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Evaluation of technological treatments impact on nutritional value and anti-nutritional factors of cashew kernel-based flour (*Anacardium occidentale*) grown in Côte d'Ivoire

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Abstract
The aim of this study was to evaluate impact of technological treatments on cashew nut flours. Study was conducted on cashew harvested from fields. Technological treatments have been applied to cashew kernels: cooking (100°C/30 min) and roasting (120°C/20 min). Flours obtained after kernels grinding namely, FTA, FAC, FRA and FIA, have been used for biochemical analysis. The analyses were on fatty acids, essential amino acids, antioxidant activities and anti-nutritional factors. Results showed that treatments had a significant influence on studied parameters. Saturated fatty acid (%) content in FIA (18.2 ± 0.01) was higher than that in other flours: FTA (15.54 ± 0.01), FAC (15.91 ± 0.01) and FRA (15.65 ± 0.01). Heat treatments promoted the increasing of essential amino acids content, a significant decreasing of antioxidant activities and anti-nutritional factors compared to the crude flour. All these features suggest that cashew flours could be used for supplemented cereal flour in child dietary.

Keywords: cashew nut, flours, roasting, cooking, anti-nutritional factors

1. Introduction
Malnutrition is a public health problem in the world and particularly in developing countries. In Côte d'Ivoire, data from nutritional surveys carried out in July 2012 in the North and West area have showed a chronic malnutrition rate of 35-39.8%, and an overall acute malnutrition rate of 4 to 8% [1]. These rates are close to the critical prevalence which is respectively 40% and 15% [2]. The increasing of child malnutrition requires the design of rapid solutions, such as the search for new sources of vegetable proteins of local product.
Cashew nuts are oleaginous seeds rich in oils. However, their protein content is not negligible and makes it a desirable dietary supplement. Indeed, almonds from these nuts are much consumed in North America, Europe and Asian countries. But, they are less consumed in Côte d'Ivoire which is the second largest producer since 2013 with 531,488 tons [3]. The recent study of [4] has showed that cashew kernels were rich in iron (0.85 mg / 100 g). Similarly, [5, 6] in Nigeria have showed an important rate of amino acids and essential fatty acids. With the high levels of protein, fat, amino acids and essential fatty acids, cashew almonds would be a potential source of nutrients for populations whose diet is deficient.
However, Cashew kernels contain also anti-nutritional factors which can act on the bioavailability of certain nutrients. To eliminate such factors, some treatments such cooking and roasting could be applied on the kernels. The previous studies realized by [7, 8] were demonstrated the loss of anti-nutritional compounds into cooking water of six vegetable. Somme authors [9] established that the heat-treatment of 150 ºC during 30 min was efficient to inactivate anti-nutrients and maintain the quality of protein in soybean. The low level of anti-utritional compounds such as tannins and phytates in heat flours could be beneficial for health. So, almonds should be treated beforehand to obtain good quality product healthy and clean. The context of the present study was focused on improving the nutritional value of cashew kernels which could be used for the infant food enrichment. The overall objective of this study was to estimate the impact of technological treatments on nutritive value and anti-nutritional factors of cashew nut flours. Moreover, antioxidant capacities and oil indicator value will be also evaluated.

2. Material and Methods
2.1 Source of raw materials and experimental design
Experiments were carried out on cashew nut varieties (*Anacardium Occidentale L.*) harvested in Côte d'Ivoire. Cashew fruits (apple and nuts) were picked in fields of local growers from April to June. Then the nuts were separated by a hand twist and sun-dried for 3 to 4 days in a ventilated area. These dried nuts were stored in bags and transported to the laboratory for the analyses. The Industrial almonds were purchased in a supermarket in Abidjan.

2.2 Pretreatments of harvested nuts
In order to extract almond, cashew nuts were soaked in water for 24 hours and the moistened nuts were dried for two days at ambient temperature in the laboratory. The dried nuts were then pound manually to recover all almonds and eliminate all traces of debris. Almonds were washed and stove dried in an oven (MMM MED CENTER) at 47°C during 48 hours. They were divided in 3 parts: one part without treatment (raw nuts), one part for cooking and one part for roasted.

2.3 Preparation of flours
2.3.1 Flour of raw cashew nuts
Dried almonds (400g) were directly crushed using a grinder

(Bomino, Italy BI-243). The flour obtained was stored in airtight containers and named FRA (Flour of Raw Almond).

2.3.2 Flour of boiled cashew nuts
Dried almonds (400 g) were heated to boiling with 0.5 L of water during 30 minutes. After cooking, almonds were drain and then dried in a ventilated oven (MMM MED CENTER) at 47 °C for 48 hours and grinded with a grinder. Flour obtained was stored in airtight containers and named FAC (Flour of Almond Cooked at water).

