards) are set for the sales and marketing in order to evaluate the customer satisfaction at the different stages of their experience until the disposal of the cosmetics.
Also, the management corresponding to communications, risk and human resources (HR from now onwards) are included in the quality management system.

6.2. Quality Policy development

The quality policy involves every aspect to take into account for assuring the fulfilment of the requirements from all stakeholders in order to achieve and exceed the pre-set objectives.
The following items define the quality policy:

- Identify any requirements coming from all stakeholders and assign enough resources to assure effective and efficient results that cover these needs in an easy way.
- Allow the continuous development of the company and its improvement without affecting the preservation of the environment, the personnel safety and the fulfilment of all stakeholders' requirements and all applicable regulatory and legal conditions.
- Provide cutting-edge services and products by preventing and avoiding any possible error that may threat customer's trust.
- Foster the company's continuous improvement by applying Total Quality Management (TQM from now onwards [49]) providing required training and information for the personnel involved along the supply chain.
- Develop an activity based in a respectful and transparent communication between the company and all stakeholders.
- Design a production which methods and processes generate a minimum environmental impact by consuming as less resources as possible.
- Be responsible at any time of all tasks outsourced or done on behalf of the company during all the contract by informing them of the required quality standards.

6.3. Customer and legal requirements definition

The identified requirements for each stakeholder are the following ones:

I. Green Cosmetics Inc (as stated in 1.4 Requirements and specifications):

- The conception, design and commercialization of the final products must be according to the environmental policy in which is based this study.
- The proposed alternatives for the extraction of M. Oleifera oil must be technically feasible.
- Any outsourcing (if needed) must be supervised as an extension of the whole activity, with the same policy as the main defined process units.

- A market research has to be done previous to determine the affordability of the alternatives proposed in this study, in order to quantify the MVP that will cover the fixed costs of the activity.

II. End user:

- The final product has to be safe, reliable and with a high perceived value in comparison with similar products from competitors.

III. Relevant authorities:

- In general, if applicable:
  - EU Directives.
  - UNE Standards.
  - Current regulations on health and safety at work.
- In particular:
  - Regulation (EC) No 1223/2009 of 30 November 2009 on cosmetic products [50].
  - Requirements from the Scientific Committee on Customer Safety (SCCS from now onwards).
  - Requirements from European Pharmacopoeia 10th Edition.
  - Requirements from the Food and Drug Administration (FDA from now onwards).
  - Requirements from any other local regulatory agency or body.

Also, this study respects other voluntary regulations such as:

- ISO 22716:2007 → Cosmetics - Good Manufacturing Practices (GMP from now onwards) - Guidelines on Good Manufacturing Practices.
- ISO/TR 24475:2010 → Cosmetics - Good Manufacturing Practices - General training document.
- ISO 16128-2:2017 → Cosmetics — Guidelines on technical definitions and criteria for natural and organic cosmetic ingredients — Part 2: Criteria for ingredients and products.
- ISO 9001:2015 → Quality management systems — Requirements.
- ISO 14001:2015 → Environmental management systems — Requirements with guidance for use.

6.4. Process identification and sequencing

The quality management system is applied to the following main processes as identified in 1.2 Scope:

- Managing of the woodlots of M. Oleifera during all their lifecycle.
- Collection and supply of the different parts that compound the M. Oleifera trees to each treatment plant.
- Processing of the ingredients at each plant in order to produce the diverse green cosmetics to commercialize.
- Packaging and labelling of the final products.
- Storage previous to its final delivery.
- Transport and distribution of the final products to the end user.
- Quality tests performed all along the supply chain.
- Customer service provided to the end user.
- The communications, marketing and sales policies used for advertising and selling the products.

6.5. Definition and assignment of roles and responsibilities

With the aim of ensuring an optimal Quality Assurance (QA from now onwards) of the processes identified above, the following roles and responsibilities are assigned:

Post	Role	Responsibilities
Quality Manager	Quality Assurance Manager	Define, manage and evaluate all quality requirements from each process along the supply chain.
Operations Manager	QA Collaborator	Ensure the achievement of the quality requirements referring to all processes starting from procurement until distribution of the final products.
R&D Manager	QA Collaborator	Ensure the achievement of the quality requirements within the design, simulation, pilot tests and MVP phases.
EHS Manager	QA Collaborator	Provide optimal assessment in terms of environmental, health and safety (EHS from now onwards) specifications related to applicable quality requirements in these fields.
Maintenance Manager	QA Collaborator	Ensure that all equipment and machinery used in every process is in optimal operating conditions in order to warranty reliability in the quality controls and requirements.
Sales & Marketing Manager	QA Collaborator	Ensure the achievement of quality requirements referring to customer service provided, communications and sales & marketing specifications and policies.
IT Manager	QA Collaborator	Ensure the achievement of quality requirements by providing, configurating and updating any software or hardware requested by QA.
HR & Communications Manager	QA Collaborator	Ensure the achievement of quality requirements by providing enough personnel with the required training & qualifications and by communicating internally and externally according to the quality guidelines.

Table 15 ***Definition and assignment of roles and responsibilities.***

6.6. Quality Assurance approach

With the intention of being able to meet all set requirements, the QA approach is based in a Plan-Do-Check-Act (PDCA from now onwards) cycle [51], as suggested in ISO 9001:2015 with the items shown in ***Figure 11***.

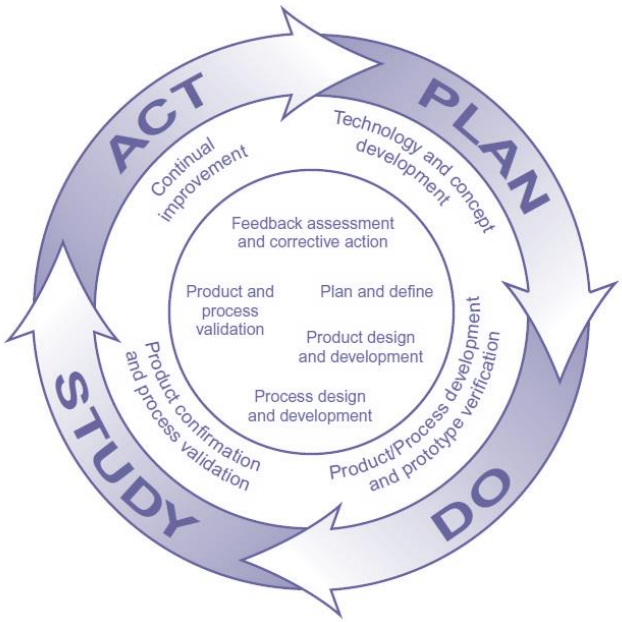


Figure 11 ***PDCA cycle flow and description.***
Credit: *https://qualitycontrolarticles.wordpress.com/2011/09/page/2/*

In order to do so, the company is provided from external consultancy services that identify any applicable requirements to the activity.
All legal, regulatory and voluntary requirements are collected in a database that allows periodical revisions and updates when new requirements have to be included. If any deviation is detected, a non-conformity is opened within the system along with its applicable corrective actions, the responsible(s) of these actions, the estimated due date and the resources needed (if any). Each non-conformity is monitored and controlled until its closure, when evidence of corrected deviation is demonstrated.

6.7. Quality Control approach and design of the Key Process Indicators

The definition of KPI is performed using SMART criteria [52] so as to allow future adequation, evaluation and follow-up of them.

The defined KPI, quality levels and quality controls for each process is shown in *Table 16*.

Process	Quality Level	KPI	Quality Control		
			WBS	Resources	Deliverables
Managing of the woodlots	The goal is to design and manage a woodlot with an optimal productivity to assure production at a minimum cost. The woodlot must cover ≥95% of the demanded raw materials at the treatment plant.	• Ratio between woodlot production and treatment plant consumption. • Fulfil all quality and environment requirements.	1.3.1 1.5.1 1.6.1	• Work hours from the Operations and R&D Departments. • Land for tests.	Woodlot design report.
Collection and supply of raw materials	The goal is to ensure an optimal procurement by having lead time deviations of less than ±10% from estimated time for each operation and for the whole supply chain, and also stay within the estimated budget with a deviation of less than ±5%.	• Respect the lead time for each operation and for the whole supply chain. • Fit within the estimated budget.	1.5.1 1.6.1	Work hours from the Operations Department.	• Certificates of analysis for each received batch of raw material. • Collection and supply design report.

Process	Quality Level	KPI	Quality Control		
			WBS	Resources	Deliverables
Raw materials processing and treatment	The goal is to process and treat each raw material according to the desired takt time [†] and the quality and environment requirements. In these terms, ≥90% of orders have to be processed within the takt time range, <5% of batches have to be out-of-specifications, breakdowns must be fixed in less than 48 hours and corrective maintenance has to be <25% from total maintenance operations.	• Ratio between orders processed within takt time range and the total amount of orders. • Ratio between batches out-of-specifications and total amount of processed batches. • Percentage of breakdowns processed in less than 48 hours since occurring. • Ratio between corrective maintenance operations and the total amount of maintenance operations.	1.3.1 1.5.1 1.6.1 1.6.2 1.8.1 1.9.1	Work hours from the Operations and R&D Departments.	• Delivery notes of processed orders. • Certificates of analysis for each batch and/or sample of intermediate and final products. • Processing and treatment of raw materials design report. • Maintenance reports for each breakdown. • Continuous improvement reports.

[†] Takt time can be defined as "the rate at which you need to complete a product in order to meet customer demand" [65].

