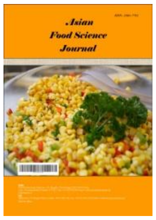

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Physicochemical and Organoleptic Characterization of Flours and Some Food Products Processed from Ten Maize Varieties *(Zea mays)* Cultivated in Côte d'Ivoire

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Authors' contributions

This work was carried out in collaboration with all authors. Author LAA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors GJN, LBK and KEA managed the analyses of the study. Authors DKP, GAG gave instructions, supervised the laboratory work and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Objective: The aim of this work was to determine the processing aptitude of maize varieties into food products to be promoted in Côte d'Ivoire.
Methodology: Three dishes have been developed from ten maize varieties (MAAN16, PGBR, PGB18, AAA3, KF18, CJB, KO/Na4, KO/Na3, KO/Wa6, and EV99MRP). The sensory criteria used for the acceptability of the food products were the taste, the flavor and the color. Prior to the preparation of maize flour based food, like cakes, cooked flour paste (tôh) and semolina porridge,

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the biochemical and physicochemical characteristics (moisture content, fat, protein content, ash content, carbohydrate, total sugar and reducers and pH) and functional characteristics of maize were determined. Hedonic and descriptive tests were performed with 30 and 15 panelists respectively.

Results: The maize varieties presented good nutritional and technological potentialities because of their high content in essential compounds likely to influence the organoleptic characteristics of the processed food. The lowest starch content was MAAN16 with 38.58 ± 0.45% dw and the highest was CJB with 71.85 ± 0.56% dw. The lowest protein content is 5.56 ± 0.17% dw at CJB and the highest protein content is 13.66 ± 0.33% dw in KO/Na3. The lowest fat content is 3.87 ± 0.12% dw (in KO/Na4) and the highest is 12.56 ± 0.50% dw (in MAAN16); the lowest carbohydrate level is 63.27 ± 0.01% dw (in MAAN16) and the highest is 74.92± 0.03% dw (in CJB). The acceptability of the cakes, the cooked flour paste and the semolina porridge depended on the maize variety. Foods prepared from maize varieties CJB, KO/Na3, KO/Wa6, MAAN16 and PGBR were the most appreciated by tasters.

Keywords: Maize; food products; physicochemical; sensory analysis.

1. INTRODUCTION

In Côte d'Ivoire, maize (*Zea mays* L.) is the most cultivated cereal after rice. Itis the staple food of many populations country wide [1]. Originating in South America, maize belongs to the Poaceaes family (Graminaceous). It can be cultivated alone or in association with other cultures such as cassava, taro, yam, palm seedlings, etc.).

The production yields have been improved with the support of research centers. Indeed, the average yields of traditional varieties in country area are about 0.8 ton per hectare, compared with 2 to 7 tons for the improved varieties [2].

It is a cereal which is more consumed in the north of Côte d'Ivoire in the form of porridge and cooked flour paste ("toh"). Several studies have shown that maize flour is used for food for children and infants. It is also used in the feed of certain animals such as poultry, pigs and cattle [1]. The food balance of maize is positive but the production yields are still insufficient as Côte d'Ivoire imports maize coming from European countries for specific needs (breweries, soap factories and oileries). The main constraints that run counter to the increase in yields of maize, millet and sorghum production are the lack of good quality seeds and the low adoption of technical routes. The prevalence of the Striga species in the northern regions, as well as the high pressure exerted by parasites such as stem and leaf borders, is also a problem. To overcome these constraints, research has developed high-yield maize varieties [1] that will address productivity and food security problems. But these new maize varieties have not been sufficiently evaluated in terms nutritional and sensory aspects. The objective of this work was to evaluate the physicochemical and functional characteristics of ten maize varieties cultivated in Côte d'Ivoire and to determine the sensory properties of local foods prepared from flour of these varieties.

2. MATERIALS AND METHODS

2.1 Raw Vegetal Material

In this study, ten maize varieties collected in various zones of Côte d'Ivoire were used as raw material (Table 1).

2.2 Production of Maize Flours

Each selected maize variety was sorted then weighed. After five successive washings the grains were dried in an oven at 45 C during 24 hours. At the end of this time, each sample was reduced to flour using a Polymix PX-MFC 90 D crusher and a 500 micrometers sieve. The flours were stored at room temperature in air tight plastic bags prior to use. The biochemical and physicochemical (moisture content, fat, protein content, ash content, carbohydrate, total sugar and reducers, starch content, acidity titrable and pH) analyses were carried out on the rough flours while the local foods were prepared from the fine flours and the semolina. obtained after sifting of the crushing using a sieve of 500 micrometers.

