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Quality Evaluation of Porridges Produced From Millet, Pigeon Pea and Crayfish Flours

Okoye, J.I., Umerah, N.N. and Ani, E.C.
Department of Food Science and Technology, Enugu State University of Science and Technology, P.M.B 01660, Enugu, Nigeria
Corresponding Author: Okoye, J.I.

Abstract: *The nutrient composition and organoleptic properties of porridges produced from millet, pigeon pea and crayfish flours were investigated. The millet flour was combined with pigeon pea and crayfish flours in the ratios of 90:5:5, 80:15:5, 70:20:10, 60:25:15, and 50:30:20 and used in the preparation of porridges. The proximate, mineral, vitamin and sensory properties of the porridges were evaluated using standard analytical methods. The protein, fat, ash and energy contents of the samples increased significantly (p<0.05) from 9.09±0.18 − 17.14 ± 0.40%, 1.30±0.03 − 3.19 ±0.10%, 3.10±0.07−4.14±0.03% and 346.78±1.14−362.07±2.64 KJ/100g, respectively as the ratios of pigeon pea and crayfish flours increased in the blends, while the crude fibre and carbohydrate contents decreased. The control sample without substitution with pigeon pea and crayfish flours (100% malted millet flour) had the highest crude fibre (3.56±0.14%) and carbohydrate (74.68±0.16%) contents. The mineral composition of the samples showed that the calcium, magnesium, phosphorus, potassium, iron and zinc contents of the samples increased sequentially with increase in substitution with pigeon pea and crayfish flours from 21.73±0.64 − 41.24 ± 0.17mg/100g, 37.39±1.32 − 42.88±0.79mg/100g, 83.60±1.27 −145.90±1.39mg/100g, 36.80±1.32 −50.07±1.66mg/100g, 21.29± 0.18−28.05±0.27mg/100g and 4.54±0.11 – 7.99 ± 0.24mg/100g, respectively. The vitamin content of the samples also revealed that the ascorbic acid, thiamine, niacin, riboflavin, folic acid and vitamin A contents of the samples increased significantly (p<0.05) as the levels of substitution of pigeon pea and crayfish flours increased in the blends. The control sample (100% malted millet flour) had the least values for all the vitamins evaluated. The sensory attributes: colour, taste, texture and aroma of the control sample were the most acceptable to the panelists compared to the samples substituted with pigeon pea and crayfish flours at different graded levels. Although, it had better consumers' sensory attributes, it was the least in nutrient contents with the exception of crude fibre and carbohydrate. However, the study showed that the composite blends of locally available and underutilized nutrient dense ingredients could be used to produce complementary foods, breakfast cereals and porridges that can be used for the feeding of infants, young children and adults in both developing and under-developed countries of the world.*

Keywords: *Complementary foods, porridges, millet, pigeon pea, crayfish, nutrient composition, sensory properties.*

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I. Introduction

Malnutrition especially under-nutrition as seen in protein- energy malnutrition and micro nutrient deficiencies is a major health problem in developing countries. It has been reported that under nutrition, together with micro nutrients deficiencies are the leading risk factors for diseases and death (Barber *et al.,* 2017). FAO (2001) showed that 184 million people or 36.0% of the population in sub-Saharan Africa are chronically hungry. Micronutrients malnutrition in infants and young children became a major concern to public health nutrition (Solomons, 2005). The focus goes beyond protein energy malnutrition to include vitamin A, iodine and iron deficiencies. There is an emerging interest on zinc and copper nutrition.

Malnutrition reduces intelligence, educability, disease resistance, productivity and activity (Echendu *et al.,* 2004). Guerrera *et al.* (2009) observed that malnutrition is a condition in which the physical activity of an individual is impaired to a point where he/ she can no longer maintain adequate performance of growth, resisting and recovering from disease, pregnancy, lactation and physical work. It is also associated with poverty, high population density and inadequate access to sanitary and health facilities. Micronutrient malnutrition, especially vitamin A, iron and iodine deficiencies cause illness, death, learning disabilities and impaired work capacity (Okaka *et al.,* 2006).

