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Technological study of different traditional processes used in the production of flavored palm oil "zomi" in southern Benin

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Abstract

Producers who still want to get a lot of oil change the production of palm oil each day. Two types of red palm oils are produced with the fruits of the palm tree (*Elaeis guineensis*). These are the standard palm oil and flavored quality palm oil whose different production technologies are purely traditional. This study aims to make a technological study of the different technologies used to produce "zomi" flavored palm oil in the high production areas in Benin. For this reason, a questionnaire was used to ask each of 220 "zomi" producers in four (4) departments. It should be noted that to produce the flavored oil "zomi", almost all the producers used the fruit of the natural variety *dura* Six (6) different technologies have been identified in the production of "zomi" oil. Numbered from one to six, the technologies 1, 2 and 3 are used respectively at 7.7%, 56.9% and 35.4% by Zou department producers. Technology 4 is used at 3.1% in Mono and 51.7% in Plateau. Technology 5 is used at 33.3% in the Atlantic, 93.9% in the Mono and 48.3% in the plateau. Atlantic's producers use technology 6 at 66.7%. We note that there were 6 different technologies used for the production of "zomi". It then becomes important to carry out a comparative study of the quality of the oils resulting from these different technologies in order to identify the one which is more indicated.

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Introduction

The palm oil (*Elaeis guineensis*) is grown extensively in South-east of Asia and Equatorial Africa agricultural crop (Muhamad *et al.*, 2012), 80% of the palm oil produced is used for human consumption and 20% are used for inedible purposes such as the manufacture of oleochemicals (Basiron and Weng, 2004). The palm oil tree is one of the major oilseed plants in economic and socio-cultural terms for the people of southern Benin (MAEP, 2013). However, the quantity of these produced oils seems insufficient, in the face of the increasingly growing demand due to the high population growth (Demol, 2002). Palm oil has become the second most consumed oil in the world at a competitive price compared to other edible oils (Bazlul, 2010). From 15.2 million tonnes in 1993, palm oil production increased to 56 million tonnes in 2015 (Cain Blandine, 2015).

West Africa has many original food products, made by artisans that contribute to the food of cities and the countryside. These local products often have limitations due to the poverty of the means of production, the inefficiency of marketing networks and the lack of knowledge in the areas of hygiene and safety of food (Segala, 2010).

Benin's economic development involves diversifying organized agricultural sectors that can improve export earnings. In the context of globalization, the oil palm sector remains one of the agricultural sectors whose development becomes indispensable so that Benin finds its place on the international market. The production of red palm oil remains vital for Benin's economy. Palm oil is used in the preparation of various dishes in Benin and sub-Saharan Africa (Ahouansou *et al.*, 2001).

If the palm oil tree is present in all the countries of the Gulf of Guinea, the sector has often evolved differently. It generally comprises three components: an industrial sector, a craft sector, and an intermediate sector, made up of units of variable size, users of processing equipment, which is described as semi-artisanal. The relative part These three sectors vary greatly from one country to another (Fournier *et al.*, 2001).

Palm oil production in Benin is mainly based on the artisanal sector (72%) (Arodokoun, 2011). It is a remunerative activity, unlike most other agri-food processing activities. This leads to high proportions of women to be interested, and the quantities produced per head remain low. This situation gave little incentive to mechanization, and the processing methods remained manual. These processes are diverse: some seek technical efficiency while others, more traditional, focus on the quality of the final product (Fournier *et al.*, 2001).

The red palm oil of Mono department "zomi" is notoriously popular and is much appreciated in Benin, the Gulf of Guinea countries and the migrant diaspora living in Europe. It is appreciated for its aroma and quality (Segala, 2010).

However, the different technologies used for the preparation of "zomi" palm oil remain to this day unmaintained. The general objective of this study is to inventory the various technical systems used to produce "zomi" palm oil in areas of high production in southern Benin.

Materials and methods

Collection of raw material

White and red of sorghum grains were purchased from local markets in Glazoué (center of Benin). *Farafara* variety was obtained from Benin Brewery Company (SBB) based in Djeregbe, municipality of Seme podji (Southern Benin). This company exports it from Nigeria to produce sorghum beer.

Mapping of the surveyed areas

The survey was conducted in southern Benin, in the departments of Atlantic, Mono, Plateau and Zou (Fig. 1). These areas were selected based on the importance of "zomi" production and palm oil tree cultivation. For example, in Mono, where the production and sale of "zomi" is the main activity of women (Paolo and Bridier, 2010), two (2) main towns were selected for

the survey. These are the towns of Athiémé and Comé. In the Atlantic, three (3) municipalities were the subject of our study. These are Abomey-calavi, Allada and Zè. In the Plateau, only the municipality of Pobè has been the subject of our study and in the Zou, four (4) municipalities including Agbangnizou, Bohicon, Covè, Zogbodomè. The choice of its communes was made in concert with the agents of the Regional Action Center for Rural Development (CARDER) who have been our guide.

