FUNCTIONAL AND RHEOLOGICAL PROPERTIES OF KUNU GYADA PRODUCED FROM EXTRUDED SORGHUM AND GROUNDNUT FLOUR BLENDS

Supported by tetfund

Orafa, P.N., Obudu. J. H. Haruna A. D., and Job, J.
Department of Food Science and Technology,
Federal University Wukari, P.M.B. 1020, Wukari, Nigeria
Correspondence: Orafa@fuwukari.edu.ng

Received: February 14, 2025, Accepted: April 28, 2025

Abstract: This study examines the functional, rheological and pasting properties of sorghum and groundnut blend extruded to produce instant kunu gyada . The sorghum and groundnut blend were extruded and fermented at a ratio of 78:22g. Functional, rheological, and pasting properties of the samples were determine using standard methods. Functional properties with bulk density, foaming capacity, gelation temperature, water absorption capacity and wettability of the flours increases from 0.607g/ml, 0.125 - 0.200ml/g, 62.500-73.500 ^{o}C, 7.860-8.400ml/g and 5.76-93.00s, respectively. The viscosity at 50 ranged from 65-359cp -86-203cp and 100 rpm ranged from 29-203cp -43-118cp and for both extruded and fermented flour at varying temperatures ranged from, respectively. There was increase in viscosity after extrusion. Pasting properties increased significantly in the extruded flour when compared with the fermented flour. The results of this study showed that the functional, rheological, and pasting properties improved after extrusion.

Keywords: Viscosity, Pasting. Extrusion, Fermentation, Kunu Gyada

Introduction

Kunu is a fermented non-alcoholic beverage consumed all over Nigeria. It is served as breakfast and is most popular in the northern part of Nigeria, and it is known for its extreme nourishing and therapeutic properties. *Kunu gyada* is a porridge from cereals, such as pearl millet, sorghum and maize which is produced by blending it with groundnut milk (Halilu, 2019).

In most cultures, food habits are based on the available agricultural raw materials. Traditional weaning foods are based on these local staples, namely rice, maize, millet, sorghum groundnuts, and beans. In the northern states of Nigeria, many traditional weaning foods are prepared mainly from cereals and grain legumes, either singly or in combination (Yunusa *et al*. 2021)

Extrusion cooking is a is a high temperature short time (HTST) process that mixes and conveyed a food material through an opening called die to give the desired attributes through increases in temperature, pressure, and shear forces (Filli *et al*., 2014; Gbenyi *et al*., 2016; Yunusa *et al*. 2022).

Sorghum (*Sorghum bicolour L*.) is a major source of calories in the diets of large number of the most widespread cereals consumed by adults and infants in Sub-Saharan Africa (SSA) and the fifth most important cereal crop in the world, which is used to prepare various dishes including gruel, fermented and unfermented bread, steamed cooked products (*dekkere*), stiff porridge (*tuwo*), snack foods, boiled whole or pearled, alcoholic and non-alc1oholic beverages (Yusuf *et al*., 2017; Kumar *et al*., 2015).

Sorghum porridge provides a substantial proportion of the protein and energy for many adults and infants in Nigeria. However, sorghum has a poor protein content and quality, low solubility, interactions with tannin Kumar *et al*., (2015). It is rich in and lysine and tryptophan, but deficient in the remaining essential amino. The sorghum protein quality can be optimized by blending it with other protein-rich legumes including soybean and groundnut. Groundnut (*Arachis hypogeal L*) is an important legume in Nigeria, rich in all the remaining essential amino acid deficient in sorghum and has potential to complement sorghum porridge Halilu, (2019).

Kunu gyada is one of the most important blends of cereals and groundnut prepared as breakfast food or weaning foods. It is very popular in northern Nigeria, just as *ogi* is in southern part of the country. It is taken as a breakfast beverage by children and adults. The combination of sorghum and groundnut in porridge (*kunu gyada*) not only brings distinctive flavor but also contributes to its nutritional composition. The study aims at comparative analysis on the functional, rheological and pasting properties of porridge derived from of sorghum and groundnut.

