Physico-Chemical, Functional and Sensory Properties of Composite Bread prepared from Wheat and defatted Cashew (*Anacardium occidentale L.*) Kernel Flour

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Abstract— *This study is part of the valuation of the cashew nut (Anacardium occidentale L.). For this purpose, defatted cashew kernel flour (powder) has been incorporated into wheat flour for the production of breads. Composite flours containing 0%, 10%, 20%, 30% and 40% of delipidated cashew kernel were analyzed for their physico-chemical and functional properties as well as the resulting loaves, for their sensory quality. The results showed that the substitution of wheat flour with cashew nuts flour increases the protein, fat, ash, fiber, energy and mineral content of wheat / cashew nut composites flours. However, this incorporation has resulted in a decrease in carbohydrate content. The study of the functional properties of composite flours showed that the substitution resulted in a significant increase (p <0.05) of the water absorption capacity (CAE) and oil (CAH) while the density decreased. Sensory tests indicated that there is a significant difference (p <0.05) between control bread and all composite breads. However, it is suggested that cashew kernel flour could be suitably incorporated into wheat flour up to a rate of 20%.*

Keywords— Cashew nut, wheat flour, composite bread, sensory quality, substitution.

I. INTRODUCTION

Bread is a global staple (Bibiana et al., 2014), produced from wheat flour (Komlaga et al., 2012). In most African countries, consumption has increased considerably in recent years (Rinaldi et al., 2015). This increased trend in bread consumption has been the result of a number of factors including urbanization and a growing population, a shift in food preferences towards snacks (biscuits, bread, etc.) and increased wealth in tropical countries (Ogunjobi and Ogunwole, 2010).

The ever-increasing consumption of this foodstuff in the tropics has increased the demand for wheat, which is the main ingredient in bread making. Also with the statistics, it is expected that demand for foods based on this cereal, such as bread, will increase by 2050 (Sibanda et al., 2015). Unfortunately, wheat is a temperate crop that is not conducive to tropical areas because of soil and adverse weather conditions (Abdelghafor et al., 2011). As a result, the countries in these areas, most of which are in the process of development, are spending huge sums (25,000 billion CFA francs in 2011) on importing wheat.

Due to concerns over the economic implications of dependence on wheat imports in developing countries, FAO in the 1960s stimulated research on the use of local resources available for partial substitution or total wheat flour (Eriksson et al., 2014). To this end, several flours derived from local cereals, tubers, oilseeds and legumes have been used at various proportions for the production of flours and composite breads (Olaoye et al., 2006, Méité et al., 2008). It is in this vein that this study was born to limit the use of wheat in the manufacture of bread and other pastries, through a mixture of wheat and cashew kernel flours.

The cashew nut is one of the most important cultures in Ivory Coast. According to the Cotton and Cashew nut Council (2016), Ivorian production has grown rapidly from 6 000 tons in 1990 to 725 000 tons in 2015, making it the world's largest producer of raw cashew nuts. However, almost all cashew nut production (+ 90%) is exported to Vietnam and India. It is good to know that the almond contained in cashew nut contains important nutrients such as fatty acids (40 to 57 g / 100 g), including linoleic and oleic acids (20% and 60% of the fat content), proteins (20 to 24 g / 100 g), carbohydrates (2 to 25 g / 100 g) and appreciable amounts of micronutrients (Ogunwolu et al., 2009, Nascimento et al., 2010). In addition, Emelike et al. (2015) showed that delipidation increased the protein content of cashew kernels from 19.8% to 34%. Moreover, Mukuddem-petersen et al. (2005) demonstrated that cashew kernel intake reduced the risk of cardiovascular disease, type 2 diabetes, and colon cancer.

Considering the economic and nutritional potential of cashew nuts, the use of cashew kernel flour could be considered as an ingredient in bakery products. However, it is very little consumed by Ivorians and moreover, very little of information are currently available on the use of this food product in food of great consumption and great distribution. The objective of this study is to evaluate the effect of the partial substitution of wheat flour by delipidated cashew kernel flour on the physicochemical, functional and sensory properties of composite breads.

II. MATERIALS AND METHODS

2.1 Biological material

Cashew nuts (*Anacardium occidentale L.*) are the plant material used in this study. These nuts peeled out of almonds were purchased in the company CAJOU FASSOU, located in Yamoussoukro (Ivory Coast), capital of the Lake District. The almonds were used to produce the flours and compound breads. Type 55 wheat flour and other ingredients such as baker's yeast (Saccharomyces cerevisiae), salt, and bread improver (Ibis) were purchased from a supermarket in the city.