2.3.3 Flour of torrefied cashew nut
Dried almonds (400g) were roasted in a pan at 120°C during 20 minutes. These roasted almonds were cooled at room temperature during 4 hours before being grinded. Flour obtained was stored in airtight containers and named FTA (Flour of torrefied Almonds).

2.3.4 Flour of industrial cashew nut
Industrial almonds (400g) were purchased in a supermarket in Abidjan and grinded directly. Flour obtained was stored in airtight containers and named FIA (Flour of Industrial Almond).

2.4 Anti-nutritional factors of flours
2.4.1 Tannins Content
Tannins of samples were quantified according to [10]. For this, 1 mL of the methanolic extract was mixed with 5 mL of vanillin reagent and the mixture was allowed to incubate at ambient temperature for 30 min. Thereafter, the absorbance was read at 500 nm by using a spectrophotometer (PG Instruments, England). Tannins content of samples was estimated using a calibration curve of tannic acid (2 mg/mL) as standard.

2.4.2 Phytate content
The quantification of phytates has based on an indirect method consisting in complexing the phytates with iron (phytates-ferric) and then in assaying the iron by spectrophotometer [11]. Sample (0.5 g) is homogenized in 25 mL of 3% (w / v) TCA. The mixture was allowed to stand for 30 min and then centrifuged at 3500 rpm for 15 min. Five (5) ml of supernatant were taken and mixed with 3 mL of 1% (w / v) ferric chloride. The solution obtained was heated in a boiling water bath for 45 minutes. After cooling, the solution was centrifuged at 3500 rpm for 10 min. The supernatant was mixed with 5 mL of hydrochloric acid (0.5 N) and then left to stand for 2 h. To the mixture obtained were added 5 mL of sodium hydroxide (1.5 N) and the whole was carried in a boiling water bath for 15 min. The solution obtained was centrifuged at 3500 rpm for 10 min. One (1) ml of the supernatant was taken and then introduced into a test tube. To the contents of the tube, 4.5 ml of distilled water were added, boiled, cooled and then 4.5 mL of orthophenanthroline reagent were added. Thereafter, the absorbance was measured at 470 nm by using a pectrophotometer (PG Instruments, England). Phytate-ferric of sample was determined using a calibration curve of mohr salt (10 µg iron / mL) as standard.

2.4.3 Oxalic acid content
The oxalic acid (OA) content was determined according to the method described in [12]. Sample (0.5 g) was weighed and added to 100 mL of 0.1N potassium hydroxide (KOH) and then boiled for 30 minutes at 80 °C. After cooling, the solution obtained was filtered and 5 mL of concentrated sulfuric acid (H_2SO_4) were added. The filtrate was heated to 60°C or 70°C for 10 min and then titrated with the potassium permanganate solution ($KMnO_4$) 0.1N until a persistent pink color at least 30s. Oxalic acid was determined by the following relationship:

$$\text{Oxalic acid (\%)} = [(V \times 0.45 \times 2) / \text{Weight of sample}]$$

Where
V: Titre value, 0.45: amount of oxalic acid corresponding to 1 liter of 0.1 N KMnO4 solution

2.5 Phenolic compounds, Flavonoids and Antioxidant activities
2.5.1 Phenolic Content
Polyphenols content was determined using Folin-Ciocalteu method [13]. A quantity (1 g) of dried powdered sample was soaked in 10 mL of methanol 70 % (w/v) and centrifuged at 1000 rpm for 10 min. An aliquot (1 mL) of supernatant was oxidized with 1 mL of Folin-Ciocalteu's reagent and neutralized by 1 mL of 20 % (w/v) sodium carbonate. The reaction mixture was incubated for 30 min at ambient temperature and absorbance was measured at 745 nm by using a spectrophotometer (PG Instruments, England). The polyphenols content was obtained using a calibration curve of gallic acid (1 mg/mL) as standard.

2.5.2 Flavonoids Content
The total flavonoids content was evaluated using the method reported by [14]. Methanolic extract (0.5 mL) was mixed with 0.5 mL methanol, 0.5 mL of $AlCl_3$ (10 %, w/v), 0.5 mL of potassium acetate (1 M) and 2 mL of distilled water. The mixture was allowed to incubate at ambient temperature for 30 min. The absorbance was measured at 415 nm by using a spectrophotometer (PG Instruments, England). The total flavonoids were determined using a calibration curve of quercetin (0.1 mg/mL) as standard.

