Sensory Analysis of Cakes Enriched with Almonds Powders of *Terminalia catappa* from Cote d'Ivoire

Douati Togba Etienne[1*], Assi Olivier[1], Aka Boigny[1], Konan N'guessan Ysidor[1], Coulibaly Adama[2], Sidibe Daouda[1] and Biego Godi Henri Marius[1,3]

[1]*Laboratory of Biochemistry and Food Science, Training and Research Unit of Biosciences, Felix Houphouet-Boigny University, 22 P.O.Box 582, Abidjan, Côte d'Ivoire.*
[2]*Training and Research Unit of Biological Sciences, Peleforo Gon Coulibaly University, P.O.Box 1328, Korhogo, Côte d'Ivoire.*
[3]*Department of Public Health, Hydrology and Toxicology, Training and Research Unit of Pharmacological and Biological Sciences, Felix Houphouet-Boigny University, P.O.Box 34, Abidjan, Côte d'Ivoire.*

Authors' contributions

This work was carried out in collaboration between all authors. Author DTE designed the study, wrote the protocol, fitted the data and wrote the first draft of the manuscript. Author KNY performed the statistical analysis, checked the first draft of the manuscript for submission and revised the manuscript. Authors AO, AB, CA and SD managed the literature and assisted the experiments implementation. Author BGHM expertized the results interpretations. All authors read and approved the submitted manuscrit.

Original Research Article

ABSTRACT

Aims: The present work evaluates the sensory properties of nine (9) cakes enriched with almonds powders of *Terminalia catappa* produced in Cote d'Ivoire.
Study Design: The current study focuses on the sensory properties (descriptive profile and hedonic analysis) of nine (9) cakes enriched with the powders of almonds of *Terminalia catappa*.
Place and Duration of Study: Laboratory of Biochemistry and Food Sciences, Biochemistry department of Biosciences Unit, Félix Houphouet-Boigny University, between October and December 2015.

Corresponding author: E-mail: douati5@gmail.com;

Methodology: The collected fruits were crushed, their almonds extracted were ground, sieved and the powders obtained were separated according to the size of their particle and their proportion. Nine (9) cakes enriched with powdered almonds of *Terminalia catappa* have been prepared and subjected to sensory analyses. Sensory analyses were realized to revel the descriptive profile regarding nine sensory descriptors, namely color crumb, ventilation crumb, texture silky, texture crumbly, sweet flavor, fat sensation, wet sensation, aroma and bitter, and then hedonic analysis.
Results: Regarding acceptability, the sensory properties, color, taste, mellow texture, mouth appearance and aroma, differ significantly (p <0.001) from the cakes enriched with almond flour from *T. catappa*. As for the scores attributed to the different cakes, they are statistically identical. Means are high and range from 6.07 / 9 to 7.13 / 9. At the perception level, the profiles showed significant differences at p<0,001 for fortified cakes. The cake scores show no statistical difference except for the color of the crumb. At this profile, the color of the crumb was more noticeable in the F3 cake with a score of 8.11 / 10, while the F2 cake showed the lowest score (3.3 / 10).
Conclusion: The almond flour of *T. catappa* weakly influences the sensory characteristics of the made cakes. It could be used to enrich the cakes and thus allow a better valorization of this plant.

1. INTRODUCTION

The consumption of bakery and pastry products is increasing today, due to changes in the eating habits of the populations. Indeed, the cake is one of the most appreciated and tasteful pastry products, prepared from flour, yeast, egg and gasoline [1]. Although the cake is not considered a staple food such as bread, it is accepted and consumed by people of various ages [2]. It is usually made from flour. In tropical countries, wheat production is limited, which implies the need to import flour to meet demand [1]. The surge in the world market for staple food prices is a constraint on manufacturers, as production costs increase [3,4]. In addition, gluten in wheat flour is a hazard to some consumers with intolerance to this substance [5]. The search for new flavors and flavors by pastry chefs in order to satisfy consumers' desires, but also to take into account their well-being by presenting functional foods, requires the search for substitute products [6,7]. Faced with these concerns, the almond-based flour of *Terminalia catappa* ("cocoma" local calling) seems an alternative.

