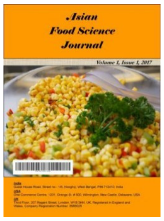

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Effects of Extrusion Components on the Compositional Characteristics of an Instant Gruel Produced from Millet-Pigeon Pea Flour Blend

G. O. Nwezeh[1] and M. B. Ndaliman[1*]

[1]*Department of Nutrition and Dietetics, The Federal Polytechnic, Bida, Niger State, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Author GON wrote the first draft of the manuscripts, designed the study. Author MBN carried out the experimental design and analysis, interpretation, vetting of the manuscripts and its final approval. Both authors read and approved.

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ABSTRACT

Extrusion cooking was used to formulate millet-pigeon pea flour blend with the aim of providing high energy, protein enriched and affordable foods for malnourished children. Five extruded samples were developed from millet-pigeon pea flour blend via extrusion cooking by loading the raw material in the feeding hopper and the screw conveys the raw materials. When the raw materials pass down the barrel, the volume is reduced and the food is compressed under pressure into a semi-solid, plasticized and form extrudates that were used for expansion index, bulk density and water absorption capacity index. Furthermore, the expansion index of 11.16, bulk density of 0.03 g/ml and swelling index of 4.10 at the screw speed of 180 to 200 rpm, feed moisture content of 15 to 25% and feed blend composition of 20 to 25% were obtained. The result of the proximate composition of the extrudates revealed that the moisture content was found to be significantly ($p<0.05$) higher in sample C (6.05) than values observed in sample A (3.68) as the concentration of pigeon pea decreases. In case of protein content, sample C (29.60) was observed to be statistically ($p<0.05$) higher among other samples. Similarly, the fat content was observed to be statistically ($p<0.05$) lower in sample C (2.03 g/100 g) and higher in sample A (3.53 g/100 g). The fibre content of millet-pigeon pea flour blend was observed to be significantly ($p<0.05$) higher in

**Corresponding author: Email: mohammedbankin@gmail.com;*

sample B than the value observed in sample A when the concentration of pigeon pea composition increased. The result of ash content indicated that sample B was significantly ($p<0.05$) higher than sample A. The carbohydrate content showed that sample A (68.34 g/100 g) was significantly ($p<0.05$) higher and lower in sample B (64.56 g/100 g). This increase in sample A could be attributed to low screw speed and high feed blend composition. The results of mineral content indicated that sodium content showed that sample A (3.01 mg/100g) was significantly higher than sample B (2.87 mg/100 g). The results of calcium content indicated that Sample B (3.56 mg/100g) was significantly higher and lower in sample C (2.86 mg/100 g). Similarly, the findings of magnesium and phosphorus content indicated that sample B was significantly ($p<0.05$) higher than value observed in sample D. The results of iron and zinc content of instant porridge produced from millet-pigeon pea flour blend showed that sample C was significantly ($p<0.05$) higher than sample A. The results of sensory properties of instant gruels produced from millet-pigeon pea flour blend indicated that sample C were statistically ($p<0.05$) higher in taste (8.34) and flavour (6.98) which could be attributed to higher screw speed and feed moisture content (Table 3.4). Thus, the result of texture indicated that sample B (7.92) was significantly ($p<0.05$) higher than value obtained in sample D (7.00). Unlike, colour rating and general acceptability of extrudates, sample C were statistically ($p<0.05$) higher when the feed moisture content increases. It was concluded that instant gruels were formulated from millet-pigeon pea which improved both the physical, chemical and sensory properties of the products.

Keywords: Home food porridge; millet; pigeon-pea; extrusion components; extrudates.

1. INTRODUCTION

Home food porridge is one of the indigenous foods developed from millet, sorghum and maize in Africa especially Nigeria. It is a semi solid food produced from cereals including millet, sorghum and maize. Similarly, there is slight variation in the preparation among different region from several communities. But the main ingredients used for the production remain unchanged (millet, sorghum and maize). Depending on the rural communities, the major limitations in its production are home based associated with local equipment and methods, contamination during processing, inconsistent quality of the product and short storage stability. Instant gruel is a precooked flake starch pulverized and mixed with water or milk for infant feeding, weakened individuals and family breakfast [1].