2.5.3 Antioxidant Activities
Antioxidant assay was carried out using the 2.2-diphenyl-1-pycrilhydrazyl (DPPH) spectrophotometric method outlined by [15]. About 1 mL of 0.3 mM DPPH solution in ethanol was added to 2.5 mL of sample solution (1 g of dried powdered sample mixed in 10 mL of methanol and filtered through Whatman No. 4 filter paper) and was allowed to react for 30 min at room temperature. Absorbance values were measured with a spectrophotometer (PG Instruments, England) set at 415 nm. The average absorbance values were converted to percentage antioxidant activity using the following formula:

$$\text{Antioxidant activity (\%)} = 100 - [(\text{Abs of sample} - \text{Abs of blank}) \times 100/\text{Abs positive control}] \quad (1)$$

Where
Abs: absorbance

2.6 Proteins content and amino acid composition

2.6.1 Protein Content

Protein was determined by determination of total nitrogen according to the Kjeldahl method [16]. The principle: under the action of NAOH and after sulfuric mineralization in the presence of catalyst (CuSO4), ammoniac formed was neutralized. The ammonia in the sample solution was then distilled into the boric acid until it changed completely to bluish green. The distillate was then titrated with 0.1 N HCl solutions until it became colorless. The percent total nitrogen and crude protein were calculated using a conversion factor of 6.25.

2.6.2 Amino acid composition

Amino acid analysis of cashew flours was measured out by liquid chromatography high performance in inverse phase (Colonne PTC RP-18, 220 mm long, 2.1mm intern diameter and pré-colonne, Applera Corp, Fosters City, CA, USA). The sample was hydrolysed in vacuum at 150°C during 60 min in Pico Tag station (Waters, Milford, MA, USA) with HCl 6 N at 1 % Phenol. Amino acids are separated in two buffer solution. Results were exploited thanks to application program Model 600 Data Analysis System.

2.7 Lipids content and fatty acid composition

2.7.1 Lipids Content

Fat content was determined based on the Sohxlet extraction method [17]. Five gram (5.0 g) of the sample was introduced into a cartridge of Whatman. An empty flask reweighed and containing 60 ml of hexane was placed on the heating block of the Soxhlet apparatus and heated at 110°C. After 6 hours of extraction, the flask was removed from apparatus and then the solvent was evaporated on a Rotary Evaporator. The flask containing the fat and residual solvent was placed on a water bath to evaporate the solvent followed by a further drying in an oven at 60°C for 30 min to completely evaporate the solvent. It was then cooled in desiccators and weighed. The fat obtained was expressed as a percentage of the initial weight of the sample.

2.7.2 Fatty acid composition

Fatty acid methyl esters (FAME) were obtained by transmethylation of lipid aliquots (100 mg). According to [18], samples were dissolved with 1.5 mL of hexane and 1.5 mL of borontrifluoride in methanol (8%, w/v), and heated at 100 °C under nitrogen for 1 h. After cooling, the fatty acid methyl esters were extracted in hexane under nitrogen. FAME were analyzed by gas chromatography on Perichrom™ 2000 system (Saulx-les-Chartreux, France), equipped with a flame ionisation detector (FID) and fused silica capillary column (50 m × 0.25 mm × 0.5 µm, BPX70 SGE Australia Pty Ltd).Temperatures were set as follows: 2 min initial period at 120 °C, increasing at 40 °C/min to the second step at 180 °C for 8 min, and flowing out at 3 °C/min to the final period at 220 °C for 45 min. Injection and detector ports were maintained at 230 °C and 260 °C respectively. Fatty acids were identified by comparing their relative retention time with appropriate vegetable standards and marine PUFA 2 standards from Supelco (Supelco Park, Bellefonte, PA 16823-0048 USA). The results, made in triplicate, were displayed as percent of total identified fatty acids.

2.8 Oils profile from flours

2.8.1 Acidity of fats

Acidity of fats was assessed by the references NF T 60-221/NF T 60-204 [19]. Ether-alcohol solution was prepared with 25 mL of petroleum ether and 50 ml of 95% ethanol. This solution was mixed with fat sample (5 g). In the mixture, a few drops of phenolphthalein 0.1% were added and then neutralized with a 0.1N sodium hydroxide solution until a permanent pink color is obtained. Then the ether-alcoholic solution was mixed with the oil. Finally, the solution was again assayed with 0.1N sodium hydroxide in the presence of phenolphthalein 0.1% (5 drops) until pink coloration. The acidity can be expressed conventionally according to the nature of the oils, in oleic, palmitic or lauric acids. Molecular weight of oleic acid is 282 and those of palmitic acid and lauric acid are respectively 256 and 200. The expression of the oleic acidity (oleic A.) was given by the formula below:

$$\text{Oleic A. (\%)} = [((\text{Fall of burette} \times 2.82) / \text{Weight of sample}) \times 100] \quad (2)$$

