International Journal of Life Sciences Vol. 3. No. 4. 2014. Pp.170-177

Full Length Research Paper

Comparative Effect of Milling Methods on the Proximate Composition and Functional Properties of Cowpea (*Vigna unguiculata*)

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Abstract
A comparative analysis of the proximate composition and functional properties of cowpea (Vigna unguiculata) was carried out. The cowpea seeds were processed into Dry milled cowpea flour (DMCF) and wet milled cowpea slurry (WMCS). The proximate composition showed that the protein content of DMCF (27.01%) was significantly different (P<0.05) from that of WMCS (23.74%). The moisture content of WMCS (12.37%) was also significantly different (P<0.05) from that of DMCF (8.67%). There was no significant difference (P>0.05) in the lipid content of DMCF (3.17%) and that of WMCS (3.20%). Also, the ash content of DMCF (3.92%) showed no significant difference (P>0.05) with that of WMCS (3.75%). However, the crude fibre content of DMCF (0.87%) showed significant difference (P<0.05) with that of WMCS (0.45%) while the carbohydrate content of DMCF (56.37%) was not significantly different (P>0.05) from that of WMCS (56.49%). The functional property revealed that water/oil absorption capacity, Swelling index, Emulsion capacity, Bulk density, Boiling point, Gelling point and Viscosity of DMCF, generally showed significant differences (P<0.05) from those of the WMCS. However, there was no significant difference (P>0.05) in the foaming capacity of both DCMF and WMCS. Based on nutritional value, the results showed that dry milling method was recommended in processing of cowpea seeds, since loses in crude protein are minimized which is the primary reason of consuming cowpea.

Keywords: *Cowpea flour, cowpea slurry, proximate composition, functional properties, milling method*

Introduction

Milling can affect the texture of solid materials by mechanical action, making them wet or dry products. However, in the milling process, foods of different textural characteristics are obtained due to the type of milling method the materials were subjected to (Earle, 1983). Grains and seeds can be milled either by a wet milling method or by a dry milling method. Common wet milled foods include cereal foods such as corn, millet, sorghum and leguminous seed such as cowpea. On the other hand, some of the dry milled food also includes cereals such as corn, wheat, barley and leguminous seeds such as cowpea. Foods subjected to these milling methods (dry or wet milling), shows variations in their obtainable products (Singh *et al*., 2003). Wet milled food products such as corn and cowpea shows a smooth pastry appearance and is used in the production of *ogi* and production *of Akara* or *moin moin* respectively especially in the South West and South Eastern Nigeria, while wheat and cowpea can be dry milled to fine flour and can be used in bread making and production of *akara or moin, moin* respectively.

Cowpea *(Vigna unguiculata)* is the most common legume consumed in Nigeria. It is an important source of plant protein and highly palatable. Cowpea is eaten in various forms either alone or in combination with cereal grains like rice, maize or tuber such as yam (Ishiwu, 2004).

According to Onyenuga (1968) and Mohammed *et al.,*(1979), cowpea is the most widely grown and distributed legume in Nigeria and in West Africa. It contains about 24% protein, 62% carbohydrate and minute amount of other nutrients (Nnayelugo *et al,* 1995). Various types of products are traditionally produced from cowpeas by soaking, dehulling, grinding, boiling or frying (Mcwatters and Brantley, 1982; Nnayelugo *et al.*, 1995). The most common delicacies from cowpea are steamed bean-cake (moin-moin) and fried bean-cake (Akara). It provides an overall amino acid balance that compares favorably well with that of animal protein sources (Ihekoronye and Ngoddy, 1985).

As a result of economic recession, the majority of Nigerians now derive protein mainly from conwpea varieties because the country is faced with acute shortage of animal protein, which is often beyond the reach of an average Nigerian (Henshaw and Sanni, 1995). Therefore, there is need to conserve the nutritional status of cowpea to meet the over-increasing demand for cowpea and cowpea products.