2.2 Defatted cashew kernel flour production

2.2.1 Cashew nut processing

For the treatment of cashews, the modified method of Falade et al. (2004), was used. Healthy, dry nuts are steamed in a 115°C cooker for 45 minutes. Once pre-cooked, the nuts are allowed to cool for 48 hours at room temperature and separated into two equal halves using a manually controlled dehuller. The almonds, inside the hulls are then removed using small knives and oven dried in hot air in cupboards (BR185H, Gallenkamp, Yorkshire, UK) at 85 °C for 2 hours before blanching. After pruning, the nuts are dried at 65 °C for 6 hours to reduce the moisture content to 5-6%, cooled, packaged and stored.

2.2.2 Defatted cashew kernel flour

The modified Sze-Tao and Sathe (2004) method was used for the production of defatted cashew kernel flour (Figure 1). Processed cashew kernels are crushed using a hammer mill. The flakes obtained are deoiled twice using an apolar solvent (hexane) using the flake / solvent ratio (w: w), in a stainless steel tank by continuous maceration for 30 minutes. The sealed vessel is boiled for 50 minutes on a hot plate. After 24 hours of incubation, the supernatant containing the mixture of the oil and hexane is removed and the remaining cakes are collected in a white cotton fabric and pressed for 24 hours. The defatted oil cakes are then oven-dried (MEMMERT, Germany) for 12 hours at 65 °C for complete solvent removal. The oil cakes are finally milled to obtain the flour of particle size 150 microns, then packaged in polyethylene bags and stored at room temperature.

2.3 Blend formulation of wheat, and defatted cashew nut flour

The composite flours composed of wheat and defatted cashew kernel flours are obtained by the incorporation of respective proportions of 10, 20, 30 and 40% of the defatted cashew kernel flour in respectively 90, 80, 70 and 60% of the wheat flour. The 100% wheat and 100% cashew kernel flour served as controls. Finally, each formulation (Table 1) was carefully mixed in a blender (Philips) for 15 minutes at high speed and stored in polyethylene bags at room temperature until use.

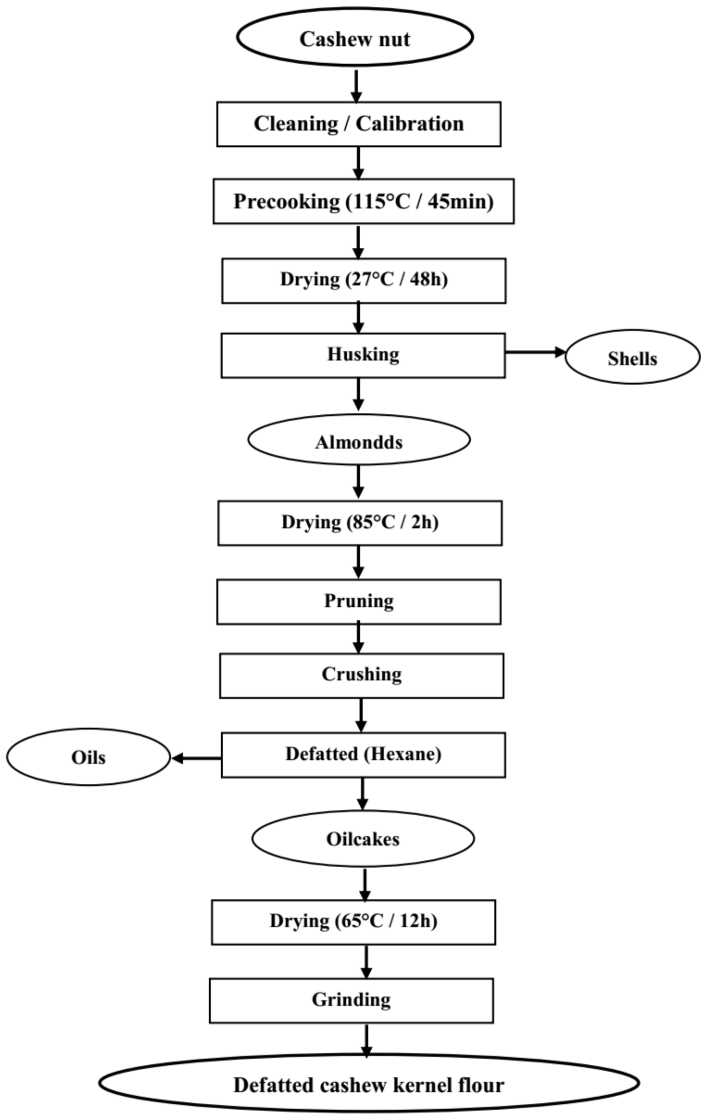

FIGURE 1: DIAGRAM OF PRODUCTION OF DEFATTED CASHEW KERNEL FLOUR

TABLE 1
PROPORTIONS OF WHEAT AND DEFATTED CASHEW KERNEL FLOURS USED IN THE PRODUCTION OF COMPOSITE BREADS

Formulations	Wheat Flour (WF)	Defatted Cashew Kernel Flour (DCF)
F1	90 %	10 %
F2	80 %	20 %
F3	70 %	30 %
F4	60 %	40 %