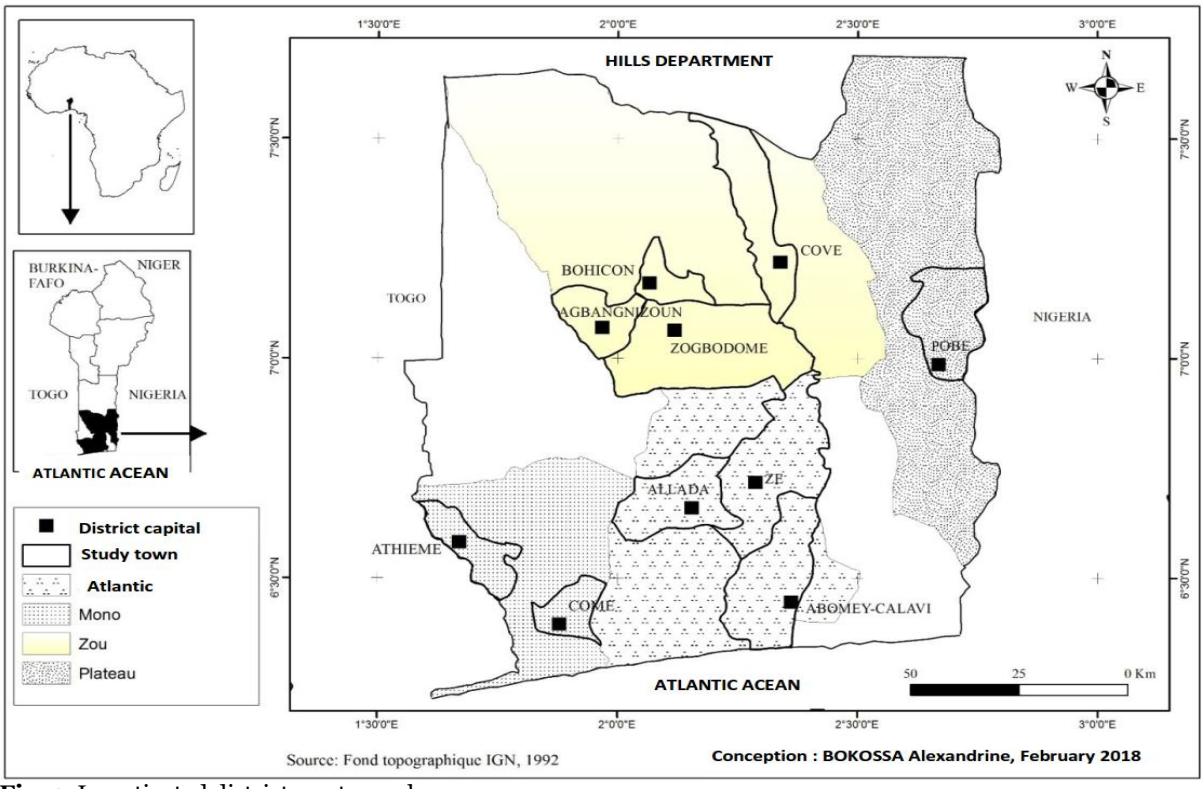

Fig. 1. Investigated districts cartography.

In total, four departments and ten (10) communes including: Abomey-Calavi, Agbangnizou, Allada, Athieme, Bohicon, Covè, Comè, Pobè, Zè, Zogbodomè were covered.

Methodology of inquiry

The survey was conducted in all the 10 communes targeted according to considerations such as the accessibility of the area, the reputation of the area in relation to the production of "zomi", the frequency of production of "zomi" and the opening of populations to collaborate. This work was carried out thanks to the permanent support of the CARDER members of each commune. The questionnaire was administered individually to the producers of "zomi" according to their availability. This allowed us to highlight the different steps involved in each "zomi" production technology. It also help to assess the producers' knowledge level on the effect of the cooking time on the quality of the oil to make the ratio price of the raw material in times of plenty and soldering compared to the selling price of the finished product ("zomi"oil) in the same periods. The sample size (N) was obtained using the normal approximation of the distribution binomial proposed by Dagnelie (1998):

$$N = [(U_{1-\alpha} / 2)^2 \times p (1-p)] / d^2$$

With: $U_{1-\alpha} / 2$ the value of the normal random variable for the probability value of $1-\alpha / 2$, where α is the risk of error. For $\alpha = 6\%$ ($1\% \leq d \leq 15\%$), the probability $1-\alpha / 2 = 0.5$ and we have $U_{1-\alpha} / 2 = 1.96$.

P = 0.7 is the proportion of people who produce zomi palm oil and the margin of error in estimation, retained at 6% in this study.

From the values of p from the results of the exploratory phase of the study, 220 producers of zomi oil were selected in the study environment. In each locality, those surveyed were identified using simple random sampling.

Statistical analyzes of data collected

The collected data were coded, entered and processed with SPSS (Statistical Package for Social Sciences) version 20.0 (Norusis, 2002) for the determination of descriptive statistics in terms of percentage and average.

The quantitative data were then subjected to ANOVA using the ANOVA procedure of the Statistical Analysis System (SAS) software version 9.2 to assess the percentage of use of different technologies from a department to another. Multiple average comparisons were made with the Student Newman-Keuls test (Dagnelie,1986). A Factorial Correspondence Analysis (FCA) was carried out with the Minitab software 14 to establish the large distributions of the different oil production technologies according to the departments (Guru *et al.*, 2011). The results of the various analyzes are presented in the tables form and figures according to (Kisauzi *et al.*, 2012).

Results

Socio-demographic characteristics of of "zomi" producers

The Table 1 presents the results of the descriptive analysis of the socio-economic variables of the persons surveyed in the four (04) departments visited in southern Benin. Generally, women make up the majority (95%) of people who produce "zomi" oil compared to (5%) for men who work on the mechanical side because they hold the strawberries used to knead fruitscooked and rented to the producers. From these results, we noted that the production of "zomi" palm oil is a legacy activity that is passed on from generation to generation.

Table 1. Socio-demographical characteristics of "*zomi* "producers.

Variables	Modalities	Answering percentage			
		Atlantique (n=30)	Mono (n=95)	Plateau (n=30)	Zou (=65)
Sex	-Man	6.7	3.1	-	-
	-woman	93.3	96.9	100	100
Age	20≤age<45years old	60	62.5	62.1	60
	45≤age<80years old	40	37.5	37.9	40
Level of instruction	- Unschooled	73.3	83.3	86.1	81.5
	- schooled	26.7	16.7	13.9	18.5
Source of funding	- Own funds	100	96.9	100	96.9
	-credit	-	3.1	-	3.1

n= Number of respondents.

The age group of women producers confirms that it is a difficult activity that requires a young workforce. However, there are older producers who are often helped by young people for production. Similarly, the analysis of the variance carried out on the age of the producers revealed that the age of the women varies very significantly in the department of Mono ($p < 0.05$). The results of the Student Newman Keuls test reveal that Comè women are significantly older than those of Athiémé (Fig. 2) while they are from the same department.

Technical systems of oil production in use

Characteristics of the raw materials used

The raw material used to produce "zomi" according to 98% of the producers is the fruit of the variety *dura*, which must be fresh and well ripe, which makes the oil smell stand out better (Table 2).

Table 2. Characteristics of the raw material used.

Variables	Modalities	Percentage of response (%)			
		Atlantique (n=30)	Mono (n=95)	Plateau (n=30)	Zou (=65)
Variety of fruit used	-dura	100	100	100	95.4
	-tenera+dura	-	-	-	4.6
availability of the raw material	-yes	20	47.9	-	46.2
	-no	80	52.1	100	53.8
Season of abundance of fruits	rainy season	80	95.8	100	69.2
	all year especially	20	4.2	-	20
	dry season	-	-	-	10.8
criteria good fruit recognition	fresh fruit	-	1	48.3	-
	fresh and ripe fruit	100	99	51.7	100

On the other hand, the mixture of the two varieties (50% *tenera* + 50% *dura*) makes it possible to have a greater quantity of oil at the end of production and at the same time the desired odor. However, this quality of oil is preserved for a short time (2 months maximum) because the smell disappears quickly unlike the oil produced with the variety *dura* only that lasts up to one (1) year. The raw material through its quality therefore plays a fundamental role in the production of a "zomi" oil. Because only the use of a raw material of natural varieties lasted of good quality, (fresh and well walled) guarantees the organoleptic qualities sought by the consumer.

There is a significant difference between the price of the raw material during the season of abundance and during the lean season.

The price of palm oil fruits is in the range of 65 to 85 francs for one (1) kilogram in periods of abundance, and 110 to 125 francs in the lean season when the fruits become a little scarce (Table 3).

Table 3. Raw Material Price.