2.3 Preparation of Plain Cakes

The preparation of plain cakes was carried out according to the modified [3] process. Two eggs were broken by separating the whites from the yolks then the whites were beaten until they were stiff. The egg yolk, sugar (50 g) and soft butter (50 g) were mixed first in a bowl. Then a quarter of chemical yeast is incorporated into 100g of corn flour and the whole was put into the bowl. The egg white was added and the unit was mixed to obtain a homogeneous paste. The molds were buttered and floured and the paste was poured for cooking in an oven at 175°C during 30 min.

Cooking is appreciated by vertical picketing of a knife in the product and by arising it without paste on the blade. After cooking, the cakes are removed from the oven, left cooled and then unmolded.

2.4 Preparation of Cooked Flour Paste (tôh)

Fine flour (50 g) is poured into water already measured (500 ml) and previously heated. The homogeneous solution obtained is poured into a pot on the fire containing the other part of the water measured, followed immediately by homogenization with a wooden spatula to avoid lumps. The suspension is left boiled during 3 to 4 minutes. The set is rehomogenized until cooked at 100°C for 25 min. The "toh" is immediately poured into a plate and left to cool.

2.5 Maize Semolina Porridge Preparation

The corn meal (60g) is placed in a pan and 600 ml of water has been added gradually depending on the volume of the pan used. The set is left boiled and homogenized with a wooden spatula for 10 min. The rest of the water was completely reduced as the amount of water decreased until the final cooking time in 45 min. at 100°C.

2.6 Physicochemical and Functional Analysis

Each sample is placed in an oven at 105°C to a constant weight. The percentage of dry matter is calculated from moisture content. Ash, pH and titratable acidity, crude protein content and fat content were determined according to AOAC [4]. The extraction and analysis of total and reducing sugars were performed as mentioned respectively by Dubois et al. [5] and Bernfeld [6]. The determination of flour water absorption capacity (WAC) and water solubility index (WSI) was carried out in accordance with Pyler [7] and Palmer et al. [8]. The starch, amylose and amylopectin contents were determined as mentioned by method Jarvis and Walker [9].

2.7 Sensory Analysis

The sensory analyses were performed by two panelist groups: a group of 30 all-sex tasters for the ranking hedonic test and a group of 15 all-sex tasters trained for descriptive analysis.

For the ranking test, the 30 panellists beforehand gathered the samples accordig to a “smile scale” according to appreciation degrees hereafter definite “do not like at all”, “do not like much”, “indifferent”, like a little” and like much”. The panelist after having tasted all the samples, had to classify them from the most appreciated (1st) to the least appreciated (10th). For the descriptive test, descriptors which were the color, the taste, the aspect and the flavor were selected MMaccording to the criteria of [10]. Sample coding was performed using random numbers of Schwartz [11] or Donald [12] ranging from 1 to 5 on a not structured scale were assigned to the descriptors.

Table 1. Characteristics of the raw vegetal material

Variety name	Colour	Collection place	Country zone
MAAN 16	White	Manouakankro	Center
KO/Na3	Yellow	Korhogo	North
KO/Wa6	Yellow-purple	Korhogo	North
KO/Na4	Red	Korhogo	North
KF18	White-purple	Bouaké	Center
CJB	Yellow-white	Bouaké	Center
Ev99MRP	White	Ferké	North
AAA3	Yellow	San-Pedro	South-west
PGBR	Red	Man	North-west
PGB18	Yellow	Danané	North-west

2.8 Statistical Analyses

All analyses were carried out in triplicates. Results were expressed by means ± SD. Statistical significance was established using one-way analysis of variance (ANOVA) models to estimate the effects of differences between maize varieties on their physicochemical characteristics. Means were separated according to Duncan's multiple range analysis ($P = 0.05$), using the statistica 7.1 software.

3. RESULTS AND DISCUSSION

3.1 Flour Production Rate

The overall extraction rate of crude flours from the maize varieties ranged from 93% to 98% (Table 2). So starting from whole maize grains, we obtained from 39% to 44% of fine flour and from 53% to 58% of semolina. From the whole homogenate, 40 to 44% of fine flour and 59% to 60% of semolina were obtained.

The rates of the flour production (40 to 44%) and the semolina production (60%) are consistent with the results obtained by Maybelline et al. [2]. Indeed, according to these authors, starting from 100 g of maize grains, it was possible to obtain 38 g of flour (38%). In this study 39.6 g fine flour is obtained from 100 g corn grains. This result, almost identical for all maize varieties, is due to the good quality of maize grains. This result, almost identical for the all maize varieties, is due to the good quality of the maize grains. The moisture content in all these varieties is less than 12%, which helps to preserve their flour.

