

Evaluation of Functional and Pasting Properties of Blends of High Quality Cassava, Defatted Tigernut and Chicken Feet Composite Flour

Efuribe Nnenna Edith^{1,*}, Adebowale Abdul-Rasaq Adesola², Shittu Taofik Akinyemi², Adebambo Ayotunde Olutumininu³

¹Department of Food Processing and Value Addition, Centre of Excellence in Agricultural Development and Sustainable Environment (CEADESE), Federal University of Agriculture, Abeokuta, Nigeria

²Department of Food Science and Technology, Federal University of Agriculture, Abeokuta, Nigeria

³Department of Animal Breeding and Genetics, Federal University of Agriculture, Abeokuta, Nigeria

Email address:

efuribennenna0791@gmail.com (E. N. Edith)

*Corresponding author

To cite this article:

Efuribe Nnenna Edith, Adebowale Abdul-Rasaq Adesola, Shittu Taofik Akinyemi, Adebambo Ayotunde Olutumininu. Evaluation of Functional and Pasting Properties of Blends of High Quality Cassava, Defatted Tigernut and Chicken Feet Composite Flour. *Journal of Food and Nutrition Sciences*. Vol. 6, No. 6, 2018, pp. 135-142. doi: 10.11648/j.jfns.20180606.11

Received: November 5, 2018; **Accepted:** December 14, 2018; **Published:** January 10, 2019

Abstract: Annually, the chicken processing industries generate significant quantities of chicken feet which are often discarded because they are undervalued and underutilized. However, this study was done to add value to chicken feet by evaluating the functional and pasting properties of high quality cassava-defatted tigernut-chicken feet composite blend. Tigernut seeds and chicken feet were processed into flour respectively. Simplex centroid mixture design was used to generate fourteen (14) blends based on the HQCF (70-90%), CFF (5-45%) and DTNF (5-45%). Standard laboratory procedures were used to determine the functional properties (swelling power (SP), water absorption capacity (WAC), oil absorption capacity (OAC), bulk density (BD), least gelation concentration (LGC) and pasting properties of the blends. Results showed significant differences ($P<0.05$) in the functional properties of composite flour in terms of swelling power, water absorption capacity (WAC), oil absorption capacity (OAC), bulk density (BD) and least gelation concentration (LGC) ranging from 3.83-5.72 (g/g), 90.43-110.40 (%), 87.86-107.23 (%), 0.51-0.75 (g/ml), and 2.00-10.00 (%w/v) respectively. The pasting profile (peak viscosity, trough, breakdown viscosity, final viscosity, setback viscosity, peak time and peak temperature) of the high quality cassava-defatted tigernut-chicken feet flour blends had significant differences ($P<0.05$) with values ranging from 76.50-434(RVU), 52.17 – 157.09 (RVU), 20.33 -262.96 (RVU), 76.71-215.13 (RVU), 24.55-59.25 (RVU), 4.17-4.90 (Min) and 94.28-95.88(OC). As CFF and DTNF inclusion increased, the peak, trough, breakdown, final and setback viscosities decreased. This study revealed that chicken feet flour could be a good food ingredient in food formulations such as short crust pastries, sauces, weaning foods and gravies to reduce their paste thickness.

Keywords: Chicken Feet Flour, Defatted Tigernut Flour, High Quality Cassava Flour, Functional and Pasting Properties

1. Introduction

Over the recent years, the poultry industry in Nigeria, a subsector of Nigerian agriculture is ranked among the highest commercialized as it has been experiencing rapid development [1]. In sub-Saharan Africa, especially in Nigeria, poultry production plays a significant part in income

generation in the rural households [2]. Production of poultry has been reported to satisfy the increasing demand for foods of animal source in these recent times [3]. Previous studies showed that the Nigerian poultry industry is rated second to South Africa in chicken population [4]. In 2013, the industry produced 650,000 metric tonnes of eggs and 290,000 metric tonnes of poultry meat and from a market perspective, the industry is valued at 80 billion naira [\$600 million] with

about 165 million birds). This increase in poultry processes has led to the generation of many by products/ waste such as gizzard, liver, bones, skin, head and chicken feet among others. Hence, the effective usage of by-products from poultry processing into value added products will reflect positively on the economy and the environment. The lower leg together with the feet are termed Chicken feet. Usually the skin and nails on the toes are removed. In Nigeria, there are many poultry industries where chicken feet are generated as a byproduct during processing, but they are not usually used as food because it has no muscle rather high presence of small bones and cartilages. Hence it is underutilized and not valued like other meat cut from poultry processing and as such often discarded. However, it is a choice food in some countries in Asia [5].

Nigerian consumers are less interested in that particular poultry cuts hence, it is often not valued because it has less or no meat. However, chicken feet contain a large amount of protein 22.46%, essential minerals and collagen is the major component of protein [6]. Sittikulwitit *et al.* [7] reported chicken bone extract as being a good source of calcium and also an alternative calcium fortificant when added to bakery products. Chicken feet can be further enhanced by processing it into useful products like ready-to-use chicken soup mixes, gelatin [8, 9]. Likewise, chicken feet have been used in extraction of gelatin by many researchers in Western and Asian countries in particular.

