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Chemical Composition, Functional and Pasting Properties of Kersting's Groundnut (Kerstingiella geocarpa Harms) Flour and Starch

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Abstract
The chemical composition, functional and pasting properties of kersting's groundnut (*Kerstingiella geocarpa*) flour and starch were studied. Kersting's groundnut flour had 4.75 % moisture, 2.43 % crude fat, 23.0 % crude protein, 2.47 % ash, 1.69 % crude fibre and 65.7 % carbohydrate. Starch yield was 34.0 %. Isolated starch had reduced ash, crude fibre and crude protein contents when compared with the flour. Higher water and oil absorption capacities values were obtained for the flour in comparison with the starch. The swelling power and solubility of both flour and starch measured from 55 to 95°C at 10 °C interval increased as the temperature increased. The pasting viscosities of the flour were lower than that of the starch. Bean starch granules were predominantly oval to kidney shaped, with granule width between 9 and 24µm and length between 10 and 45µm. Kersting's groundnut starch showed the "C" type x-ray diffraction pattern, characterized by a strong peak at 5.77, 5.12, 3.83 and a medium peak at 4.64 Å.
Keywords: Kersting's groundnut, flour, starch, amylose, pasting properties
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1. Introduction

Legume seeds are of prime importance in human nutrition because they are major sources of dietary proteins in developing countries. Aside from their protein contributions, legumes are rich in starch, dietary fibre, minerals and water-soluble vitamins. Starch constitutes the major portion of legume carbohydrates accounting for 22-45 % of the seed (Hoover & Ratnayake, 2002). There are about 60 domesticated legume species throughout the world (Hedley, 2001) of which examples include lentil bean, mung bean, cowpea, smooth pea, soybean, wrinkled pea etc. However, there are some lesser-known legumes which are underutilized outside their indigenous areas. Nigeria has a great diversity of underutilized crop species which have enormous nutritional and economic values. Some of these underutilized crops were neglected because there is little or no information on the importance of their major components. Therefore, there is need to provide background research facts and the possible ways of utilizing these valuable crops and bring out their significant nutritional and economic importance.

Starch is a natural biodegradable polymer produced by many plants as a source of energy. It is a cheap, available and renewable biomass which can be utilized in various industries, such as food, pharmaceuticals, adhesives, paper and textiles. In relation to structural and physicochemical properties, starches from various plant sources, such as wheat, maize, barley and rice have received extensive attention (Gupta *et al*., 2009). The high demand for new functional ingredients in the food industry as the world population increases makes it necessary to investigate and report on alternative source of starch apart from well-known ones.

Kersting's groundnut (*Kerstingiella geocarpa* Harms, Syn. *Macrotyloma geocarpum* Harms) also known as Hausa groundnut is an annual herb which is cultivated in the West Savannah zone from Senegal to Nigeria and Cameroon. The origin of kersting's groundnut is unknown, but it is believed to have originated from Togo or Central Benin (Achigan Dako & Vodouche, 2006). Its propagation is by seed which are sown from the beginning to the middle of rainy season in West Africa. It is grown in the middle belt and northern part of Nigeria primarily for its edible seeds. Mature seeds are boiled with salt and eaten with palm oil or groundnut oil and accompanied with fermented cassava flour called 'gaari', yam or rice. In addition to this, kersting's groundnut may be boiled in soups and served to guests as a sign of honour. Also, the medicinal and emetic properties of the seeds have been reported (Amuti, 1980; Mergai, 1993). The Igbos of Nigeria uses the plant in the treatment of dysentery, fever and diabetes (Achigan Dako & Vodouche, 2006). In West Africa, kersting's groundnut is cultivated only on a small scale (Dansi *et al*., 2012) and is classified as an underutilized crop (Popoola *et al*., 2019). Few studies have been reported by some researchers (Aremu *et al*., 2008; Aremu *et al*., 2006; Ajayi & Oyetayo, 2009) on the functional properties, chemical, amino acid and mineral compositions of kersting's groundnut flour. However, information on the amylose content and pasting properties of kersting's groundnut flour is scanty and no published work seems to have been reported on the extracted starch of this sample.

The objective of this study is to prepare kersting's groundnut flour, isolate the starch and investigate the proximate composition, functional and pasting properties of the flour and starch. It is hopeful that findings from this study would provide valuable information for the industrial utilization of kersting's groundnut flour and starch.

