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Influence of the Palm Fruit Variety (*Elaeis Guineensis*) and Manufacturing Process on the Sensory Quality of *Zomi* Palm Oil Produced in Benin

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Abstract:
Background*: In Benin, palm oil fruits (Elaeis guineensis) are commonly used for the production of red palm oil and flavored palm oil (zomi). This study aimed at assessing the influence of fruit varieties and manufacturing processes on the zomi oil quality.*
Materials and Methods*: Zomi oil was produced from Dura, Tenera and blend (50% Dura + 50% Tenera) varieties three different processes, identified during a previous work. A total of 45 zomi samples (15 from each sample) were studied. On the sample oil obtained, the determination of the color and the sensory attributes was done. The results showed that except fiber weight, the interaction of palm fruit variety and manufacturing processes was significant (P <0.05) for all other production parameters.*
Results*: The quantities of produced oil varied depending on the fruit variety. The colorimetric indices showed that the oils from the natural variety Dura were redder than those produced from the selected variety Tenera which had a yellowish tendency. The organoleptic tests carried out on the zomi palm oils proved that the samples from the Dura variety and the blend were better accepted.*
Key Word*: Elaeis guineensis; Palm fruits; manufacturing process;; sensory quality; zomi; palm oil.*

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I. Introduction

Native to tropical Africa, the palm oil tree (*Elaeis guineensis*) is widely cultivated in the tropics, especially in Asia. It has always provided food, materials and products for care and hygiene. It simultaneously produces two types of oil: palm oil and palm kernel oil. Malaysia and Indonesia are the main producers of palm oil with 80% used for human consumption and industrial uses [1].

Among fats, vegetable oils represent a large family of exclusively lipid foods [2], necessary to maintain the body in good health [3]. Nutritionally, vegetable oils are mainly composed of lipids with other minor components, including antioxidants, colors, flavors and emulsifiers [4].

Palm oil extracted by hot pressing from the pulp of the fruits of the palm oil tree is the most consumed in the world (25% of world consumption in 2010, exceeding soybean oil (24 %) and rapeseed oil (12%) and sunflower oil (7%) and these statistics have continued to increase until 2020[5,6]. Crude palm oil is called red palm oil because of its red color linked to its richness in carotenoids [7]. In Benin, several types of vegetable oils are produced. These include soybean oil, groundnut oil, cottonseed oil, and various types of palm oil, including "standard" single palm oil and flavored (*zomi*) palm oil [8].

Popularly appreciated by the Beninese for its aroma, *zomi* enjoys a price increase of around 25-30% compared to the "standard" palm oil [9]. It is characterized by a dark red color and a specific fragrance. Unlike

the standard red oil, the production of zomi is based on the processing of fresh nuts and on the activation of fragrant element precursors contained in the nut [8].

As a general rule, the production of *zomi* consists in heating over a relatively long cooking time red palm oil from a previous production to which certain products (fibers, leaves, salt, etc.) are added for flavor (Fournier et al., 2001). Indeed, the final cooking is prolonged, which gives it a particular taste (slightly salty taste), a dark red color and therefore very good organoleptic quality [9].

In Benin, there are three sub-types of palm oil namely simple palm oil called "standard or *kolè*", *zomi* palm oil called "quality" and palm kernel oil [10]. Some regions are specialists in the production of "quality" palm oil, while others produce "standard or *kole*" oil. An analysis of the different processes shows very different technical performances, and the incentives to produce "quality" oil cannot be purely commercial [11]. It is therefore important to know the role of oil palm fruit variety and processes in obtaining good quality oil.

There are three main varieties of palm oil trees, distinguished by the thickness of the fruit shell: the Dura variety characterized by a thick shell; the Pisifera variety characterized by the absence of a shell. This variety is a sterile female. The last variety is the Tenera, an hybrid of the previous varieties and characterized by its thin shell. The pollination of an inflorescence from a Dura by a pollen from a Pisifera that gives 100% Tenera, present in almost all plantations today [12]. In this study, the influences of tree variety and extraction technology process have been investigated.

II. Material And Methods

Sample manufacturing and material balance yield

In a previous study, we identified the different processing variants for *Zomi* production [13]. Six (6) different manufacturing processes (Numbers from T1 to T6) have been identified. Among these technologies, the most representative were T3, T4 and T5. In the present study, samples of *zomi* were produced using these three processes. For each technology, three (3) producers were targeted. For each producer, five (5) different productions were carried out using dura, tenera and pisifera varieties as raw material Figures 1 to 3 show the different manufacturing processes for the zomi production.

