ORIGINAL ARTICLE

ABILITY TO PRODUCE ALLOCO (FRIED PLANTAIN) FROM SOME PLANTAIN (*Musa paradisiaca* L. 1753) HYBRIDS

| Ebah Djedji Bomoh Catherine [1*] | Louis Ban Koffi [1] | N'Goran-Haddad Patricia [1] | Koné Kisselminan [2] | Serge Kouakou Kouassi [2] | Traoré Siaka [3] | and | Kouakou Amani [4] |

[1*] Centre National de Recherche Agronomique | Station de Recherche Technologique | Laboratoire de Chimie Technologie des Aliments | Côte d'Ivoire| BP 31 Bingerville.
[2.] Institut National Polytechnique Félix Houphouët-Boigny | Ecole Nationale d'Agronomie | Groupe de Nutrition et Technologie Alimentaire | Côte d'Ivoire| BP 1313 Yamoussokro.
[3.] Centre National de Recherche Agronomique | Station de Recherche sur le Plantain| Banane et Ananas | Bimbresso, Côte d'Ivoire, BP 1536 Abidjan |
[4.] Centre National de Recherche Agronomique | Station de Recherche sur les Cultures Vivrières | Côte d'Ivoire, BP 633, Bouaké |

ABSTRACT

Objective: This study was conducted to evaluate the frying suitability of some plantain hybrids for Alloco production. **Methods**: Four plantain hybrids (3 Vert, FHIA 21, PITA 3 and BITA 3) and the control variety (ORISHELE) were studied. Physico-chemical characteristics (soluble solids (SSE), dry matter, ash, lipids, fiber, reducing sugars, total carbohydrates and starch contents) of plantain at different stages of ripening were determined. Subsequently, the plantain varieties were processed into fried plantain (alloco) and a sensory analysis was conducted. Also, a study of the possible correlations of some physicochemical characteristics with the perception of the intensity of sensory attributes was conducted. Finally, the influence of the perception of the intensity of the attribute on its appreciation was determined. The evaluation of the acceptability of the hybrids was carried out in order to promote their adption. **Results:** The physico-chemical results observed showed a decrease in dry matter content during ripening, while sugar and lipid content increased. The results of the intensity perceptions of the attributes showed that the opinions of the tasters were correlated with certain physicochemical parameters (sugar and starch contents). In addition, intensity perceptions of certain attributes significantly influenced their appreciation. Perceived sweetness intensity had a significant influence ($P < .05$) on sweetness appreciation. Thus, sweeter fried plantains were appreciated by consumers. **Conclusion**: The global appreciation scores allowed us to rank the varieties in descending order. The variety 3 Vert (6.62) was in first position followed by PITA 3 (6.57), FHIA 21 (6.49), ORISHELE (6.45) and BITA 3 (6.17). The means of global appreciation did not present significant differences at the 5% threshold.

Key words: hybrids, plantain, sensory evaluation, physicochemical composition

1. INTRODUCTION

The plantain, because of its nutritional, food and socio-economic importance, is classified among the starchy products of great consumption. Plantain cultivation is an important source of employment and income. Plantain is a staple and self-sufficiency food for people in Sub-Saharan Africa as USDA (2013) [1]. In Côte d'Ivoire, plantain has always remained a very important food for the populations of the south, east and west. With a national production estimated at more than 1,600,000 tons in 2016. Plantain is among the most consumed foodstuffs in Côte d'Ivoire after rice and yam of FAOSTAT (2016) [2]. This production allows the country to occupy the 6th and 8th rankings respectively at the African and global level of plantain producing countries of Perrin (2015) [3].

Despite its importance, the plantain sector experiences periods of shortages due to the lack of robust and resistant plant material. The use of this less robust plant material has thus contributed to the decrease in yields as well as to the inflation of prices on the market. Indeed, threats such as fungal, bacterial and viral diseases and insect pests currently weaken plantain production of Assemand et al., (2012) [4]. These threats, which are quite diverse, cause losses of up to 40% of production of Coulibaly et al., (2007) [5]. Research conducted by the Centre National de Recherche Agronomique (CNRA) led in 1998 to the introduction of the PITA 3 and FIHA 21 varieties, which are characterized by high production yields (25 to 30 tons/ha) and resistance to cercosporiose Perrin (2015) [3]. However, the advent of climate change, continued deforestation and decreasing rainfall are raising new questions about the development of more robust germplasm.

It is in this context that the CNRA and the International Institute of Tropical Agriculture (IITA) are experimenting with plantain hybrids. The introduction of these new high-productivity and disease-resistant varieties would be a major asset in improving yields and the availability of plantain on the Ivorian market. However, it must be noted that despite agronomic satisfaction (high resistance and high yield) and improved nutritional values, these new varieties introduced do not have the full support of consumers. This would be due to the unsuitable culinary applications that consumers face to these hybrids. Consumers tend to bring back the culinary habits they have with the local or traditional varieties they are already used to.

