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EFFECTS OF PROCESSING METHODS ON THE FUNCTIONAL PROPERTIES AND MINERAL COMPOSITION OF CASHEW KERNEL FLOUR
EFEKTI METODA PRERADE NA FUNKCIONALNA SVOJSTVA I MINERALNI SASTAV BRAŠNA OD ZRNA INDIJSKOG ORAHA

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ABSTRACT

This research determined the effects of processing methods on the functional properties and mineral composition of cashew kernel flour. Three varieties of cashew nut were processed to flour using three methods. The oven-dried, hot oil bathed and roasted cashew nuts were cracked using a wooden mallet to obtain whole cashew kernel. The covering testa was removed by hand and winnowed to obtain whole cashew nuts. The samples were then milled separately using a manually operated attrition mill machine and sieved through a 200 µm aperture mesh screen to obtain flours with uniform particle sizes. The processed samples of flour were taken to the laboratory where functional properties and mineral composition were determined. The result showed that the functional properties of cashew flour processed with a hot oil bath, oven-dried, and roasted varied significantly at (p>0.05). Foaming capacity, emulsification capacity and foaming stability for a hot oil bath, oven-dried and roasted samples respectively were found to be higher in the roasted samples. Water absorption capacity and oil absorption capacity for a hot oil bath, oven-dried and roasted were found to be higher in hot oil bath samples. Swelling capacity and solubility for a hot oil bath, oven-dried and roasted samples respectively, were observed to be higher in oven-dried samples. The mineral composition of cashew flour samples processed using a hot oil bath, oven-dried and roasting were varied significantly at (p>0.05) across the varieties and processing methods. Phosphorus, Ca, Mg, K, Mn, Cu, Zn for hot oil bath, Oven-dried and roasted samples respectively, were significant in hot oil bath samples while Na and iron for hot oil bath, Oven-dried and roasted samples respectively were dominant in oven-dried flour samples. Generally, it was observed that the processing methods adopted significantly influenced mineral and functional properties of cashew kernel flour at (p>0.05). The cashew kernel flour displayed good characteristics of functional and mineral properties. Therefore, flour can serve as a functional ingredient in the formulation of snack products as an alternative to legumes/wheat flour.

Keywords: *cashew kernel flour, functional properties, mineral composition, processing methods*

REZIME

Ovim istraživanjem utvrđeni su uticaji metoda prerade na funkcionalna svojstva i mineralni sastav brašna zrna indijskog oraha. Tri vrste indijskog oraha prerađene su u brašno pomoću tri metode. Osušeni u pećnici, prženi vrelim uljem i pečeni indijski oraščići izlupani drvenim čekićem da bi se dobilo celo jezgro indijskog oraščića. Uzorci su mleveni odvojeno pomoću mašine za mlevenje sa ručnom rukovanjem i prosejani kroz sito sa otvorom od 200 mm da bi se dobilo brašno ujednačene veličine čestica spremno za analize. Rezultat je pokazao da su funkcionalna svojstva brašna od indijskog oraha tretiranog vrelim uljem, sušenog i pečenog značajno varirala na (p>0,05). Kapacitet pene, kapacitet emulgovanja i stabilnost pene bili su najveći u prženim uzorcima. Kapacitet upijanja vode i kapacitet apsorpcije ulja pokazalo se da su najveći u uzorcima tretiranim vrelim uljem. Kapacitet bubrenja i rastvorljivost najveći su bili u uzorcima osušenim u pećnici. Mineralni sastav uzoraka brašna od indijskog oraha značajno je varirao (p>0,05) u različitim sortama i metodama prerade. Fosfor, Ca, Mg, K, Mn, Cu, Zn bili su značajno veći u uzorcima u prženim u ulju, dok su Na i Fe za dominant bili veći u uzorcima brašna sušenog u pećnici. Generalno, uočeno je da su usvojene metode prerade značajno uticale na mineralna i funkcionalna svojstva brašna zrna indijskog oraha (p>0,05). Brašno zrna indijskog oraha ima dobre karakteristike funkcionalnih i mineralnih svojstava. Stoga, brašno može poslužiti kao funkcionalni sastojak u formulaciji grickalica kao alternativa mahunarkama/pšeničnom brašnu.