Complementary foods are foods used to meet the infant nutritional requirements, when the mothers breast milk is no longer adequate to meet its nutritional requirement after the exclusive period of breast feeding (Barber *et al.,* 2017). Complementary food is mostly produced traditionally from food crops which include cereals such as wheat, maize, millet, sorghum and rice, root and tuber crops such as cocoyam, yam, Irish potato and sweet potato and legumes such as cowpea, soybean, bambara groundnut, pigeon pea, African yam bean and ground bean etc. The formulation of porridges and complementary foods can be made by using one or a combination of more than one plant product, cereal with legume (Agu and Aluya, 2004). In Nigeria as in most developing countries, the traditional complementary foods are mainly gruels or porridges (Yusuf *et al.*, 2013). In some cases, the porridges may be too watery with low energy density or too bulky, causing reduction in infant consumption rate. Adequate processing and judicious blending of locally available food crops could result in improved intake of nutrients to prevent the problem of malnutrition. This approach would require the knowledge about the nutritional values of a variety of local food commodities that are indigenous to the affected communities.

Millet (*Pennisetum typhoideum*), pigeon pea (*Cajanus cajan*) and crayfish (*Euastacus spp*.) are food materials that are readily available in Nigeria. They have potential nutritional attributes. The protein content of millet is similar to that of sorghum and maize, with lysine as the most limiting amino acid. Millet is a tropical cereal crop that produces good yields of grains under unfavourable condition. It is a good source of some very important mineral elements such as calcium, phosphorus, magnesium, copper, manganese and iron (Singh *et al.,* 2012).

It is also a rich source of B-group vitamins particularly thiamine. Millets are also rich sources of phytochemicals and other micronutrients (Singh and Raghuvanshi, 2012). Pigeon pea is a legume that is rich in protein, carbohydrate and crude fibre. It is also rich in minerals and vitamins such as calcium, phosphorus, magnesium, iron, sulphur, potassium, thiamine, riboflavin, niacin and choline (Adebowale and Maliki, 2011). The crude protein content of most legumes varies between 23.6% in pigeon pea to 35% in soybean. Like other legumes, pigeon pea protein is limiting in essential sulphur containing amino acids (methonine and cystine etc.), but is rich in lysine. Hence, Pigeon pea could form a good supplement to millet which is low in lysine (Eneche, 1999).

Crayfish is one of the cheapest sources of animal protein in Nigeria. Generally, fish flesh contains mainly water, protein, fat with traces of carbohydrates, amino acids and other non- protein nitrogenous extractives, various minerals and vitamins (Onabanjo *et al.,* 2009). The fibres of crayfish are shorter than those of other meat products and hence, they are easier to digest. The production of porridges from the blends of millet, pigeon pea and crayfish flour could not only help to improve the macro and micro nutrient contents of the products but will also enhance the nutrients intake of infants, young children and adults, thereby preventing the problem of protein–energy and micronutrients malnutrition in developing countries of the world. In keeping with the need to explore and document other sources of affordable and nutritionally adequate alternatives to the existing commercial porridges or fortified foods, this present study was undertaken to develop and evaluate the proximate, mineral, vitamin and sensory properties of traditional millet- based porridges supplemented with pigeon pea and crayfish flours.

II. Materials And Methods

The pearl millet (*Pennisetum typhoideum*), pigeon pea (*Cajanus cajan*) and crayfish (*Euastacus spp*) used for the study were bought from Ogbete Main Market, Enugu, Enugu State, Nigeria.

Preparation of Malted Millet Flour

The malted millet flour was prepared according to the method of Bolarinwa *et al.* (2016) with slight modifications. One kilogramme (1kg) of millet grains were manually sorted to remove dirt and other extraneous materials. The sorted grains were thoroughly cleaned and steeped in 3litres of potable water in a plastic bowl at ambient temperature (30 $\pm 2^0$C) for 18 h with a change of water at every 6 h to prevent fermentation. The steeped grains were drained, rinsed and immersed in 2% sodium hypochlorite solution for 10 min to sterilize the grains. The grains were rinsed repeatedly for five consecutive times with excess water and cast on a moistened jute bag, covered with a polyethylene bag and left for 24 h to hasten sprouting. The sprouted grains were carefully spread on the jute bag and allowed to germinate in the germinating chamber at ambient temperature (30 ± 2^oC) and relative humidity of 95% for 96 h. During this period, the grains were sprinkled with water at the intervals of 12 h to facilitate germination. Non-germinated grains were handpicked and discarded. The germinated grains were collected, spread on the trays and dried in a cabinet dryer (Model HR 6200, UK) at 60^oC for 24 h with occasional stirring of the grains at intervals of 30 min to ensure uniform drying. The dried malted millet grains were cleaned and rubbed in- between palms to remove the roots and the sprouts. The millet malts were milled into flour in a hammer mill and sieved through a 400 micron mesh sieve. The flour produced was packaged in a lidded plastic container, labeled and kept in a freezer until needed for further use.

