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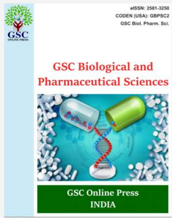

(RESEARCH ARTICLE)

Functional and sensory properties of composite flours based on FHIA 21 plantain and cassava for the preparation of instant foutou

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Abstract

Plantain (*Musa paradisiaca* L.), like most tropical fruits, is a major starchy food for rural and urban populations. It is a highly perishable product. The objective of this study was to reduce postharvest losses of plantain by processing it into instant foutou flour. Fruits of the FHIA 21 variety, harvested 90 days after flower emergence, were processed into flour by incorporating cassava. The functional and sensory characteristics of the different composite flours were determined using reference methods. The analysis of the five flours showed that the highest values of tapped density (volumic mass) and foaming power were obtained with the FH1 formulation. The highest values of WAC and WSI were obtained with the FH2 formulation. Similarly, FH3 has the highest dispersibility rate of the five flours. At the sensory level, FH2 flour was the most appreciated by the panelists thanks to its sweeter taste, its more yellow color and its stickier adhesiveness. These instant foutou flours therefore constitute an alternative solution to reduce post-harvest losses of plantain in Côte d'Ivoire and can therefore be promoted to the local population.

Keywords: Foutou Flour; Plantain; Post-Harvest Losses; Processes; Storage

1. Introduction

Plantain is an important source of food and income for all rural populations in the humid tropics of Africa [1]. In Côte d'Ivoire, its growing importance in the diet of populations makes it one of the main food crops [2]. It is the third most cultivated food crop after yam and cassava, with an estimated annual production of 2.12 million tonnes [3]. It is also a source of employment and income [4]. Despite the importance of plantain cultivation in Côte d'Ivoire, its fresh storage poses enormous post-harvest constraints. Plantain, like most climacteric tropical products, presents difficulties in fresh storage. In addition to its seasonal nature, plantain is a highly perishable product. Moreover, during periods of abundance, excess production leads to numerous post-harvest losses.

To reduce post-harvest losses of plantain in production, collection and market places, many traditional [5] and modern [6, 7] fresh storage techniques have been developed. In addition to these fresh storage techniques, one of the alternatives to reduce post-harvest losses is the transformation often called transformation-preservation of plantain into finished products.

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In Ivory Coast, several traditional dishes are made from plantain. Among these dishes, foutou is the most preferred method of consumption and the most preferred of all dishes made with plantain according to a consumption study conducted by [8] in Ivory Coast. However, to our knowledge, there are no studies conducted on the transformation of plantain into instant foutou flour whose characteristics would be close to the dietary requirements of consumers. This is why the transformation of part of the production into a finished product (instant foutou flour) is undeniable in order to significantly reduce the losses recorded in the plantain sector. The latter would make it possible to provide consumers with finished products corresponding to their eating habits.

In order to contribute to the reduction of post-harvest losses of plantain in Ivory Coast by developing new products, we proposed in this work to produce instant flours based on plantain of the FHIA 21 variety and cassava of the Bonoua 2 variety and to study their functional and organoleptic characteristics.

2. Materials and methods

2.1. Materials

2.1.1. Plant Materials

The plant material consisted of plantain banana bunches of the FHIA 21 variety, whose green (stage 1 or 2) and ripe (stage 4 or 5) fingers, and cassava roots of the Bonoua 2 variety were used. The plantain banana bunches were collected from a plantation in Azaguié-gare in the Agnéby-Tiassa region (Côte d'Ivoire), latitude 5° 37′ 60″ N and longitude 4° 4′ 60″ W. The cassava roots were purchased at the Gonzagueville market in Port-Bouët (Abidjan, Côte d'Ivoire), latitude 5°14'24''N and longitude 3°53'47''W.

2.2. Methods

2.2.1. Composition of composite flours based on plantain and cassava

Green (stage 1 or 2) and ripe (stage 4 or 5) plantain fingers (FHIA 21) at the 75th day of maturity or flowering-to-cutting interval (FCI) and cassava roots were used to make the flours.

2.2.2. Preparation of plantain chips

Green (stage 1 or 2) and ripe (stage 4 or 5) plantain fingers were washed with water and blanched with the skin in boiling water for 10 minutes. After blanching, the fingers were peeled. The pulp was then boiled for 20 minutes. After complete cooking, the pulps were cooled for 25 minutes and cut into cubes and dried in a hot air dryer (MINERGY, France) at 60°C for 24 hours.

2.2.3. Preparation of Cassava Chips

The sweet variety cassava roots (cv. Bonoua 2) were washed in water. They were peeled. The roots were then cooked in boiling water for 20 minutes. After complete cooking, the roots were cooled for 25 minutes, cut into cubes, and dried in a hot air dryer at 60°C for 24 hours.