2.4 Physicochemical composition of flours

The pH was determined according to the AOAC method (1990), after calibration of the pH meter (HANNA HI98240, China). The same method was used for the determination of the moisture content, based on the mass loss of the samples by drying in an oven (MEMMERT, Germany) at 105 °C, until a constant mass was obtained. The ash analysis was carried out according to the method of BIPEA (1976). It consisted in calcining 5g of flour in an oxidizing muffle furnace (NABERTHERM, Germany) at 550 °C during 24 hours. The protein content was determined according to the method of AOAC (1990) and the total nitrogen was assayed according to the Kjedhal method after sulfuric mineralization in the presence of selenium catalyst. The nitrogen content was multiplied by 6.25 (conversion coefficient of nitrogen into protein). The fats were extracted with hexane in a Soxhlet extractor (Unid Tecator, System HT2 1045, Sweden) according to the

AOAC method (1990). The raw fiber contents of the samples are determined by the method of Van Soest (1963). A double hydrolysis acid (H_2SO_4 0.225 N) and alkaline (NaOH 0.3 N) hot destroying proteins and digestible carbohydrates contained in 3 g of sample was performed, then the hydrolyzate was defatted with acetone. The residues were dried and weighed. After calcination, the weight of the ashs was removed. The total carbohydrate (GT) content was estimated using the calculation method recommended by FAO (1998):

$$GT\ (\%) = 100 - (\%\ \text{protéines} + \%\ \text{humidité} + \%\ \text{lipides} + \%\ \text{cendres})$$

Energy value (VE) was obtained by calculation, according to the formula proposed by Atwater and Rosa (1899):

$$VE\ (Kcal/100g) = (4 \times \%\ \text{protéines}) + (9 \times \%\ \text{lipides}) + (4 \times \%\ \text{glucides})$$

2.5 Mineral composition of flours

The mineral elements of the flours were analyzed for potassium, calcium, iron, zinc and magnesium using an atomic absorption spectrophotometer, AAS (AA800 Perkin Elmer, Germany) according to the method described by Onwuka (2005).

2.6 Functional properties of flours

The water absorption capacity, the water solubility index, the oil absorption capacity and the density of the flours were evaluated. The water absorption capacity (CAE) and the water solubility index (ISE) were determined according to the method of Philips et al. (1988) and Anderson et al. (1969). One (1) g (M0) of flour is dispersed in 10 mL of distilled water. After stirring during 30 minutes using a KS10 stirrer, the mixture is centrifuged at 4500 rpm for 10 minutes. The wet pellet collected (M2) is weighed and then dried at 105 °C to constant weight (M1). The water absorption capacity (CAE) and the water solubility index (ISE) are calculated according to the following formulas:

$$\text{CAE}\ (\%) = \frac{\text{M2} - \text{M1}}{\text{M1}} \times 100 \qquad \text{ISE}\ (\%) = \frac{\text{M0} - \text{M1}}{\text{M1}} \times 100$$

The oil absorption capacity was determined according to the method of Sosulski (1962). About 1 g (M0) of flour is dispersed in 7 mL of refined palm oil. After stirring during 30 minutes using a KS10 stirrer, the mixture obtained is centrifuged at 4500 rpm during 10 minutes using a centrifuge (TAI SHI LI XIN JI TDI-4, China). The pellet recovered is weighed (M1) and the oil absorption capacity (CAH) is calculated according to the relationship:

$$\text{CAH}\ (\%) = \frac{\text{M1} - \text{M0}}{\text{M0}} \times 100$$

The hydrophilic-lipophilic ratio according to Njintang et al. (2001) was calculated using the ratio of the water absorption capacity and oil absorption capacity:

$$RHL\ (\%) = \frac{CAE}{CAH}$$

The determination of the density (D) was made according to the method described by Chau and Huang (2003). A graduated cylinder (10 mL), previously weighed (P0) is filled with flour to a known volume V, then re-weighed (P1). The density is calculated from the following equation

$$D\ (g/ml) = \frac{\text{P1} - \text{P0}}{V}$$

2.7 Bread making process

The recipe used in the bread making process is that described by the standard method of Amani and Takano (1998), with some modifications (Table 2).

The various ingredients (except yeast) were kneaded. Three minutes after the beginning of this first kneading which is done at 40 rpm and lasts 5 minutes, the yeast, previously diluted in water and flour, was added to the rest of the mixture. The paste obtained, rested for 5 minutes, and then a second kneading was done at 84 rpm for 10 minutes (brewing). The first fermentation followed the brewing process and lasted 45 minutes. Before the second fermentation (primer) the dough was shaped and molded for 1 hour in a fermentation chamber. The cooking, which is done with moist heat, took place at 200 °C for 35 minutes in an electric oven. The bread is left at room temperature for cooling.