In order to follow material evolution during processing and storage, the following measures have been taken into consideration: fruit cooking time, fruit weight, fiber weight, nut weight, juice cooking time, oil cooking time and duration of the release.

Description of *zomi* manufacturing process by T3 technology

The palm bunches were destemmed and the fruits were cooked after sorting. After mixing, the matte obtained was defibrated by hand and the nuts were separated. The defibrated matte (without the nuts) was then pressed and the resulting crude oil was cooked after adding the hot water from the washing of the nuts and fibers. Subsequently, the oil was filtered, cooled and decanted. *Zomi* (supernatant) and *Bécoun* (deposit) were obtained.

Description of *zomi* manufacturing process by T4 technology

The fruits from the destemming of the palm bunches were sorted, cooked and the cooking water was separated. The cooled fruit was then kneaded and the resulting matte was heated and then pressed using a press machine. The crude oil and the fibers were obtained. The nuts were separated and the fibers were squeezed. The resulting oil was then mixed with the crude oil and the whole underwent prolonged cooking until the aromas appeared. Subsequently, the oil was filtered, cooled and decanted. *Zomi* (supernatant) and *Bécoun* (deposit) were obtained.

Description of *zomi* manufacturing process by T5 technology

The palm bunches were destemmed and the palm fruits sorted before cooking. After the cooking water had been separated, the cooked fruit was cooled and then kneaded. The resulting matte was emulsified and obtained oily juice was cooked before being hot skimmed. The resulting crude oil underwent a second cooking during which the matte was added. Subsequently, the oil was filtered (filtration was carried out by adding hot water from the first cooking, to which salt has been added), cooled and decanted. *Zomi* (supernatant) and *Bécoun* (deposit) was obtained (Figure 3)