2.2.4. Production of plantain and cassava flour from different formulations

For each sample of composite foutou flour, after obtaining the different dried chips, the required proportions of plantain chips (green or ripe) and cassava were weighed. The weighed chips were then mixed and crushed using a hammer mill. The crushed chip mixture was ground using a miller (Forplex, France) containing a 50 µm sieve to obtain the foutou flour.

Thus, five formulations of composite foutou flour were produced in the following proportions:

- FH1 = 60% green plantain + 40% cassava (60:40);
- FH2 = 60% ripe plantain + 40% cassava (60:40);
- FH3 = 40% green plantain + 20% ripe plantain+ 40% cassava (40:20:40);
- FH4 = 20% green plantain + 40% ripe plantain + 40% cassava (20:40:40);
- FH5 = 30% green plantain + 30% ripe plantain + 40% cassava (30:30:40).

2.3. Functional and sensory characteristics of different foutou flour formulations

The different composite flour formulations were analyzed to determine their functional and organoleptic characteristics. All measurements were repeated three times.

2.3.1. Functional characteristics

The dispersibility of the flours was determined according to the method described by [9]. The tapped density (TD) of the flours was determined according to the technique described by [10]. The water absorption capacity (WAC) and water solubility index (WSI) of the flours were determined according to the methods of [11]. The foaming capacity (FC) of the different composite flours of the three varieties was determined according to the method described by [12].

2.3.2. Sensory analysis

Sensory analysis was performed using the quantitative descriptive analysis method [13]. It consists of evaluating and quantifying the appropriate descriptors (color, firmness, adhesiveness, smoothness, elasticity, sweetness, aroma, and general appreciation) according to a graduated scale.

2.4. Statistical Analysis

All measurements were performed in triplicate for biochemical, functional, and sensory analyses. Statistical analysis of the results was performed using Statistica 7.1 software. One-way analysis of variance (ANOVA) and Duncan's test were performed to compare the analyzed variables. Differences were considered significant for P values ≤ 0.05.

To determine the sensory profile of the different plantain and cassava foutou flour formulations, the descriptive test was performed. Statistical data analyses were performed using TASTEL+ sensory analysis software, version 2013. One-way analysis of variance (ANOVA) and the Newman-Keuls test were performed to compare the analyzed variables on the generated descriptors. Differences were considered significant for P values ≤ 0.05.

3. Results

3.1. Functional properties of foutou composite flours based on FHIA 21

3.1.1. Dispersibility of FHIA 21 composite flour

The dispersibility of the FHIA 21 composite foutou flour is shown in Figure 1. The dispersibility of the different flours FH1, FH3, and FH5 increases significantly between 0 and 140 min. Beyond 140 min, they tend to stabilize. As for FH2 and FH4 flour, their dispersibility increases significantly between 0 and 160 min. After 160 min, they stabilize. FH3 flour is more dispersible than the other four formulated foutou flour.