TABLE 2
BREAD RECIPE

Ingredients	Bread	
	Control	Composites
Flour	1 kg	1 kg
Salt	13g	13g
Yeast	5g	5g
Improver	3g	3g
Water	60 %	Variable

2.8 Sensory analysis of breads

Two tests, namely general acceptability and descriptive testing, were performed during this sensory evaluation. The general acceptability of the loaves consisted in presenting simultaneously and in a random order, the different coded samples (three digits) to each taster. Each panelist, after tasting, should rank the samples according to the pleasure felt on a 9-point hedonic scale. Ratings ranging from 9 (very pleasant) to 1 (very unpleasant) were assigned to the different modalities of the scale. The samples were evaluated by 100 untrained panelists, recruited on the basis of their availability and not averse to the product.

The descriptive test of the loaves was carried out using the method described by Meilgaard et al. (2007). The method consists in evaluating and quantifying the appropriate descriptors (crumb and crust color, taste, texture, aspect and aroma) according to a category 9 hedonic scale. From 1 for very unpleasant descriptors to 9 for very pleasant descriptors. The samples were judged by 15 trained panelists composed of women and men. The coded samples, with three figures, were presented monadically to the panelists.

2.9 Statistical analysis

The analyses carried out in this study, were made in triplicate and the results were expressed on the basis of dry matter. The results were then subjected to an analysis of variance (ANOVA) carried out with the software Stastica 7.1 in order to compare the averages. If there is a significant difference, the Newman-Keuls test identified the means responsible for the difference observed at the 5% threshold.

III. RESULTS

3.1 Physicochemical composition of the different flours

The results showing the physicochemical composition of wheat flour, defatted cashew kernel and composite flours are summarized in Table 3. The protein content (28.03%), ash (3.67%), fat (25.5%), total fiber (6.67%), and pH (6.22) of defatted cashew kernel flour were significantly ($p < 0.05$) greater than of wheat which are respectively, 8.83%, 0.66%, 1.8%, 2.03% and 5.64. In contrast to these parameters, total carbohydrates (38.55%) and moisture (4.2%) levels are low in defatted cashew kernel flour.

In the analysis of the results, the partial substitution of wheat flour with cashew nut flour resulted in a significant ($p < 0.05$) increase in protein, fat and ash content as the substitution rate (0 to 40%) increases. These contents vary respectively from 8.83% (FW) to 17.56% (F4), 1.80% (FW) to 12.52% (F4) and 0.66% (FW) to 1.70% (F4). An increase in fiber content and energy value is also observed as the rate of substitution increases. These values oscillate respectively between 2.03% (FW) and 3.46 (F4), 365.55 Kcal / 100g (FW) and 419.95 Kcal / 100g (F4). As for the pH, it increases slightly and varies from 5.64% (FW) to 6.10% (F4). However, no significant difference ($p > 0.05$) was observed between formulation F1 and F3. However, between F4 and the other formulations, the difference observed is significant ($p < 0.05$).

However, substitution with cashew nut flour resulted in a decrease in moisture content (12.22% to 8.92%) and total carbohydrates (76.50% to 59.26%). The F1 Formulation obtained the highest values while F4 formulation, the lowest levels. However, our results showed a significant difference ($p < 0.05$) between composite flours and cashew nut flour on the one hand and between these flours and wheat flour on the other hand.

3.2 Mineral composition of the different flours

The mineral contents of defatted almond cashew flour (DCF) are higher than those of wheat flour (Table 4). Magnesium, potassium and calcium have high levels. These minerals vary respectively from 62.20 mg / 100g (FW) to 232.40 mg / 100g

(DCF), 96.93 mg / 100g (FW) to 181.15 mg / 100g (DCF), and 15.20 mg / 100g (FW) to 74.87 mg / 100g (DCF). With regard to the formulations, our results showed that substituting wheat flour by cashew nut flour improved the mineral content of composite flours in proportion to the rate of substitution of cashew nut. The magnesium values go from 62.20 mg / 100g (FW) to 140.00 mg / 100g (F4), potassium from 96.93 mg / 100g (FW) to 132.44 mg / 100g (F4) and the calcium from 15.20 mg / 100g (FW) to 30.84 mg / 100g (F4). Those of iron and zinc vary respectively from 0.33 mg / 100g (FW) to 2.75 mg / 100g (F4) and ND (FW) to 0.54 mg / 100g (F4). Formulation F4 had the highest mineral contents while formulation F1, the weakest. The analysis of variance of the results shows a significant difference ($p < 0.05$) in all the flours.