Ključne reči: *brašno zrna indijskog oraha, funkcionalna svojstva, mineralni sastav, metode prerade*

INTRODUCTION

Cashew (*Anacardium occidental Linn*) belongs to the Anacardiaceae family and is an extremely hardy tree that grows on poor soil under various climate conditions (Adepoju *et al.,* 2019). Cashew nut (Anacardium Occidentale Linn) is one of the most important edible tree nuts of the world that comprises an outer shell (Epicarp), honeycombed structure (Mesocarp), inner shell (Endocarp), Testa and kernel (*Kilank et al., 2018*). The mesocarp contains a natural resin known as cashew nut shell liquid (CNSL) which is blister to human skin and the endocarp is hard and it protects the kernel from the natural resin (*Adepoju et al., 2019; Bambang, 2000*). It originated in Brazil and is extensively grown in India, East Africa and Vietnam (*Chaudhari et al., 2013*). Country Nigeria, is among the main producers of cashew nut in the world (*Honorato et al., 2007*). Economically, it is one of the most important plantation crops that have attracted a huge amount of foreign exchange through its kernel and cashew nut shell liquid. The production of cashew has gained economic growth for Africa as most of the nuts produced are exported to the United State of America, the Netherlands and European countries unprocessed (*Esrif and Halil, 2007*). Nutritionally nuts are healthy foods, its consumption reduces the risk of cardiovascular disease and diabetes (*Mukuddem-petersen et al., 2005*). It contains unsaturated fatty acids, fiber, minerals and proteins (*Heinig 2006; Chen et al., 2006; Ogunwolu et al., 2009; Nascimento et al., 2010*).

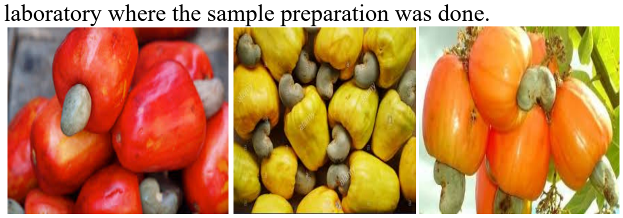
The recent trend in the supply of human nutrition is the consumption of functional food products that are not only enriched with basic nutrients but also help to limit certain diseases due to varied health-related problems associated with imported wheat flour consumption (*Ide et al., 2019 and Emelike et al., 2015*). The most apparent role is to provide the basis for dietary assessment and the formulation of healthier diets (*Ndife et al., 2014*). This situation has created the need for the consumption of low-carbohydrate diets, slowly digested starchy foods, and also increase the intake of functional foods (*Emelike et al., 2015 and Hurs and Martins, 2005*). Ready meals and food served in canteens are increasingly included in this approach considering their contribution to daily nutrition (*Anthony et al., 2018 and Ehimen et al., 2017).* For the general population, food-based dietary guidelines are considered the best means to convey more understandable recommendations for food choice (*Walter et al., 2016*). Nutrition and health claims have to be supported by sound scientific evidence, including data on the food's nutrient content (*Walter et al., 2016*). The latter is even more important when one or a group of specific nutrients have to be avoided or controlled for a pathological reason (*Walter et al., 2016; Cemaluk et al., 2014 and Owuka, 2005*). Therapeutic nutrition may require additional data that are not widely available (*Walter et al., 2016*).

