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Organoleptic Characteristics of Attiekes (*Manihotesculenta* root semolina) Enriched with Moringa Leaf (*Moringa oleifera* Lam), Curcuma Rhizomas (*Curcuma longa* Linnaeus) and Caju Almond Paste (*Anacardiumoccidentale L*)

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Abstract The Attiéké (semolina from the root of the *Manihotesculenta*plant) has become one of the most widely consumed foods in several African countries, particularly Côte d'Ivoire. This staple food is low innutrients and generally covers only a small proportion of daily nutrient requirements (vitamins, amino acids, fatty acids, and essential minerals). Increasingly, enrichment of attiéké with other vegetable sources rich in protein, lipid, essential minerals and vitamins is being recommended. Therefore, very little data is available on the organoleptic characteristics of these enriched attiékés. The aim of the present study is to evaluate the organoleptic characteristics of Agbodjama Attiéké enriched *with Moringa oleifera*leaves, *turmeric rhizomes and cashew kernels*. Based on a central composite design (CCD), 15 samples of enriched Agbodjama Attiéké and a control samplewere formulated. Different sensory profiles were established. Next, a hedonic test was carried out to quantify the degree to which consumers enjoyed or disliked the formulations.The ratings attributed to the various sensory attributes vary significantly ($p < 0.001$) from 0/9 to 7.33±0.16/9. The fresh Attiéké aroma was perceived with an intensity ranging from 4.98± 0.45/9 (MCA12) to 6.25± 0.07/9 (AT) significantly higher ($p < 0.001$) than the aromas ofturmeric, moringa and cashew almond. The fresh Attiéké aroma of samples MCA4 (5.39±1.83/9), MCA6 (5.36± 0.24/9) and MCA8 (5.85± 0.29/9)is statistically identical to that of the control sample AT (6.25± 0.07/9). Scores obtained for attributes such as homogeneity, grain size and binding, as well as sweetness and sourness in the enriched attiéké samples (MCA2, MCA4 and MCA6) remain statistically ($P > 0.05$) similar to those of the control agbodjama attiéké.On the other hand, 96% of those surveyed accept the Attiéké Agbodjama presented, and 4% of consumers surveyed neither reject nor accept them. In particular, MCA4 Attiéké Agbodjama is generally considered pleasant by consumers. Indeed, 98% of tasters surveyed approve of MCA4-enriched Attiéké Agbodjama. Consequently, it could be considered as a possible alternative to normal commercial Attiéké Agbodjama. However, due to their enrichment with proteins, minerals and vitamins, it is necessary to estimate their contribution in terms of essential nutrients.

Keywords: *Enriched Agbodjama Attiéké, Moringa, Turmeric, Cashew kernel, Organoleptic characteristics*

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1. Introduction

In Côte d'Ivoire, cassava is the main food crop after yam. Cassava production is growing by over 3% a year, almost three times faster than population growth [1]. However, cassava is highly perishable and deteriorates very quickly between 24 h and 72 h after harvest [2]. To reduce this rapid deterioration while meeting the dietary habits of the population, a variety of food products are traditionally obtained from cassava roots, notably Attiéké

[2]. TheAttiéké (cassava semolina) has become one of the most widely consumed foods in several African countries, particularly Côte d'Ivoire [3]. This high consumption of Attiéké is consecutive to rapid urbanization and economic difficulties [4]. Also, the Attiéké is widely consumed because of its distinctive organoleptic qualities, its slightly acidic flavor, its characteristic floury aroma and its non-sticky granular texture make it a prized accompaniment for Ivorians in particular [4,5].

The organoleptic properties of Attiéké vary according to preparation methods and the varieties produced. These variations in organoleptic qualities directly influence Attiéké consumption. Thus, consumers choose their type of Attiéké according to their taste preferences [6].