Tigernut (*Cyperus esculentus*) is underutilized tuber crops which are somehow spherical in shape belonging to the Cyperaceae family which produces tubers from the base. In Nigeria, it is called “*Ofio*”, in Yoruba, “*Aya*”, in Hausa while the Igbos call it “*Aki Hausa*” [10]. Tigernuts are excellent source of minerals like calcium, potassium, phosphorous, magnesium and iron essential for body growth, bone development and the blood stream formation and fibre [11, 12]. Digestive enzymes such as the amylase, catalase and lipase and are found in tigernut hence, it is suggested for persons who suffer from diarrhea, flatulence and indigestion [13]. It is also said to be beneficial for diabetic people because of its rich Arginine content, which releases the hormone that creates insulin and the carbohydrate content with a base of sucrose and starch [14]. Tigernut flour also has been found to fit into use in the baking industry because of its unique sweet taste [15]. It is a good substitute to wheat flour, as it is gluten free and good for people who cannot take gluten in their diet.

Cassava (*Manihot esculenta Crantz*) is a perennial woody shrub with an eatable root that thrives in tropical and subtropical regions of the world [16]. It is a very important staple crop in the sub-Saharan Africa as masses of people depend on it as their source of energy. Above 54% of the world’s cassava production comes from Africa, with Nigeria

leading worldwide with production output of about 54.8million MT in 2014. Nteranya [17] reported that the annual global production of cassava is at nearly 276 million metric tons (MT) in 2013 and among the leading global producers, Nigeria is ranked first followed by Thailand, Indonesia, Brazil and Democratic Republic of Congo respectively.

However, cassava is significantly perishable because of the high water content of about 70%. Falade and Akingbala [18] reported that processing of cassava root into shelf stable products helps reduce post-harvest losses and enhances the value of cassava root. Many range of products such as noodles, modified cassava starch, chips, glucose syrup and unfermented cassava flour (HQCF) etc. are derived from processing of cassava. HQCF is known as unfermented cassava flour; white in colour, very low in fat content, tasteless, odourless compared to the traditional fermented cassava flour and it can be utilized as composite flour [19].

The use of composite flour is very beneficial in unindustrialized nations as it helps to promote the use of indigenously cultivated crops thereby reducing the money spent on importation of wheat flour. Noorfarahzilah *et al.* [20] reported that composite flour can be utilized to improve the functional, physicochemical and wellbeing benefits of the final product. The functional properties of flour such as bulk density, swelling power, water absorption capacity (WAC), oil absorption capacity (OAC), least gelation concentration and pasting are major parameters that influence its utilization in food industry.

However, there is shortage of information on the functional and pasting properties of flours supplemented with chicken feet flour. Therefore, this study aimed at producing composite high quality cassava, defatted tigernut and chicken feet flour blends. It also evaluated the effect of different inclusion levels on functional and pasting properties of the flour blends.

2. Materials and Methods

Chicken feet were obtained from FUNAAB indigenous broilers of age 10 to 12 weeks. Tiger-nuts were also purchased from a local market in Lagos while high quality cassava flour [HQCF] was obtained from Thai Farm International, Ososa, in Ogun State, Nigeria.

2.1. Design of Experiment

Simplex-Centroid Design of the mixture experimental design was used to obtain different combination of the main ingredients [i.e. HQCF, chicken feet flour and tigernut flour]. A total of 14 experimental runs were obtained as shown in Table 1.

Table 1. Composition of the different formulations based on experimental design.

Experimental runs	X ₁ (%)	X ₂ (%)	X ₃ (%)
1	90.00	5.00	5.00
2	50.00	25.00	25.00
3	56.67	11.67	31.67

Experimental runs	X ₁ (%)	X ₂ (%)	X ₃ (%)
4	50.00	5.00	45.00
5	63.33	18.33	18.33
6	70.00	25.00	5.00
7	76.67	11.67	11.67
8	90.00	5.00	5.00
9	50.00	5.00	45.00
10	50.00	45.00	5.00
11	50.00	45.00	5.00
12	70.00	5.00	25.00
13	50.00	25.00	25.00
14	56.67	31.67	11.67

Where $X_1+X_2+X_3=1$ or 100%. X_1 = High quality cassava flour (HQCF), X_2 =Defatted tiger-nut flour (DTNF), X_3 = Chicken feet flour (CFF)

2.2. Preparation of Defatted Tigernut Flour

The tigernut was sorted out to remove foreign materials and spoiled ones from the good ones. The sorted tigernut seeds were washed thoroughly with clean water, spread on clean flat aluminum trays and placed in a thermostatically controlled cabinet dryer (LEEC Ltd., Nottingham, UK) set at about 70°C for about 2 hours to dry thoroughly. Thereafter, it was milled using a hammer mill and solvent extraction with petroleum ether (b.p 40 – 60°C) in continuous soxhlet extraction apparatus was used to extract the oil in the flour for 3 h. The defatted flour produced was then oven-dried for 10 hours at 50°C for complete removal of the solvent. The flour was sieved to obtain particle size of 250 µm. The flow chart for the preparation of defatted tigernut flour is shown in Figure 1.