Preparation of Malted Pigeon Pea Flour

The malted pigeon pea flour was prepared according to the method of Mbaenyi and Onweluzo (2010) with slight modifications. One kilogramme (1kg) of pigeon pea seeds were sorted to remove dirt and other contaminants. The sorted seeds were thoroughly cleaned and steeped in 3.5liters of potable water in a plastic bowl at ambient temperature (30 ± 2^oC) for 18 h with a change of water at every 6 h to prevent fermentation. The steeped seeds were drained, rinsed and immersed in 2% sodium hypochlorite solution for 10 min to sterilize the seeds. The seeds were rinsed repeatedly for five consecutive times with excess water and cast on a moistened jute bag, covered with a polythene bag and left for 24 h to hasten sprouting. The sprouted seeds were carefully spread on the jute bag and allowed to germinate in the germinating chamber at ambient temperature (30 ± 2^oC) and relative humidity of 95% for 96 h. During this period, the seeds were sprinkled with water at intervals of 12 h to facilitate germination. Non –germinated seeds were handpicked and discarded. The germinated seeds were collected, spread on the trays and dried in a cabinet dryer (Model HR 6200, UK) at 60^oC for 20 h with occasional stirring of the seeds at intervals of 30 min to ensure uniform drying. The dried malted pigeon pea seeds were cleaned and rubbed in-between palms to remove the roots and the sprouts along with the hulls. The dehulled pigeon pea malts were milled into flour in a hammer mill and sieved through a 400 micron mesh sieve. The flour produced was packaged in a lidded plastic container, labeled and kept in a freezer until needed for further use.

Preparation of Crayfish Flour

The crayfish flour was prepared according to the method of Okoye and Ene (2018). One kilogramme (1kg) of crayfish was sorted and winnowed to remove dirt and other extraneous materials. The sorted and winnowed crayfish was thoroughly cleaned with 2.5 litres of potable water. The cleaned crayfish was drained, rinsed, spread on the trays and dried in a cabinet dryer (Model HR 6200, UK) at 60^oC for 12 h with occasional stirring of the crayfish at intervals of 30 min to ensure uniform drying. The dried crayfish was milled into flour in a hammer mill and sieved through a 400 micron mesh sieve. The flour produced was packaged in a lidded plastic container, labeled and kept in a freezer until needed for further use.

Formulation and Coding of Composite Blends

Millet, pigeon pea and crayfish flours were thoroughly mixed together at varying proportions of A=100:0:0, B=90: 5: 5, C=80: 15:5, D=70: 20: 10, E=60:25:15 and F=50:30:20 in a Kenwood blender (Mini-Processor, Model A 90LD, Thom Emi Kenwood Small Appliance Ltd, Hampshire, UK) to produce homogenous complementary food blends. The composite blends produced were individually packaged in moisture –proof and air-tight plastic containers, labeled and preserved in a freezer until needed for further use.

Preparation of Porridges from Composite Blends

Porridges were prepared according to the method of Madukwe *et al.* (2013). During preparation, two hundred grammes (200g) of each sample of composite blends were dissolved in 60mL of potable water at room temperature (30 ± 2^oC) to form the slurry. Five hundred milliliters of boiling water was added to each of the slurry with continuous stirring until it developed into gel. Four grammes (4g) of granulated sugar were added to each of the sample and stirred repeatedly until well distributed. The samples were allowed to cool to 40^oC (serving temperature) and divided into two (2) lots. The first lot was kept in thermo flask to maintain the serving temperature and used for sensory evaluation after 4 h. The second lot was packaged in sealed plastic container and kept in a refrigerator until needed for analysis. The porridge prepared from 100% malted millet flour was used as control.

Proximate Analysis

The moisture, crude protein, ash, fat and crude fibre contents of the samples were determined in triplicate in accordance with the methods of AOAC (2006). Carbohydrate content was determined by difference on dry sample weight by subtracting the summation of the percentage moisture, protein, fat, crude fibre and ash contents from 100%. The energy content of the porridges was calculated from the proximate composition using the Atwater factor of 4.0 for protein and carbohydrate and 9.0 for fat.

