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IMPACT OF FERMENTATION AND INCORPORATION OF CASHEW FLOUR ON THE MICRONUTRIENT AND MACRONUTRIENT CONTENTS OF MILLET FLOUR SOLD IN THE MARKET: CASE OF THE CITY OF YAMOUSSOUKRO

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ABSTRACT

The weaning period of an infant, which should begin from 7 months, is characterized by the gradual change from a liquid to a solid diet. After 6 months, the nutrients contained in breast milk are no longer sufficient to meet the growing demands of the infant. This is the ideal period for the introduction of a complementary food to make up for any deficiencies. To contribute to this situation, two groups, each consisting of five combinations of millet flour, enriched with cashew flour were formulated. The samples M100A0 (Unenriched millet flour), M92,5A7,5, M85A15, M77, 5A22,5 and M70A30 were enriched with 7.5%, 15%, 22,5% and 30% downgraded cashew flour, respectively. The samples MF100A0 (Unenriched fermented millet flour), MF92, 5A7,5, MF85A15, MF77, 5A22,5 and MF70A30 were constructed in a corresponding manner, the only difference being that the millet flour was fermented. After analyses of the different formulations, the best proportions of proteins were observed in MF70A30, MF77, 5A22, 5 and M70A30, which were 13.13%, 12.25% and 12.25%, respectively. Samples M70A30 and M77,5A22,5 exhibited the best iron contents of 8.44 ppm and 8.12 ppm, respectively. The protein contents of the unfortified samples M100A0 and MF100A0 were 7.53% and 6.13% respectively. Formulations MF70A30, M77,5A2,5 and M70A30 with levels of 1.06 ppm, 0.98 ppm and 0.98 ppm, respectively, gave the best zinc contents. The moisture contents of the formulated samples had minimal changes. They varied between 6.16 ± 0.06% and 7.6 ± 0.99% for unfermented samples, and between 6.35 ± 0.32% and 7.0 ± 0.02% for fermented samples. The humidity values of the two groups of samples were not significantly different at $P \leq 0.05$. These low moisture contents in the flours are important for better preservation. At the end of this study, certain formulations were selected because of their good nutritional profile. Thus the formulations M70A30 composed of 70% millet flour and 30% cashew flour and MF70A30 composed of 70% fermented millet flour and 30% cashew flour present the best options and could be used as quality infant flours.

Key words : complementary food, infant, cashew kernel, weaning, millet flour

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INTRODUCTION

Various cereals are part of staple diets. Millet (*Pennisetum glaucum*) occupies a special place among the most cultivated cereals with superior nutritional value compared to rice, corn and wheat. As such, it is strongly involved in improving the nutrition of mothers and their children [1]. Another reason that could explain its high use is that millet is able to give good yields in extreme conditions (high temperatures and in periods of drought). Added to this is its richness in proteins and minerals, particularly iron and zinc, making this cereal one of the primary sources of nutritional intake for several African countries [1]. In terms of production, three countries are in the lead, namely Mali, Niger and Nigeria [2]. In Côte d'Ivoire, millet is grown mainly in the north with a production in 2009 estimated at 40,000 tonnes [3]. From a technological point of view, several operations are used for the production of millet-based foods, including soaking, dehulling, germination, washing, fermentation and cooking [4]. Fermentation is often used in Africa to prepare food [5]. It has many advantages such as acidification of the medium thus making it possible to reduce the risk of development of pathogenic microorganisms, it destroys anti-nutritional factors such as phytates and improves the taste of food by the production of organic acids and aromas. This method is traditionally used in several African countries for the preparation of food for consumption with the family or during festive ceremonies such as weddings and baptisms. Fermentation is also used in the preparation of food consumed in the form of porridge: ben-saalga in Burkina Faso, ogi and mawè in Benin, kenke in Ghana, ogi-baba, fufu and kunu-zaki in Nigeria, uji and togwa in Tanzania and kisra in Sudan [6]. It is known that several types of fermentation exist. In the case of millet, lactic fermentation is the most used [5].

The amylolytic lactic fermentation additionally improves digestibility and the availability of sugars. It increases the contents of several nutrients such as vitamins (thiamine, riboflavin, niacin, ascorbic acid) and proteins [7].

For developing countries where the majority of the population lives in difficult conditions without access to refrigeration technologies for food preservation, the use of traditional starchy fermented foods in the diet in general and in the complementary diet of the young children in particular could be a considerable asset in improving the quality of the food consumed [2].

The international recommendations issued by WHO and UNICEF have been advocating exclusive breastfeeding up to 6 months, the continuation of breastfeeding up to 2 years or more, supplemented by the gradual introduction of a diversified solid diet.

An alternative in the fight against malnutrition is, therefore, the enrichment of these local products [8]. The use of accessible local products with a source of protein may be a solution to the problem of child malnutrition. Cashew is one such product which, originally introduced to prevent the advance of the desert, has become a trademark crop in Côte d'Ivoire. The country is also the world leader in terms of production. Ivorian production is estimated at 711,236 tonnes in 2017 [9].

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Cashew kernels are an important source of nutrients. This legume, because of its richness in nutrients (micro and macronutrients), could be used for the fortification of millet-based flours [10]. Cashew kernels also contain good protein and 20% linoleic acid and 60% oleic acid, which are essential fatty acids [11]. In this study, the aim is to study the combined effect of fermentation and the incorporation of an oilseed (cashew flour) on the nutritional composition of millet flour used as a food supplement for children of weaning age.

MATERIALS AND METHODS

Two local raw materials were used in the production of flours. These were cashew kernels (*Anacardium occidental L.*) and millet (*Pennisetum glaucum*). The millet was bought in the market from a women's cooperative in the town of Yamoussoukro (6 ° 53’04.7 ’North and 5 ° 13’54.9’ West) located in the centre of Côte d'Ivoire. The cashew kernels were supplied by the school plant of the National Polytechnic Institute of Yamoussoukro (Côte d'Ivoire). A commercial infant flour was used as a reference, made in Abidjan in a local industry.

Fermented millet flour

Millet grains (500 grams) were cleaned by hand in a plastic basin with distilled water and soaked in potable water for 24 hours at room temperature. The raw material was removed and rinsed with distilled water twice. The grains were then left in potable water for 72 hours for fermentation using the microorganisms naturally present on the surface of the grains. The fermented grains were washed again with distilled water by hand twice, drained and oven dried (Plus11 Sanyo Gallenkamp PLC, UK) at 60°C for 48 hours. The dried grains were ground using a Philips laboratory blender (model HR2811), sieved through 60 mm diameter mesh and stored in a sealed plastic container at room temperature.