Moreover, the Attiéké as a staple food is low innutrients, and this type of food generally covers only a small proportion of daily requirements for most vitamins, protein, lipid and essential minerals [7]. Given this low intake, the enrichment of this root-based dish, like those based on cereals and tubers, with other plant-based foods such as legumes, rhizomes, almonds and vegetables has received particular attention in recent years [8].It is important to note that fortification of staple foods remains an important means of combating malnutrition in countries suffering from it [9]. Among the plant sources used for fortification in Côte d'Ivoire, we can cite *Moringa oleifera*leaves and *Anacardiumoccidentale*L. kernels. Both of these commodities remain available and are rich in both macronutrients (amino acids, omega 3 and 6, polyunsaturated fatty acids and carbohydrates) and micronutrients (beta carotene, tocopherol, B vitamins, and essential minerals [10,11]. In addition to this group of commodities, *Curcuma longa* rhizome are the most widely used part for both culinary, medicinal purposes[12]. They are an important source of nutrients and antioxidants and also usedas a food additive for their aromatic and coloring properties [13].

Unfortunately, very little data is available on the organoleptic characteristics of enriched Attiéké Agbodjama. A better knowledge of these organoleptic properties would be a great asset. The aim of the present study is to evaluate the organoleptic characteristics of Agbodjama Attiéké enriched with moringa leaf, turmeric rhizomes and cashew kernel paste, with a view to enhancing their value.

2. Materials and Methods

2.1. Materials

2.1.1. Biological Materials

The biological material consisted of Attiéké derived from the processing of *ManihotesculentaCrantz*roots, *Moringa oleifera*Lam leaf, *Curcuma longa* rhizome and *Anacardium*occidentale L. almond paste.

2.2. Methods

2.2.1. Production of Various Biological Materials

The biological materials used in this study were produced according to the manufacturing methods described below.

2.2.2. Cassava Root Semolina or Attiéké Agbodjama

The cassava roots were peeled with a knife and cut into chips. The strips were washed several times with plenty of water, then ground in a motorized grinder after adding palm kernel oil and traditionally prepared, and placed in jute bags. After resting for 48 hours, the fermented paste obtained was pressed, and the resulting cake was spread on a sieve to be granulated by hand in a basin. The resulting semolina was then dried in thin layers for several hours before being winnowed and defibrated. This homogeneous semolina was steamed to produce Attiéké Agbodjama, ready for consumption.

2.2.3. Moringa Leaf Concentrate

The leaflets of the fresh moringa leaves were detached from their petioles and then sorted to remove damaged leaves. They were then sanitized for 5 minutes in bleach water (50 mL of 8% sodium hypochlorite in 30 L of distilled water). After rinsing with distilled water and draining for 30 minutes, they were dried away from sunlight at 30°C for 10-14 days before being crushed in a hammer mill. The resulting powder was macerated for 24 hours in a 50/50 hydroalcoholic solvent. The extract obtained was filtered and concentrated by rotary evaporation. The Moringa concentrate obtained was stored at 4°C for the next step.

2.2.4. Cashew Nut Paste

The cashew nuts were cleaned and their shells were moistened and heated by boiling in water for 25 minutes to weaken them and make them easier to shell. The nuts were then removed from their shells using a woodpecker pliers. Once shelled, the almonds were dried at 50°C in an oven for 24 hours and then manually peeled with a knife. The almonds were ground using a disc grinder. The resulting paste was stored in jars and kept at 4°C.

2.2.4.1. Turmeric Rhizome Concentrate

The turmeric rhizomes were cleaned and sorted to remove any broken pieces. The rhizomes were then peeled and cut into pellets to maximize the surface area for drying in the sun for one to two weeks. After drying, the rhizomes were ground using a hammer mill. The resulting powder was macerated for 24 hours in a 50/50 hydroalcoholic solvent. The extract obtained was filtered and concentrated by rotary evaporation. The turmeric concentrate obtained was then stored at 4°C.

