EFFECT OF PROTEIN ENRICHMENT ON PROXIMATE COMPOSITION, FUNCTIONAL AND PASTING CHARACTERISTICS OF CASSAVA "LAFUN"

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Abstract
This study was aimed at investigating the best way of enriching "lafun", a fermented cassava meal with soy-curd and soy-residue and also to determine their proximate, functional and pasting characteristics. "Lafun" wet meal was enriched with soy protein supplements (curd and residue) before drying. A sample without supplement was used as internal control and a commercial sample as an external control. They were subjected to proximate, functional and pasting properties evaluations. The proximate composition ranged from 4.00 – 5.43%, 1.76 – 19.89%, 1.57 - 2.58%, 0.92 - 8.41%, 2.01 – 3.65%, 56.94 – 88.24% for moisture, protein, crude fibre, fat, ash and carbohydrate respectively while the energy values ranged from 343 – 407 MJ/g. There were significant ($p \leq 0.05$) differences in the functional and the pasting properties of both enriched and control samples. A peak viscosity of 359.25 RVU was observed in the control sample while the least peak viscosity of 199.83 RVU was recorded for commercial sample. The peak time increased from 4.07 min for "lafun" enriched with residue to 4.93 min for "lafun" enriched with curd while the pasting temperature and time ranged from 74.35 to 77.05°C and 4.07 to 4.89 min. respectively. The study has shown that enriching lafun with soy curd and residue improved its nutritional qualities but with a reduced peak viscosity. This will go a long way in reducing wastages normally associated with this crop in Nigeria during soymilk production.

Keywords: Lafun, enrichment, soy-curd, soy-residue, proximate, functional, pasting properties.

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1. INTRODUCTION

Cassava (*Manihot esculenta*, Crantz) is a good famine relief crop that is eaten by all classes of people. The crop has become widespread and assumed its current importance as a food during the 20th Century**.** In Africa, cassava is one of the most important food crop (FAO, 1999) and Nigeria is the current leading cassava producing country in the world (Oyewole, 1991). Cassava is well known not only for its high carbohydrate content but also for the poor quality and concentration (<1%) of its protein (Sanni and Sobamiwa, 1994). "Lafun" is one of the local names given to flour made from cassava in Nigeria, popularly consumed in the South west (Oyewole and Afolami, 2001). It is produced through the submerged soaking of cassava roots in water for about 2-3 days in order for fermentation process to take place, the product will be sun dry before milling dried fermented roots to flour. The fermented cassava flour could then be mixed with boiled water to form dough and consumed with soup (Oyewole and Afolami, 2001). The major limitation in "lafun" like other cassava product includes low protein content, low minerals, vitamins and the presence of cyanide toxicity. However, the detoxification and fortification of inexpensive staples such as cassava and maize has resulted in products of high nutritional value (Onilude *et al.*, 2004). Soybean is cheap and readily available throughout the year (Onyekwelu and Fayose, 2007). It has a high protein content (32.4% - 50.2%) which has been recorded and nutritive quality (Fasasi *et al.,* 2004). It has been described along with other legumes as the most important source of food proteins for human beings. Efforts have been made to address the protein deficiencies in cassava products including "lafun" through enrichment with soybeans and the production of acceptable nutritionally enriched food that can be stored at home. According to Rockland and Nishi (1979), soybean is under-utilized for human consumption; this has been attributed to factors such as prolonged cooking time, deficiency in methionine and presence of several heat-stable and heat labile factors that interfere with digestion such as gastrointestinal distress and flatulence associated with it. It is a useful source of both water and fat soluble vitamins including thiamine, nicotinic acid and pantothenic acid. Soy bean curd also known as Tofu in Asia, is a food cultivated by coagulating soy milk and then pressing the resulting curds into soft white cheese like blocks. Tofu has a low calorie count and relatively large amounts of protein (about 10.7%). It is high in iron, and depending on the coagulants used in manufacturing it can have a high calcium or magnesium content (Jubayer, 2013). Soybean curd residue (SCR) on the other hand namely, "okara" in Japanese, is the residue remaining after the filtration of soymilk, often regarded as a waste. The dumping of SCR has become a problem due to its contamination to the environment (Shuhong et al., 2013). SCR is rich in fiber, fat, protein, vitamins, and trace elements. It has potential for value-added processing and utilization and increased economic benefit as well as decreased pollution potential for the environment. About 1.1 kg of fresh SCR is produced from every kilogram of soybeans processed into soymilk or tofu (Khare et al., 1995). It is a good dietary fiber, which cannot be digested in the small intestine but can be fermented by microbes in the large intestine and reported to reduce blood fat and blood pressure, prevent the occurrence of constipation and colon cancer. It also reported to have ability to regulate diabetics' blood sugar levels (Periago et al., 1997). Therefore, this study is aimed at enriching "lafun" with soy curd and residue and studying the functionality of these enrichments and their effect on the pasting characteristics of the blends.

2. MATERIALS AND METHODS

2.1. MATERIALS

2.1.1. Sources of Raw Materials

Cassava roots (*Manihot esculenta* Crantz) were obtained from the Teaching and Research farm of the Federal University of Technology, Akure, Ondo State, Nigeria. Soybean (*Glycine max* (TGX) was purchased from Michael Okpara University of Agriculture (UMUDIKE), Oturu, Abia State, Nigeria.

2.2. METHODS

2.2.1. Soy Curd and Residue Extraction

Soy bean seeds (150 g) were sorted, cleaned, soaked (12 h) in 2 L of tap water containing 0.5 g $NaHC0_3$ in a cooking pot and boiled for 25 minutes. The boiled and dehulled soybean seeds were then wet milled in a hammer mill. Water was added in ratio 1:8 and a muslin cloth was used to extract the milk (pH 6.40) after which the pH was adjusted to 4.6 by adding 1 M citric acid. The soy milk was allowed to stand and the clear whey at the upper part was decanted while the lower part (curd) was collected after six hours. The residue was obtained after soy milk has been extracted from soy bean mash and filtered. The samples of curd and residue were oven dried (at 60 ^{0}C for 24 h), milled, and packaged in high density polythene HDPE and stored in the refrigerator for further use. Figure 1 showed the production of the curd and residue.