Functional properties of food products such as swelling index, solubility, oil and water absorption capacity, gelation, emulsification, bulk density, foaming capacity are the food parameters that measure food application and its end use (*Ide et al., 2019*). They usually show the materials under test will respond to other food components either directly or indirectly affecting food quality, processing applications and ultimate acceptance. (*Ide et al., 2019 and Ehimen et al., 2017*). This study narrowed its interest to some functional properties like swelling index, solubility, bulk density, foaming capacity, oil and water absorption capacity, and emulsification and gelatinization capacity (*Ide et al., 2019 and Ugwuanyi Nnadi et al., 2020*). Food mineral compositions such as calcium, magnesium, potassium, sodium, manganese, iron, copper, zinc are of great importance for scientists and practitioners working in the fields of nutrition and public health (*Chinedu et al., 2017 and Walter et al., 2016). Some* authors (Amusa *et al.,* 2012; Rahman *et al.,* 2016; Adebowale and Leal, 2003; Afoakwa *et al.,* 2001; Ide *et al.,* 2019, Ugwunyi-Nnad *et al.,* 2019; Kiin-Kabari and Giami, 2015; Hussain *et al.,* 2008; Amandikwa *et al.,* 2015; Asif-Ul *et al.,* 2014; Olualana *et al.,* 2011; Adeleke and Odedeji, 2010; Supaluk *et al.,* 2017; Anthony *et al.,* 2014; Toyin, 2001; Akpata and Miachi, 2001; Akpata and Miachi,2001; Nwosu, 2011; Iwe *et al.,* 2016; Owuamana *et al.,* 2016) reported on functional properties and mineral compositions of different food products. This research focused on the effects of processing methods on functional properties and mineral compositions of cashew varieties kernel flour which will aid the provision of required human nutrients and also enhance the development of new food products. The concern in processing cashew nuts is to shell them and extract the kernel 'whole' nut without cracking or damaging them, to improve its palatability and reduce toxicity, to develop new food products and finally to extend their shelf life and storability.

Therefore, the aim of this research determined the functional properties and mineral compositions of processed cashew flour varieties for enhancement of the cashew flour qualities and the development of new bio-products.

MATERIALS AND METHODS.

The matured red, yellow and light-red cashew apple fruits with nuts were harvested early in the morning from a well-managed cashew plantation located at Umulumgbe, in Udi Local Government Area of Enugu State, Nigeria in early April 2021. The separated nuts from the apple were properly cleaned to remove unwanted materials. The cleaned nuts were stored at a temperature of 4˚C for 12 hours until they were moved to a laboratory where the sample preparation was done.



a) b) c)

Fig. 1. Showing pictorial representative of cashew apple and nuts varieties studied.
a) Red Cashew Variety, b) Yellow Cashew Variety, c) Light-red Cashew Variety

Three kilograms (3kg) of cashew nut samples were collected and then sundried at 50 -70^{0}C drying temperature for two days to prevent deterioration during storage. They were conditioned (mild spraying with water in a sieve) to increase flexibility and prevent scorching during the roasting process. They were then divided into three batches of 900g each. The batches were introduced to different processing methods (roasting, oven drying and hot oil bating) using the methods reported by *Emelike and Ebere, (2015) and Emelike et al., (2017)* on the physiochemical properties of defatted and Undefatted Cashew flour. The cashew nuts were poured out after 1 minute and allowed to cool for 1 hour and the brittle shell was broken with a wooden mallet and the kernel extracted. The testa on the cashew kernel was removed and thereafter milled into flour using a locally fabricated disc attrition mill with Gx200, Nigeria and sieved with American Standard Sieve with 435 ppm aperture to obtain fine flour. The processed flour was packaged in an airtight plastic container with proper labeling and then moved to the laboratory where mineral composition and functional properties were carried out. All reagents used were of analytical grade and obtained from the Department of Agricultural and Bioresource Engineering, in the Bioprocess Laboratory, Enugu State University of Science and Technology, Enugu State, Nigeria.

The functional properties such as the swelling index, water absorption capacity, oil absorption capacity, foam stability and capacity, solubility and emulsion capacities were all determined using the methods described by *Ide et al., (2019); Hannington et al.,(2020); Mora et al., (2013) and Ugwuanyi-Nnadi et al., (2020).*

The mineral compositions of cashew kernel flour such as Calcium, sodium, potassium, magnesium and iron were determined according to the method of *Ogbuji et al., (2017) and Dogo et al., (2018).*

The experiment was carried out in a completely random design. The results obtained were submitted to analysis of variance (ANOVA), with the means compared by Duncan's test at 5% of significance. All results were expressed as the mean value standard error (SE). Statistical analyses were performed using SPSS for Windows 8.0.

