Effects of Fermentation of Cashew Kernel on the Nutrient Value of Cassava Semolina Flour (Attieke)

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Abstract— *Protein-energy malnutrition in children is a public health problem. This nutrition problem is attributed to inappropriate complementary feeding. Indeed, the cost of high-quality food supplements is high and traditional food supplements have a low nutritional quality related to the presence of antinutritional factors. The objective of this study is to determine acceptability and antinutritional factors in attiéké / cashew kernel composite flours. The cashew kernel flour is produced after various technological treatments to obtain two types of flour (unfermented flour and fermented flour). Physico-chemical and sensory analyzes are performed. The results showed that fermentation has an influence on the parameters studied. The protein contents of the unfermented formulations range from 7.53% to 10.62% while those of the fermented formulations range from 8.23% to 11.53%. Both formulations contain antinutritional factors.*

***Keywords—* cashew kernel, attiéké, antinutritional factors, nutritional quality.**

I. INTRODUCTION

Breast milk is considered the best food for the newborn. It provides children from zero to four months with all the essential elements in balanced proportions. It also protects them against infections. Beyond this age, breast milk is no longer sufficient to fully cover energy and protein requirements (WHO, 2003). For example, the WHO recommends that mothers feed their babies exclusively for up to 4-6 months and continue breastfeeding as much as possible for up to two years, while gradually introducing other foods including those from the family dish. It is at this time that infant malnutrition takes place, which is due to the different complementary foods given to infants. These foods are usually made from cereal flour, tubers and roots, which are high in carbohydrates and low in protein.

It is clear that in the countries of the third world, there are crops that produce foods with high calorific value and protein. Thus several attempts are made to improve the nutritional quality of flours used as complementary foods. Enrichment is defined as the addition to a food of one or more essential nutrients, normally contained or not in the food, with the objective of preventing or correcting a deficiency of one or more nutrients, within a population or specifically vulnerable population groups (WHO, 1994). Fermentation also reduces antinutritional factors that affect the bioavailability of minerals (Yao, et al., 2009). It improves the organoleptic qualities of food and limits the development of pathogenic microorganisms and / or degradation (Caplice and Fitzgerald, 1999), through the acidification of the environment. This study aims to determine the effect of enrichment and fermentation of cashew kernel meal on attiéké flour.

II. MATERIAL AND METHODS

2.1 Biological Material

The plant material used in this study consists of cassava semolina (attiéké) purchased in the village of Djahakro (Yamoussoukro, Ivory Coast) from three producers, and cashew kernel flour obtained after various treatments of cashew nuts. Two (2) commercial flours (Blédine corn and FARINOR potato) are used as controls.

2.2 Attiéké flour production

The attieke collected from the producers is dried in an oven at 60°C for 24 hours and crushed using a grinder. The flour obtained was kept in polyethylene bags.

2.3 Production of deoiled and unfermented cashew kernel flour

The cashew kernels are obtained after dehulling, drying and pruning cashews. The cashew kernel flour is produced by the method described by Sze-Tao and Sathe, 2004 modified. The dried almonds were crushed using a semi-artisanal grinder and placed in a stainless steel tank. Hexane was added 1: 1 (w / v) to the flakes for oil extraction. The mixture was macerated for 30 minutes before being heated at 130 ° for 50 minutes and allowed to stand for 24 hours at room temperature. Then the pellet is separated from the supernatant (oil and hexane). The operation is performed twice. The cakes are pressed for 24 hours to extract the rest of the oil. The deoiled cake was oven dried at 70°C for 12 hours. They are milled in a mill and the flour obtained was stored in polyethylene bags.

2.4 Production of fermented deoiled cashew kernel flour

The cashew kernels were fermented according to the method of Ijarotimi et al., (2012) modified. The almonds are boiled at 100 ° C for 1 hour. The boiled almonds are wrapped in the plantain leaf for 72 hours for fermentation. The fermented seeds are oven dried at 60 ° C for 48 hours. The fermented almonds are crushed and the hexane added (confers the production of unfermented flour). The cakes are ground in a grinder and packaged in polyethylene bags

2.5 Formulation of infant flours: attiéké / cashew kernel

Attiéké / cashew kernel composite flours were obtained by incorporating respective proportions of 0, 10, 15 and 20% of cashew kernel meal (fermented and unfermented) into attiéké flour. Each formulation was thoroughly mixed in a blender, then divided into 250 g fractions in polyethylene plastic bags and stored for analysis.

