Original Research Article

Production And Use Of Cola Follicles (*Cola nitida* vent. Schott & Endl*.*) Potash In The Formulation Of "*Kabatôh*" In Côte d'Ivoire.

ABSTRACT

Aims: The objective of this study was to produce and use potash from kola follicles *(Cola nitda)* in the formulation of an ethnic or traditional foods namely *kabatôh*.
Study design: 17 formulations of kabatoh carried out in the presence of potash were subjected to a sensory analysis
Place and Duration of Study: Laboratory of Biochemistry and Food Sciences, Biochemistry department of Biosciences Unit, Felix Houphouet-Boigny University, running 2019.
Methodology: Kola dried follicles collected from the region of Tonkpi were incinerated after sun dried. Ash obtained was used for the production of potash after maceration (with water), filtration and evaporation. The extracted potash was characterized and used in the *kabatôh* formulation procedure. Seventeen formulations of *kabatôh* and the control sample were used as part of a sensory analysis to evaluate the perception of the color, savor, texture and the flavor like their level of appreciation by tasters.
Results: The potash extraction yield determined was 10.23 ± 0.72%, with a basic pH of 11.15 ± 0.05. Results showed that potash moisture content and concentration of potassium hydroxide are 4.15 ± 0.21% and 0.81 ± 0.03 mol/L, respectively. Some of the formulations with potash were appreciated more than 83% by the panelists. The control sample was appreciated by 56.76% of the panel.
Conclusion: The presence of potash improves the organoleptic characteristics of *kabatôh*. Thus, Kola follicules could be used in the potash production process that represents an interest in food and feed but also in the industrial world.

Key words: Cola nitida, potash, kabatôh, maize flour, Côte d'Ivoire.

1. INTRODUCTION

Agriculture forms a significant portion of the economies of all African countries, as a sector it can therefore contribute towards major continental priorities, such as eradicating poverty and hunger, boosting intra-Africa trade and investments, rapid industrialization and economic diversification. In sub-Saharan Africa, particularly in Côte d'Ivoire large tonnages of agricultural products such as cocoa, coffee, pineapple, plantain, coconut, cashew nut, kola, etc. leads to high quantities of by-products which are neglected on plantations each year [1,2,3].
According to some authors, the amount of by-products derived from cash crops in West Africa would represent 10 to 50% of annual production [1]. Layrol [4], Gabriel *et al.* [5], Crentsil and Ukpong [6] and Kimou *et al*. [7] report a massive use of low-cost agricultural by-products in fish feed in most fish farms in sub-Saharan Africa. Moreover, according to FAO [2], agricultural by-products are a major alternative in livestock feed in West Africa. In addition, these by-products could, through appropriate technological treatments, lead to new products with high added value, thereby improving producers' incomes. Indeed, by simple mineralization, they can integrate the potash production process that represents an interest in food and feed but also in the industrial world [7,8,3].
According to Biego *et al.* [1], agricultural by-products from *Theobroma cacao* (cocoa pods), *Cola nitida* and *Cola acuminata* (kola follicles), *Musa paradisiaca* (plantain stalks), *Coffea robusta* and *Coffea arabica* (parches), *Oryza sativa* (rice bran), *Cocos nucifera* (coconut shell) and *Elaeis guineensis*

(palm kernel residues) can be used for potash production. Usually, potash (used in its solid form) is mainly used (around 95%) in the manufacture of soaps and fertilizers to support plant growth, increase crop yield and disease resistance, and increase water conservation [9]. Small amounts of potash are used in the manufacture of chemicals (detergents, de-icing salt substitutes, pharmaceuticals, ceramics, water softeners) that contain potassium which is an important element in human nutrition because it is essential for the growth and maintenance of tissues, muscles and organs, as well as for the electrical activity of the heart [10].