It would be important, however, in the case of plantain, to adapt the culinary applications of the hybrids according to the stages of ripening.

It is in this context that this study aimed to investigate the suitability of some plantain hybrids for the production of fried plantain (alloco).

2. MATERIAL AND METHODS

2.1. Material

The material used was plantain (Musa x AAB). Four hybrids, namely BITA 3, FHIA 21, PITA 3, 3 Vert, and a control variety ORISHELE were studied. These fruits come from the experimental plantations of the National Center of Agronomic Research (CNRA) of the station of Azaguié located at approximately 50 km in the East of Abidjan.

2.1.1. Plantain frying process: This stage was carried out on the basis of several observations. Thus, for the preparation of Alloco (fried ripe plantains), the plantain fruits were selected at different stages of ripening according to their firmness to the touch. The yellow turning stage is taken for the hybrid BITA 3, fully yellow for the hybrid PITA 3, the hybrids FHIA 21, 3 Vert and the variety ORISHELE were used at the yellow stage with black spots.

The selected plantains were washed, peeled and then the pulps were cut into slices. The slices were fried at a pulp/oil ratio of 1:6 at 150°C using a deep fryer (CAMPOMATIC FryDay) for 10 minutes.

2.1.2. Physicochemical analysis: Dry matter (DM) and ash contents were determined gravimetrically according to the methods described by AOAC (1955) [15]. The fiber content was evaluated according to the BIPEA method (1976) [16]. Soluble solids were measured using the AFNOR method (1992) [17]. Fat content was determined by Soxhlet according to the BIPEA method (1976) [16].

Reducing and total sugars were determined respectively according to the methods of Bernfeld (1955) [6] using DNS (dinitro-3,5- salicylic acid) and Dubois *et al.* (1956) [7] using sulfuric phenol and sulfuric acid. Total carbohydrate and starch contents were determined according to the calculation methods recommended by FAO (2003) [8]:

$$\text{Carbohydrate (\% DM)} = 100 - (P\ (\%\ DM) + G\ (\%\ DM) + C\ (\%\ DM)) \qquad \textbf{(1)}$$

With:
P: protein content (%) in % DM, G: fat content (%) in % DM,
C: ash content (%) in % DM, G: carbohydrate content (%) in % DM
Starch content = 0.9 (Total carbohydrate content-Total sugar content) (2)

2.1.3. Sensory analysis

2.1.3.1. Taster panel and questionnaires: The panel of tasters is made up of sixty people, ranging in age from 20 to 70 years. All the panelists are knowledgeable consumers of the dishes to be evaluated. The characteristics that were retained for the alloco were color, tenderness, fatty aspect, sweetness and saltiness. The questionnaire consisted of a first hedonic rating table where the consumer had to give his appreciation and a second one where he had to note his feeling concerning the intensity of the attribute.

2.1.3.1. Statistical analysis: Principal component analysis, correlation analysis, variance analysis (KRUSKAL-WALLIS and ANOVA) and mean comparison tests (DUNCAN and KRUSKAL-WALLIS) were used. These analyses were performed using software such as R i386 3.6.1, Statistica 7.1 and Excel 2013. They were used to establish statistical differences at the 5% threshold.

2.2. RESULTS

2.2.1. Physicochemical characteristics

Table 1 presents the physicochemical characteristics of the varieties BITA 3, PITA 3, FHIA 21, ORISHELE and 3 VERT taken at the green stage. Significant differences were observed between the dry matters contents of all the varieties studied. The hybrid 3 Vert gave the highest dry matter rate (40.15 g/100 DM), while the lowest rate was obtained with the hybrid BITA 3 (33.5 g/100 DM). The PITA 3 variety had the highest ash content (1.88 g/100 DM), but no significant differences were observed between the ash content of the other plantain varieties. Regarding fiber, the ORISHELE variety had the lowest levels (8.59 g/100 DM), and the highest were obtained by the hybrid 3 Vert (11.08 g/100 DM). Significant differences were not observed between the fiber content of BITA 3, PITA 3 and FHIA 21. Lipid content varied significantly between varieties, with BITA 3 giving the highest values (0.68 g/100 DM), while PITA 3 gave the lowest values (0.36 g/100 DM). No significant differences were observed between the soluble solids levels of the different varieties studied, which ranged from 12.1 to 12.5 g/100 DM. On the other hand, the rates of total carbohydrates, reducing sugars and starch vary significantly between the varieties. The variety ORISHELE gives the highest values of total carbohydrates (96.08 g/100 DM), the hybrid 3 Vert has the highest levels of reducing sugars (1.88 g/100 DM) and BITA 3 gives the highest starch levels with a value of 80.90 g/100 DM. The Physicochemical characteristics of the plantains that entered the different stages of ripening are recorded in Table 2.