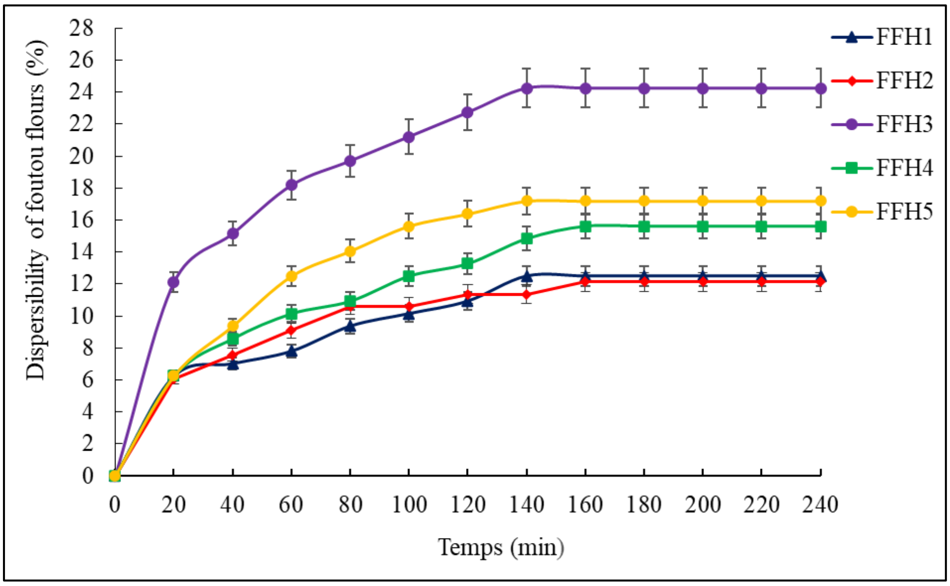

Figure 1 Dispersibility of different composite flour from FHIA 21 foutou

- FH1: 60% FHIA 21 green plantain + 40% cassava,
- FH2: 60% FHIA 21 ripe plantain + 40% cassava,
- FH3: 40% FHIA 21 green plantain + 20% FHIA 21 ripe plantain + 40% cassava,
- FH4: 20% FHIA 21 green plantain + 40% FHIA 21 ripe plantain + 40% cassava,
- FH5: 30% FHIA 21 green plantain + 30% FHIA 21 ripe plantain + 40% cassava.
- Statistical analyses were performed at the 5% level using Duncan's test. Means ± standard deviation

3.1.2. Tappeded density (TD)

The tapped density values of the various composite foutou flours formulated with FHIA 21 are shown in Table 1. Thus, the tapped density values of the various composite FHIA 21 flour range from 0.94 to 0.97 g/mL. The different tapped densities of the five instant flour are 0.97 g/mL; 0.94 g/mL; 0.97 g/mL; 0.95 g/mL and 0.95 g/mL for FH1, FH2, FH3, FH4 and FH5 respectively. Statistical analysis did not reveal any significant difference at the 5% level between the values of the five foutou flours from the FHIA 21 variety.

3.1.3. Foaming Capacity

The foaming capacity of Musa spp. plantain foutou flours (FHIA 21) is shown in Table 1. All five FHIA 21 composite flours studied have low foaming capacity. The foaming capacity of the FHIA 21 variety flours ranges from 2.87% to 5.85%. The foaming capacity values of the different FHIA 21 flours are 5.85%, 2.87%, 4.28%, 2.87%, and 2.88% for FH1, FH2, FH3, FH4, and FH5, respectively (Table 1). The foaming capacity of FH1 and FH3 flours is higher than that of FH2, FH4, and FH5. Statistical analysis reveals significant differences between the different formulated flour. On the other hand, no difference is observed between flours FH2, FH4 and FH5 but between FH1 and FH3 the foaming capacity values differ statistically at the 5% threshold.

3.1.4. Water absorption capacity (WAC) and Water solubility index (WSI)

Table 1 presents the WAC and WSI values of the five foutou flours of the FHIA 21 cultivar studied.

The WAC values of the formulated flours of the FHIA 21 variety range from 647.54 to 695.39% (Table 1). The WAC values are 647.54, 695.39, 673.81, 680.28, and 685.30% for FH1, FH2, FH3, FH4, and FH5, respectively. These values are generally similar. Statistical analysis revealed significant differences ($P \leq 0.05$) between them. The WSIs of the different formulations of foutou flours of FH1, FH2, FH3, FH4 and FH5 are respectively 21.74%, 26.86%, 25.34%, 24.40% and 22.25% (Table 1). However, statistically significant differences exist between the different ISEs of the five flours.

Table 1 Functional properties of FHIA 21 foutou flours

	FH1	FH2	FH3	FH4	FH5
TD (g / mL)	0.97 ± 0.01 a	0.94 ± 0.01 a	0.97 ± 0.01 a	0.95 ± 0.01 a	0.95 ± 0.01 a
FC (%)	5.85 ± 0.20 c	2.87 ± 0.02 a	4.28 ± 0.00 b	2.87 ± 0.02 a	2.88 ± 0.04 a
WAC (%)	647.54 ± 0.00 a	695.39 ± 0.15 e	673.81 ± 0.00 b	680.28 ± 0.01 c	685.30 ± 0.01d
WSI (%)	21.74 ± 0.01 a	26.86 ± 0.00 e	25.34 ± 0.01 d	24.40 ± 0.00 c	22.25 ± 0.02 b

Means ± standard deviations followed by the same lowercase letter on a line are not significantly different at the 5% level according to Duncan's test; FH1: 60% green plantain FHIA 21 + 40% cassava, FH2: 60% ripe plantain FHIA 21 + 40% cassava, FH3: 40% green plantain FHIA 21 + 20% ripe plantain FHIA 21 + 40% cassava, FH4: 20% green plantain FHIA 21 + 40% ripe plantain FHIA 21 + 40% cassava, FH5: 30% green plantain FHIA 21 + 30% ripe plantain FHIA 21 + 40% cassava.; PD = Packed density; FC = Foaming capacity; WAC = Water adsorption capacity; WSI = Water Solubility Index

3.1.5. Foam Stability

The foam stability of the various composite flours of FHIA 21 foutou decreases over time for all flours. However, this decline in stability is more rapid between 0 and 5 min. The foam stability values of the FHIA 21 flours remain virtually stationary after 5 min (Figure 2).