Unfermented millet flour

The millet grains (500 g) of the same origin as above were sorted and washed several times in order to get rid of all impurities. The millet grains were then dried in the oven (Plus11 Sanyo Gallenkamp PLC, UK) at 60 ° C for 48 hours, crushed using a Phillips laboratory blender (model HR2811), sieved through 60 mm diameter mesh and stored in a sealed plastic container at room temperature.

Declassed cashew flour

The production of declassed cashew flour was inspired by the modified method described by Sze-Tao and Sathe [12]. Degraded cashew kernels were crushed with a semi-artisanal crusher (YIBU TYPE 30 China). Hexane was used to extract the cashew oil twice in a stainless steel tank by continuous maceration for 30 minutes. The vat containing the kernel (5 kg) and hexane (5 liters) was placed on a hot plate (RSLAB-1C) for 50 minutes at 130 °C. The tank was stored away from all contamination for 24 hours for incubation. Oil and hexane are the supernatant and the de-oiled kernel the cake. A clean cotton cloth was used to wrap the cake, which was put under a manual press for 24 hours. The de-oiled cake was spread out on stainless trays and placed in an

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oven (MEMMERT Germany) at 70 °C for 12 hours. This allowed elimination of traces of hexane and purified the meal. The dried cake was ground with a 500 micron sieve mill. The resulting cashew flour was stored in plastic jars at room temperature and later used for the formulations.

Formulation of millet / cashew composite flour

The formulation of the various compound flours (10 samples) was carried out in accordance with the proportions indicated in Tables 1 and 2.

Each of the formulations thus obtained was homogenized in a Binatone model BLG-450 blender, then placed in fractions of 350 g in clean and dry plastic jars hermetically sealed for analyses.

Physico-chemical analyses

The analyses were carried out in triplicate in order to take the average for the determination of the parameters considered.

The dry material was determined after drying the samples in an oven (Memmert 854 Schwabach, Germany) at 105 °C for 24 hours [13].

The lipid content was determined by the Soxhlet method (Tecator unit, System HT2 1045, Sweden). The hexane was recovered using a rotary evaporator (BUCHI Rotavapor R-215). The sample contained in the capsule was dried in an oven (Memmert 854 Schwabach, Germany) at 105 ° C for 1 hour in order to remove traces of the solvent. The difference in weight obtained was used to estimate the lipid level in the sample [13].

The Kjldahl method was used to determine the crude protein level. The percentage of nitrogen (% N) was used for the calculation of the level of crude protein (% P) from the equation below [13].

$$\% P = \% N \times 6.25 \quad (1)$$

The ash content was determined by incinerating 10g of sample in a muffle furnace (Nabertherm Gmbh Babnhofstr. 20, 28865 Lilienthat, Bremen, Germany) at 550 ° C for 8 hours. The sample was removed from the oven and cooled in a desiccator for 20 minutes and then weighed on a balance (CHIMADZU Japan) [13].

The energy value and the moisture level were determined using formulas (2) and (3).

The energy value (EV) was calculated by applying Atwater thermal coefficients according to the equation below [13]

$$\text{Energy value} = (\%\ \text{protein} \times 4) + (\%\ \text{lipid} \times 9) + (\%\ \text{carbohydrate} \times 4) \quad (2)$$

The moisture level was determined from the following formula [13]:

$$\% \text{ moisture} = 100 \% \text{ dry matter} \quad (3)$$

Mineral content

One gram of the sample was digested for 3 hours in a mixture of three solutions. These are the nitric / perchloric / sulfuric acids respectively in a ratio 9 : 2 : 1. After filtration in a 100 ml flask, the solution obtained was passed through an atomic absorption spectrophotometer (model 703 Pelkin Elmes PE 3110, Norwalk USA). A standard curve was established for each mineral. The mineral content of the samples was determined from standard stallions. A flame photometer (Flamme Photometer 410, Sherwood) was used to determine the potassium and sodium contents.

Statistical analyses of data

Statistical analyses were carried out with the software Statistica 7.1. The results were expressed as the mean ± standard deviation of triplicate measurement. An analysis of variance (ANOVA) was performed and the significance of the differences between the flour samples was determined at the risk of error of 5% according to Duncan's test.

RESULTS AND DISCUSSION

Influence of cashew flour on the nutritional value of millet

Table 3 shows the chemical composition of the composite flours made from millet and cashew kernels. It appears that the composite flours formulated following the addition of cashew in millet flours allowed an increase in protein, lipid and ash contents (Table 3). This increase varies from 6.13 ± 0.23% to 12.25 ± 1.97%, from 7.32 ± 0.32% to 15.8 ± 0.02% and from 0.5 ± 0.09% to 1.87 ± 0.39% for proteins, lipids and ash, respectively. The most significant effects ($P \leq 0.05$) were observed on sample M70A30 (70% millet and 30% cashew). The increase in protein content in formulated samples is believed to be due to the high protein content of cashew flour [14]. These results are lower than those found by Ijarotimi *et al*. [15] who formulated three corn-based flours. FPC (fermented corn flour enriched with cashew), GPC (sprouted corn flour enriched with cashew), RPC (roasted corn flour enriched with cashew). The protein values of the FPC, GPC, RCC composite flours were 21.82%, 22.48% and 20.76%, respectively. All the protein contents obtained in this study's formulations remain higher than that observed in the commercial infant flour FAR COM, which is 4.73 ± 0.02%. Protein is essential for the growth of the child and is involved in several biological reactions [6]. Proteins are essential especially in the first weeks of an infant's life because they are necessary for providing essential amino acids, for tissue renewal [16].

The lipid level of the formulated samples was correlated with the increase in the incorporation rate of cashew flour (Table 3). The 30% cashew fortification had the highest fat content with 15.8 ± 0.02%. The lipid content of all the samples increased compared to the initial lipid content of millet (7.32 ± 3.88%). This increase could be explained by the high fat content of the cashew kernel [11]. The richness of cashew

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kernel in lipids was reported by Soro et *al*. [11]. However, all the samples showed higher lipid levels than that of the reference commercial flour, which is 6.27 ± 0.04%. Increasing the lipid content is a major contributor to improving the energy value of complementary foods. However, the high levels of lipids could cause rancidity and therefore do not promote good storage and do not facilitate consumption of the porridge by children.

The ash content increased in proportion to the incorporation rates of the cashew flour (Table 3). Like proteins and lipids, the highest ash contents were observed in sample M70A30, an increase of 73.28%. This significant increase (P≤0.05) could be attributed to the incorporation of the cashew flour, which is known to be rich in ash [17, 18]. The ash content provides information on the overall content of minerals contained in food products [19]. This same trend was observed by Olanipékun [20] in a study on the fortification of corn flour with beans. However, the values obtained in that study varied from 3.5 ± 1.1% to 4.30 ± 1.0%, which are all higher than values obtained in this study.