The dry matter contents of the different varieties ranged from 29.66 to 38.15%, with hybrid 3 Vert at the yellow stage with black spots recording the highest contents (38.15%), while BITA 3 at the turning-yellow stage gave the lowest contents (29.66%). Regarding ash, the hybrid PITA 3 (yellow stage) gave the highest levels (3.18 g/100 DM) and BITA 3 (yellow turning stage) recorded the lowest levels with a value of 2.66 g/100 DM.

The fiber and lipid contents vary significantly from one variety to another, ranging from 10.75 g/100 DM (BITA 3 yellow turning stage) to 6.63 g/100 DM (ORISHELE yellow with black spots), and from 0.38 g/100 DM for PITA 3 (yellow turning stage) to 0.68 g/100 DM for BITA 3 (yellow turning stage). As for the soluble dry extracts, significant differences were not observed between PITA 3, FHIA 21, ORISHELE and 3 Vert, their values were between 17.7 and 18.1 g/100 DM. On the other hand, the hybrid BITA 3 (yellow turning stage) recorded significantly the lowest levels (15.8 g/100 DM). However, significant differences were not observed in the total carbohydrate contents of all varieties, which ranged from 94.08 to 94.37 g/100 DM. Regarding the contents of reducing sugars and starch, the hybrid BITA 3 (yellow turning stage) presents the lowest contents of reducing sugars (2.72 g/100 DM) and the highest values of starch (58.07 g/100 DM). While, hybrid 3 Vert (yellow with black spots) records the highest sugar contents (6.56 g/100 DM) and hybrids PITA 3 (yellow stage) and ORISHELE (yellow with black spots) give the lowest starch contents (49.32-49.36 g/100 DM).

Table 1: Physicochemical characteristics (**g/100 g of DM**) of plantain varieties at green stage.

Varieties	Dry matter	Ash	Fiber	Fat	Soluble solids	Total carbohydrates	Reducing sugars	Starch
BITA 3 (TJ)	33,5±0,07 a	1,74±0,02 a	10,92±0,08 bc	0,68±0,00 a	12,1±0,01 a	95,45±0,03 a	1,04±0,28 a	80,90±0,03 a
PITA 3 (J)	35,91±0,07 b	1,88±0,01 b	10,69±0,44 bc	0,36±0,00 b	12,4±0,01 a	95,78±0,00 a	1,26±0,00 a	79,62±0,02 b
FHIA 21 (TJN)	36,65±0,11 bc	1,78±0,02 a	10,25±0,29 b	0,52±0,00 c	12,5±0,02 a	95,74±0,02 a	1,46±0,28 ab	80,11±0,12 c
ORISHELE (TJN)	36,95±0,49 c	1,76±0,01 a	8,59±0,14 a	0,48±0,00 d	12,1±0,01 a	96,08±0,08 a	1,46±0,28 ab	79,93±0,07 cd
3 VERT (TJN)	40,15±0,07 d	1,78±0,01 a	11,08±0,3 c	0,40±0,00 e	12,3±0,01 a	95,82±0,03 a	1,88±0,28 b	79,80±0,06 d

Values in the same column followed by different letters are significantly different at the 5% level. **FM**: fresh matter; **DM**: dry matter, **TJ**: turning-yellow stage; **J**: yellow stage and **JTN**: yellow stage with black spots

Table 2: Physicochemical characteristics (**g/100 g of DM**) of plantain varieties at different stages of ripening.

Varieties	Dry matter	Ash	Fiber	Fat	Soluble solids	Total carbohydrates	Reducing sugars	Starch
BITA 3 (TJ)	29,66±0,07 a	2,66±0,04 a	10,75±0,07 c	0,68±0,00 a	15,8±0,07 a	94,37±0,01 b	2,72±0,28 a	58,07±0,00 a
PITA 3 (J)	32,27±0,05 b	3,18±0,02 c	8,28±0,59 b	0,38±0,01 b	17,7±0,04 b	94,11±0,03 b	4,64±0,00 b	49,32±0,08 b
FHIA 21 (JTN)	32,88±0,11 bc	3,1±0,07 bc	7,59±0,15 d	0,54±0,00 c	17,9±0,03 b	94,08±0,02 b	4,88±0,88 b	52,31±0,46 c
ORISHELE (JTN)	33,66±0,20 c	3,025±0,1 bc	6,63±0,08 a	0,53±0,00 d	17,9±0,02 b	94,15±0,01 b	5,4±0,58 b	49,36±0,02 b
3 VERT (JTN)	38,15±0,36 d	2,94±0,05 bc	8,67±0,26 b	0,42±0,00 e	18,1±0,01 b	94,10±0,04 b	6,56±0,58 c	50,19±0,1 d

Values in the same column followed by different letters are significantly different at the 5% level. **FM**: fresh matter; **DM**: dry matter; **TJ**: turning-yellow stage; **J**: yellow stage and **JTN**: yellow stage with black spots.