2.2.2. Lafun Production and Enrichment

Freshly harvested cassava roots were peeled with knife, washed and was cut into chunks, fermented for 4 days (pH 3.67), washed, sifted, milled into pulp and divided into two portions as shown in Figure 2. One portion was used as control while the other portion was enriched with dry soy curd and residue supplement respectively using Pearson's square with 10% enrichment level and also taking into consideration the water content of the mash. Another commercial (commercial sample) "lafun" was obtained from Federal Institute for Industrial Research (FIIRO) Oshodi, Lagos, Nigeria.

2.3. CHEMICAL ANALYSES

2.3.1. Proximate Analyses

Moisture content, protein, fat, fibre and ash contents were determined using the AOAC (2012) methods.

Carbohydrate content was calculated by difference and was taken as the percentage total carbohydrate content of the sample which was calculated using equation below:

$$\%\, carbohydrate\ content = 100 - (\%\text{protein} + \%\text{moisture content } + \%\text{fat } + \%\text{ash } + \%\text{crude fibre}).$$

2.3.2. Gross Energy Value

Calorific values were obtained by multiplying the values of the crude protein, fat, and carbohydrate contents (except crude fibre) by their physiological fuel values of 4, 9, and 4 kcal/100g respectively taking the sum of the products (Osborne and Voogt, 1978). All the results were expressed on percentage dry weight basis.

2.3.3. Functional Properties

Bulk density: Bulk density determinations were carried out for Loosed Bulk Density and Packed bulk density according to the methods of Pearson (1973).

Swelling capacity: About 25g of the 'lafun' samples was measured into a 210ml measuring cylinder noting its original volume. 150ml of cold water was added and allowed to stand for 4 hours before observing the final volume of swelling (Ukpabi and Ndimele, 1990).

$$Swelling\ index = \frac{final\ volume}{original\ volume}$$

***Reconstitution index*:** About 100ml of boiling water was mixed with10g of the 'lafun' sample for 90seconds. It was poured into a 250ml graduating cylinder. Volume of sediment recorded after 10 minutes served as the index of reconstitution. (Banigo and Akpapunam, 1997).

Wettability: About 1g of the 'lafun' sample was allowed to drop freely from 15mm level above 200ml water in a measuring cylinder and the time it will take for the 'lafun' particles to sink totally was noted. The time was recorded as the wettability power of the 'lafun' sample (Armstrong *et al*., 1979).

Water Absorption Capacity and (WAC): Water absorption capacity was determined using the procedure of Sathe *et al.* (1982).

Oil absorption Capacity (OAC): One gram of sample was weighed, 10ml of vegetable oil of a known density (0.99/ml) were added to the sample and the mixture was stirred on a magnetic stirrer at 1000 rpm for 5minutes. The mixture was centrifuge at 3500 rpm for 30minutes and the supernatant was removed and measured with 10ml measuring cylinder (Sathe*et al*., 1982).

$$OAC = \frac{volume\ of\ oil\ absorbed\ \times density\ of\ oil\ \times 100}{weight\ of\ sample\ used}$$

2.3.4. Pasting properties*:* The pasting properties were determined using a rapid viscosity analyzer (model 3D New Port Scientific PTY. Ltd, Australia) The STD 2 profile (AACC, 2000) method was used to determine the pasting properties of the samples. 3 grams of 'lafun' was mixed with 25 ml distilled water. The slurry heated from 50 to 95°C at a rate of 1.5°C/min., held for 15min., cooled to 50°C at 1.5°C/min. and finally held at 50°C for 15min. The process was a programmed heating and cooling cycle under constant shear. Pasting parameters determined were pasting temperature, peak viscosity, holding strength, breakdown viscosity, set back from holding strength and peak time.

2.4 Statistical Analysis

Some data were subjected to two-ways analysis of variance (ANOVA). Means were separated using Duncan's New Multiple Range Test at (P $\leq$ 0.05). This was analyzed using Statistical Package for Social Scientists (SPSS) version 17.

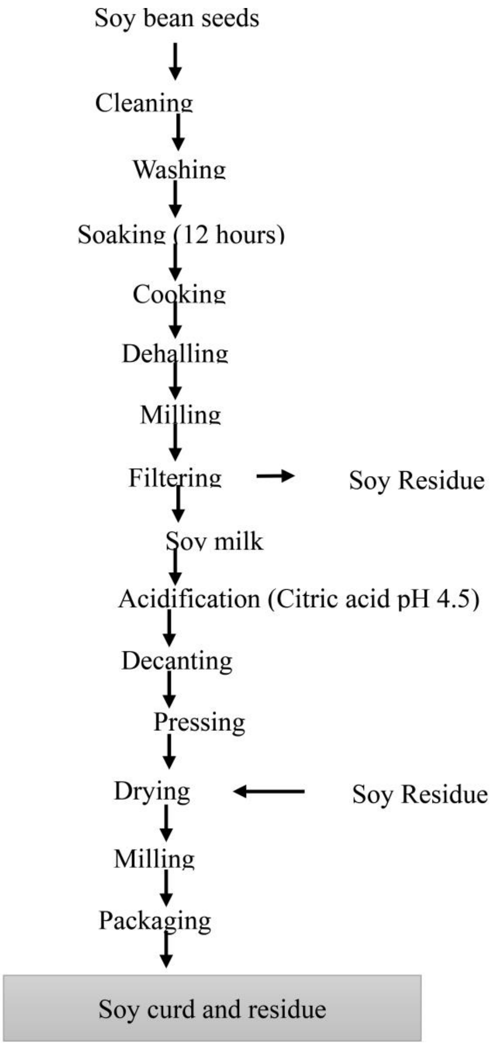

Figure 1: Flow chart showing the production of soy supplement (curd and residue).
Source:Anyaiwe and Osuji (2010)