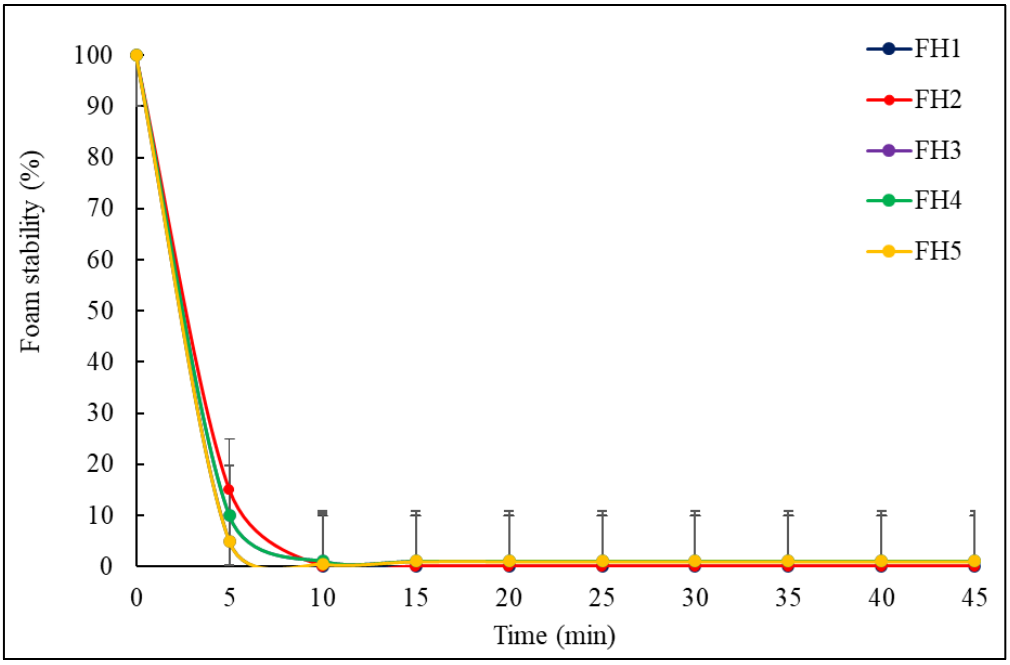

Figure 2 Evolution of foam stability (FS) of FHIA 21 foutou flours

- FH1: 60% green plantain FHIA 21 + 40% cassava,
- FH2: 60% ripe plantain FHIA 21 + 40% cassava,
- FH3: 40% green plantain FHIA 21 + 20% ripe plantain FHIA 21 + 40% cassava,
- FH4: 20% green plantain FHIA 21 + 40% ripe plantain FHIA 21 + 40% cassava,
- FH5: 30% green plantain FHIA 21 + 30% ripe plantain FHIA 21 + 40% cassava.
- Statistical analyses were performed at the 5% level using Duncan's test. Means ± standard deviation

3.2. Sensory Analysis of the composite flours of FHIA 21 foutou

Figure 3 shows the evolution of some organoleptic parameters of the different formulations of composite flours of FHIA 21 foutou. The different flours present significant differences ($P \leq 0.05$) in the various sensory characteristics studied. However, there is no significant variation ($P > 0.05$) in firmness, smoothness, elasticity, and plantain aroma for the different composite flours studied according to the statistical analysis.

In terms of color, all five foutou formulations based on the FHIA 21 variety show statistically significant variations at the 5% level. The yellow color is more pronounced in the FH2 formulation.

In terms of stickiness, the different formulations show significant differences ($P \leq 0.05$). Formulations FH2 and FH4 are significantly different from formulations FH1, FH3, and FH5.

The sweetness of the different foutou flours shows a significant difference. This difference is more pronounced in the FH2 formulation, which consists of ripe banana and cassava.

The overall appreciation differs significantly at the 5% level between the different flour composed of reconstituted foutou. Thus, there is a significant difference between the different reconstituted flours. However, the FH2 formulation was the most appreciated of the five composite flours.

