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Manufacturing Processes and Physicochemical Characteristics of Palm Oils from Artisanal Production in Benin (A Review)

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Abstract In Benin, several categories of palm oil are produced and marketed. These are mainly standart palm oil, pasty palm oil and flavored palm oil commonly known as *zomi*. These oils are obtained from different unit operations including fruit baking, treading, washing, cold skimming, juicing and hot skimming. While several studies have been based on the production and quality of palm oil, standard, very few have addressed the production of the *zomi*, adored by oil consumers but whose global spread of technology is limited. Also, the production of flavored palm oil includes a severe heat treatment. This treatment would lead to a reduction in its final nutritional value. This review compares the production technology of standart palm oil with that of *zomi* and emphasizes the nutritional characteristics of standart palm oil in order to optimize the production of *zomi* in order to preserve its quality.

Keywords: *palm oil, production technologies, physico-chemical quality, zomi, Benin*

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1. Introduction

Vegetable oils, considered as traditional ingredients in kitchens from Africa, South America and Asia, are also used in cosmetics, the biofuels industry and in the food industry [1]. Among these vegetable oils, palm oil extracted by hot pressing of the fruit pulp of the oil palm (*Elaeis guineensis*), is the most consumed in the world [2]. Demand for palm oil increased by 8.7% per year between 1995 and 2004[3], with production increasing rapidly, mainly because of its low cost [2]. It has a longer shelf life than most other edible oils because of its high level of antioxidants which makes it particularly resistant to rancidity [5]. On a nutritional level, crude palm oil contains on average 50.1% saturated fatty acids, 41% mono unsaturated fatty acids, 11% polyunsaturated fatty acids, with a good provitamin A content [6]. Tocopherol levels can decrease by up to 40% when heated.

In Benin, several types of vegetable oils are produced. These include soybean oil, peanut oil, cottonseed, and various types of palm oil, including "standard" single palm oil and flavored (*zomi*) palm oil. In palm oil producing regions, there is often a trend towards specialization in the production of a specific type of palm oil [7].

Popularly appreciated by the Beninese people for its aroma, so-called "flavored" palm oil enjoys a price increase of around 25-30% compared to the so-called "standard" palm oil [7]. It is characterized by a dark red color and a characteristic fragrance. Unlike the so-called "standard" red oil, the production of so-called "flavored" palm oil is based on the processing of fresh nuts and on the activation of fragrant element precursors contained in the nut. Over time, conditions of *zomi* production have not changed. A "severe" heat treatment is operated for generating the aromatic compounds. Also the different unit operations may vary from one producer to another. Thus, the products resulting from this transformation are very heterogeneous and hardly meet the normative criteria set. The present study aims to compare manufacturing processes of standard and flavored *zomi* palm oil and then to evaluate the physicochemical characteristics of standard palm oils in order to better understand the quality of the *zomi* palm oil in future research.

2. Palm Oils from Artisanal Production in Benin

There are several types of palm oil in Benin namely: standard palm oil, so-called "flavored" palm oil and pasty palm oil.

2.1. The Standard Palm Oil

Its color varies from light orange to dark orange-red because of its high carotene content (Figure 1). Its name varies according to the sociolinguistic and sociocultural groups of Benin. We can mention: *Amivè* in *Goungbe*, *Kolo* in *Adja*, *Ekpo kpikpa* in *Yoruba* and *Amivovo* in *Fongbe* [9].

Figure 1. Standard" palm oil [10]

2.2. The Aromatized Palm Oil

Dark red in color with a very characteristic aroma, this oil (Figure 2) is obtained from ripe and fresh palm fruit. Its names also vary according to the different regions in Benin. These are *zomi* in Adja, *Ami-wiwin* in *Fongbe* and *Goun*, *Ekpo runrun* in Yoruba [9].

Figure 2. *Zomi* palm oil [10]

2.3. The Pasty Palm Oil

This oil (Figure 3) is obtained after decantation of the palm oil zomi. In the regions of Benin it is known and used by the population. It is commonly called *Dja* in *Mahi* and *Becoun* in *Mina* [7].