2.8.2 Acid Value

Acid value (A.V.) was determined according to the method described of [20]. Ethanol was boiled on a water bath for a few minutes to remove dissolved gases, and neutralized by adding a few drops of phenolphthalein and about 10 mL 0.1 M potassium hydroxide (KOH) until a pale pink colour was obtained. Oil sample (6 g) was weighed into a conical flask and 50 mL of hot previously neutralized alcohol was added. The mixture was later boiled on a water bath. The hot mixture was then titrated with 0.1 N potassium hydroxide (KOH) sodium until the pink colour (stable for few minutes). The acid value (A.V.) was calculated from the following expressions:

$$\text{A.V. (mg KOH/g)} = [(\text{Titre value V (mL)} \times N \times 56.1) / \text{Weight of sample m (g)}] \quad (3)$$

Where
N: Normality of KOH, 56.1: Molar mass of KOH
Acid value (A.V.)

2.8.3 Peroxide Value

Peroxide value (P.V.) was determined according to the method described of [20]. Oil sample (5.0 g) was accurately weighed into a conical flask, and dissolved in solvent mixture containing 12 ml chloroform and 18 ml glacial acetic acid. To the solution 0.5 ml of a saturated aqueous potassium iodide solution (5g/5ml) was added. The flask was stoppered and allowed to stand for 1 min. About 30 ml of water was added and the solution was titrated with 0.1 M sodium thiosulphate solution until the yellow colour had almost gone. About 0.5 ml of starch solution was introduced and titration continued with the reagent added slowly until the blue black colour disappeared. During the titration, the flask was continuously and vigorously shaken to transfer the liberated Iodine from the

chloroform layer to the aqueous layer. A blank titration was also performed, and the peroxide value was obtained from the formula:

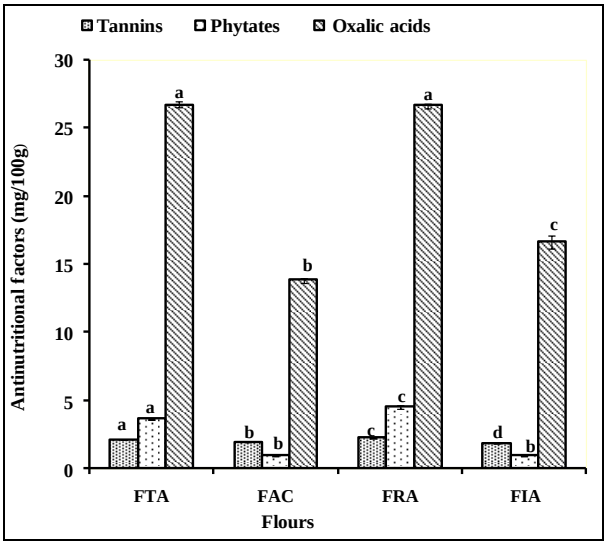
P.V. (meq O_2 /Kg) = [(V – V') x 5) /Weight of sample] **(4)**

Where
P.V: Peroxide value
V: Sample titre value,
V': Blank titre value.

2.8.4 Refractive Index
The refractive index (RI) was determined according to the method described of [21] using refractometer. Two (2) drops of fat were deposited between the prisms. The instrument is lighted to obtain the most distinct reading possible and the refractive index value was determined.

2.9 Statistical Analysis
Results were expressed as mean ± standard deviation from triplicate measurements. An ANOVA was performed and non-parametric test of Duncan was used to analyze the difference between means at p=0.05 with Statistica 7.1 software.

3. Results
3.1 Anti-nutritional Factors
Anti-nutritional factors, (tannins, phytates and oxalic acids) of cashew nut were presented in Figure 1. Results showed a significant effect of thermal treatments ($p<0.05$) on anti-nutritional factors in each flour studied. In addition, FAC and FIA show the lower concentration of phytate 0.96 ± 0.02 mg / 100 g compared to FTA (3.63 ± 0.02 mg /100g) and FRA (4.5 ± 0.11 mg / 100g). Results showed the lowest level of oxalic acids (13.38 ± 0.2 mg / 100g) on FAC compared to the other three flours.



According to each anti-nutritional factors, means with different superscript differed significantly (Duncan test, $p \leq 0.05$)
FTA: Flour of torrefied Almonds; FAC: Flour of Almond Cooked at water; FRA: Flour of Raw Almond and FIA: Flour of Industrial Almond

Fig 1: Anti-nutritional factors of flours

3.2 Phenolic compounds, flavonoids and antioxidant activities
Polyphenol, flavonoids and antioxidant activities were presented in Table 1. Results showed a significant effect ($p<0.05$) of heat treatments on Phenolic compounds, *flavonoids* and antioxidant activity in each flour. FAC had the lowest concentration of phenolic compounds (2.76 ± 0.05 mg / 100g GAE) and flavonoids (2.15 ± 0.02 mg / 100g QE). Similarly, FAC showed the lowest antioxidant activity (37.74 ± 0.1 %) compared to FTA (39.68 ± 0.07 %), FIA (39.26 ± 0.03 %), and FRA (40.08 ± 0.07 %).