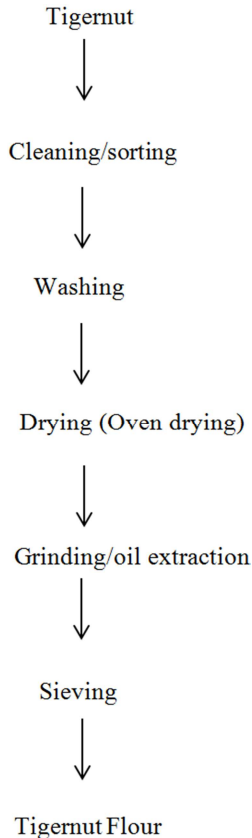


Figure 1. Modified flowchart showing Tigernut flour processing [13].

2.3. Preparation of Chicken Feet Flour

The production of dried chicken feet flour was carried out using the method described by Ilansuriyan *et al.* [21] as illustrated in Figure 2 with slight modifications. The chicken feet were thoroughly washed with clean water, and then left in warm water at temperature of 50°C for 10 minutes for easy removal of the scales and the nails. Then, they were cut with kitchen knife into smaller sizes between 2 cm and 3 cm. The chopped chicken feet were washed again with clean water, the water was separated from the solids and the descaled chicken feet pieces were placed on trays and oven dried at temperature of 60°C for 12 h. The dried chicken feet were then crushed with hammer mill and further ground into fine powder using an attrition mill. The flour was sieved using a 500 µm sieve mesh. The dried chicken feet flour was kept in an air tight container until further use.

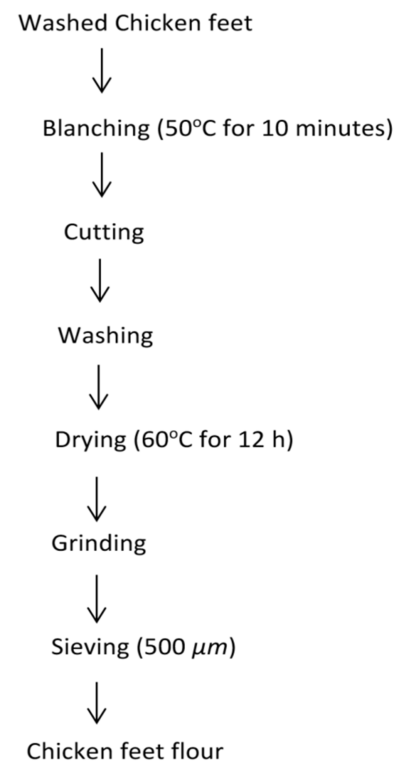


Figure 2. Modified flowchart for the production of chicken feet flour [21].

3. Analysis

3.1. Determination of Functional Properties of Composite Flour

3.1.1. Water Absorption Capacity

The Majzooobi and Abedi [22] method was employed in the determination of the water absorption capacity of the flour samples. One gram of the flour was mixed with 10 ml of water in a centrifuge tube and allowed to stand at room temperature ($30 \pm 2^\circ\text{C}$) for 1 h. It was then centrifuged at 5000 rpm for 30 min. The volume of free water on the sediment water was read from the calibrated centrifuge tube. Water absorption capacity was calculated as ml of water absorbed per gram of flour (i.e. the difference in volume of the initial amount of water added to that decanted after centrifugation).

3.1.2. Oil Absorption Capacity

This was determined by the method of Nwosu *et al.* [23]. About 1 g of the sample was measured and 10 ml refined corn oil was weighed into a dry, clean centrifuge tube and both weight were noted. Approximately 10 ml of refined corn oil was poured into the tube and properly mixed with the flour. The suspension was then centrifuged at a speed of 3500 rpm for 15 min. The supernatant was thereafter discarded and the tube content was re-weighed. The gain in mass was recorded as the oil absorption capacity of the sample.

3.1.3. Least Gelation Concentration

Least gelation concentration was studied in three replicate by employing the method described by Adeleke and Odedeji [24]. Test tubes containing suspensions of 2%, 4%, 6%, 8%, 10%, 12%, 14%, 16%, 18%, 20% (w/v) of materials in 5 ml distilled water were heated for 1 h in boiling water, followed by rapid cooling under cold running water for 2 h. The least gelation concentration (LGC) was taken as that first concentration at which the sample in the inverted test tube did not fall down or slip.

3.1.4. Bulk Density

A 50 g flour sample was put into a 100 ml measuring cylinder. The cylinder was tapped continuously until a constant volume was obtained. The bulk density (g/cm^3) was calculated as weight of flour (g) divided by flour volume (cm^3) [25].