Furthermore, challenges in the products obtained from the different milling (dry and wet milling) methods are based on its convenience and shelf life. In consonance with the above statement, cowpea flour has a longer shelf life than cowpea slurry because the high moisture content in cowpea slurry encourages proliferation of spoilage organisms (Singh *et al*.,2003).
However, cowpea flour can be successfully prepared commercially and used in the preparation of fried bean-cake (Akara) and steamed bean-cake (moin moin). This eliminates the drudgery of soaking, dehulling & grinding domestically (Ihekoronye and Ngoddy, 1985).

Many authors have stressed the important role cowpea plays in the diet of many populations in protein deficient countries. This has prompted research on various aspects of cowpea utilization and processing. Williams (1974) studied the various qualities that determine consumer preference and identified the following in descending order of priority with respect to some of the functional properties such as; ability to swell when cooked good bonding properties and desirable sensory properties such as flavour and textures.

Despite the research conducted on the functional properties and sensory characteristic of cowpea subjected to these milling methods (dry and wet milling), efforts has not been made to determine the effect of these milling methods on the nutritional composition of cowpea. The objective of this work therefore is:

- To produce a flour from cowpea *(Vigna unguiculata)* i.e. by dry milling.
- To produce a slurry from cowpea (*Vigna unguiculata)* i.e. by wet milling.
- To determine their proximate compositions and functional properties.
- To compare the effect of dry milling and wet milling on the proximate composition and functional properties of cowpea.

Methodology

Processing of Cowpea Seeds to Cowpea Slurry

The seeds were cleaned and sorted to remove extraneous materials and unwholesome seeds. The cleaned cowpea seeds were soaked in water for 30minutes so that the skin can be rubbed off by repeated working between the palms. The dehulled seeds were then wet milled into smooth pasty cowpea slurry as shown in figure 1.

Processing of Cowpea Seeds to Cowpea Flour

The cowpea seeds were cleaned and sorted to remove extraneous materials and unwholesome seeds. The cleaned cowpea seeds were passed between rollers so as to crack the seeds and loosen the skins and eyes of the cowpea seeds. The cracked seeds were winnowed to get the cotyledon which was further dry-milled and sieved using the usual and common 30 mesh sieve to get the cowpea flour as shown on figure 2.

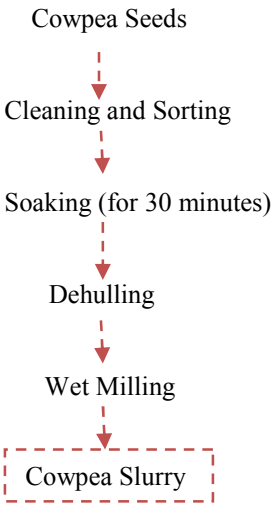

Fig 1: Flow diagram for the production of cowpea slurry

Analysis of Proximate Composition

The Proximate analysis (Moisture, Fat, Protein, Ash, Crude fibre and Carbohydrate contents) was carried out according to the methods of A.O.A.C. (1995).

Analysis of Functional Properties

Bulk Density

This was determined using the procedure described by Onwuka (2005). 10ml capacity graduated measuring cylinder was weighed and was gently filled with the sample. The bottom of the cylinder was tapped gently on the laboratory bench several times until there was no further diminution of the sample level after filling to the 10ml mark.

The bulk density (g/ml) = $\frac{\text{weight of sample (g)}}{\text{Volume of sample (ml)}}$

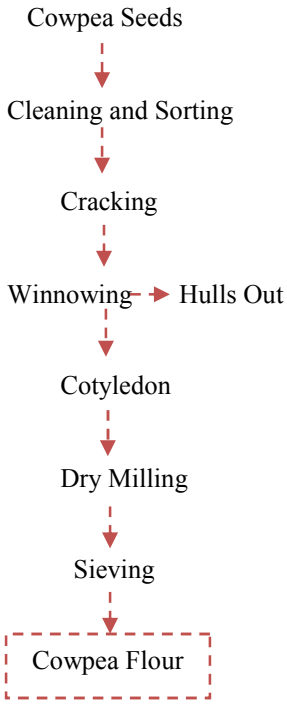

Fig 2: Flow diagram for the production of cowpea flour

Emulsion Capacity

The procedure described by Onwuka (2005) was used.