On the food plan, potash is involved in the process of formulating and making traditional dishes in sub-Saharan Africa. In the northern regions of Côte d'Ivoire, it is particularly used for the preparing several ethnic food especially *kabatôh* which is derived from the transformation of corn into a dough known under different names in West African countries (tuwo, toh, aseda, ugali, mudde, owo) [11]. Ethnic food can be defined narrowly as foods originating from a heritage and culture of an ethnic group who use their knowledge of local ingredients [12]. More broadly, ethnic or traditional foods are representative of cooked dishes of an ethnic group or country that is culturally and socially distinct and whose foods may be accepted by consumers outside of the respective ethnic group [13]. Ethnic foods provide consumers from other culinary traditions with opportunities to experience new cultures and cuisines.

Despite the many applications including among others the sensitive area of human nutrition, there are very few scientific studies on the technical system of production and conditions of the use of potash in Côte d'Ivoire. The present work aims at producing potash from kola by-products (follicles) in order to integrate the formulation of *kabatôh”* or *“tô”*. The different by-products and products obtained will be characterized and then a sensory analysis will be performed on the finished product.

2. MATERIAL AND METHODS

2.1 Material

2.1.1 Plant material

The biological material consisted of *Cola nitida* nut follicles harvested in the region of Tonpki and Zea mays kernels, of improved yellow morphotype, variety BG 8622, collected at Djedou (region of N'zi comoe). Thus, 100 kg of kola follicles were removed from the nuts, sun dried and then incinerated. The resulting ash (20 kg) was stored in a sealed bottle and transported to the laboratory for further analysis.

As for corn, after sun drying of the ears, a quantity of 50 kg was sampled, packaged in polythene bags and then transported to the laboratory for the various experiments.

2.2 Methods

2.2.1 Potash production

Potash was extracted according to the method described by Biego et al. [1] with some modifications. After incineration of the follicles, 500 g of ash was macerated in 5 L of distillated water for 12 h and the mixture was filtered through a muslin cloth. The colored filtrate was evaporated to dryness over a wood fire and the dry residues (mineral crystals) were recovered and weighed. The resulting potash was kept in a cool, dry place.

2.2.2 Potash characterization

2.2.2.1 pH determination

A sample of 10 g of potassium hydroxide was homogenized in 100 ml of distilled water and the mixture was filtered on a filter paper (Whatman N°1). Then, the pH electrode, previously calibrated with buffer, was soaked in the filtrate. The pH value was determinate directly from the pH meter screen [14].

2.2.2.2 Determination of titratable acidity and potash concentration (KOH)

A sample of 10 g (Me) of potassium hydroxide was homogenized in 100 ml of distilled water and the mixture was filtered. Then, 10 mL (V_0) of the filtrate was taken from a 250 mL erlenmeyer flask and 3 drops of phenolphthalein were added. After homogenization, the mixture was titrated with a hydrochloric acid solution 0.1 N (V_1) until a persistent pink color was obtained.

The titratable acidity was expressed in mg of H_3O+ equivalent (mg Eq H_3O+) per 100 g of dry matter according to equation 1 and the potash concentration according to equation 2 [14].

$$\text{Acidity } (mg \text{ Eq }/100 \text{ g}) = \frac{N \times V1 \times 10^4}{m_e \times V_0} \qquad (1)$$

With N : Concentration of the hydrochloric acid solution (mol/L) ; V_1 : volume of hydrochloric acid (mL) ; Vo : volume of filtrate (mL) ; me : mass of potash (g).

$$C_b \times V_b = C_a \times V_a \qquad (2)$$

With, C_b : Potash concentration (mol/L); V_b : volume of filtrate (mL); C_a : concentration of the hydrochloric acid solution (mol/L) ; V_a : volume of hydrochloric acid (mL).