RESULTS AND DISCUSSION

The result of the mineral composition of hot oil bath, oven-dried and roasted cashew sample flour was presented in table 1. The phosphorus was found to be more pronounced in the samples (HOCS, HRCS and HYCS) processed with a hot oil bath at

0.72%, 0.69% and 0.68% respectively than in samples (OOCS, ORCS and OYCS) processed with oven dry method with their values which ranged from 0.65%, 0.32% and 0.26%.

Table.1. Effect of Processing Method on Mineral Composition of Cashew Nut Varieties.

Properties	HOCS	HRCS	HYCS	OOCS	ORCS	OYCS	ROCS	RRCS	RYCS
P (%)	0.72 (0.01)	0.69 (0.01)	0.68 (1.52)	0.65 (0.21)	0.32 (1.11)	0.29 (1.20)	0.26 (0.45)	0.25 (1.23)	0.30 (0.29)
Ca (%)	0.30 (0.07)	0.37 (1.23)	0.39 (2.72)	0.30 (0.55)	0.09 (0.20)	0.12 (1.24)	0.09 (1.31)	0.12 (5.01)	0.09 (3.00)
Mg (%)	0.23 (0.12)	0.26 (0.83)	0.25 (1.12)	0.23 (0.32)	0.03 (0.44)	0.03 (2.93)	0.03 (1.12)	0.02 (011)	0.02 (2.03)
K(%)	0.66 (0.15)	0.68 (1.03)	0.68 (5.64)	0.64 (4.42)	0.17 (1.72)	0.12 (6.82)	0.08 (2.45)	0.10 (0.91)	0.16 (1.23)
Na (ppm)	34.54 (0.93)	28.22 (3.40)	37.41 (0.92)	28.17 (2.91)	34.75 (0.12)	44.07 (4.91)	31.26 (1.63)	28.22 (0.09)	40.72 (1.03)
Mn (ppm)	17.66 (0.93)	26.30 (1.18)	24.37 (2.04)	21.07 (0.42)	12.57 (1.90)	20.24 ()0.88	11.59 (1.03)	9.92 (2.04)	5.62 (1.32)
Fe (ppm)	86.40 (2.30)	83.91 (2.01)	82.02 (0.29)	89.97 (0.63)	131.66 (2.01)	52.00 (1.19)	62.70 (0.57)	42.37 ()1.02	117.53 (1.99)
Cu (ppm)	22.63 (0.93)	25.04 (3.93)	24.84 (2.03)	22.59 (0.67)	4.00 (2.03)	5.61 (1.82)	5.59 (0.71)	7.25 (2.03)	4.78 (3.01)
Zn (ppm)	141.29 (2.09)	139.45 (0.45)	141.10 (0.83)	136.42 (2.06)	26.52 (1.34)	33.75 (2.93)	36.34 (1.06)	49.89 (3.04)	6.64 (1.62)

Note: RRCS=Roasted red cashew sample, HRCS=Hot oil bath red cashew sample, ORCS=Oven dried red cashew sample, RYCS=Roasted yellow cashew sample, HYCS=Hot oil bath yellow cashew sample, OYCS=Oven dried yellow cashew sample, ROCS= Roasted Light-red cashew sample, HOCS= Hot oil bath cashew sample, OOCS=Oven dried Light-red cashew sample. The values in brackets represent the standard deviation of the replicated treatments.

The sample that recorded the lowest values of phosphorus was roasted cashew flour with values that ranged from 0.26%, 0.25% and 0.30% for ROCS, RRCS and RYCS respectively. This report is significantly lower than the report of *Emelike et al., (2015)* on the mineral composition of defatted and raw cashew flour. The values are not enough to contribute significantly to the Nigerian diet and thus mitigate the prevalent micronutrient deficiency disease. Calcium (Ca) showed a better result in samples prepared with a hot oil bath at 0.30% for HOCS, 0.37% for HRCS and 0.39 for HYCS than in Oven-dried sample with values of 0.30%, 0.09% and 0.12% for OOCS, ORCS and OYCS while the least values of Ca was found in ROCS (0.09%), RRCS (0.12%) and RYCS(0.09). The Ca content of this study completely disagreed with *Aremu et al., (2006) and Omosuli et al., (2009)* on the mineral composition of cashew flour. Calcium which is responsible for bone formation in conjunction with phosphorus was statistically lower to compare the required nutritional approved calcium consumption of an individual per diet.