Table 1: Phenolic compounds, flavonoids and antioxidant activities

Flours	FTA	FAC	FRA	FIA
Phenolic C. (mg/100g GAE)	4.17 ± 0.47 ^{a}	2.76 ± 0.05 ^{b}	5.56 ± 0.33 ^{c}	3.03 ± 0.1 ^{d}
Flavonoids (mg/100g QE)	3.91 ± 0.16 ^{a}	2.15 ± 0.02 ^{b}	5.40 ± 0.16 ^{c}	4.3 ± 0.16 ^{d}
Antioxidant A. (%)	39.68± 0.07 ^{a}	37.74± 0.1^{b}	40.08± 0.07^{c}	39.26± 0.03^{a}

In line, means with different superscript differed significantly (Duncan test, $p \leq 0.05$)
FTA: Flour of torrefied Almonds; FAC: Flour of Almond Cooked at water; FRA: Flour of Raw Almond and FIA: Flour of Industrial Almond
Phenolic C.: Phenolic compounds, Antioxidant A.: Antioxidant activities

3.3 Protein and Amino acid composition
Protein content and amino acid profile of *Anarcadium occidentale* were presented in Table 2. Results showed that Protein levels were significantly different in each flours ($P<0.05$). Heat treatments were decreased protein contents in FTA, FAC and FIA than those of the raw FRA flours. In addition, cooking affect significantly amino acid profile whatever the flour considered. Results showed that Histidine, Tyrosine, Methionine have been weakly represented (< 2.5). On the other hand, isoleucine and Leucine were the most highly concentrated of essential amino acid. It was observed that heating condition «30 min/100°C or 20 min/120°C» reflects an increasing amino acid profile compared to raw flour. Result also showed that the low content of total amino acid was obtained in the raw flour.

Table 2: Protein and Amino acid contents

Flours	FTA	FAC	FRA	FIA
Protein (%)	20.42 ± 0.5[a]	19.23 ± 0.2[b]	21.85 ± 0.4[c]	17.79 ± 0.5[d]
Amino acid content				
Histidine *	1.71 ± 0.03[a]	2.12 ± 0.06[b]	1.92 ± 0.03[c]	1.71 ± 0.01[a]
Arginine *	4.97 ± 0.03[a]	4.22 ± 0.02[b]	3.01 ± 0.03[c]	3.25 ± 0.01[d]
Threonine *	6.89 ± 0,05[a]	7.10 ± 0.04[b]	6.21 ± 0.05[c]	6.72 ± 0.01[d]
Tyrosine *	1.75 ±0.05[a]	1.07 ± 0.01[b]	1.01 ± 0.04[c]	0.94 ±0.01[d]
Valine *	5.21 ± 0.04[a]	4.36 ± 0.06[b]	4.27± 0.02[c]	5.02 ± 0.01[d]
Methionine *	1.09 ± 0.05[a]	0.79 ± 0.01[b]	0.61 ± 0.03[c]	0.69 ± 0.02[d]
Isoleucine *	10.19 ± 0.05[a]	9.44 ± 0.02[b]	8.98 ± 0.01[c]	10.53 ± 0.02[d]
Leucine *	11.69 ± 0.05[a]	11.05 ± 0.05[b]	9.41 ± 0.05[c]	8.72 ± 0.01[d]
Phenylalanine *	4.17 ± 0.01[a]	4.08 ± 0.02[b]	3.33 ± 0.05[c]	3.81 ± 0.01[d]
Lysine *	4.25 ± 0.05[a]	4.61 ± 0.01[b]	4.04 ± 0.02[c]	4.43 ±0.02[d]
Total amino acids	51.92 ± 0.31[a]	49.16 ± 0.01[b]	42.8 ± 0.02[c]	46.23 ± 0.01[d]

In line, means with different superscript differed significantly (Duncan test, $p \leq 0.05$)
(*): Essential amino acid
FTA: Flour of torrefied Almonds; FAC: Flour of Almond Cooked at water; FRA: Flour of Raw Almond and FIA: Flour of Industrial Almond