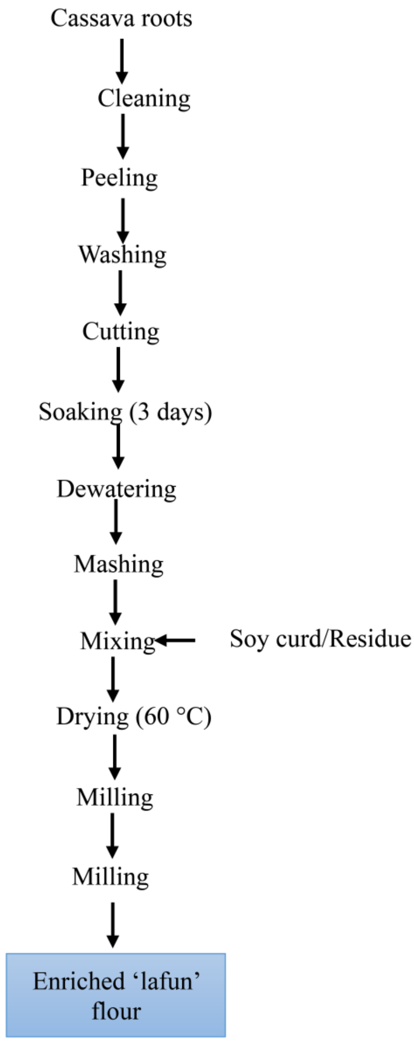

Figure 2: Flow chart showing the production of enriched 'lafun' flour.
Source:Shittu and Adedokun (2010)

3. RESULTSAND DISCUSSION

3.1. Proximate Composition

The chemical composition of the commercial, control and enriched 'lafun' is shown on Table 1. The proximate composition ranged from 4.00 – 5.43 %, 1.76 – 19.89 %, 1.57 - 2.58 %, 0.92 - 8.41 %, 2.01 – 3.65 %, 56.94 – 88.24 % for moisture, protein, crude fibre, fat, ash and carbohydrate respectively while the energy valued ranged from 343 – 407 MJ/g. There was a significant difference ($p<0.05$) in all the samples. The values for the moisture content of lafun samples ranged from 4.45% to 5.43% with enriched samples having the lowest values (4.00%). The moisture content reduced with the enrichment (Table 1). Sanni *et al.* (2006) reported that lowering the moisture content of a product leads to a better shelf stability of such product.

Generally, all the "lafun" samples had low moisture contents which are within the range of values (5.23% - 6.12%) reported for cassava flour (Kuye and Sanni, 2002) and sweet-potato by Sanni *et al.*, (2007). They were also lower when compared with the values of cassava flour (9.2% - 12.3% and 11% - 16.5%) reported by Charles *et al.* (2005) and Shittu *et al.*, (2007) respectively. Soybean flour has been reported to have a high water absorption capacity (Samuel *et al.*, 2006), which could explain the significant reduction in moisture content of soy-maize flour formulation (Lasekan and Akintola, 2002). Enrichment using soybean reduced the available water and thus would likely extend the shelf life of the enriched meal by reducing its susceptibility to microbial spoilage. The fibre content of the enriched ‘‘lafun’’ samples ranged from 1.57 to 2.28% with sample LER having the highest value while the commercial sample had the least fibre content (1.57%) as shown in Table 1. The values obtained are in the range of values reported by Folake *et al.* (2012) for soy-enriched with tapioca. From the results, significant differences ($p < 0.05$) existed among the fibre contents of all the “lafun” samples.

These values were higher than 1.10% (Buitrago, 1990) and 1.4% (Bradbury and Holloway, 1988) for cassava root, but lower than sweet cassava (10.31%), but comparable with bitter cassava (3.09%) (Okigbo, 1980).This range falls below the value (6.13 %) reported for control gari by Oluwamukomi and Adeyemi (2013). The major increase in the fibre content of sample LER and slight increase in sample LEC, showed that enrichment increased the fibre content which corroborates with Folake *et al.* (2012) for tapioca enriched with soy. This agrees with the findings of Hwei-Ming *et al*. (1994) and Balagopalan (1996).The ash content of a food material could be used as an index of mineral constituents of the food (Sanni *et al.*, 2008). Table 1 shows significant differences between the enriched samples (LER, LEC) and control samples (CL and CS). Enrichment with soy supplement resulted in higher ash contents hence, shows the presence of more mineral content in the enriched samples compared to the commercial and the control samples. Enrichment increased the ash content from 2.01% in the control sample to 3.65% in the soy curd enriched samples. This shows a significant difference ($p < 0.05$) between the samples enriched with soy supplement and the control samples. This is similar to the findings of Edem *et al.*, (2004) and Njoku *et al.* (2013) observed the increased in the ash content of “gari” from 5.17% to 5.58% by enriching with 10% and 15% soy meal respectively. The higher values of ash contents observed in the “lafun” enriched with soy supplement when compared with commercial and control samples is nutritionally advantageous to consumers. The fat contents (Table 1) showed 0.92% for commercial sample, 0.98% for control sample, 4.02% “lafun” enriched with soy residue and 8.41 % ‘lafun’ enriched with curd. “Lafun” samples enriched with soy curd had the highest fat contents followed by sample enriched with soy residue. Significant difference ($p<0.05$) existed between the enriched ‘lafun’ samples with the commercial sample (CS) and control sample (CL). This increase in the fat content in ‘‘lafun’’ enriched with soy supplements might have been as a result of the presence of the oil in the soy supplement. This agreed with the report of Uche and Aprioku, (2008) that enriched cassava with soybean. Enrichment significantly increased the protein content of the product, from 1.76% in the commercial sample (CS), 1.85% in the control sample (CL), to 14.37% for ‘lafun’ enriched with soy residue and finally to 19.89% in ‘lafun’ enriched with soy curd supplement. This means that the sample enriched with soy curd supplement had the highest mean protein followed by the sample enriched with soy residue supplement while those without supplement had the lesser values. The highest value observed in ‘lafun’ sample enriched with soy curd might have been due to the protein composition of the soy curd thus increasing the values of the protein contents (Iwe and Onu, 1992; Uche and Aprioku, 2008). This agrees with Goyal *et al.* (2012) that soybean contains approximately 40-45% protein. The carbohydrate content were 88.16% for commercial sample (db), 88.24 % for control sample, 70.93 % for sample enriched with soy residue and 56.94% (db) sample enriched with soy curd. Similar decrease in carbohydrate with increase in protein content was reported in “Ugali”, a Kenyan soy-enriched maize meal (Nyotu *et al.*, 1996), soy-enriched rice (Iwe, 2002), soy-sweet potato meal mixtures and soy-sweet potato meal cookie (Ingram, 1975). It has previously been noted that the total carbohydrate decreased with increase in protein enrichment (Lasekan and Akintola, 2002; Lasekan *et al.*, 2004; Samuel *et al.*, 2006). This could be a desirable attribute for weight watchers and diabetic patients who require less carbohydrate and high protein intake. The energy values increased significantly ($P < 0.05$) from 343.06 MJ/g for CS to 407.17MJ/g for LEC. The increase in the values of energy obtained in the 'lafun' sample enriched with soy curd 407MJ/g might have been due to its fat content since oil has twice the energy for the same quantities for both protein and carbohydrate. The enriched samples would therefore yield more energy per gram of the sample consumed