3.2 Biochemical Composition of the Maize Varieties Flours

The data showed that the flour content varied between 88.23 ± 0.05% (KF18) and 90.86 ± 0.10% (PGB18). There is a significant difference (P=0.05) between most varieties, with the exception of MAAN16, CJB and Ko/Wa6, which have almost the same dry matter content. Ash levels range from 1.05 ± 0.04% (CJB) to 2.12 ± 0.00% (PGB18). The protein content ranges from 5.56 ± 0.17 g/100 g dw (CJB variety) to 13.66 ± 0.33 g/100 gdw (Ko/Na3). Of the ten maize varieties, BPC (8.6 ± 0.50 g/100 g dw) and AAA3 (8.6 ± 1.91 g/100 g dw) had the highest fat content, while MAAN16 had the lowest fat content (1.9 ± 0.16 g/10 g dw) (w). The total carbohydrate content exceeds 60%, with Ko/Wa6 (74.65 ± 0.35%) and CBJ (74.92 ± 0.03%) having the highest amount of carbohydrates (Table 3). The ash levels of maize varieties are comparable to those found by (13) and (14), respectively 1.6 g/100 g and 1.05 g/100 g. These data recorded in this study are also similar to ash content in sorghum (2.10%) and wheat (2.00%) by (14). The four most ash-rich varieties of corn are PGB18, EV99MRP, PGBR and KO/Wa6. Differences in ash content can be explained by the nature of the soil and the rain that leads to soil that is low in mineral salts.

3.3 Physicochemical and Functional Properties

Titratable acidity, pH, water absorption capacity (*WAC*) and water solubility index (*WSI*) of the

Table 2. Flour extraction rates from the ten (10) maize varieties

Varieties	Rate (%)		
	Gross flour (% whole grains) ≤ 1 mm	Fine flour (% homogenate) ≤ 500 µm	Semolina (% homogenate) ≤ 1 mm
Ko/Na4	97.00	41.00	59.00
PGB18	98.00	41.00	59.00
Ko/Na3	96.60	40.00	60.00
Ko/Wa6	96.8	41.00	59,00
PGBR	93.00	41.50	58.30
MAAN 16	98.00	40.60	59.20
KF18	96.00	44.00	56.00
AAA3	98.00	40.80	59.20
EV99MRP	98.00	41.90	58.00
CBJ	98.00	39.88	59.70

Table 3. Biochemical characteristics of the ten (10) maize varieties

Varieties	Dry matter (% dw)	Proteins (% dw)	Fat (% dw)	Ash (% dw)	Total glucids (% dw)
MAAN 16	89.8 ±0.12^{d}	12.1 ± 0.20^{e}	1.9 ±0.16^{cd}	1.89 ± 0.16^{cd}	63.27 ± 0.01^{b}
Ko/Na3	89.3 ± 0.08^{c}	13.6 ± 0.33^{f}	5.3 ± 0.05^{zmp}	1.09 ± 0.17^{f}	69.35 ± 0.63^{a}
PGB 18	90.8 ± 0.10^{e}	9.8 ± 0.56^{c}	6.9 ± 0.04^{p}	2.12 ± 0.00^{d}	71.95 ± 0.02^{a}
EV99MRP	89.1± 0.03^{c}	11.9± 0.85^{e}	4.7 ± 0.21^{zm}	2.08 ± 0.30^{cd}	70.55 ± 0.21^{a}
Ko/Na4	89.2± 0.02^{c}	9.9 ± 0.35^{c}	3.8 ± 0.12^{z}	1.68 ± 0.16^{kc}	73.79 ± 0.04^{c}
CBJ	90.0 ±0.05^{d}	5.56 ± 0.17^{a}	8.6 ± 0.50^{r}	1.05 ± 0.04^{f}	74.92 ± 0.03^{c}
PGBR	89.3 ± 0.05^{c}	10.4±0.15^{cd}	6.1 ± 0.18^{mp}	2.08 ± 0.29^{cd}	70.95 ± 0.21^{a}
KF18	88.2±0.05^{a}	7.10 ± 0.09^{b}	6.7 ± 0.26^{p}	1.45 ± 0.04^{k}	72.97 ± 0.01^{p}
AAA3	88.6 ±0.25^{b}	10.97 ± 0.64^{d}	8.6 ± 1.91^{r}	1.77 ± 0.00^{kcd}	66.83 ± 0.69^{z}
Ko/Wa6	90.2 ±0.37^{d}	7.51 ± 0.37^{b}	5.3± 0.60^{zmp}	2.10 ± 0.00^{cd}	74.65 ± 0.35^{cm}