3.4 Lipids and Fatty acid composition of cashew nut oil

Results showed a significant effect ($p<0.05$) of heat treatments on lipids content and fatty acid profile of cashew nut (Table 3). Heat treatments were decreased lipids contents in FTA, FAC and FIA than those of the raw FRA flours. The fatty acids treated in this study were saturated fatty acids (SFA). SFA were represented by palmitic acid (C16: 0), stearic acid (C18: 0), arachidic acid (C20: 0). Mono unsaturated fatty acids (MUFA) were represented by oleic acid (C18: 1n9). Polyunsaturated fatty acids (PUFA) were represented by linoleic acid (C18: 2n6) and linolenic acid (C18: 3n3). Results showed that acid palmitic level did not differ in FTA, FAC and FRA flours. FIA reveals the highest content of acid palmitic (11.7 ± 0.02%). Results also showed that FAC have the higher level of stearic acid (C18: 0), arachidic acid (C20: 0), oleic acid (C18: 1n9) and linolenic acid (C18: 3n3) respectively (6.91 ± 0.02), (0.55 ± 0.01), (63.57 ±0.01) and (0.4 ± 0.01) than the other flours. On the other hand, FRA shows the highest concentration of linoleic acid (C18:2n6) with (19.15). For the saturated fatty acid (SFA result showed the high content on FIA (18.2 ± 0.01). Moreover unsaturated fatty acids (UFA) were higher from FRA (19.50 ± 0.02) and decreased with heat treatment.

Table 3: Lipid and Fatty acid contents (%)

Flours	FTA	FAC	FRA	FIA
Lipid (%)	41.15±0.18 [a]	40.76±0.2 [b]	41.18±0.16 [a]	42.45±0.31 [c]
Fatty acid content				
C16:0	8.94 ± 0.02[a]	9 ± 0.07[a]	9 ± 0.02[a]	11.7 ± 0.02[b]
C18:0	6.6 ± 0.02[a]	6.91 ± 0.02[b]	6.65 ±0.00[c]	06.5 ± 0.01[d]
C20:0	0.51 ± 0.01[a]	0.55 ± 0.01[b]	0.46 ± 0.01[c]	0.43 ± 0.03[c]
C18:1n9	63.65 ± 0.01[a]	63.57 ± 0.01[a]	63.4 ± 0.1[b]	61.01 ± 0.01[c]
C18:2n6	19.12 ± 0.01[a]	18.80 ± 0.01[b]	19.15 ± 0.01[c]	18.80 ± 0.02[b]
C18:3n3	0.31 ± 0.2[a]	0.4 ± 0.01[b]	0.35 ± 0.01[c]	0.40 ± 0.02[b]
Saturated fatty acid (SFA)	15.54 ± 0.01[a]	15.91 ± 0.01[b]	15.65 ± 0.01[c]	18.20 ± 0.01[b]
Unsaturated fatty acids (UFA)	19.46 ± 0.04[a]	19.20 ± 0,2[b]	19.50 ± 0,02[c]	19.20 ± 0,03[b]

In line, means with different superscript differed significantly (Duncan test, $p \leq 0.05$)
FTA: Flour of torrefied Almonds; FAC: Flour of Almond Cooked at water; FRA: Flour of Raw Almond and FIA: Flour of Industrial Almond

3.5 Oil profile of cashew nut

The oil profiles of cashew nut were showed in table 4. Cooking had a significant influence on oil parameters. It has been established that FRA (2.91 ± 0.32 %) showed the high degree of oleic acidity compared to FAC (1.93 ± 0.3 %), FTA (1.31 ± 0.26 %) and FIA (0.65 ± 0.26%). Similarly, FRA (2.64 ± 0.02 %) showed the highest acid value. Concerning the peroxide value, FTA (4.93 ± 0.27 meq O_2 / Kg), and FIA (6.29 ± 0.29 meq O_2 / Kg) were showed the highest values than FAC (3.66 ± 0.14 meq O_2 / Kg) and FRA (3.58 ± 0.14 meq O_2 / Kg). For refractive index, all oils studied have the same value and did not differ significantly.

Table 4: Oil profile of cashew nut

Flours	FTA	FAC	FRA	FIA
Oleic Acidity (%)	1.31± 0.26 [a]	1.93± 0.3 [b]	2.91± 0.32 [c]	0.65± 0.26 [d]
Acid Value (mg KOH/g)	1.18± 0.02 [a]	1.75± 0.06 [b]	2.64± 0.02 [c]	0.59± 0.02 [d]
Peroxide Value (meq O_2/Kg)	4.93± 0.27 [a]	3.66± 0.14[b]	3.58± 0.14[b]	6.29± 0.29[c]
Refractive index	1.469± 0.15 [a]	1.469± 0.37 [a]	1.469± 0.15 [a]	1.469± 0.2 [a]

In line, means with different superscript differed significantly (Duncan test, $p \leq 0.05$)
FTA: Flour of torrefied Almonds; FAC: Flour of Almond Cooked at water; FRA: Flour of Raw Almond and FIA: Flour of Industrial Almond