Figure 3. Pasty palm oil [7]

3. Comparative Study of Manufacturing Processes of Standard and *zomi* Palm Oil

In this review, we focus on two processes: those of production standard and *zomi* palm oil. The artisanal production of standard palm oil is carried out in several stages namely: fruit baking, treading, washing, cold skimming, juicing and hot skimming.

Cooking: this operation takes place 4 to 5 days after the harvest. The fruits are cooked in a metal drum and the added water does not rise to the same level as the fruits. The fruits remaining above the water level cook with steam. This operation is most often done the night before the day of treatment. The fire is maintained for about 3 hours, then the drum stays on the embers all night long.

Fouling on the feet: The cooked fruits are trampled in pits with cemented walls commonly called "dédo" or in basins until they obtain a more or less homogeneous mixture of pulp (fiber) and palm nuts.

Washing: water is added to the mixture resulting from the mixing so as to double the volume and to dilute the mass in order to be able to separate the nuts and fibers of the oily cream emulsion released by pulping. Nuts and fibers drawn in the mass with a large mesh basket are brushed against the wall of said basket. The nuts cleared of the fibers are put in piles. The fibers are taken again at the end of the process to be washed.

Cold skimming: the oily cream that floats on the surface is pumped to the calabash or gathered in the palm of the hands. A spontaneous rise of the cream on the surface by introducing air into the liquid free of the emulsion, is carried out after a certain period of rest. The inclusion of air is performed by jetting the contents of a bowl raised at shoulder height. The air microbubbles created by this "whipping" fetch the globules of fat and collect them on the surface.

Cooking: the oily cream obtained after cold skimming contains air and colloidal agents. These will be coagulated and the liquids deaerated by boiling for a period of 20 to 30 minutes and is at an average temperature of 110 ° C.

Hot skimming: after decantation, the oil is collected by calabash and filtered through a sieve basket that retains the few entrained fibers and coagulants.

Note that there are industrial technologies for producing this oil. These technologies use more modern tools

A comparative study of this technology to this of *zomi* (Figure 5) palm oil process reveals that the *zomi* production requires a purely artisanal know-how, whereas that of standard oil requires improved, semi-industrial or even industrial know-how. Innovations allowing the transition from "traditional" to "improved" are all in the direction of an improvement in hourly productivity and extraction yields. But, in the opinion of the producers, the oil produced with the "improved" know-how does not have the same organoleptic qualities as the "traditional" oil (Figure 4). This can be explained quite easily for some innovations among which we can mention:

- the delay of the day of treatment (2nd or 3rd day for the *zomi*, the 4th or 5th day for the standard oil) increases the acidity percentage in the final oil;

- the suppression of the hand pressing of the fibers no longer makes it possible to obtain a pure, more tasty oil;
- the introduction of a skimming cold reduces the cooking time, and it is during a prolonged cooking that the oil begins to release a "good smell".

The explanation of the consequences of pilling on the organoleptic qualities of the final oil has never been very clear. But this innovation is related to the delay of treatment day. When fruit is young, only the pounding in a mortar can grind them effectively. It is only when the reated fruit is more mature, the risk of a more acid oil, the crushing can be done feet.

This difference in organoleptic qualities explains why innovations have not been adopted by all producers in regions like Pobè (Southeast Benin), where these innovations are nevertheless known.

The second cooking, which is prolonged for several hours, gives the oil a characteristic odor that consumers appreciate. In some regions, traditional oil is sold more expensive than "standard" oil in the markets. But in the region of Pobè, it is not better valued, and it is therefore uninteresting to produce for uses other than its own consumption. However, it is occasionally found on the markets, where it is undeniably the object of a stronger demand. It is interesting to note that the traditional oil, produced from young fruit is less acidic than oil from improved skills, which has become the standard of quality. However, it is the *zom*i oil which is the most sought after in the markets, which contradicts the belief that a certain acidity of the oil would be sought by African consumers [6].