Data are expressed in terms of means ± standard deviation in triplicate analysis (n=3). Within a column, values with the same superscript letters are not significantly different at P=0.05

maize flours are depicted in Table 4. There was any significant difference ($P = 0.05$) between the pH contents in *MAAN16* and *AAA3*, in *Ko/Na3* and *EV99MRP* and also between pH contents in *Ko/Wa6*, *KF18*, *PGBR* and *PGB18* varieties. The pH values ranged from 5.94 ± 0.01 (*CJB*) to 6.44 ± 0.03 (*AAA3*). Titratable acidity being proportional to the pH, CJB variety had the highest acidity content (8.97 ± 0.05 meq / 100 g) and *AAA3* the lowest content (6.03 ± 0.07 meq / 100 g). Water absorption capacity and solubility index in water data showed that there was a significant difference ($P=0.05$) between all the varieties. The water absorption capacity of maize flour was all greater than 168%, Ko/Wa6 (209.27 ± 0.50%), EV99MRP (204.23 ± 0.49%) and Ko/Na4 (201.83 ± 0.35%). The flour most soluble in water was MAAN16 (20.49 ± 0.77%) and KF18 (20.05 ± 0.29%). The pH values of corn flour are variable and significant differences (P=0.05) are observed between the titrable acidity levels. Near-neutral pH values were obtained due to the low fermentation activity of the micro-organisms during the flour processing and hence the reduction of organic acids production and the stabilization of the pH as stated earlier by Abiodum et al.[13].

The starch granules were optimally configured with a highest contact surface, increasing the water absorption capacity. In this study, the maize varieties that flours absorbed more water are *EV99MRP* (209.27 ± 0.05% dw), *MAAN 16* (201.61 ± 0.35% dw) and *AAA3* (204.23 ± 0.49% dw). KF18 variety had the lowest water absorption capacity (168.31 ± 0.20%). This aptitude can be explained by the capacity of the water molecules to bind to a hydrophilic function of amylose and amylopectin. Moreover, the protein content can be a key factor for water absorption. Indeed, maize varieties with the highest protein content had also the highest water absorption capacity. The flour of *CJB* variety had the lowest protein content and that of *KO/Na3* the highest content. Some of our protein content data were higher than 10%, which is consistent with those reported by Boyeldieu [14] that were about 10.23% in some maize varieties and 10 to 13% in cereals in general. These flours (mainly from *KO/Na3* and *MAAN16* varieties) can be used for the preparation of complementary food for less five years old children in order to avoid under nutrition. The difference in protein content could be due to the variety, the germ bulk and soil effect. Indeed, according to Maybelline et al. [2], most part of the proteins are located in the germ.

The explanatory parameters involved in the significant differences between the rates in the maize biochemical components are the genetic origin of maize varieties and the transformation of carbohydrates into fatty acids, leading to energetic reserve and some metabolic transformations in the grains and in all the plants. Therefore, the lipid richest *MAAN16* variety contains for this reason the lowest rate of carbohydrate. The hydrolysis of lipids into free fatty acid (FFA) during ripening and the production of alcoholic and acidic compounds increased the titrable acidity of the maize flours.

3.4 Starch and Sugar Contents

Total sugars and reducing sugars contents are depicted in table 5. *PGBR* (9.62 ± 0.10 g / 100 g dw) and *KF18* (9.40 ± 0.32 g / 100 g dw) had the highest total sugars rates levels. However, *PGB18* variety had the lowest total sugars value (3.65 ± 0.38 g / 100 g dw). Furthermore, any

Table 4. Physicochemical and functional characteristics of the flour

Variétés	pH	Titrable acidity (meq /100 g)	WAC (%)	WSI (%)
MAAN 16	6.37 ± 0.00^{d}	6.30 ± 0.07^{w}	188.11 ± 1.11^{a}	20.49 ± 0.77^{d}
Ko/Na3	6.20 ± 0.01^{b}	7.70 ± 0.02^{q}	183.91 ± 0.72^{b}	18.34 ± 0.64^{b}
PGB18	6.28 ± 0.03^{c}	6.53 ± 0.01^{a}	180.57 ± 0.42^{c}	19.19 ± 0.63^{bc}
EV99MRP	6.19 ± 0.02^{b}	8.05 ± 0.15^{t}	204.23 ± 0.49^{d}	18.07 ± 0.53^{b}
Ko/Na4	6.22 ± 0.00^{b}	7.70 ± 0.01^{q}	201.83 ± 0.35^{e}	19.17 ± 0.19^{bc}
CJB	5.94 ± 0.01^{a}	8.97 ± 0.05^{f}	190.70 ± 0.77^{f}	15.17 ± 0.28^{a}
PGBR	6.29 ± 0.02^{c}	6.51 ± 0.01^{a}	177.91 ± 0.86^{g}	18.63 ± 0.18^{b}
KF18	6.27 ± 0.01^{c}	6.50 ± 0.03^{a}	168.31 ± 0.20^{h}	20.05 ± 0.29^{cd}
AAA3	6.44 ± 0.03^{d}	6.03 ± 0.07^{v}	198.56 ± 0.63^{i}	18.56 ± 0.46^{b}
Ko/Wa6	6.27 ± 0.04^{c}	6.70 ± 0.02^{b}	209.27 ± 0.50^{k}	19.80 ± 0.47