2.2.5. Use of the Central Composite Design for Enriching Attiéké Agbodjama with Moringa, Cashew Nuts, and Turmeric

The central composite design (CCD) was developed with the aim of optimizing the production method for Attiéké enriched with cashew nut paste, moringa leaf concentrate, and turmeric rhizome concentrate. This second-degree polynomial design of experiments, introduced by Box and Wilson [14], aims to study the effect of each independent variable and the possible interactions between the different parameters. It consisted of studying these interactions by varying all the factors or parameters, then assessing the effect of the variations on the response [15]. The experimental domain of this study

took into account the ratio of moringa concentrate to press cake (X1), the ratio of turmeric concentrate to press cake (X2), and the ratio of cashew almond paste to press cake (X3) (Table 1). Each factor had five levels (-α, -1, 0, +1, and +α), and the combination of the levels of the three factors studied led to the implementation of 23 + 2 x 3 + 6 = 20 trials (3 represents the number of factors) comprising eight factorial trials, six star trials, and six trials at the center of the experimental domain [16]. The actual values of -1 and +1 for each factor were estimated according to the following relationship:

$$X_k = X_{cent} + Z_k \times \frac{X_{max} - X_{min}}{Z_{max} - Z_{min}}$$

With: Xk, coded value of the factor; Xmin, minimum actual value of the factor; Xmax, maximum actual value of the same factor; Xcent, actual value of the same factor at the center; Zk, coded value of the variation limit; Zmin, minimum actual value of the variation limit; Zmax, maximum actual value of the variation limit.

The experiment matrix was established by replacing the coded values with the actual values of the factor levels, presented in the experimental domain table and converted into percentages. For each trial, according to the fixed values of the factors, the production of the different composite attiékés was assessed in relation to measurable responses, in particular color intensity (Y1), aroma (Y2), and sourness (Y3). The results of each response obtained are linked to the three independent variables by a second-degree polynomial model of the form:

$$Y_n = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_{11}X_1^2 + b_{22}X_2^2 + b_{33}X_3^2 + b_{12}X_1X_2 + b_{13}X_1X_3 + b_{23}X_2X_3$$

With: Yn: experimental response; bn: values representing the corresponding regression coefficients ; X1, X2, X3: independent variables that are respectively the ratio of moringa concentrate/press cake, the ratio of turmeric concentrate/press cake, and the ratio of cashew almond paste/press cake

Referring to Feinberg [16], the combination of the levels of three factors led to 20 formulations. These formulations included eight factorial tests, six star tests, and six tests at the center of the experimental domain. The tests at the center were reduced to one formulation (Table).

Table 1. Experimental parameters of the Central Composite Design and their coded and actual values used

Independente variables	Symboles	Coded levels/Actual values				
		-1.682	-1	0	1	1.682
Ratio M/GP(mL/kg)	X_1	5	8	12.5	17	20
Ratio C/GP(mL/kg)	X_2	4	6.8	11	15.2	18
Ratio AC/GP (g/kg)	X_3	3	5.4	9	12.6	15

M: Moringa concentrate; C: Turmeric concentrate; GP: Press cake; AC: Cashew almond paste

The Agbodjama Attiéké were produced on the basis of a composite central plan (CCP) from the pressing cake (**GP**), cashew almond paste (**AC**), moringa leaf concentrate **(MO)** and turmeric rhizomes (**CU**) obtained previously. Fifteen (**15)** formulations were produced, including attiéké agbodjama with moringa, turmeric and cashew almonds (MCA) (Table 2 and Figure 1).

Table 2.Percentage of composite Attiékés and enrichment products

PRODUCT CODES	GP	M	C	PA
MCA1	98.00	0.79	0.67	0.54
MCA2	97.16	1.65	0.66	0.53
MCA3	97.22	0.78	1.48	0.52
MCA4	96.38	1.64	1.46	0.52
MCA5	97.33	0.78	0.66	1.23
MCA6	96.49	1.64	0.66	1.21
MCA7	96.54	0.77	1.47	1.22
MCA8	95.71	1.63	1.45	1.21
MCA9	97.56	0.49	1.07	0.88
MCA10	96.15	1.92	1.06	0.87
MCA11	97.51	1.22	0.39	0.88
MCA12	96.20	1.20	1.73	0.87
MCA13	97.42	1.22	1.07	0.29
MCA14	96.29	1.20	1.06	1.45
MCA15	96.85	1.21	1.07	0.87

MCA: attiéké with moringa, turmeric, cashew nuts; GP: pressed cake; M: moringa concentrate; C: turmeric concentrate; PA: cashew nut paste

2.2.6. Sensory Evaluation of Agbodjama Attiéké Studied

Organoleptic characteristics were assessed by tasting enriched Attiéké and reference Attiéké. Descriptive tests and hedonic assessments were carried out. The tasting sessions took place at the Laboratory of Biotechnology Agriculture and Valorization of Biological Resources of the Université Félix HOUPHOUËT-BOIGNY in Abidjan. Each tasting was carried out with 15 g of samples served in disposable plastic plates.