Cashew flour has a significantly high energy value (517.06 ± 0.05 kcal per 100g) (P≤0.05), higher than that observed in commercial flour (392.84 ± 3.92 kcal for 100 g), which was the control. The energy values of the formulated samples were correlated with the incorporation rates of the cashew flour. They varied between 407.95 ± 7.03 kcal per 100g of dry matter for M100A0 and 444.70 ± 2.11 kcal per 100g of dry matter for M70A30. They are all high and significantly higher (P≤0.05) than the energy value of control commercial flour (392.84 ± 3.92 kcal per 100 g). These high values can be explained by the high content of fat in the cashew. This observation was made by Lautié *et al*. [21] who reported a 45% fat content in cashew.

Unlike protein, fat, and ash, the incorporation of cashew flour into millet flour caused a significant decrease (P≤0.05) in carbohydrate content (Table 3). Millet is a cereal rich in carbohydrates with 71.6 g per 100 g of dry matter [22]. Carbohydrate levels in formulated samples decreased in proportion to the increase in the incorporation rate of cashew. This could be due to the gradual decrease in the amount of millet in the formulated samples. The carbohydrate content went from 79.39 ± 0.02 g in the sample M100A0 (100% millet) to 63.47 ± 0.03 g in sample M70A30 (70% millet and 30% cashew). Regarding the moisture content, there was no significant difference between the different samples. The moisture content of the samples varied from 6.16 ± 0;06% to 7.60 ± 0.99%. Low water content is an important factor in food preservation.

Influence of cashew flour on the mineral content of millet

A gradual increase in mineral contents was observed depending on the rate of incorporation of cashew flour (Table 5). The iron contents varied between 4.44 ± 1.73 ppm for sample M100A0 and 8.44 ± 0.04 ppm for sample M70A30. The M70A30 sample had the highest iron content. This gradual increase in the iron content in the formulated samples is believed to be due to the high iron content of the cashew. High levels of iron have been reported in millet and cashews [23, 24]. The iron content could be due to the iron intake of millet on the one hand and cashew on the other. Cashew flour, known to be a good source of iron [24] may be indicated for the enrichment of

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cereals with iron. This could help fight iron deficiency through cereals often used for making complementary foods for infants [23].

The contents of potassium, calcium, phosphorus, magnesium and sodium in the formulated samples followed the same trend as that observed in the case of iron. These contents varied from 0.85 ± 0.03% to 1.64 ± 0.23%, from 0.19 ± 0.05% to 0.49 ± 0.02%, from 0.29 ± 0.04% to 0.47 ± 0.03%, from 0.14 ± 0.05% to 0.3 ± 0.04% and from 5.25 ± 0.05 ppm to 7.63 ± 0.48 ppm, in potassium, calcium, phosphorus, magnesium and sodium, respectively. These results indicate a significant increase ($P \leq 0.05$) in minerals, in samples fortified with cashew. Cashew kernels are therefore a good source of trace elements and micronutrients [10].

Cashew kernels have calcium levels close to those observed but lower than those in the commercial infant flour. Cashew flour has a content of 0.41 ± 0.03% while commercial flour has 0.42 ± 0.05%. The highest calcium content was observed in sample M70A30, at 0.49 ± 0.02%, which was significantly higher than the calcium content in commercial flour. These results are lower than those obtained by Olorode [25] in the determination of the calcium contents in different qualities of seeds. The results obtained by Olorode [25] are between 4.93 and 5.30% calcium.

Cashew flour could be recommended for fortifying grain-based foods, which are generally low in calcium. Calcium is essential in building bone thickness and length [26]. Calcium deficiency causes rickets and osteoporosis. Calcium is involved in the function of locomotion and children’s upright position.

The highest mineral content was observed in the millet sample blended with 30% cashew flour (Table 5). The high mineral contents are said to be attributed to cashew which is a good source of minerals [10].

Flours formulated with the introduction of cashew flour into millet all exhibited significantly ($P \leq 0.05$) high levels of magnesium, phosphorus and sodium. The magnesium contents ranged from 0.14 ± 0.05% to 0.31 ± 0.04% and are all significantly ($P \leq 0.05$) higher than the magnesium content observed in commercial infant flour, which is 0.13 ± 0.04%. The phosphorus content ranged from 0.9 ± 0.04% to 0.47 ± 0.03%. The samples M77, 5A22, 5 and M70A30 with contents of 0.42 ± 0.04% and 0.47 ± 0.03%, respectively had significantly higher ($P \leq 0.05$) phosphorus content than the commercial infant flour which is 0.35 ± 0.02%. The sodium contents in the samples varied from 5.25 ± 0.05 ppm to 7.63 ± 0.48 ppm and are all lower than the sodium content in commercial flour, which is 14.27 ± 0.01 ppm. The sodium content of cashew kernels is 4.10 ± 0.12 ppm. An increase in the sodium level was observed in samples M70A30 and M77,5A22,5, which were, 7.63 ± 0.48 ppm and 7.04 ± 0.07 ppm, respectively. These rates were higher than that of unfortified millet, which was 5.25 ± 0.05 ppm.

Blending of millet and cashew flours gave satisfactory results as all samples had significantly improved mineral contents. This improvement in mineral content was proportional to the rate of cashew incorporated. Thus the highest levels were obtained in the sample M70A30 (70% millet and 30% cashew) and the lowest mineral contents were obtained in the sample M100A0 (with 100% millet flour). The improvement in the mineral content by incorporating cashew flour is said to be due to the richness of cashew in minerals [27]. This same tendency was observed by Olanipékun [20] in a study relating to the fortification of corn flour with beans.

Effect of fermentation on the nutritional value of composite flours

Comparison of the samples of unfermented and fermented composite flours are shown in Table 7. The results indicate higher protein and lipid contents in the fermented samples. The protein content of fermented flours varied between 7.53 ± 0.03% and 13.13 ± 0.03% and that of unfermented flours varied between 6.13 ± 0.23% and 12.25 ± 1.97 %. For the same cashew flour incorporation rates, fermented samples had higher protein contents than unfermented samples. The high values obtained in the fermented samples could be explained not only by the gradual increase in the level of nuts incorporated but also by the effect of fermentation. During fermentation the microbial mass increases resulting in the hydrolysis of proteins into simpler peptides and amino acids. This increase is also thought to be due to the enzymatic hydrolysis of protein inhibitors.