Data are expressed in terms of means ± standard deviation in triplicate analysis (n=3). Within a column, values with the same superscript letters are not significantly different at P=0.05

significant difference ($P = 0.05$) were observed between *MAAN16* (5.01 ± 0.09 g/100 g dw), *Ko/Na4* (4.81± 0.13 g/100 g dw) and *CJB* (4.67 ± 0.13 g/100 g dw). The same trend was observed between *AAA3* (5.97 ± 0.06 g / 100 gdw), *EV99MRP* (5.83 ± 0.03 g / 100 g) and *Ko/Na3* (5.72 ± 0.07 g / 100 gdw) which exhibited statistically identical total sugars rates. The levels of reducing vary from 1.39 ± 0.09 g / 100 g dw in *CJB* to 3.79 ± 0.17 g / 100 g dw in *MAAN16* and showed significant differences ($P=$ 0.05) between some varieties.

There is an underlying proportional relationship between starch, amylose and amylopectin contents in the maize flours. Starch rates ranged from 38.58 **±** 0.45% dw (*MAAN 16*) to 71.85 **±** 0.56 % dw (*CJB*). These rates were significantly different ($P=$ 0.05) in all the studied varieties. Amylose contents of the ten varieties is also statistically different ($P=$ 0.05) and ranged from 14.37 ± 0.30% dw (MAAN 16 variety) to 37.64 ± 0.41% dw (*CJB* variety). Amylopectin rates were higher than those of amylose and varied between 24.32 ± 0.36% dw (*MAAN 16*) and 37.38 ± 0.41% dw (*KF 18*). *MAAN 16* (24.32 ± 0.36% dw) and *EV99MRP* (25.62 ± 0.44% dw) were the two varieties with the lowest amylopectin content.

Maize flour contains few amount of sugars. Inside the grains, total sugar rates ranged from 1 to 3%. Data recorded for simple sugars, were consistent with those of sucrose ranging from 4% to 8% dw in maize after 15 to 18 days of pollination. *CJB, PGB18* and *KO/Na3* varieties presented a low amount of simple sugars but *PGBR* and *KF18* have the highest with sugar values of 9.4%. That is an important parameter to consider in the formulation and preparation of maize based food.

The starch rates recorded in this study are in general comparable to those of Regent [15] and Standstead et al. [16]. For these authors, starch amount ranges from 68% dw to 73% in maize grains. However, some results are lower than those of these authors. This difference could be due to the long duration of post-harvest preservation of maize grains, leading to the degradation of maize starch by α-amylase enzymatic reaction.

The rates of amylose and amylopectin, the main starch components, are conformable with the data reported by Standstead et al. [16]. They attested that in general, amylopectin rate is higher than amylose rate in maize grains. However, in our study, amylose rate in CJB variety is higher than that of amylopectin. Boyer and Shannon [17] points that this can be explained by the fact that some genes, alone or in combination, are able to modify the proportion of amylose and amylopectin in maize flour. Precisely, an albumen mutant called amylose-extender, can induce an increase of amylose rate by more than 50%. [2].

3.5 Organoleptic Characteristics of the Dishes

3.5.1 Food products preparation

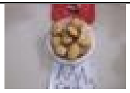
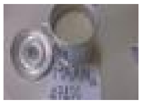
The food products were prepared starting from maize flours according to the same cooking “Time/Temperature” couples. After several formulation and cooking trials, the suitable