2.2.2.3 Potash moisture

Moisture was determined by the method of steaming which consisted of drying 5 g of potash contained in an aluminum capsule at 105 ° C to a constant weight [14]. The analysis was performed three times. The calculation of the water content was carried out according to equation 3.

$$\text{Moisture } (\%) = \frac{P_1 - P_2}{P_1 - P_0} \times 100 \qquad (3)$$

with P_0 : mass of the empty aluminum (g) ; P_1 : masse the empty aluminum with sample before drying (g) ; P_2 : mass of the aluminum capsule containing the sample after drying and cooling (g).

2.2.3 Production of maize flour

2.2.3.1 Soaking and grinding corn kernels

A quantity of 2 kg of shelled corn kernels was soaked for 24 h in 5 L of water containing 100 g of potash. After filtration, the corn kernels were ground with a hammer mill to obtain flour. The drying of this flour was carried out in an oven at 40° C for 72 hours and then stored in a bag protected from moisture for the subsequent production of *kabatôh* according to the method described by Seogo [15] (Fig. 1) A control flour was produced under the same experimental conditions but in the absence of potash (soaking without potassium).

2.2.3.2 Optimization of the method of formulation of kabatôh

A composite central plan (PCC) was used for the formulation of *kabatôh* For this, an experimental domain was determined based on 3 parameters considered influential in the production of corn flour (Table 1).For this plan, each parameter has 5 levels (-α, -1, 0, +1 and + α) whose interactions allowed the realization of 17 experiments with 8 factorial tests, 6 star trials and 3 central tests (Table 2).

2.2.4- Sensory evaluation

The sensory analysis consisted in the tasting of the various *kabatôh* produced. Hedonic assessments and descriptive tests have been carried out. The tasting sessions have been made at the laboratory of biochemistry and food sciences of the Felix Houphouët-Boigny University of Abidjan. Every tasting has been made with 20 g of samples served in disposable rubber plates. The answers have been given by the scores on a scale where the inferior tip expresses the lack of sensation and the superior tip expresses the full sensation.

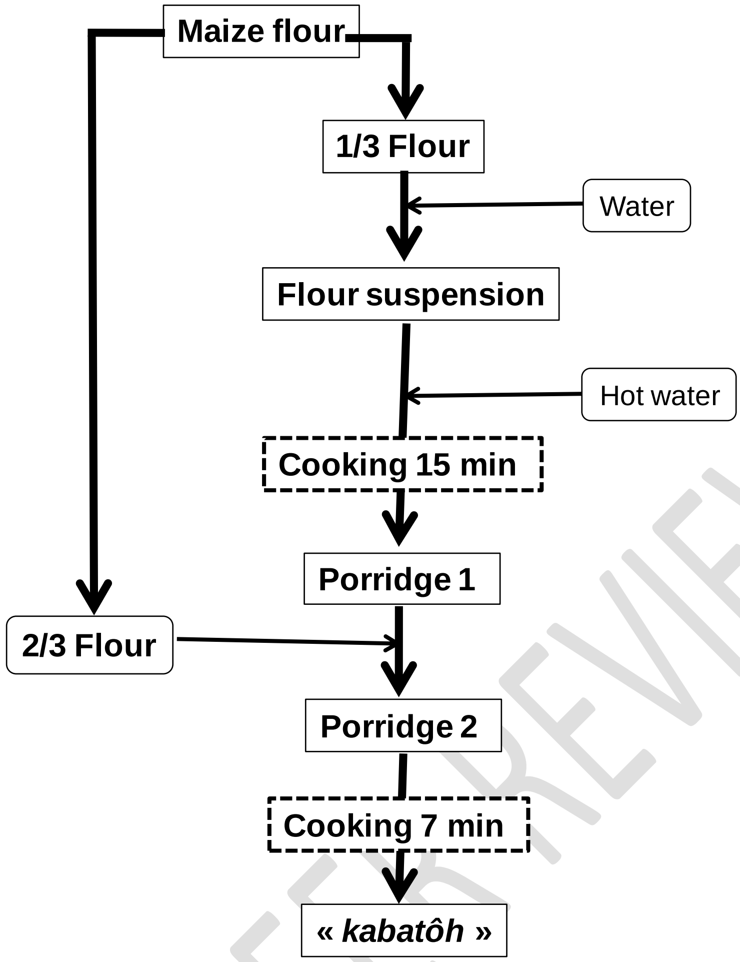

Fig. 1. Diagram of production of *kabatôh* according to Seogo [15] with slight modification