Process	Quality Level	KPI	Quality Control		
			WBS	Resources	Deliverables
Packaging and labelling	The goal is to design and provide a practical, ergonomic and user-friendly packaging that ensures legal compliance with all required data on its label. For this, each batch must be traceable along all the supply chain by means of an SAP/ERP, packages and labels defects must be <2%, breakdowns must be fixed in less than 48 hours and corrective maintenance has to be <25% from total maintenance operations.	• Traceability of all batches on an SAP/ERP. • Ratio between defective final products and total produced. • Percentage of breakdowns processed in less than 48 hours since occurring. • Ratio between corrective maintenance operations and the total amount of maintenance operations.	1.5.1 1.6.1 1.6.2 1.8.1	Work hours from the Operations Department.	• Delivery notes of processed orders. • Packaging and labelling design report. • Maintenance reports for each breakdown. • Continuous improvement reports.
Final product storage, transport and distribution	The goal is to keep final products in proper storage conditions until its delivery by preserving its quality. To ensure that, ≥98% of deliveries have to be done within the specified lead time and stocks must be enough to ensure a delivery service within 48 hours since receiving the order.	• Ratio between deliveries served within lead time and total number of deliveries. • Ratio between expedited deliveries in less than 48 hours after receiving the order and total number of expedition orders.	1.5.1 1.6.1	Work hours from the Operations Department.	• Packing list for each delivery. • Incidents database. • Continuous improvement reports.

Process	Quality Level	KPI	Quality Control		
			WBS	Resources	Deliverables
Quality tests	The goal is to assure that product fulfils all stakeholders' requirements as well as legal and regulatory compliance. In order to do so, each parameter needs an specific method of analysis according to the European Pharmacopoeia (see 3.6 Parameters of analysis for the extracted oil) and opened non-conformities must be below 5 at all times.	• Register of updated analysis methods for each parameter. • Number of opened non-conformities.	1.8.1	Work hours from the R&D and Quality Departments.	• Compendium of methods used for the quality control of each sample. • Certificates of analysis for each batch and/or sample of intermediate and final products. • Quality assurance report for each final product (including stability studies, if necessary). • Audit reports.
Customer service	The goal is to provide a fast and reliable customer service to effectively solve any complaints from the end user. In this sense, results from customer satisfaction must obtain an average mark higher than 4 from 5 in order to proof the performance of this service.	• Average score in Likert scale ‡ from customer satisfaction surveys.	1.4.1	Work hours from the IT and Sales & Marketing Departments.	• Customer satisfaction surveys database. • Complaints database.

‡ A questionnaire performed using Likert scale allows the surveyed to express "attitudes and opinions with a greater degree of nuance than a simple "yes/no" question" [66].

Process	Quality Level	KPI	Quality Control		
			WBS	Resources	Deliverables
Sales & Marketing	The goal is to achieve enough sales to compensate cost for the MVP and to create a portfolio that promotes and differentiates the company's brand. To attain this, sales have to be distributed on time at ≥90% of the orders, must be equal to the production of the MVP after two year and the portfolio must include at least 10 products after five years in 3 languages (English, French and Spanish).	• Ratio between delivery notes distributed on time and total delivery notes of distributed sales. • Ratio between units sold and units produced for each product. • Number of products in the portfolio.	1.4.1	Work hours from the Sales & Marketing Department.	• Instructions for use of each final product. • Delivery notes for each order.

Table 16 ***Defined KPI, quality levels and quality controls for each.***

6.8. Continuous improvement plan

As the QA approach has to be reviewed and updated with time, the following activities are part of the continuous improvement strategy:

I. Fortnightly meetings with all QA collaborators where problems are deviations are exposed to be discussed and managed according to the QA approach. The meeting minutes is available for all the staff in a shared server for later views or modifications, as well as to add new topics to treat.
II. Monthly sessions of training in TQM and Total Productive Maintenance (TPM from now onwards) as a way to promote the participation from all employees in these fields.
III. Quarterly workshops to expose the company's results and performance to all the staff along with suffered deviations and the corrective actions applied.
IV. Biannual internal audits in order to assure the fulfilment of requirements according to the Integral Management System (IMS from now onwards) composed by all ISO regulations.
V. Perform repeatability and reproducibility (R&R from now onwards) studies when deviations in lead time are detected or when new machinery or equipment is installed at the facility.

7. Human Resources Management

7.1. Definition of profiles, roles and responsibilities

The following table includes de identification and register of roles, responsibilities and required skills for each member or participant in the team for the correct development of the study:

Name	Role	Collaborators	Responsibilities	Required skills
Aida Ballester	Study Manager, Coordinator	External expertise	Coordinate, manage and report	Knowledge of the chemical industry, ISO certifications, management and engineering.
External expertise	Legal advisers, auditors, inspectors, technical services, etc.	None	Report	Any other required skill.

Table 17 Description of the HR profiles.

7.1.1. Assignment of personnel to the required departments

Listed below are the departments to cover according to the defined profiles:

- **Operations:** including a purchasing department, a logistics department, a production department, a maintenance department, an EHS department a R&D department and an engineering department.
- Sales & Marketing.
- Accounting and Finance.
- Quality.
- **HR & Communications:** including an Information Technology (IT from now onwards) department.

All departments may be assisted by external expertise in specific tasks if they require so.

7.1.2. Computation of human resources

Details about personnel and their salaries are included in *Table 32* within the Study Charter.

7.2. Organizational structure and organization chart

Figure 12 ***Organization chart of the study.***

7.3. Team development plan

In order to assure the team development, the following actions are carried out:

I. Making of an individual development at the enrolment of the employee to be revised annually.
II. Annual 360 reviews [53] along with individual interviews with the direct manager as a way to detect strengths to foster or weaknesses to improve.
III. Annual objectives personalized for each employee as a way to encourage them to participate into the company's results.
IV. Offer at least one training course for each employee related to the area of work.

8. Communications Management

The communications management includes the definition of channels for transferring information between key roles in and out in a proper way. Also, it includes key items for a successful marketing campaign that presents the product to the end user with a high perceived value and an environmentally-friendly approach that makes it outstand from the rest. To this end, several tools are used for the diffusion of information and news such as a web site, presence in social media, publication of technical articles, etc.

8.1. Internal communications management

	Sender	Receiver	Channel	Minimum Frequency	Records	Control	Description
Internal communications	Study Manager	Green Cosmetics Inc	Emails	Weekly	Sent mailbox	Confirmation of receipt	Report current status of the study according to planning.
			Meetings	Monthly	Meeting minutes	Signed certificate of assistance	Follow-up meetings on specific topics.
			Phone calls	When needed	Phone calls register	Phone calls register	When issues need to be solved quickly or are difficult to communicate by email.
			Deliverables	Monthly	Report	Signatures on cover page with date	Paper support of each chapter of the study.
	Study Manager	External expertise	Emails	Weekly	Sent mailbox	Confirmation of receipt	Specification of tasks, resolution of doubts, follow-up of current status and results.
			Meetings	Weekly	Meeting minutes	Signed certificate of assistance	
			Phone calls	When needed	Phone calls register	Phone calls register	

Table 18 ***Internal communications management.***

8.2. External communications management

	Sender	Receiver	Channel	Minimum Frequency	Records	Control	Description
External communications	Study Manager	Suppliers	Emails	Weekly	Sent mailbox	Confirmation of receipt	Inquiries about orders or non-conformities, resolution of doubts, tracking of orders, etc.
			Meetings	Weekly	Meeting minutes	Signed certificate of assistance	For dealing with specific issues where several persons must assist at the same time, when opening or reviewing contract conditions.
			Phone calls	When needed	Phone calls register	Phone calls register	When issues need to be solved quickly or are difficult to communicate by email.

Table 19 External communications management.

Added to this, other tools are also implemented within the marketing campaign:

- **Company's web site:** the web includes information about the own company and its policies, the products offered, constant updates with the latest news and products added to the portfolio, a product browser, a free subscription for newsletters and private account to manage orders and personal data and a contact section to enable inquiries from customers.
- **Social media:** company must have presence in Facebook, Twitter, Instagram and also publish the most relevant articles on LinkedIn when relevant technological advances or new formulations are achieved.

8.3. Communications performance reporting

For the communications performance reporting, the KPI set in section 6.7 Quality Control approach and design of the Key Process Indicators for the customer service process is applied and the variance analysis is obtained by using the CPI and SPI described in 14.2.2 Formulas and calculations used for making the cost management plan when new reports are delivered.

9. Risk Management

In this section are included the threats detected at the beginning of the study and the initial assessment of the identified uncertainties, serving as a baseline for later revisions.

9.1. Identification and definition of high-level risks

The preliminary identification and definition of high-level risks for this study is shown below:

Risk ID	Risk Statement
R01	Significant delay in the overall planned schedule and/or in any critical activity
R02	Significant cost deviation in the overall budget
R03	Lack or insufficient funding, insolvency
R04	Lack or insufficient management personnel
R05	Lack or incomplete contingency plan for external factors
R06	Loss of data or documents
R07	Lack or inefficient communication
R08	Failure in the product formulation
R09	Failure in the product design
R10	Lack or insufficient technological development
R11	Order delay from a supplier
R12	Order cancellation from a supplier
R13	Final product out-of-specifications
R14	Insufficient customer satisfaction
R15	Low productivity and/or production process predictability
R16	Significant deviation in sales forecast

Table 20 ***Identification and definition of high-level risks.***

9.2. Risk evaluation

The initial evaluation for the risks defined in *Table 20* is detailed in *Table 21* according to the following parameters:

- **Category:** it refers to the origin or inner nature from which is derived the risk. Risks are classified in four main categories:
  I. Technical.
  II. External.
  III. Organizational.
  IV. Project Management.
- **Probability of occurrence:** a percentage score is assigned for each risk.