Indeed, *T. Catappa* is a fruit tree of the family Combretaceae, it was introduced in the côte d'Ivoire in favor of colonization, through urban decoration [8]. The almonds produced are consumed as an aperitif in more or less salty forms [9]. They also contain high levels of protein (23.78%) and are a good source of essential amino acids [10,11]. Almonds also showed high levels of oleic and linoleic acids [12]. These substances contribute beneficially to the growth and development of children and also reduce the risk of cardiovascular disease and also help fight against inflammation and immunological disorders [13,14]. Then almonds *T. Catappa* have the advantage of being locally produced, free of speculation and there by saving money for industry professionals over imports.

Considering the nutritional and economic potential and to contribute to improving the processing of almonds *T. Catappa*, we will proceed in this work for making cakes enriched with these almonds monitoring their sensory evaluation.

2. MATERIALS AND METHODS

2.1 Vegetable Material

The vegetable material consisted of dried ripe fruits from *T. catappa* collected from suppliers in different regions of Côte d'Ivoire.

2.2 Sampling

The ripe dried fruits of *T. catappa* were collected between October and December 2016 from farmers in two regions of Côte d'Ivoire, namely Tonkpi region (Man and Danané cities) and Guemon region (Duékoué city), where this crop is cultivated. Per location, 3 suppliers were considered, from each of them 60 kg of dried fruits of *T. catappa* were collected. Thus, a total volume of 540 kg of dried fruits were collected, convoyed in the laboratory for analyses.

2.3 Preparation of Powdered Almonds of Dried Fruits of *Terminalia catappa*

Dried fruits of *T. catappa* were crushed using nutcracker. Once extracted, the almonds were dried at 50°C for 48 h in an oven (MEMMERT,

Germany). After cooling to room temperature, they were crushed (Magimix Crusher) and sieved using a column of sieves of different meshes (0.1, 0.14, 0.25, 0.36 and 0.4 mm) thus giving 5 batches of flour (Fig. 1). These batches of flour were stored in sealed polyethylene bags and stored in the desiccators until the cakes were made.

2.4 Preparation of Composite Powders

The Composite Central Plane (PCC) was used to obtain a well-structured range of almond powders that will provide various nutrient characteristics. Two controllable factors have been taken into account: the quantity of *T. catappa* almond powder varying from 5% to 10% and the particle size of the almond powder of *T. catappa* which oscillates between 0.1 mm and 0.4 mm (Table 1). For this plane, each factor presented 5 levels (-α, -1, 0, +1 and + α). Referring to Plackett and Burman [15], the combination of the levels of the two factors studied led to the implementation of 11 trials corresponding in reality to 9 formulas, since tests 9, 10 and 11 have the same proportions and Sizes of almond powder to be used (Table 1).

Table 1. Experimental plan for the composite plan used for the formulation of different cakes

Test	Factors	
	X1 **Amount of** ***T. catappa*** **almond powder** **(%)**	**X2** **Particle size of the** **almond powder of** ***T. catappa***
1	5	0.10
2	9.25	0.14
3	5.75	0.36
4	9.25	0.36
5	5	0.25
6	10	0.25
7	7.50	0.10
8	7.50	0.40
9	7.50	0.25
10	7.50	0.25
11	7.50	0.25

X1, the amount of almond powder of T. catappa which varies from 5% to 10%, X2, the particle size of the almond powder of T. catappa