The protein contents observed in the samples are roughly equal to those obtained by Koné *et al.* [28] in the implementation of corn-based complementary foods fortified with fermented cashew flour. However, the protein contents observed in all the samples formulated, fermented or not, were higher than those of commercial cerelac flour (4.73 ± 0.02%). Cashew could, therefore, be a good fortifier for complementary foods made from cereals because of its high protein content, but since legume proteins lack some essential amino acids, such complementary foods should not be fed independently of other nutritious foods. This finding was made by Ijarotimi *et al*. [15] in a study where cashew flour was used to fortify popcorn-based foods.

In general, fermented foods presented higher lipid levels than unfermented foods. This finding is similar to that reported in the study by Oyarekua [29], which indicated that lipid contents are higher in fermented foods than in unfermented foods. This could be explained by the activity of lactic acid bacteria during fermentation. Lipases hydrolyze lipid molecules to generate fatty acids, which are then used for the synthesis of new lipids [29]. The lipid contents, although high compared to the initial lipid content in millet, still comply with the recommended level of fat which varies between 10 and 25% in complementary foods [30]. These lipid contents are higher than those obtained by Fofana [19].

The energy values of the formulated flours varied between 407.95 ± 7.03 kcal per 100 g of dry matter (for sample M100A0) and 444.70 ± 2.11 kcal per 100 g of dry matter (for sample M70A30) for unfermented samples (Table 3) and 426.93 ± 0.03 kcal per 100 g dry matter (for sample MF100A0) and 458.35 ± 0.99 kcal per 100 g dry matter (for the sample MF70A30) for the fermented samples (Table 4). All values were above 400 kcal per 100g, which is the recommended value in complementary foods for children of weaning age [31]. The values obtained are all higher than the Cérélac commercial flour manufactured and sold in Côte d'Ivoire (392.84 ± 0.92 kcal) and the Nigerian commercial flour Ogi (389.88 kcal) and Nutrend (397.68 kcal) presented by Ijarotimi *et al.* [15]. Samples from fermented millet and cashew kernels in general show all higher energy values than samples formulated with unfermented millet with the same level of cashew incorporation (Table 7). This could be explained by the effect of fermentation which improves the lipid content by the activity of lipases which hydrolyze fats into fatty acids and glycerols influencing the energy value [32].

The carbohydrate content decreased in all samples after 72 hours of fermentation. It went from 79.39 ± 0.02% to 74.98 ± 3.09%; from 73.6 ± 1.00% to 73.57 ± 2.98%; from 70.3 ± 0.01% to 68.49 ± 0.01%; from 66.41 ± 1.82% to 64.9 ± 0.03%; and from 63.47 ± 0.03%, to 60.71 ± 0.94%, in samples M100A0, M92, 5A7, 5, M85A15, M77, 5A22, 5, and M70A30, respectively. This decrease in the carbohydrate content in the different formulations could be attributed to the use of simple sugar [33] and carbohydrate in the synthesis of new molecules [34]. The decrease in carbohydrate content could be attributed to the use of these nutrients by microorganisms during fermentation [35].

The moisture content of formulated samples varied between 6.16 ± 0.06% and 7.6 ± 0.99% for samples obtained from unfermented millet and cashew and between 6.35 ± 0.32% and 7.00 ± 0.02% for samples obtained from fermented millet and cashew. Unlike other parameters, the humidity level does not follow the same trend. The moisture level in food is a very important parameter because a low moisture level is favorable for better preservation of the food. According to a study by Giami [36], low humidity reduces microbial activity. This also helps to extend the shelf life of this product. The moisture values were all less than 12%, which remains the maximum value allowed in infant foods [37].

Ash contents decreased with the effect of fermentation in all samples. The ash contents of fermented samples were lower than those of unfermented samples, this could be due to the fermentation, which causes the loss of water-soluble minerals and also to the heat treatments undergone by the cashew [19]. However, the ash content of samples from unfermented millet complied with standards, which is between 1.5 and 2.5% [19].

Effect of fermentation on the mineral content of composite flours

In samples obtained from fermented millet and fortified with cashew, the mineral contents were all lower than the values of samples obtained from unfermented millet and fortified with cashew (Table 8). However, the iron and magnesium contents obtained both in the fermented formulations and in the non-fermented formulations were all higher than the iron and magnesium content observed in commercial cerelac flour. These values were 2.61 ± 0.01 ppm for iron and 0.13 ± 0.04% for magnesium (Table 8). The magnesium content in the cashew kernel was significantly higher ($P \leq 0.05$) than the magnesium content in the control Cerelac flour, which is 0.13 ± 0.04%. All the composite flours formulated thus exhibited higher levels of magnesium than that observed in the commercial flour taken as a control. This method of fortification and this technology could be used to produce infant flours rich in minerals, in particular magnesium, which remains a mineral of particular importance because it is present in more than 99% of the intracellular sector and it is involved in more than 300 enzymatic systems and essential metabolic pathways [38].

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The decrease in mineral content could be explained by the effect of fermentation causing a loss of minerals through the activity of lactic acid bacteria involved during this phenomenon. This observation was made by Oyarekua [29] and also by Olorode [25] who in another study to determine the mineral compositions of the different samples from several plants, in particular benoil seeds, watermelon flour, pear seed flour, obtained calcium contents that were all higher than the calcium levels contained in these various samples. However, the potassium contents of these formulations were all significantly (P≤0.05) higher than those presented by Olorode [25]. Potassium maintains the acid-base balance in the body cells and the hydration of body cells. It is involved in several enzymatic reactions, in particular at the level of protein synthesis, in the metabolism of macronutrients (carbohydrates and lipids). It helps to reduce urinary calcium excretion, which is essential in the phenomenon of osteoporosis [39]. Although the mineral contents increased in proportion to the incorporation rates of cashew, the most significant effects were seen in the unfermented samples (Table 8). In fact fermentation causes a loss of water-soluble minerals. In addition, heat treatments of kernels can also increase the loss of these minerals [35]. Zinc contents, unlike other minerals, increased after fermentation in two samples M70A30 and M77,5 A22,5. The zinc content in commercial flour (1.04 ± 0.01 ppm) is significantly (P≤0.05) higher than the zinc content in all formulated flours except sample MF70A30, which had a zinc content of 1.06 ± 0.04 ppm, higher than that of commercial flour. The zinc content decreased in samples MF100A0, MF92,5A7,5 and MF85A15, then the opposite effect was observed in samples MF77,5A22,5 and MF70A30. This could be attributed to the effect of fermentation. In one study by Kalpana et *al*. [40], it was reported that fermentation caused a decrease in the zinc content in some cereals but caused a significant increase in the zinc content in others. This increase had been attributed to the formation of organic acids during fermentation which form soluble ligands with zinc increasing its bioavailability. This same study indicated that the combination of cereals and legumes significantly reduced both phytates and tannins thus increasing the bioavailability of zinc but the concentration of anti-nutrients (phytates and tannins) eliminated varied according to the type of cereal [40]. In addition to improving organoleptic properties, fermentation induces hydrolysis of phytates by activating phytases, thus improving the bioavailability of zinc [41]. Zinc is involved in the growth of children [42] and its deficiency is often associated with deficiencies in iron, iodine, and vitamin A [43]. Zinc deficiency is recognized as a public health problem and has serious repercussions on the health of children. It causes weak cognitive functions and weakened memory. The zinc contents reported by this study are lower than those reported by Fofana [19].