2.2.6.1. Descriptive Analysis of Agbodjama Attiéké Studied

A panel of 15 volunteers aged between 20 and 30 was selected on the basis of their availability, their ability to recognize and appreciate the level of perception of the characteristic aroma, smell, color, flavor and texture of food products. They have been trained in the methodology for analyzing and assessing selected qualitative characteristics according to the requirements of sensory analysis [17]. To evaluate the dishes, panelists were asked to test anonymous samples with 3-digit codes, provided in several orders of presentation. They then indicated the intensity value on a scale**.**

2.2.6.2. Hedonic Analysis of Agbodjama Attiéké Studied

The hedonic analysis was carried out with a group of 30 untrained volunteer subjects aged between 20 and 30 from the Felix HOUPHOUËT BOIGNY University during the experimental period (10 days). This analysis focused on the tasters' preference for the characteristics of taste, aroma, smell, color and homogeneity of the beans, using a scale ranging from 1 to 9 points. Level 1 was "extremely unpleasant", while level 9 was "extremely pleasant" [18].

2.2.7. Statistical Analysis of Data

Statistical processing of the data consisted of an

analysis of variance (ANOVA) using SPSS software (SPSS 25 for Windows). Means of measured parameters were compared using the Student Newman Keuls test at the 5% significance level (α). Statistical evaluation consisted of an analysis of variance (ANOVA) with 1 factor: the sensory descriptor. Hedonic test data were analyzed using a chi-square (X2) test to compare proportions, relative to the 1/9-1/9-1-1/9-1/9-1/9-1/9-1/9-1/9-1/9/9/9 distribution, under SPSS software. In addition, multivariate analysis consisting of principal component analysis (PCA) was performed using STATISTICA software (STATISTICA version 7.1) to structure variability between Attiékés and sensory descriptors.

The respective percentages of press cake, moringa, turmeric and cashew kernel of the different formulation:

AT:*100 ;* ***MCA1:****98-0,79-0,67-0,54 ;* ***MCA2:****97,16-1,65-0,66-0,53 ;* ***MCA3:****97,22-0,78-1,48-0,52 ;* ***MCA4:*** *96,38-1,64-1,46-0,52 ;* ***MCA5:*** *97,33-0,78-0,66-1,23 ;* ***MCA6:*** *96,49-1,64-0,66-1,21 ;* ***MCA7:*** *96,54-0,77-1,47-1,22 ;* ***MCA8:*** *95.71-1.63-1.45-1.21 ;* ***MCA9****: 97.56-0.49-1.07-0.88;* ***MCA10****: 96.15-1.92-1.06-0.87;* ***MCA11****: 97.51-1.22-0.39-0.88;* ***MCA12****: 96.2-1.2-1.73-0.87;* ***MCA13****: 97.42-1.22-1.07-0.29;* ***MCA14****: 96.29-1.2-1.06-1.45;* ***MCA15****: 96.85-1.21-1.07-0.87*