- **Impact:** a score from 0 to 10 is assigned for each risk in each of its possible effects or losses in scope, quality, schedule and cost.
- **Importance:** it evaluates the immediate severity of each risk in a qualitative scale (low-medium-high).
- **Possible causes:** points out the root(s) that have derived into a risk.
- **Responsible(s):** identifies whether the responsibility is internal, external or from both sides.
- **Planned response:** different strategies may be assumed depending on the evaluation for each risk. The four main strategies to deal with risks that are managed as threats are:
    I. **Avoid:** to do so, risk must be studied to obtain more information and controlled by eliminating uncertainty.
    II. **Mitigate:** in order to mitigate the risk, this must be studied, and actions must be taken to modify or reduce the initial exposure to the risk.
    III. **Transfer:** this strategy reallocates the ownership of the risk, without making it disappear.
    IV. **Accept:** if nothing else could be done, risk has to be assumed within the study's baseline and absorb its possible impacts.
- **Actions:** linked to the defined planned response, it describes in more detail the countermeasures adopted to manage the risk.

Risk ID	Category	Probability of Occurrence (%)	Impact				Importance	Possible Causes	Responsible(s)	Planned Response	Actions
			Scope	Quality	Schedule	Cost					
R01	Project Management	20	6	3	10	8	High	Errors or missing information in the initial planning or during its control.	Internal	Avoid	Revise assigned resources for critical activities in order to assure the completion of the study on time.
R02	Project Management	25	8	5	3	10	High	Errors or missing information in the estimated budget or during its control.	Internal	Avoid	Revise assigned resources for critical activities in order to assure the completion of the study within the budget.
R03	Project Management	10	7	7	4	10	High	Errors or missing information in the estimated funding, changes in external factors.	Internal/External	Avoid	Include an evaluation of this scenario within the contingency plan of the enterprise.
R04	Organizational	10	6	8	7	7	Medium	Staff with missing or inadequate qualifications and/or skills.	Internal	Avoid	Define job descriptions for each position with the required qualifications, skills and further training.
R05	Organizational	5	5	7	3	10	Medium	Outdated or incomplete risk assessment, other external factors.	Internal/External	Assume	Perform periodical revisions to the risk management plan.

Risk ID	Category	Probability of Occurrence (%)	Impact				Importance	Possible Causes	Responsible(s)	Planned Response	Actions
			Scope	Quality	Schedule	Cost					
R06	Organizational	5	2	4	8	8	Low	Missing or insufficient backups, inefficient communication and/or management, other external factors.	Internal/External	Transfer	Establish several backups in external servers in order to assure enough copies and fast information recovery.
R07	Organizational	10	2	7	7	7	Low	Poor management, work overload, errors in planning, other external factors.	Internal/External	Mitigate	Foster vertical communication, provide specific training to improve communication.
R08	Technical	15	4	5	10	10	High	Insufficient technical knowledge, low productivity or process predictability.	Internal	Avoid	Recruit staff with adequate technical knowledge, assess and monitor process productivity and predictability.
R09	Technical	15	4	5	10	10	High	Insufficient technical knowledge, insufficient technical development.	Internal	Avoid	Recruit staff with adequate technical knowledge, assess technical development.

Risk ID	Category	Probability of Occurrence (%)	Impact				Importance	Possible Causes	Responsible(s)	Planned Response	Actions
			Scope	Quality	Schedule	Cost					
R10	Technical	5	10	9	3	10	Medium	Insufficient research on the state of the art, other external factors.	External	Assume	Include a research of the state of the art within the scope of the study.
R11	External	20	1	1	7	8	Low	Contract without definition of terms and conditions about external responsibilities and delivery times, other external factors.	External	Transfer	Preestablish terms and conditions for each contract, define safety stocks for each raw material to avoid production shutdowns.
R12	External	10	1	1	10	10	Medium	Interruption of activity from the supplier due to force majeure, insolvency, other external factors.	External	Transfer	Have one or more approved alternative suppliers for each raw material.
R13	Technical	5	7	9	10	10	High	Human errors, shortcomings in machinery, inefficient maintenance, other internal factors.	Internal	Mitigate	Provide training in TPM, TQM and Six Sigma to the involved personnel to reduce non-conforming batches.

Risk ID	Category	Probability of Occurrence (%)	Impact				Importance	Possible Causes	Responsible(s)	Planned Response	Actions
			Scope	Quality	Schedule	Cost					
R14	External	1	9	10	3	6	High	Inadequate or incomplete market analysis, other external factors.	Internal/External	Mitigate	Assess market studies from different agencies to have representative information from customers.
R15	Technical	15	8	6	9	7	Medium	Human errors, shortcomings in machinery, inefficient maintenance, other internal factors.	Internal	Avoid	Define Standard Operating Procedures (SOP from now onwards) for each process, monitor production equipment and register results, provide training in TPM and TQM to the involved personnel.
R16	External	10	5	4	6	10	Medium	Errors or missing information in the estimated budget, inefficient research from the marketing agency, other external factors.	Internal/External	Mitigate	Assess market studies from different agencies to have representative information from customers, include an evaluation of this scenario within the contingency plan of the enterprise.

Table 21 Initial evaluation of identified risks.

9.3. Risk control indicators

Risk ID	Risk Statement	KPI
R01	Significant delay in the overall planned schedule and/or in any critical activity	Number of days overdue for each task
R02	Significant cost deviation in the overall budget	Difference between estimated budget and actual cost
R03	Lack or insufficient funding	Difference between estimated funding and actual funding
R04	Lack or insufficient management personnel, insolvency	Number of incidences due to internal errors
R05	Lack or incomplete contingency plan of external factors	Number of incidences due to external factors
R06	Loss of data or documents	Number of losses
R07	Lack or inefficient communication	Number of incidences due to inefficient communication Number of days overdue for a task due to inefficient communication
R08	Failure in the product formulation	Number of attempts during the formulation phase
R09	Failure in the product design	Number of attempts during the design phase
R10	Lack or insufficient technological development	Number of days overdue during the research of the state of the art
R11	Order delay from a supplier	Average days overdue from a supplier
R12	Order cancellation from a supplier	Number of orders cancelled from a supplier
R13	Final product out-of-specifications	Number of batches out-of-specifications
R14	Insufficient customer satisfaction	Average marks from customer satisfaction surveys
R15	Low productivity and/or production process predictability	Average lead time for producing one batch of final product
R16	Significant deviation in sales forecast	Percentage deviation from initial sales forecast

Table 22 ***Risk control indicators.***

9.4. Risk monitoring strategy

As risk monitoring is an ongoing process that takes place during all the study, the following loop describes the adopted risk monitoring strategy:

a) **Identification:** after the start of the study, new risks or existing but modified risks may appear, so the identification step must be done periodically to ensure optimal risk management.
b) **Analysis:** this includes the measurement and evaluation of the identified risks.
c) **Control:** setting of response strategies, KPI and actions to be taken.
d) **Communication:** the results obtained from the risk management must be internally reported and reviewed regularly as also externally for audits and stakeholders. In these meetings, performance must be evaluated and derived into improvement actions.

9.5. Risk prioritization

By adding the scores of impact included in *Table 21* and multiplying by the probability of occurrence, the final scores for each risk are obtained and the following order of priority can be set:

Risk ID	Score	Order of priority
R02	6,5	1
R01	5,4	2
R15	4,5	3
R08	4,35	4
R09	4,35	5
R11	3,4	6
R03	2,8	7
R04	2,8	8
R16	2,5	9
R07	2,3	10
R12	2,2	11
R13	1,8	12
R10	1,6	13
R05	1,25	14
R06	1,1	15
R14	0,28	16

Table 23 Prioritization of risk management.

10. Environmental Evaluation

In accordance with the objectives stated in *Table 31* , the environmental approach of this study pretends to "achieve a better BPEO from the research of the 3 main methods to produce oil from M. Oleifera by reducing a 10% the overall environmental impact compared with the current BPEO".

Since the most used and extended method for the extraction of oil is the SE, the comparison will be performed against the AE method given this is the best alternative in terms of affordability and sustainability.

To do so, the environmental aspects related to each method are identified in conformity with the regulations from ISO 14001:2015 (see chapter A.6.1.2) [54], as summarized in *Table 24*:

Environmental aspect	SE	AE
Consumption of energy	As the method requires a high operating temperature, the consumption of non-renewable natural resources (such as fuel, gasoil, propane, etc.) and/or electricity to get to the desired temperature represents a significant environmental aspect to take into account. Added to this, there is an extra expenditure of energy to recover and recycle hazardous solvents by means of distillation.	The whole procedure is developed at room temperature, so there is no need to heat at all times.
Consumption of water	The consumption of water is higher than the one required in AE due to the need of bleaching and degumming, also generating a higher amount of wastewater after these operations.	As the method produces already a clean mixture that does not need to degum or bleach, this method reduces both water consumption and wastewater.
Consumption of raw materials	Hazardous organic solvents are needed to perform the oil extraction in order to obtain the maximum yield.	No solvents needed; required pH for the enzymes is adjusted with little quantities of non-hazardous solutions.
Generation of wastewater, waste and/or subproducts	Streams of wastewater with traces of hazardous solvents are produced, which will require the use of energy and resources to recover this waste or a disposal treatment for no longer use.	Wastewater is rich in proteins and can be used as dietary supplement, so it is treated as a reusable subproduct and not as a waste.
Air emissions	The use of organic solvents produces Volatile Organic Compounds (VOC from now onwards) emissions to the atmosphere that pollute the air and can end up forming smog [55].	No air emissions are generated with this method.
Waste disposal	Given the use of hazardous substances, the waste disposal is more complicated and expensive, representing a safety risk for humans, ecosystems and the environment.	None waste is generated by using this method that cannot be recovered and used again for other purposes.

Environmental aspect	SE	AE
Discharges into soil	Accidental leakage or spill of any of the raw materials used in this method would provoke severe damage into soil.	Leaks or spills would not imply damages into soil.

Table 24 ***Identification of environmental aspects for SE and AE methods.***

In order to determine which of the identified environmental aspects is significant and establish a priority order, a series of criteria has to be established as a way to quantify them [54]. Therefore, environmental indicators (see *Table 25*) must be assigned to each criterion to ensure a correct evaluation and further follow-up.