Table 5. Total glucids contents of the ten (10) maize varieties

Varieties	Starch (% dw)	Amylose (% dw)	Amylopectin (% dw)	Total sugars (% dw)	Reducingsugars (% dw)
MAAN 16	38.58 ± 0.45^{a}	14.37 ± 0.30^{a}	24.32 ± 0.36^{k}	5.01 ± 0.09^{b}	3.79 ± 0.17^{d}
Ko/Na3	53.10 ± 0.50^{d}	20.00 ± 0.60^{b}	33.11 ± 0.39^{p}	5.72 ± 0.07^{c}	2.43 ± 0.04^{b}
PGB 18	50.65 ± 0.07^{c}	17.84 ± 0.26^{c}	32.80 ± 0.66^{p}	3.65 ± 0.38^{a}	2.97 ± 0.12^{c}
EV99MRP	46.49 ± 0.45^{b}	21.06 ± 0.38^{d}	25.62 ± 0.44^{a}	5.83± 0.03^{c}	3.19 ± 0.03^{c}
Ko/Na4	50.14 ± 0.34^{c}	23.36 ± 0.63^{e}	26.73 ± 0.46^{t}	4.81 ± 0.13^{b}	3.22± 0.07^{c}
CBJ	71.85 ± 0.56^{h}	37.64 ± 0.41^{f}	34.20 ± 0.16^{q}	4.67 ± 0.13^{b}	1.39± 0.09^{a}
PGBR	63.08 ± 0.15^{e}	31.32 ± 0.49^{g}	31.76 ± 0.29^{m}	9.62 ± 0.10^{e}	3.63 ± 0.13^{d}
KF18	65.09 ± 0.14^{f}	27.70 ± 0.38^{h}	37.38 ± 0.41^{b}	9.40 ± 0.32^{e}	3.04 ± 0.22^{c}
AAA3	62.43 ± 0.36^{e}	26.48 ± 0.60^{i}	35.94 ± 0.22^{c}	5.97 ± 0.06^{c}	3.62 ± 0.25^{d}
Ko/Wa6	70.71 ± 0.74^{g}	34.35 ± 0.49^{j}	36.35 ± 0.80^{c}	6.55± 0.20^{d}	2.34± 0.07^{b}

Data are expressed in terms of means ± standard deviation in triplicate analysis (n=3). Within a column, values with the same superscript letters are not significantly different at P=0.05

Table 6 (a,b). Food products prepared from the ten (10) maize flours

a)				b)			
Variétie	**Cake**	**Cooked flour paste**	**Semolina porridge**	**Variéties**	**Cake**	**Cooked flour paste**	**Semolina porridge**
Ko/Na 3				*AAA3*			
CJB				*MAAN16*			
PGBR				*KF 18*			
PGB 18				*Ko/Wa6*			
Ko/Na 4				*EV99MRP*			

"time/Temperature" couples were: 170°C / 30 min for the cakes, 100°C / 25 min for cooked flour paste (tôh) and 100°C / 45 min for the semolina porridge (Table 6).

The fat levels in our study ranged in general from 3, 87% dw to 12, 56% dw. This rate is comparable to those of Poneleit [18] with values recorded from 3% to 18% dw. Other data recorded, around 10% dw, were consistent with those reported by [13]. *AAA3, MAAN16* and *CJB* varieties have the highest rate of fats and can be used for processing of food oils and some dishes such as cooked maize paste.

3.5.2 Sensory classification by the sum of rows

After the tasting of different cooked flour paste dishes ("tôh"), the sums of rows ranged from the 45th and the 86th positions (Table 7). There was not a significant difference (*P= 0.05*) between "tôh" prepared starting from *EV99MRP* (72th ±1), *KF18* (70th±2.88), *KO/Na3* (69th±1) and those prepared starting from *MAAN16* (57th ±1.52) and *KO/Wa6* (59th ±0.57). Notations attributed by the same panelists after the tasting of maize semolina porridge were added. The notes vary between the 45th and the 83th positions and show any significant difference (*P= 0.05*) between *CJB* (53th) and *PGBR* (52th), *EV99MRP* and *KO/Na4*, and between *KF18* and *KO/Wa6*. That is to say that the suitability of the three dishes was variously expressed by the panelists. However, plain cakes prepared from fine flours of *MAAN* 16 (73th), *KO/Na3* (95th), *AAA3* (97th) and *PGBR* (98th) exhibited the most pleasant taste. Concerning cooked flour pastes (tôh), those prepared from *CJB* (45th), *MAAN 16* (57th) and *KO/Wa6* (59th) were considered to be more delicious, but the "tôh" of the *PGBR* variety was rejected by 50% of the tasters. The tasters indicated that semolina porridges prepared from *MAAN 16* (45th), *PGBR* (52th) and *CJB* (53th) were the best. For this hedonic test, 6% of the panelists (2 out of 30) decidedly rejected the natural cakes of the varieties *KF18* and *KO/Wa6*.

3.5.3 Sensory descriptive tests

The results of the descriptive tests revealed that there were no significant differences (*P=0,05*) between the notations attributed by the panelists to the cooked flour pastes, the plain cakes, and the maize semolina porridges for the relevant sensorial descriptors such as the color, the taste, the consistency or the aspect and the aroma (Figs. 1, 2 and 3).