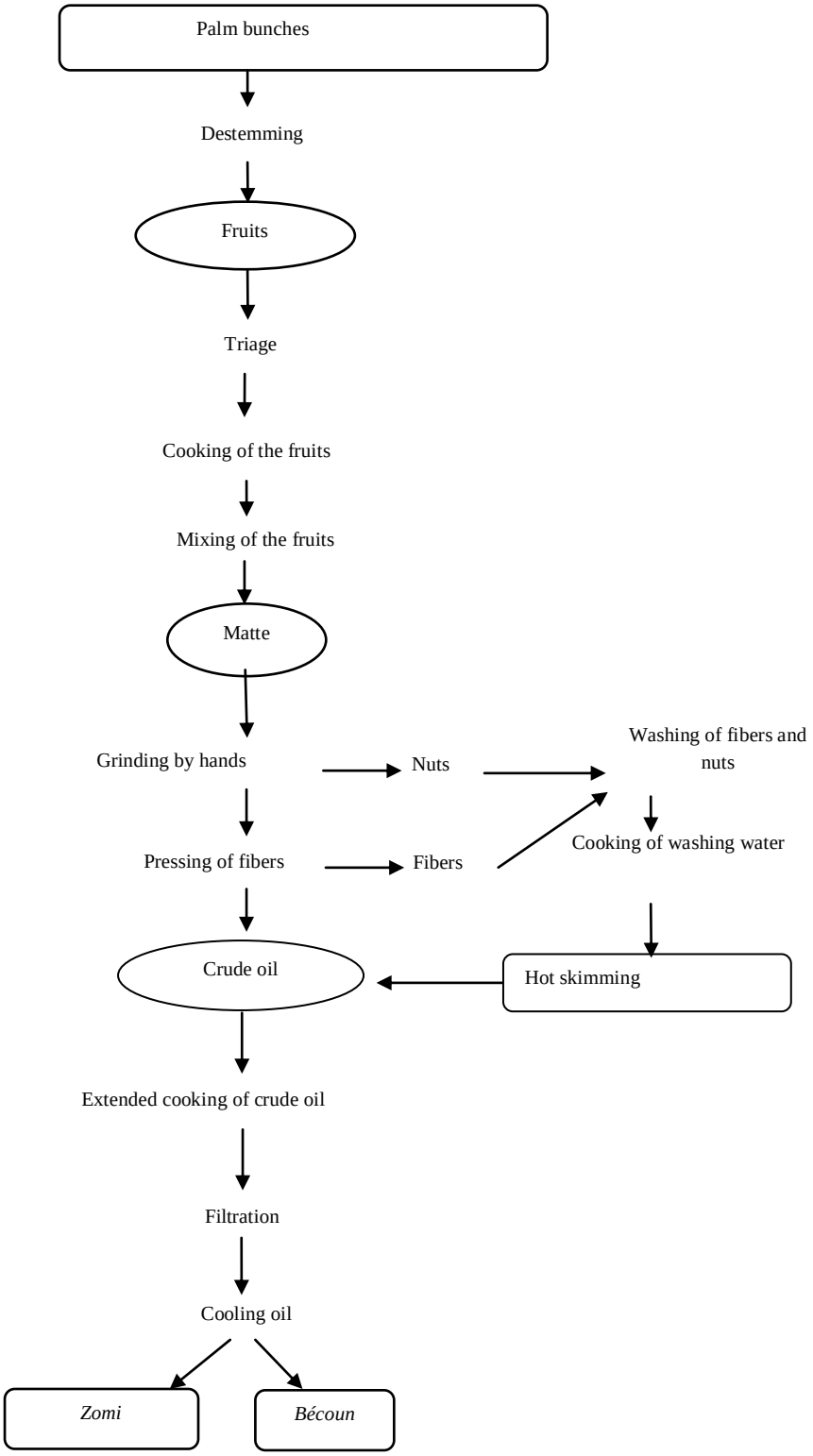


Figure 1: Manufacturing process of *Zomi* (technology 3) [13].

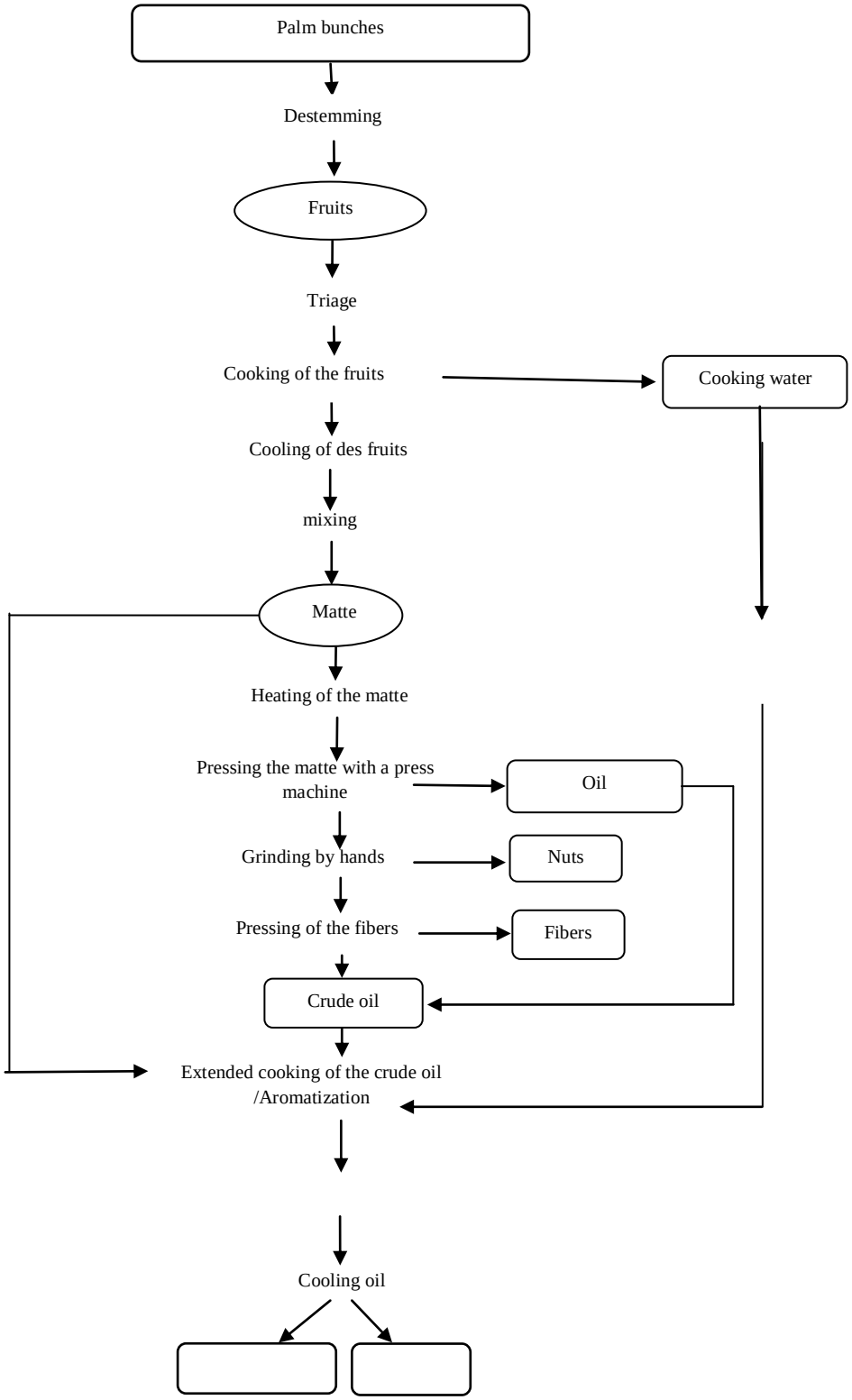


Figure 2: Manufacturing process of *Zomi* (technology 4) [13].