Table 1. Experimental domain of the composite central design

Independent variables	Symbol	Coded level				
		-1,682	**-1**	**0**	**+1**	**+1,682**
Ratio potash/Corn kernels (m/m)	X_1	1,25/100	1,25/100	3,125/100	5/100	5/100
Soaking time (h)	X_2	4	4	14	24	24
Ratio water/Corn kernels (v/m)	X_3	1/2	1/2	3/2	5/2	5/2

Table 2. Experimental plan of the composite central design

	Values of factors		
Run number	**X_1 (m/m)**	**X_2 (h)**	**X_3 (v/m)**
1	1.25/100	4	1/2
2	5/100	4	1/2

3	1.25/100	24	1/2
4	5/100	24	1/2
5	1.25/100	4	5/2
6	5/100	4	5/2
7	1.25/100	24	5/2
8	5/100	24	5/2
9	1.25/100	14	3/2
10	5/100	14	3/2
11	3.125/100	4	3/2
12	3.125/100	24	3/2
13	3.125/100	14	1/2
14	3.125/100	14	5/2
15	3.125/100	14	3/2
16	3.125/100	14	3/2
17	3.125/100	14	3/2
Level -1	1.25/100	4	1/2
Level +1	5/100	24	5/2

2.2.4.1 Descriptive analysis

A panel of 15 volunteers aged 20-30 years was selected on the basis of their availability, their faculty to recognize and appreciate the level of perception of the flavor, color and texture characteristic of food products. Panelists have been trained in the methodology of analysis and appreciation of qualitative characteristics selected according to the requirements of sensory analysis, trained on the taste areas of the tongue and familiarized with cakes [16]. For the sensory evaluation of *kabatôh*, panelists were invited to taste samples filled into various orders of presentation, then to fit the rating scale by indicating the value for the intensity perceived [17]. The values varied from 1, when the sensory parameter is not perceived to 14 when it is extremely felt.

2.2.4.2 Hedonic analysis

The analysis was carried out by a group of 50 people (male and female) of age understood between 20 and 40 years. The panelists have been invited to express their level of acceptance of the color, taste, texture silky, appearance in mouth and aroma. Preference tests were carried out on a 9-point hedonic scale where level 1 translated "extreme disagreeability" while 9 was "extreme pleasant" [12].

<u>2.2.5 Statistical analysis</u>

The statistical processing of the data consisted of an analysis of variance (ANOVA) with a classification criterion using the SPSS software (SPSS 16.0 for Windows, SPSS Inc.). Means were compared by the Newman Keuls test at the 5% significance level. A Principal Component Analysis (PCA) was also performed using STATISTICA software (STATISTICA version 7.1) in order to structure the variability between *kabatôh* and sensory descriptors. Data from the hedonic assays were analyzed using a Chi-square (X2) of proportions of comparison.

3 RESULTS

3.1 Physicochemical characteristics of potash

Table 3 presents the results of the characterization of the potash produced. We note a basic pH of 11.15 ± 0.05. The values of acidity and moisture are respectively 813.0 ± 3.0 mg Eq H_3O^+/100 g and 4.15 ± 0.21%. Also, the determined KOH concentration is 0.813 ± 0.03 mol / L. While the potash extraction yield represents 10.23% of the initial amount of follicles used.

3.2 Descriptive sensory profile of *kabatôh*

The intensity of the yellow color of 'kabatôh' varies from one formulation to another with $p < 0.001$ (Fig. 2). It is between 2.23 and 11.00 for a scale ranging from 1 to 14. According to the panel, the formulation F7 (2.23/14) and the control Ft (3.79/14) are the least colored. While the most marked coloration is presented by the formulation F9 (11/14).