Extrusion technology plays a central role in improving food and nutritional security for production of wide range of products associated with breakfast cereals, flakes, quick cooking paste, instantised legume powders and breakfast gruel [2]. This technology requires a high temperature short time (HTST) cooking process which offers hope for developing nations [3]. It has the ability to produce a shelf stable food of reduced microbial load, minimal anti-nutrient content and low moisture content which do not require refrigeration storage. Similarly, products with these characteristics are suitable for countries like Nigeria where infrastructure is limited and inadequate [4]. Extrusion method is one of the contemporary food processing technologies applied to foods in order to solve the problems associated with traditional cereal based products in terms of functional properties, physical state and shelf life [5]. It offers many advantages over spray-drying and roller drying technologies in terms of preparation of ready-to-eat foods of desired shape, size, texture and sensory characteristics at very low processing cost [6,7].

Pearl millet (*Pennisetum glaucum*) is an important food crop and the sixth among cereals crop that contribute to the amount of daily nutrients needed by people in tropical areas [8]. It is grown mostly in areas of low rainfall and it has the ability to withstand adverse agro-climatic conditions [9]. More than 80% of cereals production is used for human consumption, especially in the tropical areas of Africa. Several food formulations are prepared from pearl millet in Africa. In Nigeria, pearl millet serves as staple food in the form of beverages, including bread gruels, porridges and snacks food for the less privileged and low income earners, especially in their respective societies [10,11]. In addition to their nutritive value, several potential health benefits such as curing of cancer and cardiovascular diseases, reducing tumor incidence, lowering blood pressure, risk of heart disease, cholesterol and rate of fat absorption, delaying gastric emptying, and supplying gastrointestinal bulk have been reported for millet

[12,13]. Therefore, millet grains has gained specific attention from developing countries in terms of utilization as food as well as its good potential that could contribute to nutritional health benefits [14]. Several efforts have been made to improve the traditional food processing using modern extrusion cooking technology for proper diversification and utilisation of millet. Therefore, with value-added strategies and appropriate processing technologies (extrusion), the millet grains can find a place in the production of several value-added products which could result in high demand from large urban populations and non-traditional millet users [15].

Leguminous and cereals crops provide the major sources of calories and proteins for the large population of the world [16]. The composition of amino acid complement those of the cereal proteins, and this provides a better opportunity to reorganise starch and protein based components to produces a variety of convenience foods. Pigeon pea (*Cajanus cajan)* has become an indigenous crop in Nigeria and one of the major leguminous crops cultivated in the tropics [17]. It is considered the number four after ground-nut, cowpea and bambara ground-nut. Grain legumes are recommended because of their protein content which make them indispensable along with cereals in human diet. The plant has been listed among the under-utilized legumes with broad potentials and its seed flour was exploited for biscuit production [18,19]. According to Amaefule and Obioha [20], the major limitation in utilization of pigeon pea is its inability to cook fast. Nutritionally, it contains about 17-30% protein which recommend its use for complementary and breakfast cereal [21]. The seed is rich in nutrients making it an ideal supplement to traditional cereals and tuber-based diets of Africans which are generally protein deficient [22]. Hence, the aim of this study was to develop an instant gruel from millet-pigeon pea flour blend using extrusion cooking method with objectives of determining some physical, chemical and functional properties of the gruel

2. MATERIALS AND METHODS

2.1 Materials

2.2.1 Sample collection

Millet (*Pennisetum glaucum*) was collected from breeding programme, National Cereals Research Institute Badeggi Niger State, and Pigeon pea (*Cajanus cajan*) was purchased from Minna Modern Market, Niger State. All chemicals/reagents used were of analytical grades.