2.5 Preparation of Cakes

The bakery flour, the 9 types of almond powders of *T. catappa*, fresh eggs, butter, sugar and baking powder were used for the preparation of cakes. Thus, from these ingredients, 5 cakes were prepared according to the method described by Bennion and Bamford [16] (Table 2). Indeed, using a Kenwood drummer (Kenwood Chef - Model A910D), the sugar was whitened in white and egg yolk at 240 rpm for one minute. Then baking flour and yeast were added to the mixture and the mixture was blended at 300 rpm for five minutes. To this mixture, the almond powder of *T. catappa* was added and mixed at 240 rpm for one minute. Finally, the butter was added and mixed again at 300 rpm for four minutes. The paste obtained was carefully reversed in a pre-induced oil mold, introduced into a preheated oven and baked at 150° C. for 45 minutes. After cooking, the cakes (Fig. 2) were cooled to room temperature (25°C), demolded, packed in aluminum foil and then stored in a dry place. After 24 h, cakes were evaluated.

2.6 Sensory Evaluation

The sensory analysis consisted in the tasting of the various cakes enriched with almond powders of *T. catappa*. Hedonic assessments and descriptive tests have been carried out. The tasting sessions have been made at the laboratory of biochemistry and food sciences of the Felix Houphouët-Boigny University of Abidjan. Every tasting has been made with 20 g of samples served in disposable rubber plates. The answers have been given by the scores on a scale of 9 points where 1 expressed the lack of sensation and 9 expressed the full sensation.

2.6.1 Hedonic analysis

The analysis was carried out by a group of 30 people (15 male and15 female) of age understood between 20 and 30 years. The panelists have been invited to express their level of acceptance of the the color, taste, texture silky, appearance in mouth and aroma. Preference tests were carried out on a 9-point hedonic scale where level 1 translated "extreme disagreeability" while 9 was "extreme pleasant" [17].

2.6.2 Descriptive analysis

A panel of 10 volunteers aged 20-30 years was selected on the basis of their availability, their faculty to recognize and appreciate the level of perception of the flavor, color, flavor and texture

Douati et al.; AJB2T, 2(1): 1-9, 2017; Article no.AJB2T.36696

characteristic of food products. Panelists have been trained in the methodology of analysis and appreciation of qualitative characteristics selected according to the requirements of sensory analysis, trained on the taste areas of the tongue and familiarized with cakes [18]. For the sensory evaluation of the cakes, panelists were invited to taste samples with codes (A, B and C) and and filled into various orders of presentation, then to fit the rating scale by indicating the value for the intensity perceived [19]. The values varied also from 1, when the sensory parameter is not perceived, to 9 when it is extremely felt.

2.7 Statistical Analysis

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

3. RESULTS

3.1 Hedonic Analysis of Cakes

Regarding acceptability, the sensory properties namely color, taste, mellow texture, mouth appearance and aroma, differ significantly (p <0.001) from the cakes enriched with almond

flour from *T. catappa*. As for the scores attributed to the different cakes, they are statistically identical. Means are high and range from 6.07 / 9 to 7.13 / 9 (Table 3).