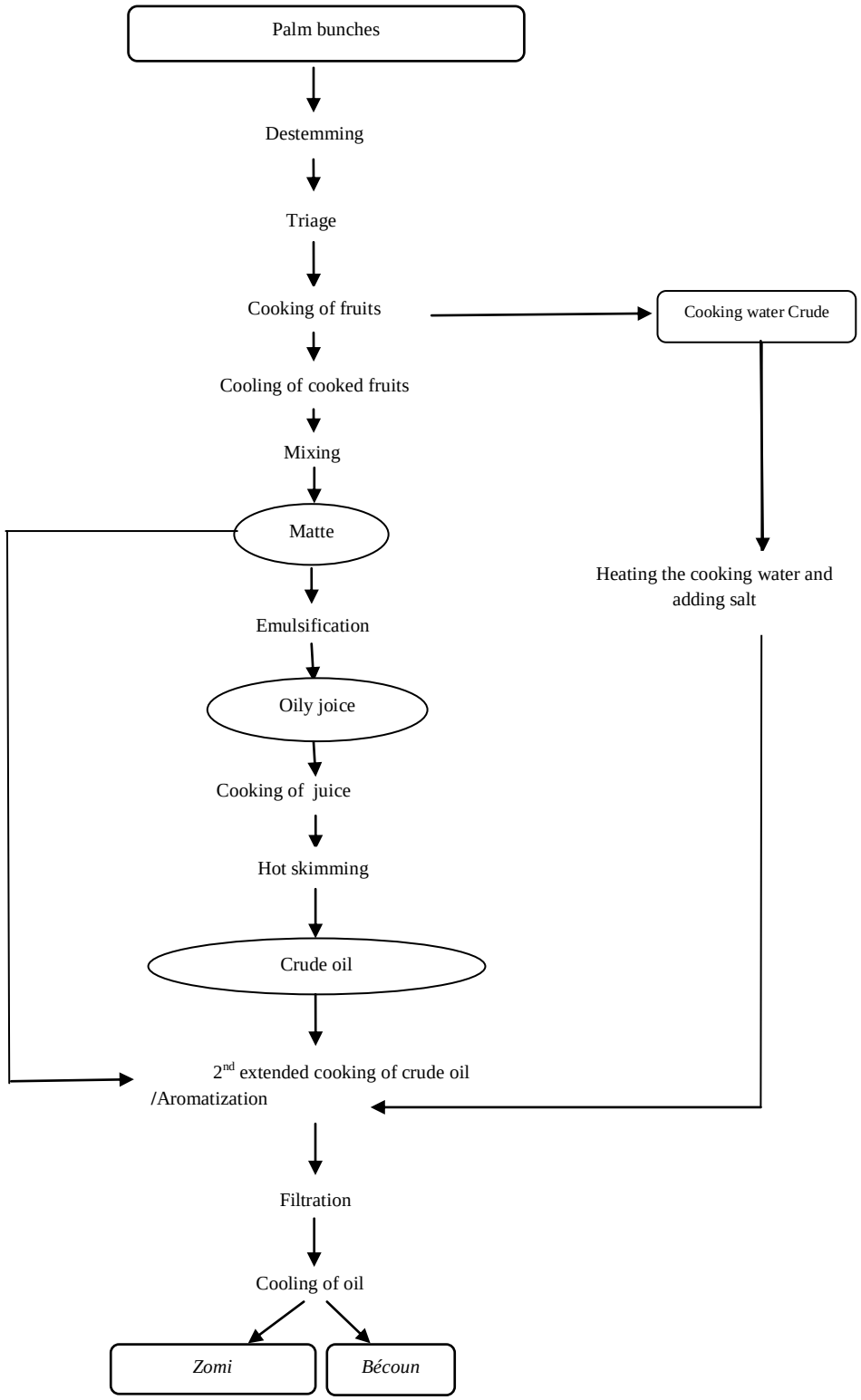


Figure 3: Manufacturing process of *Zomi* (technology 5) [13].

Characterization of the oil color

The method used is that of Lovibond usually used for control in industry [14]**.**

Sensory characterization of *zomi*

The evaluation of the sensory characteristics was carried out with a panel of 50 experienced zomi tasters chosen among the students, producers and sellers of *zomi*. A hedonic test to assess the taste, aroma, color, texture and overall appreciation of the samples was carried out using a tasting sheet designed for this purpose [15].