Material and Methods

Materials

Sorghum and groundnut seeds was purchased at new market, wukari, Taraba state

Preparation of Sorghum Flour

Sorghum grains
↓
Sorting
↓
Cleaning
↓
Dehulling
↓
winnowing and milling (attrition mill, de-demark super GX 160.55)
↓
Sieving (60 um)
↓
Heat sealing in polyethylene pouches
↓
Sorghum flour
↓
Storage

Figure 3. 1: Flow chart for the production of sorghum flour
Copied and modified: Ibrahim,2018

Production of Groundnut Paste

Groundnut
↓
Sorting/cleaning
↓
Roasting at 60 °– 90 ° C for 15 minutes
↓
Dehulling
↓
Milling
↓
Groundnut pastes

Figure 2 : Flow chart for the production of groundnut paste Copied and modified: Oche *et al*, (2016).

Preparation of Instant Kunu gyada

Sorghum flour /groundnut paste
↓
Mixing
↓
Adding liquids
↓
Mixing and kneading
↓
Extrusion process
↓
Cooling and drying
↓
Pulverizing
↓
Reconstitution with cold water
↓
Gelation
↓
Porridge (kunu gyada)

Figure 3: Flow chart for the production of instant *kunu gyada* by extrusion.
Source: modified (Yunusa *et al*. 2021)

Analytical Methods

Rheological Analysis

Viscosity Measurement

A Brookfield rotational viscometer (Model LV8 Viscometer UK Ltd). Was used for measuring the viscosities of the two samples (extruded and fermented sorghum and groundnut) at 55,60,65,70,75°C using a spindle of size 62 of the viscometer. Viscosity reading was in centipoises(10-3Ns/m2). About 20ml of the sample was placed in a water bath and allowed to increase in temperature with the maximum temperature at 75°C. The viscosity of the sample was measured at 55,60,65,70,75°C at 50 and 100 rpm and the viscosity reading were replicated two times Derbrew and Moges. (2017)

Functional Analysis

The following functional analysis was determined:

The Foam Capacity (FC)

The FC was determined using the method of Radha *et al*. (2008) with slight modifications. Briefly, a 2% aqueous dispersion (20 mg/mL) of the sample will be mixed thoroughly in a blender for 1 min at high speed and the content was immediately transferred into a graduated measuring cylinder. FC (obtained after 30 min of standing) was calculated using the equations below:

FC= Volume of foam after whipping _ volume of foam before whipping / Volume of foam before whipping

Water Absorption Capacity

Water absorption capacity was determined using the method modified by Yunusa *et al. (*2022); where 10 ml of distilled and deionized water were added to 1.0 g of the sample in a beaker. The suspension was stirred using magnetic stirrer for 5 min. The suspension obtained was then centrifuged at 3500 rpm for 30 min and the supernatant measured into a 10 ml cylinder.

Bulk Density

The volume of 10g of the flour was measured in a measuring cylinder (25ml) after tapping the cylinder on a table until visible decrease in volume was noticed. and based on the weight and volume, the apparent bulk density was calculated Chandra and Samsher, (2013). Bulk density = v1/v2

Where v1 is mass of flour

V2 is volume of cylinder

Wettability

The wettability of the flours was determined according to the technique of Nguyen *et al*., (2015). 3g of flour is placed in a graduated 25 ml test tube having a diameter. A finger was placed on the opening of the specimen (to avoid pouring the sample by reversing it). The finger closing the specimen were placed at a height of 10 cm from the surface of a 600 ml beaker containing 500 ml of distilled water. The finger was removed and the sample were poured into the beaker. Wettability is the time needed for the sample to become completely wet.

Gelation Temperature

The method described by Onwuka (2005) was used to determine Gelation Temperature. A test tube containing a 10% of the flour sample was prepared. The aqueous solution was then stirred continuously while heated in a water bath. The temperature was noted 30 seconds after gelatinization began and was observed visually. This process was repeated two times for each sample.

Pasting Properties

Pasting properties analysis: The pasting properties of the samples were determined using a

Rapid Visco-analyzer (Newport Scientific Australia) as described by Anderson *et al*. (2019). The peak, viscosity, trough, breakdown, final viscosity, set back, peak time and pasting temperature were read with the aid of Thermocline for Windows Software connected to a computer.

Statistical Analyses

Data was analyzed in two replicates by t-test using statistical package for social science (SPSS) version 27.00.the statistically significant difference ($p < 0.05$).