Departments	Districts	Price Abundance	Welding price
Atlantique	Ab – Calavi	62.50±7.50a	110±4.08a
	Allada	60.71±2,30a	113.57±3.89a
	Zè	62.37±2,14a	107.10±2.52a
	Moyenne	62±1.69C	109±1.92B
Mono	Athiémé	67.69±1.62a	11934±1.87a
	Comè	67.321±2.54a	118.21±3.49a
	Moyenne	67.58± 1.359BC	119.01±1.66A
Plateau	Pobè	73.59 ± 0.57B	94.55± 1.23C
Zou	Agbangnizou	125a	175a
	Bohicon	94±3.55 ba	145±5 ba
	Covè	76.52± 1.37 b	104.66± 1.97 ba
	Zogbodomè	81.89± 5.22 b	140.51± 8.60 b
	Moyenne	80.74± 2.56 A	124.21±4.60A

This means that the raw material is available all year but less expensive especially in the season of abundance that covers almost the entire rainy season. It is expensive and less available during the lean season, which covers the dry season, this in the four departments.

Equipment used

Different equipment or materials are used in the production of "zomi" oil. This equipment are specific

to each operation and vary from a producer to another. For cooking, the pot is used for small quantities and barrel for large quantities.

For mixing, the mixer or foot treading are for large production and mortar for small productions.

The pressing is done with the press machine and for others, in basins. For emulsification, the (wooden back or cemented hole) were the most used. The filtering is done with baskets, the purification / aromatization is done in pots or barrels and the cooling in basins. Packaging is usually done in cans.

Table 4. Distribution of technologies by department.

Variables	Modalities	Percentage of respondents (%)			
		Atlantique (n=30)	Mono (n=95)	Plateau (n=30)	Zou (=65)
Technologies used	Technology 1		-	-	7.7
	Technology 2		-	-	25.4
	Technology 3		-	-	66.9
	Technology 4		3.1	55.7	-
	Technology 5	43.3	96.9	44.3	-
	Technology 6	56.7	-	-	-

Table 5. Variability of production parameters by technology.

Technologies	Production Frequency	cooking duration	Quantity of oil produced	Preserving duration
Technology 1	1.2±0.20	3.4±0.50	18.4±3.47	31.2±8.23
Technology 2	1.35±0.13	5.25±0.136	32.29±0.49	8.29±2.89
Technology 3	1.521±0,10	3.59±0,27	22.09±0.45	19.96±4.33
Technology 4	1.16±0.03	6.66±0.66	20.66±4.80	22.66±4.80
Technology 5	1.66±0.33	833±0.28	22.50±0.24	27.108±1.24
Technology 6	1.10±0.06	5.40±0.24	20.42±0.37	32.239±1.8
F value	5.90***	8.82***	2.11*	5.75***

The averages followed by the same alphabetic letters of the same characters and for the same characteristics are not significantly different (P> 0.05) from the Student Newman-Keuls test. ns: P> 0.05; *: P <0.05; **: P <0.01; ***: P <0.001.

Kow-how identified

Several production technologies have been referenced and reorganized into production charts. In total, six (6) production technologies were referenced in the 10 municipalities of the various departments visited, (Figs 3,4,5,6,7,8).

Specificity of "zomi" production technologies related to geographical origins

The factorial analysis of the correspondents (Fig. 9) shows the large distributions of the different "zomi" oil production technologies according to the departments. We therefore note that technology 5 is the most used technology.

The Table 5 presents the results of the analysis of the variance and Student Newman Keuls technology test. The results collected show that there is a very significant difference (p <0.05 to p <0.001) between the six technologies in terms of their production frequency, cooking time and shelf life. Also, there is a significant difference (P <0.05) between the six (6) technologies in terms of the amount of oil produced by technology. It is also noted that producers using technology 5 have a higher production frequency.

This technology offers a better performance, followed by technologies 6 and 2. Also, technology 6 has a longer shelf life than other technologies (Table 4).

Table 6. Organoleptic characteristics of "zomi".

Variables	Modalities	Percentage of respondents (%)			
		Atlantique (n=30)	Mono (n=95)	Plateau (n=30)	Zou (=65)
Color of a good "zomi"	Bright red	30	42.7	-	16.9
	Dark red	70	57.3	100	83
Texture	Fluid	73.3	84.4	100	50.8
	a little heavy	26.7	15.6	-	49.2
The good taste of "zomi"	-pronounced	-	-	-	9.2
	-Very Pronounced	100	100	100	90.8
Taste of a good "zomi"	Slightly dirty	-	43.8	35.6	16.9
	Unsalted	100	56.3	64.4	83.1
Packaging	Basin	-	5.2	-	21.5
	Can	70	54.6	100	56.9
	Bottles	30	40.6	-	21.5
The duration of the conversation (weeks)	[1-24 [	20	33.3	20.7	52.3
	[24-60[	80	66.7	79.3	47.7

N= Number of respondents.

Table 7. "zomi" marketing and production circuit following the departments.

Variables	Modalities	Percentage of respondents (%)			
		Atlantic (n=30)	Mono (n=95)	Plateau (n=30)	Zou (=65)
Selling location	Home	50	26	41.4	35.4
	Home and Market	50	74	58.6	64.6
Market	On the place	50	26	41.4	35.4
	town	50	71.9	58.6	52.3
	Department	-	2.1	-	12.3
advantage between "zomi" and *kolo*	Sells fast	26.7	26	20.7	27.7
	More appreciate	23.3	37.5	58.5	33.8
	More ask	26.7	18.8	10.3	20
	Profitable	23.3	17.7	10.3	18.5

N= Number of respondents.

Characteristic of the "zomi" oil according to the producers

The Table 6 presents the characteristics of "zomi" oil. All women producers are unanimous about the fluid texture with a very strong smell (90%) to recognize a good "zomi".

The taste of the oil varies from one producer to another. Those who add salt to the cooking estimate that the oil is slightly salted and that it is the *bécoun* which is especially salted.

Economic characteristics of "zomi" oil production in the production areas

Circuit of marketing and production of "zomi" according to the departments

The marketing circuit of "zomi" varies from one producer to another and especially according to the departments (table 7). Most women producers (60%) sell the oil at home and in the markets mainly in the municipal markets. The reasons why female producers sell "zomi" oil over *kolè* oil is that "zomi" sells fast *Economic profitability according to the*

production zones. The result of the analysis of the variance performed on the different departments (Table 8) reveals that the different sales prices and the benefits obtained vary very significantly ($p < 0.05$ a $p < 0.001$) from one commune to another.

Table 8. Result of analysis of the variance a factor realized on the municipalities and departments.