3.2. Functional Properties

The essence of determining the functional properties of the 'lafun' flour was for identification of the usage of the flour for food application or product development (Adebowale *et al.*, 2012). Functional properties of the mean value of 'lafun' samples in (Table 2) showed the difference between enriched, commercial and control samples. The loose bulk density from (Table 2) have their values as CL 0.33, CS 0.35 to LEC 0.39 and LER 0.67, while that of packed bulk density were given as CL 0.66, CS 0.64 to LEC 0.81 and LER 0.77 respectively. The bulk density values of the enriched samples were higher when compared with the 'lafun' flour without enrichment. The higher values observed in the enriched 'lafun' samples signified that they were heavier and with larger particle size. The bulk density is generally affected by the particle size and the density of flour or flour blends and it is very important in determining the packaging requirement, raw material handling and application in the food industry (Adebowale *et al.*, 2008a; Ajanaku *et al.*, 2012). The water absorption capacity is a term which describes the ability of the flour to absorb or take in water during processing. The enriched 'lafun' samples have the higher water absorption capacity value (LER 3.50 - LEC 3.69) with slight difference between the enriched samples and the control samples (CS 2.50 -CL 2.59).

Table 1: Effect of enrichment on the proximate composition and energy values of "lafun" samples (%db)

Sample	Moisture (%)	Protein (%)	Crude Fibre (%)	Crude Fat (%)	Total Ash (%)	Carbohydrate (%)	Energy (MJ/g)
CL	5.25 ± 0.02^{b}	1.85 ± 0.01^{c}	1.71 ± 0.13^{c}	0.98 ± 0.01^{cd}	2.01 ± 0.01^{cdc}	88.19 ± 0.78^{a}	354.76 ± 1.54^{c}
CS	5.43 ± 0.00^{a}	1.76 ± 0.00^{cd}	1.57 ± 0.00^{d}	0.92 ± 0.03^{c}	2.08 ± 0.00^{c}	88.24 ± 0.11^{a}	343.06 ± 1.19^{c}
LEC	4.00 ± 0.00^{c}	19.89 ± 0.82^{a}	1.96 ± 0.00^{b}	8.41 ± 0.30^{a}	3.36 ± 0.00^{b}	56.94 ± 0.18^{c}	407.36 ± 1.84^{a}
LER	4.45 ± 0.01^{d}	14.37 ± 0.00^{b}	2.58 ± 0.16^{a}	4.02 ± 0.01^{b}	3.65 ± 0.00^{a}	70.93 ± 1.75^{b}	372.05 ± 0.54^{b}

Values are means ± standard deviation with different superscripts are significantly different ($P \leq 0.05$).
KEY: CL = Control sample, CS= commercial sample LEC, = 'lafun' enriched with 10% curd, LER= 'lafun' enriched with 10% residue.

These high values of water absorption capacity can be attributed to lose structure of starch polymers while low value indicates the compactness of the structure (Adebowale *et al.*, 2005; Oladipo and Nwokocha, 2011). The ability of flour materials to absorb water is sometimes attributed to their protein content thus the observed water absorption capacity of the samples could therefore be attributed to their protein content as provided by the soy bean flour. The water absorption capacity of sample enriched with curd (3.69) was comparatively higher than the sample enriched with soy residue (3.50) which agreed with (Padilla *et al.*, 1996), African yam bean flour (118-179%) (Oshodi *et al.*, 1997) and lima bean flours (130 - 140%) (Adeyeye and Aye, 2005). This high value of water absorption capacity of the flour is an indication that it would be useful as a functional ingredient (Olaofe *et al.*, 1998). Swelling takes place when the starch is heated; the intra-molecular hydrogen bonds are broken and water is absorbed leading to swelling. Swelling capacity provides information on the nature of the associative forces within starch granules (Ogunmola *et al.*, 2001). When starch is pasted in excess water system, the granules imbibe water through the amorphous regions in a reversible manner, and the amount of water imbibed increases with temperature until a critical temperature is reached (gelatinization temperature) at which the starch swells irreversibly with loss of crystalline order.

Table 2 shows the effect of starch modification through protein enrichment of 'lafun' on the swelling properties of the product (Perez *et al.*, 1998). A significant decrease in swelling index of 'lafun' sample ranged from 0.44 in LEC to 0.59 in CL. This agrees with the findings of Oluwamukomi *et al.* (2005), and Oluwamukomi *et al.* (2007). This may be attributed to the reduced starch component in the enriched samples which could have reduced the absorption of water. Several studies have shown that swelling capacity is well correlated to amylose and its properties; flour with high amylose content tends to have high swelling capacity (Nuwamanya *et al.*, 2011). In a related study by Prinyawiwatkul *et al.* (1994) the reduced swelling capacity was attributed to high fat content which might have reduced the ability of the mixture of wheat and peanut flours to bind water. Cheftel *et al.* (1985) also attributed this phenomenon to the presence of lipids in the soy-melon supplement which must have reduced the swelling capacity of the gari granules.