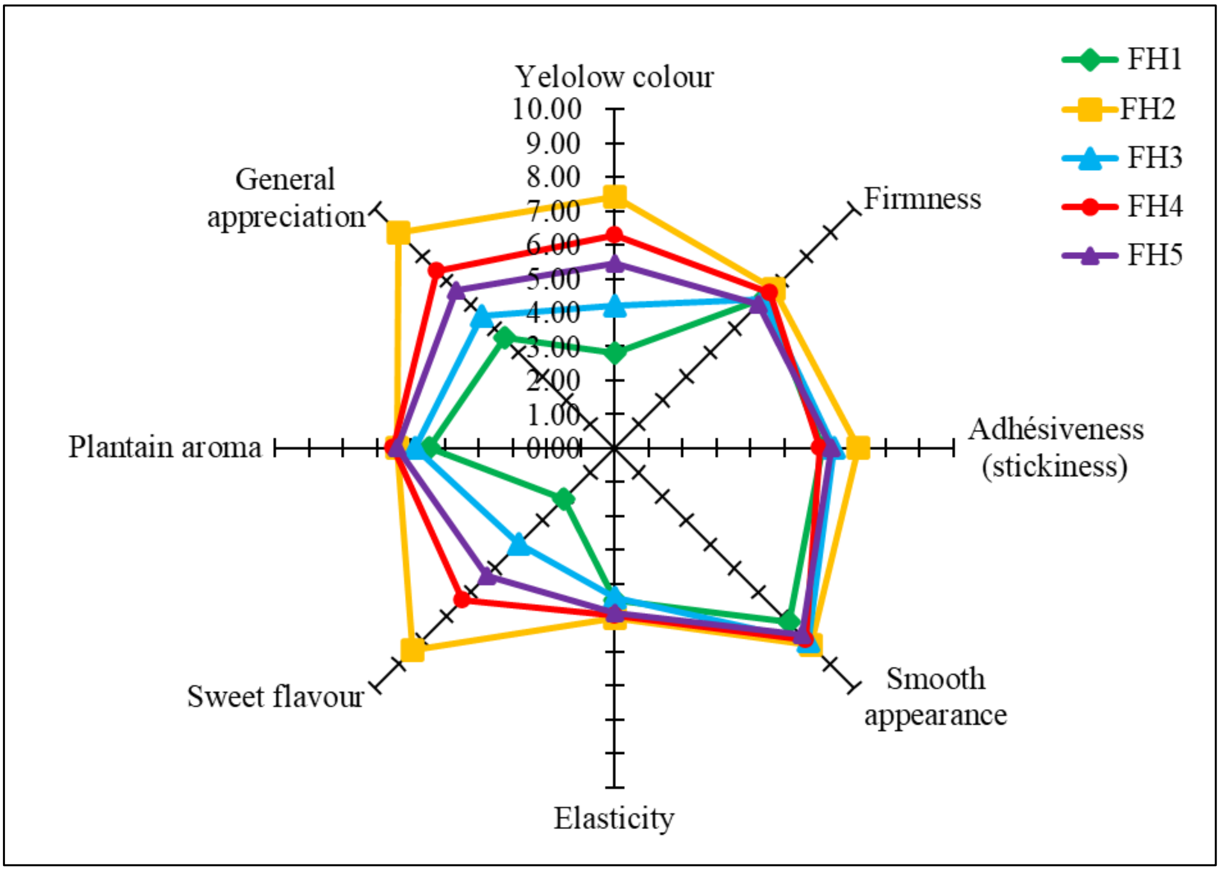

Figure 3 Sensory profiles of different formulations of plantain composite flour

- FH1: 60% FHIA 21 green plantain + 40% cassava,
- FH2: 60% FHIA 21 ripe plantain + 40% cassava,
- FH3: 40% FHIA 21 green plantain + 20% FHIA 21 ripe plantain + 40% cassava,
- FH4: 20% FHIA 21 green plantain + 40% FHIA 21 ripe plantain + 40% cassava,
- FH5: 30% FHIA 21 green plantain + 30% FHIA 21 ripe plantain + 40% cassava.
- Statistical analyses were performed at the 5% level using the Newman-Keuls test. Means ± standard deviation

4. Discussion

Plantain is one of the floury products highly valued and consumed by rural and urban populations, thus contributing to food security in Côte d'Ivoire [14]. It is the preferred food of most households in production areas and major urban centers in Côte d'Ivoire [8]. The functional properties provide information on future applications in food formulations [15].

The dispersibility of a flour is an indicator of its reconstitution power in water. According to [16], it is a useful functional parameter in the formulations of various food products. The dispersibility percentages of flours formulated from FHIA 21 foutou increase. The increase in flour dispersibility is explained by the gelatinization of flour, which increases the water binding capacities [17]. The higher the dispersibility, the greater the flour's capacity to reconstitute in water to give a fine and coherent paste [9]. The dispersibility percentages of formulated foutou flours are lower than those of local Nigerian rice (56-66%) reported by the work of [18].

The difference between the tapped density of the different formulations of instant foutou flours from FHIA 21 is due to the fact that cooking reduced the air spaces in the pulp of bananas (green or ripe) and cassava for the formulated flour. According to [19], flours resulting from cooking have higher inter-particle bonding, thus resulting in a higher tapped density. This observation is also in agreement with those of [20] and [21] who showed that the tapped density of flour from cooked *Artocarpus communis* and *Artocarpus altilis* pulp respectively is higher than that of uncooked pulp. The values of the tapped density of flours composed of foutou of FHIA 21 are higher than that of yam flour (0.49 to 0.63 g/cm3) [22], unfermented pulp of *Artocarpus altilis* (0.57 g/cm3) [23] and that of wheat flour (0.80 g/cm3) [24].