4. Discussion

The objective of this study was to evaluate the impact of technological treatments on, nutritional value and anti-nutritional factors of on cashew nut flours. Anti-nutritional factors present in fruit and oilseeds form complexes with proteins, iron and enzymes in the digestive tract and reduced their bioavailability. These fruits and oilseeds could undergo technological treatments before being consumed. The result showed that roasting and boiling-water treatment led to a significant decrease the anti-nutritional factors of FTA, FAC and FIA flours. This decrease of the anti-nutritional compounds could be explained by the strong degradation of cell walls by heat. Indeed, this degradation of the cell walls would lead to release the anti-nutritional factors in cooking water. The results were in accordance with those obtained by [7, 8] which demonstrated the loss of anti-nutritional compounds into cooking water of six vegetables. Moreover, [9] established that the heat-treatment of 150 ºC for 30 minutes was efficient to inactivate anti-nutrients and maintain the quality of protein in soybean. Another authors [22] showed that roasting partially eliminated the anti-nutrients with the reduction ranged from 15.6% to 61.2% in all anti-nutrients.

The average level of tannins in the flours studied was approximately 3 mg/100 g and decreased with heat treatment. This result was lower compared to 5 mg/100g reported by [23]. The decrease of tannins contents in heat flours agree with the earlier investigations in boiled, microwave cooked, autoclaved and roasted plant foodstuff obtained by [24, 25, 26]. The reduction of tannins contents during heat treatments might be due to the loss of compound at high temperature. Also, this loss may be due to the degradation or interaction with other components of seeds, such as proteins, to form insoluble complexes. The apparent decrease in phytate content during thermal processing may be partly due either to the formation of insoluble complexes between phytate and other components, such as phytate-protein and phytate-protein-mineral complexes. Similarly, the significant reduction of phytate contents by thermal processing (roasting, cooking, autoclaving and microwave) has been observed in other plant foodstuff [24, 25, 27, 28]. The low level of tannins and phytate in the heat flours could be beneficial for health because they indicate astringency in foods consumed. Indeed, the high content of phytate in the diet could be responsible for the unavailability of certain minerals such as iron, zinc, magnesium and calcium. They could also influence the activity of certain enzymes such as pepsin, trypsin and amylases. Phytate content can also form complexes with proteins and reduces their solubility and digestibility [29]. In previous study, [4] revealed the high level of Iron and magnesium on cashew nut flours. So the reduction of these anti-nutritional factors may be important on the nutritional plan. The result showed significant effect ($P<0.05$) of heat treatment on oxalic acid. Heat treatments (boiling cooking and roasting) led to decrease oxalic acid content in the cooked flours compared to the raw flour. The decrease in oxalic acid content could be explained by the solubilization of this compound in the cooking water during these treatments. These results were in accordance with those obtained by [30]. These authors demonstrated the losses of total oxalates ranging from 22.4% to 70.3% after boiling vegetables such as spinach, carrots, beetroot, white bean, red bean and soya. The vegetables contribution of minerals and vitamins to human nutrition was however limited due to the presence of anti-nutritional factors that could render some of the nutrients unavailable for human nutrition. The phenolic compound content was lower than those obtained by [31] which were 381 mg / 100 g. These low levels of phenolic compounds could be very beneficial because these phenolic compounds can interact with other molecules such as proteins, metals and other polyphenols.

Antioxidant compounds in food play an important role as health protecting factor. Scientific evidence suggests that antioxidants reduce the risk of chronic diseases including cancer and heart disease. FAC showed the lowest antioxidant activity (37.74 ± 0.1%) compared to FTA (39.68 ± 0.07), FIA (39.26 ± 0.03) And FRA (40.08 ± 0.07). The loss of antioxidant with heating could be due to the loss of vitamin C, vitamin E, total phenolic and carotenes which could be diffused in the cooking water.

Cooking affect significantly protein and amino acid profile whatever the flour considered. Protein content of the raw flour is higher than those of flours which were undergone heat treatments. This low protein from kernels heat could be partly due by the distribution of these nutrients in cooking water and also by the Maillard reaction. Protein contents obtained in FRA (21.85%) were similar to those obtained by [32]. The study of [33] demonstrated that heat treatment increased ($p < 0.05$) the solubility of protein for soybean flour. For the amino acid profiles, results showed that Histidine, Tyrosine, Methionine have been weakly represented (< 2.5). On the other hand, isoleucine and Leucine were the most highly concentrated essential amino acid. These low values obtained could be explained by the varieties used and the geographical distribution. It was observed that heating condition «30 min/100°C or 20 min/120°C» reflects an increasing essential amino acid profile such as histidine, arginine, threonine, tyrosine, valine, methionine, isoleucine, leucine, phenylalanine and lysine compared to raw flour. Therefore, FRA (42.8%) revealed the lowest total amino acid content

compared to the other FTA, FAC and FIA flours. The increase in amino acid after heat could be explained by the solubilization reaction. These results were no accordance with those obtained by [34] who found that cooking reduced amino acid profil in faba bean. The low level of Histidine, Tyrosine, Methionine observed after heat treatment could be explained by their diffusion into cooking water.