Figure 1. The different formulation of Attiéké Agbodjama

3. Results and Discussion

3.1. Results

3.1.1. Sensory Profiles

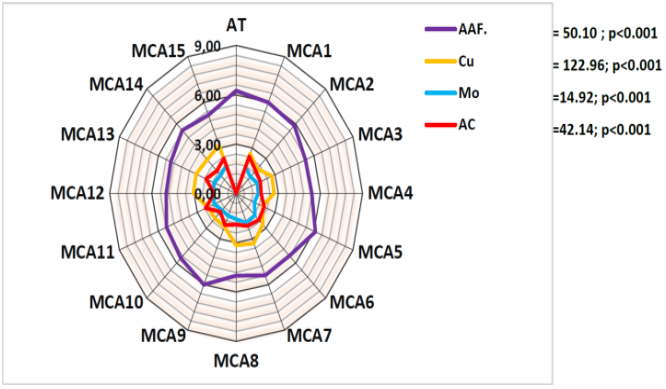
The descriptive analysis of enriched Agbodjama Attiéké and the control yielded sensory profile (Figure 2; Figure 3 and Figure 4). Ratings for the various sensory attributes varied significantly ($p < 0.001$) from 0/9 to 7.33± 0.16/9. The aromas of turmeric, moringa and cashew almond were not felt in the control Attiéké Agbodjama (AT). On the other hand, the fresh Attiéké aroma was perceived with an intensity ranging from 4.98±0.45/9 (MCA12) to 6.25±0.07/9 (AT) significantly higher ($p < 0.001$) than turmeric aroma (2.13±0.13/9 to 3.18±0.09/9), moringa aroma (1.42±0.29/9 and 1.94±0.23/9) and cashew kernel aroma (1.58±0.29/9 and 2.43±0.07/9) (Figure 2). The fresh Attiéké aroma of sample MCA4 (5.39±1.83/9) is statistically identical ($p > 0.05$) to that perceived in samples MCA6 (5.36±0.24/9) and MCA8 (5.85±0.29/9), but sample MCA8 has a fresh Attiéké aroma that differs statistically from that of the control sample AT (6.25±0.07/9).

The perception of other attributes, namely Attiéké color, homogeneity and kernel size, kernel bonding (Figure 3), sweet and sour flavors (Figure 4), differed from one attribute to another in the Agbodjama Attiéké studied. Scores ranged from 3.70±0.43/10 (MCA11) to 5.95±0.03/9 (AT) for color; 5.51±0.73/9 (MCA1) to 7.33±0.16/9 (MCA12) for kernel homogeneity; 3.39±0.12/9 (MCA11) to 5.55±0.23/9 (AT) for kernel size; 4.30±0.19/9 (MCA12) and 6.34±0.58/9 (MCA5) for kernel bonding ; 4.23±0.25/9 (AT) and 7.01±0.10/9 (MCA15) for sweetness; and 1.05±0.02/9 (MCA7) and 3.63±0.13/9 (MCA6) for sourness.

3.1.2. Sensory Variability of Attiéké Studied

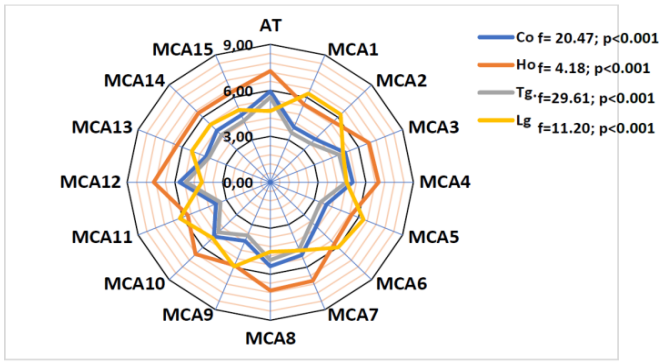
The principal component analysis (PCA) correlated all the traits studied with 2 factors. However, according to Kaïser's rule, these two (2) factors, with an eigenvalue greater than or equal to one (1), are taken into account when interpreting the PCA data. They account for 87.26% of total variability. The first factor (F1) has an eigenvalue of 5.11 and accounts for 51.13% of total variability. It establishes mostly positive correlations with flavors: fresh Attiéké, moringa, turmeric, cashew almond, with sweet and sour taste, then negative correlations with color, homogeneity, kernel size and binding. The F2 factor, with an eigenvalue of 3.61 and 36.13% of variance, was positively correlated with color, homogeneity and kernel size, with the aromas of fresh Attiéké, moringa and cashew kernel, and with sweetness. On the other hand, it was negatively correlated with fresh Attiéké aroma, kernel bonding and sourness (Table 3).