2.6 Physicochemical composition

About 0.1 g of attiéké-almond cashew meal is used to determine crude protein levels from the total nitrogen assay using the Kjeldhal method (AOAC, 1990). The protein level was obtained by multiplying the total nitrogen content by a factor of 6.25 convention.

The total phenols are extracted according to the AOAC Method (Christensen, 1974) using the FolinCiocalteu reagent. For extraction, 1 g of flour is placed in a beaker into which are added 100 ml of oxalic acid at 0.3% (g / v). The mixture is stirred with a magnetic stirrer for 30 minutes the whole is centrifuged at 3000trs for 15 minutes. Then the extract is filtered on Whatman paper No. 41. For the assay, 1 ml of the extract diluted in 8 ml of distilled water is added to a tube, plus 0.5 ml of diluted FolinCiocalteu reagent (1 ml). / 10), and 1.5 ml of sodium carbonate solution (7.5%). The mixture is left in the dark for 1 hour at room temperature. The reading is made at an absorption of 765 nm at the spectrophotometer. A standard range is made with gallic acid at different concentrations (0 to 1 mg / ml).

The tannins are determined according to the method described by Ba et al., 2010). One (1) mL of methanolic extract is introduced into a test tube. To the contents of the tube are added 5 ml of vanillin reagent at 1% (w / v). The tube is left standing for 30 min in the dark and the optical density (OD) is read at 500 nm against a blank. The amount of tannin in the samples is determined using a standard range established from a stock solution of tannic acid (2 mg / mL) carried out under the same conditions as the test.

Phytates were quantified according to the method of Latta and Eskin (1980) based on the discoloration of the Wade reagent by phytates. The oxalate assay is performed according to the method described by Day and Underwood (1986) using potassium permanganate. One (1) gram of oven-dried and ground sample is homogenized in 75 mL of 3M sulfuric acid. The mixture is magnetically stirred for 1 hour and then filtered. Twenty-five (25) mL of the filtrate is heat-titrated with 0.05M potassium permanganate solution until a steady pink turn. Hydrocyanicacid contents were determined by the AOAC method (1990). A quantity of 10 g of sample was milled in a distillation flask and 200 ml of distilled water added. Distil the mixture for 3 hours by trapping the distillate in a 250 mL receiver flask containing 50 mL of 2.5% NaOH and make up the distillate with distilled water to the mark. 100 ml of the mixture were taken and 2 ml of 5% KI are added and titrated with a solution of 0.02M $AgNO_3$, until cloudiness appears.

2.7 Swelling

The swelling was performed by the method of Okezie and Bello, 1988. A well-defined volume (10 mL) of each flour sample was introduced into a graduated cylinder (initial volume). 50 ml of distilled water were introduced into the test tube. The volume occupied by the swollen flour (final volume) was read after 30 min. The rate of swelling is given by the following formula:

$$Tg = \frac{\text{final volume}}{\text{initial volume}} X\ 100$$

2.8 Sensory Analysis

2.8.1 Preparation of the Porridges

The porridges were cooked by introducing 50 g of flour into 300 ml of drinking water. The cooking lasted 6 minutes over a low heat. Then 6% sugar was added at the end of cooking. The slurries were cooled to room temperature in the preparation room before being served.

2.8.2 Acceptability Test

The panel was formed with 60 untrained people recruited on the basis of their availability. The coded (three-digit) coded porridge samples were presented to each panelist in a randomized order. The pleasure perceived by each panelist was scored on a nine-point hedonic scale. Notes ranging from (9) nine (extremely pleasant) to (1) one (extremely unpleasant) were assigned to the different modalities of the scale (Meilgaard et al., 1999).

2.8.3 Descriptive Analysis

The method consists of evaluating and quantifying the appropriate descriptors (odor, taste, color and texture) according to a category scale. A panel of 15 people was recruited and trained in the analysis methodology. Then, he became familiar with the groceries produced by the commercial infant flours (BLEDINE Corn and FARINOR Potato). These porridges were coded (with three digits). The various slurries of attiéké flour enriched at 0%, 10%, 15% and 20% of the fermented cashew kernel flour were presented simultaneously in a random order and then the attiéké meal mixes enriched at 10% 15%, 20% of the unfermented cashew kernel meal was presented simultaneously in a randomized order.