2.2.2 Processing of samples

Ten kilogrammes of millet grain were manually cleaned and dried. The dried grains were milled into flour using attrition mill and sieved to pass through a 2 mm sieve mesh. The sieved flour was packaged in polyethylene bag until required for extrusion. Pigeon pea seeds (5 kg) were cleaned from all the foreign materials and soaked in cold water for three (3) hrs, and followed by continuous rubbing with hand to remove the seed coat. Furthermore, the water was drained off and the seeds were dried until constant weight was achieved. The dried seeds were milled using attrition mill and sieved to pass through a 2 mm sieve mesh. It was then packaged in polyethylene bag for extrusion.

2.2 Composite Flour Formulation

Millet and pigeon pea flours were mixed at different proportion (10-25 wet weight basis) with millet as the basic ingredients. The moisture content of flour of different ratios was measured by hot air oven method. After getting the initial moisture content of the blends (M_1), the blended samples were conditioned to appropriate moisture content by spraying with a calculated amount of water and mixing continuously at medium speed in a blender. The samples were put in closed containers and stored overnight. The amount of water to be added was calculated according to Wilmot [23].

$$W_w = W_d \times \frac{(M_2 - M_1)}{(1 - M_1)(1 - M_2)} \quad (2.1)$$

Where W_w is the amount of water to be added, W_d is dry weight of the raw flour, M_1 is initial moisture content and M_2 the desired moisture content.

2.3 Extrusion Experiment

In order to define the experimental range, a small scale laboratory single screw extruder (DUISBURG DCE – 330 Models Germany) with three zones (feeding, cooking and die zones) equipped with a screw feeder and a 3mm die was used to extrude the different samples. This was done by varying millet (90, 85, 82, 80 and 75

Table 1. Experimental design of mixed flour ratio associated with other extrusion variables

Samples	Screw speed (rpm)	Feed moisture content (%)	Feed blend composition (%)
Sample A	100	10	10
Sample B	150	15	15
Sample C	180	18	18
Sample D	200	20	20
Sample E	250	25	25

respectively) with pigeon-pea (10, 15, 18, 20 and 25 respectively) at different ratios. Thus, samples were collected and dried overnight in an oven at 60℃. These samples were then removed from the oven and stored in a desiccator for further analysis.

2.4 Determination of Functional Properties

2.4.1 Bulk density

The method of Onwuka [24] was employed where ten grams of each sample were measured into a clean 100 ml graduated measuring cylinder and its volume was recorded in each case. However, the bottom of the cylinder was tapped repeatedly on a padded table until no further reduction was seen in volume. The volume was recorded as the packed volume. The bulk density was calculated based on the volumes using the general formula below:

$$\text{Bulk density (g/ml)} = \frac{\text{Weight of Sample (g)}}{\text{Volume occupied by the sample (ml)}} \quad (2.2)$$

2.4.2 Expansion index (EI)

Expansion index was determined by dividing the cross sectional area (mean of five measurements) of the extrudates by the cross-sectional area of the die nozzle [25]. Six lengths of extrudates (approximately 120 mm) were selected at random during collection of each of the extruded samples. The diameter of the extrudates was measured at 10 different positions along the length of each of the six samples, using a vernier caliper. Expansion Index (EI) was calculated using the mean of the measured diameters.

$$\text{Expansion index} = \frac{\text{Diameter of the extrudate}}{\text{Diameter of the nozzle}} . \quad (2.3)$$

2.4.3 Water absorption capacity

The water absorption capacity was determined using the method described by Qing-Bo et al. [26]. The ground extrudates was suspended in water at a temperature of 30℃ for 30 min; it was stirred gently during this period and centrifuged at 3000 × g for 15 min. The supernatant was decanted into an evaporating dish of known weight. The water absorption capacity was considered as the weight of gel obtained after removal of the supernatant through a strainer per unit weight of original dry solids.

$$\text{Water absorption capacity} = \frac{\text{Weight of wet sediment}}{\text{Weight of dry sample}} \quad (2.4)$$

2.5 Proximate and Mineral Composition

Moisture, Fat, Protein, Fibre, Ash and Mineral (Mg, Ca, Zn, Fe, P, Na and K) composition were determined using AOAC, [27], while Carbohydrates were calculated by difference. Gross energy value (Kcal/100 g) was calculated as described by FAO [28].