3.2 Descriptive Analysis of Cakes

At the perception level, the profiles showed significant differences at p<0,001 for fortified cakes. The cake scores showed no statistical differences except for the color of the crumb (Fig. 2). At this profile, the color of the crumb was more noticeable in the F3 cake with a score of 8.11 / 10, while the F2 cake showed the lowest score (3.3 / 10). The aeration of the crumb, the soft texture and the aroma were moderately perceived. Thus the aeration displayed scores between 5.77 / 10 and 7.55 / 10, the soft texture between 5.62 / 10 and 8.61 / 10 and the flavor between 5.35 / 10 and 8, 61/10. The friable texture and wet sensation were less evident with averages varying from 1.9 / 10 to 4.66 / 10 and from 2.04 / 10 to 4.63 / 10, respectively. On the other hand, the sweetness and the sensation of fat displayed the highest intensities. They varied from 7.91 / 10 to 9.1 / 10 and from 6.34 / 10 to 8.78 / 10 respectively (Fig. 3).
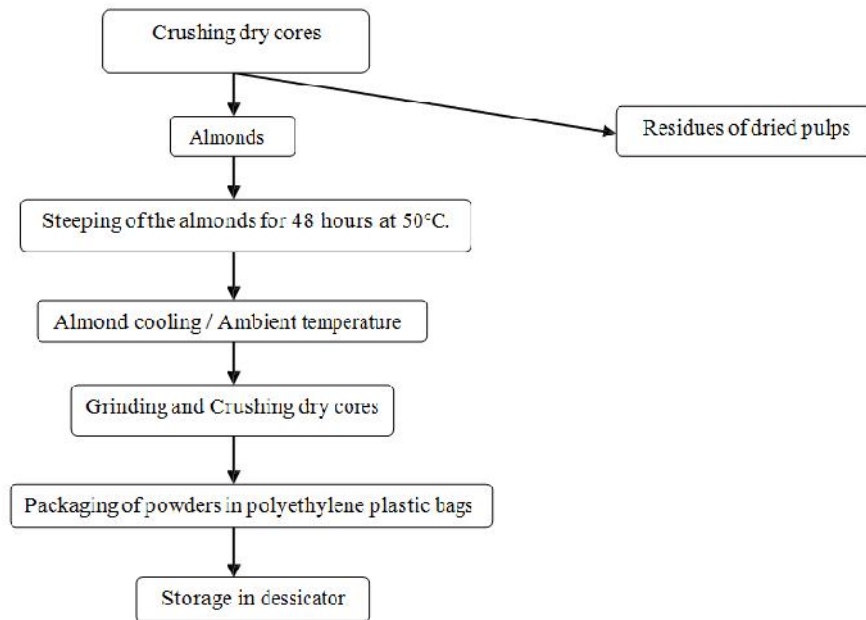
3.3 Sensory Variability of Cakes

The F1-F2 factorial design of main component analysis, which accounts for 85.05% of the variability, shows a strong correlation between cakes F3, F5, F8 and color, taste, texture, appearance and 'aroma. On the other hand, cakes F1, F2, F4, F6, F7 and F9 are not associated with any of the sensory profiles studied (Fig. 4).
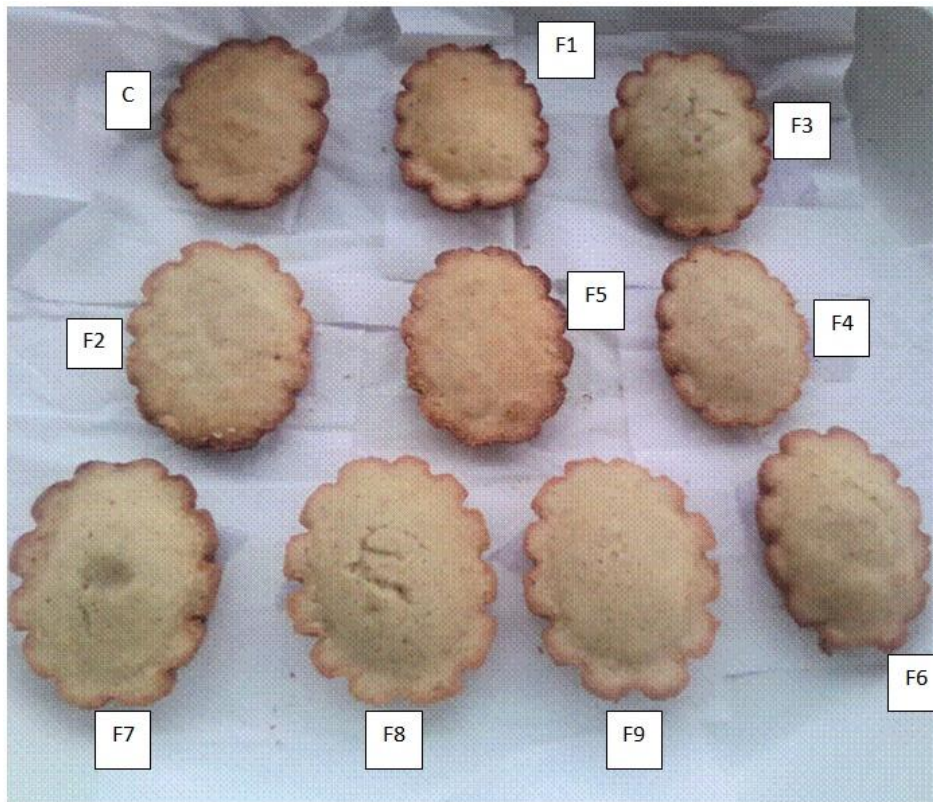
Table 2. Composition of cakes prepared