4. Nutritional Characteristics of Standard Palm Oil

Crude palm oil is a concrete fat, semi-solid at ordinary temperature. This aspect was given to him by his composition in triglycerides or monooléoglycerides or even monolinoleglycerides dispersed in the dioleic fluid phase [32].

The orange-red color of palm oil is due to the presence of carotenoids. Palm oils from selected plantations are low in β-carotenes. For the latter, the characteristics seem to be uniform [33].

Palm oil is rich in vitamins A and protects against certain diseases of the eyes thus very important for the health. At the industrial level, it is used in bakery pastry and margarinerie [34]. Table 1 and Table 2 show respectively fatty acid content and physico-chemical indices of palm oil from different countries.

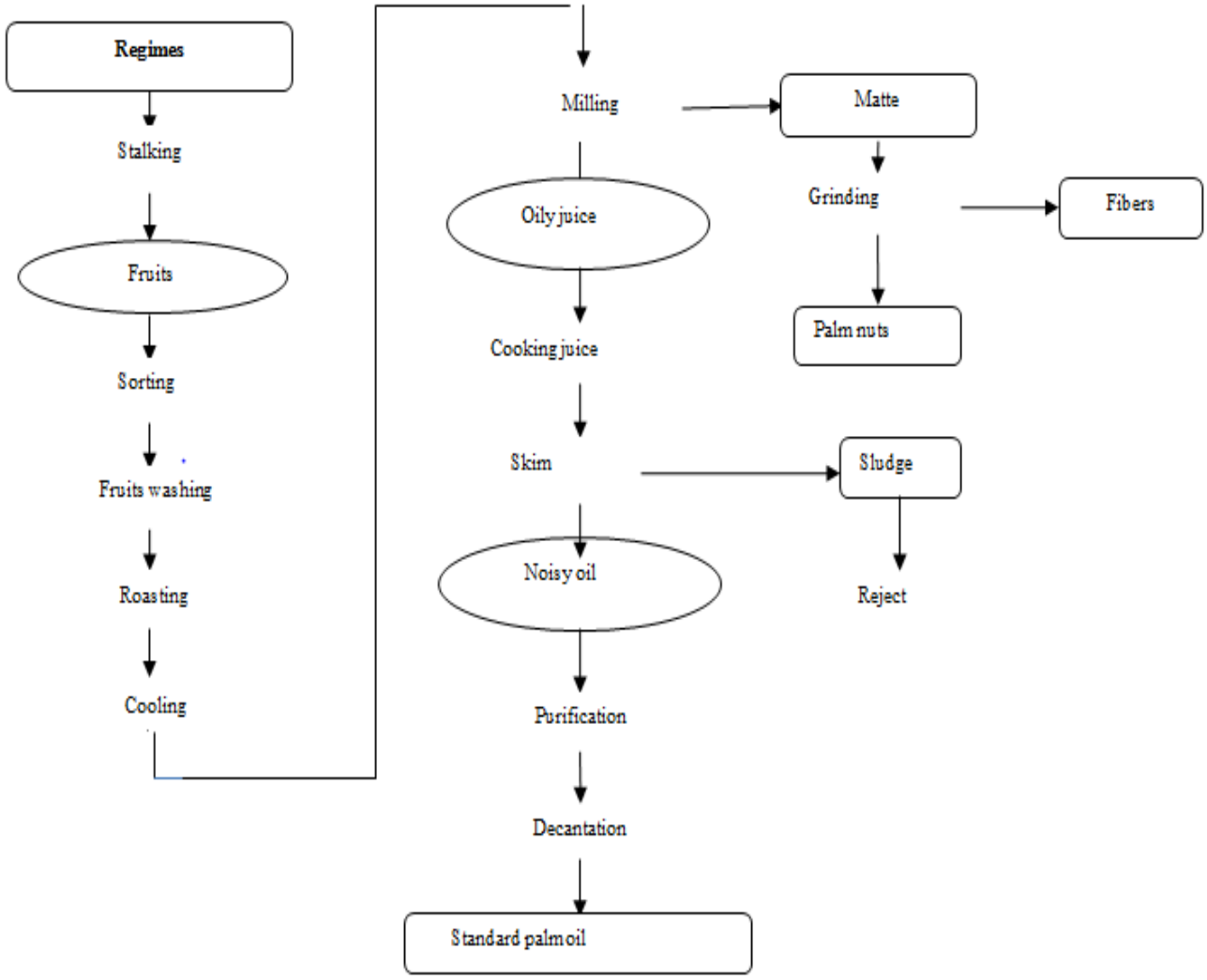

Figure 4. Artisanal process for producing standard palm oil [9]