2g of the sample was blended with 25ml distilled water at room temperature for 30seconds in a warring blender at 1600pm. After complete dispersion, 25ml vegetable oil was gradually added and the blending was continued for another 30seconds. It was then transferred into a centrifuge and centrifuged at 1600rpm for 5minutes. The volume of oil separated from the sample after centrifuge was read directly from the tube.

Emulsion capacity (%) = $\frac{\text{Height of emulsified layer}}{\text{Height of whole solution in the centrifuge tube}} \text{x} \frac{100}{1}$

Foam Capacity

The method described by Onwuka (2005), was used to determine the foam capacity of the samples.

2g of the sample was blended with 100ml distilled water in a blender; the suspension was whipped at 1600rpm for minutes. The mixture was poured into a 250ml measuring cylinder and the volume was recorded after 30seconds.

Foam capacity (%)= $\frac{(Volume\ after\ whipping) - (Volume\ before\ whipping)}{Volume\ before\ whipping} \times \frac{100}{1}$

Water/Oil Absorption Capacity

The procedure described by Onwuka (2005) was followed.

1g of sample was weighed into a conical graduated centrifuge tube with a warring when mixer. The sample and 10ml distilled water or oil were thoroughly mixed for 30seconds. The sample was allowed to stand for 30minutes at room temperature and then centrifuge at 4000rpm for 15minutes.

Gain weight = $\frac{Weight\ of\ sample\ after\ centrifuge}{Weight\ before\ centrifuging}$

Swelling Index

1g of the sample was transferred into a clean, dry graduated (50ml) cylinder. The samples were then gently leveled and the volume noted. 10ml of distilled water was then added to the sample. The cylinder and its content were then swirled and allowed to stand for 60mins, while change in volume (swelling) was recorded every 15mins. The swelling power of the sample was calculated as a multiple of the original volume. The percentage swelling power was calculated as follow

$$\% \text{ Swelling Power} = \frac{Final\ Volume}{Initial\ Volume} \times \frac{100}{1}$$

Gelation

The gelling point and boiling point were determined according to the method of Narayana and Rao (1982) with slight modifications.3g of each sample was weighed into a 50ml beaker; the sample was then dispersed to make 30ml suspension using distilled water. After this, thermometer was clamped into a retort stand with its bulb submerged in the beaker. The beaker was then supported by a tripod stand heated on a Bunsen burner and stirred gently with stirring rod. The temperature at which the suspension began to gel was recorded as the gelling point. The stirring continued until the suspension began to boil. The boiling point was also recorded.

Viscosity

The apparent viscosity measurement was carried out as described by Sopade and Kassum (1992). A Brookfield Synchro-lectric Rotational Viscometer (model LVT of Brookfield Engineering Laboratory Inc. Stoughton MA, USA) was used for the rheological measurement. Apparent viscosities of the samples were determined at ambient temperature. The spindle and probe protection arm of the viscometer were immersed in a beaker containing 15g of sample, made into slurry in 300ml of water. The spindle rotational speed (shear rate) was set at 30rpm. The viscometer dial readings were converted to centipoise [millipaschal seconds (MPa.s)] by using Brookfield conversion chart.

Statistical Analysis

Triplicate determinations were done. The significant differences obtained from the result were calculated using fisher's least significant difference (FLSD) test in one way analysis of variance (ANOVA) which was used to separate the means of the measured parameters.

Results and Discussion

Table 1: Mean values for proximate composition of cowpea flour and cowpea slurry

Proximate Composition	Cowpea Flour	Cowpea Slurry	LSD
Moisture Content (%)	$8.67^{b} \pm 0.84$	$12.37^{a} \pm 0.82$	0.68
Protein Content (%)	$27.01^{a} \pm 1.43$	$23.74^{b} \pm 0.22$	1.02
Lipid Content (%)	$3.17^{a} \pm 0.13$	$3.20^{a} \pm 0.08$	0.29
Crude Fibre (%)	$0.87^{a} \pm 0.06$	$0.45^{b} \pm 0.08$	0.20
Ash Content (%)	$3.92^{a} \pm 0.10$	$3.75^{a} \pm 0.04$	0.22
Carbohydrate Content (%)	$56.37^{a} \pm 1.34$	$56.49^{a} \pm 0.74$	3.00

Means within the same row not followed by the same superscripts are significantly different (P<0.05).