The F1-F2 factorial design of the principal component analysis (PCA) accounts for the largest proportion (87.26%) of total variability. Correlations between Agbodjama Attiéké samples and sensory traits are assessed using the F1-F2 factorial design (Figure 5). It divides the samples into two (2) groups. Group one (1) is made up of the control Attiéké Agbodjama (AT), distinguished by a much more pleasant fresh Attiéké aroma, less sourness, less pronounced color and good kernel homogeneity. Sweetness was perceived as less pronounced and overall in all the Attiékés studied, while grain homogeneity, size and binding varied little between Attiéké. Enriched Agbodjama Attiéké make up the second group with the highest turmeric, moringa and cashew almond aromas, and very little difference in sourness from the control. Samples MCA1, MCA2, MCA5 and MCA9 are characterized by the highest fresh Attiéké aroma (AAF), close to that of the control. Sample MCA12, on the other hand, had the lowest sensation of fresh Attiéké aroma. The other composite Attiékés (MCA) have a pleasant fresh Attiéké aroma. In addition, turmeric, moringa and cashew almond aromas are very weakly felt in all the Agbodjama composite Attiékés samples. The most basic sourness is perceived in samples MCA5, MCA7, MCA9 and MCA15. The Agbodjama Attiéké samples MCA2, 4, 5, 6, 7, 8, 9, 10 and 15 had statistically identical sourness levels to the control. Sample MCA6 recorded the highest sourness value (3.63±0.13). However, this sour taste is acceptable for all the Attiéké studied.



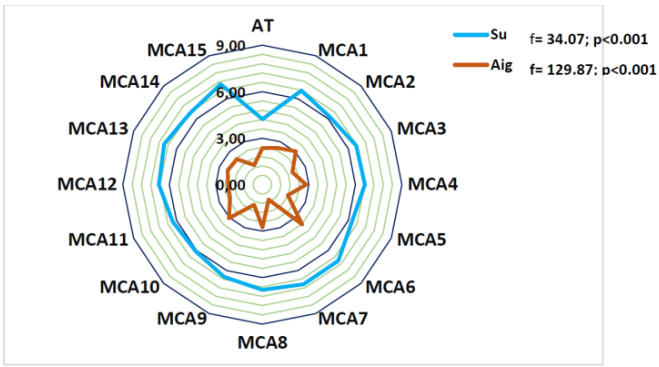
AAF: fresh attiéké flavouring; **Cu:** turmeric flavouring; **Mo:** moringa flavouring; **AC:** cashew almond flavouring

Figure 2. Sensory profile of aromas: fresh Attiéké, turmeric, moringa and cashew almonds of enriched Agbodjama Attiéké



Co: Color; **Ho:** Grain homogeneity; **Tg:** Grain size ;**Lg:** Grain bonding

Figure 3. Sensory profile of the color, homogeneity, size and grain bond of enriched Agbodjama Attiéké



Su:sugar; **Aig:** tartness

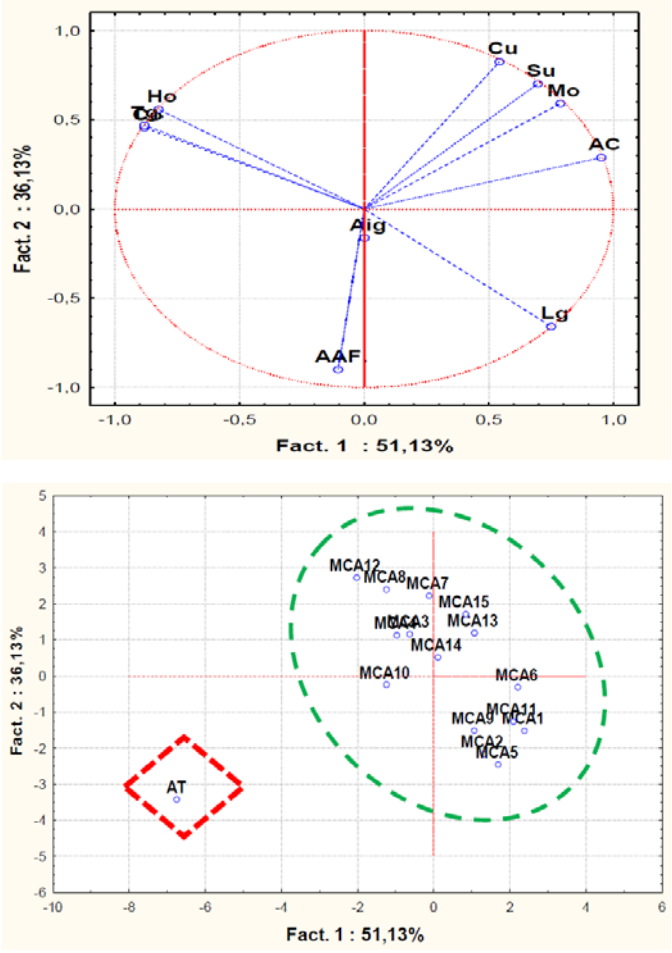
Figure 4. Sensory profile of sweet and sour flavours in enriched Agbodjama Attiéké