CONCLUSION

This study tested the effect of cashew flour in different proportions in a cereal flour on one hand and the effect of fermentation on the other hand, on the quality of the flours as part of complementary foods. All formulated flours fortified with cashew had an improvement in their protein content, ash and an increase in energy value. This was seen in both fermented and unfermented formulations. Ash contents in the fermented formulations were lower than in the unfermented formulations. This shows the effect of fermentation on ash content. In fact the fermentation caused a drop in the ash (mineral) level in the samples. Mixtures of millet cereal and cashew flour are exploitable avenues for the establishment of complementary foods for young children with a rate of 30% of cashew flour giving the best results. With regard to the fermentation on the same matrices, it is undeniable that the fermentation has a proven beneficial character.

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Table 1: Formulation of infant flours based on millet and cashew

Sample	Unfermented millet	Cashew
M100A0	100%	0%
M70A30	70%	30%
M85A15	85%	15%
M92,5A7,5	92.5%	7.5%
M77,5A22,5	77.5%	22.5%
M85A15	85%	15%
M85A15	85%	15%

Table 2: Formulation of infant flour based on fermented millet and cashew

Sample	Fermented millet	Cashew
MF100A0	100%	0%
MF70A30	70%	30%
MF85A15	85%	15%
MF92,5A7,5	92.5%	7.5%
MF77,5A722,5	77.5%	22.5%
MF85A15	85%	15%
MF85A15	85%	15%

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Table 3: Chemical composition of composite flours made from millet and cashew

	Protein (%)	Lipid (%)	Carbohydrate (%)	VE (%)	Moisture (%)	Ash (%)
M100A0	6.13±0.23^{f}	7.32±0.32^{f}	79.39±0.02^{a}	407.95±7.03^{f}	6.66±1^{a}	0.5±0.09^{g}
M92,5A7,5	7.35±0.38^{e}	10.35±0.32^{e}	73.6±1^{b}	416.10±2.92^{e}	7.60±0.99^{a}	1.1±0.02^{f}
M85A15	9.27±0.99^{d}	11.97±1.01^{d}	70.3±0.01^{c}	429.53±0.07^{d}	7.08±0.04^{a}	1.38±0.02^{e}
M77,5A22,5	10.85±0.04^{c}	15.11±0.03^{b}	66.41±1.82^{d}	445.20±4.93^{b}	6.16±0.06^{a}	1.45±0.02^{d}
M70A30	12.25±1.97^{b}	15.8±0.02^{c}	63.47±0.03^{e}	444.70±2.11^{c}	6.32±1^{a}	1.87±0.39^{c}
CASHEW	26.25±0.03^{a}	30.42±0.42^{a}	34.56±0.05^{f}	517.06±0.05^{a}	5.50±0.06^{a}	3.33±0.03^{a}
FAR COM	4.73 ±0.02^{g}	6.27 ±0.04^{g}	34.56± 0.03^{f}	392.84 0.03^{f}	6.25± 1.74^{a}	3.3± 0.01^{b}

All of these values are the means of three determinations. Notes in the same column with different superscript letters are statistically different at $P \leq 0.05$

Cashew: cashew flour; M70A30: millet flour enriched with 30% cashew flour; M100A0: unenriched millet flour; M85A15: millet flour enriched with 15% cashew flour; M77, 5A22, 5: millet flour enriched with 22.5% cashew flour; M92,5A7, 5: millet flour enriched with 7.5% cashew fine flour; FAR COM; Commercial Cerelac flour

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Table 4: Chemical composition of composite flours made from fermented millet and cashew

	Protein (%)	Lipid (%)	Carbohydrate (%)	VE (kacl)	Moisture (%)	Ash (%)
MF100A0	7.53±0.03[e]	11.06±1.73[e]	74.98±3.09[a]	426.93±0.03[e]	6.84±0.04[a]	0.25±0.01[e]
MF92,5A7,5	9.1±1.04[d]	10.71±0.07[d]	73.57±2.98[b]	428.36±1.57[d]	6.35±0.32[a]	0.27±0.04[d]
MF85A15	10.32±0.04[c]	13.82±0.18[c]	68.49±0.01[c]	439.62±0.01[c]	6.77±1.54[a]	1.58±0.13[a]
MF77,5A22,5	12.25±0.06[b]	15.64±0.03[b]	64.9±0.03[d]	449.36±0.06[b]	6.49±0.02[a]	0.72±0.03[c]
MF70A30	13.13±0.03[a]	18.11±0.01[a]	60.71±0.94[e]	458.35±0.99[a]	7±0.02[a]	1.05±0.04[b]

All of these values are the means of three determinations. Notes in the same column with different superscript letters are statistically different at P≤0.05

MF70A30 : fermented millet flour enriched with 30% cashew flour ; MF100A0 : unenriched fermented millet flour ; MF85A15 : fermented millet flour enriched with 15% cashew flour ; MF77,5A22,5 : fermented millet flour enriched with 22.5% cashew flour ; MF92,5A7,5 : fermented millet flour enriched with 7.5% cashew flour

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Table 5 : Mineral composition of composite flours made from millet and cashew

	Iron (ppm)	Zinc (ppm)	Potassium (%)	Calcium (%)	Phosphorus (%)	Magnesium (%)	Sodium (ppm)
M100A0	4.44±1.73^{f}	0.56±0.07^{f}	0.85±0.03^{f}	0.19±0.05^{f}	0.29 ±0.04^{g}	0.14±0.05^{f}	5.25±0.05^{f}
M92,5A7,5	5.54±0.52^{e}	0.77±0.01^{e}	0.77±0.14^{g}	0.19±0.05^{f}	0.3 ±0.05^{f}	0.15±0.03^{e}	5.94±0.05^{e}
M85A15	7.83±0.06^{d}	0.78±0.06^{e}	1.15±0.01^{e}	0.20±0.04^{e}	0.32 ±0.04^{e}	0.19±0.03^{d}	5.98±0.02^{d}
M77,5A22,5	8.12±0.21^{c}	0.8±0.03^{d}	1.41±0.03^{d}	0.4±0.01^{d}	0.42 ±0.04^{c}	0.24±0.05^{c}	7.04±0.07^{c}
M70A30	8.44±0.04^{b}	0.98±0.01^{c}	1.64±0.23^{b}	0.49±0.02^{a}	0.47± 0.03^{b}	0.3±0.04^{b}	7.63±0.48^{b}
CASHEW	9.61±1.03^{a}	1.12±0.03^{a}	1.94±0.02^{a}	0.41±0.03^{c}	0.54 ± 0^{a}	0.31±0.03^{a}	4.1±0.12^{g}
FAR COM	2.61 ±0.01^{g}	1.04± 0.01^{b}	1.44 ±0.07^{c}	0.42± 0.05^{b}	0.35 ± 0.02^{d}	0.13 ± 0.04^{g}	14.27± 0.01^{a}