3.1.5. Swelling Power

The swelling powers of the samples were determined with the method described by Heny *et al.* [26] with modification. One gram of the flour sample was mixed with 10 ml distilled water in a centrifuge tube and heated at 80°C for 30 min in a water bath with continuous shaking during the heating period. After heating, the suspension was centrifuged at $1000 \times g$ for 15 min. The supernatant was decanted and the weight of the paste taken. The swelling power was calculated as:

$$\text{Swelling power} = \text{weight of the paste} / \text{weight of dry flour} \quad (1)$$

3.2. Determination of Pasting Properties of Composite Flour

This was determined using a Rapid Visco Analyzer (Tecmaster Perten N103802 Australia). About 3.5 g of the samples was weighed into the test canister. Then 2.5 g of flour blends sample were weighed into a dried empty canister; 25 ml of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister was well fitted into the RVA, as recommended. The slurry was heated from 50 to 95°C with a holding time of 2 min followed by cooling to 50°C with 2 min holding time. The rate of heating and cooling were at constant rate of $11.25^\circ\text{C}/\text{min}$. Peak viscosity, trough, breakdown, final viscosity, setback, peak time and pasting temperature were read from the pasting profile with the aid of ThermoLine for Windows Software connected to a computer.

3.3. Statistical Analysis

The obtained data were subjected to analysis of variance (ANOVA) using Statistical Packaging for Social Science (SPSS) version 20.0 software 2011 to test the level of significance ($p < 0.05$). Duncan New Multiple Range Test was used to separate the differences in the mean scores.

4. Result and Discussion

The functional property of the flour composites is shown in Table 2. The swelling power of a sample measures the ability of starch to absorb water and swell. Significant ($p < 0.05$) difference was observed among the flour blends. The extent of the starch granule swelling in the various flour blends ranged from 3.83 – 5.72 g/g. Increase in HQCF inclusion resulted in higher swelling power, while sample with the highest amount of CFF had the lowest swelling power. This may be attributed to the formation of the amylose complexes with the lipids and protein. This is in line with the report of Pomeranz [27] that formation of protein-amylose complex in flour may be responsible for the reduction in swelling power. The differences could also be indicative of the variations in the structural composition in the starch granules of the flour blends.

Water absorption capacity (WAC) is a measure of the extent of water retention in flour. There were significant differences ($p < 0.05$) among the samples which ranged from 90.43 to 110.40%. The increasing trend can be associated to the weak intermolecular forces between starch granules in the composites while the low values could be as a result of the compactness of the flour blends structure imposed by the CFF and DTF which did not allow more molecular surfaces to be available for binding with water [28, 29].

Oil Absorption Capacity (OAC) is an important functional property in food formulations and from the results obtained, significant ($P < 0.05$) difference in oil absorption capacity was recorded among the flour samples. The values of OAC ranged from 87.86 – 107.23% with sample 90:5:5 having the least value while the highest value was recorded by sample

50:5:45. The increase in oil absorption capacities of the flour could be due to the protein in the chicken feet flour which is lipophilic and also has strong affinity to hold fat globules. Oil absorption in food is very important as the oil helps to retain flavor and improve the mouth feel of foods. Higher oil absorption is also needed in food systems such as sausages production, meat analogues where optimum fat absorptions are desired [30].

There is a significant difference ($p < 0.05$) in the bulk density of the flour blends which ranged from 0.51 to 0.75g/ml with sample 90:5:5 having the least value while sample 50:5:45 had the highest value. From this result, it is obvious that an increase in inclusion of HQCF led to decrease in bulk density while an increase in Chicken feet flour resulted in an increase in bulk density. The knowledge of bulk density is important in package design, storage and transport of foodstuff. Udensi and Eke [31] reported that high

bulk density is required for ease of dispersibility and decrease in thickness of paste.

The least gelation concentration (LGC) of flour measures the least level of flour or blends of flour needed for a gel to be formed in a given volume of water. There was an increase in the value of LGC as inclusion of CFF and DTNF increased with values ranging from 2.00 to 10.00%. This could be as a result of the starch-lipid complexes formed which is insoluble in water thereby inhibiting the starch granules from gelling during heating. The findings from this research supports Adebowale *et al.* [29] which reported that if more quantity of flour required to form a gel, the LGC value will be higher while greater degree of gelling indicates lower LGC value. Ocheme *et al.* [32] reported that flour blends with lower LGC could be used in food systems where thickening and gel-forming agents are required.

Table 2. Functional properties of flour blends.