Data processing and statistical analysis

Statistical analysis was performed using R version 3.5.1 statistical environment [16]. Regarding the effect of manufacturing process on the colorimetric indices (the difference between color, luminance, red and yellow colors) of *Zomi* oil, Kruskal Wallis test was carried out due to non-compliance with the conditions of application of ANOVA, except for the difference between colors [17]. Boxplots were produced to highlight the results of organoleptic tasting tests.

III. Result

Material balance of productions

Using T3 technology, the fruit cooking time was 80 minutes for the dura variety, 50 minutes for tenera and 58 minutes for pisifera. For the T4 technology, this time was 80, 57 and 67 minutes respectively for these same palm fruit varieties. As for the T4 technology, the measured values were 78, 50 and 40 minutes respectively. Other parameters such as fruit weight, fiber weight, nut weight, juice, oil cooking time and duration of released aroma also varied according to the varieties and technologies (Table 1). However, statistical analysis showed that, except for fiber weight, palm tree variety and technology process significantly ($p < 0.05$) influence others parameters (nut weight, juice cooking time, oil cooking time, duration of the released aroma).

Table 1: Material balance of production

Paramètres	T3			T4			T5	
	Me	SD		Me	SD		Me	SD
Dura variety								
Fruit cooking time (minutes)	80.00^{a}	2.28		80.00^{a}	2.39		78.00^{a}	4.22
Fruit weight (Kg)	10.50^{a}	0.25		10.50^{a}	0.22		10.50^{a}	0.26
Fiber weight (Kg)	2.00^{a}	0.00		-	-		2.00^{a}	0.22
Nut weight (Kg)	7.00^{a}	0.00		-	-		7.00^{a}	0.27
Juice cooking time (minutes)	24.00^{a}	2.19		-	-		12.00^{b}	3.44
Oil cooking time (minutes)	18.00^{ab}	2.17		25.00^{a}	2.07		12.00^{b}	1.64
Duration of released aroma (minutes)	15.00^{ab}	1.52		20.00^{a}	1.82		10.00^{b}	1.67
Tenera variety								
Fruit cooking time (minutes)	50.00^{b}	2.28		57.00^{a}	4.27		50.00^{b}	4.16
Fruit weight (Kg)	10.50^{a}	0.35		10.50^{a}	0.14		10.50^{a}	0.42
Fiber weight (Kg)	2.00^{a}	0.00		-	-		2.50^{a}	0.27
Nut weight (Kg)	6.00^{a}	0.76		-	-		6.00^{a}	0.55
Juice cooking time (minutes)	24.00^{a}	1.52		-	-		22.00^{a}	1.79
Oil cooking time (minutes)	20.00^{ab}	2.12		22.00^{a}	2.95		15.00^{b}	2.39
Duration of released aroma (minutes)	17.00^{a}	2.05		17.00^{a}	2.39		10.00^{b}	1.30
50% Dura + 50% Tenera								
Fruit cooking time (minutes)	58.00^{ab}	5.46		67.00^{a}	2.12		40.00^{b}	3.03
Fruit weight (Kg)	10.50^{a}	0.27		10.50^{a}	0.00		10.50^{a}	0.27
Fiber weight (Kg)	2.00^{a}	0.55		-	-		2.00^{a}	0.55
Nut weight (Kg)	5.50^{a}	0.57		-	-		6.50^{a}	0.65
Juice cooking time (minutes)	20.00^{a}	1.48		-	-		18.00^{a}	3.58
Oil cooking time (minutes)	23.00^{a}	1.67		21.00^{ab}	1.67		13.00^{b}	1.30
Duration of released aroma (minutes)	19.00^{a}	2.30		15.00^{ab}	1.52		10.00^{b}	0.89

In the same line, the values bearing different letters are significantly different at 5%

Effect of palm tree variety and manufactured process on oil yield

A quantity of 2.5 L / kg was obtained for the three technologies with the Tenera variety, unlike the other varieties where there is a significant difference between the quantities of oils obtained. For the dura variety, the oil quantity varied between 1 and 1.25L / Kg while for pisifera, 1.75 to 2.25L of oil was obtained per kilogram (Figure 4).