2.6 Statistical Analysis

Data collected were expressed as mean ± standard deviation. Analysis of Variance (ANOVA) using Duncan Multiple Range were carried out to determine the differences among the samples with significant differences accepted at $p<0.05$.

3. RESULTS AND DISCUSSION

3.1 Physical Characteristics of Instant Gruels from Millet-pigeon pea Blend Using Extrusion Cooking Method

Physical characteristics are among the important components that describe the product quality in food formulations [29]. Thus, extrusion cooking is solely dependent on important components including moisture, feed content, particle size, temperature, screw speed, screw configuration and die plate [30]. The combined effect of these components and the nutritional properties of the extrudates determine the quality of the final product. Based on the selected physical characteristics, expansion index of the extrudates was found to be statistically ($p<0.05$) higher in sample C (11.16) than value observed in sample E (4.78). This could be as a result of pigeon pea composition. Seker, [31] reported that increasing screw speed with decrease in feed blend composition improved the expansion index during extrusion of soybean-corn flour. High starch content is associated with high expansion index especially where significant gelatinization occurs due to dough viscosity [32]. Low screw speed with increased feed blend composition affects expansion index during better dough development [33]. In case of extrudates obtained from rice-based expanded snack, expansion index was found to be significantly influenced by moisture content and barrel temperature [34]. Bulk density serves as important physical characteristics for extrudates which facilitate the level of expansion during extrusion cooking process [35]. Similarly, high screw speed has been associated to low bulk density due to starch gelatinization under such conditions [36]. Also, Ding et al. [37] reported that increase in screw speed reduces bulk density. The lower bulk density observed in sample C (0.03) could be due to slight increase in screw speed and lower feed blend composition that could stay together to increase energy content derivable from such diet [38]. In this study, the bulk density values of the extrudates suggested that the samples could be used as complementary food with high nutrient density and semi-solid consistency.

Water absorption capacity is a determination of starch digestibility and dextrinization [39]. During extrusion cooking, sample C (4.10) showed reduction in water absorption capacity associated with the presence of polar head groups which determines its interaction with water molecules during production of the blends. Similarly, slight increase in screw speed was revealed to support low swelling index during extrusion cooking of starch based binders [40]. Complementary foods do not need high water absorption capacity because it could result in low nutrient density associated with maximum water holding index and less solid.

3.2 Proximate composition (%) of Instant gruels from Millet-pigeon pea blend using Extrusion Cooking Method

Proximate composition of the formulated millet-pigeon pea blend was shown in Table 3.2 The moisture content was found to be significantly ($p<0.05$) higher in sample C (6.05 g/100 g) than values observed in sample A (3.68 g/100 g) as the concentration of pigeon pea decreases. The results suggested that variation in moisture content was associated with the higher screw speed. Similarly, higher screw speed lead to low quantity of water absorbed by the extrudates [41]. The findings of this study indicated that the extrudates had low moisture content that could extend its shelf life. Danbaba et al. [42] reported that moisture content between 6% and 10% support extension of shelf life of dry food products; and above this range, the shelf life stability of the products could be affected by both chemical and microbiological agents. In case of protein content, sample C (29.60 g/100 g) was observed to be statistically ($p<0.05$) higher among other samples (Table 3.2). This increase could be attributed to addition of pigeon pea composition. Filli et al. [43] showed that fortification of millet with cowpea for development of fura extrudates resulted in the rise of protein content from 11.23% to 16.23% due to addition of cow pea. Similarly, the fat content was observed to be statistically ($p<0.05$) lower in sample C (2.03 g/100 g) and higher in sample A (3.53 g/100 g). Low fat content observed in sample C could be associated to increase in screw speed and feed blend composition (Table 3.2) since most legumes such as pigeon pea contain less than (3%) of fat. The reduction of fat content observed in this study was in agreement with the findings of Anounye et al. [44] where significant reduction in fat content was reported when soybean was blended with acha. High screw speed was also linked to lower fat content as reported by Filli et al. [45]. Fats are important in the body and also regarded as carriers of fat soluble vitamins in the diet and as mediators of some physiological activities associated with development, inflammation and brain function [46]. The fibre content of millet-pigeon pea flour blend was observed to be significantly ($p<0.05$) higher in sample B (6.31 g/100 g) than value observed in sample A (4.48 g/100 g) when the concentration of pigeon pea composition increased. Fibre is very important in maintaining healthy life as increased risk of coronary heart disease could occur to individuals who consume low levels of fibre over time [47]. It also promotes beneficial effects associated with lowering of cholesterol [48]. The result of ash content indicated that sample B (1.35 g/100 g) was significantly ($p<0.05$) higher than sample A (0.97 g/100 g). In this study, the significant ($p<0.05$) differences in ash content was associated with