2.8.4 Statistical Analysis

Results are expressed as mean ± standard deviation from triplicate measurements. The non-parametric test of Duncan is used to analyze the difference between the means at 5% risk, using Statistica 7.1 software ANOVA analysis of variance method.

III. RESULT

3.1 Physicochemical and functional composition

Table 1 show the results in protein, swelling and antinutrients. Protein content, flour FCNF and FCF respectively have the highest values (24.57%, 33.77%). The lowest value is observed with FA flour (2.97%). An increase in the level of protein was observed with the rate of incorporation of the different cashew kernel flours but these contents are higher with the incorporation of fermented cashew kernel flour.

Polyphenol values range from 104.66 mg GAE / 100 g DM for FA flour to 631 mg GAE / 100 g DM for FCF flour. The values of the different formulations are higher than that of the commercial meal BM (104, 26 mg GAE / 100g MS) and those of the fermented formulations are the highest.

Incorporation of unfermented cashew flour increases the rate of swelling (192.33 ± 2.51% for FAFCNF10 to 214.33 ± 4.04% for FAFCNF20) significantly ($P < 0.05$). However, the opposite is observed with fermented cashew flour where the rate of swelling decreases (217.33 ± 2.51% for FAFCF10 to 158.00 ± 2.64% for FAFCF20) with the rate of incorporation. BM shows the highest value (433.66 ± 3.21%) compared to the different formulations. All the values of the different formulations are lower than that of attiéké flour (298.33 ± 2.88%) thanks to its high carbohydrate content.

3.2 Antinutritional Factors

Tannin values range from 10.07 mg / 100g (FCF) to 28.83 mg / 100g (FCNF). The values of the formulations with the fermented cashew meal are lower than those of the unfermented cashew flour formulations. All these values are lower than that of commercial flour BM (39.29 mg / 100g).

Fermentation decreases the content of oxalates in flours. The contents of the fermented formulations are between 73.99 mg / 100g for the flour FAFCF10 and 140mg / 100g for the flour FCF. As for unfermented formulations, the values vary from 198 mg / 100g for FCNF flour to 76mg / 100g for FAFCNF10 flour. These are superior to that of commercial flour.

Phytate results ranged from 72.72 mg / 100g (FA) to 23.74 mg / 100g (FAFCF20). These levels decrease with the incorporation rate of different cashew kernels. Sample values with fermented cashew kernel meal are significantly ($P < 0.05$) lower than samples with unfermented cashew kernel meal.

The different formulations have a low content of hydrocyanic acid. Hydrocyanicacidvalues range from 0.27 mg / 100g to 1.08 mg / 100g. All show significant differences ($P < 0.05$).

3.3 Sensory Analysis

3.3.1 Acceptability of the porridges

The overall acceptability of the porridge presented in Table 2 shows that the porridge were variously appreciated. unfermented attiéké-almond composite meal mixes (score greater than 6) are more popular than the attiéké-fermented cashew almond meal mixes (note 5 except FAFCF15 with a score of 6). The porridge of attiéké flour enriched in 10% of unfermented cashew kernel flour (7.35) is the most popular of the unfermented formulations, commercially flours (BLEDINE Mais and FARINOR) and attiéké flour. The attiéké flour mixture enriched with 15% fermented cashew kernel flour is the most popular fermented formulation.

3.3.2 Sensory profiles

The sensory profiles of the unfermented -attiéké- cashews kernel flour (FAFCNF10, FAFCNF15 and FAFCNF20) and commercial flours are presented in Figure 1. The porridge based on fermented attiéké- cashews kernel meal (FAFCF10, FAFCF15 and FAFCF20) and commercial flours are shown in Figure 2. Figures 1 and 2 show that the different descriptors taste, texture, creamy appearance influenced the acceptability of the most popular porridge (FAFCNF10 and FAFCF15).