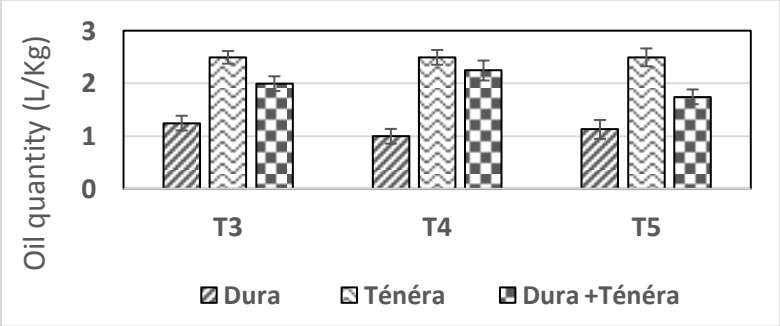


Figure 4: effect of fruit varieties and manufacturing processes on oil quantities

Colorimetric index of *zomi*

The manufacturing process has not induced a significant difference ($p > 0.05$) on the colorimetric index of the oils (Table 2). Moreover, except for the red color the index varied significantly ($p < 0.05$) according to the variety of palm fruits. The interaction process and fruit variety are significant ($p < 0.05$) linked, meaning that for each colorimetric index, the observed variation by variety also depends on the applied technology (table 3 and 4).

Table 2: Effect of manufacturing process and fruit variety on colorimetric index of *zomi*

Sources de variation	ΔE	L	A	B
Cooking technology (T)	1.63ns	1.91ns	5.49ns	0.51ns
Fruit variety (V)	25.46*	14.65*	3.28ns	23.13*
T × V	35.49*	27.15*	26.12*	32.63*

*ΔE:difference between colors; L: luminance; A: red color; B: yellow color. ns: not significant; *: significant at the 5% level.*

Table 4: Effect of manufacturing processes and fruit varieties on colorimetric index of zomi oil

Varieties	Processes	Luminance		Red color		Yellow color		Difference ΔE	
		Me	SD	Me	SD	Me	SD	Me	SD
Dura	T3	71.01^{a}	0.40	8.54^{ab}	0.70	2.46^{b}	0.44	40.50^{b}	0.43
	T4	68.63^{a}	0.84	9.97^{a}	0.48	4.90^{a}	0.41	41.65^{a}	0.45
	T5	71.37^{a}	0.27	9.89^{a}	0.19	2.66^{ab}	0.12	39.10^{ab}	0.09
Tenera	T3	72.45^{a}	0.09	6.45^{a}	0.06	3.60^{ab}	0.13	38.50^{a}	0.15
	T4	71.15^{b}	0.07	6.52^{a}	0.08	4.49^{a}	0.07	38.57^{a}	0.13
	T5	71.72^{ab}	0.14	6.48^{a}	0.12	3.80^{b}	0.18	39.38^{a}	0.17
Pisifera	T3	68.10^{b}	0.30	6.71^{a}	0.56	3.49^{a}	0.96	41.75^{a}	0.49
	T4	70.09^{a}	0.09	6.64^{b}	0.10	3.47^{a}	0.11	40.07^{ab}	0.24
	T5	68.58^{b}	0.03	7.04^{a}	0.09	4.82^{a}	0.08	41.67^{ab}	0.39

Difference ΔE: the difference between the colors. For the same calorimetric index and for the same variety, the values followed by the same letter are not significantly different ($p < 0.05$).

Sensory characteristics *zomi*

The analysis of figures 5 and 6 reveals that the oils produced with technology process 5 exhibits the best organoleptic characteristics (very pleasant viscosity, taste, aroma, smell and texture, excellent color: - 5 <test value <0) followed by oils produced with technology 4 (pleasant characteristics with regard to taste, aroma and odor). In addition to that, the oils produced with technology 3 exhibit less appreciated organoleptic characteristics (0 <test value <5). The oils produced with the *Dura* variety reveal the best organoleptic characteristics with a very pleasant color, aroma, texture, taste, and pleasant viscosity (-20 <test value <0) followed by those produced from *pisifera*.

The oils produced from dura variety also offer the best organoleptic qualities in terms of color, taste, smell and aroma (for technology 4). This is followed by the oil from *pisifera* variety which also has good organoleptic qualities. The same remarks were made on products of the technology 5 where only the oil from dura variety showed the best organoleptic characteristics with excellent color, texture, aroma, taste and very pleasant viscosity (Figure 7). Statistical analysis revealed a significant difference ($p < 0.05$) between color, viscosity, taste, aroma and odor of the oils.