Results and Discussion

Pasting Properties of Kunu Gyada

The pasting properties of *Kunu Gyada*, with Sample A representing extruded sorghum flour with groundnut blend and Sample KG 2 representing fermented sorghum with groundnut blend (Table 4.4), revealed distinct trends that reflect the impact of processing methods on the starch characteristics and behavior.

The peak time results ranged from 4.68 -4.81 which indicate that the extruded has high starch granules then fermentation it is due to the high temperature and shear forces during the extrusion which led to rapid gelatinization and swelling during extrusion. Higher pasting temperature values recorded for blends containing soybeans could be due to the buffering effect of fat (from soybean) on the starch component of sorghum (Oluwamukomi *et al.*, 2005).

The peak viscosity ranged from the 161.00-259 RVU which show high peak viscosity in the extruded than in the fermentation, Peak viscosity refers to the maximum viscosity achieved during the pasting process, reflecting the gel strength and water-binding capacity of the starch. The extruded had the higher peak viscosity observed can be attributed to the gelatinization of starch molecules cause by the extrusion process (Anderson *et al*., 2019). The intense heat and mechanical energy applied during extrusion would have disrupted the starch granules, allowing for better hydration and swelling.

The trough, breakdown, final viscosity and setback viscosity value had significant effect at (p<0.005) effect on the samples. values obtained for this parameter ranged from 23.50-136.10 RVU,8.50-124.00 RVU,247.00-340.00RVU,124.90-204.15RVU respectively the trough ranged from 23.50-136.10 RVU which extruded, had higher trough value suggests a more pronounced setback in viscosity compared fermented. The extrusion process may have altered the starch molecules, leading to a weaker gel network that is more prone to retrogradation. The breakdown of starch components during extrusion could result in a less stable gel structure, reflected in the higher trough value in extruded

The breakdown viscosity value raged from 8.50-124.00 RVU 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). In the context of extruded, a higher breakdown value suggests that the starch gel maintained its viscosity well after reaching the peak, indicating a more stable gel structure. The extrusion process likely resulted in starch molecules with enhanced gel strength, leading to less breakdown compared to fermented.

Final viscosity value ranged from 247.00-340.00RVU is a measure of gelling tendency and refers to the ability of the material to form a viscous paste or gel after cooking and cooling (Jan *et al*., 2016). In extruded sample, a higher final viscosity indicates the ability of the starch gel to retain viscosity and form a stable gel network after cooling. The extrusion-induced modifications in starch molecules likely contributed to the higher final viscosity observed in extruded compared to fermented, where the fermentation process may have led to a weaker gel structure and lower final viscosity. This increase in final viscosity values at the end of the cooling cycle could be due to the alignment of amylose chains and other interactions between proteins, lipids, and complex carbohydrates (Kaur *et al.,* 2007).

Pasting temperature ranged 80.00-85.30° temperature at which the starch paste reaches peak viscosity during heating. The pasting temperature can be influenced by the gelatinization properties of the starch. In extruded, the extruded sorghum flour with groundnut may have exhibited a lower pasting temperature due to the pre-processing effects of extrusion, which could have partially gelatinized the starch granules, making them easier to hydrate and swell at lower temperatures

Table 1: Pasting Properties of *Kunu Gyada from extruded sorhum and groundnut*

Samples	Peak time	Peak viscosity	Trough	Breakdown	Final viscosity	Pasting temperature	Setback
KG1	$4.81^{f}\pm0.007$	$259.00^{b}\pm0.00$	$136.10^{d}\pm0.14$	$124.00^{e}\pm1.41$	$340.00^{a}\pm0.00$	$80.00^{g}\pm0.00$	$204.15^{c}\pm0.21$
KG2	$4.68^{g}\pm0.45$	$161.00^{c}\pm1.41$	$23.50^{e}\pm0.71$	$8.50^{f}\pm0.14$	$247.00^{a}\pm0.0$	$85.30^{d}\pm0.00$	$124.90^{b}\pm0.00$

Data presented as mean ± standard deviation (n=2). Means with the different letters (subscript) in the same column indicate values that are significantly different (p 0.05)