Ingredients	Ingredients proportion to bake cakes									
	Nature	Cake F1	Cake F2	Cake F3	Cake F4	Cake F5	Cake F6	Cake F7	Cake F8	Cake F9
Wheat (g)	100	100	100	100	100	100	100	100	100	100
Sugar (g)	64.4	64.4	64.4	64.4	64.4	64.4	64.4	64.4	64.4	64.4
Fresh eggs (g)	75	75	75	75	75	75	75	75	75	75
Butter (g)	60	60	60	60	60	60	60	60	60	60
Baking powder (g)	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Almond powder (g)	00	5	9.25	5.75	9.25	5	10	7.5	7.5	7.5

With, Nature, cake enriched without (00%) almond powder, F1 and F5, cakes enriched with 5% almond powder, F2 and F4, cakes enriched with 9.25% almond powder, F3, cake enriched with 5.75% almond powder, F6, cake enriched with 10% almond powder, F7, F8 and F9: cakes enriched with 7.5% almond powder

Table 3. Acceptability (out of 9) of sensory parameters of cakes

Cakes	Mean per sensory parameter (out of 9)				
	Color	**Taste**	**Soft texture**	**Appearance in mouth**	**Aroma**
F1	6.5±1.19[a]	6.67±1.24[a]	6.47±1.13[a]	6.7±1.20[a]	6.8±1.06[a]
F2	6.23±1.19[a]	6.47±1.27[a]	6.3±1.11[a]	6.53±1.04[a]	6.13±1.35[a]
F3	7±1.17[a]	7.13±1.22[a]	6.47±1.43[a]	7±1.28[a]	6.83±1.14[a]
F4	6.53±1.30[a]	6.87±1.30[a]	6.53±1.50[a]	6.53±1.65[a]	6.87±1.13[a]
F5	6.73±1.23[a]	7.07±0.94[a]	6,73±1.36[a]	6.83±1.11[a]	6.87±0.97[a]
F6	6.07±1.43[a]	6.77±1.25[a]	6.47±1.33[a]	6.57±1.27[a]	6.6±1.24[a]
F7	6.23±1.43[a]	7.03±1.35[a]	6.87±1.01[a]	6.83±1.17[a]	6.67±1.37[a]
F8	6.5±1.16[a]	7.07±1.04[a]	6.67±1.06[a]	7.07±1.11[a]	6.93±0.94[a]
F9	6.3±1.34[a]	6.77±1.27[a]	6.43±1.10[a]	6.43±1.22[a]	6.67±1.18[a]
F	6874	8562	7525	7879	8911
P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Means ± SD with the same letters on the same line / column are statistically identical to 5%., F, value of the statistical test factor; P, calculated probability value of the statistical test.