2. Materials and Methods

2.1 *Sample Collection and Preparation*

Kersting's groundnut seeds were purchased from local farmers in Jagindi, Kaduna State, Nigeria. The seeds were manually dehulled and screened to remove stones and impurities. The seeds were then dry milled and the flour stored in refrigerator at 4°C until further use.

2.2 *Starch Isolation and Purification*

Kersting's groundnut starch was isolated by using the procedure described by Akintayo and Akintayo (2009) with slight modifications. 1kg of the non-defective seeds were soaked overnight in 4litres of 0.2% NaOH solution. The seeds were dehulled manually. The softened dehulled seeds were wet milled in a warring blender at low speed with ice cold 0.5 % NaOH. The slurry obtained was re-suspended in 5 litres of distilled water and pH was adjusted to 7.0 using 0.2M NaOH while stirring. The mixture was screened using 106 µm sieve to remove the fibres, and the slurry was centrifuged at 5000 rpm. The starch cake was re-slurried in water and re-screened using 75µm sieve. The starch obtained was washed three times with distilled water and air dried at room temperature.

2.3 *Proximate analysis and Amylose Content Determination*

2.3.1 *Moisture*

The moisture content was determined by using the procedure of AOAC (2005). Clean and dried crucible was weighed and the weight was recorded (W_1). 3 g of the sample was weighed into the crucible (W_2). The crucible with the sample was dried in the oven at 105 °C for three hours. The crucible was transferred to the desiccator to cool and the weight was noted. The process was continued until a constant weight (W_3) was obtained. The percentage loss in weight during drying was taken to be the percentage moisture content (Equation 1).

$$\% \text{ Moisture} = \frac{Weight\ loss}{Weight\ of\ sample} \times 100 \quad (1)$$

2.3.2 *Ash*

The ash content was determined by weighing 1 g of each sample into a clean, dried and previously weighed crucibles with lid (W_1). After removing the lid, sample was ignited over a low flame to char the organic matter. The crucible was then placed in a muffle furnace at 550 °C (lid removed). The ashing continued until a light grey or white ash obtained. Crucible was then transferred directly into a desiccator, cooled and weighed immediately (W_2). The percentage ash content was obtained using Equation 2 (AOAC, 2005).

$$\% \text{ Ash} = \frac{W_1 - W_2}{Weight\ of\ sample} \times 100 \quad (2)$$

2.3.3 *Crude Fat*

The Soxhlet extraction method (AOAC, 2005) was used for the determination of fat content of sample by weighing 2 g of sample into a filter paper. The filter paper with sample was folded neatly. Sample was thereafter placed inside a pre-dried thimble. Thimble with sample was inserted into the Soxhlet flask. A clean and dried boiling flask was weighed (W_1) and diethyl ether was poured into it. The boiling flask containing diethyl ether, Soxhlet flask with sample and condenser were assembled. Extraction was carried out under reflux for six hours. After extraction, the thimble was removed from the extraction barrel and dried. The solvent was distilled off and the boiling flask containing the fat was dried in the oven at a low temperature. The weight of the flask plus oil was recorded (W_2). Fat extracted from given quantity of sample was the calculated as the percentage fat content (Equation 3).

$$\% \text{ Fat} = \frac{(Weight\ of\ flask + fat) - (Weight\ of\ flask)}{\text{sample weight}} \times 100 \quad (3)$$

$$= \frac{W_2 - W_1}{Sample\ Weight} \times 100$$

2.3.4 *Crude protein*

1g of the sample was weighed into a micro-Kjeldahl digestion flask and one tablet of selenium catalyst and 15 ml of concentrated H_2SO_4 were added. The mixture was digested on an electro thermal heater until clear solution was observed. The flask was allowed to cool after which the solution was diluted with distilled water to 50 ml. 5 ml of this was transferred into the distillation apparatus. 50 ml of 2 % boric acid was pipetted into a 100 ml conical flask (the receiver flask) and four drops of screened methyl red indicator were added. 50 % NaOH was

continually added to the digested sample until the solution became turbid, which indicated that the solution had become alkaline. Distillation was carried out into the boric acid solution in the receiver flask with the delivery tube below the acid level. As the process of distillation was still going on, the pink colour solution of the receiver flask changed to blue which indicated the presence of ammonia. The distillation was continued until the content of the round bottom flask was about 50 ml after which the delivery of the condenser was rinsed with distilled water. The resulting solution in the conical flask was then titrated with 0.1 M HCl (Pearson, 1976). Percentage nitrogen was calculated using Equation 4. The percentage nitrogen was converted to crude protein by multiplying the obtained value by 6.25.