KG1 - Extruded *kunu gyada* KG2 - Fermented *kunu gyada*

Viscosity of Kunu Gyada

The viscosity profile ranged from 55°C, 60°C, 65°C, 70°C, 75°C respectively the values obtained from this parameter ranged from 29.50-86.50 ,39.50-89.30,70.50-129.50,107.50-324.50,203.50-357.50 Pa respectively. The higher viscosity exhibited by the extruded blend suggests a more viscous and potentially thicker texture, which could enhance attributes such as mouth feel, stability, and sensory perception. This increased viscosity may also indicate improved water holding capacity and better stability during storage, which are crucial factors in food product development. Conversely, the lower viscosity in the fermented blend stems from the enzymatic activities of microorganisms during the fermentation process (Filli et al., 2010).

Table 2 Viscosity of Kunu Gyada at 50RPM

Sample	**55°C**	**60°C**	**65°C**	**70°C**	**75°C**
KG1	$86.50^{a}\pm0.70$	$89.30^{a}\pm0.70$	$129.50^{a}\pm0.70$	$324.50^{a}\pm0.70$	$357.50^{a}\pm0.70$
KG2	$29.50^{b}\pm0.71$	$39.50^{b}\pm0.71$	70\.$50^{b}\pm2.12$	$107.50^{b}\pm2.12$	$203.50^{b}\pm4.95$

Data presented as mean ± standard deviation (n=2). Means with the different letters (subscript) in the same column indicate values that are significantly different (p 0.05). KG1 - Extruded *kunu gyada* and KG2 - Fermented *kunu gyada*

Functional Properties of Extruded and Fermented Kunu Gyada Flour

Table 3 presents the functional properties of extruded and fermented *kunu gyada* flour. Processing methods had significant effect ($p \leq 0.05$) on the functional parameters under consideration. Values obtained for bulk density, foaming capacity, wettability, water absorption capacity, and gelation temperature ranged from 0.60-0.61 ml/g, 22.5-24.0ml/g, 57.6-93.0 ml/g, 7.86-8.40 ml/g, 62.50-73.5 degree respectively.

The extruded has a bulk density of 0.60g/ml which was not of any significant difference fermented sample 0.60g/ml as shown at table 3. the result is lower than 0.90 g/ml as reported by Duguma *et al*., (2021). for extruded composite flour (oats, soybean and linseed) This shows that extrusion process had no great effect on the blend. Bulk density (BD) is the measure of heaviness of flour (Oladele and Aina.,2007).BD represent the porous structure of the extrudate, and the fermented flour and it can be defined as the heaviness of the extruded and fermented material (Nagaraju *et al*.,2021). Bulk density indicates the relative volume of packaging material required. Segev *et al*., (2012) reported that higher bulk density is generally desirable for the reduction of paste thickness and the greater ease of dispensability which is desirable for in the preparation of infant and weaning foods. The higher bulk density is attributed to more crude fiber in the blends Nagaraju *et al*., (2021); Dayakar *et al*., (2018).

In this study the wettability of the samples ranges from 57.6-93.00 with extruded sample having the highest value. This could be due to the increase in soluble fiber during extrusion in which takes higher time to dissolve completely due to the gelatinization of starch at low moisture content during extrusion. The optimized wettability of this study agrees with the findings of Yunusa *et al*., (2022); Danbaba *et al*. (2016) that for a product to be considered instant, it must ultimately become wet within a few seconds. Therefore, the porridge in this study may be regarded as an instant porridge because the open texture allows for the absorption of water quickly.

The foaming capacity, water absorption and gelation temperature show great significant effect at ($P<0.05$) where all extruded values were higher than the fermented this could be attributed to solubilization and dissociation of proteins leading to exposure of non-linear constituents in the protein matrices (Deepali *et al*., 2013).