f= 235,8 p <0,001 ; f= 406,1 p <0,001 ;
f = 563,8 p <0,001 ; f = 101,2 p <0,001
(A)

f= 476,6 p <0,001; f= 1620 p <0,001;
f= 730,8 p <0,001 f= 124,4 p <0,001
(B)
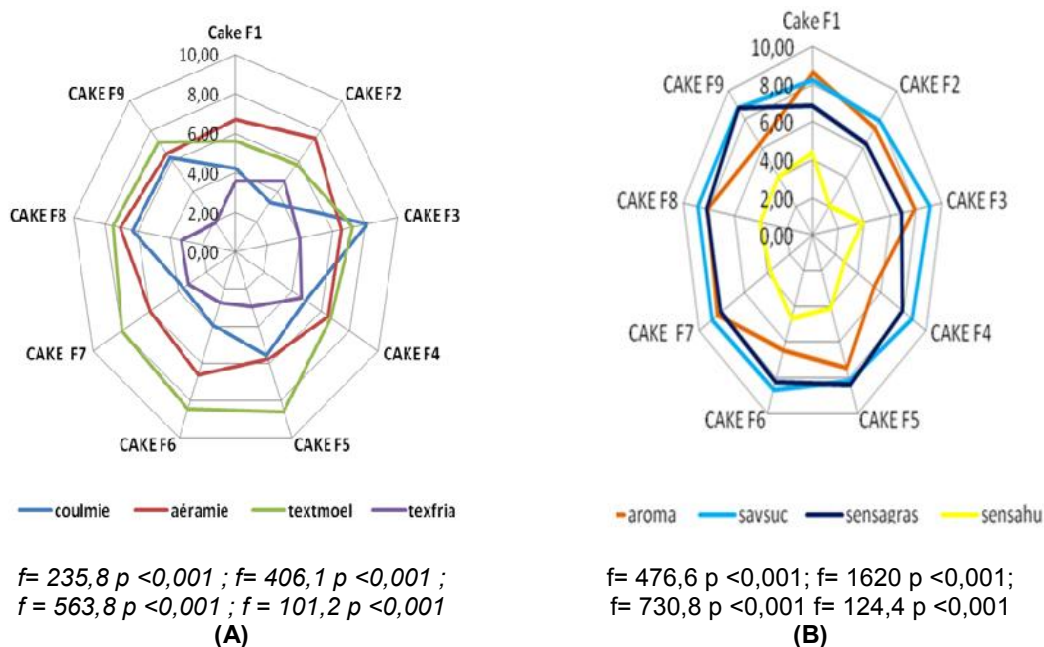
Fig. 3. Profiles of color perception, aeration, soft and friable texture (A) and aroma, bitter and sweet flavor, wet and wet feel (B) of the studied cakes
*with F1 and F5, cakes enriched with 5% almond powder, F2 and F4, cakes enriched with 9, 25% almond powder, F3, cake enriched with 5.75% almond powder, F6, cake enriched with 10% almond powder, F7, F8 and F9, cakes enriched with 7,5% almond powder., coulmie, Crumb color ; aeramie, crumb ventilation; textmoel, silky texture, texfria, crumbly texture,. savsuc, sugary flavor, sensagras, greasiness sensation , sensahu, humid sensation*

4. DISCUSSION

Today's research into quality foods to satisfy organoleptic needs and contribute to the improvement of consumer health is a major challenge for manufacturers. Several studies have been carried out for the substitution or enrichment of wheat flour mostly used in the field
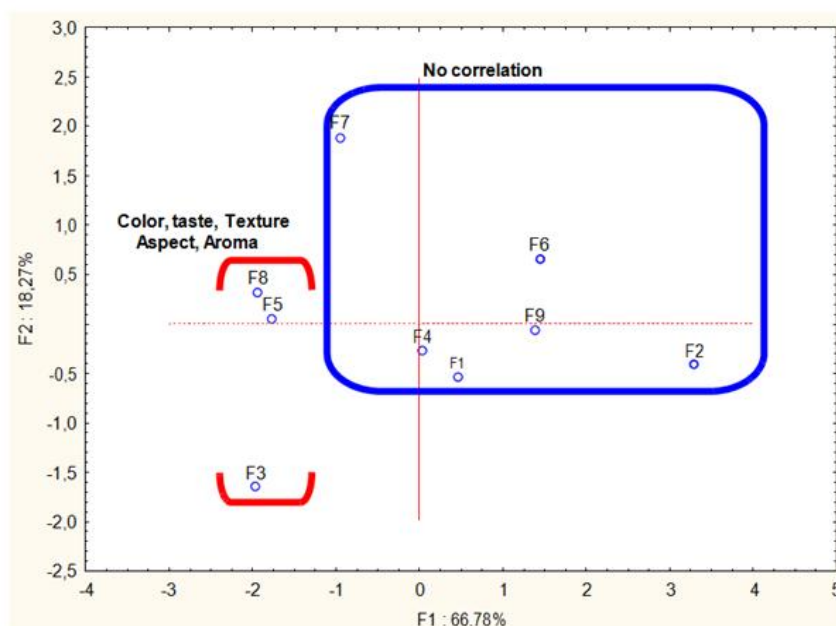
Fig. 4. Distribution of the different cakes studied and their descriptors in the plan formed by the factors F1 and F2 of the analysis in principal components