All of these values are the means of three determinations. Notes in the same column with different superscript letters are statistically different at $P \leq 0.05$

Cashew: cashew flour; M70A30: millet flour enriched with 30% cashew flour; M100A0: unenriched millet flour; M85A15: millet flour enriched with 15% cashew flour; M77,5A22,5: millet flour enriched with 22.5% cashew flour; M92,5A7,5: millet flour enriched with 7.5% cashew flour; FAR COM; Commercial Cerelac flour

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Table 6: Mineral composition of composite flours made from fermented millet and cashew

	Iron (ppm)	Zinc (ppm)	Potassium (%)	Calcium (%)	Phosphorus (%)	Magnesium (%)	Sodium (ppm)
MF100A0	2.94±0.09^{e}	0.17±0.02^{e}	0.7±0.03^{e}	0.19 ±0.04^{e}	0.19±0.04^{e}	0.14±0^{e}	4.83±0.04^{e}
MF92,5A7,5	3.85±0.06^{d}	0.49±0.04^{d}	1.01±0.03^{d}	0.20 ± 0.01^{d}	0.27±0.02^{d}	0.15±0.02^{d}	4.91±0.04^{d}
MF85A15	7.07±0.58^{c}	0.9±0.04^{c}	1.08±0.04^{c}	0.3 ± 0^{c}	0.3±0.01^{c}	0.17±0.01^{c}	5.20±0.42^{c}
MF77,5A22	7.77±0.03^{b}	0.98±0.02^{b}	1.3±0.05^{b}	0.35 ±0.08^{b}	0.32±0.04^{b}	0.23±0.01^{b}	5.46±1.78^{b}
MF70A30	7.99±0.02^{a}	1.06±0.04^{a}	1.42±0.07^{a}	0.47 ±0.05^{a}	0.4±0.02^{a}	0.29±0.06^{a}	6.25±0.05^{a}

All of these values are the means of three determinations. Notes in the same column with different superscript letters are statistically different at $P \leq 0.05$

MF70A30 : fermented millet flour enriched with 30% cashew flour; MF100A0 : unenriched fermented millet flour; MF85A15 : fermented millet flour enriched with 15% cashew flour; MF77, 5A22,5: fermented millet flour enriched with 22.5% cashew flour; MF92,5A7,5: fermented millet flour enriched with 7.5% cashew flour

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Table 7 : Comparative table of chemical compositions of composite flours made from millet and cashew

	Protein (%)	Lipid (%)	Carbohydrate (%)	VE (kcal)	Moisture (%)	Ash (%)
M100A0	6.13±0.23[f]	7.32±0.32[f]	79.39±0.02[a]	407.95±7.03[f]	6.66±1[a]	0.5±0.09[g]
MF100A0	7.53±0.03[e]	11.06±1.73[e]	74.98±3.09[a]	426.93±0.03[e]	6.84±0.04[a]	0.25±0.01[e]
M92,5A7,5	7.35±0.38[e]	10.35±0.32[e]	73.6±1[b]	416.10±2.92[e]	7.60±0.99[a]	1.1±0.02[f]
MF92,5A7,5	9.1±1.04[d]	10,71±0,07[d]	73.57±2.98[b]	428.36±1.57[d]	6.35±0.32[a]	0.27±0.04[d]
M85A15	9.27±0.99[d]	11.97±1.01[d]	70.3±0.01[c]	429.53±0.07[d]	7.08±0.04[a]	1.38±0.02[e]
MF85A15	10.32±0.04[c]	13.82±0.18[c]	68.49±0.01[c]	439.62±0.01[c]	6.77±1.54[a]	1.58±0.13[a]
M77,5A22,5	10.85±0.04[c]	15.11±0.03[b]	66.41±1.82[d]	445.20±4.93[b]	6.16±0.06[a]	1.45±0.02[d]
MF77,5A22,5	12.25±0.06[b]	15.64±0.03[b]	64.9±0.03[d]	449.36±0.06[b]	6.49±0.02[a]	0.72±0.03[c]
M70A30	12.25±1.97[b]	15.8±0.02[c]	63.47±0.03[e]	444.70±2.11[c]	6.32±1[a]	1.87±0.39[c]
MF70A30	13.13±0.03[a]	18.11±0.01[a]	60.71±0.94[e]	458.35±0.99[a]	7±0,02[a]	1.05±0.04[b]
CASHEW	26.25±0.03[a]	30.42±0.42[a]	34.56±0.05[f]	517.06±0.05[a]	5.50±0.06[a]	3.33±0.03[a]
FAR COM	4.73 ±0.02[g]	6.27 ±0.04[g]	34.56 ± 0.03[f]	392.84 ±3.92[g]	6.25± 1.74[a]	3.3± 0.01[b]

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Table 8: Comparative table of the mineral compositions of composite flours based on millet and cashew

