# Study of the extraction of avocado oil *Persea americana* (Lauraceae) from fresh and dry pulp

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## ABSTRACT

*The purpose of this research is to determine the method of extraction of avocado oil suitable and suitable for Madagascar. Four extraction trials were carried out : the method of extraction by press of fresh pulp preceded by heating, the method of extraction by press of dry pulp, maceration of dry pulp and extraction by Soxhlet using dry pulp. The oils obtained for each test are analyzed quantitatively by measuring yields and qualitatively by analyzing their fatty acid composition. Analytical results for each of the oils are compared taking into account extraction yields, oil quality and cost of extraction. The oils have comparable qualities despite the different nature of the raw material (dry or fresh) and the difference in methods. Yields are different but proportional to expectations depending on the methods used. On the other hand, the costs of operations are very different. After this comparison, it was concluded that the dry pulp press method is the most suitable.*

**Key words:** *extraction, oil, avocado, comparison, press, pulp*

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### 1. Introduction

Dietary vegetable oil is a lipid, liquid at a temperature of 15°C extracted from a plant organ. An edible oil is valued by its quality, its fatty acid composition, its taste and its aroma [1, 2]. Oil quality is often associated with its basic composition of triglycerides, free fatty acids and unsaponifiables [2]. Fatty acids are the major constituents of oils and the unsaponifiable the minor constituents because its proportion is low in the oil ; but it can valorize the oil because they are generally vitamins, trace elements and aromas which give it its specificity [1].,

Fatty acids are generally a linear chain and have only a carboxyl function. Fatty acids are classified as saturated and unsaturated fatty acids. Saturated fatty acids are acids that are totally saturated with hydrogen. They are considered unhealthy. Unsaturated fatty acids are acids with one or more double bonds. Unsaturated fatty acids are divided into two categories: monounsaturated fatty acids, ω9, which have only one double bonds, and polyunsaturated fatty acids, which have two or more double bonds [1]. The ω9 are monounsaturated fatty acids, considered the main constituent of food, but they are also present in the body. It is proven that the ω9 not only ensure the decrease of bad cholesterol but also promotes the increase of good cholesterol. Also, they reduce saturated fatty acids and the risk of type 2 diabetes. The most encountered ω9 is oleic acid [3, 4]. Polyunsaturated fatty acids include those that the human body cannot produce. In fact, these acids must come from the diet. They are called essential fatty acids such as ω3 and ω6. The ω3 are found mainly in aquatic plants, in seafood products and in certain vegetable oils such as linseed oil, rapeseed oil, etc. But not all ω3 are essential, it is especially alpha-linolenic acid (ALA) [5]. The remaining ω3 can be synthesized by the body from ALA (Figure 1) [2].

*Figure 1 : alpha-linolenic acid (ω3)*

These ω3 play important roles in the prevention of cardiovascular diseases by regulating blood pressure. Among other things, they are also useful in immune and inflammatory reactions. The human body requires an intake of ω3 (ALA) between 0.8 g and 1.1g per day. The ω6 can be found in some vegetable oils such as rapeseed oil, soybean oil and nut oil. But they also come from eggs and dairy products. They ensure the proper functioning of the cardiovascular system, the immune system and the nervous system. Like the ω3, they are also involved in immune and inflammatory reactions. Adequate daily intake of ω6 (LA) ranges from 2 to 4 g. Excess consumption of the ω6 may impair its beneficial effects particularly on cardiovascular function. Thus, it is essential to balance the consumption of the ω6 and the ω3 for the good of the human body. The ideal ratio between the ω6 and the ω3 is closest to 5/1 [5].