TABLE 1
PHYSICOCHEMICAL AND FUNCTIONAL COMPOSITION

Samples	Protein%	Swelling%	Polyphenolsmg EAG / 100g	Tannins mg/100g	Oxalates mg/100g	Hydrocyanic acidmg/100g	Phytates mg/100g
FA	2,97 ± 0.17^{a}	298,33±2.88^{e}	104, 66±0,7^{a}	27,65±00^{h}	88,00±0^{d}	1,08±0^{J}	72,72±0,48^{i}
FCNF	24,57 ± 0.3^{i}	-	521, 33±0,7^{h}	21,17±0,08^{d}	198,66±1,15^{i}	0,31±0,02^{b}	56,50±0^{h}
FAFCNF10	7,53 ± 0.10^{c}	192,33±2.51^{c}	210,42±0,14^{b}	20,85±0,08^{c}	76,66±0,57^{c}	0,86±0,02^{i}	49,50±0,15^{g}
FAFCNF15	9,16 ± 0.09^{e}	197,33±2.51^{c}	250,57±0,7^{c}	25,53±0,16^{g}	99,33±0,57^{e}	0,68±03^{g}	35,92±0,47^{d}
FAFCNF20	10,62 ± 0.32^{g}	23,42 ± 0,46^{a}	312,55±0,5^{d}	28,83±0,16^{i}	110,33±0,57^{g}	0,45±0,01^{d}	31,25±0,9^{C}
FCF	33,77 ± 0.17^{j}	-	631,52±0,7^{i}	10,74±0,19^{a}	140,00±0^{h}	0,27±0^{a}	45,50±0,61^{e}
FAFCF10	8,23 ± 0.20^{d}	217,33±2.51^{d}	319,28±0,6^{e}	19,29±0^{b}	73,66±0,22^{b}	0,80±0,04^{h}	25,24±0,42^{b}
FAFCF15	9,98 ± 0.10^{f}	167,66±2.51^{b}	416,71±0,1^{f}	22,54±0,11^{e}	88,66±0,19^{d}	0,58± 0,01^{f}	24,49±0,72^{ab}
FAFCF20	11,53 ± 0.28^{h}	158,00±2.64^{a}	421, 10±0,7^{g}	24,74±0,39^{f}	104,66±0,5^{f}	0,41±0^{c}	23,74±0,70^{a}
BM	5,40 ± 0.09^{b}	433,66±3.21^{f}	104,26±0,14^{a}	39,29±0,12^{j}	33,33±0,47^{a}	0,54±0^{e}	47,39±0,31^{f}

Values are mean ± standard deviation of three measurements (n = 3). The same letter in the same row index indicates that there is no significant difference between samples for the parameter concerned (p<0.05).). According to Duncan's test.
FA :** Attiéké Flour ; **FAFCNF10 :**Attiéké Flour enriched with 10% unfermented cashew kernel flour ; **FAFCNF15 :** Attiéké Flour enriched with 15% unfermented cashew kernel flour ; **FAFCNF20 :** Attiéké Flour enriched with 20% unfermented cashew kernel flour ; **FAFCF10 :** Attiéké Flour enriched with 10% fermented cashew kernel flour ; **FAFCF15 :**Attiéké Flour enriched with 15% fermented cashew kernel flour ; **FAFCF20 :** Attiéké Flour enriched with 20% fermented cashew kernel flour ; **BM: Commercial infant flour BLEDINE corn

TABLE 2
OVERALL ACCEPTABILITY OF DEHYDRATED SEMOLINA CASSAVA / CASHEW KERNEL FLOUR AND CONTROL FLOURS

Flours	ACCEPTABILITY
Unfermented flour	
FA	6,63±1,79[c]
FAFCNF10	7,35±1,4[d]
FAFCNF15	6,64±1,54[c]
FAFCNF20	6,22±1,84[b]
BM	5,64±1,70[b]
FP	5,00±1,52[a]
Fermented flour	
FA	6,63±1,79[b]
FAFCF10	5,67±1,74[b]
FAFCF15	6,53±0,95[c]
FAFCF20	5,89±1,35[b]
BM	5,64±1,70[b]
FP	5,00±1,52[a]

Values are mean ± standard deviation of three measurements (n = 3). The same letter in the same row index indicates that there is no significant difference between samples for the parameter concerned (p<0.05).). According to Duncan's test. ***FA :*** *Attiéké Flour ;* ***FAFCNF10 :****Attiéké Flour enriched with 10% unfermented cashew kernel flour;* ***FAFCNF15 :*** *Attiéké Flour enriched with 15% unfermented cashew kernel flour;* ***FAFCNF20 :*** *Attiéké Flour enriched with 20% unfermented cashew kernel flour;* ***FAFCF10 :*** *Attiéké Flour enriched with 10% fermented cashew kernel flour ;* ***FAFCF15 :****Attiéké Flour enriched with 15% fermented cashew kernel flour ;* ***FAFCF20 :*** *Attiéké Flour enriched with 20% fermented cashew kernel flour;* ***BM: Commercial infant flour BLEDINE corn;***