Fig. 3A presents the evaluation of the kabatôh flavor. We notice that the sweet, salty and acidic tastes are poorly perceived by the whole panel. There is no statistical difference between the indices of these different parameters. The values expressed are between 2.34 and 5.50 for the salty taste, 1.59 and 3.86 for the sweet taste and 1.25 and 4.68 for the acid taste.

On the other hand, the texture (consistency, homogeneity and smooth appearance) of kabatôh varies significantly (P <0.001) from one formulation to another (Fig.3B).

The consistency indices are between 0.5 and 11.17. The Formulation F14 (10.96/14) and F5 (11.17/14) have a greater consistency while the lower values are observed with the formulations F12 (0.50/14), F17 (1.15/14), F3 (1.30/14), F8 (2.03/14) and Ft (2.17/14).

Regarding the homogeneity of *kabatôh*, the results indicate that the F12 formulation has the lowest index (3.40/14), whereas the F7 formulation has the most homogeneous structure (10.80/14).

As for the smooth aspect, the values are between 4.20 (F3) and 11.60 (F7).

The aroma of the *kabatôh* formulations was evaluated through the *kabatôh* aroma and the potash aroma (Fig. 3C). The results obtained indicate a variation of the indices from one formulation to another. The *kabatôh* aroma is less felt in samples F15 (6.25/14), F16 (6.31/14), F12 (6.63/14), F1 (6.67/14) and F6 (6.75/14), unlike the F9 formulation corresponding to 10.80. In addition, the values relating to the potash flavor vary from 0.10 to 10.90 respectively corresponding to the F7 and F14 formulations.

Table 3. Extraction yield and physicochemical characteristics of potash

Parameters	Values
Extraction yield (%)	10,23±0,72
pH	11,15±0,05
Acidity (mg Eq H_3O^+/100g)	813,0±3,0
Potash Concentration (KOH), mol/L	0,81±0,03
Moisture (%)	4,15 ± 0,21

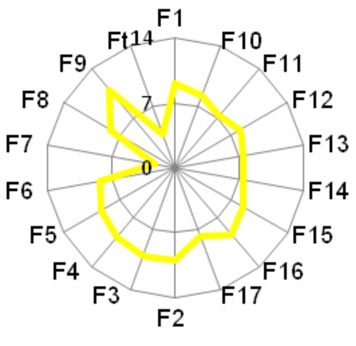

Fig. 2: Intensity of sensory perception of the yellow coloring of " *kabatôh* " formulated with corn flour and kola potash.