Runs	HQCF	DTNF	CFF	Swelling power (g/g)	WAC (%)	OAC (%)	Bulk density (g/ml)	Least gelation capacity(%w/v)
1	90.00	5.00	5.00	5.71± 0.00 ^k	110.40± 0.17 ^g	87.86± 0.19 ^a	0.51± 0.02 ^a	2.00± 0.00 ^a
2	50.00	25.00	25.00	4.39± 0.01 ^d	95.40± 0.87 ^c	98.96± 0.67 ^f	0.67± 0.00 ^d	6.00± 0.00 ^c
3	56.67	11.67	31.67	4.19± 0.00 ^c	92.23± 0.21 ^b	104.67± .38 ^g	0.73± 0.03 ^c	8.00± 0.00 ^d
4	50.00	5.00	45.00	3.86± 0.02 ^b	90.50± 0.20 ^a	107.23± .15 ^h	0.75± 0.03 ^c	10.67± 1.15 ^e
5	63.33	18.33	18.33	5.26± 0.01 ^g	98.60± 0.53 ^d	97.25± 0.08 ^e	0.58± .03 ^{bc}	6.00± 0.00 ^c
6	70.00	25.00	5.00	5.67± 0.01 ^j	104.97± 0.25 ^f	92.79± 0.23 ^b	0.54± 0.02 ^{ab}	4.00± 0.00 ^b
7	76.67	11.67	11.67	5.44± 0.00 ⁱ	105.07± 0.71 ^f	93.81± 0.44 ^c	0.58± .02 ^{bc}	2.00± 0.00 ^a
8	90.00	5.00	5.00	5.72± 0.00 ^k	110.37± 0.31 ^g	88.12± 0.24 ^a	0.52± 0.02 ^a	2.00± 0.00 ^a
9	50.00	5.00	45.00	3.83± 0.06 ^a	90.43± 0.25 ^a	107.23± .27 ^h	0.75± 0.03 ^c	10.67± 1.15 ^e
10	50.00	45.00	5.00	5.34± 0.01 ^h	101.23± 0.15 ^e	92.69± 0.89 ^b	0.63± .00 ^{cd}	4.00± 0.00 ^b
11	50.00	45.00	5.00	5.34± 0.01 ^h	101.47± 0.47 ^e	92.83± 1.36 ^b	0.63± .04 ^{cd}	4.00± 0.00 ^b
12	70.00	5.00	25.00	4.74± 0.01 ^e	95.23± 3.24 ^c	95.13± 0.12 ^d	0.57± 0.02 ^b	4.00± 0.00 ^b
13	50.00	25.00	25.00	4.38± 0.00 ^d	95.97± 0.91 ^c	99.40± 0.62 ^f	0.67± 0.00 ^d	6.00± 0.00 ^c
14	56.67	31.67	11.67	4.94± 0.01 ^f	100.27± 0.29 ^e	97.58± 0.02 ^c	0.67± 0.04 ^d	6.00± 0.00 ^c

± Standard deviation of triplicates. Mean values with different superscripts within the same column are significantly different ($p < 0.005$). Where CFF-Chicken feet flour; DTNF-Defatted Tigmnut flour; HQCF- High quality cassava flour

Table 3 shows the pasting properties of the high quality cassava-defatted tigernut and chicken feet composite flours. There were significant differences ($p < 0.05$) in all the pasting properties of the flour blends. As percentage of CFF and DTNF inclusion increased, the peak, trough, breakdown, final and setback viscosities decreased while peak time and peak temperature increased, this may be due to the low starch content of CFF and DTNF.

Peak viscosity depicts the ability of starch to absorb water. There was significant ($p < 0.05$) difference in the peak viscosity of the flour blends. The variations observed in the values of peak viscosity in the flour samples might be as a result of the low starch content due to the inclusion of CFF and DTNF [33]. The observed reduction in peak viscosity with increasing levels of CFF and DTNF inclusion might be linked to higher content of protein and fat which has been reported to lower paste viscosity. Singh *et al.* [34] reported that lipid content could form amylose-lipid complexes that are insoluble in water and inhibit gelatinization.

The result show significant differences ($P < 0.05$) in trough among the flour blends. Sample 50:5:45 had the lowest value of 52.17 RVU while highest trough value of 157.09 RVU was

recorded in sample 90:5:5 as HQCF inclusion increased. The increase in the trough value indicates that as HQCF inclusion increases, the sample possesses greater ability not to breakdown during cooling while the low value observed in sample 50:5:45 could be due to starch-lipid complex which inhibit swelling of starch as a result of reduction in amylose leaching.

Higher Breakdown Viscosity indicates that the sample has lower ability to withstand heat and shear stress when cooling [29]. However, blends with higher CFF and DTNF inclusion recorded low breakdown viscosity because the starch possessed cross-linking properties and it indicates that the samples will not be easily disrupted when heated at high temperature while blends with high HQCF inclusion level had lower ability to withstand heat and shear stress. This could be attributed to the weak associative forces within the flour blends.

Final Viscosity indicates the stability of cooked starch after cooking and cooling at 50°C. The final viscosity of flour blend with inclusion rate of 90:5:5 recorded the highest value of 215.13 RVU while the lowest value of 76.71 RVU was recorded in sample 50:5:45. The decrease in final viscosity

can be said to be due to reduction in the arrangement of the chains in the starch granules of the flour [35]. This shows that thickening/gelling property of the blends will reduce with increased CFF and DFF inclusion.