The magnesium content of the processed cashew flour samples was 0.23%, 0.26% and 0.25% for HOCS, HRCS and HYCS. The oven-dried sample showed lower values (0.23%, 0.03% and 0.03) to compare with hot oil bath samples while roasted samples were found to be lowest with 0.03%, 0.02% and 0.02% for Light-red, red and yellow cashew flour. The magnesium content was found to be more dominant in hot oil bath samples than in oven and roasted samples. It is, therefore, concluded that when the magnesium content of cashew flour under this treatment is concerned, the hot oil bath method is preferred over others. Potassium (k) was found to be higher with values ranging from 0.66%, 0.68% and 0.68% for HOCS, HRCS and HYCS respectively. Oven-dried samples had values of 0.64%, 0.17% and 0.12% for Light-red, red and yellow cashew varieties while roasted samples recorded the lowest values (0.08%, 0.10% and 0.16%) for Light-red, red and yellow cashew varieties. It is known that potassium is the most important mineral in the human body as it helps to regulate fluid balance, muscle contractions and nerve signals. It also helps to reduce blood pressure and water retention, protect against stroke and prevent osteoporosis and kidney stones in the human body (*Ephraim et al., 2020).* The sodium content of the processed cashew sample flour was 34.54 ppm, 28.22 ppm, 37.41 ppm, 28.17 ppm, 34.75 ppm, 44.07 ppm, 31.26 ppm, 28.22 ppm and 40.72 ppm for HOCS, HRCS, HYCS, OOCS, ORCS, OYCS, ROCS, RRCS and RYCS respectively. Sodium was found to be dominant in oven-dried samples (28.17ppm, 34.75ppm, 44.07ppm) but there is no significant difference at ($p>0.05$) in hot oil bath and roasted samples. Above all, the study showed that the cashew flour varieties investigated recorded low sodium content compared to the Recommended Daily Allowance of 70 mg/100 g (*Ephraim et al., 2020).* It is therefore recommended that among the pretreatment, the oven-dried samples should be adopted when the sodium content is paramount. Manganese content for HOCS, HRCS and HYCS were 17.66ppm, 26.30ppm and 24.37ppm. Oven-dried samples had manganese content as 21.07ppm, 12.57ppm and 20.24ppm for Light-red, red and yellow cashew varieties while 11.59ppm, 9.92ppm and 5.62ppm was found in ROCS, RRCS and RYCS respectively. Manganese contributes to the proper functioning of the body, including the metabolism of amino acids, cholesterol, glucose and carbohydrates. It also plays a role in bone formation, blood clotting and reduces inflammations. Based on this reveal, it is recommended that the hot oil bath method is the best. Iron content was 86.40ppm, 83.9ppm and 82.02ppm for HOCS, HRCS and HYCS. Oven dries samples had 89.97ppm, 131.66ppm and 52.0ppm for OOCS, ORCS and OYCS whiles roasted samples recorded 62.70ppm, 42.37ppm and 117.53ppm for ROCS, RRCS and RYCS respectively. The highest value of iron was found ORCS (131.66PPM) followed by RYCS (117.53PPM) while the lowest value (42.37ppm) was found in RRCS. From this result, oven-dried cashew sample flour should adopt when the iron content of cashew flour is concerned. Iron content in food flour is required for proper growth and development of the human body and it also helps to preserve some vital functioning in the body. The copper content of hot oil processed sample cashew flour was 22.63ppm, 25.04ppm and 24.84ppm for Light-red, red and yellow cashew varieties respectively. The lowest value (5.59ppm, 7.25ppm and 4.78ppm) was found in the roasted sample followed by the oven-dried sample which recorded 22.59ppm, 4.00ppm and 5.16ppm for Light-red, red and yellow cashew varieties respectively. Among all the processing methods adopted, the hot oil bath had the highest values (22.63ppm, 25.04ppm, 24.84). Copper is an essential nutrient for the as it enables the body to form red blood cell and help to maintain health bones, blood vessels, nerves, iron absorption and immune functioning (Ephraim *et al.,* 2020). The zinc content of the processed cashew flour ranged from 141.29ppm, 139.45ppm, 141.10ppm, 136.42ppm, 26.52ppm, 33.75ppm, 36.34ppm, 49.89ppm and 6.64ppm for HOCS, HRCS, HYCS, OOCS, ORCS, OYCS, ROCS, RRCS and RYCS respectively. The values (141.29ppm, 139.45ppm, 141.10ppm) of zinc content in the hot oil bath processed cashew flour varied significantly at ($p>0.05$) compare to the oven (136.42ppm, 26.52ppm, 33.75ppm) and roasted (36.34ppm, 49.89ppm, 6.64ppm) samples. Zinc is essential for cell growth and division, immune function, enzyme reactions, DNA synthesis and protein production in the human body (*Ephraim et al., 2020*).