3.3 Functional properties of the different flours

Table 5 shows the functional properties of wheat flour, defatted cashew kernel and composite wheat / defatted cashew kernel flour. The present study demonstrated that the water (WAC) and oil (OAC) absorption capacities as well as the water solubility index (WSI) of composite flours increase with the substitution rate while the ratio H/L and density (D) decrease. The analysis of variance of these parameters showed the existence of a significant difference ($p < 0.05$) between the composite flours. The water and oil absorption capacities vary respectively from 112.22% (F1) to 125.20% (F4) and from 94.67% (F1) to 109.65% (F4). However, between formulation F1 (116.80%) and F2 (117.85%), no difference ($p > 0.05$) was observed for the WAC. In this regard, the density and the H / L ratio are higher in the F1 and F2 formulations with respectively 0.72% and 1.18%, while they are low in the F4 formulation. Despite the difference in these values, the statistical analysis shows no significant variation ($p > 0.05$) between F1 (1.18%), F2 (1.18%) and F3 (1.16%) for the ratio H / L and between F1 (0.72%) and F2 (0.72%) for density. In the analysis of the results, it arises the existence of a significant difference ($p < 0.05$) between wheat flour, cashew kernel flour and composite flour (Table 5).

3.4 Sensory evaluations of control and composite breads

The results of the descriptive tests of the control and composite breads in Figure 2 show that the control bread (100% wheat) obtained the highest scores compared to the composite breads (10 - 40%) in the flavor (8.3), the texture (8.4), the aroma (8.7), the color of the crumb (8.7), the presence of cell (8.1) and the thickness of the crust (8.3). However, he had the lowest score (3.2) for the color of the crust. Moreover, when comparing the composite breads between them, the results indicate that loaves with 10% (P1) and 20% (P2) of cashew flour scored highest (>5) in all sensory attributes studied except the color of the crust. Only the bread with 10% of cashew flour had a grade (4.4) below 5. For the general acceptability of the loaves, the results show that the substitution leads to significant ($p < 0.05$) decrease in general acceptability of breads with the increase of the rate of incorporation of the cashew nut flour. However, despite this decrease, bread (P2) substituted up to 20% cashew is appreciated with a score of 7.18 (Table 6).

TABLE 3
PHYSICO-CHEMICAL COMPOSITION OF THE DIFFERENT FLOURS

Different formulations of flour made from wheat and defatted cashew kernel						
Parameters	**WF**	**DCF**	**F1**	**F2**	**F3**	**F4**
Moisture (%)	12,22±2,05[a]	4,2±0,28[f]	11,53±3,02[b]	10,75±2,85[c]	10, 36±3,11[d]	8,98±1,03[e]
Fats (%)	1,80±0,21[f]	25,50±6,01[a]	3,94±0,11[e]	7,06±0,15[d]	10,03±1,47[c]	12,52±3,65[b]
Proteins (%)	8,83±3,32[f]	28,03±2,15[a]	10,71±0,81[e]	13,73±0,42[d]	14,94±0,34[c]	17,56±1,34[b]
Carbohydrates (%)	76,50±5,03[a]	38,55±4,22[f]	73,02±7,01[b]	67,31±2,51[c]	63,32±4,62[d]	59,26±2,84[e]
Ash (%)	0,66±1,51[f]	3,67±0,43[a]	0,80±1,68[e]	1,11±0,51[d]	1,32±0,02[c]	1,70±0,22[b]
pH	5,64±1,01[d]	6,22±2,11[a]	6,04±0,11[c]	6,05±1,15[c]	6,05±0,21[c]	6,10±0,25[b]
Crude fiber(%)	2,03±0,13[d]	6,67±0,60[a]	2,17±0,22[d]	2,82±0,32[c]	3,04±0,11[c]	3,46±0,12[b]
Energy (Kcal/100g)	365,55±3,76[f]	496,16±5,52[a]	370,37±3,82[e]	387,96±4,10[d]	403,40±4,62[c]	419,95±7,06[b]

The values are the means ± standard deviation of three measurements (n= 3). The values carrying the same letters in the line are not significantly different at the 5% threshold according to the Newman-Keuls test.