In rich countries, many types of edible oils are available on supermarket shelves and on the internet, such as rapeseed oil, sunflower oil, grape seed oil, peanuts, olive oil, etc. [1]. So many choices rich in taste, aroma, essential fatty acids, adapted to each type of cooking, etc. In Madagascar, soya and sunflower oil are especially present on the market because they are the most affordable by the population. Most of these oils are imported, with only two types of table oil, one of soybean and the other of sunflower, produced in Madagascar for local consumption [6]. They are also the cheapest on the market. As for olive oil, it is still totally imported, because olive cultivation does not yet have a place in the country. However, some industries do bottling locally. This is not enough to solve the still exorbitant price problem, three to four times more expensive than soya and sunflower oil, for ordinary citizens. The other oils are luxury products that most of the population does not even know about them. Table oil poverty in a country like Madagascar remains a nutritional problem, as it is necessary to balance oil intakes for proper nutrition. To diversify table oils, however, other sources are available, such as avocado.

The avocado is the fruit of the avocado tree, a tropical fruit tree native to Mexico and Central America [2, 7, 8]. It is divided into two distinct parts, the seed and the pulp or pericarp. The pericarp is subdivided into exocarp or epicarp, which constitutes the skin formed by a thin waxy film; into mesocarp that forms the flesh near the skin of the fruit having a darker color than the endocarp. The mesocarp consists of parenchymal cells and contains very little oil. The endocarp is the part richest in oil (Figure 2) [2, 6, 9]. The pulp is creamy, sometimes greenish-yellow to yellowish and has a pleasant taste [8, 9]. The fruit does not ripen on its tree. It ripens a few days, after harvest, at room temperature [9]. The fruit reaches its ripening stage when the fingertip remains on its skin under gentle pressure.

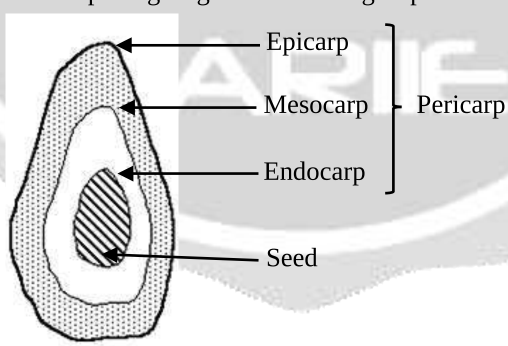


*Figure 2 : Longitudinal Section of an Avocado*

Not all fruits have the same shapes, masses and colors. The avocado may be spherical, pear-shaped or elongated. It is bulky in the range of 50 g to 1 kg. Its skin may be smooth or rough and may be green, red, brown and black [2, 6, 9].
The seed is not edible. It contains a natural toxin called glycoside cyanogen which is transformed into cyanide during digestion. Even if the level of cyanide does not reach the lethal level, its consumption is therefore not recommended [10].
The pulp consists mainly of water, 60 to 80%. It is rich in mineral elements, notably K, P, Mg, and S, but also contains S, Ca, Si, Na, Fe, Al, Mn, Cu and B. It is also a source of fat-soluble vitamins A, D, E and K, but also vitamins B2, B9, H, PP and C [6, 8, 9]. It contains small amounts of carbohydrates such as glucose, fructose and sucrose. It contains proteins rich in essential amino acids such as lysine, tryptophan, cysteine and histidine. It contains fiber. And finally, it contains a considerable amount of oil, which characterizes it most. Avocado pulp contains a high level of oil among the fat-rich fruits [11, 12], except perhaps with the olive. Its oil content depends on several factors, namely, the maturity of the fruit before harvest, its breed and variety and other growing conditions [9]. Table 1 shows the average content of constituents in avocado pulp [2, 5, 7].