The functional properties of cashew flour processed using three different methods were presented in table 2.

Table.2. Effect of processing method on functional properties of cashew nut varieties.

Properties	HOCS	HRCS	HYCS	OOCS	ORCS	OYCS	ROCS	RRCS	RYCS
Foaming capacity	2.00 (0.02)	2.30 (0.02)	2.00 (1.00)	2.00 (0.30)	3.00 (0.31)	2.00 (0.94)	8.00 (1.03)	6.00 (1.21)	4.00 (4.02)
Foaming Stability	1.00 (0.82)	1.50 (4.02)	2.00 (2.22)	1.00 (2.04)	1.00 (1.03)	2.00 (0.34)	1.00 (2.01)	2.00 (0.23)	4.00 (0.34)
Water absorption capacity	92.54 (2.11)	172.32 (0.43)	116.42 (1.02)	35.57 (1.95)	137.32 (2.03)	80.92 (0.31)	110.11 (0.31)	74.85 (0.34)	58.60 (0.45)
Oil absorption capacity	88.55 (0.21)	85.80 (0.23)	73.64 (0.43)	70.16 (3.03)	67.82 (2.00)	63.34 (0.32)	75.42 (3.02)	68.83 (3.05)	67.56 (0.21)
Swelling power	7.89 (0.23)	10.98 (2.03)	7.02 (0.43)	8.21 (0.23)	8.35 (2.01)	11.00 (1.22)	7.58 (0.32)	6.95 (1.03)	9.28 (1.91)
Solubility index (%)	9.66 (0.32)	10.42 (1.90)	10.94 (1.03)	16.64 (1.32)	14.70 (0.48)	20.91 (0.33)	10.92 (0.31)	14.30 (0.21)	14.44 (3.02)
Emulsification capacity	2.50 (0.21)	2.50 (1.04)	2.00 (0.32)	1.50 (0.31)	2.00 (0.32)	2.50 (1.03)	2.00 (2.01)	2.50 (0.32)	4.50 (1.32)

Note: RRCS=Roasted red cashew sample, HRCS=Hot oil bath red cashew sample, ORCS=Oven dried red cashew sample, RYCS=Roasted yellow cashew sample, HYCS=Hot oil bath yellow cashew sample, OYCS=Oven dried yellow cashew sample, ROCS= Roasted Light-red cashew sample, HOCS= Hot oil bath cashew sample, OOCS=Oven dried Light-red cashew sample. The values in brackets represent the standard deviation of the replicated treatments.