Table 3. Eigenvalue matrix and correlations of sensory parameters of Agbodjama Attiéké with F1 and F2 components of principal component analysis

Components	F1	F2
Eigenvalues	5.11	3.61
Variability expressed (%)	51.13	36.13
Cumulative variability expressed (%)	51.13	87.26
Color	-0.88	0.46
Grain homogeneity	-0.82	0.56
Grain size	-0.88	0.47
Grain bonding	-0.10	-0.90
Fresh Attiéké flavouring	0.75	-0.66
Turmeric flavor	0.54	0.83
Moringa flavor	0.79	0.59
Cashew almond flavor	0.95	0.29
Sweet taste	0.70	0.70
Tartness (acidity)	0.00	-0.16

3.1.3. Sensory Acceptability

The sensory properties of the various Agbodjama Attiéké enriched with moringa and turmeric concentrates and cashew kernels (MCA) analyzed revealed the most interesting acceptability scores and organoleptic characteristics. To this end, the overall acceptability of the MCA2, MCA4 and MCA6 composite Agbodjama Attiéké and the control Agbodjama Attiéké were assessed (Table 4). Moreover, 96% of respondents accepted the AgbodjamaAttiékés presented. Thus, the MCA2, MCA4 and MCA6 Agbodjama Attiéké are generally considered pleasant by consumers. Indeed, an average of 96% of tasters surveyed approved of MCA2, MCA4 and MCA6 enriched AgbodjamaAttiékés, with 96%, 98% and 95% respectively expressing full satisfaction. A statistically low 4%, 2% and 5% of subjects audited had neither aversion nor satisfaction with AgbodjamaAttiékés MCA2, MCA4 and MCA6 respectively. Unlike the MCA2, MCA4 and MCA6 enriched Agbodjama Attiéké, the control Agbodjama Attiéké was accepted by all tasters. In fact, 100% of those questioned approved the control Attiéké Agbodjama.



With: **AAF:** Fresh attiéké flavour; **Aig**: sourness; **Lg:** grain length; **Su:** sweetness; **Mo:** moringa flavour; **AC:** cashew almond flavour; **Tg:** grain size; **Cu:** turmeric flavour; **Hg:** grain homogeneity; **AT:** Attiéké control; **MCA:** Attiéké with moringa, turmeric, cashew almond;

Figure 5. Correlations of the F1 and F2 factorial axes of the principal component analysis with the sensory parameters (A) and the samples of Agbodjama Attiéké studied (B)

Table 4. Percentages of tasters of the composite Attiéké samples and the control Aattiéké studied, according to level of appreciation

Assessment levels		1	2	3	4	5	6	7	8	9	X^2	P
General trend		Dissatisfaction				M	Acceptance					
DDL		8										
Theoretical distribution (%)		11.11	11.11	11.11	11.11	11.11	11.11	11.11	11.11	11.11		
Formulation	AT	0.00	0.00	0.00	0.00	0.00	44.00	43.00	9.00	4.00	249.38	<0.001
	MCA2	0.00	0.00	0.00	0.00	4.00	46.00	39.00	9.00	2.00	236.42	<0.001
	MCA4	0.00	0.00	0.00	0.00	2.00	48.00	39.00	8.00	3.00	251.18	<0.001
	MCA6	0.00	0.00	0.00	0.00	5.00	47.00	38.00	10.00	0.00	240.02	<0.001