Set back viscosity indicates resistance to retrogradation [36]. From this investigation, set back value was highest for sample 90:5:5 at 59.25 RVU while the flour blends with 50:5:45 recorded the lowest setback value of 24.55 RVU. Lower setback viscosity indicates higher resistance to retrogradation. High setback is linked with syneresis, or weeping, during freeze/thaw cycles [37]. The inclusion of starch-lipid complexes are of great importance in food

processing industries because the presence of fatty acids and their monoglyceride esters play a significant role in retarding the rate of starch retrogradation, which result in anti-staling of products such as bread, biscuits, doughnuts etc [38, 39].

Pasting temperature and Pasting time are linked together. Pasting temperature is a pasting property that gives an indication of minimum temperature needed when cooking a food sample. Higher Pasting temperature results to longer pasting time. From the result obtained, flour blend 90:5:5 cooked faster and required less energy, thereby saving cost and time compared to other flour blends.

Table 3. Pasting properties of flour blends.

Runs	HQCF	DTNF	CFF	Peak Viscosity (RVU)	Trough (RVU)	Breakdown (RVU)
1	90.00	5.00	5.00	434.04± 3.48 ^c	157.09± 16.85 ^c	262.96± 6.42 ^c
2	50.00	25.00	25.00	113.84± 1.29 ^b	71.84± 0.23 ^b	42.00 ± 1.06 ^b
3	56.67	11.67	31.67	122.25± 0.95 ^b	73.55± 0.17 ^b	48.71 ± 1.12 ^b
4	50.00	5.00	45.00	76.59± 0.47 ^a	52.17± 2.35 ^a	20.33± 0.71 ^a
5	63.33	18.33	18.33	165.75± 0.95 ^c	89.04± 0.65 ^c	76.71 ± 0.30 ^c
6	70.00	25.00	5.00	249.04± 1.82 ^d	115.25± 1.06 ^d	133.79± 0.76 ^d
7	76.67	11.67	11.67	268.05± 0.53 ^d	118.83± 0.35 ^d	141.21± 0.88
8	90.00	5.00	5.00	424.38± 2.06 ^e	144.38± 5.37 ^c	258.50± 1.17 ^e
9	50.00	5.00	45.00	76.50± 1.17 ^a	56.04± 0.06 ^a	20.46± 1.12 ^a
10	50.00	45.00	5.00	192.59± 43.96 ^c	100.08± 14.85 ^c	72.50± 29.10 ^c
11	50.00	45.00	5.00	172.58± 2.12 ^c	93.21± 0.88 ^c	79.38± 1.24 ^c
12	70.00	5.00	25.00	189.79± 0.41 ^c	96.84± 0.12 ^c	92.96± 0.30 ^c
13	50.00	25.00	25.00	119.46± 0.53 ^b	73.96± 0.41 ^b	45.50± 0.11 ^b
14	56.67	31.67	11.67	172.38± 1.25 ^c	92.71± 0.18 ^c	79.67± 0.47 ^c

Table 3. Continued.

Runs	Final viscosity (RVU)	Setback (RVU)	Peak time (min)	Pasting temperature (°C)
1	215.13± 15.73 ^f	58.04± 1.12 ^c	4.17± 0.05 ^a	94.28± 0.18 ^a
2	106.05± 1.59 ^b	34.21± 1.82 ^b	4.84± 0.05 ^{ef}	95.85± 0.07 ^c
3	109.21± 1.12 ^b	35.64± 0.94 ^b	4.80± 0.10 ^{def}	95.03± 0.04 ^b
4	76.71± 4.30 ^a	24.55± 1.94 ^a	4.90± 0.04 ^f	95.8± 0.043 ^c
5	132.46± 0.76 ^c	43.42± 0.12 ^c	4.67± 0.00 ^d	95.88± 0.04 ^c
6	163.25± 1.77 ^c	48.00± 0.71 ^{cd}	4.53± 0.00 ^c	95.20± 0.14 ^b
7	166.04± 0.76 ^c	47.21± 1.12 ^{cd}	4.33± 0.00 ^b	95.08± 0.04 ^b
8	203.63± 5.37 ^f	59.25± 0.00 ^c	4.20± 0.00 ^a	94.30± 0.00 ^a
9	82.75± 0.24 ^a	26.71± 0.30 ^a	4.90± 0.14 ^f	95.83± 0.04 ^c
10	152.38± 5.75 ^{cd}	52.29± 10.90 ^{de}	4.67± 0.00 ^d	95.85± 0.00 ^c
11	165.42± 6.72 ^c	47.21± 1.59 ^{cd}	4.74± 0.09 ^d	95.88± 0.04 ^c
12	141.88± 0.18 ^{cd}	45.04± 0.30 ^{cd}	4.37± 0.05 ^b	95.08± 0.04 ^b
13	108.55± 0.88 ^b	34.59± 1.29 ^b	4.80± 0.00 ^{def}	95.48± 0.53 ^{bc}
14	138.30± 0.38 ^{cd}	45.59± 0.28 ^{cd}	4.50± 0.02 ^c	95.48± 0.51 ^{bc}

± Standard deviation of triplicates. Mean values with different superscripts within the same column are significantly different ($p < 0.005$). CFF-Chicken feet flour; DTNF-Defatted Tignut flour; HQCF- High quality cassava flour

5. Conclusion

This study showed the effect of different levels of high quality cassava, defatted tignut and chicken feet composite flour on the functional and pasting properties of the flour blends. There were significant differences in the functional properties of the flour blends. As the inclusion of CFF increased in the blends, there were significant ($p < 0.05$) reductions in the swelling power, bulk density, and water absorption capacity while the least gelation concentration and oil absorption capacity increased. Higher oil absorption is useful in food industries such as in sausage production, meat

analogues where optimum fat absorptions are desired. Likewise, the peak, trough, setback and final viscosities of the flour blends also decreased as the inclusion level of CFF increased. In this regard, chicken feet flour (CFF) could be a good food ingredient in food formulations especially in short crust pastries.