Source of variation	Degree of freedom	retail price abundance mt	retail price welding mt	price wholesale abundance 25l	price wholesale soldering 25l	price retail abundance 1l price	detail weld 1l	profit
Districts Atlantic	2	0.08ns	0.98ns	0.12ns	0.10ns	2.10ns	0.05ns	0.89ns
Districts Mono	1	0.2ns	0.09ns	10.42**	15.65***	10.02**	8.32**	299ns
Districts Zou	3	2.75ns	7.58***	8.73***	10.89***	3.82*	6.23***	9.9***
Departments	3	15.12***	12.28***	17.03***	31.09***	12.81***	5.02**	2.76*

ns : P >0.05 ; * : P < 0.05 ; **: P < 0.01 ;***P< 0.001.

Discussion

Socio-demographic plan

The socio-demographic results showed that women were represented by the majority (95%) of people producing "zomi" oil against (5%) for men who tend to work on the mechanical side because they are holders of pulpers for kneading. the cooked fruits and rent them to the producers. No male producers have been registered in the departments of Zou and Plateau. Women producers were mostly 20 to 45 years old (60%) and otherwise uneducated (82%). Almost all women surveyed (100%) produce "zomi" palm oil since childhood and this on own funds (Table 1). The majority of female producers (98%) work individually and the minority work as a group (2%). The production of "zomi" palm oil is also an inheritance activity that is passed from generation to generation.

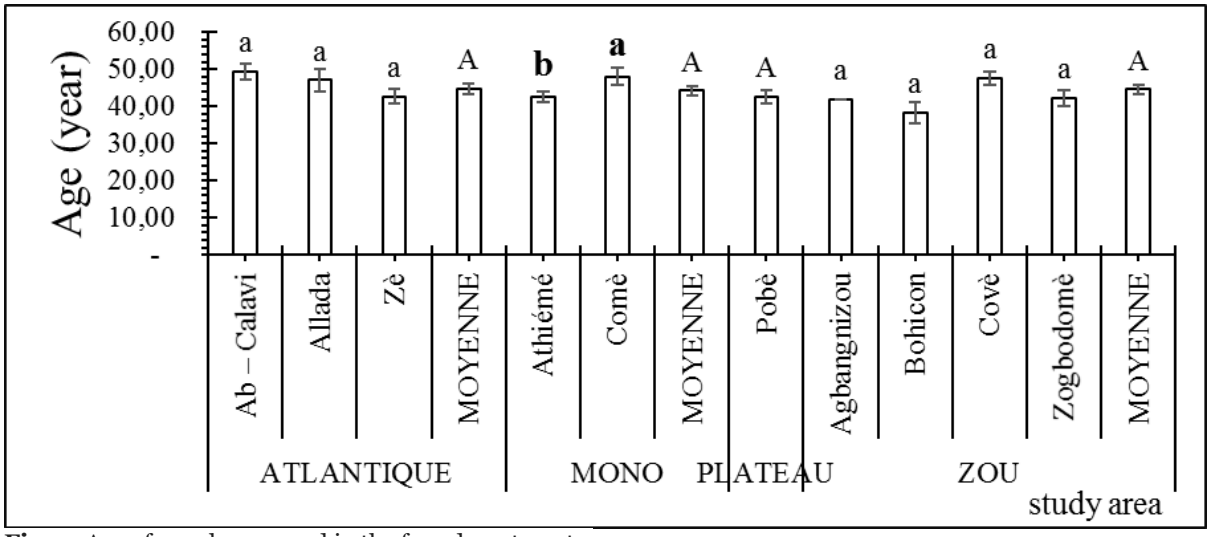

Fig. 2. Age of people surveyed in the four departments.

The bars on the histograms indicate the standard errors. Histograms, which are affected by the same alphabetic letters, are not significantly different (P> 0.05).

The age group of women producers confirms that it is a difficult activity that requires a young workforce. Nevertheless, we note the presence of older producers who are often helped by young people for production. These results are in line with those of (Fournier *et al.,* 2001) and (Paolo and Bridier,2010), according to which agro-food processing constitutes one of the bases of women's income-generating activities, whose importance is no longer demonstrate for the balance of household budgets and the development and

education of children. Often the mechanization of the most painful operations entails men taking charge of the activity and evicting women from their traditional income-generating activities.

Raw materials

The raw material is often very available in the rainy season. The raw material through its quality therefore plays a fundamental role in the production of"zomi" oil. Because only the use of a raw material of natural varieties lasted of good quality (fresh and well walled) guarantees the organoleptic qualities sought by the consumer.