3.5.3.1 Descriptive tests of the plane cakes

Concerning the color sensory evaluation, after tasting the plain cakes by 15 trained panelists, the average data obtained range from 1.98 ± 0.71 (*MAAN 16*) to 3.30 ± 1.06 (*CJB*) (Fig. 1). As a whole, one group of varieties, namely *AAA3, KO/Na3, KO/Na4, MAAN16, PGBR* and PGB18, emerged and exhibited no significant difference (*P= 0,05*) between their color. Moreover, the color of *KF18* (2.9 ± 0.89), *EV99MRP* (3.05 ± 1.14) and *CJB* (3.30 ± 1.06) were more pleasant than those of the other cakes. For the savor and the aroma, the average data range from 1.91 ± 0.79 to 2.94 ± 0.87 and from 1.85 ± 0.50 to 3.21 ± 0.56 and showed no significant differences (Fig. 1).

3.5.3.2 Descriptive tests of the "toh"

The cooked flour pastes (tôh) obtained were characterized by three main colors, white (*MAAN16, EV99MRP, AAA3*), yellow (*KO/Na4, KO/Na3, PGB18, CJB, KF18, KO/Wa6*) and brown (*PGBR*). Concerning the taste, the two predominant sensorial sub-attributes are « sweet taste » and « neutral taste ». Similarly, for the consistency, we obtained soft cooked flour pastes and hard compact cooked pastes such as that of *CJB* variety. The less hard cooked paste was obtained from *KF18* variety with mean data of 2.22 ± 0.56 and the hardest cooked paste was obtained from *CJB* variety with mean data of 3.58 **±** 0.69. There were not a significant difference (*P=0.05*) between the consistency of the cooked paste prepared from *EV99MRP, KO/Na3, KO/Na4, KO/Wa6* and *PGBR* varieties. According to the panelists, fragrances that emerged most from these foods were like those of roasted cereals, French fries and hazelnuts. The mean data ranged from 1.98 **±** 0.53 and 3.54 ± 0.80 (Fig. 2).

Table 7. Ranking test of cakes (SRPC), cooked flour paste (SRCFP) and maize semolina porridge (SRMSP)

Varieties	SRPC	SRCFP	SRMSP
MAAN 16	73th ±1.08^{a}	57th±1.52^{b}	45th±0.67^{m}
Ko/Na3	95th±1.72^{b}	69th±1.00^{c}	83th±2.08^{y}
PGB 18	103th±2.00^{e}	64th±1,90^{f}	75th±0.57^{d}
EV99MRP	100th±1.57^{c}	72th±1.00^{c}	81th±1.52^{yp}
K_O/Na4	99th±1.00^{c}	77th±1.15^{d}	79th±2.64^{p}
CBJ	107th ± 1.52^{d}	45th± 2.05^{a}	53th± 0.57^{f}
PGBR	98th ± 2.00^{c}	86th ± 1.52^{e}	52th ± 1.30^{f}
KF18	125th ± 2.08^{f}	70th ± 2.88^{c}	68th± 1.93^{z}
AAA3	97th ± 1.59^{c}	74th± 2.51^{d}	73th±2.00^{d}
K_O/Wa6	105th± .70^{ed}	59th ± 0.57^{b}	68th ± 0.59^{z}

Sum of rows attributed by 30 panellists after tasting of plain cakes, cooked flour pastes and maize semolina porridges . Within a column, values with the same superscript letters are not significantly different at P=0.05
SRPC: Sum of rows for plain cakes; SRCFP: Sum of rows for cooked flour paste
SRMSP: Sum of rows for maize semolina porridge