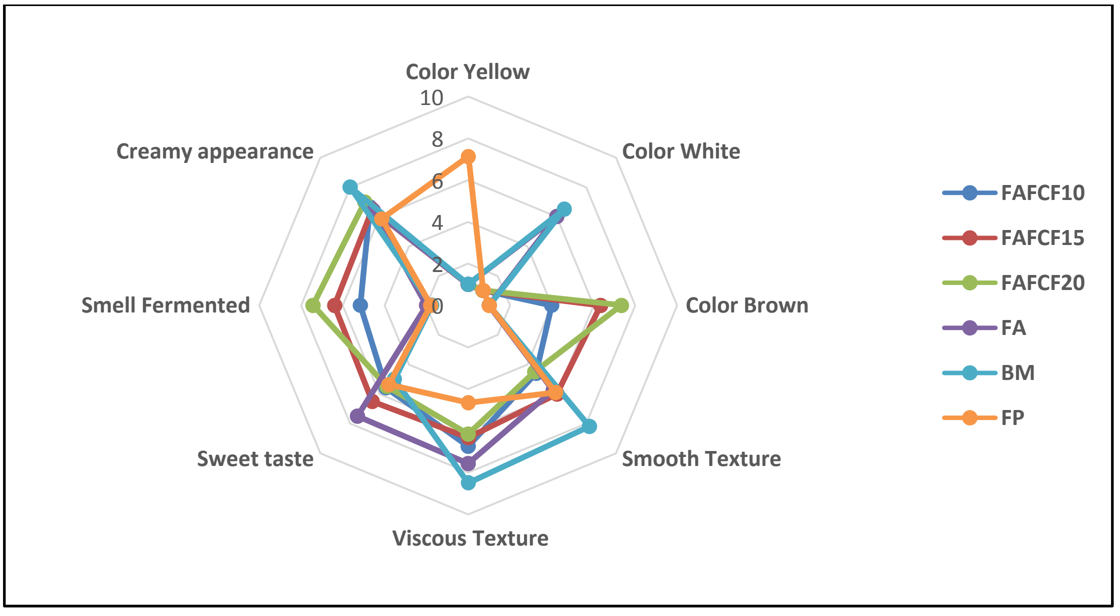

FIGURE 1: SENSORY PROFILES OF COMPOSITE MEAL MIXES OF ATTIÉKÉ / FERMENTED CASHEW KERNEL AND COMMERCIAL FLOURS

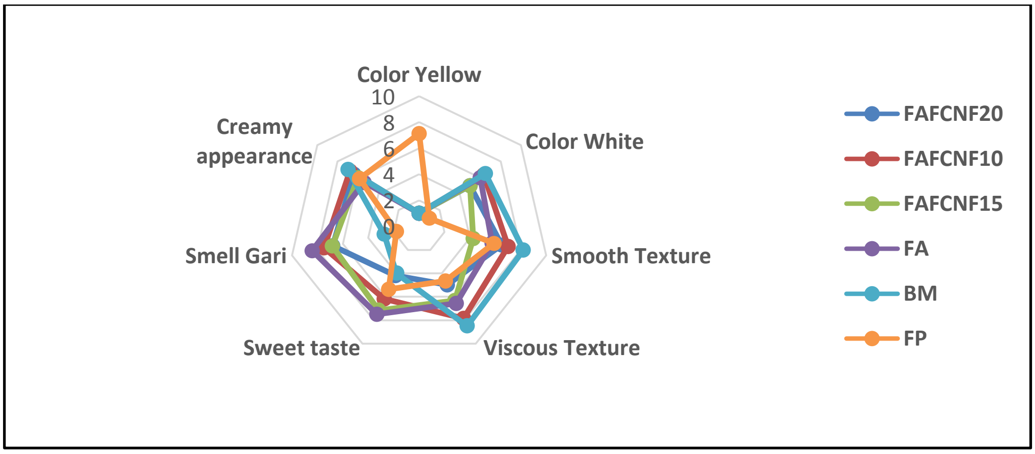

FIGURE 2: SENSORY PROFILES OF ATTIÉKÉ / UNFERMENTED CASHEW KERNELS AND COMMERCIAL FLOURS

IV. DISCUSSION

An increase in protein level was observed with the incorporation rate of fermented and unfermented cashew kernel meal. These results are in agreement with those found by Fofana et al. (2017) for the fortification of plantain flour with cashew kernel meal. However, fermented cashew kernel flour has the highest rate. This may be due to the proteolytic activities of the enzymes produced by the microorganisms during fermentation (Amankwah et al., 2009, Ojokoh et al, 2013, Ojokoh et al, 2014). This increase has been shown by (Amankwah et al., 2009) for fermented maize meal and fermented millet meal (Sade, 2009).