Table 2. Physical characteristics of Instant gruel from Millet-pigeon pea Flour blend

Parameters	Sample A	Sample B	Sample C	Sample D	Sample E
Expansion Index	7.62±0.04[c]	6.46±0.05[b]	11.16±0.1[d]	5.76±0.07[ab]	4.78±0.03[a]
Bulk density (g/ml)	0.09±0.01[a]	0.06±0.03[a]	0.03±0.04[a]	0.04±0.02[a]	0.07±0.06[a]
Water absorption capacity	5.08±0.08[b]	5.05±0.10[b]	4.10±0.07[a]	5.69±0.03[b]	5.06±0.05[b]

Values are expressed as mean± Standard Deviation. Values with different superscripts on the same row are significantly different at p<0.05.
Sample A= 90% millet:10% pigeon-pea Sample B = 85% Millet:15% Pigeon-pea Sample C= 82% Millet:18% Pigeon-pea Sample D= 80% Millet:20% Pigeon-pea Sample E= 75% Millet:25% Pigeon-pea

Table 3. Proximate Composition (%) of Instant gruel from Millet-Pigeon pea flour blend

Parameters	Sample A	Sample B	Sample C	Sample D	Sample E
Moisture	3.68±0.06[a]	4.12±0.08[b]	6.05±0.09[c]	4.11±0.07[b]	4.13±0.10[b]
Protein	20.24±0.07[a]	22.91±0.04[b]	29.60±0.01[d]	24.56±0.02[c]	25.01±0.05[c]
Fat	3.53±0.08[c]	2.09±0.02[a]	2.03±0.07[a]	2.22±0.11[b]	2.24±0.05[b]
Fibre	4.48±0.06[a]	6.31±0.08[c]	5.50±0.02[a]	5.72±0.04[ab]	5.57±0.03[a]
Ash	1.35±0.10[b]	1.37±0.06[b]	0.96±0.04[a]	1.13±0.03[a]	1.16±0.05[a]
CHO	66.72±0.01[c]	63.20±0.03[b]	55.86±0.05[a]	62.26±0.02[b]	61.89±0.04[b]
Energy	379.61±0.02[c]	363.25±0.06[b]	360.11±0.04[a]	367.26±0.01[b]	367.76±0.08[b]

Values are expressed as mean± Standard Deviation. Values with different superscripts on the same row are significantly different at p<0.05. CHO=Carbohydrates
Sample A= 90% millet:10% pigeon-pea Sample B = 85% Millet:15% Pigeon-pea Sample C= 82% Millet:18% Pigeon-pea Sample D= 80% Millet:20% Pigeon-pea Sample E= 75% Millet:25% Pigeon-pea

lower screw speed and feed moisture content in the samples. El-Samahy et al. [49] showed that blending of rice with cactus pear resulted in significant (p<0.05) differences in ash content. The carbohydrate content showed that sample A (68.34 g/100 g) was significantly (p<0.05) higher and lower in sample B (64.56 g/100 g). This increase in sample A could be attributed to low screw speed and feed blend composition. High carbohydrate values could be attributed to carbohydrate of the raw material that were not affected by processing. Energy store of food products is generally indicated by its high carbohydrate composition. Similarly, variation in pigeon pea composition affected the overall carbohydrate content as observed by Filli et al. [50]. Similarly, the differences in calorific values of the developed millet-pigeon pea blend would promote its wider application and utilization in food industry; especially in development of ready-to-eat foods [51].