Protein Content

The result in Table 1showed that the cowpea slurry had lower protein content (23.74%) as compared with the flour (27.01%).The result is in line with the work of Sosulki *et al.*, (1987). However, it was expected that there would be losses in protein in both milling methods. The protein loss in wet-milled product is expected to have resulted from leaching of the soluble protein components, into the water that was used to soak the cowpea seeds prior to dehulling as reported by Okpala and Mamah (2001). The loss in the protein content of the dry milled cowpea is expected to be as a result of the heat dissipated from the attrition machine used in milling the cowpea seeds. Rayben (1994) suggested that heat application result to further denaturation of protein content. The amount of protein in both products was significantly different (P<0.05). This significant loss could be attributed to the difference in amount of protein leached out of the cowpea during wet milling pretreatment and the quantity destroyed by heat.

Lipid Content

The lipid content of cowpea slurry (3.20%)was significantly different (P<0.05) from that of cowpea flour (3.17%) as shown in Table 1. From literature, Lasekan *et al*., (1987); and Oyenuga (1968) recorded the lipid content of cowpea to be 1-2% fat. However, the result for the lipid content of dry milled cowpea flour and wet milled cowpea slurry is not in line with the above stated literature. This could be attributed to the variation in cowpea species utilized. Although statistically, the cowpea slurry and cowpea flour showed no significant difference (P<0.05) in their lipid content, but the lipid content of wet milled, based on proximate was slightly greater than that of dry milled as shown in Table 1.The lower lipid content of flour could be attributed to the melting of some fat soluble vitamin due to heat dissipated from the milling machine and also due to some fat molecule entrapped in the internal parts of the milling machine, thus, resulting to loss in total lipid content of the dry milled cowpea flour. There could also be possible losses in the lipid content of wet milled cowpea slurry with respect to the wet milling method. However, this could be as a result of some fat/oil molecules that leached out from the cotyledon, forming suspension on the surface of the spent water. The suspension was decanted together with the spent water, thus, resulting in loss in total lipid content of the wet milled cowpea slurry.

Moisture Content

The result in Table 1 showed that the wet milled cowpea slurry had higher moisture content (12.37%) as compared to the dry milled cowpea flour of lower moisture content (8.67%). The results showed a significant difference ($P<0.05$). This significant difference ($P<0.05$) in the moisture content of the two cowpea products could be attributed to the absorption of water by the cotyledons during soaking prior to wet milling and also due to added water in the course of milling. This result is in line with the work of Kulkarni and Patil (2001). The quantity of water absorbed by the cowpea cotyledons is dependent on the soaking time (Steele, 1972).

Furthermore, the dry milled cowpea flour followed a different processing pattern that led to its lower moisture content of 8.67%. The lower moisture content of the flour could be as a result of the evaporation of some of the unbounded-free water molecules in the cowpea seed. Due to the moisture loss in the dry milled cowpea flour, products derived from the flour may be of undesirable texture which may not be acceptable to the consumer. Water absorbed during soaking improves the texture of cowpea as suggested by Tombery (1980)

Ash Content

The result in Table 1 showed that the dry milled cowpea flour had an ash content of 3.92% ,while the wet milled cowpea slurry had an ash content of 3.75%, and there was no significant difference ($P>0.05$) between the products. The result is in line with the work of Lasekan *el al.,* (1987) and Oyenuga, (1968). They reported that the ash content of cowpea ranged from 3-4%. The lower ash content of the cowpea slurry could be as a result of some minerals that leached out with other nutrients during soaking into the spent water, during milling pretreatment. However, despite the heat dissipated from the attrition mill, the ash content of the cowpea flour might not have been affected by heat. This is expected because heat cannot destroy mineral content in food. Therefore to minimize losses in the ash content, the soaking time should be reduced.