*Table 1: Composition of avocado pulp*

| Elements | Content (%) |
|---|---|
| Water | 60 to 80 |
| Minerals | 1 to 2 |
| Vitamins | 0,23 |
| Carbohydrate | 2 to 5 |
| Protein | 1.8 to 2.5 |
| Lipid | 5 to 30 |

From this composition, the avocado has a high nutritional value. It also has important medicinal properties. The presence of fibers facilitates digestion and intestinal transit [8]. It has antioxidant properties, mainly due to vitamins that protect and defend cells against infection [8]. It is also proven that avocado fights skin aging [13] and improves heart function [14, 15, 16]. Its richness in lipids makes this fruit a source of fatty acids used in the agri-food, cosmetics and pharmaceutical fields [1, 13, 16].
Avocado oil is an oil known and used in developed countries, it costs as much as olive oil and often compared to it, because they have a similar composition. In addition, avocado is a fruit produced in Madagascar. Admittedly, Madagascar is not one of the avocado producing countries because its production is small compared to the large producer such as Mexico and Peru, whose global production of avocado is currently growing and amounts to 2.3 million tons per year in 2019 [5, 17]. However, the production is still sufficient and abundant for local exploitation. In fact, during the fruiting season, avocados are cheap, and are abundant on the market, so the production of oil at affordable prices from this source is possible.
The purpose of this research is to determine the appropriate and feasible extraction method in Madagascar to produce avocado oil. Two techniques are used, press extraction with fresh and dry pulps, and solvent extraction with dry pulps only. Qualities, quantities of extracted oils and costs of extraction will be compared.

## 2. Materials and Methods

### 2.1 Extraction

Four extraction tests are carried out:
1st – extraction by pressure of fresh pulp preceded by heating;
2nd – pressure extraction of dry pulp;
3rd - maceration of dry pulp with hexane;
4th - Extraction of dry pulp with hexane by Soxhlet.
The last three tests require drying of the pulp. To do this, the avocados are weighed, washed in clean water, pitted, cut in half and peeled manually. The resulting pulp is then weighed. The pulps are sliced into fine cossette and dried in the sun for 2 days. The weighed dried pulp is then ground into powder.

#### 2.1.1 First test: extraction by pressure of fresh pulp preceded by heating

The extraction is carried out from fresh pulp. 3545 g of pulps sliced in cossette are mixed and divided into a batch of 250 g each. After that, each batch is heated for 45 min. The heated pulp is then weighed. And an amount of sand corresponding to 35% of the mass of the pulp is added to make it withstand the pressure. This mixture is subjected to a pressure of the order of 125 $kg.cm^{-2}$ for extraction. The resulting oil is then filtered through fine nylon.

#### 2.1.2 Second test: extraction by pressure of dry pulp

Cold pressing extraction of avocado oil is carried out from the dried pulp. After the pulps have dried, the powder equivalent of 5 kg of avocado fruit is pressed at a pressure of the order of 125 $kg.cm^{-2}$. The oil obtained is filtered on fine nylon.

#### 2.1.3 Third test: maceration of dry pulp with hexane

The equivalent of 5 kg of dry powdered avocado fruit is macerated in 1000 mL of hexane for one week. The mixture is stirred from time to time to improve the transfer. Then it is filtered using a fine nylon. The oil is recovered by evaporating the hexane by means of a rotary evaporator.

#### 2.1.4 Test 4: Extraction of dry pulp with hexane by Soxhlet

This test makes it possible to determine the maximum extraction efficiency. The equivalent of 5 kg of dry powdered avocado fruit is fed into the extractor and then sprinkled with hexane until siphoning. 1500 mL of hexane is thus used. Three hours of boiling extraction of hexane were necessary to exhaust the powder. The solution in the flask is filtered to get rid of fine particles in the mixture. The oil is recovered by evaporating the hexane by means of a rotary evaporator.

### 2.2 Analysis

Each of the oils obtained for each method is analyzed quantitatively and qualitatively in the laboratory.