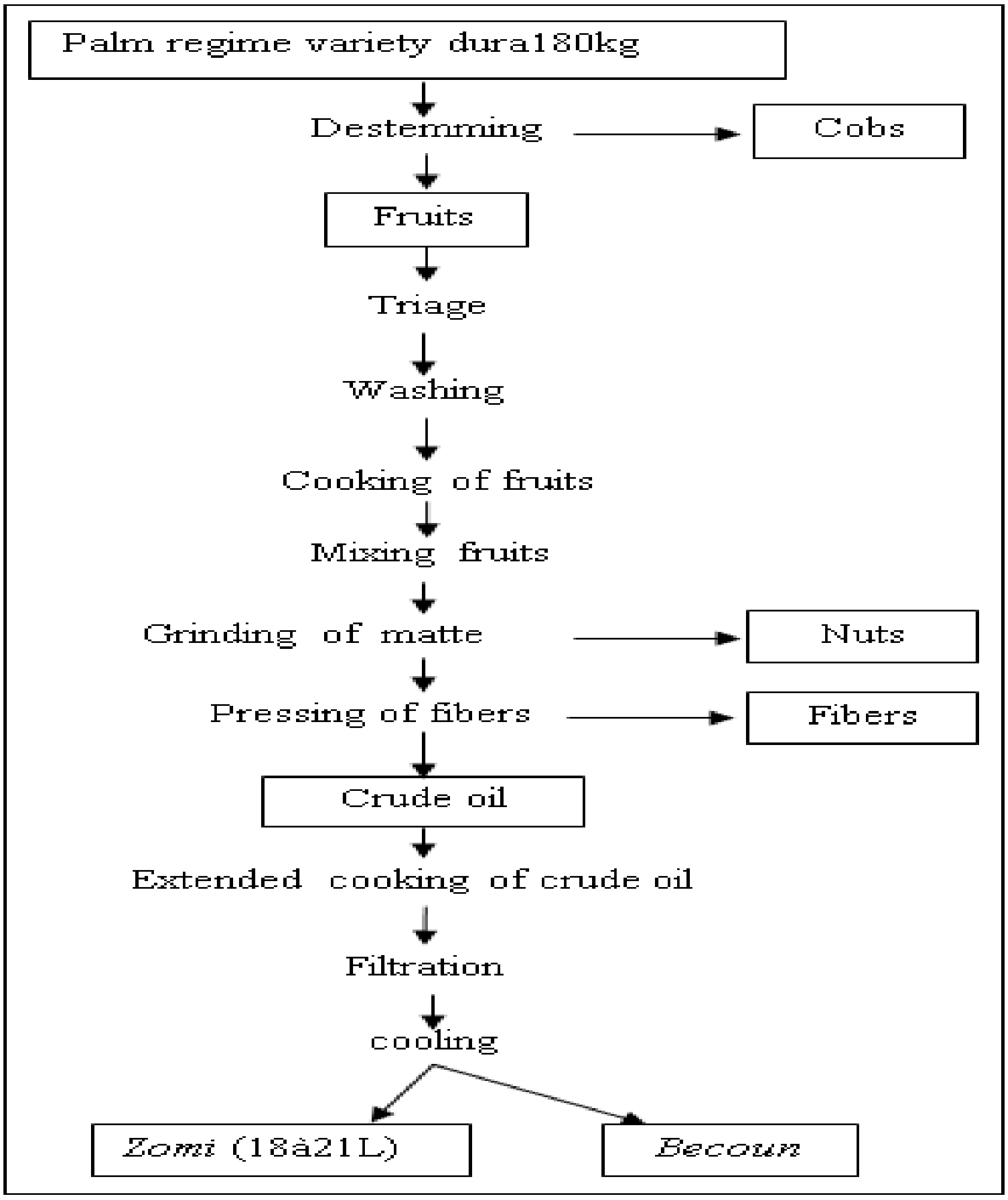

Fig. 3. Production technology diagram No. 1 used in the Zou department by 7.7% of women producers.

The "zomi" production time is on average 3 hours. The "zomi" obtained from this technology has a dark red color, a fluid texture, a very strong smell and an unsalted taste. The shelf life varies from 1 to 4 months.

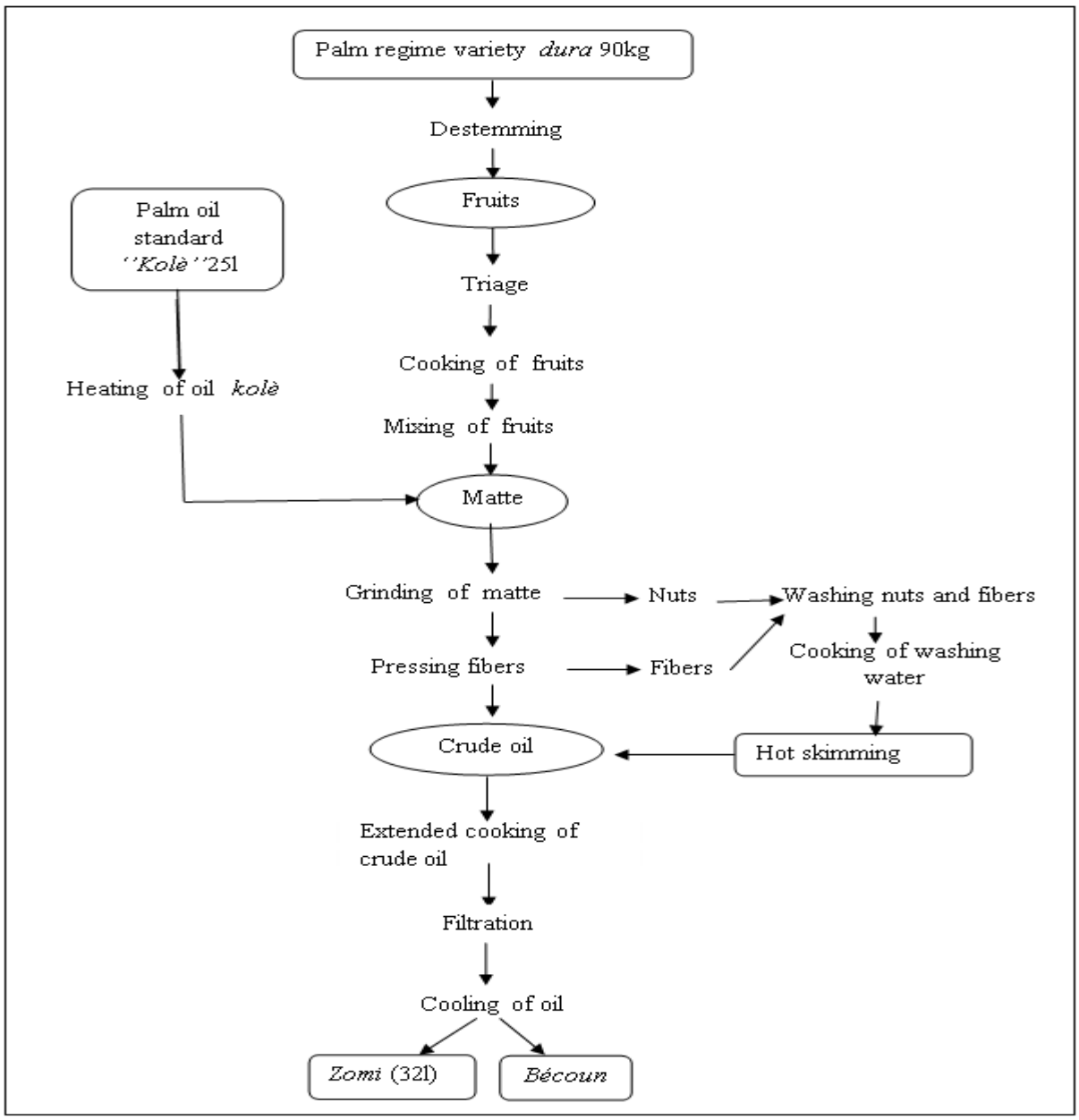

Fig. 4. Technology 2 diagram used in Zou department by 56,9% of producers.

"zomi" obtained by this technology has a red colour, a heavy texture, a pronounce odour and non-salty taste. The conservation period is often two months.

These results were in agreement with those of Fournier *et al.* (2001) and Paolo and Bridier (2010) according to which agro-food processing constitutes one of the bases of the income-generating activities of women, whose importance is no longer demonstrate for the balance of household budgets and the development and education of children.

Often the mechanization of the most painful operations leads to men taking control of the activity and to evicting women from their traditional income-generating activities.

The *dura* variety must be fresh and ripe, which enhances the smell of the oil. This variety used at 100% allows having a larger amount of oil at the end of production and at the same time the desired odor.

The mixture of variety is preserved for a short time (2 months maximum) because the smell disappears quickly unlike the oil produced with the variety *dura* only that lasts up to one (1) year (Table 2).