	Iron (ppm)	Zinc (ppm)	Potassium (%)	Calcium (%)	Phosphorus (%)	Magnesium (%)	Sodium (ppm)
M100A0	4.44±1.73^{f}	0.56±0.07^{f}	0.85±0.03^{f}	0.19±0.05^{f}	0.29±0.04^{g}	0.14±0.05^{f}	5.25±0.05^{f}
MF100A0	2.94±0.09^{e}	0.17±0.02^{e}	1.01±0.03^{d}	0.20 ± 0.01^{d}	0.19±0.04^{e}	0.14±0^{e}	4.83±0.04^{e}
M92,5A7,5	5.54±0.52^{e}	0.77±0.01^{e}	0.77±0.14^{g}	0.19±0.05^{e}	0.3 ±0.05^{f}	0.15±0.03^{e}	5.94±0.05^{e}
MF92,5A7,5	3.85±0.06^{d}	0.49±0.04^{d}	1.01±0.03^{d}	0.20 ± 0.01^{d}	0.27±0.02^{d}	0.15±0.02^{d}	4.91±0.04^{d}
M85A15	7.83±0.06^{d}	0.78±0.06^{e}	1.15±0.01^{e}	0.20±0.04^{d}	0.32 ±0.04^{e}	0.19±0.03^{d}	0.19±0.03^{d}
MF85A15	7.07±0.58^{c}	0.9±0.04^{c}	1.08±0.04^{c}	0.3 ± 0^{c}	0.3±0.01^{c}	0.17±0.01^{c}	5.20±0.42^{c}
M77,5A22,5	8.12±0.21^{c}	0.8±0.03^{d}	1.41±0.03^{d}	0.4±0.01^{b}	0.42 ±0.04^{c}	0.24±0.05^{c}	7.04±0.07^{c}
MF77,5A22,5	7.77±0.03^{b}	0.98±0.02^{b}	1.3±0.05^{b}	0.35 ±0.08^{b}	0.32±0.04^{b}	0.23±0.01^{b}	5.46±1.78^{b}
M70A30	8.44±0.04^{b}	0.98±0.01^{c}	1.64±0.23^{b}	0.49±0.02^{c}	0.47± 0.03^{b}	0.3±0.04^{b}	7.63±0.48^{b}
MF70A0	7.99±0.02^{a}	1.06±0.04^{a}	1.42±0.07^{a}	0.47 ±0.05^{a}	0.4±0.02^{a}	0.29±0.06^{a}	6,25±0,05^{a}
CASHEW	9.61±1.03^{a}	1.12±0.03^{a}	1.94±0.02^{a}	0.41±0.03^{a}	0.54 ± 0^{a}	0.31±0.03^{a}	4.1±0.12^{g}
FAR COM	2.61 ±0.01^{g}	1.04± 0.01^{b}	1.44 ±0.07^{c}	0.42± 0.05^{b}	0.35 ± 0.02^{d}	0.13 ± 0.04^{g}	14.27 ± 0.01^{a}

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REFERENCES

1. **Madelyn V** Comité de l'Agriculture, Millets Sorghum : Forgot. Foods Futur. Foodlank, 2018 [en ligne], Vingt-Sixième Session, Rome, Octobre 2018: Proposition relative à la célébration d'une Année internationale du mil : 1-9.

2. **Donatien K, Aly S, Tankoano A, Michel BD and SL Haagrétou** Les Aspects Technologiques, Microbiologiques et Nutritionnels des Aliments Fermentés à base de Lait et de Mil en Afrique de l'Ouest, *Int. J. Adv. Res.* 2017 ; **5(8)** : 1509-1526.

3. **Fall CA, Abdourahamane S, Edmond K and A Fataye** Rapport National sur L'Etat des Ressources Phytogénétiques pour l'Alimentation et l'Agriculture : Ministère de l'Agriculture République de Côte d'Ivoire, Second Rapport National, Octobre 2009.

4. **Turpin W** Vers une Evaluation des Potentialités Probiotiques et Nutritionnelles des Bactéries Lactiques Constitutives du Microbiote d'un Aliment Fermenté Traditionnel à Base de Mil par une approche Moléculaire, Thèse sur les Bactéries Lactiques, Université de Montpellier 2011.

5. **Blandino A, Al-Aseeri ME, Pandiella SS, Cantero D and C Webb,** Review : Cereal-Based Fermented Foods and Beverages, Food *Res. Int.,* 2003; **Vol. 36, no. 6** : 527-543.

6. **Tou EH, Mouquet-Rivier C, Picq C, Traoré AS, Trèche S and JP Guyot** Improving the Nutritional Quality of Ben-Saalga, a Traditional Fermented Millet-Based Gruel by Co-Fermented Millet with Groundnut Modifying the Processing Method, LWT-Food *Sci. Technol*., 2007; **Vol. 40, no. 9**: 1561-1569.

7. **Yao AA, Egounlety M, Kouamé LP and P Thonart** les Bactéries Lactiques dans les Aliments ou Boissons Amylacés et Fermentés de l'Afrique de l'Ouest : leur Utilisation Actuelle, *Ann. Med. Vet.,* 2009 ; **Vol. 153, no. 1** : 54-65.

8. **WHO.** Principes Directeurs pour l'Alimentation des Enfants de 6 à 24 Mois Qui ne pas sont pas allaités au Sein, Département de la santé et du développement de l'enfant et de l'adolescent. Catalogage à la Source Bibliothèque de l'OMS, 2005 : 44.

9. **Coulibaly A** Evolution Récente de la Filière Anacarde Côte d'Ivoire Conseil du Coton et de l'Anacarde, Sietta 2018.

10. **Songré-Ouattara LT, Gorga K and A Savadogo** Evaluation de l'Aptitude Nutritionnelle des Aliments Utilisés dans l'Alimentation Complémentaire du Jeune Enfant au Burkina-Faso, *J. Soc. Ouest-Afr. Chim* 2016; **Vol. 041**: 41-50.

https://doi.org/10.18697/ajfand.108.20500

11. **Soro D** Couplage de Procédés Membranaires pour la Clarification et la Concentration du Jus de Pomme de Cajou : Performances et Impacts sur la Qualité des Produits Montpellier Supagro Thèse pour l'Obtention du Grade de Docteur, 2012.

12. **Sze-Tao KWC and SK Sathe** Functional Properties and in Vitro Digestibility of almond (Prunus Dulcis L.) Protein Isolate, Department of Nutrition, Food and Exercice Sciences, Florida State University, Tallahassee, USA, Food Chem., 2000 **Vol. 69, no. 2** : 153-160.

13. **AOAC**. Official Methods of Analysis of AOAC International, 16th ed, Choice Rev. Online, 1990 **Vol. 35, no. 02** : 35-0912.

14. **Emilke NJT, Barber Li and CO Ebere** Proximate, Mineral and Functional Properties and Defatted and Undefatted Cashew (Anacardium Occidental Linn.) Kernel Flour, *J. Chem. Inf. Model.*, 2015 **Vol. 53, no. 9** : 1689-1699.

15. **Ijarotimi OS, Oluwalana IB and MO Ogunedojutimi** Nutrient Composition, Functional, Sensory and Microbial Status of Popcorn-Based (Zea May Everta) Complementary Foods Enriched with Cashew Nut (Anacardium occidentale L.) Flour. *African J. Food, Agric. Nutr. Dev.,* 2012 **Vol. 12, no. 5** : 6424-6446.

16. **Butte NF, Wong WW, Hopkinson JM, Heinz CJ, Mehta NR and EO Smith** Energy Requirements Derived from Total Energy Expenditure and Energy Deposition During the First 2 y of Life, *Am. J. Clin. Nutr.,* 2000 **Vol. 72, no. 6** : 1558-1569.

17. **Aremu MO, Olonisakin A, Bako DA and PC Madu** Compositional Studies and Physicochemical Characteristics of Cashew Nut (Anacardium occidentale) Flour, Pakistan Journal of Nutrition 2006 ; **5 (4)** 328-333.