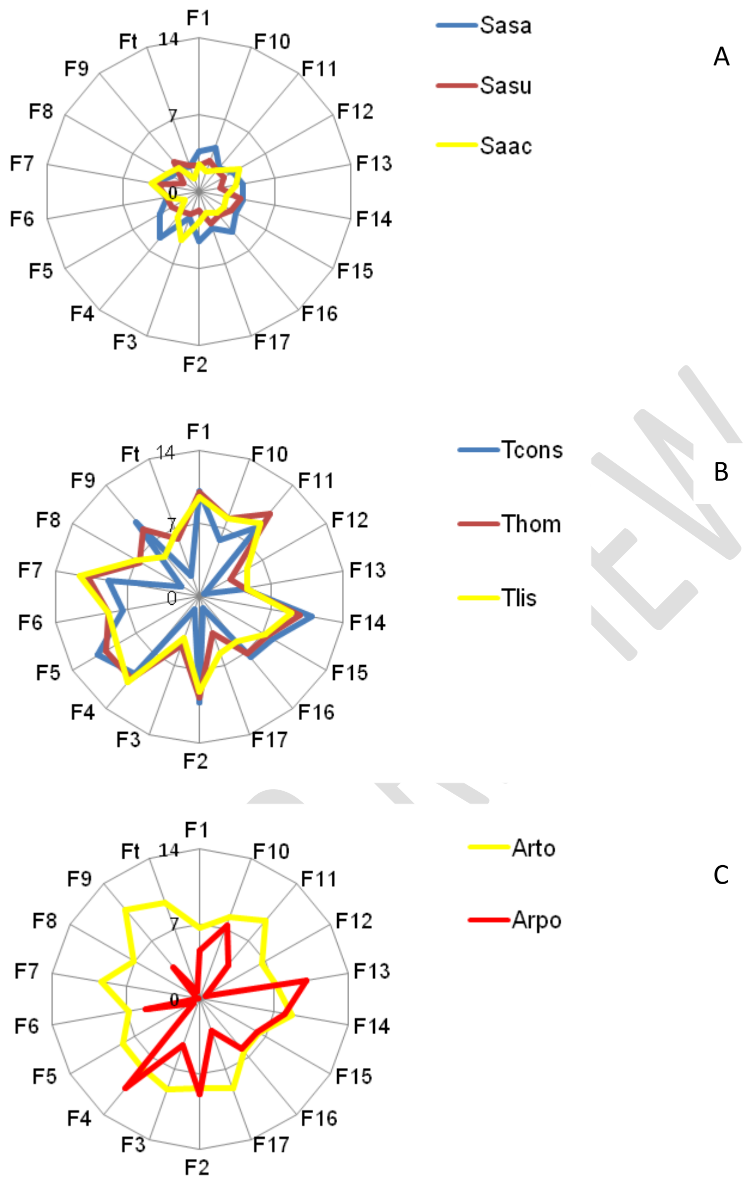

Fig. 3. Intensities of sensory perception of flavors (A), textures (B) and aroma (C) of formulations of " kabatôh " made from corn flour and cola potash

Flavors: *Sasa, salty; Sasu, sweet and Saac, acid*

Texture: *Tcons, consistent ; Thom, homogenous Tlis, smooth.*

Aroma: *Arto, tôh ; Arpo, potash*

3.3 Hedonic analysis of *kabatôh*

The sensory acceptance of tasters varies from one formulation of *kabatôh* to another. The results obtained indicate that *kabatôh* F4, F5, F7, F9, F11, F14 and F15 were considered pleasant by the panel (Table 4). The optimum conditions for obtaining these formulations are presented in the table 4. The percentage of acceptance varies from 62.15% to 86.49%, against 56.76% for the control formulation. Likewise, results obtained revealed a link between the use of potash and the quality of the flour produced. Indeed, the presence of potash during the flour production procedure increases the organoleptic characteristics of the different *kabatôh* obtained. Passing from 0 g (Ft) to 25 g (F7) of potash increases the acceptability of *kabatôh* by 35%.

Table 4: Acceptability of sensory parameters of *kabatôh*

Formulations	Corn kernel (kg)	Soaking time (h)	Water (L)	Potash (g)	Acceptability	X^2	*P*
F4	2	24	1	100	73.27	78.16	<0,0001
F5		4	5	25	62.17	59.75	<0,0001
F7		24	5	25	86.49	78.17	<0,0001
F9		14	3	25	65.72	63.85	<0,0001
F11		4	3	62,5	83.78	82.10	<0,0001
F14		14	5	62,5	74.29	56.51	<0,0001
F15		14	3	62,5	85.72	107.95	<0,0001
Ft		24	5	0	56.76	61.07	<0,0001

The values of P <0.05 reflect a significant difference between the percentages of panelists corresponding to the levels of appreciation of each sensory parameter.