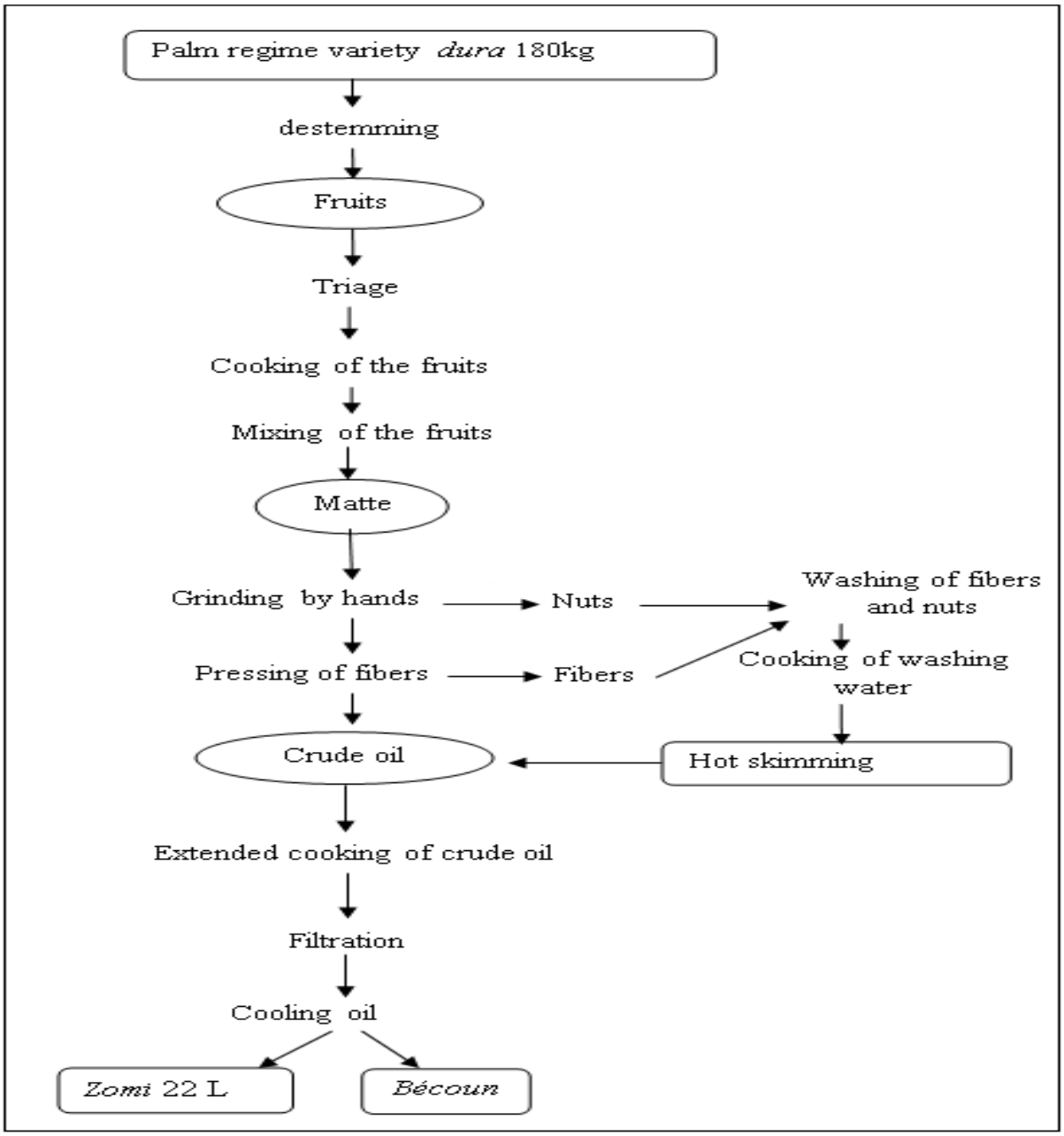

Fig. 5. Production diagram of technology 3 used in the department of Zou by 35.4% of women producers.

With this technology, the "zomi" production time is about 4 hours. The "zomi" obtained from this technology has a dark red color, a slightly heavy texture, a strong smell and a non-dirty taste. The shelf life varies from 4 to 5 months.

Notwithstanding the economic importance of the *ténéra* variety for the production of red oil, it does not allow having quality "zomi" oil and therefore is not suitable for this purpose. The raw material is often very available in the rainy season. The raw material through its quality therefore plays a fundamental role in the production of a "zomi" oil because only the use of a raw material of natural varieties lasted of good quality (fresh and well walled) guarantees the organoleptic qualities sought by the consumer.

The raw material is available all year but less expensive especially in the season of abundance that covers almost the entire rainy season.

It is expensive and less available during the lean season, which covers the dry season. And this in the four departments (Table 3).