WF: wheat flour; DCF: defatted cashew kernel flour; F1: 90% wheat flour + 10% defatted cashew kernel flour; F2: 80% wheat flour + 20% defatted cashew kernel flour; F3: 70% wheat flour + 30% defatted cashew kernel flour; F4: 60% wheat flour + 40% defatted cashew kernel flour

TABLE 4
MINERAL COMPOSITION OF THE DIFFERENT FLOURS (mg / 100g)

Different formulations of flour made from wheat and defatted cashew kernel						
Parameters	**WF**	**DCF**	**F1**	**F2**	**F3**	**F4**
K	96,93±0,20[f]	181,15±0,40[a]	98,33±0,42[e]	107,04±0,15[d]	118,96±0,1[c]	132,44±0,50[b]
Zn	ND	1,87±0,04[a]	ND	0,08±0,31[d]	0,30±0,02[c]	0,54±0,01[b]
Ca	15,20±0,45[e]	74,87±0,11[a]	15,87±0,26[e]	20,41±0,54[d]	24,73±0,30[c]	30,84±1,13[b]
Fe	0,33±0,05[f]	6,57±0,10[a]	0,86±0,01[e]	1,34±0,06[d]	2,20±0,01[c]	2,75±0,02[b]
Mg	62,20±0,60[f]	232,40±0,17[a]	78,66±0,01[e]	97,63±0,75[d]	120,61±0,55[c]	140,00±0,23[b]

The values are the means ± standard deviation of three measurements (n= 3). The values carrying the same letters in the line are not significantly different at the 5% threshold according to the Newman-Keuls test.
WF: wheat flour; DCF: defatted cashew kernel flour; F1: 90% wheat flour + 10% defatted cashew kernel flour; F2: 80% wheat flour + 20% defatted cashew kernel flour; F3: 70% wheat flour + 30% defatted cashew kernel flour; F4: 60% wheat flour + 40% defatted cashew kernel flour. ND: non déterminé

TABLE 5
FUNCTIONAL PROPERTIES OF THE DIFFERENT FLOURS

Different formulations of flour made from wheat and defatted cashew kernel						
Parameters	**WF**	**DCF**	**F1**	**F2**	**F3**	**F4**
WAC(%)	109,31±0,76[e]	144,03±0,35[a]	112,22±0,2[d]	116,80±0,94[c]	117,85±0,34[c]	125,20±0,71[b]
WSI(%)	22,35±0,36[e]	36,95±0,06[a]	22,05±0,07[e]	23,20±0,18[d]	24,80±0,01[c]	26,60±0,20[b]
OAC (%)	89,67±1,15[f]	125,67±1,15[a]	94,67±0,57[e]	98,33±0,57[d]	101,33±1,15[c]	109,65±0,6[b]
LHR (%)	1,22±0,01[a]	1,14±0,01[c]	1,18±0,06[b]	1,18±0,11[b]	1,16±0,10[b]	1,13±0,01[c]
D (g/mL)	0,72±0,02[a]	0,50±0,22[d]	0,72±0,05[a]	0,72±0,11[a]	0,70±0,42[b]	0,63±0,15[c]

The values are the means ± standard deviation of three measurements (n= 3). The values carrying the same letters in the line are not significantly different at the 5% threshold according to the Newman-Keuls test.
WF: wheat flour; DCF: defatted cashew kernel flour; F1: 90% wheat flour + 10% defatted cashew kernel flour; F2: 80% wheat flour + 20% defatted cashew kernel flour; F3: 70% wheat flour + 30% defatted cashew kernel flour; F4: 60% wheat flour + 40% defatted cashew kernel flour; WAC: water absorption capacity; WSI: water solubility index; OAC: oïl absorption capacity; LHR: lipophilic hydrophilic ratio; D: density

TABLE 6
GENERAL ACCEPTABILITY OF COMPOSITE BREADS MADE FROM WHEAT/DEFATTED CASHEW KERNEL

Composite breads					
Parameters	**PW**	**P1**	**P2**	**P3**	**P4**
GENERAL ACCEPTABILITY	8,26±0,63[a]	7,53±0,95[b]	7,18±0,80[c]	5,41±0,90[d]	4,56±1,18[e]