Table 3: Functional Properties of Extruded and Fermented Kunu Gyada

SAMPLE	BD(g/ml)	FC(g/ml)	WET(s)	WAC(g/ml)	GT (oC)
KG1	$0.60^{e}\pm0.262$	$24.0^{c}\pm0.071$	$93.00^{a}\pm1.414$	$8.40^{d}\pm0.007$	$62.50^{b}\pm0.707$
KG2	$0.60^{e}\pm0.026$	$22.5^{b}\pm0.035$s	$57.6^{d}\pm0.509$	$7.86^{c}\pm0.014$	$73.50^{a}\pm0.707$

Data presented as mean ± standard deviation (n=2). Means with the different letters (subscript) in the same column indicate values that are significantly different (p 0.05).
KG1- extruded kunnu gyada and KG2- fermented kunnu gyada,
BD is bulk density, FC is foaming capacity, WAC is water absorption capacity, WET is wettability, GT is gelation temperature.

Conclusion

The kunu gyada produced from the blends of sorghum and groundnut yielded better results in the respect of its nutrients. the improved blends also recorded great acceptability rate in relation to the consumed of kunu gyada made from sorghum and groundnut. From the results obtained in the study, we concluded that the incorporation of the groundnut into the kunu will give good degree of diversification of the product and also improved the sensory qualities. The result of the study showed that the functional, rheological, and pasting properties of kunu gyada improved after extrusion. The rheological properties of the extruded which is the viscosity increased significantly compared to the fermented after extrusion. The pasting properties of the extruded had higher peak viscosity and breakdown compared to the fermented. Extrusion of sorghum and groundnut blends at this ratio of 78: 22g is recommended for the production and consumption of instant kunu gyada..further studies should be carried out the storage stability and safety of the product.

Acknowledgements

Authors appreciate Mrs. Orafa Patience Nguseer of Department of Food Science and Technology of Federal University Wukari Taraba State for providing the enabling environment to carry out the analysis for this study.

References

Derbrew, H., & Moges, D. (2017). Effect of germination duration on nutritional and functional properties of sorghum (sorghum bicolor). *Ethiopian journal of science and technology*,10(3) 165-180.

Deepali A, Anubha U, Preeti SN, & Krishi VKD (2013). Functional characteristics of malted flour of foxtail, barnyard and little millets. *Annals Food Sci. & Tech.*,14(1): 44-49.

Gbenyi, D.I., Nkama, I., and Badau, M. H. (2016). Physical and Functional Properties of Extruded Sorghum-Cowpea. *Food Science and Quality Management*, 1.

Gbenyi, D.I., Nkama, I., and Badu, M.H. (2016). Modeling mineral profile of extruded sorghum,bambara groundnut breakfast cereals. *british journal of applied science and technology*,17(4),1-14.

Halilu, M. (2019). Production of a nutritionally improved and shelf stable ready-toconsume kunnu gyada powder made from blends of rice,groundnut,sesame seed and germinated soybean.Doctoral thesis,university putra Malaysia

Kumar, T.V.A., Samuel, D.V.K., Jha, S.K., and Sinha, J.P. (2015). Twin screw extrusion of sorghum and soy blends: a response surface analysis. *journal of Agriculture science technology*,17(3) 649-662.

Nguyen, D.Q., Mounir, S., Allaf, D. (2015). Functional properties of water holding capacity, oil holding capacity, wettability, and sedimentation of swell-dried soybean powder. *scholars journal of engineering and technology*,3(4) 402-412.

Oluwamukomi, M.O, Eleyinmi M.O. (2005). Effect of Soy Supplementation and its stage of inclusion on the quality of ogi – a fermented maize meal. *Food Chem.*, 91: 651-657.

Yunusa, B. M, Siddiqui, S.A and Jiddum, F. A. (2023). Effect of extrusion cooking on some physical and functional properties of instant porridge from blends of sorghum and groundnut. *ssrn*, 37

Yunusa, B.M., Filli, K.B., Jiddum, F.A. (2022). Application of RSM in modelling and numerical optimization of proximate composition of instant extruded Kunu Gayda (porridge) from blend of sorghum-groundnut. *journal of food science and technology 7(1)*, 431-441.

Yusuf, M., Halilu, M., Umari., and filli, K.B. (2017). Effect of barrel temperature feed composition and feed moisture content on some functional properties of dakuwa extrudates from blends of sorghum, groundnut and tiger nut. *Africa journal of food science and technology*,8(9) 150-161.

Radha, C., Ramesh, k., Prakash, V. (2008). Preparation and characterization of a protein hydrolysate from an oilseed flour mixture. *food chemistry*,106(3) 1166-1174.