Mineral Analysis

The minerals were analyzed by dry-ashing of the samples at 500^oC to constant weight and dissolving the ash in volumetric flask with 50mL of de-ionised water and a few drops of concentrated hydrochloric acid for proper extraction. The calcium, magnesium, phosphorus and potassium contents of the complementary blends were determined by the use of the flame photometer (Model 405, Corning, UK) according to the methods of

Gibson *et al.* (2010). The iron and zinc contents were determined using the atomic absorption spectrophotometer (Perkin – Elmer 403, Norwalk, CT, USA) according to the standard methods of AOAC (2006).

Vitamin Analysis

The ascorbic acid, niacin, thiamine and riboflavin contents of the samples were determined according to the methods of AOAC (2006). The folic acid and vitamin A contents were determined using the flourimetric methods of Onwuka (2005).

Sensory Evaluation

Twenty (20) students were randomly selected by balloting from fourth and final year students of the Department of Food Science and Technology, Enugu State University of Science and Technology, Enugu, Nigeria. The selection was based on their previous participation in similar sensory tests. The samples were evaluated for the attributes of colour, taste, texture, aroma and overall acceptability using a nine- point Hedonic scale with 1 and 9 representing dislike extremely and like extremely, respectively (Iwe, 2007). The sensory evaluation was carried out in the Food Research Laboratory of the Department of Food Science and Technology, Enugu State University of Science and Technology, Enugu, Nigeria. The laboratory was adequately lighted and free from distraction. The judges were arranged in such a way that they could not see the rating of each other. The samples were randomly coded and presented in plain coloured plastic cups and each judge was provided with a teaspoon and a glass of potable water to rinse his/her mouth after testing each sample to avoid residual effect. The sensory test was done around 11:00am and the samples were served at $40^{o}C$ (serving temperature) in portions of 150mL. The judges were asked to assess and score each sample of the porridges based on their degree of preference and acceptance of each of them. Expectoration cups with lids were provided to the panelists who did not wish to swallow the samples.

Statistical Analysis

The data generated were subjected to one –way analysis of variance (ANOVA) using SPSS Software (version, 17.0). Means were separated using Duncan's New Multiple Range Test (DNMRT) at $p<0.05$ and the results were expressed as mean $\pm$ standard deviation of triplicate determinations.

III. Results And Discussion

Proximate Composition of porridges

The proximate composition of millet, pigeon pea and crayfish porridges are shown in Table 1. The control sample without pigeon pea and crayfish flours substitution had significantly ($p<0.05$) the highest moisture content (8.27%) compared to that of the substituted samples which ranged from 6.62 to 7.37%. The decrease in the moisture content could be due to the addition of pigeon pea and crayfish flours in the blends. This is good as it will greatly enhance the keeping quality of the products. The low moisture content obtained in this study is in agreement with the report of Barber *et al.* (2017) for complementary food formulated from fermented maize, soybean and carrot flours. The protein content of the samples was observed to increase with the increase in pigeon pea and crayfish substitution. The sample substituted with 30% pigeon pea and 20% crayfish flours had the highest protein content and this is in consonance with the report that pigeon pea and crayfish are good sources of protein (Enwere, 1998; Onabanjo *et al.*,2009). Protein is important in building and replacement of tissues in infants, young children and adults. The fat content of the porridges increased significantly ($p<0.05$) with increase in crayfish flour substitution. The sample with 20% crayfish flour substitution had the highest fat content. Fat is important in human diets as it provides essential fatty acids and facilitates the absorption of fat soluble vitamins (Michealsen *et al.,* 2000). The ash content of the formulations ranged from 3.10 to 4.14% with the control (100% malted millet flour) and the sample substituted with 30% pigeon pea and 20% crayfish flours having the least (3.10%) and highest (4.14%) values, respectively. The ash content of a food material could be used as an index for estimating the mineral constituents of the food (Abasiekong *et al.,* 2010; Okoye and Ene, 2018). The crude fibre content of the samples decreased significantly ($p<0.05$) with increase in substitution with pigeon pea and crayfish flours. The control (100% malted millet flour) had the highest crude fibre content of 3.56%.The crude fibre content of the substituted samples ranged from 2.71 to 3.44% with the sample substituted with 30% pigeon pea and 20% crayfish flours having the least value of 2.71%. Fibre helps to increase the utilization of nitrogen and absorption of some other micronutrients in the body (Okaka *et al.,* 2006). The carbohydrate content of the samples decreased with increase in substitution with pigeon pea and crayfish flours. The carbohydrate content varied between 66.20 and 74.68% with the control and the sample substituted with 30% pigeon pea and 20% crayfish flours having the highest (74.68%) and the least (66.20%) values, respectively. Millet is mostly a carbohydrate rich food hence the reduction in millet content resulted in decrease in carbohydrate content of the samples. The energy content of the porridges increased steadily with increase in pigeon pea and crayfish substitution. The significant ($p<0.05$) increase in the energy content could be attributed to increase in protein and fat contents of the samples. The substitution of millet-based porridges with pigeon pea and crayfish flours greatly enhanced their nutrient contents.