Environmental aspect	Environmental indicator	Impact reduction by using AE (%)
Consumption of energy	J/kg production	As the AE method does not require any heat during the process, the reduction is of 100%.
Consumption of water	L water/ kg production	Due to lack of specific data from the consulted literature, this aspect cannot be quantified for the methods compared.
Consumption of raw materials	L solvent/ kg production	Due to lack of specific data from the consulted literature, this aspect cannot be quantified for the methods compared.
Generation of wastewater, waste and/or subproducts	L wastewater/ kg production	AE method guarantees the non-generation of wastewater, waste or non-reusable subproducts, so the reduction is of 100%.
Air emissions	VOC ppm/ kg produced	As the AE method does not release emissions during the process, the reduction is of 100%.
Waste disposal	kg waste/ kg produced	Given the absence of waste for the AE method, the reduction of this aspect is of 100%.
Discharges into soil	L discharged/ kg produced	As product streams in the AE process are non-hazardous, the reduction of this aspect for the AE method is of 100%.

Table 25 ***Environmental indicators.***

At this point, it is possible to determine the environmental impact as it is the cumulative result of the evaluated aspects. Even though a couple of aspects cannot be quantitively evaluated, it is clear that the AE method offers a BPEO with more than a 10% reduction in the overall environmental impact, as 5 from the 7 evaluated aspects are reduced in a 100% by completely eliminating these aspects.

In that sense, as described by the ISO 14001:2015, the final environmental impact has been significantly reduced in terms of magnitude, severity, duration and exposure [54].

To sum up, the use of the AE method instead of the SE method, delivers the improvements demanded in section **1.1 Aim**, which are the following:

- Generated subproducts during the processing of M. Oleifera do not need to be disposed as they can readily be recovered and reused for secondary purposes without pre-treatment.
- The expenditure of energy and resources is significantly lower, promoting a responsible consumption and a sustainable approach for the production of green cosmetics.
- The resulting overall environmental impact is reduced by reducing the number of environmental aspects assigned to this activity.

11. Financial Evaluation

As stated in 3.5 Decision of the extraction method to be used and in 10 Environmental Evaluation, due to the high production process complexity and costs of the SFE method and the poor environmental performance of the SE method, the preferred method would be the AE according to technological and environmental criteria.

At this point, the aim of the financial evaluation is to determine the affordability for the proposed alternative to implement the AE method instead of the SE method by means of 3 investment criteria: dynamic payback, Net Present Value (NPV from now onwards) and Internal Rate of Return (IRR from now onwards).

Due to the lack of specific data of the operative process for the implementation of the AE method, the calculations of the investment criteria are done with sales and purchases forecasts and prices for the next 5 years (see **14.2.3 Formulas and calculations used for making the financial evaluation** for further details), by presenting 3 different scenarios: pessimistic, optimistic and optimal.

11.1. General considerations

I. The initial investment includes the cost of permanent equipment, lab equipment and storage equipment (see **14.1.9 Estimated budget** for further details), along with the study budget (see separate document).
II. Depreciation is calculated as straight-line without residual value.
III. Imposed corporation tax rate is of 25% as a generic value for Spanish companies [56]. Tax is deducted at the cash flow statement as of second year from the initial investment.
IV. Imposed update rate has been taken from inflation by consumer price index according to data from Spain in 2017 [57].
V. Purchases forecast are calculated with a surplus of 5% from sales forecast to prevent in case of defects or other non-conformities.
VI. Purchase price is estimated yearly as an average price for all the required components.
VII. Other costs include the sum of expendables, other costs, laboratory reagents, packaging material as stated in the study invoice (see document attached to final report) and are equally distributed along the 5 years after the initial investment.
VIII. It is assumed that one year equals to 360 natural days.
IX. Opening cash at the beginning of the activity is 0.

11.2. Investment criteria

11.2.1. Dynamic Payback

	Pessimistic	Optimistic	Optimal
Year 1	-40.273,69 €	-26.175,02 €	-26.175,02 €
Year 2	-74.999,72 €	-21.071,43 €	-44.518,30 €
Year 3	-98.493,74 €	29.041,89 €	-27.621,64 €
Year 4	-108.138,61 €	110.962,77 €	22.010,26 €
Year 5	-89.427,49 €	263.153,32 €	107.082,97 €
Conclusions	It is not advisable to invest.	Payback of 3 years: it is advisable to invest.	Payback of 4 years: it is advisable to invest.

Table 26 ***Results of the dynamic payback after 5 years of investment for each scenario.***

As observed in the table above, the investment would be recommended in terms of dynamic payback for 2 of the 3 evaluated scenarios, provided that forecasts for optimistic and optimal scenarios are met.

11.2.2. Net Present Value (NPV)

	Pessimistic	Optimistic	Optimal
Year 1	-74.618,69 €	-60.520,02 €	-60.520,02 €
Year 2	-109.344,72 €	-55.416,43 €	-78.863,30 €
Year 3	-132.838,74 €	-5.303,11 €	-61.966,64 €
Year 4	-142.483,61 €	76.617,77 €	-12.334,74 €
Year 5	-123.772,49 €	228.808,32 €	72.737,97 €
Conclusions	It is not advisable to invest.	NPV > 0: it is advisable to invest.	NPV > 0: it is advisable to invest.

Table 27 ***Results of the NPV after 5 years of investment for each scenario.***

Again, as observed above, the investment would be recommended in terms of NPV for 2 of the 3 evaluated scenarios, provided that forecasts for optimistic and optimal scenarios are met.

11.2.3. Internal Rate of Return (IRR)

		Pessimistic	Optimistic	Optimal
Rate of return (r)	Year 1	No feasible solution[§]. It is not advisable to invest.	No feasible solution.	No feasible solution.
	Year 2		No feasible solution.	No feasible solution.
	Year 3		No feasible solution.	No feasible solution.
	Year 4		33%	No feasible solution.
	Year 5		54%	22%

Table 28 Results of the IRR after 5 years of investment for each scenario.

Finally, the obtained IRR for each scenario reveals that the investment would be highly recommended in the optimistic scenario and affordable in the optimal scenario as of the fifth year.

[§] By no feasible solution it is meant that the Solver tool included in Microsoft Excel was not able to find any possible solution within the mathematical constraints.

12. Conclusions and future work

12.1. Conclusions

At the end of this study, the aim has been accomplished by finding an alternative method for the extraction of M. Oleifera oil, by using a better environmental performing procedure with a reduced environmental impact. Furthermore, the study also includes a complete sales potential as demanded.

In terms of time, the whole study requires a total of 62 weeks with the activities detailed in the WBS.

In order to proceed to the evaluation of potential suppliers, a body soap formulation is proposed and ingredients are chosen according to environmental criteria.
After the evaluation of suppliers, Alfa Aesar is the selected provider for the laboratory reagents supplies, Scharlab SL is the selected provider for the laboratory and storage equipment and Saica SL is the selected supplier for the packaging equipment.

The estimated budget at completion of the study is of 6.454 €. Costs are controlled according to CPI and SPI indexes and actions are taken when budget falls out of the established threshold of ±5% variance.

Referring to quality, the scope of the quality management system is defined along with its policy development, its customer and legal requirements and processes are identified and sequenced in order to define and assign roles and responsibilities. Also, a quality assurance approach is set and KPI are designed for the quality control, ending with a continuous improvement plan.

For the management of human resources, profiles, roles and responsibilities are defined and structured into an organizational chart, including a team development plan.

In terms of communications, both internal and external strategies for communications management are defined and instructions of how to report performance are specified.

With respect to risk management, this chapter includes a definition of high-level risks, its evaluation, control indicators for each risk, prioritization and a subsequent monitoring strategy. The risk resulting with the highest impact and first priority is a significant cost deviation in the overall budget.

At the environmental evaluation, the proposed AE method is found suitable with a successful reduction of the environmental impact higher than 10%, as demanded.

Finally, the financial evaluation shows that the sales potential for the body soap are positive in 2 from the 3 evaluated scenarios (pessimistic, optimistic and optimal), which proves the affordability of the product.

12.2. Future work

After thorough revision of state-of-the-art literature, some aspects have been identified as possible research to carry on in order to obtain better results in the extraction of M. Oleifera oil such as:

- Improvement of oil yield in enzyme-assisted aqueous extraction (AE from now onwards) by testing new combinations of enzymes in different ratios to find the optimal amount and pH range ([11], [16]).
- Define new strategies to improve oil yield and minimize losses: better assistance in mechanical treatment to break more efficiently the cellular structure without extensive heat treatment or use of organic solvents [16].
- Conduct RSM (response surface methodology) experiments to find optimal operating conditions and interactions between variables by using AE method [19].

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14. Report Attachments

14.1. Study Charter

14.1.1. Study purpose and justification

It wasn't until the celebration of the *United Nations Conference on the Human Environment* [2] held in Stockholm in 1972 that environmental concerns (such as the climate change and sustainable development) started to play an important role in the European society and economy.
One year later, in 1973, the oil crisis [3] and the significant rise of oil prices definitely woke up the urgent need of renewable energies and promoted the investment in research for better environmental policies.

In 2000, concepts as green or sustainable brands [4], greenwashing [5] or ethical consumerism [6] became powerful marketing tools that serve companies nowadays to differentiate their products from their competitors in order to stand out from the rest. So much so, it appeared a new trend in the chemical industry called *green chemistry* [7] which intends to significantly minimize the environmental impacts associated to this sector by using eco-friendly substances.