2.2.2. Sensory analysis

Differences in perception of attribute intensity.
Table 3 shows the averages of the tasters' ratings of perception. Alloco tenderness of BITA 3 and PITA 3 hybrids has the highest means (7.21 and 6.98). The fat test gives results with non-significant differences. The hybrids FHIA 21 and 3 Vert had the highest average values for fat. For sweetness, the alloco of PITA 3, FHIA 21, and 3 Vert hybrids have the highest intensity averages.

2.2.3. Correlation between sensory attributes and the overall rating (APG) of plantains

Figures 1, 2, 3, 4 and 5 present the results of the principal component analysis performed on the varieties BITA 3, FHIA 21, ORISHELE, PITA 3 and 3 Vert respectively.

Table 3: Perceived level of intensity of sensory attributes by tasters.

	BITA 3 (TJ)	PITA 3 (J)	FHIA 21 (JTN)	ORISHELE(JTN)	3 VERT (JTN)
Tenderness	7.21 ± 0.86 a	6.98±1.30 a	6.18 ± 1.18 b	5.96 ± 1.64 b	6.16±1.85 b
Fat	6.28 ± 1.02 a	6.23±1.18 a	6.36 ± 1.16 a	5.96 ± 0.95 a	6.53±1.56 a
Sweet	5.68 ± 1.20 a	6.80±1.42 b	6.86 ± 1.32 b	6.38 ± 1.33 b	7±1.1 b

Values in the same row followed by different letters have significant differences at the 5% level. **TJ**: turning-yellow stage; **J**: yellow stage and **JTN**: yellow stage with black spots.

In general, the attributes (color, tenderness, fat, sweetness and saltiness) and the general appreciation (APG) move in the same direction for all varieties, due to the positive correlation coefficients. The GPA of all varieties is therefore

due to the combination of the five attributes. On the other hand, the correlation coefficients and the importance or not of an attribute differ from one variety to another.

Thus, sweetness is the most important attribute in the overall assessment of BITA 3 and FHIA 21. For these two varieties, the highest correlation coefficient is expressed between the sweetness variable and APG (BITA 3, r= 0.72 and FHIA 21, r= 0.78). For the variety ORISHELE and the hybrid PITA 3, the fatty aspect is the most important attribute with respective correlation coefficients of r= 0.83 and r= 0.7. For the 3 Vert hybrid, it is rather the tenderness aspect with r= 0.72 that is the most important attribute of the alloco.

Overall, the results showed that for all varieties, the salty aspect has the lowest correlation coefficients, so it is the least important attribute in the alloco of all the plantains studied.

2.2.4. Consumers' overall rating

The results of the overall assessment for each attribute were recorded in Table 4.

In terms of color, there was a significant difference in appreciation between the plantains. The hybrid BITA 3 was the least appreciated for its color while the variety ORISHELE was the best appreciated.
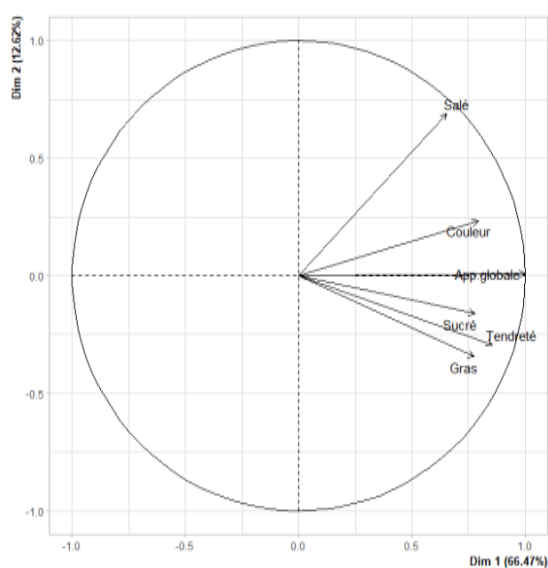

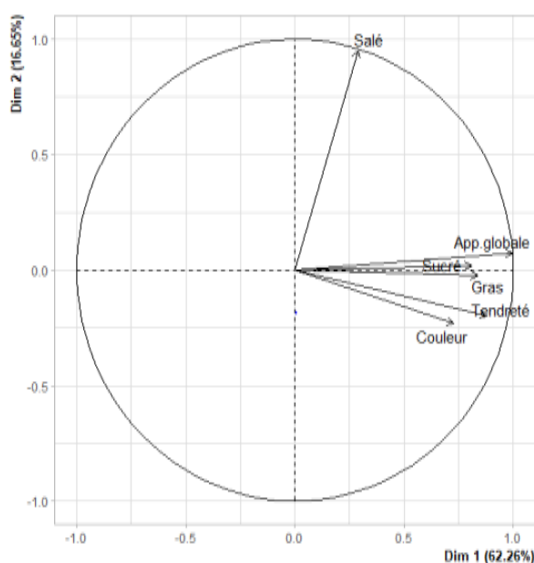**Figure 1:** Correlation circle between sensory attributes and overall appreciation of the BITA 3 hybrid.