Mineral Composition of porridges

The mineral composition of millet, pigeon pea and crayfish porridges are shown in Table 2. The calcium, magnesium, phosphorus, potassium, iron and zinc contents of the samples increased significantly ($p<0.05$) with increase in substitution with pigeon pea and crayfish flours in comparison with the control (100% malted millet flour) from 21.73 - 41.24mg /100g, 33.72 - 42.88mg/100g, 83.60 - 145.90mg/100g, 36.80 - 50.07mg/100g, 23.29 - 28.05mg/100g and 4.54 - 799mg/100g, respectively. The increase in mineral content of the samples confirms the beneficial effect of substitution caused by the high levels of minerals in pigeon pea and crayfish flours as reported by Echendu *et al.* (2004) and Onabanjo *et al.* (2009). Minerals are vital to the proper functioning of many body processes. They are critical players in the functioning of the nervous system, other cellular processes, water balance and structural systems such as skeleton and muscles. They also play significant role in cell division, protein synthesis and growth (Berdanier and Zempleni, 2009).

Vitamin Composition of porridges

The vitamin composition of millet, pigeon pea and crayfish porridges are shown in Table 3. The levels of the vitamins: ascorbic acid, thiamine, niacin, riboflavin, folic acid and vitamin A increased with increase in substitution with pigeon pea and crayfish flours. The increase could be due to supplementation effect caused by the high levels of vitamins in pigeon pea and crayfish flours as reported by Okorie and Okoro (2009) and Fashakin and Ige (2014). Ascorbic acid and thiamine contents of the porridges increased significantly ($p<0.05$) with increased levels of supplementation from 11.99 - 16.30mg/100g and 10.27 - 15.09mg/100g, respectively. There were also similar increase in niacin, riboflavin, folic acid and vitamin A contents of the samples from 11.11 - 15,08mg/100g, 3.10 - 4.14mg/100g, 3.15 - 6.00 mg/100g and 1.09 - 3.19mg/100g, respectively. The significant($p<0.05$) increase in vitamin A content of the substituted samples could be attributed to the addition of crayfish flour and this is in agreement with the report that crayfish is a rich source of vitamin A (Nzeagwu and Nwaejike, 2008).

Vitamins in human diets help to regulate body processes. The B-group vitamins, are particularly essential in carbohydrate, fat and protein metabolism. Thiamine plays a central role in the generation of energy from carbohydrates, while riboflavin is involved in energy production for the electron transport chain, the citric acid cycle, as well as the catabolism of fatty acids. Niacin plays an important role in energy transfer reactions in the metabolism of glucose, fat and alcohol (Gropper and Smith, 2009). The deficiencies of vitamins manifest in diseases such as Beriberi, night blindness, sterility and Pellagra etc.

Sensory Properties of Porridges

The sensory properties of millet, pigeon pea and crayfish porridges are shown in Table 4. The scores of the porridges prepared from both the control and substituted samples differed significantly ($p<0.05$) in colour, taste, texture, aroma and overall acceptability. The sample substituted with 5% pigeon pea and 5% crayfish flours had the highest scores for colour, taste, texture, aroma and overall acceptability, while the sample substituted with 30% pigeon pea and 20% crayfish flours had the least scores for all the parameters evaluated. The porridge made from 100% malted millet flour (control) was generally more acceptable compared to the porridges prepared from the substituted samples. The increase in substitution resulted in decrease in acceptability of the samples. The change in colour observed, could be due to the increased substitution of the pigeon pea and crayfish flours and the addition of sugar which gave the porridge a slightly dark coloration. Colour darkening of the porridge could be due to caramelization of sugar and the Maillard reaction between sugar and amino acids of the proteins. Maillard browning reaction is related to temperature, time and the presence of water (moisture). Colour appeared to be a very important criterion for the initial acceptability of the food product by the consumer. The sample with 30% pigeon pea and 20% crayfish substitution was also reported to have crumbly texture and a beany flavour, attributable to the increased substitution and the beany flavour of pigeon pea. Therefore, there is need to explore alternative ways of formulating nutrient dense and organoleptically acceptable porridges from millet, pigeon pea and crayfish flour blends at higher levels of substitution.