The wettability was measured by the time taken in seconds by the 'lafun' samples to sink in water when dropped at a distance of 13 cm from the surface of the water (Adebowale *et al.*, 2008). The enriched samples took longer period to sink in water. This might have been due to the effect of the soy supplement which must have changed the physical and chemical compositions of the 'lafun' and made it less susceptible to imbibe water. Hence the wettability was impaired and reduced drastically (Oluwamukomi *et al.*, 2007). This result is in agreement with the previous findings of 27 - 35 seconds reported for D. alata yam flour and 42.5 seconds reported for D. rotundata yam (Udensi and Okaka, 2000). Oil absorption capacity of 'lafun' flour values varied from 0.91 for LEC to 1.39 for CS. The highest oil absorption capacity for 'lafun' samples was observed in the commercial sample (CS1.29) and did not differ significantly with the control sample (CL 1.26) due to their similar composition. The lowest oil absorption capacity was observed in sample enriched with soy curd (0.91 LEC). These results showed that the oil absorption capacity of 'lafun' samples was affected by soybean enrichment. The oil absorption capacity is influenced by the lipophilic nature of the granular surface and interior which affect the functional properties of starches (Babu and Parimalavalli, 2012). High oil absorption capacity of flour suggests that they may be useful in food preparation that involves oil mixing such as in bakery products where oil is an important ingredient (Fagbemi and Olaofe, 2000). The reconstitution index was reduced with enrichment ranging from 3.02 for LER to 4.30for CL. These lower values of reconstitution index with the enriched samples must have been due to the higher concentration of oil in the soy curd supplement. This behavior is similar to that of swelling index which was also found to decrease with soy flour enrichment. It has been shown that the presence of lipids acted as a buffer thus lowering the swelling power of starch granules (Oluwamukomi and Adeyemi, 2013).

3.3. Pasting Properties of 'Lafun' Samples

Pasting temperature of the 'lafun' samples ranged from 74.25 ℃ for LEC to 77.05 ℃ for CS. (Table 3), which is in agreement with values reported for dried fufu (76 - 78 ℃) by Sanni and Jaji (2003), (63.07 - 63.60 ℃) by Adebowale *et al.* (2008) for toasted tapioca. The pasting temperature is a measure of the minimum temperature required to cook a given food sample (Sandhu *et al.*, 2005), it can have implications for the stability of other components in a formula and also indicate energy costs (Newport Scientific, 1998). The pasting temperature of the 'lafun' was generally lower than the boiling temperature hence; the 'lafun' could form a paste in hot water below boiling point (Adebowale *et al.*, 2008; Oluwamukomi and Jolayemi, 2012). The peak time is a measure of the cooking time (Adebowale *et al.*, 2005). The peak time is the period it took the 'lafun' samples to gel which increased from 4.07 min. for CL to 4.93 min. for LEC respectively. The time to attain peak viscosity is considerably lower than those reported for dried fufu (22 -38 min) by Sanni and Jaji (2003), pupuru (37 - 43 min) by Shittu *et al.*, (2001), but in the same range with toasted tapioca (3.62 - 4.27 min) reported by Adebowale *et al.* (2008). In Table 3, it could be observed that the control sample CL has the highest peak viscosity of 359.25 RVU while LER has the lowest value of 99.83 RVU. This agreed with the study of (Maziya-Dixon *et al.*, 2004) who reported a significant decrease in the pasting viscosity of mung. Peak viscosity is often correlated with the final product quality. It also provides an indication of the viscous load likely to be encountered during mixing (Maziya-Dixon *et al.*, 2004; Maziya-Dixon *et al.*, 2005). Two factors interact to determine the peak viscosity of a cooked starch paste: the extent of granule swelling (swelling capacity) and solubility. Higher swelling index is indicative of higher peak viscosity while higher solubility as a result of starch degradation or dextrinization results in reduced paste viscosity (Shittu *et al*., 2001; Zobel, 1988). There was a decrease in peak viscosity with an increase in pasting temperature unlike the findings of Oluwamukomi and Jolayemi. (2012). The enriched samples, commercial and control samples formed pastes almost at the same temperature range of 74.25 - 77.05°C and also took almost the same range of time of 4.13 - 4.93 min. to gel apart from the control sample (CL 4.07 min.) that spent lesser time than other samples. However, due to insignificant difference ($p < 0.05$) in the pasting temperature and relatively short pasting time of all the samples, their ease of cooking would depend on their granule swelling (Zobel, 1988). Peak viscosity which is the maximum viscosity developed during or soon after the heating portion of the pasting test (Newport Scientific, 1998), and was significantly lower in the enriched samples (LER 199 - LEC 203.08 RVU) than the control CL 359.25 and commercial sample CS 305.33. The ability of a mixture to withstand heating and shear stress that is usually encountered during processing is an important factor for many processes especially those requiring stable paste and low retrogradation/syneresis. It is an indication of breakdown or stability of the starch gel during cooking (Zaidhul *et al*., 2006). The lower the value the more stable is the starch gel. The breakdown is regarded as a measure of the degree of disintegration of granules or paste stability (Dengate, 1984; Newport Scientific, 1998). At breakdown, the swollen granules disrupt further and amylose molecules will generally leach out into the solution (Whistler and BeMiller, 1997).

Table 3: Pasting properties of 'lafun' samples
Values are means ± standard deviation with different superscripts are significantly different ($P \leq 0.05$).

Sample	Peak (1)	Trough (1)	Breakdown	Final viscosity	Set back	Peak time	Pasting temp.
CL	359.25	117.42	241.83	186.42	69.00	4.07	75.20
CS	308.33	129.08	179.25	172.92	43.83	4.13	7.05
LEC	203.08	93.00	110.08	133.00	40.00	4.93	74.25
LER	199.83	95.75	104.08	135.58	39.83	4.89	74.35

Higher values of breakdown are associated with higher peak viscosities which in turn are related to the degree of swelling of starch granules during heating (Ragaee and Abdel-Aal, 2006). More starch granules with a high swelling capacity resulted in a higher peak viscosity.