#### 2.2.1 Yield

The quantitative analysis consists in determining the extraction yield by calculating the ratio between the quantity of oil obtained and the initial quantity of pulp (equation 1), and the density of the oils obtained for each of these methods (equation 2).

$$r = \frac{q_h}{q_i} \times 100 \quad (1)$$

Where, r is the extraction yield expressed in %, $q_h$ the amount of oil obtained expressed in g and qi the amount of the initial pulp expressed in g.

$$a = \frac{m}{v} \quad (2)$$

Where a is the density in $g.cm^{-3}$, m is the mass in g and v is the volume in $cm^{-3}$

#### 2.2.2 GPC

Qualitative analysis provides information on the degree of unsaturation of fatty acids in the oil and the degree of rancidity of the oil. The higher the proportion of unsaturated fatty acids, the higher the quality. This rate of unsaturation can be obtained by determining the fatty acid composition of the oil [2]. First, the fatty acids are transformed into fatty acid methyl esters by a trans-esterification reaction. The mixture is then injected. This analysis is carried out by the Malagasy Institute for Applied Research. The gas chromatograph is PE Clarus 580 type with an automatic injector. It has an ELITE-WAX column (30m × 0.32mm × 0.25μm), the temperature of the furnace varies from 50°C to 245°C (5°C.$min^{-1}$). The detector is FID type, hydrogen is used as a carrier gas. The pressure is in the order of 0.33 bar. These parameters are accompanied by a split mode injection (1/75) with an integration equal to 0.02%. Fatty acid identification was performed by applying the formula for calculations of equivalent chain lengths or LCE (equation 3).

$$LCE = n - 2\frac{\log\left(\frac{t'r}{t'n}\right)}{\log\left(\frac{t'n-2}{t'n}\right)} \quad (3)$$

Where n is the carbon atom number of the saturated fatty acid taken as reference, generally n=18, t'r the retention time, corrected for dead time, of the fatty acid to be determined, t'n is the retention time, corrected for dead time, saturated fatty acid with n carbon atoms.

The proportion of each fatty acid is obtained by the normalization method (equation 4).

$$X = \frac{S_X}{\sum S_i} \times 100 \quad (4)$$

Where X is the constituent to be determined expressed in %, S is the area delimited by the peak and i is the set of fatty acids to be identified.

## 3. 3. Results and Discussions

### 3.1 Yield

After drying, the pulp constitutes 18% of the initial mass, so the moisture content of the avocado pulp is 82%.

The results of the four tests are summarised in table 2.

*Table 2: Comparison of the quantity of oils obtained from 5 kg of fruit*

| Quantities | Extraction by press | | Solvent extraction with dry pulp | |
|---|---|---|---|---|
| | Fresh pulp preceded by heating | Dried pulp | Maceration | Soxhlet |
| Mass (g) | 186 | 186 | 173 | 268 |
| Volume (mL) | 202 | 202 | 188 | 274 |
| Density (g.cm$^{-3}$) | 0.92 | 0.92 | 0.92 | 0.96 |

The quantity of oil extracted by Soxhlet is the highest because it corresponds to the quantity of extractable oils in the raw material and corresponds to the maximum oil yields for extraction (Table 3). The quantity obtained from the extraction by press is the average value among these methods. The pressure used for cold pressing is still insufficient, identical to that used for pressure preceded by heating. This results in a significant loss of oil for this method. And the minimum quantity obtained by maceration is due to the realization of a single theoretical stage. According to these results, the density of each of these oils is identical and corresponds to the density of the oils which is equal to 0.9 g.cm$^{-3}$.

Yields in relation to the initial mass of fresh pulp were calculated as well as those in relation to dry pulp for the last three tests (Table 3).

*Table 3 : Extraction efficiency for the four tests*

| Yield | Extraction by press | | Solvent extraction with dry pulp | |
|---|---|---|---|---|
| | Fresh pulp preceded by heating | Dried pulp | Maceration | Soxhlet |
| | | | Dried pulp | Dried pulp |
| Compared to fresh pulp (%) | 5.24 | 5.64 | 5.71 | 7.54 |
| Relative to dry pulp (%) | - | 27.72 | 29.77 | 40.12 |

Table 3 shows whether in relation to fresh pulp or to dry pulp, the extraction yield per Soxhlet is always the highest among the extraction methods. The yield obtained by maceration follows that of Soxhlet. The maceration, which is also solvent extraction, is expected to yield better. However, when carried out cold, the extraction rate of the maceration is slow. In addition, a single stage is insufficient to extract all the oils contained in the raw material. As for the extraction by press, the extraction from dry pulp has the best yield compared to the extraction from fresh pulp. The reason is that when extracting by press preceded by heating, the pulp after heating is soft. Even if this quantity is added with sand, the mixture cannot withstand high pressure and therefore has a low yield.