The numbers with different letters are statistically different at p <0.05

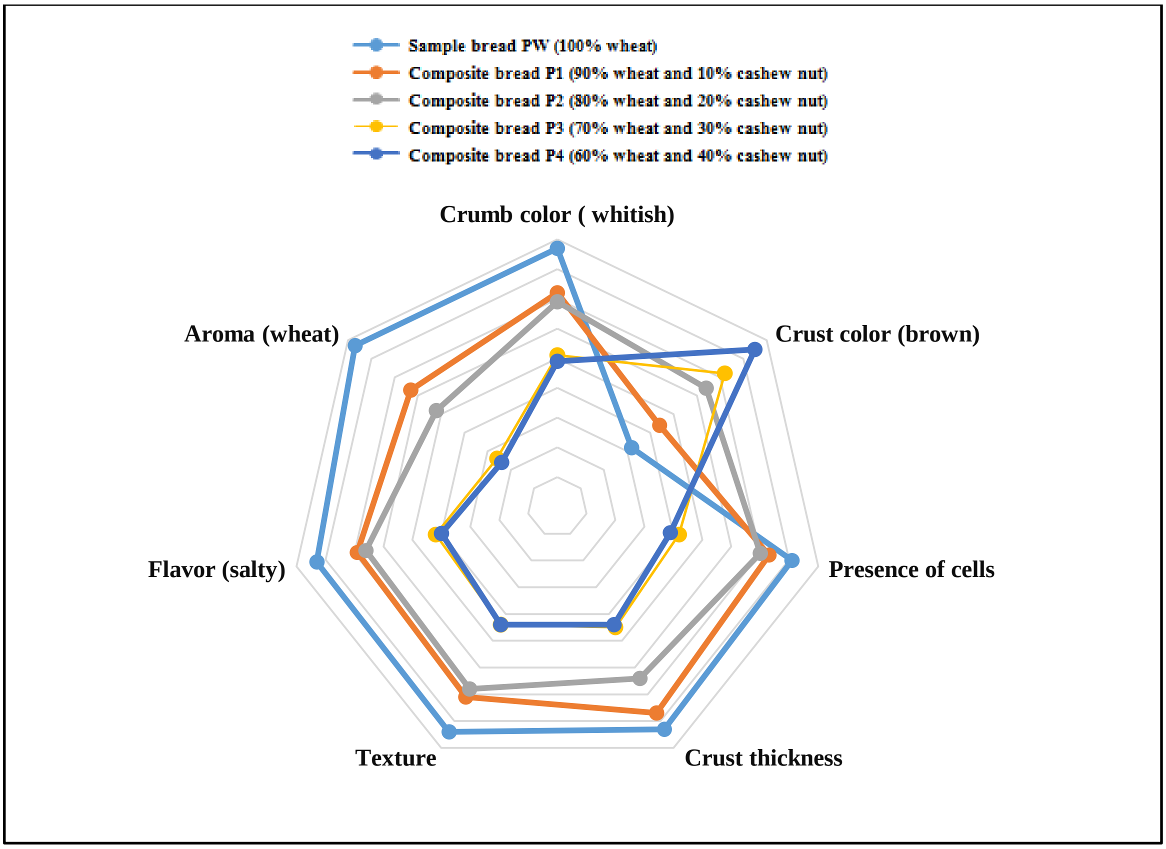

FIGURE 2: SENSORY PROFILES OF COMPOSITE BREADS MADE FROM WHEAT / DEFATTED CASHEW KERNEL

IV. DISCUSSION

The physicochemical analysis showed that defatted cashew kernel flour contains significantly higher ($p < 0.05$) protein, lipid, fiber and ash contents compared to wheat flour. This finding was also reported by Diallo et al. (2015), in a study where they compared wheat flour to groundnut flour. The difference between the chemical components would be due to varietal difference. The high nutrient content of the cashew nut will make this food an excellent naturally available supplement for foods that are deficient.

The substitution of wheat flour by the defatted cashew kernel flour has led to an increase in the protein, fat, fiber, ash and energy value of the composite flours as the substitution rate increases, while water and carbohydrates contents decreased. The increase in the protein content of composite flours could be attributed to defatted cashew kernel flour, which is high in protein (Emelike et al., 2015). The same observation was made by Ojinnaka and Agubolum (2013), in a study in which they incorporated the cashew nut flour into wheat flour when making biscuits. Igbabul et al. (2014) reported similar results with bread made from wheat, plantain and soy. Indeed, the protein content is an essential element in determining the rheological behavior of the dough and later the quality of bread (Goesaert et al., 2005). The protein contents (10.71% to 17.56%) of our formulations are appreciable since they remain in the acceptable range of 10.5 to 14% which are the recommended values for a bread flour (Keran et al. 2009).

The improvement in the lipid content of the mixtures is comparable to the finding of Méité et al. (2008) and Olaoye et al. (2006). They showed that the substitution of wheat flour by *Citrullus lanatus* seed and soya bean flours, respectively, increased the lipid content of composite breads. This increase is probably attributed to the high lipid content of cashew nut flour. However, despite this increase, the lipid content of the formulations remained within the recommended values (10-25%) (FAO / WHO, 1991). This content may contribute to prolonging the life of composite flours while reducing the chances of rancidity due to release of free fatty acids during storage (Kaced et al., 1984).

In contrast to the lipid and protein content, carbohydrates contents decreased significantly ($p < 0.05$) with the substitution rate. Similar trends have been reported by Serrem et al. (2011), in the fortification of wheat flour with defatted soy flour. This decrease is due to cashew nut flour which is almost twice as rich in protein and fat as wheat flour. Despite this decline, the values (73.02% - 59.20%) of this study are moderate and are close to the recommended value (68%) (FAO / WHO, 2006). In addition, the use of these composite flours are of paramount importance in reducing the risk of diabetes thanks to their low glycemic index (Ugwuona et al., 2012).