of bakery and pastry. These studies have generally focused on starches (yam, cassava, sweet potato etc.), cereals (but, rice, beans etc.) and other plants [20,21]. The use of almond flour from *T. catappa* has been considered to enrich wheat flour. The sensory analysis of the enriched cakes obtained revealed a weak influence of this flour on the organoleptic characteristics of the cakes. The cakes, thus enriched, have retained their quality, unlike the use of banana flour [22] and soya flour [23]. Enriched cakes have been much appreciated in terms of sweetness and the sensation of fat. Indeed, these attributes are characteristic of a good cake [24]. Moreover the cakes produced are not bitter.

Principal component analysis revealed that cakes F3, F5 and F8 are the most preferred and therefore the best, because they are correlated to both color, taste, texture, appearance and 'aroma. Concerning the cakes F1, F2, F4, F6, F7 and F9, they are not correlated to any of the attributes but do not remain of less good quality.

The combination of the quantity of *T. catappa* almond flour and the particle size showed that the quantities (5, 5, 75 and 7.5) and sizes (2.5, 3.6 and 4) were used. They made it possible to form the following characteristic torques: F3

(5.75, 3.6), F5 (5.2.5) and F8 (7.5;4). These combinations did not reveal any significant difference in the texture of the different cakes, but rather in the coloring. Indeed, coloring is an important quality factor directly linked to the acceptability of the cakes produced.

5. CONCLUSION

The use of the almond flour of *T. catappa* to enrich the cakes presents itself as a way of valorization of this plant more and more forsaken. The various combinations provided by the composite central plane at the level of the quantity of flour and the size of the particles, allowed to retain 9 cakes. Sensory analysis revealed that cakes F3, F5 and F8 are the most appreciated by tasters. The analysis also showed the low interaction of *T. catappa* flours on color, taste, texture, appearance and aroma on prepared cakes. The flour of almonds of *T. catappa* could be used to enrich cakes made from wheat flour without altering their original organoleptic appearance.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Giami SY, Amasisi T, Ekiyor G. Comparison of breadmaking properties of composite flour from kernels of roasted and boiled African breadfruit (*Treculia africana decne*) seeds. Journal of Raw Material Research. 2004;1:16-25.

2. Borges JTS. Utilização de farinha mista de aveia e trigo na elaboração de bolos. Boletim CEPPA. 2006;24(1):145-162.

3. FARM. The agricultural potential of West Africa, Paris. French; 2008.

4. CSAO. Settlement, market and food security, collection, West African papers. French; 2012.

5. Turcsik R. Flour power. Supermarket Grocery Business; 2004.

6. Gularte MA, de la Hera E, Gómez M, Rosell CM. Effect of different fibers on batter and gluten-free layer cake properties. *Lebensmittel-Wissenschaft and-Technologie*. 2012;48(2):209-214.

7. Matos ME, Sanz T, Rosell CM. Establishing the function of proteins on the rheological and quality properties of rice based gluten free muffins. Food Hydrocolloids. 2014;35:150-158.