18. **Omosuli SV, Ibrahim TA, Oloye D, Agbaje R and JO Bolande** Proximate and Mineral Composition of Roasted and Defatted Cashew Nut (Anacardium Occidentale) Flour, Pakistan Journal of Nutrition 2009; **8 (10):** 1649-1651.

19. **Fofana I, Soro D, Yeo MA and EK Koffi** Influence de la Fermentation sur les Caractéristiques Physicochimiques et Sensorielles de la Farine Composite à Base de Banane Plantain et d'Amande de Cajou, Eur. Sci. Journal, ESJ, 2017; **Vol. 13, no. 30**: 395.

20. **Olanipekun OT, Olapade OA, Suleiman P and SO Ojo** Nutrient and Sensory Analysis of Abari Made from Composite Mixture of Kidney Bean Flour and Maize Flour, 2015 ; **Vol. 4, no. 2** : 19-23.

21. **Lautié E, Dornier M, Filho MDS and M Reynes** les Produits de l'Anacardier: Caractéristiques, Voies de Valorisation et Marchés, Articles de Synthèse 2001; **Vol. 56, no. 4** : 235-248.

22. **Isabelle L, Christelle I, Christian P and T Serges** Effet du trempage de graines et de Farines de Céréales et de Légumineuses sur leur Teneur en Phytates et leurs Rapports Molaires Phy/Fe et Phy/Zn, Deuxième Atelier Inter., Voies alimentaires d'amélioration des situations nutritionnelles, 2003: 23-28.

23. **Béninga MB** Caractérisation Chimique et Minérale des Grains de Mil [Pennisetum glaucum (L.) R. Br.] de Côte d'Ivoire 2011; **Vol. 5** : 2039-2044.

24. **Guénette L** Le Guide Santé, la Moisson, Marché Santé, 2005.

25. **Olorode OO, Idowu MA, Bamgbose A and AE Ayano** Chemical, Phytochemical and Functional Properties of Selected Seeds Flours, *Int. J. Nutr. Food Sci*., 2014; **Vol. 3, no. 6** : 572.

26. **Esterle L**Calcium et Santé Osseuse chez l'Enfant et l'Adolescent (Calcium and Bone Health During Childhood and Adolescence), *J. Pediatr. Pueric.,* 2010; **Vol. 23, no. 2** : 65-69.

27. **Songré-Ouattara LT, Gorga K and A Savadogo** Evaluation de l'Aptitude Nutritionnelle des Aliments Utilisés dans l'Alimentation Complémentaire du Jeune Enfant au Burkina-Faso, *J. Soc. Ouest-Afr. Chim* 2016 ; **Vol. 041**: 41-50.

28. **Koné S, Soro D and EK koffi** Formulation et Caractérisation Physicochimique de la Farine Infantile Composée: Attiéké Déshydraté-Amande de Cajou (Formulation and Physical Chemical Characterization of Infant Flour Compound: Attiéké – Cashew Kernel Flours), *Int. J. Innov. Appl. St*. 2019; **Vol. 25, no. 2** : 700-708.

29. **Oyarekua MA** Effect of Co-Fermentation on Nutritive Quality and Pasting Properties of Maize/ Cowpea/Sweet Potato as Complementary Food, *African J. Food, Agric. Nutr. Dev*., 2003; **Vol. 13, no. 1** : 7171-7191.

30. **Codex Alimentarius**, Guidelines on Formulated Complementary Foods for Older Infants and Young Children CAC/GL 8-1991,1991: 1-10.

31. **Fanni O, Claire MR, Clémence BM, Claire K, Mirrdyn D, Noel MZ, Anne-sophie LD and FN Ndeye** Rapport de l'étude la filière des farines infantiles produites localement dans 6 pays sahéliens réalisé de juille 2019 à janvier 2020.

32. **Odunfa SA** Biochemical Changes During Melon Fermentation for Ogiri Production, *J.* Plant Foods, 1982; **Vol. 4, no 2**: 111-116.

33. **Achinewhu SC** Some Biochemical and Nutritional Changes During the Fermentation of Fluted Pumpkin (Telferia occidentalis). Qual Plant Plant Foods Hum. Nutr., 1986; **Vol. 36,** 97-106.

34. **Kazanas N and ML Fields** Nutritional Improvement of Sorghum by Fermentation, *J. Food Sci.*, 1981; **Vol. 46, no. 3** : 819-821.

35. **Nuum NM and PN Obiakor** Effect of Fermentation on the Nutrient and Antinutrient Composition of Baobab (Adansonia digita) Seeds and Rice (Oryza sativa) Grains, *Ecol. Food Nutr.,* 2003 **Vol. 42, no. 4 – 5** : 265-277.

36. **Giami SY and DA Bekebain** Proximate Composition and Functional Properties of Raw and Processed Full-Fat Fluted Pumpkin (Telfairia occidentalis) Seed Flour, *J. Sci. Food Agric.,* 1992;**Vol. 59, no. 3** : 321-325.

37. **Soro S** Formulation d'Aliments Infantiles à Base de Farines d'Igname Enrichies au Soja, *African J. Food. Agric. Nutr. Dev.,* 2013; **Vol. 13, no. 5** : 8313-8339.

38. **Marret S and P Ancel** Protection Cérébrale de l'Enfant né Prématuré par le Sulfate de Magnésium, la Rev. Sage-Femme, 2017; **Vol. 16, no. 4** : 262-278.

39. **Haddy FJ, Vanhoutte PM and M Feletou** Role of Potassium in Regulating Blood Flow and Blood Pressure, Am. J. Physiol – Regul. Integr. Comp. Physiol., 2006; **Vol. 290, no. 3** : 546-552.

40. **Kalpana P, Krishnapura S and S Hemalatha** Influence of Germination and Fermentation on Bioaccessibility of Zinc and Iron from Food Grains, *Eur. J. Clin. Nutr.,* 2007; **Vol. 61, no. 3** : 342-348.

41. **Svanberg U and AS Sandberg** Lactic Fermentation of Non – Tannin and High-Tannin Cereals: Effects on in Vitro Estimation of Iron Availability and Phytate Hydrolysis, *J. Food Sci.,* 1993; **Vol. 58, no. 2** : 408-412.

42. **Aguayo VM and AMD Pierre** Nutrition en Côte d'Ivoire, un Appel à l'Action, African Journal of Food and Nutritional Sciences 2002; **Vol. 2 no. 2**.

43. **Ezzati M Lopez AD, Rodgers A, Vander HS and CJL Murray** Selected Major Risk Factors and Global and Regional Burden of Disease, Lancet, 2002; **Vol. 360, no. 9343**: 1347-1360.