$$\%N = N\ HCl\ x\ \frac{\text{Corrected acid volume}}{\text{g of sample}}\ x\ \frac{14\ g\ N}{\text{mole}}\ x\ 100 \quad (4)$$

Where: N HCl = Normality of HCl in moles/1000 ml
Corrected acid vol. = (ml std. acid for sample) – (ml std. acid for blank)
14 = Atomic weight of nitrogen

2.3.5 *Crude Fibre*

2 g (W_1) of defatted sample was weighed into one litre conical flask; 200ml of boiling 1.25% H_2S0_4 was added and boiled gently for 30 min. The mixture was filtered through muslin cloth and rinsed well with hot distilled water. The sample was scraped back into the flask with spatula and 200ml of boiling 1.25% NaOH was added and allowed to boil gently for 30 min. It was filtered through muslin cloth and the residue washed thoroughly with hot distilled water and then rinsed once with 10% HCl, and then followed by acetone. The residue was later scraped into a crucible, dried in an oven at 105°C, cooled in a desiccator and weighed (W_2). The residue was ashed at 550°C for 90 min. in a muffle furnace. After ashing, it was transferred into the desiccator to cool and weighed (W_3) (Joslyn, 1970). Percentage crude fibre was calculated using the equation below:

$$\%\ \text{Crude fibre} = \frac{W_2 - W_3}{W_1} \times 100 \quad (5)$$

2.3.6 *Carbohydrate*

Carbohydrate content was evaluated by difference as presented in the equation below:

% CHO = 100 - (sum of the percentages of moisture, ash, fat, protein and crude fibre) (6)

2.3.7 *Amylose*

Amylose content was determined by using the procedure reported by Babu & Parimalavalli (2014). 0.1g of sample was weighed into a 100 ml volumetric flask and then 1 ml of 99.7 % - 100 % (v/v) ethanol and 9 ml of 1 M sodium hydroxide (NaOH) were carefully added. The mouth of the flask was covered with parafilm and the content was mixed thoroughly. The sample was heated for 10 min. in a boiling water bath to gelatinize the starch and timing started when boiling began. The sample was removed from the water bath and allowed to cool very well, then made up to mark with distilled water and shaken thoroughly. Thereafter, 5 ml was pipetted into another 100 ml volumetric flask and 1 ml of 1 M acetic acid and 2 ml of iodine solution were added. The flask was topped up to the mark with distilled water. Absorbance (A) was read using a spectrophotometer at 620 nm wavelength. The blank contained 1ml of ethanol, 9 ml of sodium hydroxide, boiled and topped up to the mark with distilled water. Finally, 5 ml was pipetted into a 100 ml volumetric flask, 1ml of 1 M acetic acid and 2 ml of iodine solution were added and made up to the mark. This was used to standardize the spectrophotometer. The amylose content was calculated using Equation 7.

Amylose (%) = 3.06 x A x 20 (7)
Where A is the Absorbance value.

2.4 *Functional Properties*

2.4.1 *Water and Oil Absorption Capacities*

The method of Beuchat (1977) was employed. 1 g of the sample was mixed with 10 ml distilled water/oil (using a vortex mixer) for 30 s. The samples were then allowed to stand for 30 min. at room temperature. These were then centrifuged at 5000 rpm for 30 min. and the volume of the supernatant from each sample was noted in 10 ml graduated cylinder. Density of distilled water was assumed to be 1 g/ml and that of the oil was determined to be 0.87 g/ml. Results were expressed on a dry weight basis.

2.4.2 *Gelation*

Gelation property was studied by using the method of Coffman & Garcia, (1977) as modified by Sathe and Salunkhe (1981). Appropriate sample suspensions of 2, 4, 6, 8, 10, 12 14, 16 and 18 % (w/v) were prepared in 5 ml distilled water. The flour/starch suspensions were mixed with a vortex mixer for 5 min. The tubes were heated in a water bath at 80 °C for 30 min., followed by rapid cooling under running cold tap water. The test tubes were further cooled for 2 hr at 4 °C. Least gelation concentration was determined as that concentration

when the sample from the inverted test tube did not fall or slip.