Crude Fibre Content

The result in Table 1 showed that the cowpea flour had higher crude fibre content (0.87%) as compared with the cowpea slurry (0.45%). This result showed a significant difference ($P<0.05$). However, the above result obtained is not in the line with the work of Lasekan *et al;* (1987) and Oyenuga (1968) in the literature. The variation in the value could be as a result of the type of cowpea species used. Moreover, crude fibres are indigestible carbohydrate component that is found in food and it consists of cellulose, hemi-cellulose and gum. The lower crude fibre content of cowpea slurry could be attributed to the leaching out of these indigestible carbohydrates (hemi-cellulose, cellulose & gum) in the spent water during soaking, in wet milling pretreatment. The water absorbed by the cotyledon dissolves the gum, thus, giving room for easy leaching of some hemi-cellulose and cellulose into the spent water, during soaking. However, the higher crude fibre content of the cowpea slurry is expected. In the cowpea flour, the cellulose, gum, and hemi-cellulose within the cotyledon seeds were not removed during milling unlike in the wet milling method, rather the indigestible carbohydrate formed part of the cowpea flour. Also the higher crude fibre of the cowpea flour could be attributed to starch degradation due to heat dissipated from the attrition mill, thus, rearranging the structure network of the starch in the cowpea into an indigestible carbohydrate molecule, thereby increasing the fibre content in the flour.

Carbohydrate Content

From the Table 1, the carbohydrate content of Cowpea slurry (56.49%) and Cowpea flour (56.37%), showed no significant difference ($P>0.05$). This was not expected since the carbohydrate content were expected to leach into the soaking water and lost in spent water during the wet milling pretreatment. Furthermore, since the carbohydrate content was found by difference, the actual loss in the cowpea slurry may not be feasible i.e. it is covered by the fact that the carbohydrate content was not directly measured but was determined by difference of the sum of other nutrients from 100%. It should also be noted that this is applicable in the dry milled product, that whatever loss that exists in the flour is covered up by the method of determination i.e. by difference. Therefore, comparatively, it can be said that neither processing method affected the carbohydrate and the little difference (5%) only is due mainly to the processing method.

Table 2: Mean values of functional properties of cowpea flour and cowpea slurry

Functional Properties	Cowpea Flour	Cowpea Slurry	LSD
Water Absorption cap. (g/g)	2.92^{a}±0.03	1.22^{b}±1.13	0.27
Oil Absorption cap. (g/g)	2.27^{a} ± 0.09	1.26^{b}±0.06	0.22
Swelling Index	1.23^{b} ± 0.02	1.50^{a}±0.00	0.04
Emulsion Capacity (%)	9.73^{a} ± 0.09	3.87^{b}±0.03	0.19
Bulk density (g/cm^3)	5.27^{a}±0.04	4.03^{b} ±0.02	0.09
Boiling Point (°C)	80.30^{b}± 0.47	93.00^{a} ±0.82	1.85
Gelling Point (°C)	62.00^{b} ±0.82	81.00^{a}±0.82	2.27
Foaming Capacity (%)	47.22^{a} ± 1.00	47.84^{a}±1.01	2.79
Viscosity (CP)	4.00^{a} ±0.16	1.13^{b}±0.09	0.37

Means within the same row not followed by the same superscripts are significant different ($P < 0.05$).

Water Absorption Capacity

The water absorption capacity of the cowpea flour was significantly different (P<0.05) from that of cowpea slurry (1.22g/g) as shown in Table 2. The cowpea flour had a higher water absorption capacity compared to cowpea slurry due to the fact that no water was used during the processing operation of cowpea seeds into cowpea flour and therefore, has the tendency to hold and absorb more water. Unlike cowpea flour, the low water absorption capacity of the cowpea slurry could be attributed to the amount of water absorbed by the cowpea seeds during soaking in the wet milling pretreatment method and also, the quantity of water added during the actual wet milling operation.