4. CONCLUSION

It can be concluded from the study that soy curd and residue inclusion to the 'lafun' improved the protein, crude fibre, fat content and ash contents while there was also an increase in the energy value. Invariably, the water absorption capacity, packed/loose bulk density, and wettability increased with the increase in the level of enrichment process with a significant decrease in swelling capacity, oil absorption capacity and reconstitution index. High pasting values were also recorded for the control 'lafun' sample in relation to other samples. Lafun enriched with soy curd and residue could gain acceptability among customers of the product and also, help to enhance the utilization of soy beans, thereby reducing wastages normally associated with this crop in Nigeria.

5. REFERENCES

[1]. FAO. (1999). World Bank, Food and Agricultural Organization of the United Nations. Rome.

[2]. Sanni, M. O. and Sobamiwa, A. O. (1994). Processing and Characteristics of Soybean-fortified Gari. *World Journal of Microbiology and Biotechnology*. 10:266-270.

[3]. Oyewole, O. B. and Afolami, O. A. (2001). Quality and preference of different cassava varieties for 'lafun' production. *J. Food Technol.* 6:27-29.

[4]. Onilude, A. A., Sanni, A. I. and Ighalo, M. I. (2004). Process upgrade and the microbiological, nutritional and consumer acceptability of infant weaning food from fermented composite blends of cereal and soya beans. *J Food AgricEnvt.* 2(3&4): 64-68.

[5]. Onyekwelu, J. C. and Fayose, O. J. (2007). Effect of storage methods on the germination and proximate 11 of *Treculia Africana* seeds. University of Kassel-Witzenhausen and University of Gottingen conference on International agricultural research for development Oct. 9-11.

[6]. Fasasi, O. S., Eleyinmi, A. S., Fasasi, A. R. and Karim, O. R. (2004). Chemical properties of raw and processed bread fruit (*Treculia africana)* seed flour. *Food Agric Envt*. 2(1): 65-68.

[7]. Rockland, L. B. and Nishi, S. K. (1979). Tropical grain legumes. Paper presented at the Conference on Tropical Foods, March 1, 1979, Honolulu

[8]. Jubayer, M. F. M. B. Uddin and M. O. Faruque(2013). Standardization parameters for production of tofu using WSD-Y-1 machine. J. Bangladesh Agril. Univ. 11(2): 307–312,

[9]. Shuhong Li, Dan Zhu, Kejuan Li, Yingnan Yang, Zhongfang Lei, and Zhenya Zhang (2013). Soybean Curd Residue: Composition, Utilization, and Related Limiting Factors. ISRN Industrial Engineering, Volume 2013 Article ID 423590, 8 pages

[10]. Khare, S. K., K. Jha, and A. P. Gandhi, "Citric acid production from okara (soy-residue) by solid-state fermentation," Bioresource Technology, vol. 54, no. 3, pp. 323–325, 1995).

[11]. Periago, M. J. ;G. Ros, F. Rincón, and C. Martínez, "Nutritional meaning of dietary fibre and phytic acid in meat-based homogenised weaning foods," Food Research International, vol. 30, no. 3-4, pp. 223–230, 1997).

[12]. Anyaiwe U. C. and Osuji M. C. (2010). Stability, Yield and Chemical properties of soymilk Whey from Soybean (Glycine Max) Varieties (2010). *Nigeria Food Journal (NIFOJ)* vol.28 No.2

[13]. Shittu T. A. and Adedokun L.L. (2010) comparative evaluation of the functional and sensory characteristics of three traditional fermented cassava products. *J. Nat. Sci. Engr. Tech*. 9(2):106-116

[14]. AOAC, (2012). Official methods of analysis, Association of official analytical chemist 19th edition, Washington D.C., USA.

[15]. Osborne, D.R. and Voogt, P., (1978)**.** In: Calculations of caloric value in the analysis of nutrients in foods. Academic Press New York. 239-240

[16]. Pearson, David, and D. Pearson (1973). *Laboratory techniques food analysis*. No. TX 541. P42.

[17]. Ukpabi, U. J. and Ndimele, C. (1990). Evaluation of the quality of gari produced in Imo State. *Nigerian Food Journal*, 8: 105-109.

[18]. Banigo, E.B. and M.A. Akpapunam, 1987. Physicochemical and nutritional evaluation of protein enriched fermented maize flours. *Nig. Food J.*, 5: 30-36

[19]. Armstrong BI, Sternly DW, Maurice TJ. (1979). Functionality of Protein Structure. Ed. Akiva Pour-EL ACs symposium Series 92; American Chemical Society, Washington, DC.