3.4 Sensory variability of *kabatôh*

The F1-F2 factorial design of main component analysis, which accounts for 61.26% of the variability, shows a strong correlation between *kabatôh* F4 and F14 and taste (salty, acidic) and texture (smooth, homogeneous and consistency). Likewise, the yellow color and the potash aroma are positively correlated with F15. On the other hand, *kabatôh* F1, F5, F7, F9 and the control sample (Ft) are not associated with any of the sensory profiles studied (Fig. 4)

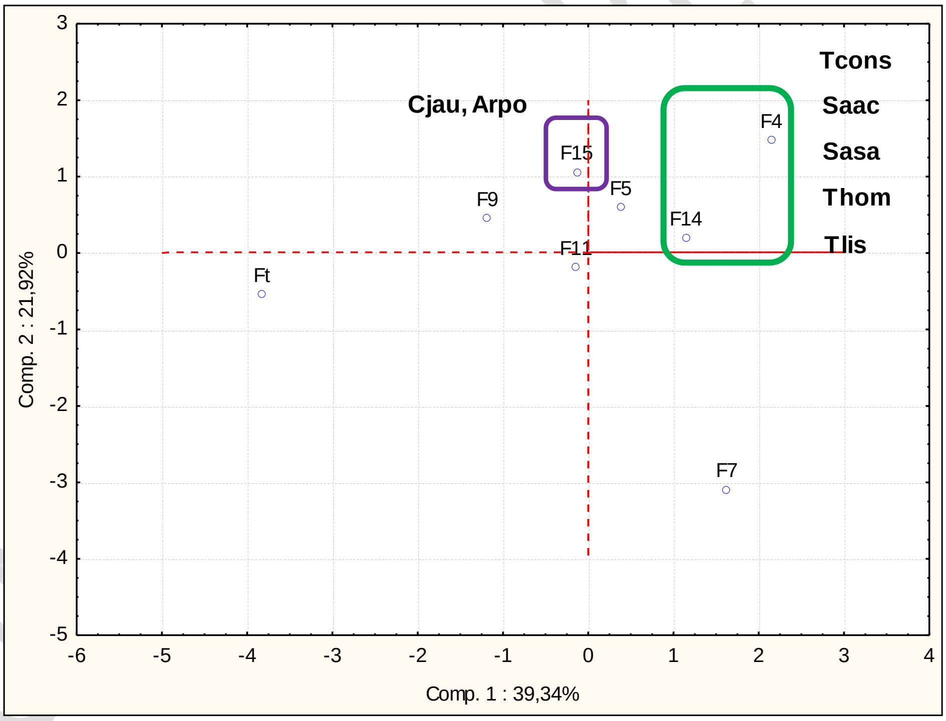

Fig.4 Distribution of the different *kabatôh* studied and their descriptors in the plan formed by the factors F1 and F2 of the analysis in principal components

Thom : homogeneity texture, Tcons : consistency texture, Tlis : smooth texture, Saac : acidic taste, Sasa : salty tatste, Cjau : yellow color ,Arpo : potash aroma,

4. DISCUSSION

The potash extraction yield from the ashes of cola follicles was 10.23 ± 0.72%. This yield is lower than those obtained on other agricultural by-products including pineapple, banana, cocoa, coffee, corn and flowers of *Elaeis guineesis*. This finding could be explained by the difference in raw materials used for incineration. Indeed, Biego et al. [1] obtained yields ranging from 46.1% (*Elaeis guineensis*) to 96.3% (*Musa sp.*). In addition, in the same species, the extraction yield varies from one organ to another. Evidenced by the yields obtained from branches (3%), female flowers (7.3%) and male flowers (7.6%)

of the species *Elaeis guineensis*.

The molar concentration of potassium hydroxide (KOH) determined was 0.81 ± 0.03 mol/L, which indicates the presence of potassium. In fact, by-product ash is an important source of minerals, especially macroelements (Ca, K, Na, etc.) and microelements (Mg, Cu, Mn, Zn, Fe, etc.), which play an important role in biological systems and promote the stability of the soil structure that is essential to optimize their fertility regulate their acidity [18,19,7]. In addition, the basic pH (11.15 ± 0.05) determined would justify its use in the regulation and stabilization of acid pH soils.