IV. Conclusion

The study showed that porridges of high nutrient contents and good sensory characteristics could be prepared from millet, pigeon pea and crayfish composite blends. The porridges formulated were nutritionally superior to the control in protein, fat, ash, energy, calcium, magnesium, phosphorus, iron, zinc, ascorbic acid and vitamin A contents. Although, the products had high mineral, vitamin and fat contents, there is still need for further supplementation of the porridges with better sources of minerals, vitamins and fat. The porridge prepared from the blend containing 5% pigeon pea and 5% crayfish flours generally had better acceptability than the other test samples. Pigeon pea and crayfish are cheap and readily available food ingredients that can be used in both developing and under-developed countries to supplement traditionally processed cereal-based products used as human foods for feeding of infants, young children and adults.

Table 1: Proximate composition (%) of millet, pigeon pea and crayfish porridges

Sample ID	% Substitution MF	PPF:	CF	Moisture	Protein	Fat	Ash	Crude Fibre	Carbohydrate	Energy (KJ/100g)
A	100:	0:	0	$8.27^{a} \pm 0.07$	$9.09^{c} \pm 0.18$	$1.30^{f} \pm 0.03$	$3.10^{e} \pm 0.07$	$3.56^{a} \pm 0.14$	$74.68^{a} \pm 0.16$	$346.78^{f} \pm 1.14$
B	90:	5:	5	$7.37^{b} \pm 0.07$	$9.84^{e} \pm 0.68$	$1.67^{e} \pm 0.07$	$3.76^{d} \pm 0.14$	$3.44^{b} \pm 0.11$	$73.92^{b} \pm 0.82$	$350.07^{e} \pm 1.20$
C	80:	15:	5	$7.29^{c} \pm 0.18$	$12.09^{d} \pm 0.32$	$1.90^{d} \pm 0.11$	$3.84^{c} \pm 0.11$	$3.22^{c} \pm 0.06$	$72.56^{c} \pm 0.37$	$355.07^{d} \pm 1.23$
D	70:	20:	10	$7.06^{d} \pm 0.11$	$13.51^{c} \pm 0.35$	$2.19^{c} \pm 0.04$	$4.02^{b} \pm 0.05$	$3.05^{d} \pm 0.04$	$70.17^{d} \pm 0.23$	$354.43^{c} \pm 1.30$
E	60:	25:	15	$6.69^{d} \pm 0.12$	$15.35^{b} \pm 0.81$	$2.90^{b} \pm 0.17$	$4.10^{a} \pm 0.14$	$2.92^{e} \pm 0.06$	$68.09^{e} \pm 1.00$	$359.86^{b} \pm 1.74$
F	50:	30:	20	$6.62^{f} \pm 0.57$	$17.14^{a} \pm 0.40$	$3.19^{a} \pm 0.10$	$4.14^{a} \pm 0.03$	$2.71^{f} \pm 0.07$	$66.20^{f} \pm 0.42$	$362.07^{a} \pm 2.64$

Values are mean $\pm$ standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different ($p<0.05$).
MF- Malted millet flour, PPF- Malted pigeon pea flour, CF- Crayfish flour.