Figure 2: Correlation circle between sensory attributes and overall rating of the FHIA 21 hybrid.
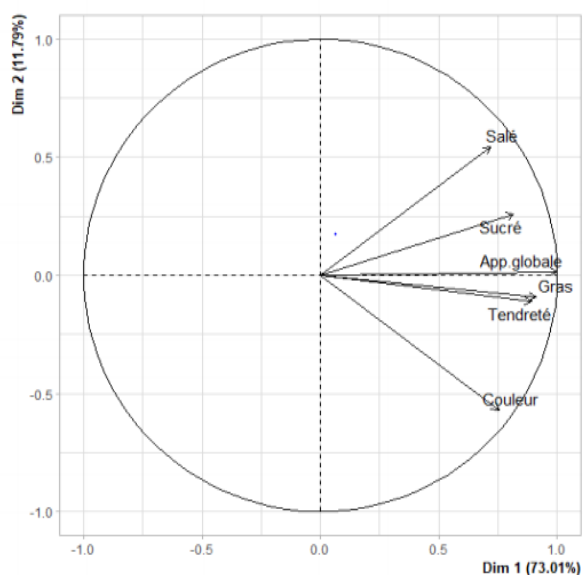

Figure 3: Correlation circle between sensory attributes and overall appreciation of the ORISHELE variety.
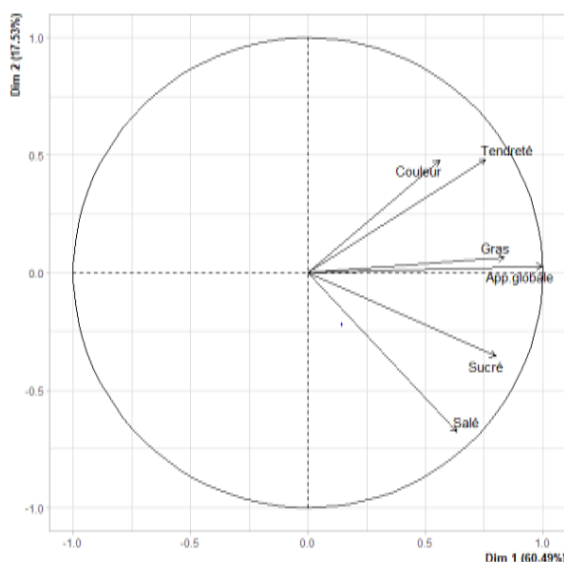

Figure 4: Correlation circle between sensory attributes and overall appreciation of the PITA 3 variety.
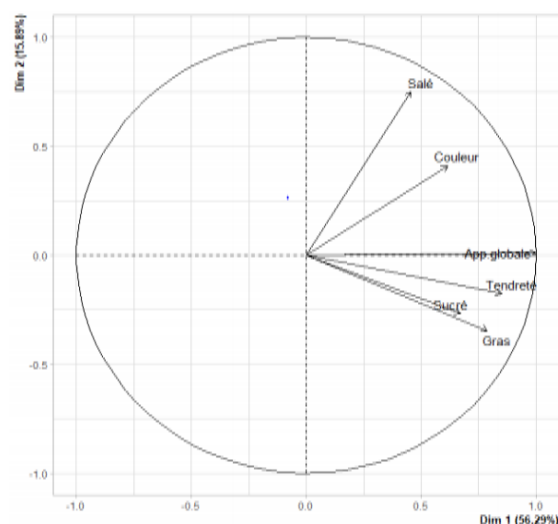
Figure 5: Correlation circle between sensory attributes and overall appreciation of the variety 3 Vert.

The hybrids FHIA 21, PITA 3 and 3 Vert had appreciations that were not significantly different at the 5% threshold. At the level of tenderness, a significant difference of appreciation is observed between the plantains, particularly between the hybrid 3 Vert and BITA 3. Hybrid BITA 3 was the least appreciated for its tenderness while hybrid 3 Vert was the one that was the most appreciated. The hybrids FHIA 21, PITA 3 and the local variety ORISHELE did not show significant differences regarding the appreciation of tenderness. There were no significant differences in the appreciation of the fatty aspect of the plantains. Concerning the sweetness aspect, there is a significant difference between the appreciation of the 5 varieties, particularly between the hybrids BITA 3, 3 Vert and the variety ORISHELE. The hybrid BITA 3 and the variety ORISHELE were the least appreciated for their sweetness while the hybrid 3 Vert was the most appreciated for the sweetness.