With this approach and taking into account the continuous increase of the negative consumer perception of most synthetic preservatives and drugs present in cosmetics and food [8], *Moringa Oleifera* tree (M. Oleifera from now onwards) is one of the raw materials that offers a wider range of opportunities to produce green chemicals from its constituents (see ***Figure 1***), as very few parts of this tree are toxic [9] and almost every part is edible like its flowers, fruits, leaves and roots. In particular, M. Oleifera offers a valuable source of oil from its seeds (19 to 47%), commercially known as Ben oil, with a high content of oleic acid (about 70%), that provides great resistance against oxidation resulting into great stability. Moreover, Ben oil confers a great medium where fragrances can be retained, reason for which M. Oleifera is even a better source of green chemicals within the perfume industry and in cosmetics in general, as it is also considered an excellent emollient commonly used in hair and skin care ([10] [11] [12]). In fact, cosmetic uses have been reported since 150 A.D. for Romans, Greeks and Egyptians in the preparation of skin lotions and ointments, but it wasn't until the 19th century that M. Oleifera oil started being exported to Europe from the West Indies and not until 1970s that nutritional and industrial research started to be formally conducted [13].

Up to now, several industries have taken profit from specific parts of M. Oleifera tree producing a portfolio of products in different presentations (dehydrated, powder, pulp, oil, etc.) depending on the final application (see ***Figure 2***).

The large scale cultivation of M. Oleifera and its relative species due to the increasing popularity natural products all over the world claims for an urgent need to find a sustainable processing and waste disposal of the residues derived from the commercial exploitation of this tree [9].

This study consists in the analysis of the marketing and sales potential for the commercialization of the so-called green cosmetics coming from M. Oleifera oil, as a high added value product still untapped. In turn, the study is based in a strong environmental approach that claims for a better performance when compared to present processes. To determine the affordability of the proposed alternatives, a financial report is issued ultimately as a final step of this study.

14.1.1.1. Vision

Avoid the generation of any waste all along the supply chain due to the production and commercialization of cosmetics by using M. Oleifera oil as a key ingredient.

14.1.1.2. Objectives

The main aims for this study are the following ones:

- Propose an alternative waste disposal as part of a green cosmetic supply chain.
- Evaluate the environmental impact and its reduction compared to data from current process by means of the carbon footprint.
- Determine the feasibility and affordability for the commercialization of M. Oleifera cosmetics.

14.1.1.3. Scope

The scope of this study includes the following main items:

- Perform a research of the state of the art for the extraction of M. Oleifera oil.
- Managing of the woodlots of M. Oleifera during all their lifecycle.
- Collection and supply of the different parts that compound the M. Oleifera trees to each treatment plant.
- Processing of the ingredients at each plant in order to produce the diverse green cosmetics to commercialize.
- Packaging and labelling of the final products.
- Storage previous to its final delivery.
- Transport and distribution of the final products to the end user.

Added to these items, other issues must be considered in relation with the waste disposal of the final product:

- Design and engineering of the products and the different processes involved in obtaining the cosmetics from M. Oleifera oil.
- The quality control and assurance from each process unit.

The following items are considered to be outside of the scope of this study:

- The intermediate transports the final product may experience until its final consumption by the customer and until it arrives to the waste treatment plant.
- Whether the customer performs or not the correct disposal of the product after its whole consumption.
- The influence the M. Oleifera may have in the ecosystems where produced as an aggressive and invasive species [1].

14.1.2. Study description

As stated in previous section, M. Oleifera offers great opportunities to produce green chemicals. In turn, different appearances of M. Oleifera (raw, powder, capsules, dried, dissolved, etc.) lead to a broad variety of applications that make M. Oleifera an all-rounder for industrial purposes. The different ways to extract M. Oleifera oil from the plant are explained at the beginning of this study and are taken into account when deciding the most feasible method for obtaining the M. Oleifera oil.

As M. Oleifera oil represents the ingredient with the highest foresight of benefits, this study intends to propose alternative disposals of the waste produced during the extraction of oil from the M. Oleifera tree, using the subproduct as raw material for the production of green cosmetics, in view of reducing the environmental impact associated to this activity and its resource and energy consumption. The quantification of these impacts is performed in accordance with ISO 14001:2015 [54].

To increase the environmental performance, a deposit-refund system (DRS from now onwards) is suggested in this study to close the loop as a measure for minimizing the packaging waste generated by the end user. This system has been successfully integrated in many countries all over the world, as governments have published specific legislations to promote it [58].

Figure 13 Metal cans used for milk runs in a wagon. Credit: https://www.plusonline.nl/sites/plusonline/files/styles/pol_carousel/public/melkboer_1220.jpg?itok=dGLc_JLq

In fact, this system is not new, as exemplified by the original milk run [59] started in 1860 in United Kingdom where the milkman took the empty bottles and replaced them for full ones, reusing the containers lots of times until the end of their lifespan (see *Figure 13*).

This system was fast extended along Europe and can still be locally found with more and more vending machines that offer fresh daily milk to the consumers. Recently, initiatives like Loop™ from Terracycle [60] and ©Jean Bouteille [61] are becoming popular and encourage the consumer to actively participate in the packaging waste reduction.

In particular, an example of a DRS within the cosmetics industry is the one established by the company LUSH [62], who engages consumers to return single-use containers to get one free item per 5 consumed. Returned containers are reconditioned to get filled again with fresh product and brought back to shops. Alternatively, cosmetics can be kept in tins that avoid the use of any packaging as the tins can be directly refilled each time at the shop (see *Figure 14*).

Figure 14 ***Examples of tins commercialized by LUSH for his DSR.***
Credit: https://www.lushusa.com/gifts/accessories/round-tin/22016.html

Finally, the study ends with a financial risk report with basic investment measures (payback, NPV and IRR).

14.1.3. Requirements and specifications

The initial requirements that must be fulfilled in this study are:

- The conception, design and commercialization of the final products must be according to the environmental policy in which is based this study.
- The proposed alternatives for the extraction of M. Oleifera oil must be technically feasible.
- Any outsourcing (if needed) must be supervised as an extension of the whole activity, with the same policy as the main defined process units.
- A market research has to be done previous to determine the affordability of the alternatives proposed in this study, in order to quantify the minimum viable product (MVP from now onwards [14]) that will cover the fixed costs of the activity.

Moreover, the initial specifications for this study are the following ones:

- Guarantee an MVP that covers at least a 95% of the fixed costs based on the results of the market research.
- Achieve the quality standards set for each product and process by using six sigma techniques [15].
- The actual costs of the study must not be greater than those established in the estimated budget. Otherwise, the proposal will be considered as unfeasible.
- Reach a better environmental performance or best practicable environmental option (BPEO from now onwards) by comparison with current process data (see *Table 31* for specific objectives).

14.1.4. Acceptance criteria

To ensure the correct management of this study, the following criteria must be accomplished:

- Result into an improved BPEO to produce and commercialize green cosmetics from M. Oleifera oil.
- Receive enough financing from investors (according to the financial report) in order to implement the best alternative proposed.

14.1.5. High-level risks

During the initiation of this study, several high-level risks have been identified with different:

- **Possible mistakes at the different organizational levels:** to avoid them, each significant aspect of the study must be dealt together in periodical meetings to share and discuss the relevant information in an effective and productive way.
- **Lack or absence of the expected financing needed:** to accept this, a flexible and adaptable budget must be created with options to redistribute and adjust the time, cost and staff planned for each activity as a means of minimizing this risk.
- **Significant deviations of the market research according to reality:** this risk can be mitigated both with an optimal design of the marketing strategy and with a correct determination of the MVP.
- **Inexistence of a better BPEO:** in order to accept this, a state-of-the-art report is performed at the beginning of this project assessed with the ISO 14001:2015 as a way to validate the alternative.
- **Quality defects:** to mitigate this, a quality plan must be implemented with specific indicators that allow monitoring and controlling the different processes of the activity.

14.1.6. Study deliverables

Below is shown the list of deliverables and the estimated due date of each until the completion of this study:

Deliverable	Description	Estimated due date (YYYY-MM-DD)
Study Charter	Set of the fundamentals of this study prior to its start.	2019-04-02
Time Management Plan	Planning, hierarchy and decomposition of the different activities into manageable work packages by means of WBS and Gantt & PERT charts.	2019-05-07
State-of-the-art Report	Research of the current techniques for the extraction of M. Oleifera oil from the existing literature.	2019-05-26
Procurement Management Plan	Planning of the procurement and solicitation including the selection and evaluation of available sources.	2019-06-14
Cost Management Plan	Resource planning, cost estimating and budgeting and definition of cost control indicators to monitor and control its compliance.	2019-06-14

Deliverable	Description	Estimated due date (YYYY-MM-DD)
Quality Management Plan	Definition of the quality specifications along with its assurance plan and control indicators.	2019-06-28
Human Resources Management Plan	Definition of the organizational structure and roles, the staff needed and the team development requirements.	2019-06-28
Communications Management Plan	Planning of the communications required, of how to distribute the information and how to report the performance acquired.	2019-06-28
Risk Management Plan	Risk identification, quantification and evaluation in order to obtain the risk response and control strategies.	2019-07-12
Environmental Report	Evaluation of the proposed alternatives by means of the ISO 14001:2015 to determine the current BPEO for the extraction of M. Oleifera oil.	2019-08-23
Financial Report	Determination of the most affordable alternative using various investment criteria.	2019-09-06
Final Report	Document with the end result of the study for the production and commercialization of green cosmetics from M. Oleifera oil.	2019-09-30

Table 29 ***List of the study deliverables.***

14.1.7. Study milestones

Here below, there is the identification and sequencing of the milestones that compose this study:

Milestone	Description	Estimated due date (YYYY-MM-DD)
Initiation and Scope Management Approach	Drafting of the Study Charter including the objectives, scope, justification, requirements and specifications of the study.	2019-04-02
Time Management Approach	Development of the WBS and its dictionary.	2019-05-07
	Making of the Gantt Chart.	2019-05-07
	Making of the PERT Chart.	2019-05-07
Procurement Management Approach	Making of the state-of-the-art report to know current methodologies for extracting M. Oleifera oil.	2019-05-26
	Identification of the required materials, its selection criteria and choice of sources.	2019-06-14
Cost Management Approach	Implementation of the Earned Value Management method for the cost control.	2019-06-14
	Cost estimation and budgeting and establishment of financial forecasts.	2019-06-14