[20]. Sathe, S. K., Deshpande, S.S. and Salunkhe, D.K., (1982). Functional properties of winged bean (*Psophocarpus tetragonolobus L.* DC) proteins. *Journal of Food Science*, 47, 503-509.
[21]. AACC (2000). Approved Methods of the AACC, 10th Edition, MN *American Association of Cereal Chemists*, St Paul.
[22]. Sanni, L. O., Adebowale, A. A., Filani, T. A., Oyewole, O. B., & Westby, A. (2006). Quality of flash and rotary dried fufu flour. *J. Food Agric. Environ*, *4*(3and4), 74-78.
[23]. Kuye A and Sanni L.O. (2002). Analysis of the equilibrium moisture sorption data for lafun and soy flour. *Journal of Modeling, Design and Management of Engineering systems*, 1(1): 63 – 71.
[24]. Sanni L., B. Alenkhe, R. Edosio, M. Patino and A. Dixon (2007). Technology transfer in developing countries: Capitalizing on Equipment Development. *Journal of Food, Agriculture and Environment*. 5(2): 88 – 91.
[25]. Charles, A. L., Srirothand, K. and T. C. Huang. (2005). Proximate composition, mineral contents, hydrogen cyanide and phytic acid of 5 cassava genotypes. *Food Chemistry*, 92: 615–20.
[26]. Shittu, T. A., Sanni, L. O., Awonorin, S. O., Maziya-Dixon, B. and Dixon, A. (2007). Use of multivariate techniques in studying the flour making properties of some CMD resistant cassava clones. *Food Chemistry*, 101: 1606–1615.
[27]. Samuel, F. O., Ayoola, E. O. and Ayinla, F. O. (2006). Chemical Analysis and consumer acceptability of tapioca fortified with soybeans. *Int. J. of Food and Agric Res*. 3(1): 1-5.
[28]. Lasekan OO. and Akintola AM, 2002. Production and nutritional evaluation of puffed soy – maize snack. *Nig. Food J.* 20: 15 – 19.
[29]. Folake, O. Samuel, F. A., Bolanle, O. Otegbayo, T. and Titilope, A. (2012) Nutrient and Anti-Nutrient Content of Soy-Enriched Tapioca *Food and Nutrition Sciences*, 3, 784-789.
[30]. Buitrago, A. J. A., (1990). La yucca en la alimentacion animal. Centro Internacional de Agricultura Tropical, Cali, Colombia, 446 p.
[31]. Bradbury, J. H.; Holloway, W. D.(1988). Chemistry of tropical root crops: significance for nutrition and agriculture in the Pacific. pp.201 pp. ref.14 pp.
[32]. Okigbo, B. N. (1980). Nutritional implications of projects giving high priority to the production of staples of low nutritive quality. In the case for cassava (*Manihot esculenta* Crantz) in the humid tropics of West Africa. Food and Nutrition Bulletin 2, 1–10.
[33]. Oluwamukomi M. O. and Adeyemi I. A. (2013). Physicochemical Characteristics of “Gari” Semolina Enriched with Different Types of Soy-melon Supplements. *European Journal of Food Research and Review*, 3(1): 50- 62.
[34]. Hwei-Ming Bau, Christian Villaume, Ching-FwuLin, Jacgues Evrard, Bernard Quemener, Jean-Pierre Nicolas and Luc Mejean, (1994). Effect of a solid state fermentation using *Rhizopus oligosporus* sp. t-3 on elimination of anti-nutritional substances and modification of biochemical constituents of defatted rapeseed meal. *Journal of Science of Food and Agric*, 65 (3): 315–322.
[35]. Balagopalan C (1996). Nutritional improvement of cassava products using microbial techniques for animal feeding. Monograph of the Central Tuber Crops Research Institute, Kerala, India. 44 p.
[36]. Sanni, L. A.; Ogunsina, B.S.; Oladigbo, C. (2008) Development of a Rotary Pulverizer for Cassava Cake in Gari Production *Journal of Food Process Engineering*, 31:6, 783–797.
[37]. Sanni, L.O., A. A. Adebowale, W. Awoyale and G.O. Fetuga, 2008. Quality of gari (roasted cassava mash) in Lagos State, Nigeria. *Nigerian Food J.*, 26(1): 125-134.
[38]. Edem, C. A. (2004). Efficient regeneration and antioxidant potential in regenerated-tissues of *Piper nigrum* L. *Plant Cell, Tissue and Organ Culture*, 102: 129-134.
[39]. Njoku C. (2013). Mitigation and Management of Flood Disaster in Nigeria; Proceeding of the Workshop of Local Government in Ebonyi State at Local Government Service Commission, Abakaliki: 11 – 14.
[40]. Lasekan OO. and Akintola AM, 2002. Production and nutritional evaluation of puffed soy – maize snack. Nig. Food J. 20: 15 – 19.
[41]. Iwe, M. O. and Onuh J.O. (1992). Functional and sensory properties of soybean and sweet potato flour mixtures. *Lebesm-Wiss. U. Technol*. 25:569-573.
[42]. Uche, F. I, and Aprioku, J. S. (2008). The phytochemical constituents, analgesic and anti-inflammatory effects of methanol extract of *Jatropha curcas* leaves in mice and Wister albino rats. *Journal of Applied Sciences and Environmental Management*, 12(4): 99– 102.
[43]. Goyal, M.; Nagori, B. P.; Sasmal, D., 2012. Review on ethno medicinal uses, pharmacological activity and phytochemical constituents of *Ziziphus mauritiana* (Z. jujuba Lam., non Mill). Spatula DD, 2 (2): 107-116.
[44]. Nyotu, H. G, Alli, I. and Paquette, G. (1996). Soy enrichment of a maize based Kenyan food (Ugali). *J. of Food Sci.* 51(5):1204-1206.
[45]. Iwe, M. O. (2002). Proximate, physical and sensory properties of soy-sweet potato flour cookie. *Global J. Pure and Applied Sciences*, 8(2):187-192.