The averages obtained by the different varieties concerning the salty aspect do not show significant differences at the 5% threshold.

In terms of overall appreciation, hybrid 3 Vert had the highest score (6.61), followed by PITA 3 (6.57), FHIA 21 (6.49), ORISHELE (6.44) and BITA 3 (6.17). However, the averages obtained are not significantly different at the 5% threshold.

Table 4: Overall ratings of "Alloco" from plantain hybrids.

	FHIA 21 (TJN)	BITA 3 (TJ)	PITA 3 (J)	3 VERT(TJN)	ORISHELE(TJN)
Color	6.51±1.90 a	6.11±1.49 b	6.88±1.12 a	6.51±1.64 a	6.93±1.49 a
Tenderness	6.58± 2.08 ab	6±1.55 a	6.30±1.04 ab	6.85±1.67 b	6.40±1.85 ab
Fatness	6.21±2.12 a	6.46±1.72 a	6.38±1.04 a	6.36±1.85 a	6.53±1.80 a
Sweet	6.85±1.70 a	6.16±1.37 b	6.86± 1.04 a	6.91±1.25 a	6.25±1.52 b
Salty	6.25±1.44 a	6.10±1.41 a	6.45±1.19 a	6.41±1.54 a	6.3±1.55 a
Overall app	6.49±1.36 a	6.17±1.68 a	6.57±0.69 a	6.61±1.12 a	6.44±1.42 a

Values in the same row followed by different letters have significant differences at the 5% level. **TJ**: turning-yellow stage; **J**: yellow stage and JTN: yellow stage with black spots.

2.2.5. Correlation between physicochemical characteristics and perceived intensity of attributes

Table 5 presents the correlation coefficients between physicochemical characteristics and intensity perception of attributes. The correlations concern the couple's Fat content-Perception of fat intensity, Reducing sugar content-Perception of sweetness intensity, Starch content-Perception of tenderness intensity.

The strongest correlations are between the couples, Reducing sugar content-Perception of sweetness intensity (r= 0.83) and Starch content-Perception of tenderness intensity (r = 0.56). The weakest correlation is in the couple Fat content-Perception of fat intensity.

Table 5: Table presents the correlation coefficients between physicochemical characteristics and the perception of intensity of sensory attributes.

Couples	Correlation coefficient France
Fatty matter- Perception of fat	0.06
Reducing sugars-Sweetness perception	0.83
Starch- Perception of tenderness	0.56

3. DISCUSSION

2.1. Physico-chemical characteristics

The analysis of our work shows that the 5 varieties of plantain that we studied present physicochemical characteristics that vary from one variety to another. Thus, at the green stage, hybrid 3 Vert gives the highest contents of dry matter, ash, fiber, soluble dry extract and reducing sugars compared to the control variety (ORSHILE) and the other hybrids (BITA 3, PITA3 and FHIA). Similar results were reported by Kouakou *et al.*, (2019) [9] and N'da *et al.,* (2016) [10]. The objective of creating new hybrids was to address challenges on the agronomic level (disease control, yield improvement...) and also to design fruits that have higher or lower physicochemical characteristics than control or parental varieties as Kouakou et *al.,* (2019) [9]. The hybrid FHIA 21 is the one that is closest to the control ORISHELE of Kouakou et *al.,* (2019) [9] showed in their study that the hybrids CRBP, FHIA 17 and FHIA 21 have the same nutritional value with that of the control variety ORISHELE. Regarding the physicochemical characteristics of these same hybrids or variety, several changes were observed during their ripening. Compared to the green stage, we note a significant increase in the content of reducing sugars, ash and soluble solids, and also a significant decrease in the content of starch, dry matter and fiber. The ripening of the plantain is a phenomenon that induces many changes. Thus, several authors such as Coulibaly *et al.*, (2007) [5] and N'da *et al.,* (2016) [10] have reported these changes in physico-chemical characteristics during and plantain ripening.

The aim of this study was to determine the ripening stages of each hybrid or variety suitable for making ripe plantain French fries (alloco). It appears from our work that the reducing sugar contents of the hybrids FHIA 21 and 3 Vert and the control ORISHELE are significantly higher than those of the hybrid BITA 3. This could be explained by their more advanced ripening stage (yellow with black spots for FHIA 21 and 3 GREEN hybrids and ORISHELE control and yellow for PITA 3). The physico-chemical characteristics of PITA 3 at the yellow stage are almost identical to those of FHIA 21, ORISHELE and 3 Vert all taken at the yellow stage with black spots. This would show that the processing and/or culinary abilities (frying, flour, cooking...) of PITA 3 at the yellow stage would be identical to those of FHIA 21, 3 Vert and ORISHELE at the yellow stage with black spots.