2.4.3 *pH Determination*

The pH was determined at room temperature (30 ± 2 ºC) by suspending 5 g of the sample in 50 ml distilled water and measuring with Omega HPPX digital pH meter.

2.4.4 *Effect of Temperature on the Swelling and Solubility Properties*

The procedure described by Lawal (2004) was employed for the determination of swelling properties of flour/starch. Sample (1 g) was accurately weighed and quantitatively transferred into clear dried test tube and reweighed (W_1). The weighed sample was then dispersed in 50 ml distilled water using a vortex mixer. The resultant slurry was heated at the desired temperatures, 55, 65, 75, 85, 95 ºC for 30 min. in a water bath. The mixture was cooled to 30±2 ºC and centrifuged at 5000 rpm for 15 min. The residue obtained from the above process (after centrifugation) with the water retained was quantitatively transferred to clean dried test tube used earlier and weighed (W_2). Percentage swelling power was calculated using Equation 8. Aliquot (5 ml) of the supernatant was dried to a constant weight at 110 ºC. The residue obtained after drying the supernatant represented the amount of starch solubilized in water. Solubility was calculated as g per 100 g of starch on dry weight basis.

$$\text{Swelling Power (\%)} = \frac{W_2 - W_1}{Weight\ of\ sample} \times 100 \qquad (8)$$

2.5 *Pasting Properties*

Starch pasting properties were evaluated using Rapid Visco Analyser model 3D+ (RVA) Newport Scientific, Australia). 3 g of sample was weighed into a weighing vessel. 25 ml of distilled water was dispensed into a new test canister. Sample was then transferred onto the water surface in the canister after which the paddle was placed into the canister. The blade was then vigorously jogged up and down through the samples ten times or more until no starch/flour lumps remained on the water surface or on the paddle. The paddle was placed into the canister and both were inserted firmly into the paddle coupling so that the paddle is properly centred. The measurement cycle was initiated by depressing the motor tower of the instrument. The test was then allowed to proceed and terminate automatically (RVA Operation Manual, 1995). Pasting properties which includes pasting temperature (PT), peak viscosity (PV), viscosity at trough (also known as minimum viscosity, TV), final viscosity (FV), breakdown (BV) (which is PV minus TV) and setback (SV) (which is FV minus TV) were recorded on the computer system attached to the Visco Analyser.

2.6 *Scanning Electron Microscopy of Starch*

Starch sample was dried at 110 ºC in an air-oven for 2 hr. The starch sample was sprinkled onto aluminium specimen stubs with double-sided adhesive tape while the non- sticking portion was blown off. The sample was coated with a 30 nm layer of gold using a sputter coater. The coated starch sample was observed using a scanning electron microscope (SEM) (FEI, HELOIS NANOLAB 600) operated at a voltage of 5.00 kV and amperage of 0.17 mA. Secondary electron (SE Mode) and ETD detector were employed and image was captured for morphological studies (Alvani *et al*., 2011).

2.7 *X-ray Diffraction Analysis of Starch*

X-ray diffractogram of starch powder was obtained using X-ray powder diffractometer STADI P (STOE & Cie., Darmstadt, Germany) with Cu K- alpha-1-radiation (Ge-monochromator) in transmission geometry. The diffractometer was equipped with a sample changer and an image plate detector, measuring time was 1800s and the scanning region of the diffraction angle was from 5º to 50º with targets voltage of 40 kV and current 100mA (Adebowale *et al*., 2009).