3.3 Mineral composition (mg/100 g) of Instant Gruels from Millet-pigeon pea blend Using Extrusion Cooking Method

Minerals in foods are chemical components that cannot be ordinarily synthesized and are required for normal metabolic activities of the body [52]. However, sodium is one of the minerals whose high intake is considered as a factor in the etiology of hypertension; hence its low intake is encouraged [53]. The results of sodium content showed that sample A (3.01 mg/100 g) was significantly higher than sample B (2.87 mg/100 g). This increase could be as a result of the decrease in screw speed during extrusion of the extrudates [54]. Also, lower screw speed favored sodium content due to the activity of phytic enzymes [55]. The results of calcium content indicated that Sample B (3.56 mg/100 g) was significantly higher and lower in sample C (2.86 mg/100 g). Higher calcium content has been attributed to millet and pigeon pea as a good dietary sources of minerals. Calcium is the most important mineral that is needed by the body and its deficiency is more prevalent than any other minerals [56]. Also, Singh et al. [57] reported the increase in calcium, phosphorus and iron content during production of cereal based extrudates which was attributed to feed composition and water content. Calcium, phosphorus and vitamin D combined together to prevent rickets in children and Osteomalacia (the adult rickets) as well as osteoporosis (bone thinning) among older people [58]. Similarly, the findings of magnesium content indicated that sample B (2.27 mg/100 g) was significantly (p<0.05) higher than value observed in sample D (1.70 mg/100 g). Also, the result of phosphorus contents was observed to be significantly

($p<0.05$) higher in sample B (1.55 mg/100 g) than value obtained in sample D (1.20 mg/100 g). This could be due to activities of protease, lipase and amylase during gelatinization of the extrudates which could serve as an added advantage for product enhancement, especially complementary food where potassium is an important macro nutrient among other minerals. It has been revealed that, magnesium is an activator of many enzyme systems which aids in maintaining the electrical potential of the nerve cells [59]. It assists in muscle contraction, blood clotting, and the regulation of blood pressure and lung functions [60]. Potassium is primarily an intracellular cation, which is bound to protein and functions together with sodium in maintaining the normal pH [61]. The results of iron and zinc content of instant porridge produced from millet-pigeon pea flour blend showed that sample C was significantly ($p<0.05$) higher than sample A. This increase could be attributed to destruction of antinutrients (phytic acid) during production of the extrudates. Minerals element such as iron, calcium and zinc are often added to food for the improvement of nutritional composition [62]. Similarly, iron and zinc act as cofactors for enzymes during normal metabolic processes [63]. In addition, iron is needed for the prevention of anaemia; while zinc is a component of living cells and essential for assisting enzyme reaction and wound healing [64].

3.4 Sensory Properties of Instant Gruels from Millet-pigeon pea Blend Using Extrusion Cooking Method

The results of sensory properties (Table 3.4) of instant porridge produced from millet-pigeon pea flour blend indicated that sample C were statistically ($p<0.05$) higher in taste (8.34) and flavour (6.98) which could be attributed to increase in screw speed with lower feed moisture content (Table 3.4). Thus, the result of texture indicated that sample B (7.92) was significantly ($p<0.05$) higher than value obtained in sample D (7.00) This result is in agreement with report of Iwe [65] who observed the increase in texture when cereal was blended with legumes. He also recommended that taste and flavour had physiological relativity depending on the consumer's responses. In addition, results from this work revealed that taste and flavour of the extrudates were improved during extrusion. Furthermore, Iwe [66] reported that slight variation observed in taste and flavour could be as a result of increase in screw speed and feed moisture content. Unlike, colour rating (6.55) and general acceptability (6.68) of extrudates, sample C were statistically ($p<0.05$) higher when the feed moisture content increases. These results were in agreement with Rampersad et al. [67] who reported the degree of likeness in all the sensory attributes.