This consequently reduces the water holding capacity of the wet milled product (i.e. the slurry). Okpala and Mamah (2001) reported that soaking in water reduced the water absorption capacity of pigeon pea flour and this was attributed to the reduction in protein content, thus, reduction in water holding capacity.

Oil Absorption Capacity

The result showed that the oil absorption capacity of cowpea flour was significantly different (P<0.05) from cowpea slurry. The cowpea slurry had an oil absorption capacity of 1.26g/g and the cowpea flour had oil absorption capacity of 2.27g/g (Table 2). Oil absorption capacity is the physical entrapment of oil by protein (Njoku, 1992). The higher oil absorption capacity in the cowpea flour could be attributed to its high protein content based on the proximate and also to the small amount of heat energy dissipated, during the dry milling operation. This heat energy dissipated from the attrition mill was due to internal friction between the cowpea cotyledons and the machine parts. From literature, Abbey and Ibeh (1988) showed that heat increased the oil absorption capacities of some legume flours and this was attributed to the heat of dissociation of proteins, gelatinization of carbohydrate and swelling of crude fibre. However, the result obtained was in line with the above statement. In contrast the lower oil absorption capacity in the cowpea slurry could be attributed to the leaching of water-soluble protein into the soaking, resulting to low protein content, thus reducing its capacity to absorb and hold oil.

Bulk Density

There was a significant difference (P<0.05) between the bulk density of dry milled product (cowpea flour) and wet milled product (cowpea slurry). The bulk density of cowpea flour was 5.27gcm^{-3} and the bulk density of cowpea slurry was 4.03gcm^{-3}(Table 2). Moreover, bulk density depends on the nature of the particulate matter such as solid density, geometry size and surface properties (Okorie, 2002). The significant difference (P<0.05) between cowpea flour and cowpea slurry could be attributed to variations in textural characteristics of the sample, as a result of different milling methods utilized. In consonance with the above statement, it implies that the high bulk density of the dry milled cowpea (cowpea flour) could be as a result of its textural characteristics since it exists as a particulate solid.

According to Onimawo and Egbekun (1998), the bulk density of flour protein is important in the preparation of infant food formulations. High bulk density limits the calorie and nutrient intake per feed and it's advisable to be used in formulation of food for people watching weight, while low bulk density is advantageous for the infant as both calorie and nutrient is enhanced per feed of the child.

Emulsion Capacity

There was a significant difference (P<0.05) between the emulsion capacity of cowpea flour and cowpea slurry. The emulsion capacity of cowpea flour was 9.73% while the emulsion capacity cowpea slurry was 3.87% (Table 2). However, the stability of an emulsion varies with the type of protein, its concentration and method of preparation (Mc Watters and Holmes, 1979; Abbey and Ibeh, 1988). The low emulsion capacity for the cowpea slurry was expected because of the low protein content based on its proximate food products with high protein content had greater emulsion capacity (Singh *et al*., 2003).

Shanmugasundaran and Venkaranman (1989) had earlier stated that emulsion capacity of soluble protein depends on the lipophilic and hydrophilic proteins. In other words, cowpea slurry with low emulsion capacity could be attributed to the preliminary unit operations such as soaking and dehulling utilized during the wet milling process of the cowpea seeds that leached out the lipophilic and hydrophilic protein. Emulsion stability is enhanced by high protein and oil concentration and it depends primarily upon the water absorption activity and oil absorption activity of protein (Singh *et al*., 2003).

Foaming Capacity

There was no significant difference (P>0.05) in the foaming capacity of cowpea slurry and cowpea flour. The cowpea slurry had a foaming capacity of 47.84% and the cowpea flour had a foaming capacity a 47.22% (Table 2). This could imply that the milling methods (dry milling and wet milling) had little or no effect on the foaming capacity of the cowpea. However, foaming property is very important to improve texture, consistency and appearance of food such as baked and confectionary goods. The process of whipping results in partial protein denaturation, which aids foam formation by unfolding of protein molecules (Njoku, 1992).