3. Results and Discussion

3.1 *Chemical composition*

The results of the chemical compositions of kersting's groundnut flour and starch are presented in Table 1. Kersting's groundnut flour (KGF) had 4.75 % moisture, 2.43 % crude fat, 23.0 % crude protein, 2.47 % ash, 1.69 % crude fibre and 65.7 % carbohydrate. The obtained protein content of the flour was to a slight extent more than 21.3 % reported by Ajayi & Oyetayo (2009), but higher than the value reported for raw pinto bean flour (18.0 %) (Audu & Aremu, 2011) and bambarra groundnut flour (15.48 %) (Sirivongpaisal, 2008). The result in the present study suggests that KGF can be used as a source of supplementary proteins in human diet. The observed low ash content recorded for KGF would make it suitable for use as animal feed, since seed ash content should fall within a range of 1.0 - 2.5 % to be of value to livestock (Akinhanmi *et al*., 2008). The carbohydrate contents obtained by difference for KGF, was within the expected range for legume flours, which has been established to contain about 60 % carbohydrates (Maphosa & Jideani, 2017). The yield of starch from kersting's groundnut seed was 34.0 %. This value was higher than those reported for mucuna bean (27.1 %;

Siddhuraju & Becker, 2005) and chickpea (31.3%; Hoover & Ratnayake, 2002).

Isolated kersting's groundnut starch (KNS) had reduced ash, crude fibre and crude protein and increased carbohydrate contents when compared with the flour, this is because of several washings during extraction. The amylose content of KNS (31.5 %) was higher than amylose content of kersting's groundnut flour (15.5 %). High amylose starches impact thermal viscosity properties and require higher temperature for processing and making different food items (Tayade *et al*., 2019). The amylose content of KNS is consistent with the value reported for other legume starches such as starches from faba bean varieties (31.38 - 32.23 %) and black bean varieties (30.74 - 33.66%) (Ambigaipalan *et al*. (2011).

Table 1: Chemical Composition of Legume Flour and Starch

Parameters (%)	KGF	KNS
Moisture Content	4.75±0.03	10.7±0.2
Crude Fat	2.43±0.01	0.09±0.02
Crude Protein	23.0±1.0	0.85±0.04
Ash content	2.47±0.04	0.25±0.02
Crude Fibre	1.69±0.03	ND
Carbohydrate	65.7±1.1	88.1±0.3
Starch yield	34.0±1.7	--
Amylose	15.5±0.2	31.5±0.2

Results are means of triplicate determinations
KGF = Kersting's groundnut flour KNS = Kersting's groundnut starch

3.2 *Functional Properties*

The functional properties of kersting's groundnut flour and starch are shown in Table 2. The water absorption characteristic represents the ability of a product to reassociate with water under condition where water is limiting, in order to improve its handling characteristics and dough making potentials (Iwe & Onalope, 2001). The water absorption capacity (WAC) of KGF was higher than 120.58 % reported for wheat flour (Hyacinthe *et al.,* 2021) and 76.1g/100g reported for red gram organic flour (Rajesh *et al*., 2016). Lower water absorption capacity was obtained for KNS which implies that the flour is more hydrophilic than the starch. The oil absorption capacities of KGF and KNS were 104 % and 84.1 % respectively. The result showed that KGF can entrap more oil than KNS possibly because of its higher protein and fat contents. Oil absorption capacity is useful in flavour retention, improvement of palatability and extension of shelf life, particularly, in bakery or meat products (Adebowale & Lawal, 2004).

Protein gelation is very important in the development and acceptability of many foods, including vegetables and other products. The least gelation concentration (LGC) of KGF (14 % (w/v) was similar to the LGC value (14 %) of jack bean flour (Adebowale & Lawal, 2004). The low LGC of KNS is an indication that the starch can readily form gel when heated and this is a desirable quality in the food industry, where it can be used as a thickener, gelling or bulking agent. The pH of both flour and starch were below 7. KGF has a comparable pH with unfermented mung bean flour (6.24) as reported by Onwuruafor *et al*. (2014).

Table 2: Functional Properties of Kersting's Groundnut Flour and Kersting's Groundnut Starch

Parameters	KGF	KNS
Water Absorption Capacity (%)	130±1	120±1
Oil Absorption Capacity (%)	104±2	84.1±1.9
Least gelation concentrations % (w/v)	14	10
pH	6.33±0.02	6.96±0.02

Results are means of triplicate determinations
KGF = Kersting's groundnut flour KNS = Kersting's groundnut starch

Results of the swelling power and solubility of flour and starch of kersting's groundnut seeds investigated over the temperature range between 55 and 95°C are presented in Figures 1 and 2. From the curve, it was observed that there was a slight increase in the swelling power of both flour and starch between 55 and 75 °C, while a rapid increase was observed between 75 and 85 °C. However, the increase between 85 and 95 °C was only gradual. In these results, the swelling power of KNS was slightly higher than KGF. The lower swelling power of KGF when compared with KNS may be attributed to its higher protein content and presence of other food components. Jangchud *et al*. (2003) stated that differences in swelling power of starchy materials can be attributed to starch content, the presence of proteins, lipids, pre-treatment and processing history. The solubility of both flour and starch varies with temperature. Except at 65°C, KNS exhibited higher solubility at all temperatures when compared with KGF.