According to [25], tapped density is a measure of the weight of the flour. According [26], the tapped density helps determine the suitability of a flour to be easily packed and packaged, which would facilitate the transportation of a large quantity of food.

Water absorption capacity (WAC) is an index of the maximum amount of water that a food product would absorb and retain [27]. This property is important for some product characteristics, such as product rehydration and flour retrogradation [28]. WAC is one of the criteria that determine the sensory quality, in particular, the texture of food products [29]. The high WAC values of foutou composite flours from cooked plantain and cassava pulp are thought to be related to flour gelatinization, which increases water binding capacities [17]. According to [30], the presence of lipids in large quantities in a flour reduces the binding capacity of water to particular substances, thus limiting the WAC. Indeed, water retention would be due to the presence of hygroscopic constituents possessing hydrophilic groups. For these different plantain flours (FHIA 21), these hygroscopic constituents would essentially be carbohydrates (possessing free hydroxyl groups: – OH) and proteins (having hydrophilic groups: = CO, – NH –), because these flours contain these compounds. These same observations were reported by [31] in his work on rice flour in Madagascar. By the presence of these hydrophilic groups, these compounds can therefore bind with water molecules by hydrogen bonds [31]. WAC is related to the amorphous nature of flour and its amylopectin content [32]. The WAC values of formulated flours are within the range of that of cassava (171.3% - 551.2%) [33] and that of precooked taro (562.5%) [34]. The WACs of different composite foutou flours are higher than those of uncooked and cooked rice (225% and 250% respectively) [35], uncooked and cooked plantain flours (118.5 – 125.5%) [36] and flours of six varieties of taro (*Colocasia esculenta* L. Schott) (242.5% - 374.9%) obtained by [37]. According to [38], WAC is an important property of flours used in pastry making. It allows for the addition of a lot of water to the dough while improving its handling.

The water solubility index (WSI) reflects the extent of starch degradation because hydrothermal cooking degraded the starch grains [37]. The high WSI percentages of the different foutou flours show that cooking had an effect on starch degradation. The results obtained are higher than those recorded by [22] for cooked yam (*Dioscorea spp*) flours (15.31%). The ISE percentages of flours composed of foutou are lower than those of cooked breadfruit flours (20.70% to 42.68%) [21] and clearly equal to those of raw taro flours (18% to 27%) [37].

Foaming capacity (FC) and foam stability (FS) improve the texture, uniformity and appearance of the food [39]. The FC decreased significantly with cooking. The FS decreases over time at room temperature until stabilization. According to [40], foam formation and stability depend on pH, viscosity, proteins and processing methods. Heat treatment of banana pulp in water denatured its proteins promoting the formation of protein aggregates [41] hence the decrease in FC and FS. The FC of flours composed of foutou (2.87% to 5.86%) is lower than that of cassava flour (13.70%) [42].

The study of the organoleptic characteristics of plantain banana foutou flour formulations with cassava incorporation from FHIA 21 shows that the FH2 formulation is the most appreciated. This appreciation is favored by the quantities of green and ripe banana in the foutou flour formulations. Indeed, the FH2 flour contains 60% ripe plantain and 40% cassava. Also, this appreciation of the panelists would be due to the sweeter character and the more pronounced yellow color of this formulation. Thus, the sweet taste is due to the use of ripe plantains whose flour is hydrolyzed into sugars during ripening, which would increase the sweetness of these formulations. Similar observations were reported by [43] on the biochemical characterization of plantain fruits (*Musa paradisiaca* L.) variety French from Ivory Coast and the sensory evaluation of its derived products. According to these authors, the preference for foutou was due to their tenderness and sweeter character. This observation corroborates the results obtained in our study regarding the sweet flavor and stickiness of FC2, FH2 and FP2 flours reconstituted into foutou.

5. Conclusion

The objective of this study was to reduce post-harvest losses in order to contribute to the food security of the Ivorian population by transforming plantain (FHIA 21) into a composite flour with cassava incorporation for the preparation of an instant foutou adapted to our eating habits. Overall, this study showed that the five different formulations of composite foutou flour based on plantain and cassava presented significant functional and sensory characteristics. Thus, formulation FH2 was the most appreciated by the panelists, probably due to its sweeter taste, its more pronounced yellow color, its plantain aroma and its stickiness.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no conflicts of interest.