Regarding the sensory analysis of the alloco of the different plantains studied, the global appreciation made by the tasters indicates that the hybrids 3 Vert (6.61), PITA 3 (6.57) and FHIA 21 (6.49) occupied the first positions of the classification. Thus, the alloco of these hybrids would seem to be better appreciated by the panelists than that of the control variety ORISHELE. These results are in agreement with those of Coulibaly *et al.,* (2007) [5], who stated that the alloco from the FHIA 21 hybrid could validly replace that of the ORISHELE variety. This finding would also mean that the appropriate ripening stages for the production of alloco would be yellow for hybrid PITA 3 and yellow with black spots for hybrids 3 Vert and FHIA 21.

Regarding the correlations between physicochemical characteristics and the perception of the intensity of the attributes (tenderness, fat and sweetness), the difference in the perception of the intensity of the sweet taste obtained from the organoleptic tests is only the result of the unequal contents of total and reducing sugars in the plantain varieties. The contents of sugars identified in the banana as sucrose, glucose and fructose are higher in the varieties 3 Vert, FHIA 21, PITA 3 and ORISHELE, hence the sweeter taste felt by the tasters in the alloco of Gnakri (1993) [11]. There is a strong correlation between the perception of sweetness intensity (R= 0.83 and 0.84) and the total and reducing sugar content. Thus, higher levels of total and reducing sugars would result in a sweeter alloco as demonstrated by Assemand *et al.,* (2012) [4].

Consumer perception of fat intensity was not significant. The allocos all obtained average scores above 6. Therefore, they were all perceived by the tasters as fatty. There was a very weak correlation between the fat content of the cultivars and the perception of fat by the tasters (R=0.06). Thus, fat perception would not be influenced by the fat content of the plantains in the fresh state. This could be due to the very low proportions of lipid in plantains which are practically negligible. Indeed, it has been shown by Courtois *et al.*, (2012) [12] that foods with very low lipid contents would have no impact on the fat of the final product. This fat perceived by alloco tasters would therefore be due to the frying oil, temperature, frying time and also to other physicochemical parameters (Oil absorption capacity).

The perception of tenderness intensity by consumers showed significant differences at the 5% level. The allocos all obtained average scores above 6. As a result, they were all judged to be tender. The correlation is R=0.56 between the starch contents at the optimal alloco stage of the cultivars and the perception of tenderness given by the tasters. The perception of tenderness could therefore be influenced by the starch contents. Pedreschi *et al.*, (2004) [13] would have demonstrated that deep frying (120-180℃) would act on the tenderness of foods. Indeed, according to these authors deep frying leads to a gelatinization of starch which would influence the plasticity as well as the tenderness of the food. A high amount of starch could therefore make the plantain tenderer during frying. However Gilbert *et al.*, (2010) [14], showed from another point of view that the tenderness could, during the gelatinization of the starch, be due to the elastic properties and the absorption capacities in water and oil of the starch but not to the quantity.

The influence of the perception of the intensity of the attributes on the appreciation of these attributes indicates that the appreciation of the tenderness between the plantains presents significant differences particularly between the hybrid 3 Vert and the BITA 3. The BITA 3 hybrid was the least appreciated for its tenderness while the Vert 3 hybrid was the most appreciated. The BITA 3 hybrid was the least appreciated by the tasters because it was tenderer. This result would be in contradiction with that of Assemand *et al.*, (2012) [4] who would have shown that softer allocos would be appreciated. However, there may be an interval where the tenderness of the alloco is considered perfect. Beyond and below this interval the appreciation of tenderness could decrease.

The 3 Vert, FHIA 21 and PITA 3 hybrids were more appreciated for their sweetness compared to the BITA 3 hybrid and the ORISHELE variety. In addition, the hybrids 3 Vert, FHIA 21 and PITA 3 were the ones that were perceived as sweeter. Allocos perceived as sweeter by the tasters would be the best appreciated. These results would confirm those of Assemand *et al.*, (2012) [4], who demonstrated by comparison of the varieties AGNRIN and ORISHELE that a sweeter alloco was more appreciated by consumers.

The appreciation of fat the consumers shows that the cultivars were well appreciated. The means obtained did not show any significant difference at the 5% level. On the other hand, the non-significant difference in the perception of the intensity of fat could be the reason for the appreciation for fat.