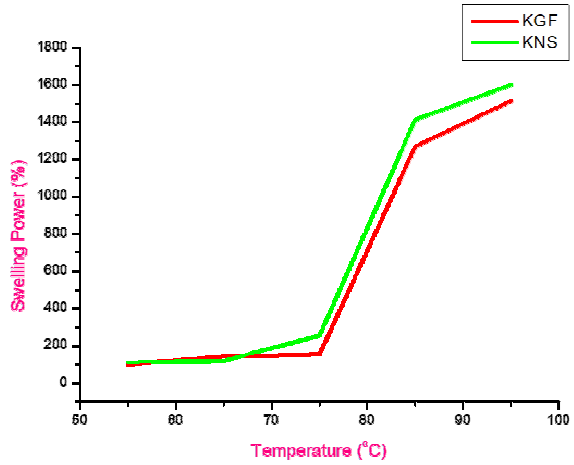

Figure 1: Swelling Power of Kersting's Groundnut Flour (KGF) and Starch (KNS)

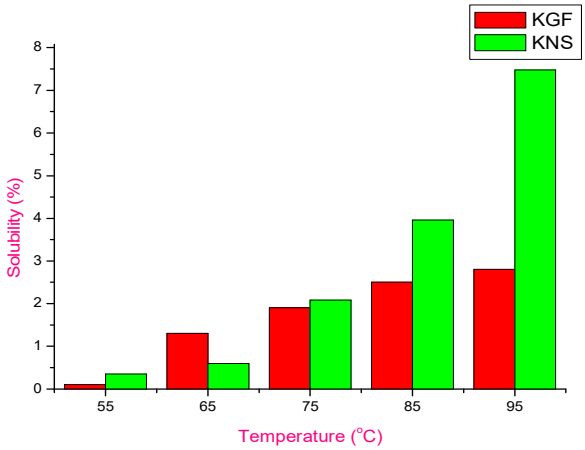

Figure 2: Solubility of Kersting's Groundnut Flour (KGF) and Starch (KNS)

3.3 *Pasting Properties*

The difference in the pasting parameters of flour and starch of kersting's groundnut are presented in Table 3. Observations from the results showed that KNS had higher pasting values for all the parameters determined except the peak time and pasting temperature. Decrease in pasting viscosities may be due to lower starch content in the flour and the presence of other food components, such as protein, lipid, etc. The high peak viscosity of KNS indicates that gel from starch dispersion of KNS was highly viscous when compared with sword bean starch with 438 RVU peak viscosity (Adebowale *et al*., 2006). It can be suggested that KNS has better thickening capacity than conventional starches which are important in stabilizing food system. The breakdown viscosity of KNS was 533 RVU. Breakdown viscosity is an index of the stability of the starch and a measure of the ease with which the swollen granules can be disintegrated (Kaur *et al*., 2007).

Setback represents amylose-amylose aggregation and the presence of fragmented granules embedded in the leached amylose network (Chung *et al*., 2008). The setback value of KNS (110 RVU) was higher than the reported setback value of white and red cowpea cultivars (71.17 and 91.56 RVU) as reported by Ashogbon & Akintayo, (2013). The high setback value implies higher tendency of retrogradation, this may be valuable in food products where gelling agents are needed. The pasting temperature of KNS (79.4 °C) which fell within the expected range for legume starches indicates high resistance towards swelling.