The foaming capacity of the processed samples was 2.00%, 2.30% and 2.00% for hot oil bath samples. The roasted cashew which recorded the highest values of foaming capacity had 8.00%, 6.00% and 4.00% for ROCS, RRCS and RYCS respectively. These results were in disagreement with the report of Kasaye et al.. (2018) on yam flour and inversely related to the report of Hussain et al., (2008) who reported a decrease in roasted as compared to non-roasted flaxseed flours. The higher foaming capacity observed in roasted samples indicated the manifestation of an increase in the percentage of protein content in samples while the samples with low foaming capacity showed that the protein content in it has been denatured irreversibly (Kasaye et al., 2018). The oven-dried samples showed 2.00, 3.00 and 2.00 of foaming capacity for OOCS, ORCS and OYCS respectively. From the result presented above, it was observed that there was no significant difference between the hot oil bath and oven-dried sample at ($p>0.05$) confidence interval. The lowest values of foaming capacity found in hot oil bath and oven-dried samples may be attributed to the low protein content of the flour since foam ability is related to the amount of solubilized protein and the amount of polar and non-polar lipids in a sample (Kasaye et al., 2018).

The foaming stability of the processed flour samples varied from 1.00%, 1.50%, 2.00%, 1.00%, 1.00%, 2.00%. 1.00%, 2.00% and 4.00% for HOCS, HRCS, HYCS, OOCS, ORCS, OYCS, ROCS, RRCS and RYCS respectively. The highest values of foaming stability were observed for roasted flour (1.00%, 2.00%, 4.00%) followed by hot oil bath processed flour (1.00%, 1.50%, 2.00%) and the lowest was found in oven-dried (1.00%, 1.00%, 2.00%). These results were not in the range of the report of Suresh et al., (2015) on composite flour of biscuits. The foaming stability which is the ability of the protein to stabilize against gravitational and mechanical stresses (Suresh et al., (2015) was found to be more in the roasted cashew sample. Flour with high foaming ability could form large air bubbles surrounded by thinner less flexible protein film and the bubble might collapse easily consequently lowering the foaming stability (Jitingarmkusol et al., 2008).

Water absorption capacity (WAC) of the processed cashew flour samples for HOCS, HRCS, HYCS, OOCS, ORCS, OYCS, ROCS, RRCS and RYCS were 92.54%, 172.32%, 116.42%, 35.57%,137.32%, 80.92%, 110.11%, 74.85% and 58.60% respectively. The water absorption capacity was found to be highest in hot oil bath samples (92.54%, 172.32%,116.42%) followed by oven-dried samples (35.57%, 137.32%, 80.92%) while the lowest values were found in roasted cashew flour samples (110.11%, 74.85%, 58.60%) respectively. The lower WAC in roasted cashew flour may be due to less availability of polar amino acid in the flour samples while the higher values of WAC observed in a hot oil bath may be due to an increase in the amylose leaching and solubility and loss of starch crystalline structure (Suresh et al., 2015).

The oil absorption capacity (OAC) ranged from 88.55%, 85.80%, 73.64%, 70.16%, 67.82%, 63.34%, 75.42%, 68.83% and 67.56% for HOCS, HRCS, HYCS, OOCS, ORCS, OYCS, ROCS, RRCS and RYCS respectively. Hot oil bath flour samples had the highest values of oil absorption capacity (88.55%, 85.80%, 73.64%) followed by roasted samples (75.42%, 68.83%, 67.56%) while the lowest was found in oven-dried samples (70.16%, 67.82%, 63.34%) this could be due to the presence of large proportion of hydrophilic groups and polar amino acids on the surface of the protein molecules *(Daramola and Aina, 2007).* The highest values of OAC noticed in hot oil bath samples could be attributed to the variations in the presence of a non-polar side chain, which might bind the hydrocarbon side chain of the oil among the flours. The result of this experiment showed that processed flour is potentially useful in structural interaction in food especially in flavor retention, improvement of palatability and extension of shelf life, particularly in bakery or meet products where fat absorption is desired *(Suresh et al., 2015 and Aremu et al., 2007).*