However, the results obtained indicate a humidity value of 4.15 ± 0.21%, which could indicate a rehydration of the potash during storage. According to Zhou [20], potash is hygroscopic and remoistens when stored in a high relative humidity environment. In addition, the water content of potash serve as an indicator of quality and a good control tool during storage, shipping and use [21].

The organoleptic analysis of the various *kabatôh* dishes focused on color, flavor (salty, sweet and sour), texture (consistency, homogeneity and smooth appearance) and aroma (*kabatôh* and potash). Regarding the color, its intensity is more noticeable with the formulation F9 and less with Ft and F7. This situation could be explained by the soaking conditions of corn kernels. Indeed, for the yellow coloring, the optimum conditions of production of the flour for F9 formulation require the maceration of 2 kg of corn kernels for 14 hours in 3 L of water. The amount of water used and the duration of maceration are less than those fixed for F7 and Ft formulations (5 L and 24 h). In fact, the potash that weakens the membrane of corn kernels during maceration results in the release of lipids, proteins and anthocyanins during milling. Too much maceration would therefore reduce the color of the finished product.

The use of potash in all the conditions defined in this study does not lead to a change in the flavor (salty, sweet, acid) of *kabatôh*. Thus the unsalted, unsweetened and non-acidic properties of *kabatôh* are preserved during preparation. This observation is the same as that observed during the work of Seogo [15] on the processes for making traditional maize and sorghum dishes. These authors indicated the perception of a particular taste (acid, salty) during the tasting of *kabatôh* made from potash. The *kabatôh* texture (consistency, homogeneity and smooth appearance) is an important factor in expressing the firmness of the porridge and its ability to conserve itself over time. According to Greffeuille et al. [22], African families appreciate a firm, non-sticky *kabatôh* that retains this texture during the night without surface water exudation. The formulations F14 (consistent), F5 (consistent) and F7 (homogeneous and smooth) give *kabatôh* with good texture. Thus, the conditions for obtaining a *kabatôh* of good texture requires the maceration of the corn kernels in 5 liters of water containing 25 g to 62.5 g of potassium hydroxide for 4 hours to 24 hours.

As for the flavors of *kabatôh* and potash, the soaking conditions of F9 formulation make it possible to develop the aroma *kabatôh* in the finished product, while those of the formulation F4 promote the development of aroma potash. Indeed, the latter could be due to the longer maceration time (24 h) and the high concentration of potash used, resulting from the ratio of water-potash formulation equivalent to 100 g of potassium hydroxide in 1 L of water.

In addition, the sensory acceptability of the formulations indicates a great satisfaction of the tasters for 7 formulations. More than 83% of the tasters liked the F7 (86.48%), F11 (83.78%) and F15 (85.72%) formulations, while for the F4 (67.56%), F5 (62.17%), F9 (65.72%) and F14 (74.29%) acceptance percentages vary between 60% and 74%. These percentages are higher than that of the control (accepted at 56.76%). This could be explained by the absence of potash in the preparation of the *kabatôh* control. Indeed, the acceptance results indicate that apart from the absence of potash in the formulation control (Ft), the parameters amount of maize, maceration time and amount of water used does not really influence the choice of panelists.

5. CONCLUSION

This study note that potash from kola follicles ashes is rich in potassium hydroxide. Its use in corn kernels soaking improves the color, texture and aroma of the resulting *kabatôh*. Thus, some of the formulations (F7, F11 and F15) are appreciated more than 83% of the panelists. As a result, the transformation of the follicles into potash can be a practice that both enhances the by-products of cola but also improves the organoleptic characteristics of *kabatôh*, which accounts for more than 60% of the dishes consumed in the North of Côte d'Ivoire.

COMPETING INTERESTS

Authors have declared that no competing interests exist

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