Swelling Index

There was a significant difference (P<0.05) in the swelling index of cowpea slurry and cowpea flour. The cowpea slurry had a swelling index of 1.50 and the cowpea flour had a swelling index of 1.23 (Table 2). Swelling implies the ability to increase in volume when protein flours are mixed in water (Enwere, 1985). Both protein and starch have been shown to be responsible for the swelling of legume flour with protein playing dominant role at low temperature and starch at high temperature (Henshaw and Adebowale, 2004). The reduced swelling index of cowpea flour could be attributed to the degradation of some carbohydrate components such as cellulose, hemi-cellulose, starch granules and denaturation of some protein molecules, resulting from the heat dissipated when using the dry milling method. However, several native proteins which are insoluble in water may occur in greater amount in the cowpea flour thereby reducing its ability to swell (Okorie, 2002).

Viscosity

The result obtained showed that there was a significant difference (P<0.05) in the viscosity of cowpea flour and cowpea slurry. The cowpea flour had a viscosity of4.00 centipoises (cp) and the cowpea slurry had a viscosity of 1.13 centipoises (cp) (Table 2). Moreover, viscosity is a measure of a fluids resistance to flow. During the test for viscosity, the same amount of water was added to the cowpea slurry and the cowpea flour. However, the volume of water in the slurry might have exceeded the amount of water needed to create an interface for bonding of hydrophilic molecules due to the increase in distance between hydrophobic molecules (i.e. decrease in density) whereas the amount of water to the flour created a room for hydrophilic molecules to come together. Thus instead of an increase in the viscosity of slurry rather, the reverse was the case as a result of excess water.

Gelation Temperature

The result obtained showed milling (dry milling or wet milling) method had an effect on the gelation temperature of the milled cowpea. The dry milled product (cowpea flour) had a gelation temperature of 62°C and statistically different (P<0.05) from the wet milled product (cowpea slurry) with a gelation temperature of 81°C (Table 2). The increased gelation temperature of cowpea slurry could be due to low protein and carbohydrate content associated with leaching out of protein during soaking in the wet milling processing operation. It could also be attributed to degradation of some solubilized starch or carbohydrate component. Sathe *et al.,* (1982) associated the variation in gelling properties of different legume flours to the relative ratio of different constituents - protein, lipids, and carbohydrates - that make up the legume.

Conclusion

The results obtained revealed that there were obvious considerable relationship between the proximate composition and functional properties of dry milled cowpea flour and wet milled cowpea slurry. Dry milling produced a higher protein and crude fibre content while wet milling produced higher moisture content. This implies that dry milled cowpea flour will be rich in protein which is essentially important, being the primary reason for cowpea consumption; and the fibre content which was higher in the dry milled cowpea flour is an indication that digestion of dry milled cowpea flour will be faster than the wet milled cowpea slurry since fibre increases speed of digestion and also improves bulk. On the other hand, the moisture content which was higher in the wet milled cowpea slurry improves palatability which is of interest to the ultimate consumer as it is a parameter that affects quality. However lipid, ash, and carbohydrate content were statistically equivalent in both products. Dry milling conserved more of the minerals which are necessary for regulation of the body's metabolic function. The cowpea flour with a lower lipid and carbohydrate content is an advantage to the amount of fat consumed per ml and major source of energy respectively which however cannot be a major problem in the slurry since the difference was insignificant. Dry milling produced a higher water/oil absorption capacity, emulsion capacity, bulk density and viscosity while wet milling produced a higher swelling index, boiling point and gelling point. Foaming capacity showed insignificant difference in both milling methods. This implies that dry milled cowpea flour might yield a product of good palatability, good grain texture, and increased volume, when used to prepare baked & confectionary products.

Recommendation

Therefore based on nutritional requirement, the cowpea flour is recommended. However, there is need to improve on the flour's palatability possibly, by processing the cowpea flour under controlled atmospheric condition or environment. It is also recommended that the soaking time of the slurry could be reduced, to check for the possibility to improve/ reduce the loss of food material and thus the nutritive value.

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