Swelling capacity of different processed flours ranged from 7.89%, 10.98%, 7.02% for HOCS, HRCS, HYCS, 8.21%, 8.35%, 11.00% for OOCS, ORCS, OYCS, 7.58%, 6.95%, 9.28% for ROCS, RRCS, RYCS respectively. From table 1, it was clear that the lowest values of swelling capacity were found in roasted flour samples (7.58%, 6.95%, 9.28%) whereas the maximum values were found in oven-dried samples (8.21%,8.35%,11.00%). The value swelling capacity was found for hot oil bath samples (7.89%, 10.98%, 7.02%). Swelling capacity depends on the size of particles, types of variety and type of processing methods or unit operations. Therefore, oven dried method is perhaps adopted when the swelling capacity of cashew flour is concerned *(Ide et al., 2019).*

Solubility of the processed flour sample was 9.66%, 10.42% 10.94% for HOCS, HRCS, HYCS respectively. The highest values were found in oven-dried flour samples (16.64%, 14.70%, 20.91%) for OOCS, ORCS, OYCS respectively and this could be attributed to the fact that the samples with higher solubility index showed how sticky and adhesive the food products is *(Ehimen et al., 2017).* Hot oil bath sample flours which had the lowest values (9.66%, 10.42%, 10.94%) of solubility was due to the presence of protein and lipid in the flour as it reduces the solubility of the starch molecules *(Ide et al., 2019).* The roasted cashew flour samples had 10.92%, 14.30% and 14.44% for ROCS, RRCS and RYCS respectively. The findings showed that the processed flour samples had good solubility that can be adopted in binding and blending for food products.

Emulsification capacity(EC) of the processed flour samples were 2.50%, 2.50%, 2.00%, 1.50%, 2.00%, 2.50%, 2.00, 2.50% and 4.50% for HOCS, HRCS, HYCS, OOCS, ORCS, OYCS, ROCS, RRCS and RYCS respectively. EC measures the maximum amount of oil emulsified by protein in a given amount of flour was found to be higher in roasted cashew flour (2.00%, 2.50%, 4.50%). The samples with higher emulsification capacity indicated that they have a higher chance to emulsify during baking because of the globular nature of the protein present in the flour samples *(Ide et al., 2019).* Hot oil bath and oven dries samples were slightly difference by a 1% fraction and significantly different from the roasted cashew sample with a 4% fractional difference at ($p>0.05$) level.

CONCLUSION

Functional properties of cashew flour processed with hot oil bath, oven-dry and roasting varied significantly at ($p>0.05$). Foaming capacity (8.00%, 6.00% and 4.00%), emulsification capacity (2.00%, 2.50%, and 4.50%) and foaming stability (1.00%, 2.00%, and 4.00%) were found to be higher in the roasted samples. Water absorption capacity (92.54%, 172.32%, 116.42%) and oil absorption capacity (88.55%, 85.80%, 73.64%) were found to be higher in hot oil bath samples. Swelling capacity (8.21%, 8.35%, 11.00%) and solubility (16.64%, 14.70%, 20.91%) were observed to be higher in oven-dried samples. All the tested cashew flour samples displayed good characteristics of functional properties and this indicates that the flour can serve as a functional ingredient in the formulation of snack products and compares very well with those of legumes/wheat flours and in turn reduce the importation of wheat flour into Nigeria. The mineral composition of nine cashew flour samples processed using a hot oil bath, oven-dried and roasting varied significantly at ($p>0.05$) across the varieties and processing methods. Phosphorus (0.72%, 0.69% and 0.68%), Ca (0.30%, 0.37% and 0.39%), Mg (0.23%, 0.26% and 0.25%), K (0.66%, 0.68% and 0.68%), Mn (17.66ppm, 26.30ppm and 24.37ppm), Cu (22.63ppm, 25.04ppm and 24.84ppm), Zn (141.29ppm, 139.45ppm, 141.10ppm) were significant in hot oil bath samples while Na (28.17ppm, 34.75ppm, 44.07ppm) and iron (131.66ppm, 117.53ppm,42.37ppm) were dominant in oven-dried flour samples. Generally, it was observed that all the proximate content, minerals and functional properties were significantly high ($p>0.05$).

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