8. Cavalcante MA, Maïa GA, Figueiredo RW, Teixeira EAM. Caracteristicas fiscas e quimicas da castanhola, *Terminalia catappa* L. Ciência Agronômica. 1986;17: 111-116.

9. Biego GHM, Konan AG, Douati TE, Kouadio LP. Physicochemical quality of kernels from *Terminalia catappa* L. and sensory evaluation of the Concocted kernels. Journal of Sustainable Agriculture Research. 2012;1(2):1-6.

10. Kimbonguila A, Nzikou JM, Maltos L, Loumouamou B, Ndangui CB, Pambou-Tobi N. PG, Abenan AA, Silou TH, Scher J, Desobry S. Proximate composition of selected Congo oil seeds and physicochemical properties of the oil extracts. Research Journal of Applied Sciences, Engineering and Technology. 2010;2(1):60-66.

11. Ezeokonkwo CA, Dodson WL. The potential of *Terminalia catappa* (tropical almond) seed as a source of dietary protein. Journal of Food Quality. 2004;27: 207-219.

12. Ladele B, Kpoviessi S, Ahissou H, Gbenou J, Kpadonou-Kpoviessi B, Herent M, Bero J, Larondelle Y, Quetin-Leclerq and Moudachirou M. Chemical composition and nutritional properties of *Terminalia catappa* L. oil and kernels from Benin. *Comptes rendus.* Chimie. 2016;19(7): 876-883.

13. Hussain S. Physical and sensory attributes of flaxseed flour supplemented cookies. Turkish Journal of Biology. 2006;30(2):87-92.

14. Martin CA. Ácidos graxos poliinsaturados ômega-3 e ômega-6: importância e ocorrência nos alimentos. Revista de Nutrição (Rev. Nutr). 2006;19(6):761-770.

15. Plackett RL, Burman JP. The design of optimum multifactirial experiments. Biometrica. 1946;33:305-325.

16. Bennion EB, Bamford GST. The technology of cake making 6th ed. Londres: Blackie Academic& Professional; 1997.

17. Meilgaard MC, Civille GV, Carr BT. Technicals of sensory evaluation. 3rd Edition CRC Press. LLC, Boca Raton, Florida, New York, USA. 1999;387.

18. AFNOR. Compendium of French Agro-food Standards: sensory analysis. Paris the defense, France. French. 1984;159.

19. Aka BAA, Konan N, Coulibaly A and Biego GHM. Nutritional and sensory analysis of milk processed from seeds of sweet pea (*Cyperus esculentus* L.) consumed in Côte d'Ivoire. Journal of Applied Life Sciences International. 2016;8(2):1-12.

20. Alozie YE, Udofia S, Lawal O, Ani IF. Nutrient composition and sensory properties of cakesmade from wheat and African yam bean flour blends. Journal of Food Technology. 2009;7:115-118.

21. Eke J, Sanni SA, Owuno F. Proximate and sensory properties of banana cakes. Nigerian Food Journal. 2009;27:102-106. Available:http://dx.doi.org/10.4314/nifoj.v2 7i2.47479

22. Yao AK, Koffi DM, Irié ZB, Niamke SL. Effect of partial substitution of wheat flour by mature plantain puree (Musa AAB) on the quality of pastry products. Journal of Applied Biosciences. French. 2014; 82:7436-7488.

23. Sanful Rita E, Sadik Adiza, Darko Sophia. Nutritional and sensory analysis of soya bean and wheat flour composite cake.

Pakistan Journal of Nutrition. 2010; 9(8):794-796.

24. Esteller MS, Yoshimoto RMO, Amaral RL, Lannes SCS. Uso de acucares em produtos panificados. Ciência e Tecnologia de Alimentos. *2004*;24(4):602-607. Available:http://dx.doi.org/10.1590/S0101-20612004000400021

Peer-review history:
The peer review history for this paper can be accessed here:
http://prh.sdiarticle3.com/review-history/21662