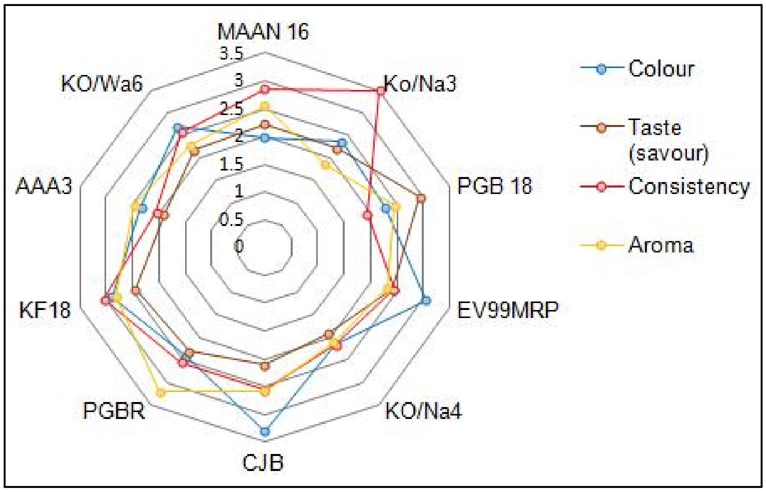


Fig. 1. Mean data for plain cakes descriptive test

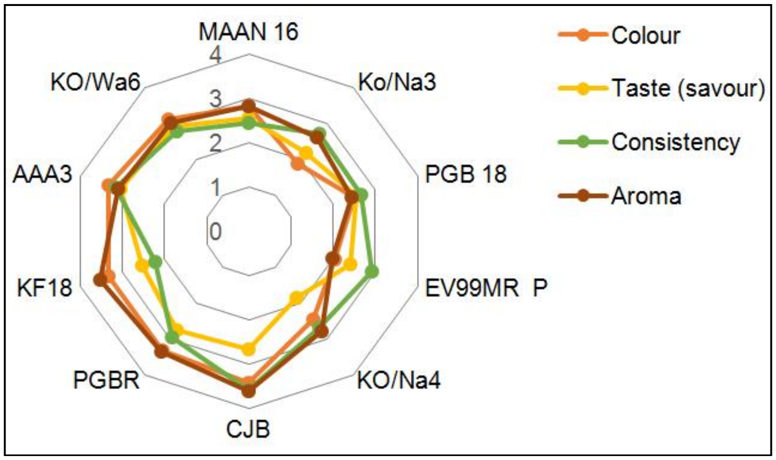


Fig. 2. Mean data for cooked paste descriptive test

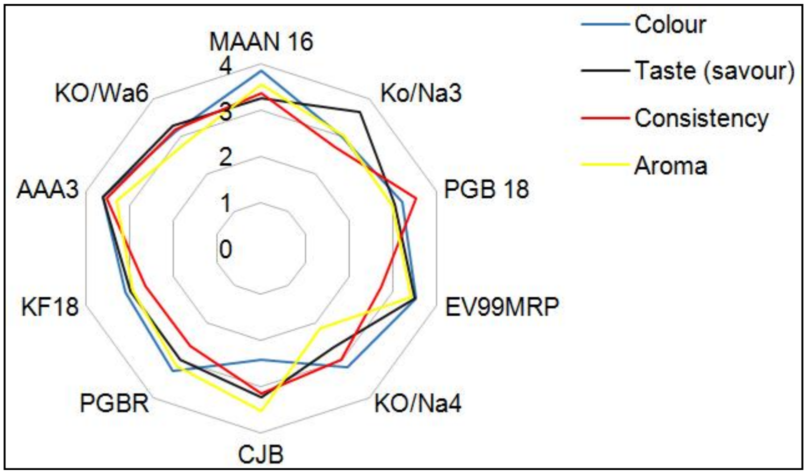


Fig. 3. Mean data for semolina porridge descriptive test

3.5.3.3 Descriptive tests of semolina porridges

The first characteristic color of the processed semolina porridges was « pale yellow » and the second color is white. The higher is the notation the nearer the color is white. *MAAN 16* (3.85 ± 0.60), *AAA3* (3.62 **±** 0.78) and *EV99MRP* (3.55 ± 0.64) varieties were classified in this category. The variety was as more yellow as its rating out of five was smaller. Mostly two sensorial sub attributes, « soft » and « sweetened taste », influenced the overall taste of the porridges. The most soft and sweet porridges were those that ratings were near to five. Within Between the all attributes, there were significant differences (*P=0.05*) as depicted in the Fig. 3.

Physicochemical and functional properties are the key factors both for the successful processing of local dishes and for the expression of their best organoleptic and nutritional qualities. Food dishes (such as plain cake, cooked paste, semolina porridge) from the *white MAAN 16*, the yellow-red *CJB*, the yellow-purple *KO/Wa6*, the red *PGBR* and the yellow *KO/Na3* varieties were more palatable than food from the other maize varieties. This difference is linked to the maize grain physicochemical composition, particularly the simple sugars and lipid rates and the rheological properties of the dough.

4. CONCLUSION

The aim of this work was to determine the processing aptitude of maize varieties into food products usually consumed or likely to be promoted in Côte d'Ivoire. Indeed, high nutritional quality dishes such as cakes, cooked flour paste (tôh) and were prepared starting from the flours of these maize varieties. The sensorial quality of the food products would be linked to the physicochemical properties of the maize grains. So, cooked flour pastes (tôh), obtained from *CJB, MAAN16* and *KO/Wa6* varieties were the most appreciated by the panellists. Furthermore, *CJB, PGBR* and *MAAN16* would be suitable for the maize semolina porridge preparation; *MAAN16* and *KO/Na3* would be suitable for the production of simple corn cakes of good quality.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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