### 3.2 Qualitative analysis

After observation and sensory analysis of these oils, the organoleptic characteristics are determined and given in table 4.

*Table 4 : Organoleptic characteristics of oils*

| Extraction | | Appearance | Color | Smell |
|---|---|---|---|---|
| Press releases | Fresh pulp preceded by a heating | Fluid, viscous | Greenish yellow | Characteristic of the lawyer |
| | Dried pulp | Fluid, viscous | Greenish yellow | Characteristic of the lawyer |
| Solvent | Maceration | Fluid, viscous | Green | Characteristic of the lawyer |
| | Soxhlet | Fluid, viscous | Green | Characteristic of the lawyer |

This table shows that the oil obtained from each of these extraction methods has the same appearance and odor. However, there is a slight difference in color: the oil obtained by the press is greenish yellow and the oil obtained by the solvent is green. In this case, the color of the oil varies according to the type of extraction method. After observing the oils at room temperature, the oil obtained by solvent is frozen and the oil obtained by press remains the same. Even if the oils extracted from the press have the same greenish yellow color, the one preceded by heating is darker than the one obtained by cold pressing. This dark state is due to heating of the pulp before extraction which cause a reaction. The darker the color, the less nutrients in the oil. The oil extracted from the press, from the dry pulp, is the clearest. So, it's the most interesting.

The fatty acid composition and their proportions are given by CPG analysis (Table 5).

*Table 5 : Fatty acid composition of avocado oils*

| Fatty acid composition | Avocado oil | | | | | Olive oil [19] |
|---|---|---|---|---|---|---|
| | Extraction by press | | Solvent extraction | | Reference [18] | |
| | Fresh pulp preceded by heating | Dry pulp | Maceration | Extraction by Soxhlet | | |
| Palmitic acid | 22,8 | 31,3 | 27,4 | 24,4 | 7 to 29 | 7.5 to 20% |
| Palmitoleic acid | 6,9 | 6,7 | 9,8 | 6,8 | 3 to 12 | 0.26 to 1.76 |
| Stearic acid | 0,8 | 0,9 | 0,7 | 1,2 | 0.1 to 1.5 | 1.3 to 3.3 |
| Oleic acid | 53,7 | 37,2 | 31,7 | 45,6 | 42 to 73 | 64.5 to 80.3 |
| Linoleic acid | 9,6 | 17,1 | 14,5 | 12,2 | 6 to 16 | 3.6 to 16.8 |
| Linolenic acid | 0,9 | 1,4 | 1,7 | 0,8 | Trace at 5 | 0.39 to 0.98 |
| Arachidic acid | 0,1 | 0,1 | 0,1 | 0,1 | Trace | 0.23 to 0.49 |

The fatty acid composition for each of these oils are all the same and identical to the reference results. And their proportions are within the reference values. According to the literature, vegetable oils consist of 99% of fatty acids and the rest of the fatty acids are the unsaponifiable content. For avocado oil, unsaponifiables can reach 5% of the proportion. The proportion of fatty acids for the four extraction tests, pressure from fresh pulp preceded by heating, pressure from dry pulp, maceration and extraction by Soxhlet, were respectively 94.8%, 94.7%, 85%, 91.1%. The proportions obtained by the press have a higher fatty acid content than oils extracted by solvent. This difference in proportion may be caused by the presence of the solvent in the oil to be analyzed for those obtained by solvent or by the impurity of the oil. The oils extracted by the press are then captivating.