References

[1] Swennen R. Joining forces to help banana growers, in: The fruits of agricultural research. Dimensions 3, the journal of Belgian Cooperation. 2006; 5: 8-9. Available at: http://www.diplomate.be (accessed 11-09-2023).

[2] N'guessan AE, Ganry J. Cultivation system and cultural techniques for plantain production. Fruits. 1989; 45:103-106.

[3] FAO. (2021). Bananas. Crops and livestock products; 2021. Access date 18-08-2023. URL:https://www.fao.org/faostat/en/#data/QCL/visualize

[4] Foure E, Tezenas DM. (2000). Banana production: a major economic issue for food security. Regional cooperation bulletin for the development of horticultural products in Africa. 2000; 18:23-28.

[5] Dick E. Contribution to the study of the physiology of ripening, storage and preservation of plantain bananas after harvest. State thesis, University of Cocody-Abidjan (Côte d'Ivoire); 2006.

[6] Varoquaux P, Gouble B, Ducamp M, Self G. Method for optimizing the packaging of fruit under modified atmosphere. Fruits 2002; 57(5-6):313-322

[7] Lepengué NA, Mouaragadja I, Dick E, Mbatchi B, Ake S. Improving the shelf life of plantain bananas at ambient temperatures. International Journal of Biology Chemistry and Sciences. 2010; 4(3):730-737.

[8] Amani NG, Kamenan A Nutritional potential and traditional technology for processing starchy foods in Côte d'Ivoire. In Food processing at household and community level to improve the (bio) availability of (micro) nutrients. 2nd International Workshop. Food pathways for improving nutritional situations. Ouagadougou. 2003 nov 23-28.

[9] Kulkarni KD, Kulkarni DN, Ingle UM. Sorghum malt-based weaning formulations. Preparation, functional properties, and nutritive value. Food and Nutrition Bulletin. 1991; 13:322-327.

[10] Oladele AK, Aina JO. Chemical composition and functional properties of flour produced from two varieties of tigernut (*Cyperus esculentus*). African Journal of Biotechnology. 2007; 6:2473-2476.

[11] Phillips RD, Chinnan MS, Branch AL, Miller J, Mcwatters KH. Effects of pre-treatment on functional and nutritional properties of cowpea meal. Journal of Food Science. 1988; 53:805-809.

[12] Coffman CWL, Garcia VC. Functional properties and amino acid of a protein isolate from mungbean flour. Journal of Food and Technology. 1977; 12:473-484.

[13] Stone H, Siedl J, Bloomquist J. Quantitative descriptive analysis. Cereal Food World. 1980; 25(10):642-644.

[14] Soler A, N'Da AA. Improving post-harvest systems. Seminar of the CIRAD-IRFA Multidisciplinary Program, Abidjan, Côte d'Ivoire. 1990 jan 29 au fév 01. p. 9.

[15] Hermansson, AM, Svegmark K. Developments in the understanding of starch functionality. Trends in Food Science and Technology. 1996; 7:345–353.

[16] Mora-Escobedo R, Lopez OP, Lopez GFG. Effect of germination on the rheological and functional properties of amaranth seeds. Lebensmittel Wissenschaft und Technologie. 1991; 24:241-244.

[17] Dengate HN. Swelling, pasting and gelling of wheat starch. in Advances in Cereal and Technology, ed. By Pomeranz Y. AACC Eagan Press, St Paul, MN; 1984. Chapter 2: p. 49-84.

[18] Eke-Ejiofor J, Barber LI, Kiin-Kabari DB. Effect of Pre-Boiling on the Chemical, functional and Pasting Properties of Rice. Journal of Agriculture and Biological Sciences. 2011; 2:214 -219.

[19] Itiola AO. Compressional characteristics of three starches and the mechanical properties of their tablets. Pharmaceutical World Journal. 1991; 8:91-94.

[20] Mayaki OM, Akingbala JO, Baccus-Taylor GSH, Thomas S. Evaluation of breadfruit (*Artocarpus communis*) in traditional stiff porridge foods. Food Agriculture and Environment. 2003; 1:54-59.

[21] Oulaï SF, Ahi AP, Kouassi-Koffi DJ, Gonnety TJ, Faulet MB, Djè KM, Kouamé PL. Treatments Effects on Functional Properties of Breadfruit (*Artocarpus altilis*) Pulp Flour harvested in Côte d'Ivoire. International Journal of Recent Biotechnology. 2014; 2(4):1-12.

[22] Hsu CL, Chen W, Weng YM, Tseng CY. Chemical composition, physical properties, and antioxidant activities of yam flours as affected by different drying methods. Food Chemistry. 2003; 83: 85-92.