With regard to the water content of the samples analyzed (8.98% - 11.53%), it complies with the standard required for the storage of flours which is 10 to 15% (Borget, 1989). Similar results were reported by Yetunde and Chiemela (2015) and Diallo et al. (2015), during the substitution of wheat flour by yam and vanilla flour, respectively. Indeed, water content is a quality criterion and an important indicator for the shelf life of the flour (Aryee et al., 2005). Low water contents allow long-term storage by inhibiting the proliferation of microorganisms that can alter the product (Ntuli et al., 2013).

The increase in the fiber and ash content of composite flours can be explained by the incorporation of cashew flour rich in fiber and ash. The increase in fiber content will be beneficial to the health of consumers by facilitating the digestion of food at the colon. This action reduces the risk of constipation associated with the consumption of wheat flour dishes (Elleuch et al., 2011. According to the literature, the fiber also plays a significant role in the prevention of cardiovascular disease, cancer and diabetes (Slavin, 2005). The fiber (2.17 to 3.46%) and ash (0.8 to 1.70%) contents of the formulations are in accordance with the recommended values which are less than 5% for the fibers and less than 3% for ashes (FAO / WHO, 1991).The use of flours as food ingredients depends mainly on their interaction with oil and water.In our study, water absorption capacity (WAC) and oïl absorption capacity (OAC) increase with the rate of substitution. This evolution is similar to that observed by Diallo et al. (2015) during the substitution of wheat flour by voandzou flour. The observed variation in water uptake may be due to differences in protein content, degree of interaction with water, and conformational characteristics (Butt and Batool, 2010). Indeed, it is the polar amino acids of the proteins that have favored this increase. The same observations were made by Brou et al. (2013). The water absorption capacity is of paramount importance in the quality, texture and taste of various foods, including cold cuts and bakery pastes (Singh et al., 2010). Thus, the higher the wac of the flour, the better it is for making bread.

A high WAC allows more water addition to the dough, improving handling and keeping freshness of the bread. The oïl adsorption capacity (OAC) of food flours is important in the food industry because oil is absorbed through a complex process of capillarity. The capacity of a food component to trap oil is an important characteristic in food formulations as it would act as a flavor and mouthfeel enhancer (Yadahally et al., 2012). The evolution of the oil absorption capacity of formulations has been also reported by Diallo et al. (2015) in a study on wheat / voandzou bread. As far as the density of composite flours is concerned, it decreases with the increase in the substitution rate. This is advantageous if one takes into account the work of Giami (1993) who has shown that a reduction in the density of flours promotes a good formulation of infant foods. Akubor and Badifu (2004) also observed a decrease in density during the incorporation of *Treculia africana* flour into wheat flour.

The mineral contents of the composite flours had higher values than that of the wheat flour. This is due to the incorporation of cashew flour into wheat flour. These results agree with those of Ameh et al. (2013), in a study in which rice flour was incorporated into wheat flour to make bread. The presence of these minerals in composite flours is very beneficial because they play a role in the building of the body and in the growth of the child. In addition, these minerals could reduce the occurrence of certain nutritional deficiencies. Thus, Langford (1983) has shown that a high intake of potassium protects against the increase of blood pressure and other cardiovascular risks. It also plays an essential role in the synthesis of amino acids and proteins (Malik and Srivastava, 1982). As for magnesium, it participates in biochemical reactions in the body, helping to maintain the normal state of the muscles, fortifying the functioning of the nerve, maintaining the regular heart rate and regulating blood sugar levels (Saris et al., 2000).

Sensory analysis is an important criterion for assessing quality in the development of new products and for meeting consumer requirements. The decrease in the general acceptability of composite breads in this study was reported in another study on wheat / yam composite bread by Amandikwa et al. (2015). Ojinnaka and Agubolum (2013) reported similar results. This decrease could be attributed to the too strong flavor and aroma of the cashew nut, which was not appreciated by the panelists. Added to this is the Maillard reaction, but also the cooking time and temperature which are responsible for the strong coloration of the poorly accepted crust. Despite this decline in acceptability, bread made from 20% cashew flour was appreciated by the jury for its texture, flavor, aroma and color.

V. CONCLUSION

The partial substitution of wheat flour with cashew flour considerably improves the physicochemical and biochemical composition of flours, especially protein, ash, fiber and energy, as well as functional properties. The values obtained show that these flours can be used in breadmaking. Sensory analysis carried out in this study showed that the defatted cashew kernel flour could be incorporated up to a level of 20% in the wheat flour without greatly influencing the organoleptic characteristics of the breads. Even if the bread made from 100% wheat is the most popular, the bread supplemented with up to 20% cashew kernel nut was also moderately appreciated. With the current cost of wheat, it would be beneficial to seriously explore the possibility of using wheat / cashew composite flour for bread production. This will reduce the cost of importing this cereal, add value to the cashew nut and ultimately combat nutritional deficiencies.

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