Milestone	Description	Estimated due date (YYYY-MM-DD)
Quality Management Approach	Definition of the scope, requirements and specifications of the quality plan, process identification and sequencing, definition and assignment of roles and responsibilities.	2019-06-28
	Design of the quality assurance and its KPI, drafting of the continuous improvement plan.	2019-06-28
Human Resources Management Approach	Identification of profiles, roles and responsibilities required for the different departments, making of the organizational chart, definition of staff acquisition needs and drafting of the team development plan.	2019-06-28
Communications Management Approach	Definition and planning of the internal and external communications strategies and its performance reporting.	2019-06-28
Risk Management Approach	Identification and definition of high-level risks, quantification and evaluation of risks and establishment of risk control indicators and monitoring strategies.	2019-07-12
Environmental Evaluation	Determination of the best environmental practice to choose among the ones evaluated.	2019-08-23
Financial Evaluation	Determination of the most affordable alternative in view of the results from the financial report.	2019-09-06
Administrative Closure	Drafting of the conclusions and the final report of the study.	2019-09-30

Table 30 ***List of the study milestones.***

14.1.8. Study objectives

In this study, several types of objectives have been taken in account [63] that can be resumed in the list below:

- **Performance objectives:** the study must be efficient and fulfil all the requirements indicated at the initial stage.
- **Economic objectives:** the estimated budget has to be accomplished within a minimum deviation.
- **Time scale objectives:** the study must be completed on time with the minimum possible delay.
- **Environmental objectives:** in this case, the study must attain a more environmentally friendly way of producing given the initial specifications.

In *Table 31* it can be found the detailed explanation of the objectives imposed to this study. Each objective has been set out in a SMART way, which means they are Specific, Measurable, Attainable, Realistic and Time-bound [52].

Type of Objective	Description	Scope	Time	Cost	Quality	Other	Person Approving
Performance	Satisfy all the requirements and specifications of this study.	At the end of the final report.	N/A*	N/A*	Accomplish over 90% of the requirements and specifications of the study at the closure of it.	If not, any deviation must be justified in a proper way.	Project Manager
Economic	Finishing the study without any excess of expenditure.	For all the ensemble of activities defined in the WBS.	During the full study.	N/A*	Keep the budget with a deviation of the Cost Performance Index (CPI) within a ±5%, to be checked each month.	The monitoring will be done using the Earned Value Management (EVM) technique.	
Time Scale	Finishing the study within the time scheduled.	For all the ensemble of activities defined in the WBS.	During the full study.	N/A*	End the activities with a deviation of the Schedule Performance Index (SPI) within a ±5%, to be checked each month.	The monitoring will be done using the Earned Value Management (EVM) technique.	
Environmental	Achieve a BPEO for obtaining M. Oleifera oil.	From the research of the main 3 methods to produce M. Oleifera oil.	After finishing the State-of-the-art Report, during the making of the Environmental Report.	2.500 € (≈50 hours of estimated work)	It is intended to obtain a reduction in the overall environmental impacts of 10% comparing to the current BPEO.	The evaluation will be done using the ISO 14001:2015.	

Table 31 Detailed explanation of the study objectives.

14.1.9. Estimated budget

14.1.9.1. Description of the budget

For the estimated budget, it is assumed that the study will take about 36 months to its completion. Within this period, diverse concepts are taken in account for the budget breakdown:

- **Personnel cost:** according to the occupational categories, basic salaries (including social security contributions), accrued and total incomes and the proportion of time spent by each member of the team to the study.
- **Expendables:** any of the articles or materials required during the making of the study that are going to be consumed after its use, mainly office supplies like paper, toner cartridges, pens, etc.
- **Permanent equipment:** each of the equipment needed for the execution of the study until its completion.
- **Pilot tests:** the materials and extra equipment that may be needed when performing the pilot tests before the commercialization of the final products. This group includes all lab equipment, chemical reagents and packaging and storage materials needed for elaborating the tests.
- **Supplies:** such as water, electricity, gas, internet or any other that may be needed.
- **Maintenance:** any of the maintenance operations that may be needed during the study.
- **Other:** any other costs that may have to be included in the estimated budget.

14.1.9.2. Budget breakdown

- Direct costs

The following table shows the annual estimated personnel costs including extra pays:

Name	Category	Gross Salary (€/month)	Contribution Base	Social Security (%)	Total Cost (€/month)	Time (%)	Annual cost (€)
Aida Ballester	Bachelor	1.500	1.450	33	1.983	100	27.762
External expertise	Qualified Personnel	20.000	19.333	33	25.713	100	25.713
TOTAL							53.475

Table 32 Annual personnel costs breakdown.

Below there are different tables with the cost breakdown for each concept identified as direct cost until the completion of the study:

Expendables	Quantity (Units*)	Price (€/unit)	Subtotal (€)
Paper	10 (500)	2,35	23,5
Toner cartridges for HP Envy 5030	5 (1)	21	105
Pens	1 (50)	11,30	11,3
Folders	1 (10)	27,50	27,5
TOTAL (€)			167,3

Table 33 Cost in expendables breakdown.

Permanent equipment	Quantity (Units)	Price (€/unit)	Subtotal (€)
Lenovo Ideapad 720S-13IKBR	1	650	650
Screen Asus VP249H	1	127	127
Printer HP Envy 5030	1	65	65
Microsoft Project Professional License	1	1.509	1.509
DWSIM Software	1	0	0
European Pharmacopoeia 10th Edition Electronic Version	1	540	540
TOTAL (€)			2.891

Table 34 Cost in permanent equipment breakdown.

Pilot tests	Quantity (Units)	Price (€/unit)	Subtotal (€)
Lab equipment	-	-	20.000
Laboratory reagents	-	-	5.000
Packaging material	-	-	3.000
Storage equipment	-	-	5.000
TOTAL (€)			33.000

Table 35 Cost in pilot tests breakdown.

- Indirect costs

Here are included all costs related to any ancillary services required for the correct development of the activity, such as facility supplies, maintenance, administrative and construction services. Given the complexity of an exact quantification of these concepts, it is commonly assumed that the indirect costs represent a percentage of the direct costs. This percentage is chosen depending on the sponsor management board and its financing sources.

* A single unit refers to the smallest package that can be bought, e.g. for a package of pens this includes 20 pens. The number of real units per package is indicated in brackets.

For this study, it is assumed that the indirect costs will represent a 50% of the total amount of the direct costs due to foreseen high levels of maintenance of the lab and pilot equipment.

- Other costs

Since the study may produce other unexpected costs, it is assumed that this concept will represent a 10% from the total amount of the direct costs, as a way to minimize the deviation experimented during the development of the study.

14.1.9.3. Estimated budget summary

Concept	Concept subtotal (€)
Personnel	53.475
Expendables	167,3
Permanent equipment	2.891
Pilot tests	33.000
Indirect costs	18.056
Other costs	3.611
TOTAL (€)	57.779

Table 36 Estimated budget summary.

14.1.10. Study organization

14.1.10.1. Stakeholders

The following groups and organizations are the key stakeholders in this study:

Stakeholder Name	Roles/Responsibilities
Green Cosmetics Inc.	The company for which this study is made and the one who will implement it after its completion.
End users	The customers that are going to buy the final product.
Relevant authorities	Any of the administrations that demand to meet any requirements due to the applicable laws and/or regulations.

Table 37 Stakeholders of the study.

14.1.10.2. Roles and responsibilities

The following key roles have been defined for this study:

Role	Resource Name	Organization	Responsibilities
Study Sponsor	Research Manager	Green Cosmetics Inc.	Supervise the study and demand any inquiry until its completion.
Study Manager	Beatriz Amante	UPC	Comprehensive advice during the making of the whole study.
Study Team	Aida Ballester	UPC	Development of the study until its completion.

Table 38 ***Definition of the key roles and responsibilities for this study.***

Approvals:

Signature,	Signature,
Project Management Name	Project Sponsor Name
Date:	**Date:**

14.2. Formulas and calculations

14.2.1. Formulas used for the selection of suppliers

14.2.1.1. Normalization formulas

- For criteria where lower values are preferred (e.g. for cost) *Equation 1* is applied:

$$V_{norm,i} = \frac{(V_{max} - V_i)}{(V_{max} - V_{min})}$$

Equation 1 Normalization formula when lower values are preferred.

- For criteria where higher values are preferred (e.g. for capacity) *Equation 2* is applied:

$$V_{norm,i} = \frac{(V_i - V_{min})}{(V_{max} - V_{min})}$$

Equation 2 Normalization formula when higher values are preferred.

Where:

- $V_{norm,i}$: refers to the resulting normalized value.
- V_{max}: refers for the maximum reported value among the evaluated suppliers.
- V_i: refers to the initial value for the evaluated supplier "i".
- V_{min}: refers for the minimum reported value among the evaluated suppliers.

14.2.1.2. LAM method

For obtaining the LAM result for a group of suppliers *Equation 3* is applied:

$$LAM = \frac{\sum_{i=1}^{n} p_i \cdot g_i}{p_{max} \cdot \sum_{i=1}^{n} g_i}$$

Equation 3 LAM method formula.

Where:

- LAM: refers to the result of evaluating the group of suppliers. The higher LAM value indicates the chosen supplier.
- p_i: refers to the mark associated to the specific criteria "g_i".
- g_i: refers to the weight associated to the criteria with the mark "p_i".
- p_{max}: refers to the maximum reported mark among the evaluated criteria for the supplier "i".