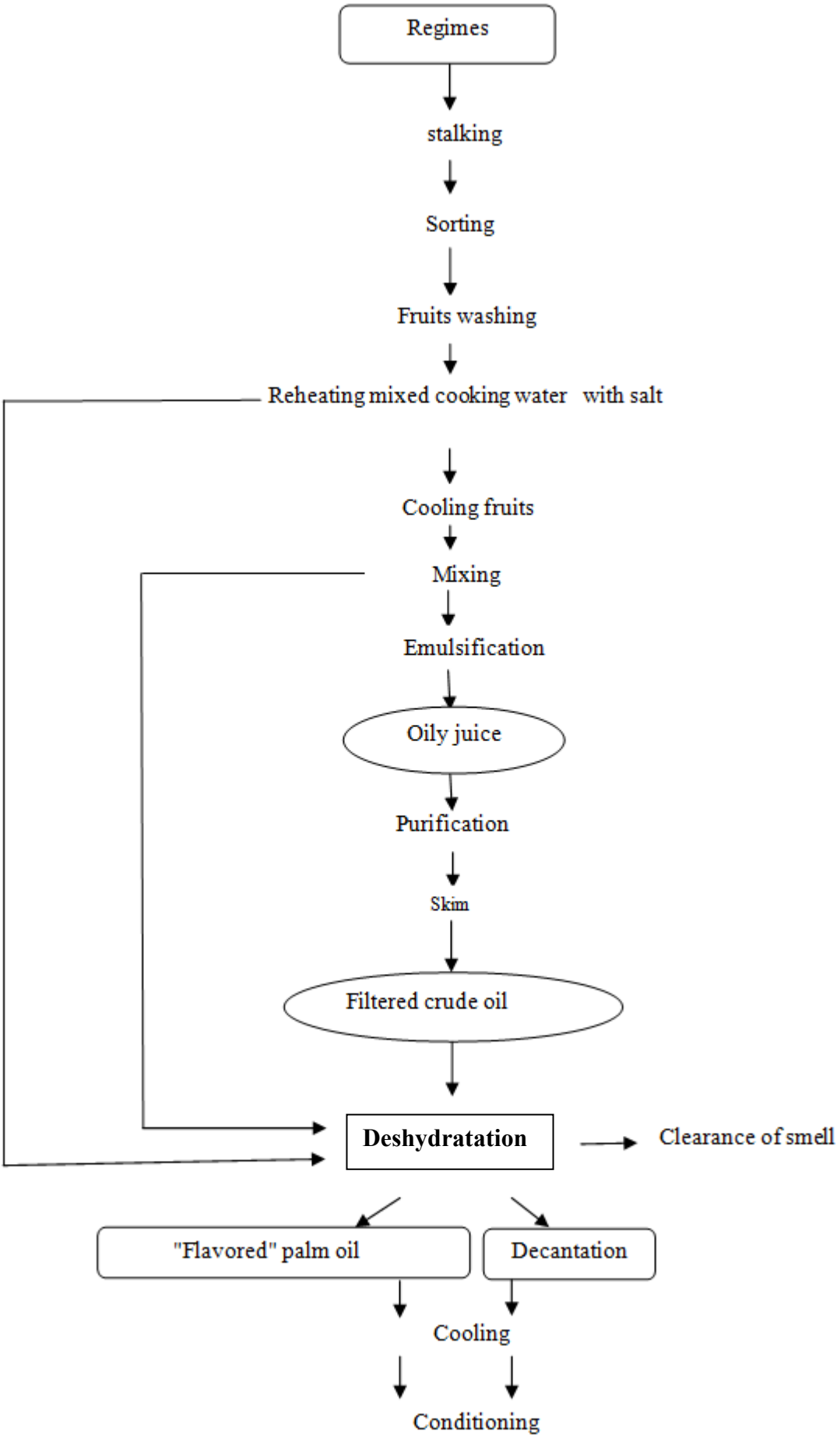

Figure 5. Artisanal process for producing of "flavored" palm oil [11]

Table 1. Fatty acid content of palm oil from different countries

Countries	L A (12:0)	MA 14:0	PA (16:0)	SA(18:0)	OA (18:1)	LiA (18:2)	LnA (18:3)	AA (20:0)	Sat	MU	PU	References
Nigeria	0.2	1.1	44	4.5	39.2	10.1	0.4	0.1	49.9	39.2	10.5	[12]
Nigeria	0-0.2	0.8-1.3	43.1-46.3	4-5.5	36.7-40.8	9.4-11.9	0.1-0.4	0.1-0.4	50.2	39.2	10.5	[12,13]
Senegal	_	1.4	42.3	5-6	50.7	_	_	_	_	_	_	[14]
Malaysia	0.24	1.11	44.14	4.44	39.04	10.57	0.37	0.38	_	_	_	[15]
Hombourg	0-1.2	1-6	41.1-53.3	3.7-6	27.6-53.3	4.4-10.1	0-1.5	_	_	_	_	[16]
France	< 5	0.5-2	39.5-47.5	3.5-6	36-44	9-12	<0.5	_	45-55	38-45	9-12	[17]
Malaysia	0.20	1.10	44	4.50	39.20	10.10	0.40	0.40	_	_	_	[18]
Malaysia	_	1.1	43.7	4.3	39.8	10.2	0.3	0.6	_	_	_	[19]
Italie	≤ 1	3	45	4.0	39.0	9.0	_	_	52	48		[20]
Malaysia	0-0.5	0.9-1.5	39.2-45.8	3.7-5.4	37.4-44.1	8.7-12.5	0-0.5	_	45.3-55.4	37.4-44.1	44.8-57.3	[21,22]

LA= Lauric acid, MA= Lauric acid, PA= Palmitic Acid, SA=Stéaric Acid, OA= Oléic Acid, LiA= linoleic Acid, LnA= linolénic Acid, AA= Acid Arachidic, Sat= Saturated, MU= Mono- Unsaturated, PU= Poly-unsaturated.