According to this table, oleic acid is the majority component of avocado oil, as is olive oil. This fatty acid is a monounsaturated acid that is beneficial for health. Comparing the level of unsaturated fatty acids with that of saturated fatty acids, the level of unsaturated fatty acids was higher, ranging from 57.8% to 71.1%. This high proportion indicates that the avocado oil has a good quality. The proportion of essential fatty acids (ω3 + ω6) of each of the methods, pressure from the pulp preceded by heating, pressure from the dry pulp, maceration and extraction by Soxhlet, are respectively, 10.5, 18.5, 16.2 and 13. The pressure from the dry pulp has high content.

In this table, the proportion of the ω6 is all higher than that of the ω3 even for olive oil. As for the proportion in ω3, it varies from 0.8 to 1.7%, as for ω6 it is between 9.6 to 17.1% for these methods. These proportions allow the ω6/ω3 ratio to be calculated (Table 6).

*Table 6 : ω6/ω3 ratio of oil extracted*

| | Avocado oil | | | | Olive oil |
|---|---|---|---|---|---|
| | Extraction by press | | Solvent extraction with dry pulp | | |
| | Fresh pulp preceded by heating | Dry pulp | Maceration | Extraction by Soxhlet | |
| ω6/ω3 | 10/1 | 12/1 | 8/1 | 15/1 | 9/1 to 17/1 |

Of these extraction methods, maceration gives the lowest ratio, which implies that it is the easiest to rebalance. Considering this ratio, the oil extracted by this method therefore has the best quality. For avocado oil, the ω6/ω3 ratio varies from 8/1 to 15/1. For olive oil, however, it is in the range of 9/1 to 17/1. So, avocado oil is the most interesting compared to olive oil.

### 3.3 Financial analysis

Cost estimates for each trial are compared in table 7.

*Table 7 : Comparison of mining cost*

| Factors | Extraction by press | | Solvent extraction with dry pulp | |
|---|---|---|---|---|
| | Fresh pulp preceded by heating | Dry pulp | Maceration | Soxhlet |
| Drying | + | ++ | ++ | ++ |
| Solvent | + | + | ++++ | ++++ |
| Electrical energy | ++++ | + | ++ | ++++ |
| Equipment investment | +++ | +++ | + | + |
| Waste | ++++ | ++ | ++++ | ++++ |

Appreciation: ++++: costly, +++: expensive, ++: affordable; + : cheap

The sum of the estimates shows that the extraction by press from dry pulp is the most advantageous from a financial point of view. Indeed, it does not require heating which consumes a lot of energy, no expensive solvent with a minimum of uncontaminated waste and therefore easier to treat or recover.

By putting the results of these extraction tests together in table 8, the appropriate method will be determined.

*Table 8: Comparison of results for the four extraction tests*

| | Extraction by press | | Solvent extraction | |
|---|---|---|---|---|
| | Preceded by a heating | Cold pressure | Maceration | Soxhlet |
| | Fresh pulp | Dried pulp | Dried pulp | Dried pulp |
| Yield | ×× | ×× | ××× | ×××× |
| Qualities | ×××× | ×××× | ×× | ××× |
| Costs | × | ×××× | ×× | × |
| Extraction time | ××× | ×××× | × | × |

Rating : ××××: satisfactory,×××: good , ×× : moderate, × : poor

Despite an average yield, extraction by pressure from dry pulp gives the best compromise between all the parameters to be taken into account in order to make the extraction profitable. In addition, this efficiency can be further improved by using a higher pressure. For this, certain elements of the press must be improved for better resistance.

Also, the type of avocado used as raw material must be clearly distinguished since the oil content of the fruit depends on its breed.