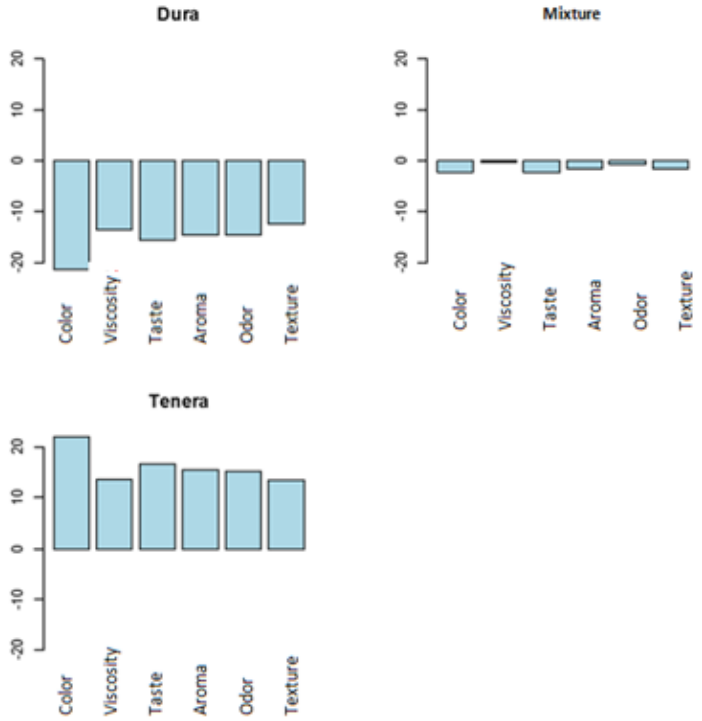


Figure 5: Effect of palm fruit on sensory characteristics of *zomi* oil

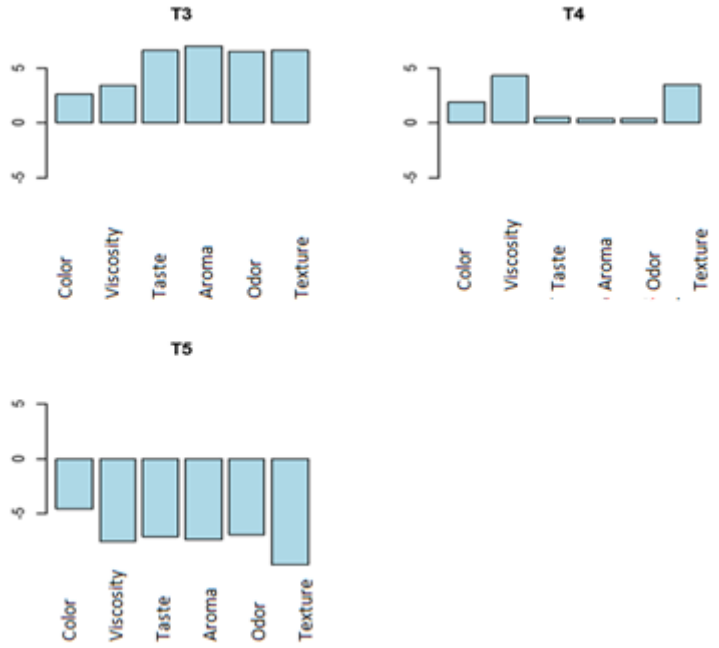
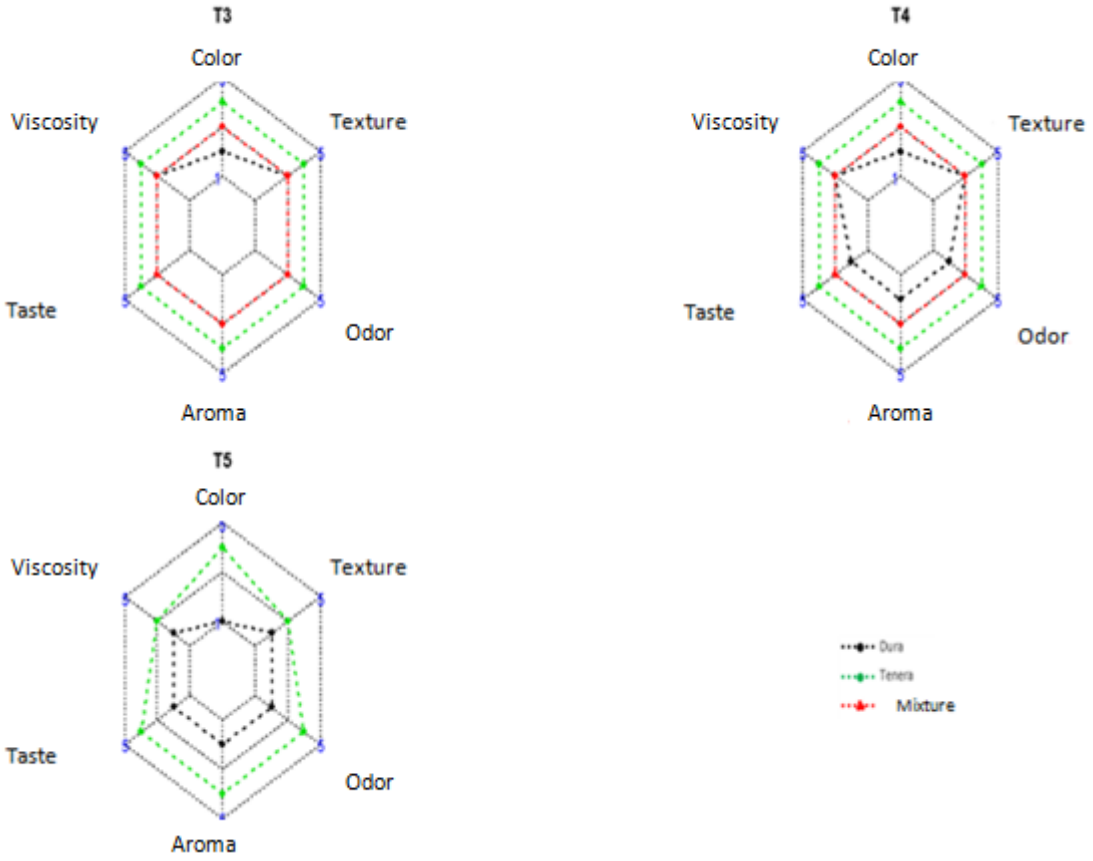