Acknowledgements

The authors gratefully thank the World Bank Africa Centre of Excellence in Agricultural Development and Sustainable Environment, Federal University of Agriculture, Abeokuta, Nigeria for the financial support during the research of this

work.

References

- [1] United States Department of Agriculture USDA. (2013). International Egg and Poultry Report.
- [2] Heinke Heise H, Crisan A and Theuvsen L (2015). The Poultry Market in Nigeria: Market Structures and Potential for Investment in the Market. International Food and Agribusiness Management Review Volume 18 Special Issue A. Ibadan, Nigeria.
- [3] FAO (2011). Mapping supply and demand for animal-source foods to 2030. Animal production and health working paper No. 2. <http://www.fao.org/docrep/014/i2425e/i2425e00.pdf> [accessed August 25, 2018].
- [4] Sahel (2015). An Assessment of the Nigerian Poultry Sector. Sahel Newsletter Volume 11.
- [5] Almeida P F, Calarge, F. E and Santana J. C (2013). Production of a Product Similar to Gelatin from Chicken Feet Collagen. *Engineering and Agricultural Journal*, v.33, n.6, p.1289-1300.
- [6] Polian, F. A., (2012). Collagen extraction from chicken feet for jelly production. *Acta Scientiarum. Technology Maringá*, 34, (3):345-351.
- [7] Sittikulwitit, S., Sirichakwal, P. P., Puwastien, P., Chavasit, V. and Sungpuag, P. (2004). In vitro bioavailabilities of calcium from chicken bone extract powder and its fortified products. *Journal of Food Composition and Analysis* 17: 321–329.
- [8] Taha A. E., Dina M. S., Mahmoud F. S. A. K., and Ragab A. A. (2015). Utilization of the chicken feet and skeleton meat for the production of dried chicken soup. *Middle East Journal of Agriculture*, 4(4): 938-948.
- [9] Jayathilakan, K., Sultana, K., Radhakrishna, K. and Bawa, A. S. (2010). Utilization of by-products and waste materials from meat, poultry and fish processing industries: A review. *Journal of Food Science and Technology* 49(3): 278-293.
- [10] Omode A, Fatoki O and Olaogun K. A (1995). Physicochemical properties of some under-exploited and non-conventional oil seed. *J. Agric. Food Chem.*, 1995; 11: 50-53.
- [11] Oladele, A. K and Aina J.O (2007). Chemical composition and functional properties of flour from two varieties of tigernut (*Cyperus esculentus*). *African Journal of Biotechnology*. 6(21): 2473-2476.
- [12] Osagie A U and Eka O. U. (1998). Nutritional quality of plant foods. Post-harvest research unit, University of Benin, Nigeria. Pp 246-249.
- [13] Adejuyitan, J. A, Otunola, E. T., Akande, E. A., Bolarinwa, I. F. and Oladokun, F. M. (2009). Some physicochemical properties of flour obtained from fermentation of tigernut (*Cyperus esculentus*) sourced from a market in Ogbomoso, Nigeria. *African Journal of Food Science*. Vol 3(2) pp.051-055.
- [14] Chevallier A (1996). The Encyclopedia of medicinal plants. Dorling Kindersley Press London. 48-51.
- [15] Gambo, A. and Da’u, A. (2014). Tigernut (*Cyperus esculentus*): Composition, Products, uses and Health Benefits – A Review. *Bayero Journal of Pure and Applied Sciences*, 7(1): 56 – 61.
- [16] Onyenwoke C. A. and Simonyan K. J (2014). Cassava post-harvest processing and storage in Nigeria: A review. *African Journal of Agricultural Research*, 9(53): 3853-3863.
- [17] Nteranya Sanginga, IITA (2015). Root and Tuber Crops (Cassava, Yam, Potato and Sweet Potato). Feeding Africa 21 to 23 October, 2015. An Action Plan for African Agricultural Transformation. Abdou Diouf International Conference Center Dakar, Senegal.
- [18] Falade, K. O., and Akingbala, J. O. (2010). Utilization of cassava for food. *Food Reviews International*, 27, 51–83.
- [19] IITA (2005). Pre-emptive management of the virulent cassava mosaic disease in Nigeria. Annual report, July 2003-June, 2004. International Institute of Tropical Agriculture, Ibadan, Nigeria.
- [20] Noorfarahzilah, M., Lee, J. S., Sharifudin, M. S., Mohd Fadzelly, A. B. and Hasmadi, M.(2014). Applications of composite flour in development of food products. *International Food Research Journal* 21(6): 2061-2074.
- [21] Ilansuriyan P, Marimuthu M and Sasikala S (2015). Physicochemical, storage and sensory characteristics of chicken drumstick dried powder. *European Journal of Biotechnology and Bioscience* 3(7): 12-16.
- [22] Majzoobi, M. and Abedi, E. (2014). Effects of pH changes on functional properties of native and acetylated wheat gluten. *International Food Research Journal* 21(3): 1183-1188.
- [23] Nwosu, J. N., Onuegbu, N. C., Kabuo N. O. and Okeke, M. O. (2010). The Effect of Steeping with Chemicals (Alum and Trona) on the Proximate and Functional Properties of Pigeon pea (*Cajanus cajan*) Flour . *Pakistan Journal of Nutrition* 9 (8): 762-768.
- [24] Adeleke R O and Odedeji J O (2010) functional properties of wheat and sweet potato flour blends. *Polastan Journal of Nutrition*. 9(6);535-538.
- [25] Islam M. Z, Taneya M. L. J, Shams-Ud-Din M, M. Syduzzaman M and Hoque M. (2012). Physicochemical and Functional Properties of Brown Rice (*Oryza sativa*) and Wheat (*Triticum aestivum*) Flour and Quality of Composite Biscuit Made Thereof. *The Agriculturists* 10 (2): 20-28.
- [26] Heny Kusumayanti, Noer Abyor Handayani and Herry Santosa (2015). Swelling power and water solubility of cassava and sweet potatoes flour. *Procedia Environmental Sciences* 23 : 164-167.
- [27] Pomeranz, Y., (1991). Functional properties of food components, 2nded. Academic Press, New York. Pp.27-28.
- [28] Rickard, J. R; Asaoka, M. A and Blanshard, J. M. V. (1991). The physicochemical properties of cassava starch. *Journal of Tropical Science*. 31:11189-207.
- [29] Adebowale, A. A., Sanni, L. O. and Awonorin, S. O. (2005). Effects of texture modifiers on the physicochemical and sensory properties of dried fufu. *Food Science Technology International*, 11, (5) 373-382.