For the fat content, results showed the low content of flour from almond cooked in water compared with the other three flours (FTA, FIA and FRA). This low content can be due to the fact that mainly short chains of fatty acids were extracted during cooking. The Average fat content (41.5%) obtained is similar to those obtained by [35]. As far as lipid content, result showed that cooking treatments (roasting and water cooking) have an effect of the fatty acid profiles. FIA revealed the high palmitic acid (C16: 0) content than the other flours. This high palmitic acid content in FIA could be explained by the high temperatures applied (180°C to 200°C) in the industry during roasting. Roasting temperature high than 180°C results in an increase of saturated fatty acids content. These results were in accordance with those obtained by [36]. Results also showed that FAC had a higher level of stearic acid (C18: 0), arachidic acid (C20: 0), oleic acid (C18: 1n9) and linolenic acid (C18: 3n3) respectively (6.91 ± 0.02), (0.55 ± 0.01), (63.57 ±0.01) and (0.4 ± 0.01) than the other flours. These high levels of stearic acid, arachidic acid, oleic acid and linolenic acid could be explained by the triglycerides hydrolysis at high temperature. The low content of linoleic acid in FAC and FIA could be explained by the fact that these acids undergo oxidations during boiling cooking. Indeed, the hydrolysis and the oxidation produced respectively during the water cooking and the roasting could lead to a decrease the PUFA. These idea were in agreement with those of [37] who reported that unsaturated fatty acids are more sensitive to oxidation than saturated fatty acids with oxidation rates of 1: 10: 100: 200 respectively for C18: 0, C18: 1 n-9, C18: 2 n-6 and C18: 3 n-3. For the saturated fatty acid (SFA), results showed the high content in flours studied. These higher SFA levels in flours studied were significantly lower than those reported by [38] in three cucurbit species with the respective values of 20.97 ± 0.24, 25.10 ± 0.2 and 30.22 ± 0.5. The difference between these results may be due to the heat technique and also the couple time/temperature using during processing. Unsaturated fatty had higher in FRA compared to cooked flours. The low value of unsaturated fatty in cooked flour can be explained by the couple time/temperature used during processing. In general, this fatty acid has predominated in each flours studied. The cashew oils used in this study give an oleic acid/linoleic acid ratio of 3.35 greater than that of the groundnut 1.48 reported by [39]. This high ratio could be explained by the fact that cashew oils are more stable than peanut oil. Cashew oil with high oleic/linoleic acid ratios could be preferred by the industry due to their increased shelf life and improved health benefits. Unsaturated fatty are protective oils of cardiovascular diseases. It is known to reduce the level of cholesterol-LDL and increase the cholesterol-HDL. So cashew nut flour could be used as the ideal food for alimentation.

Oil profile of cashew nut from the different flours studied showed the degree of alteration, the quality and the purity of these various oils. Results showed that the oil profiles varied according to the treatments applied, except the refractive index, which had similar values in all flours. The high values of oleic acidity and acid number in oil could be explained either by the hydrolysis of the ester linkages, glycerids and phospholipids to release fatty acids by the phenomenon of oxidation. The acid index obtained in the study is lower than 5 mg KOH/g which is correspond to the standard of [40]. The peroxide value is below 10 meq O2 / kg. According to [41] this value confirms the stability of these oils. Peroxide index value obtained from FTA and FIA were higher than those obtained in FRA and FAC. This high value could be explained by the oxidation reactions produced during roasting treatments. Indeed, the oxidation of lipids could lead to the formation of hydroperoxides, free radicals and very unstable compounds rapidly decomposed into secondary products: aldehydes, alcohols, ketones.

5. Conclusion

This study has showed that heat treatments have affected the nutritional values and anti-nutritional factors of cashew nut flours. The application of heat treatments (boiling water and roasting) revealed a significant decrease of protein content, anti-nutritional factor, antioxidant activity and fatty acid profiles. In addition, the increased in the essential amino acid by heating have been showed. Given the high content of essential amino acid and essential fatty acids of cashew flour, the incorporation of cashew kernel flour into infant feeding in Côte d'Ivoire, specifically in disadvantaged areas, could be help to ensure the food security of children less than 5 years.

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