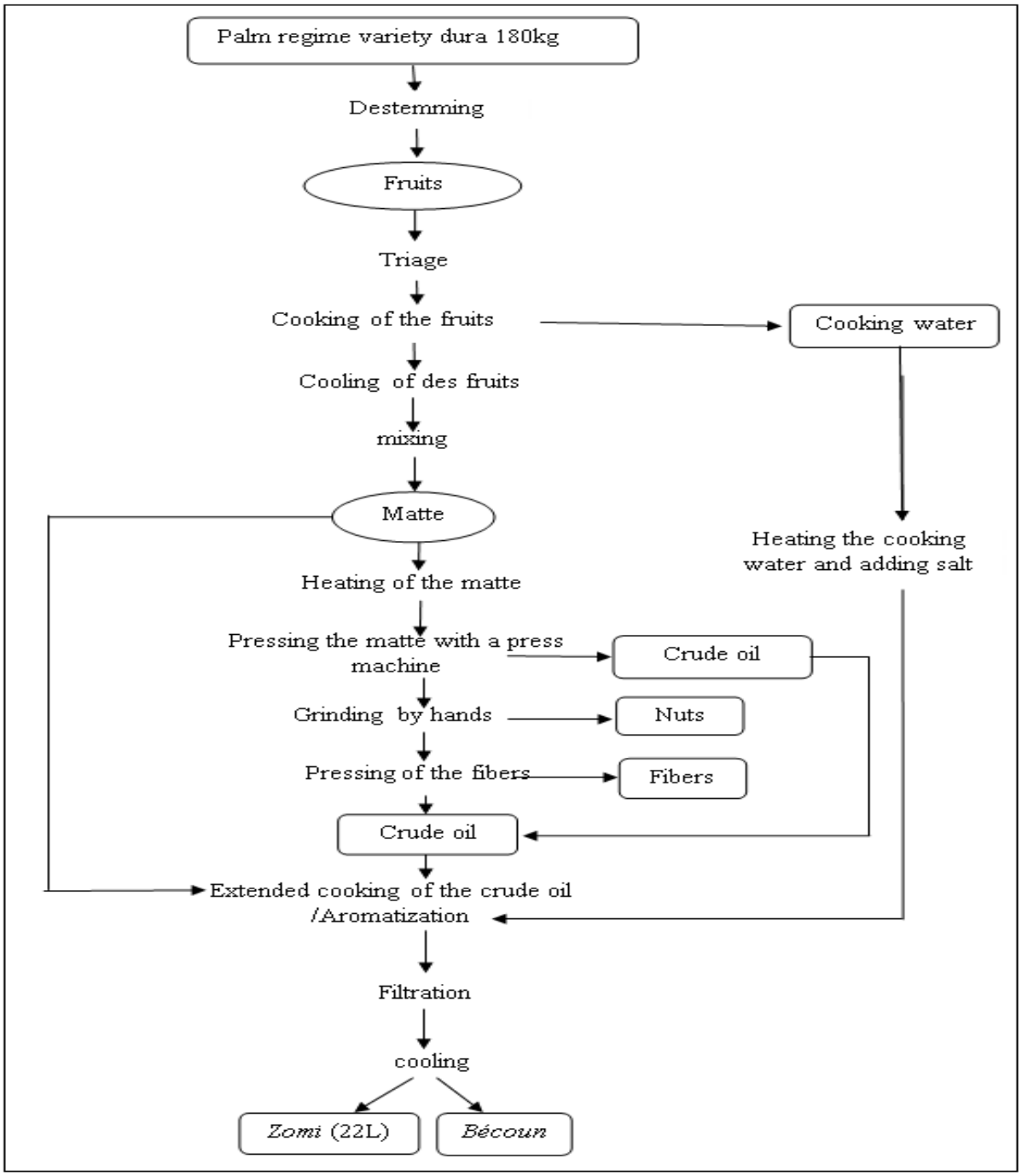

Fig. 6. Technology 4 diagram usesd at 3.1% in mono and at 51.7% in Plateau.

With this technology, the "zomi"'s production time is 6 hours. "Zomi" obtained with this technology has a red colour a fluid texture, a pronounce odour and a slightly salty taste. The conservation period is approximatively 6 months.

These results also corroborate those of Paolo and Bridier, (2010) for whom the palm nuts used for this production come from the exploitation of the traditional palm grove of *dura* variety, which, unlike the "improved" variety *tenera*, allows the production of a red oil appreciated by consumers. Unlike the *Kolo* red oil, the production of "zomi" oil is based on the processing of fresh walnuts harvested for less than 72 hours and on the activation of precursors of odorous elements contained in the nuts.

Characteristics of "zomi"

The characteristics of "zomi" oil (Figure 6) were related to those of Paolo and Bridier, (2010)

according to which "zomi" is completely dry by lack of water, it has a typical red burnt color, a very strong aroma that recalls caramel or smoked, and is more fluid than *kolò* (standard palm oil).

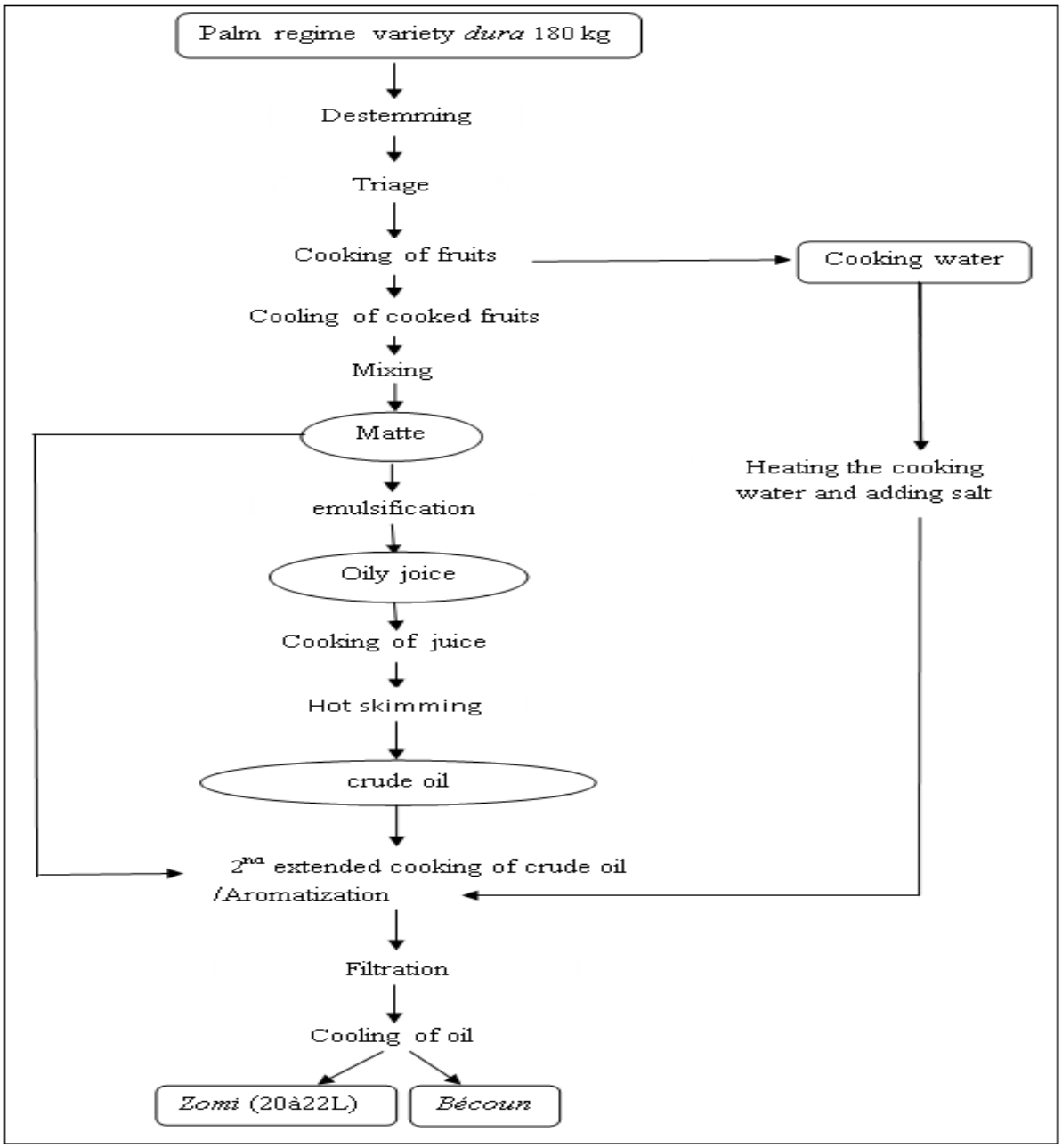

Fig. 7. Production diagram of the technology used in the Atlantic departments by 33.3% of the producers, in the Mono by 93.9% of the producers and in the Plateau by 48.3% of the producers.

With this technology, the production time of "zomi" is on average 8 hours. The "zomi" obtained from this technology has a bright red color, a fluid texture, a very strong smell and a slightly salty taste. The shelf life of this oil is about 7 months.

These characteristics were also the evaluation indicators of "zomi" in the markets. According to the producers, "zomi" can keep its quality characteristics, especially its aroma, for 4-6 months if it is well prepared and if it is stored tightly.

Since technology 5 is the most widely used technology, the different stages of this technology described by the producers are the same as those described by Fournier *et al* .(2001).