Table 2. Physico-chemical indices of palm oil from different countries

Countries	Index acid KOH/g	Iodine index	Refractive index at 20 °C	Peroxide index meq0_2 /kg d'huile	Saponification index mgKOH /g	Insaponifiables	Relative density	References
Benin	_	53.15	1.47	7.97	_	0.53	_	[22]
Senegal	29.174	15.23	1.46	12.10	-	-	-	[23]
Nigeria	_	47-55.83	1.46	_	196 -208.2	_	0.89-0.92 (x=50°C/eau à 25°C	[24,25,26,27]
France	20	_	1.46	2.6	_	_	_	[28]
Nigeria	0.40±0.12	26.04±0.54	_	1.60±10	186.97±2.67	_	_	[29]
Malaysia	≤10.95	50.4-53.7	1.4521-1.45	_	194-21	0.19-0.44	_	[30,31]

-: Not determined.

5. Conclusion

This study highlighted the different categories of palm oil marketed in Benin and compared the manufacturing processes of the most two consumed categories: standard palm oil and palm oil. It appears that these processes have many similar operations but that for *zomi*, complementary operations aim to generate the aromatics compounds sought by consumers. Nevertheless, the nutritional value of the oil could be affected by these relatively severe temperature scales. It is therefore urgent to optimize the production technology in order to preserve the nutritional quality of the oil.

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