When cashew kernel flour is added to attiéké flour, the swelling rate decreases. The swelling rate of attiéké flour with incorporation of fermented cashew kernel meal is lower than that of flour with incorporation of unfermented cashew flour. This is due to fermentation which allows the hydrolysis of starch into simpler compounds such as glucose, fructose, sucrose, maltose and dextrins. Thus, the reduced viscosity increases the energy and nutritional density of the pores (Nguyen et al., 2007b, Songré-Ouattara et al., 2009).

The polyphenol contents increase with the rate of incorporation of cashew kernel flour; with fermented formulations with higher values. These results are consistent with several studies that show that fermentation increases polyphenol levels (Dajanta et al., 2013, Guzmán-Uriarte et al., 2013, Plaitho et al., 2013). In fact, the phenolic compounds in the natural form are combined or linked to sugar; which reduces their availability in the body. During fermentation, the proteolytic enzymes in the body hydrolyze phenolic complexes to yield free and simple soluble phenols that are biologically more active and easily absorbed (Shrestha et al., 2010, Ademiluyi and Oboh, 2011). These high levels of polyphenol make it possible as an antioxidant to combat free radicals, cancer, cardiovascular diseases and the aging process (Saluanke, 2006).

The presence of antinutritional factors in flours limits the nutritional quality and digestibility of vitamins, minerals, proteins and carbohydrates by preventing their proteolytic and amylolytic activities. The operations used for the production of flours make it possible to reduce these antinutritional factors, notably fermentation, which reduces them to more than 60%. The values obtained in tannin in this study are higher than that of Magdi, (2010) for the fermentation of millet. The decrease in tannin content was observed by Abdel-Haleem et al., 2008 for the fermentation of sorghum. This decrease may be due to the action of microorganisms on phenoloxidase. The low total oxalate content obtained after fermentation is due to the activity of microorganisms. During fermentation, the reduction in pH results in the separation of oxalate salts to give calcium ions and soluble oxalates (Simpson et al., 2009). These are used by bacteria as sources of energy. This decrease in oxalate content is shown by Wadamori, et al (2014) for fermented kimchi. The reduction in the phytate content of the various flours is due to the operations used for the production of flours (drying, cooking, fermentation). Fermentation reduces phytates by 90%. During fermentation, the decrease in pH is likely to increase the enzymatic activity of phytases for phytate degradation. PH is the influencing factor of phytate reduction (Buddrick et al., 2013). Thus the reduction of phytates could increase the mineral content and their bioavailability. The fermentation of the cassava paste for the production of attiéké causes a decrease in the content of hydrocyanic acid. In fact, linamarin is converted into hydrocyanic acid by linamarase. This has an optimal activity at pH 6 (Askurrahman 2010, Diallo et al., 2013). During fermentation microorganisms break down toxins into organic acids, leading to a decrease in pH and inactivation of linamarase. Fermentation therefore reduces the level of hydrocyanic acid in flours (Gunawan et al., 2015). Fermentation is an effective process for reducing antinutritional factors in flours.

The porridge of Attiéké-cashew kernels flour fermented are less acceptable than unfermented cashew kernelflour. This result is due to the aroma developed during fermentation. The attiéké flour mixture enriched with 15% fermented cashew kernel flour is the most popular fermented formulation with a score of 6.53. This result is consistent with that of (Ijarotimi et al., 2012) for porn corn enriched with fermented cashew kernel flour (6,50). The attiéké flour mixture enriched with 10% unfermented cashew kernel flour is more popular than attiéké flour. This result agrees with those of Achi (1999) which shows enrichment as a method of improving the nutritional and organoleptic quality of infant foods. These results are influenced by smell, taste, viscosity and texture.

V. CONCLUSION

Antinutritional factors in the fermented formulations are lower than those of the unfermented formulations. This could increase the digestibility of the nutrients in these flours. However, the boils of fermented flours are less appreciated than the boiled flours of unfermented flours because of the very strong fermented odor. So enrichment and fermentation are strategies for improving the quality of food. These attiéké / cashew almond composite flours can be used in children's diets.

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