4. CONCLUSION

The physico-chemical characteristics of the plantains studied vary from one variety to another, and whatever the ripening stage taken into account, the variety 3 Vert presents the highest nutritional values. The results of the sensory analyses showed first that the appreciation of plantain cultivars is not related to a particular variable (color, fat, tenderness, sweetness or saltiness) but to the combination of these variables. This was revealed by the results of the principal component analysis. In addition, it was shown that some physicochemical constituents of the plantains correlated with the perception of the intensities of the attributes (sweetness and tenderness) given by the tasters. In addition, the appreciation of certain attributes (sweetness) was influenced by their perception in intensity. The results of the evaluation of each attribute showed that the cultivars differed. The appreciation of the color was more inclined towards the hybrids FHIA 21, PITA 3, 3 Vert and the variety ORISHELE. There was no difference of appreciation for the fat attributes. Concerning tenderness, the hybrid BITA 3 was the least appreciated. The hybrids 3 Vert, PITA 3 and FHIA 21 were the most appreciated for sweetness. The analysis of the global appreciation showed that all the varieties were appreciated. However, a classification could be made according to the averages obtained. In decreasing order of preference of the tasters, the ranking is as follows: 3 Vert, PITA 3, FHIA 21, ORISHELE and BITA 3. However, our work has shown that the frying ability (Alloco) of the hybrid PITA 3 would be more adapted to the yellow stage, while that of FHIA 21 and ORISELE to the yellow stage with black spots.

5. REFERENCES

[1]. USDA, 2013. Agricultural Research Service United States Department of Agriculture. Rapport de base : 09277, des plantains. 26, logiciel v.1.3.1., 2-5

[2]. FAOSTAT, 2016. Statistics production yearbook. Rome, Food and Agriculture Organization of the United Nations.195-196

[3]. Perrin A., 2015. Etude de la filière banane en Côte d'Ivoire. Projet « Promotion et commercialisation de la Banane Plantain et du Manioc en Côte d'Ivoire », 66 p.

[4]. Assemand, E., Fatoumata Camara, F. A. Kouame, V. Konan and L. P. Kouamé. Caractérisation biochimique des fruits de plantain (Musa paradisiaca L.) variété « Agnrin » de Côte d'Ivoire et évaluation sensorielle de ses produits dérivés. *J. Appl. Biosci.* 2012 ; 60 : 4438-4447.

[5]. Coulibaly S., Koffi L. B., Amani N. G. Analyse sensorielle comparée de deux produits de fritures à l'huile végétale. *Agron. Afr.* 2007;19(2):223-231

[6]. Bernfeld P, 1955. Amylase and Proteases. In Methods in Enzymology, Colswick SP, Kaplan NO (eds). Academic press: New-York, USA; pp 149–154

[7]. Dubois M., Gilles K.A., Hamilton J.K., Rebers P.A., Smith F. Colorimetric method for determination of sugars and related substances. *Anal. Chem.* 1956; 350-356.

[8]. FAO, 2003. Food composition data : Production, management and use. Second edition, 295p

[9]. Kouakou K. R., Kone T., Aby N., Traore S., Dogbo D.O., Kone M. Performances comparées de vivo plants issus de deux techniques de multiplication chez trois cultivars de bananier plantain [*Musa paradisiaca*, (musaceae)] à Azaguie. *Agronomie Africaine*. 2019;(8): 12.

[10]. N'da K., 2016. Effet de la durée de cuisson sur les paramètres physiques des bananes plantains fhia 21 et pita 3. Rapport de master, université Nangui Abrogoua, UFR sciences et technologies des aliments, abidjan-Cote divoire, 53p.

[11] Gnakri D. Valorisation du fruit de plantain (Musa spp.) I- Caractérisation physicochimique de l'amidon. II- Etude nutritionnelle, métabolique et physiologique des aliments dérivés : foutou et foufou. Doctorat d'état ès sciences. Abidjan, Côte d'Ivoire, 1993, 233p/

[12] Courtois F., Mohammad A., Trezzani I., Trystram G. Friture profonde : les interactions huile-produit. OCL. 2012;19(2): 89-95.

[13] Pedreschi, F., Kaack, K., Granby K., 2004. Reduction of acrylamide formation in fried potato slices. Lebensmittel-Wissenschaft und-Technologie, 27(6):679–685.

[14] Gibert O., Giraldo A., Ucles S., Sanchez T., Fernandez A., Bohuon P., Reynes M., Gonzalez A., Pain J., Dufour D., 2010. A kinetic approach to textural changes of different banana genotypes (*Musa* sp.) cooked in boiling water in relation to starch gelatinization. *Journal of Food Engineering*. 98(4):471-479.

[15] AOAC (Association of Official Analytical Chemists) 1955. AOAC Official Methods of Analysis. Appendix G : Guideelines for Collaborative Study Procedures to validate characteristics of method of analysis. 12

[16] BIPEA, 1976. Recueil des méthodes d'analyse des communautés européennes. Bureau Interprofessionnel d'Études Analytiques, Gennevilliers, France, 140

[17] AFNOR ISO 5492, 1992. Analyse sensorielle - Vocabulaire, édition 1, 22