- [30] Aremu M O, Olaofe O and Akintayo ET (2007). Functional properties of some Nigerian varieties of legume seed flour concentration effect on foaming and gelation properties. *Journal of Food Technology*. 5(2):109–115.
- [31] Udensi A. and Eke O, (2000). Proximate composition and functional properties of flour produced from *Mucuna cochinchensis* and *Mucuna utles*. In: Proceedings of the 1st Annual Conference of the College of Agriculture and Veterinary Medicine, Abia State University. 10–13th Sept. pp. 170–174.
- [32] Ocheme, O. B., Oloyede, O. O., and Mahmud, A. H. (2010). Production and evaluation of bread using blends of wheat flour and fermented plantain flour. *Nigerian Food Journal*, 28(2), 284–293.
- [33] Ikegwu, O. J, Nwobasi V. N, Odoh, M. O and Oledinma, N. U. 2009 Evaluation of the pasting and some functional properties of starch isolated from some improved cassava varieties in Nigeria. *African Journal of Biotechnology* 8(10):2310-2315.
- [34] Singh N, Singh J, Kaur L, Singh Sodhi N and Singh Gill B.(2003). Morphological, thermal and rheological properties of starches from different botanical sources. *Food Chemistry*. 81:219–231.
- [35] Flores-Farias F, Martinez-Bustos Y, Salinas-Moreno YK, Chang JS, Hernandez R and Rios E (2000) Physicochemical and rheological characteristics of commercial nixtamalised Mexican corn flours for tortillas. *J Sci Food Agric*. 80:657–664.
- [36] Sanni, L. O., Ikuomola, D. P., and Sanni, S. A. (2001). Effect of length of fermentation and varieties on the qualities of sweet potato gari. Proc. 8th triennial Symposium of the International Society for Tropical Root. Crops. Africa Branch (ISTRC-AB), Ed. M. O. Akoroda, IITA, Ibadan, Nigeria, 12 - 16 November, pp. 208-211.
- [37] Maziya-dixon, B., Adebowale, A. A., Onabanjo, O. O. and Dixon. A. G. O, (2005). Effect of variety and drying methods on physico-chemical properties of high quality cassava flour from yellow cassava roots. African Crop Science Conference Proceedings. 7: 635-641.
- [38] Yang S, Cheng P, Wang L, Lin S, Yang C and Wang T (2017). Bread quality improvement by means of selected pregelatinized waxy rice flour (PWRF) *Emirates Journal of Food and Agriculture*. 29(9): 664-673.
- [39] Wang S, Li C, Copeland L, Niu Q and Wang S (2015). Starch Retrogradation: A Comprehensive Review. *Comprehensive Reviews in Food Science and Food Safety*. 14: 1541-4337.