M: *medium, neither accepted nor rejected;* ***X2****: Chi-square statistical test value;* ***P:*** *observed probability value Values of P<0.05 indicate a significant difference between the percentages of panelists corresponding to the assessment levels of each sensory parameter;* ***AT:*** *Attiéké control; MCA2: Attiéké with moringa, turmeric, cashew almond group 2; MCA4: Attiéké with moringa, turmeric, cashew almond group 4 ; MCA6: Attiéké with moringa, turmeric, cashew almond group 6.*

3.2. Discussion

The enriched agbodjama attiéké were appreciated in different ways by tasters. Taste perception of the AgbodjamaAttiékés studied showed that sweetness was moderately perceived in all Attiéké, and acid taste (sourness) was less perceived. This could be due, on the one hand, to the fact that Attiéké occupies a proportion of over 95% in the different formulations and, on the other hand, that in terms of nutritional composition, Attiéké is made up of over 90% carbohydrates, which are the basis of the sweet sensation [7].In addition, studies also indicate that sweet taste is an important parameter of appreciation that is observed from birth[19,20]. As for the weakly recorded sour taste, this could be explained firstly by the presence of fermentative bacteria including bacillus (3.7 10^7 to 1.2 10^8 CFU/g), enterococcus (3 10^6 to 2.5 10^7 CFU/g) in addition to lactic acid bacteria, yeasts and moulds prior to processing into attiéké [21]. Secondly, through the preparation method, as it is a high-standard attiéké prepared with all possible care (a superior quality cassava variety, better fermentation of the cassava paste, complete defibration and uniform grain size), offering a richer flavor [22,23].

The descriptive test results show that the perception of moringa, turmeric and cashew almond aromas varies proportionally with the quantities of moringa, turmeric and cashew almond concentrates added. The Fresh Attiéké aroma varies according to the quantities of moringa concentrate, turmeric and cashew kernels added. Moreover, these sensory attributes positively influence the acceptability of enriched Agbodjama Attiéké when the quantities of these different products added are low. On the other hand, the addition of large quantities of these products (turmeric, moringa and cashew kernels) has a negative interaction on hedonic characteristics, as Attiéké loses this important property that characterizes it. Thus, the MCA2, MCA4 and MCA6 composite Agbodjama Attiéké, in which these sensations are weakly expressed, are judged pleasant by a large number of consumers.

With regard to homogeneity, grain size and binding positively influence the acceptability of Agbodjama Attiéké, as the acceptability test for these attiékés shows no significant difference between them. Djeni et *al*[24], also showed that Attiéké is well accepted by consumers when it is less sour, with homogeneous granules that are pleasant to smell and taste.

Moreover, the colors observed depend on the proportions of moringa and turmeric concentrates. In fact, the color of the turmeric concentrate (yellow-orange) affects the visual pleasantness of the attiéké.The yellow-orange colour given to attiéké by turmeric is due to its main active molecule (curcumin), which is used to effectively treat various conditions[25]. On the other hand, cashew kernels do not affect the color of Attiéké.Despite the diversity of Attiéké' appearance, the results do not indicate any influence on their acceptability. In short, composite AgbodjamaAttiékés could all be accepted by consumers. As a result, the composite Attiékés produced could be introduced into the population's food offer.

4. Conclusion

Sensory evaluation of Agbodjama Attiéké enriched with cashew kernels, moringa leaf concentrate and turmeric rhizomes showed an improvement in their organoleptic characteristics. The tasters found the composite Agbodjama Attiéké acceptable, in particular the MCA2, MCA4 and MCA6 Attiéké Agbodjama, with a sweet flavor, pleasant aroma, more appreciated texture and low sourness. The Attiéké Agbodjama MCA4 presented the most interesting values for these organoleptic characteristics. This formulation would represent a considerable improvement over simple AgbodjamaAttiékés. Thus, it could be considered a possible alternative in the diet of vulnerable populations.

StatementofCompetingInterests

The authors declare that there was no conflict ofinterest in the writing of this article.

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