14.2.1.3. Normalization and LAM results for the selection of suppliers

Selection criteria	Normalization criteria	Weight (%)	Normalized values from 0-1			
			A	B	C	D
Price (€/kg)	Lower is better	40	0,00	0,86	0,82	1,00
Availability (working days until shipment)	Lower is better	30	0,00	1,00	0,00	0,00
Proximity (km)	Lower is better	15	0,62	0,30	1,00	0,00
Quality (ISO certifications)	Higher is better	10	0,00	1,00	1,00	1,00
Capacity (products in stock)	Higher is better	5	0,00	0,33	1,00	0,00
		LAM	0,15	0,81	0,63	0,50

Table 39 Normalization and LAM results for the laboratory reagents supplier selection.

Selection criteria	Normalization criteria	Weight (%)	Normalized values from 0-1			
			E	F	G	H
Capacity (products in catalogue)	Higher is better	30	0,00	1,00	0,93	0,15
Proximity (km)	Lower is better	30	0,64	0,00	1,00	1,00
Sales growing rate (€ turnover)	Higher is better	20	0,22	0,00	0,85	1,00
Technical service availability (Y=1/N=0)	Higher is better	10	1,00	1,00	0,00	1,00
Quality (ISO certifications)	Higher is better	10	0,00	0,00	1,00	0,00
		LAM	0,34	0,40	0,85	0,65

Table 40 Normalization and LAM results for the lab & storage equipment supplier selection.

Selection criteria	Normalization criteria	Weight (%)	Normalized values from 0-1			
			I	J	K	L
Proximity (km)	Lower is better	40	0,98	0,64	1,00	0,00
Sales growing rate (€ turnover)	Higher is better	25	0,88	0,38	0,00	1,00
Product development experience (years established)	Higher is better	15	0,94	1,00	0,00	0,31
Ratio of recycled packaging (%)	Higher is better	10	1,00	0,27	1,00	0,00
Quality (ISO certifications)	Higher is better	10	0,67	1,00	0,00	0,33
		LAM	0,92	0,63	0,50	0,33

Table 41 Normalization and LAM results for the packaging material supplier selection.

14.2.2. Formulas and calculations used for making the cost management plan

- Internal personnel cost:

Knowing that:

- Total salary for academic personnel is equivalent to 4500 €.
- Duration of the study is 8 weeks.

$$\text{Weekly internal personnel cost} = \frac{4500\ €}{8\ \text{weeks}} = 562{,}5\ \frac{€}{\text{week}}$$

Given that there is only one internal employee, it is not necessary to divide this cost per person.

- Variance analysis in work performance:

$$CV = EV - AC$$

Equation 4 ***Formula for Cost Variance.***

$$SV = EV - PV$$

Equation 5 ***Formula for Schedule Variance.***

$$CPI = \frac{EV}{AC}$$

Equation 6 ***Formula for Cost Performance Index.***

$$SPI = \frac{EV}{PV}$$

Equation 7 ***Formula for Schedule Performance Index.***

Where EV is the Earned Value. From the results for this indicators, different situations may occur:

- Cost Performance Index (CPI from now onwards):
  a) CPI = 1: current budget is as planned. This is the ideal situation.
  b) CPI > 1: current budget is lower than planned, which means that cost performance is higher than expected.
  c) CPI < 1: current budget is higher than planned, which means that cost performance is below expected, and root cause analysis is needed in order to implement corrective actions that eliminate budget deviations.

- Schedule Performance Index (SPI):
  a) SPI = 1: current schedule goes as planned. This is the ideal situation.
  b) SPI > 1: current schedule runs ahead of planned schedule, which means that schedule performance is higher than expected.
  c) SPI < 1: current schedule lags behind planned schedule, which means that schedule performance is below expected, and root cause analysis is needed in order to implement corrective actions that eliminate schedule deviations.

- Cost forecasts:

$$EAC = AC + BAC - EV$$

Equation 8 ***Estimate at completion forecast formula.***

Where:

- EAC (Estimate At Completion): result of budget forecast assuming suffered deviations up to this moment.
- AC (Actual Cost): real costs until now.
- BAC (Budget At Completion): original estimated budget until the completion of the study.
- EV: quantified work done until this moment.

14.2.3. Formulas and calculations used for making the financial evaluation

14.2.3.1. Formulas used for the calculations of the income statement and cash flow statement

$$\text{Revenue } [€] = \text{Sales forecast } [pu] \cdot \text{Sale price } \left[\frac{€}{pu}\right]$$

Equation 9 ***Formula for the annual revenue.***

$$\text{Variable costs } [€] = \text{Purchases forecast } [pu] \cdot \text{Purchase price } \left[\frac{€}{pu}\right]$$

Equation 10 ***Formula for the annual variable costs.***

Where "pu" stands for Physical Units (PU from now onwards).

- Income Statement breakdown:

+	Revenue
	- Variable costs from sold units [€] = Sold units [pu] · Purchase price [€/pu]
	- Other costs
	- Depreciation
EBIT = Earnings Before Interest and Taxes	
	- Corporation tax = EBIT · Corporation tax rate [%]
EBT = Earnings Before Taxes	

- Cash flow statement:

Opening cash
Inflows
+ Net turnover [€] = Revenue · (360 – Collection period [days]) / 360
+ Customers (what remained to collect from past period)
Outflows
- Net variable costs = Variable costs · (360 – Payment period [days]) / 360
- Net other costs = Other costs · (360 – Payment period [days]) / 360
- Personnel costs (from the study invoice)
- Corporation tax
Closing cash = Opening cash + Inflows – Outflows

- Year cash flow:

Cash flow = Inflows – Outflows

Equation 11 ***Formula for the year cash flow.***

14.2.3.2. Formulas for the investment criteria

- **Dynamic payback:** it establishes the number of years (n) for which the initial investment (A_0) is recovered by updating the cash flows (CF), by applying an update or inflation rate (k).

$$A_0 = \frac{CF_1}{1+k} + \frac{CF_2}{(1+k)^2} + \ldots + \frac{CF_n}{(1+k)^n}$$

Equation 12 ***Formula for the dynamic payback.***

- Net Present Value (NPV):

$$NPV = -A_0 + \frac{CF_1}{1+k} + \frac{CF_2}{(1+k)^2} + \ldots + \frac{CF_n}{(1+k)^n}$$

Equation 13 ***Formula for the NPV.***

The resulting NPV is interpreted as follows:

- NPV > 0: it is advisable to invest.
- NPV = 0: indifferent.
- NPV < 0: it is not recommended to invest.

- **Internal Rate of Return (IRR):** is the result of applying an update or inflation rate (r) that makes the NPV equal to 0.

$$IRR = r \qquad NPV = -A_0 + \frac{CF_1}{1+r} + \frac{CF_2}{(1+r)^2} + \ldots + \frac{CF_n}{(1+r)^n} = 0$$

Equation 14 ***Formula for the IRR.***

The resulting IRR is interpreted as follows:

- If r > k: it is advisable to invest.
- If r = k: indifferent.
- If r < k: it is not recommended to invest.

14.2.3.3. Calculations for the pessimistic scenario

- Preliminary estimates:

Initial investment (A_0)	34.345,00 €				
Years to payback	5				
Straight-line depreciation	6.869,00 €				
Corporation tax rate	25%				
Update rate (k)	0,0196				
CONCEPT	**YEAR 1**	**YEAR 2**	**YEAR 3**	**YEAR 4**	**YEAR 5**
Sales forecast (pu)	10000	15000	20000	30000	50000
Sale price (€/pu)	3,00 €	3,00 €	3,50 €	4,00 €	4,50 €
Revenue (€)	30.000,00 €	45.000,00 €	70.000,00 €	120.000,00 €	225.000,00 €
Collection period (days)	30	30	30	30	30
Purchases forecast (pu)	10500	15750	21000	31500	52500
Purchase price (€/pu)	1,50 €	1,75 €	2,00 €	2,50 €	3,00 €
Variable costs (€)	15.750,00 €	27.562,50 €	42.000,00 €	78.750,00 €	157.500,00 €
Payment period (days)	60	60	60	60	60
Other costs (€)	2.355,66 €	2.355,66 €	2.355,66 €	2.355,66 €	2.355,66 €
Payment period (days)	60	60	60	60	60

Table 42 ***Preliminary estimates for the pessimistic scenario.***

- Income Statement:

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
+ Revenue	30.000,00 €	45.000,00 €	70.000,00 €	120.000,00 €	225.000,00 €
- Variables costs from sold units	-15.000,00 €	-26.250,00 €	-40.000,00 €	-75.000,00 €	-150.000,00 €
- Other costs	-2.355,66 €	-2.355,66 €	-2.355,66 €	-2.355,66 €	-2.355,66 €
- Depreciation	-6.869,00 €	-6.869,00 €	-6.869,00 €	-6.869,00 €	-6.869,00 €
EBIT	5.775,34 €	9.525,34 €	20.775,34 €	35.775,34 €	65.775,34 €
- Corporation tax	-1.443,84 €	-2.381,34 €	-5.193,84 €	-8.943,84 €	-16.443,84 €
EBT	4.331,51 €	7.144,01 €	15.581,51 €	26.831,51 €	49.331,51 €

Table 43 Income statement for the pessimistic scenario.