## 4. Conclusion

The objective of this work is to determine the avocado oil extraction method suitable for Madagascar. This method is determined by comparing the results for each of the four extraction tests, taking into account the extraction yield, the quality of the oil extracted and the cost of extraction. Extraction by Soxhlet has the best extraction efficiency but consumes a lot of energy. From a qualitative point of view, the extraction by press from dry pulp is excellent compared with the other tests. And in terms of cost, extraction by press from dry pulp is the most affordable. The method chosen, in combining the results, is the extraction by press from the dry pulp, thanks to its best compromise. However, the output of this extraction is still unsatisfactory. It is therefore necessary to apply a higher pressure than that used in this work to achieve better performance. However, the strength of the press must be consistent with the necessary pressure by performing calculations on the strength of the materials.

## 5. References

[1] : Charreyron M., Valorisation of agricultural resources, oil; Pasteur Conference, Poligny, 52 pages, 2014

[2] : Andrianorosoanirina H., Production of edible oil from avocado fruit of the genus Persea, master's thesis 2, chemical engineering department, Ecole Supérieure Polytechnique d'Anatananarivo, University of Antananarivo, Madagascar, 131 pages, 2013

[3] : Florence Daine, monoinsturated fatty acids, nutrition, nutrition journalist 2018

[4]: Kitane S., Atalla Y. and Benq lilou C., New eco-process for the extraction of avocado and sea buckthorn oil based on drying and treatment by vacuum distillation of a water soluble solvent extraction, Moroccan Office of Industrial and Commercial Property, 9 pages, 2016

[5] : Vautier A., Omega 3: nutrition-health role and what are the issues for pork? article, TECHNI Pig, IFIP Institut Pig, 30 (1) 2007

[6]: Rabenasolo H. M. E., Avocado oil production: techno-economic feasibility study of an extraction unit, final thesis, Department of Agricultural and Food Industries, Higher School of Agronomic Sciences, University of Antananarivo, Madagascar, 90 pages, 2003

[7] : Bazin J., Bilga A., Mexican lawyer: the underside of "green gold", article, 4 pages, 2017

[8] : Orchina H., The lawyer, The January vegetable, article, Brussels Diabetes Health Network, 4 pages, 2014

[9] : Gaillard J.P., Godefroy J., The avocado, techniques of tropical agriculture, edition Maisonneuve and Larose, Paris, 89 pages,1994

[10] : My beautiful company, The avocado kernel: make do with the pulp, Jardiner, Binette & Jardin, Plants and health, article

[11]: Leonard, Lewis Y and Pierre G. Sylvain, Treatise on Fruit Growing. All University Books. Published under the Technical Service Directorate of the Department of Agriculture and Vocational Education. Republic of Haiti. Port-Au-Prince, 303 pages, 1931.

[12] : Gaillard J.P. The avocado tree: its cultivation, its products, agricultural techniques and tropical production, Maisonneuve et Larose edition, ACCT. Paris, 419 pages, 1987

[13] : Rosario G., The ultimate guide to beard oil, everything you need to know, paperblog,18 pages, 2018

[14]: HealthLinkBC, Diet high in potassium, why is a diet high in potassium important? article, The Global Resource for Nutrition Practice, 8-1-1, 13 pages, 2015

[15] : Raharinirina L., Chemical study of leaf and nucleus of Persea americana from Madagascar and evaluation of their antioxidant activity, Master thesis 2, University of Antananarivo, 111 pages, 2016

[16] : Chantal and Lionel C., The vegetable oils of Pranarôm, Nutrient and cosmetic, Source of Health - Pearls of Beauty, Pranarôm, book, 20 pages, 2019

[17]: OECD/FAO, OECD/FAO Agricultural Outlook 2020-2029, book, OECD Publishing, Paris/FAO, Rome, 357 pages, 2020

[18]: Ucciani E. ; Helme J.P., Avocado oil, New Dictionary of Vegetable Oils, Lavoisier, Paris, 644 pages, 1995

[19] : Monnatte, L. S. ; Gilette, C., Olive oil - Composition, benefits and use, Vegetable oils, article, 2017