[46]. Ingram, J. S. (1975). Standard specifications and quality requirements for processed cassava products. *Tropical product Institute,* London:11 – 12.
[47]. Lasekan, O. O. and Akintola, A. M. (2002). Production and nutritional evaluation of puffed soy –maize snack. *Nig. Food J*. 20: 15 – 19.
[48]. Lasekan, O. O, Babajide, J. M. and Adebayo, O. J. (2004). Effect of soy on the physico-chemical properties of pupuru flour. *Nig. Food J*. 22:87 – 96.
[49]. Samuel, M. D., R. G. Botzler, and G. A. Wobeser. 2006. Avian cholera. N. J. Thomas, C. T. Atkinson, and D. B. Hunter, editors. Infectious and parasitic diseases of wild birds. Iowa State University Press, Ames, USA, (In press).
[50]. Adebowale, A.A. and Adegoke, M.T. and Sanni, S.A. and Adegunwa, M.O. and Fetuga, G.O. (2012) Functional Properties and Biscuit Making Potentials of Sorghum-wheat Flour Composite. *American Journal of Food Technology,* 7 (6). pp. 372-379.
[51]. Adebowale, A.A., Sanni, L.O. and Onitilo. M. O. (2008). Chemical composition and pasting properties of tapioca grits from different cassava varieties and roasting methods. *African Journal of Food Science,* 2 (7): 077-082.
[52]. Ajanaku K.O., Ajanaku, C.O., Edobor- osoh, A and Nwinyi, O.C. (2012). Nutritive value of sorghum ogi fortified with groundnut journal seed (*Arachis hypogeal*). *American Journal of Food Technology*; 79:82-88.
[53]. Adebowale, A. A., Sanni, L. O. and Awonorin S. O. (2005). Effect of texture modifiers on the physicochemical and sensory properties of dried fufu. *Food Sciences and Technology International,* 11(5): 373-382.
[54]. Oladipo F. Y. and Nwokocha L.M. (2011). Effect of *sidaacuta* and *Corchorus olitorious mucilages* on the phytochemical properties of maize and sorghum starches. *Asian J. Applied Sci*. 4; 514-525.
[55]. Padilla, F.C., M. T. Alvarez and M. J. Alfaro(1996).Functional properties of barinas nut flour (*Caryodendron orinocense* Karst, *Euphorbiaceae*) compared to those of soybean. Volume 57, Issue 2: 191-196.
[56]. Oshodi, A. A., Ipinmoroti, K. O. and Adeyeye, E. (1997).). Functional properties of some varieties of African yam bean. *International Journal of Food Science and Nutrition* 48: 243-250.
[57]. Adeyeye E. I and Aye PA (2005). Chemical composition and the effect of salts on the food properties of wheat flour. *Pak. J. Nut*. 4: 187-196.
[58]. Olaofe, O., Arogundade, L. A., Adeyeye, E. and Falusi, O. M. (1998). Composition and food of the variegated grasshopper. *Tropical Science* 38: 233-237.
[59]. Ogunmola, G.B., L.M. Nwokocha and V.O. Oke, (2001).Granule architecture: Swelling power, amylose leaching and pasting characteristics of some tropical root and tuber starches. *Nig. J. Sci*., 35: 111-116.
[60]. Perez, E. E., Breene, W. M. and Bahnassey, Y. A. (1998). Gelatinization profiles of Peruvian carrot, cocoyam and potato starches as measured with Brabendervisco-amylograph, Rapid Visco-Analyzer, and differential scanning.
[61]. Oluwamukomi, M. O., Adeyemi, I. A. and Oluwalana, I. B. (2005). Effects of soybeans supplements on 63 physiochemical and sensory properties of gari. *Applied Tropical Agriculture,* 10: 38- 50.
[62]. Oluwamukomi, M. O., Famurewa, J. A. V. and Babalola, Y. O. (2007). Physicochemical, sensory and pasting characteristics of soy-enriched cassava “fufu” flour. *Biotechnology: An Indian Journal, BTAIJ,* 1(2): 77-81.
[63]. Nuwamanya E, Baguma Y, Wembabazi E, Rubaihayo P (2011). A comparative study of the physicochemical properties of starches from root, tuber and cereal crops. *Afr. J. Biotech*. 10: 12018-12030.
[64]. Prinyawiwatkul, W., McWatters, K. H., Beuchart, L. R. and Phillips, R. D. (1994). Physical properties of cowpea paste and akara as affected by supplementation with peanut flour. *Journal of Agriculture and Food Chemistry,* 42: 1750-1756.
[65]. [67] Cheftel, G. S., Cuq, J. L. and Loriet, D. (1985). Amino acids, peptides and proteins. In: *Food Chemistry*, 2nd ed., Fennema, O.R, ed. Marcel Dekker, New York, pp 245-369.
[66]. Udensi, E. A. and J. C. Okaka. (2000). Predicting the effect of particle size profile, blanching and drying temperature on the dispersibility of yam flour. *Global Journal of Pure and Applied Science,* 6: 589-592.
[67]. Babu, A. S. and Parimalavalli, R. (2012). Functional and chemical properties of starch isolated from tubers. *International Journal of Agricultural Food Science,* 2: 77-80.
[68]. Fagbemi, T. N. and Olaofe, O (2000). The Chemical Composition and Functional Properties of Raw and Precooked Taro (*Colocasia esculenta*) and Tannia (*Xanthosoma sagittifolium*) Flours. *Journal of Biological and Physical Sciences*. 1: 98 – 103.
[69]. Sanni, L. O. and Jaji, F. F. (2003). Effect of drying and roasting on the quality attributes of fufu powder. *International Journal of Food Properties,* 6 (2): 229-238.
[70]. Sandhu, K. S., Singh, N. and Malhi, N. S. (2005). Physicochemical and thermal properties of starches separated from corn produced from crosses of two germ pools. *Food Chemistry*, 89 (14): 541-548.

[71]. Newport Scientific. 1998. Applications manual for the Rapid Visco Analyzer using thermocline for windows. Newport Scientific Pty Ltd., 1/2 Apollo Street, Warriewood NSW 2102, Australia. pp. 2-26.
[72]. Oluwamukomi M. O. and Jolayemi O. S. (2012). Physico-thermal and pasting properties of soy-melon-enriched "gari" semolina from cassava. *Agric Eng Int: CIGR Journal*, Vol. 14 (3): 105-116. 26.
[73]. Shittu, T. A., Lasekan, O. O., Sanni, L. O. and Oladosu, M. O. (2001). The effect of drying methods on the functional and sensory characteristics of pupuru-a fermented cassava product *Asset-An International Journal of Agricultural Sciences, Environment and Technology*, 1 (2): 9-16.
[74]. Maziya-Dixon, B., Dixon, A. G. O. and Adebowale, A. (2004). Targeting different end uses of cassava: genotypic variations for cyanogenic potentials and pasting properties. *A paper presented at ISTRC-AB Symposium*, 31 October – 5 November 2014.
[75]. Maziya-Dixon, B., Sanni, L. O., Adebowale, A. A., Onabanjo, O. O. and Dixon, A. G. O. (2005). Effect of 77 variety and drying methods on proximate composition and pasting properties of high quality cassava flour from yellow cassava roots. In: *Proceedings of the African Crop Science Society Conference*, Entebbe, Uganda. 5th – 9th December 2005.
[76]. Zobel, H. F. (1988). Molecules to granules: A comprehensive starch review. *Starch/Starke,* 40:44-67.
[77]. Zaidhul, I. S. M., Hiroaki, Y., Sun-Ju, K., Naoto, H. and N. Takahiro. (2006). RVA study of mixtures of wheat flour and potato starches with different phosphorus contents. *Food Chemistry*, 10:1016.
[78]. Dengate, H. N. (1984). Swelling, pasting, and gelling of wheat starch. In: Pomeranz Y (ed) *Advances in Cereal Science and Technology*, AACC, USA, 49–82.
[79]. Whistler, R. L. and Be Miller, J. N. (1997). Carbohydrate chemistry for Food Scientists. Sty Paul, MN: American Association of Cereal Chemists. 117-15.