- Cash flow statement:

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Opening cash	0,00 €	-41.063,05 €	-77.163,69 €	-102.066,40 €	-112.489,96 €
Inflows	27.500,00 €	43.750,00 €	67.916,67 €	115.833,33 €	216.250,00 €
+ Net turnover	27.500,00 €	41.250,00 €	64.166,67 €	110.000,00 €	206.250,00 €
+ Customers		2.500,00 €	3.750,00 €	5.833,33 €	10.000,00 €
Outflows	68.563,05 €	79.850,64 €	92.819,39 €	126.256,89 €	195.631,89 €
- Net variable costs	13.125,00 €	22.968,75 €	35.000,00 €	65.625,00 €	131.250,00 €
- Net other costs	1.963,05 €	1.963,05 €	1.963,05 €	1.963,05 €	1.963,05 €
- Personnel	53.475,00 €	53.475,00 €	53.475,00 €	53.475,00 €	53.475,00 €
- Corporation tax		1.443,84 €	2.381,34 €	5.193,84 €	8.943,84 €
Closing cash	-41.063,05 €	-77.163,69 €	-102.066,40 €	-112.489,96 €	-91.871,84 €
Year Cash Flow	-41.063,05 €	-36.100,64 €	-24.902,72 €	-10.423,55 €	20.618,12 €

Table 44 Cash flow statement for the pessimistic scenario.

14.2.3.4. Calculations for the optimistic scenario

- Preliminary estimates:

Initial investment (A_0)	34.345,00 €				
Years to payback	5				
Straight-line depreciation	6.869,00 €				
Corporation tax rate	25%				
Update rate (k)	0,0196				
CONCEPT	**YEAR 1**	**YEAR 2**	**YEAR 3**	**YEAR 4**	**YEAR 5**
Sales forecast (pu)	20000	50000	75000	100000	150000
Sale price (€/pu)	3,00 €	3,00 €	3,50 €	4,00 €	4,50 €
Revenue (€)	60.000,00 €	150.000,00 €	262.500,00 €	400.000,00 €	675.000,00 €
Collection period (days)	30	30	30	30	30
Purchases forecast (pu)	21000	52500	78750	105000	157500
Purchase price (€/pu)	1,50 €	1,75 €	2,00 €	2,50 €	3,00 €
Variable costs (€)	31.500,00 €	91.875,00 €	157.500,00 €	262.500,00 €	472.500,00 €
Payment period (days)	60	60	60	60	60
Other costs (€)	2.355,66 €	2.355,66 €	2.355,66 €	2.355,66 €	2.355,66 €
Payment period (days)	60	60	60	60	60

Table 45 Preliminary estimates for the optimistic scenario.

- Income Statement:

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
+ Revenue	60.000,00 €	150.000,00 €	262.500,00 €	400.000,00 €	675.000,00 €
- Variables costs from sold units	-30.000,00 €	-87.500,00 €	-150.000,00 €	-250.000,00 €	-450.000,00 €
- Other costs	-2.355,66 €	-2.355,66 €	-2.355,66 €	-2.355,66 €	-2.355,66 €
- Depreciation	-6.869,00 €	-6.869,00 €	-6.869,00 €	-6.869,00 €	-6.869,00 €
EBIT	20.775,34 €	53.275,34 €	103.275,34 €	140.775,34 €	215.775,34 €
- Corporation tax	-5.193,84 €	-13.318,84 €	-25.818,84 €	-35.193,84 €	-53.943,84 €
EBT	15.581,51 €	39.956,51 €	77.456,51 €	105.581,51 €	161.831,51 €

Table 46 Income statement for the optimistic scenario.

- Cash flow statement:

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Opening cash	0,00 €	-26.688,05 €	-21.382,44 €	31.735,68 €	120.270,46 €
Inflows	55.000,00 €	142.500,00 €	253.125,00 €	388.541,67 €	652.083,33 €
+ Net turnover	55.000,00 €	137.500,00 €	240.625,00 €	366.666,67 €	618.750,00 €
+ Customers		5.000,00 €	12.500,00 €	21.875,00 €	33.333,33 €
Outflows	81.688,05 €	137.194,39 €	200.006,89 €	300.006,89 €	484.381,89 €
- Net variable costs	26.250,00 €	76.562,50 €	131.250,00 €	218.750,00 €	393.750,00 €
- Net other costs	1.963,05 €	1.963,05 €	1.963,05 €	1.963,05 €	1.963,05 €
- Personnel	53.475,00 €	53.475,00 €	53.475,00 €	53.475,00 €	53.475,00 €
- Corporation tax		5.193,84 €	13.318,84 €	25.818,84 €	35.193,84 €
Closing cash	-26.688,05 €	-21.382,44 €	31.735,68 €	120.270,46 €	287.971,91 €
Year Cash Flow	-26.688,05 €	5.305,62 €	53.118,12 €	88.534,78 €	167.701,45 €

Table 47 Cash flow statement for the optimistic scenario.

14.2.3.5. Calculations for the optimal scenario

- Preliminary estimates:

Initial investment (A_0)	34.345,00 €				
Years to payback	5				
Straight-line depreciation	6.869,00 €				
Corporation tax rate	25%				
Update rate (k)	0,0196				
CONCEPT	**YEAR 1**	**YEAR 2**	**YEAR 3**	**YEAR 4**	**YEAR 5**
Sales forecast (pu)	20000	30000	50000	75000	100000
Sale price (€/pu)	3,00 €	3,00 €	3,50 €	4,00 €	4,50 €
Revenue (€)	60.000,00 €	90.000,00 €	175.000,00 €	300.000,00 €	450.000,00 €
Collection period (days)	30	30	30	30	30
Purchases forecast (pu)	21000	31500	52500	78750	105000
Purchase price (€/pu)	1,50 €	1,75 €	2,00 €	2,50 €	3,00 €
Variable costs (€)	31.500,00 €	55.125,00 €	105.000,00 €	196.875,00 €	315.000,00 €
Payment period (days)	60	60	60	60	60
Other costs (€)	2.355,66 €	2.355,66 €	2.355,66 €	2.355,66 €	2.355,66 €
Payment period (days)	60	60	60	60	60

Table 48 ***Preliminary estimates for the optimal scenario.***

- Income Statement:

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
+ Revenue	60.000,00 €	90.000,00 €	175.000,00 €	300.000,00 €	450.000,00 €
- Variables costs from sold units	-30.000,00 €	-52.500,00 €	-100.000,00 €	-187.500,00 €	-300.000,00 €
- Other costs	-2.355,66 €	-2.355,66 €	-2.355,66 €	-2.355,66 €	-2.355,66 €
- Depreciation	-6.869,00 €	-6.869,00 €	-6.869,00 €	-6.869,00 €	-6.869,00 €
EBIT	20.775,34 €	28.275,34 €	65.775,34 €	103.275,34 €	140.775,34 €
- Corporation tax	-5.193,84 €	-7.068,84 €	-16.443,84 €	-25.818,84 €	-35.193,84 €
EBT	15.581,51 €	21.206,51 €	49.331,51 €	77.456,51 €	105.581,51 €

Table 49 Income statement for the optimal scenario.

- Cash flow statement:

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Opening cash	0,00 €	-26.688,05 €	-45.757,44 €	-27.847,65 €	25.791,30 €
Inflows	55.000,00 €	87.500,00 €	167.916,67 €	289.583,33 €	437.500,00 €
+ Net turnover	55.000,00 €	82.500,00 €	160.416,67 €	275.000,00 €	412.500,00 €
+ Customers		5.000,00 €	7.500,00 €	14.583,33 €	25.000,00 €
Outflows	81.688,05 €	106.569,39 €	150.006,89 €	235.944,39 €	343.756,89 €
- Net variable costs	26.250,00 €	45.937,50 €	87.500,00 €	164.062,50 €	262.500,00 €
- Net other costs	1.963,05 €	1.963,05 €	1.963,05 €	1.963,05 €	1.963,05 €
- Personnel	53.475,00 €	53.475,00 €	53.475,00 €	53.475,00 €	53.475,00 €
- Corporation tax		5.193,84 €	7.068,84 €	16.443,84 €	25.818,84 €
Closing cash	-26.688,05 €	-45.757,44 €	-27.847,65 €	25.791,30 €	119.534,41 €
Year Cash Flow	-26.688,05 €	-19.069,39 €	17.909,78 €	53.638,95 €	93.743,12 €

Table 50 Cash flow statement for the optimal scenario.

14.3. Invoice to Green Cosmetics Inc

Universitat Politècnica de Catalunya BarcelonaTech

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Escola Tècnica Superior d'Enginyeries
Industrial i Aeronàutica de Terrassa

INVOICE

Carrer de Colom, 11
08222 Terrassa, Barcelona, Spain
Phone: +34 937 39 81 02

BILL TO:
Green Cosmetics Inc.

DATE: September 30, 2019
INVOICE # 100
FOR: Study for the production and commercialization of green cosmetics from moringa oil

DESCRIPTION	UNITS	RATE	AMOUNT
Personnel			53.475,00 €
Aida Ballester	-	27.762,00 €	27.762,00 €
External expertise	-	25.713,00 €	25.713,00 €
Expendables			167,30 €
Permanent equipment			2.891,00 €
Lenovo Ideapad 720S-13IKBR	1,00	650,00 €	650,00 €
Screen Asus VP249H	1,00	127,00 €	127,00 €
Printer HP Envy 5030	1,00	65,00 €	65,00 €
Microsoft Project Professional License	1,00	1.509,00 €	1.509,00 €
DWSIM Software	1,00	0,00 €	0,00 €
European Pharmacopoeia 10th Edition Electronic Version	1,00	540,00 €	540,00 €
Pilot tests			33.000,00 €
Lab equipment	-	20.000,00 €	20.000,00 €
Laboratory reagents	-	5.000,00 €	5.000,00 €
Packaging material	-	3.000,00 €	3.000,00 €
Storage equipment	-	5.000,00 €	5.000,00 €
Other costs			3.611,00 €
		SUBTOTAL	93.144,30 €
		TOTAL	**93.144,30 €**

Make all checks payable to Universitat Politècnica de Catalunya BarcelonaTech.
Total due in 30 days. Overdue accounts subject to a service charge of 1% per month.
Please include the invoice number on your check.
If you have any questions about this invoice, please contact:

Aida Ballester
aida.ballester@estudiant.upc.edu

THANK YOU FOR YOUR BUSINESS!