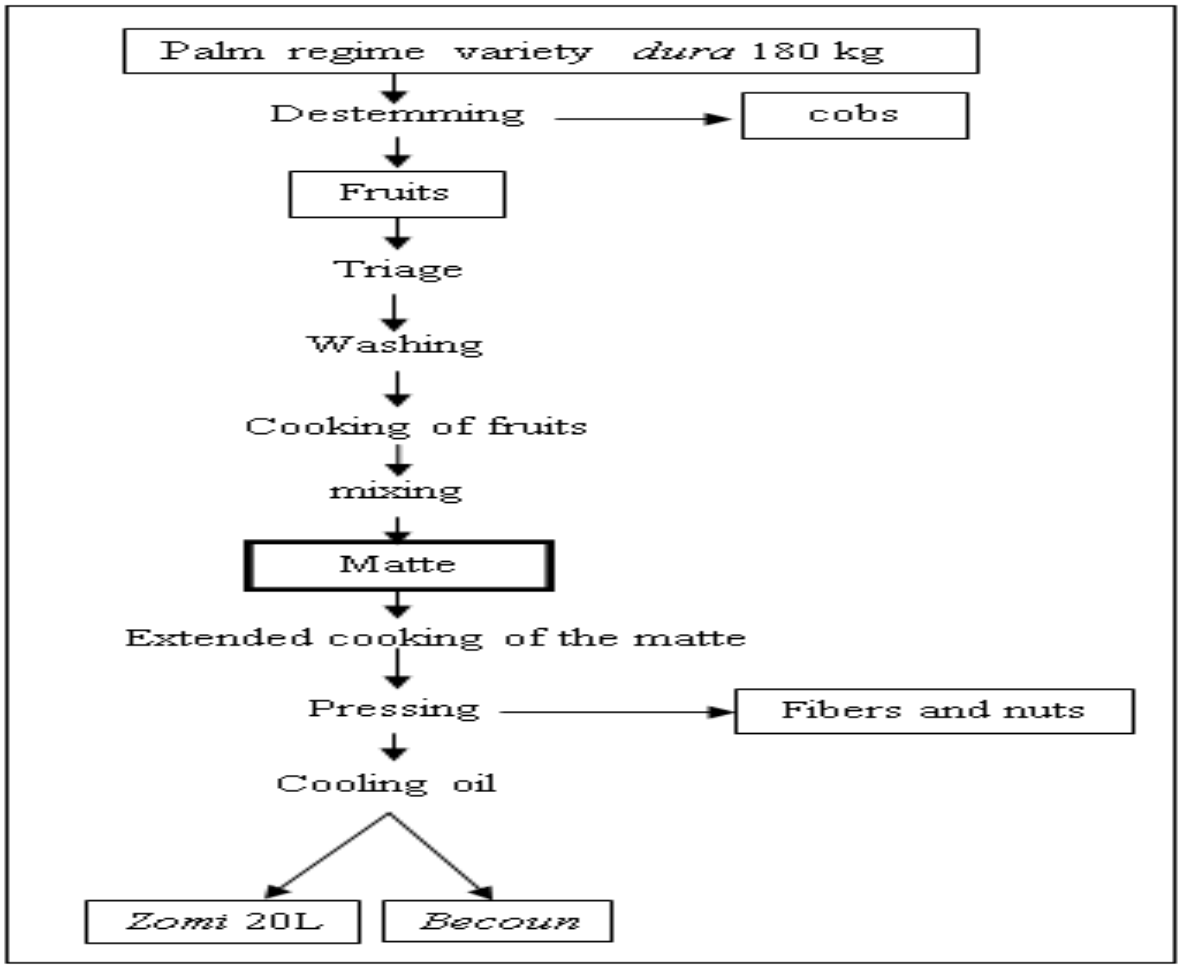

Fig. 8. Production diagram of technology 6 used in the department of Atlantic by 66.7% of women producers.

With this technology, the production time of "zomi" is on average 5 hours of time. The "zomi" obtained from this technology has a bright red color, a fluid texture, a very strong smell and an unsalted taste. The shelf life of this oil is about 8 months.

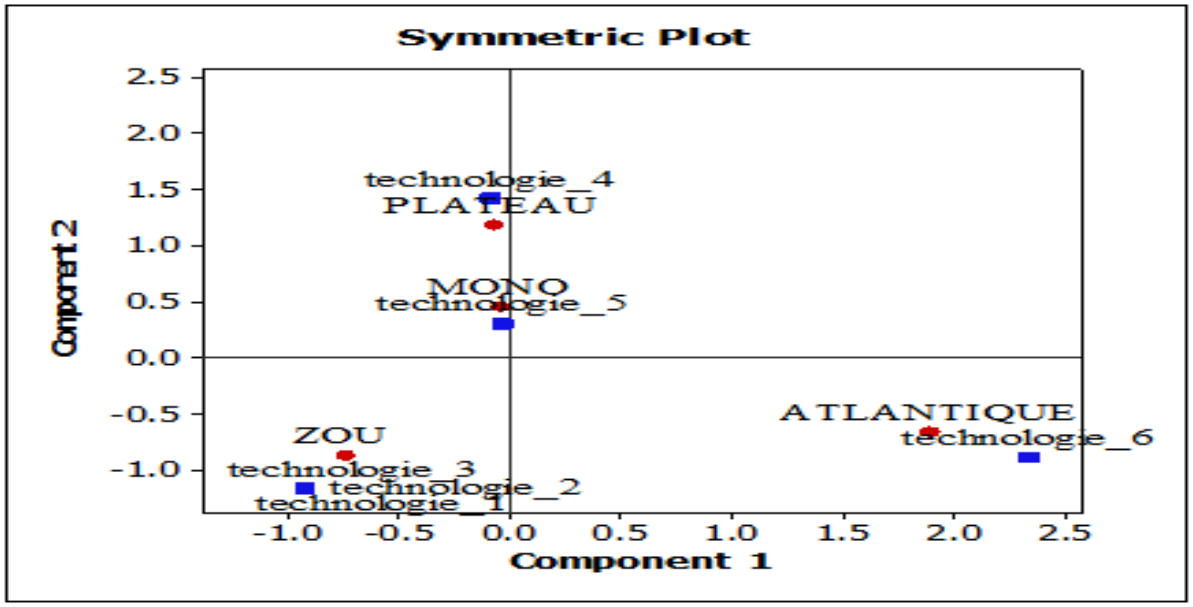

Fig. 9. Technologies used by departments.

Conclusion

This survey allowed to make a technological study of the different technologies used to produce "zomi " palm oil in Benin. There were six different technologies spread over the four departments taken into account. The production of "zomi" palm oil was a predominantly female activity and the most popular palm nut variety is *dura*. This study has also allowed highlighting the most sought after characteristics for "zomi". According to the producers, the desired sensory profiles were the dark red color, a fluid texture, a pronounced odor and a slightly salty taste. It then becomes urgent to optimize the unit operations identified in the various technologies in the perspective of improving the quality of the finished product.

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