[23] Appiah F, Oduro I, Ellis WO. Functional properties of *Artocarpus altilis* pulp flour as affected by fermentation. Agriculture and Biology Journal of North America. 2011; 2(5):773-779.

[24] Ijarotimi O.S. Influence of germination and fermentation on chemical composition, protein quality and physical properties of wheat flour (*Triticum aestivum*). Journal of Cereals and Oil seeds. 2012; 3:35-47.

[25] Adejuyitan JA, Otunola ET, Akande EA, Bolarinwa IF, Oladokun FM. Some physicochemical properties of flour obtained from fermentation of tigernut (*Cyperus esculentus*) sourced from a market in Ogbomoso, Nigeria. African Journal of Food Sciences. 2009; 3: 51-55.

[26] Shittu TA, Sanni LO, Awonorin SO, Maziya-Dixon B, Dixon A. Use of multivariate techniques in studying flour making characteristics of some Cassava Mosaic Disease resistant cassava clones. African Crop Science Conference Proceedings. 2005; 7:621-630.

[27] Marero LM, Pajumo EM, Librando EC. Technology of weaning food formulation prepared from germinated cereals and legumes. Journal of Food Science. 1988; 53: 1391-1395.

[28] Siddiq M, Ravi R, Harte JB, Dolan KD. Physical and functional characteristics of selected dry bean (*Phaseolus vulgaricus* (L.) flours. LWT-Journal Food Sciences and Technology. 2010; 43:232-237.

[29] Selmane, D. (2010). Study of proteins extraction from slaughter co-products and their use as functional ingredients. Doctoral thesis, Université Blaise Pascal-Clermont Ferrand II, France; 2010; p. 225.

[30] Nelson-Quartey FC, Amagloh FK, Oduro I, Ellis WO. Formulation of an infant food based on breadfruit (*Artocarpus altilis*) and breadnut (*Artocarpus camansi*). Acta Horticulturae (ISHS). 2007; 757:212-224.

[31] Solofoniaina, T.E. (2019). Nutritional value of rice flour (*Mamoriaka mena*) for the development of infant flour. Master's thesis, Biochemistry and Environmental Sciences of Mahajanga University, Madagascar; 2019; p. 92.

[32] Akpossan, RA, Digbeu YD, Koffi DM, Kouadio NEJP, Ahipo DE, Kouamé PL. Protein fractions and functional properties of dried *Imbrasia oyemensis* larva full fat and defatted flours. International Journal of Biochemistry Reasearch and Review. 2015 ; 5(2):116–126.

[33] Nwabanne JT. Drying characteristics and engineering properties of fermented ground cassava. African Journal of Biotechnology. 2009; 8:873-876.

[34] Fagbemi TN, Olaofe O. The chemical composition and functional properties of raw and precooked Taro (*Colocasia esculenta*) flour. Journal of Biology Physics and Science. 2000; 1:98-103.

[35] Abulude FO. Effects of processing on nutritional composition, phytate and functional properties of rice (*Oryza sativa*) flour. Nigerian Food Journal, 2004; 22:97-104.

[36] Oluwalana IB, Oluwamukomi MO. Proximate composition, rheological and sensory qualities of plantain (*Musa parasidiaca*) flour blanched under three temperature regimes. African Journal of Food Science. 2011; 5(14):769-774.

[37] Mbofung CMF, Aboubakar NY, Njintang A, Bouba A, Balaam F. Physicochemical and functional properties of six varieties of taro (*Colocasia esculenta* L. Schott) flours. Journal of Food Technology. 2006; 4:135-142.

[38] Wolf WJ. Soybean proteins: their functional, chemical and physical properties. Journal of Agriculture and Food Chemistry. 1970; 18: 965-969.

[39] Akubor PI. Chemical, functional and cookie baking properties of soybean/maize flour blends. Journal of Food Science and Technology. 2007; 44: 619-622.

[40] Yasumatsu K, Sawada. K, Moritaka S, Mikasi M, Toda J, Wada T, Ishi K. Whipping and emulsifying properties of soybean products. Agricultural and Biological Chemistry. 1972; 36:719-727.

[41] Morr CV. Current status of soy protein functionality in food systems. Journal of the American Oil Chemists's Society. 1990; 67:265-271.

[42] Ubbor SC, Akobundu ENT. Quality Characteristics of Cookies from Composite Flours of Watermelon Seed, Cassava and Wheat. Pakistan Journal of Nutrition. 2009; 8:1097-1102.

[43] Assemand E, Camara F, Kouamé F, Konan V, Kouamé LP. Biochemical characterization of plantain fruits (Musa paradisiaca L.) variety "Agnrin" from Côte d'Ivoiret and sensory evaluation of its derived products. Journal of Applied Biosciences. 2012; 60:4438– 4447.