Table 4. Mineral composition (mg/100 g) of Instant gruel from Millet-Pigeon pea flour blend

Parameters	Sample A	Sample B	Sample C	Sample D	Sample E
Na	3.01 ± 0.05^b	2.87 ± 0.08^a	2.99 ± 0.06^b	3.00 ± 0.04^b	2.98 ± 0.01^b
K	6.04 ± 0.03^b	5.95 ± 0.04^b	5.54 ± 0.01^a	5.90 ± 0.02^b	5.59 ± 0.07^a
Ca	3.42 ± 0.02^b	3.56 ± 0.05^c	2.86 ± 0.07^a	3.30 ± 0.03^b	2.93 ± 0.01^a
Mg	2.01 ± 0.05^b	2.27 ± 0.03^c	1.89 ± 0.10^a	1.70 ± 0.09^a	1.84 ± 0.02^a
P	1.47 ± 0.10^b	1.55 ± 0.15^b	1.45 ± 0.12^b	1.20 ± 0.11^a	1.41 ± 0.13^b
Fe	12.45 ± 0.04^a	13.34 ± 0.02^b	14.25 ± 0.03^c	13.59 ± 0.06^b	13.49 ± 0.08^b
Zn	6.81 ± 0.06^a	8.42 ± 0.08^b	9.44 ± 0.02^c	8.12 ± 0.03^b	8.07 ± 0.05^b

Values are expressed as mean± Standard Deviation. Values with different superscripts on the same row are significantly different at p<0.05. Sample A= 90% millet:10% pigeon-pea Sample B = 85% Millet:15% Pigeon-pea Sample C= 82% Millet:18% Pigeon-pea Sample D= 80% Millet:20% Pigeon-pea Sample E= 75% Millet:25% Pigeon-pea

Table 5. Sensory properties of instant gruel from millet-pigeon pea flour blend

Parameters	Sample A	Sample B	Sample C	Sample D	Sample E
Taste	8.09 ± 0.06^a	8.10 ± 0.07^a	8.34 ± 0.09^b	8.21 ± 0.05^b	8.15 ± 0.05^a
Texture	7.89 ± 0.04^b	7.92 ± 0.03^b	7.09 ± 0.01^a	7.00 ± 0.02^a	7.03 ± 0.05^a
Flavour	6.53 ± 0.03^a	6.91 ± 0.02^b	6.98 ± 0.01^b	6.65 ± 0.04^a	6.50 ± 0.05^a
Colour	6.12 ± 0.07^a	6.22 ± 0.05^b	6.55 ± 0.01^c	6.51 ± 0.03^c	6.05 ± 0.05^a
Acceptability	6.38 ± 0.05^a	6.63 ± 0.04^b	6.68 ± 0.06^b	6.66 ± 0.02^b	6.30 ± 0.05^a

Values are expressed as mean± Standard Deviation. Values with different superscripts on the same row are significantly different at p<0.05.
Sample A= 90% millet:10% pigeon-pea Sample B = 85% Millet:15% Pigeon-pea Sample C= 82% Millet:18% Pigeon-pea Sample D= 80% Millet:20% Pigeon-pea Sample E= 75% Millet:25% Pigeon-pea

4. CONCLUSION

In this study, an effort had been made to develop different samples from millet-pigeon pea flour blends using extrusion cooking method. The optimum extruded samples were established between 180 to 200 screw speed (rpm), 15 to 25% feed moisture content and 20 to 25% feed blend composition with optimum expansion index of 11.16, bulk density of 0.03 g /ml and water absorption capacity of 4.10. In conclusion therefore, convenient and affordable complementary foods could be produced from millet-pigeon pea blend using extrusion cooking method which improved both the physical, nutritional and sensory properties of the products.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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