Figure 6: Effect of processing technology on sensory characteristics of *zomi* oil



Legend: 1 = excellent, 2 = Very pleasant, 3 = pleasant, 4 = unpleasant, 5 = very unpleasant.

Figure 7: Effect of palm fruit varieties and cooking process on sensory characteristics of zomi oil

IV. Discussion

West Africa has many original and handcrafted food products. The local products sometimes have limits due to poor production means, inefficient marketing system and lack of knowledge in hygiene and food safety. Moreover, industrial products usurp the reputation of traditional products, driving them out of "modern" markets and thus depriving traditional producers of their economic resources [9].

This study was conducted to assess the influences of palm fruit varieties and process technology on the sensory quality of *zomi* oil produced in Benin. *Zomi* is oil characterized by a dark red color and a particular fragrance. The production of *zomi* is based on the processing of fresh nuts and the activation of odorant precursors.

In an earlier study authors [13] came to the conclusion that there were six different processes of *zomi* oil production in Benin. The production of *zomi* was a predominantly female activity and the most used palm fruit variety was dura. The study also identified the most desirable characteristics of *zomi* oil. According to the producers, the desired sensory profile is the dark red color, the fluid texture, the strong smell and the slightly salty taste [13]. These are the reasons that have guided the present study.

The significant difference observed in the fiber weight could be explained by the fact that the fruits of the natural variety dura have a larger stone than those of the fruits of the selected variety tenera. According to Mensah [10], we can distinguish three varietal types according to their morphology: dura (with a thick shell around the kernel); pisifera (without a shell and generally sterile female); and tenera (with a thin shell).

The cooking times of the palm juice, the oil as well as the released aroma were not only linked to the process, but also specific to each producer. It was further observed that the cooking time of the dura variety fruits was longer (80 min) than that of the tenera variety fruits (50 min) and the pisifera variety (58 minutes).

The production with the variety tenera gave the the largest oil quantity, followed by the mixing of the two varieties (50% Tenera, 50% Dura), unlike production with the dura-only variety which yielded a relatively low oil quantity. Process 3 (T3) seems to give a better oil yield with the natural variety, whereas for pisifera, technology 4 is slightly more profitable. This information shows that the oil yield is not necessarily linked to the production technology.

Results from colorimetric analysis have shown that manufacturing processes have no effect on the color of oils. All produced oils had a red color; with those from the natural variety having a dominant red color. The oil color is therefore clearly linked to the quality of the raw material [18].

The manufacturing process and the raw material affected the produced oil quality o. The technology 5 applied on dura fruit variety gave the best sensory characteristics, followed by pisifera variety. According to Segalla and Bridier [9], *zomi* is completely dry due to the absence of water, it has a typical burnt red color, a very strong aroma reminiscent of caramel or smoked, and is more fluid than *kolo*. These characteristics are also the valuation indicators of *zomi* in the markets.

V. Conclusion

This study revealed that the production of *zomi* with the tenera variety results in the best oil yield, followed by pisifera varieties. All the produced oils have a red to red-yellow color. The sensory tests clearly showed the preference of consumers for the oil produced with the natural variety dura. The fruit variety and the manufacturing process play a major role in the *zomi* oil quality.

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