Table 3: Pasting Properties of Kersting's Groundnut Flour and Starch

Pasting Properties	KGF	KNS
Peak viscosity, PV (RVU)	208±2	801±17
Trough viscosity, TV (RVU)	178±4	269±5
Breakdown (PV- TV) (RVU)	30.0±3.0	532±13
Final viscosity, FV (RVU)	259±8	379±55
Setback (FV-TV) (RVU)	81.0±3.9	110±57
Peak Time (min)	5.91±0.04	4.09±0.19
Pasting temperature (°C)	83.0±1.0	79.4±1.0

Results are means of triplicate determinations
KGF = Kersting's groundnut flour KNS = Kersting's groundnut starch

3.4 *Morphology of Kersting's Groundnut Starch*

The scanning electron micrograph of KNS is shown in Figure 3. Granules of kersting's groundnut starch were predominantly oval to kidney shaped and although irregularly shaped granules were also found. KNS has granule width of between 9 and 24µm and granule length between 10 and 45µm. Oval shape has been reported for legume starch granules and it has also been confirmed by researchers that spherical, round, elliptical and irregularly shaped starch granules also exist in legume starches (Ashogbon *et al*., 2020). Starch granule morphology depends on the biochemistry of the chloroplast/amyloplast and the physiology of the plant (Singh & Kaur, 2016). Some authors (Mathobo *et al.*, 2020; Wang *et al.*, 2020) have reported that morphological properties of granules, size and surface play a significant role in the food and industrial utilization of starch.

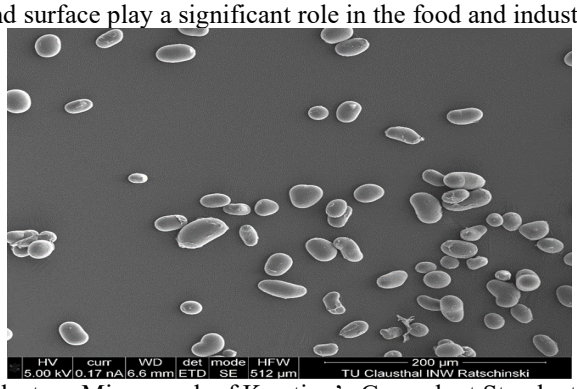

Figure 3: Scanning Electron Micrograph of Kersting's Groundnut Starch at 1500x Magnification

3.5 *X-ray Diffraction of Kersting's Groundnut Starch*

The X-ray Diffration (XRD) pattern of kersting's groundnut starch is presented in Figure 4. The diffractogram has been found to follow the expected "C" pattern characteristics of legume starches. Kersting's groundnut starch was characterized by a strong peak at 5.77, 5.12, 3.83 and a medium peak at 4.64 Å. Gernat *et al*. (1990), have shown that the 'C' crystalline polymorph is a mixture of 'A' and 'B' unit cells and that legume starches contain pure 'A' and 'B' polymorphs in varying proportions. Both 'A' and 'B' type starches are based on parallel stranded double helices in which the helices are closely packed in the 'A' type starch but loosely packed in the 'B' type starch. Generally, the A-type starches were found in cereals, B-type starches in root and tuber, while legumes are predominant in the C-type starches (Ashogbon *et al*., 2020). The C-type starch is more complex than the A- and B-starches and possesses remarkable characteristics depending on the distribution and the proportion of A- and B-type polymorphs (He & Wei, 2017)

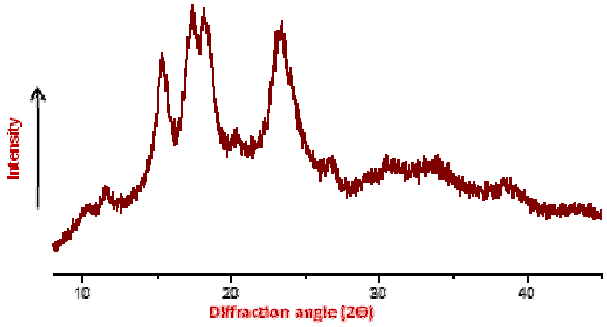

Figure 4: X- ray Diffraction of Kersting's Groundnut Starch

Conclusion

Results obtained from the study revealed that kersting's groundnut flour is a good source of protein. This flour can be added to convenient foods such as noodles to improve their nutritional quality. The water and oil absorption capacities of the flour showed that it has potential use in food systems as thickener and flavour retainer. The percentage starch yield (34.0%) showed that bean flour contains significant amount of starch which can be utilized as alternative source of starch for domestic and industrial purposes. The level of amylose content of bean starch would make it suitable for noodle production. High peak viscosity of the starch indicates its suitability for food products that need high gel and elasticity, while the high setback value which implies higher tendency of retrogradation, suggests that it may be used to modify the structural, mechanical and organoleptic properties of starch products such as jam, gels and jelly.

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