Table 2: Mineral composition (mg/100g) of millet, pigeon pea and crayfish porridges

Sample ID	% Substitution MF:	PPF:	CF	Calcium	Magnesium	Phosphorus	Potassium	Iron	Zinc
A	100:	0 :	0	$21.73^{f} \pm 0.64$	$33.72^{f} \pm 0.76$	$83.60^{f} \pm 1.27$	$36.80^{f} \pm 1.53$	$23.29^{f} \pm 0.18$	$4.54^{f} \pm 0.11$
B	90:	5:	5	$25.21^{e} \pm 0.07$	$35.10^{e} \pm 1.11$	$124.67^{e} \pm 1.27$	$38.69^{e} \pm 0.42$	$24.22^{e} \pm 0.06$	$5.05^{e} \pm 0.04$
C	80:	15:	5	$33.19^{d} \pm 0.44$	$37.39^{d} \pm 1.32$	$132.17^{d} \pm 1.44$	$42.41^{d} \pm 0.07$	$25.54^{d} \pm 0.17$	$5.20^{d} \pm 0.03$
D	70:	20:	10	$37.00^{c} \pm 0.10$	$38.30^{c} \pm 0.06$	$134.85^{c} \pm 1.58$	$44.80^{c} \pm 0.45$	$26.30^{c} \pm 0.25$	$6.05^{c} \pm 0.27$
E	60:	25:	15	$39.17^{b} \pm 1.34$	$41.17^{b} \pm 1.34$	$143.77^{b} \pm 1.57$	$47.97^{b} \pm 0.63$	$26.99^{b} \pm 0.15$	$700^{b} \pm 1.17$
F	50:	30:	20	$41.24^{a} \pm 0.17$	$42.88^{a} \pm 0.79$	$145.90^{a} \pm 139$	$50.07^{a} \pm 0.21$	$28.05^{a} \pm 0.27$	$7.99^{a} \pm 0.24$

Values are mean $\pm$ standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different ($p<0.05$).
MF- Malted millet flour, PPF- Malted pigeon pea flour, CF- Crayfish flour.

Table 3: Vitamin composition (mg/100g) of millet, pigeon pea and crayfish porridges

Sample ID	% Substitution MF:	PPF:	CF	Ascorbic Acid	Thiamine	Niacin	Riboflavin	Folic Acid	Vitamin A
A	100:	0:	0	$11.99^{f} \pm 0.24$	$10.27^{f} \pm 0.07$	$11.11^{f} \pm 0.21$	$3.10^{e} \pm 0.07$	$3.15^{f} \pm 0.04$	$1.09^{f} \pm 0.42$
B	90:	5:	5	$12.67^{e} \pm 0.30$	$11.53^{e} \pm 0.56$	$11.62^{e} \pm 0.42$	$3.76^{d} \pm 0.14$	$3.56^{e} \pm 0.14$	$1.25^{e} \pm 0.42$
C	80:	15:	5	$13.27^{d} \pm 0.21$	$11.96^{d} \pm 0.09$	$12.26^{d} \pm 0.11$	$3.84^{c} \pm 0.11$	$3.76^{d} \pm 0.05$	$1.37^{d} \pm 0.07$
D	70:	20:	10	$14.16^{c} \pm 0.40$	$13.12^{c} \pm 0.08$	$13.26^{c} \pm 0.14$	$4.02^{b} \pm 0.05$	$4.05^{c} \pm 0.08$	$1.70^{c} \pm 0.03$
E	60:	25:	15	$15.17^{b} \pm 0.86$	$14.09^{b} \pm 0.28$	$14.02^{b} \pm 0.23$	$4.10^{a} \pm 0.14$	$5.04^{b} \pm 0.25$	$2.02^{b} \pm 0.23$
F	50:	30:	20	$16.30^{a} \pm 0.47$	$15.09^{a} \pm 0.33$	$15.08^{a} \pm 0.28$	$4.14^{a} \pm 0.07$	$6.00^{a} \pm 0.15$	$3.19^{a} \pm 0.28$

Values are mean $\pm$ standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different ($p<0.05$).
MF- Malted millet flour, PPF- Malted pigeon pea flour, CF- Crayfish flour.

Table 4: Sensory properties of millet, pigeon pea and crayfish porridges

Sample ID	**% Substitution MF:**	**PPF:**	**CF**	**Colour**	**Taste**	**Texture**	**Aroma**	**Overall Acceptability**
A	100:	0:	0	$6.90^a \pm 0.72$	$6.15^a \pm 0.75$	$6.30^a \pm 0.85$	$6.40^e \pm 0.88$	6.75^a. 0.70
B	90:	5:	5	$5.60^b \pm 0.94$	$5.70^b \pm 0.76$	$5.60^a \pm 0.51$	$5.65^b \pm 0.59$	$5.60^b \pm 0.60$
C	80:	15:	5	$5.30^c \pm 0.57$	$5.35^c \pm 0.75$	$5.10^c \pm 0.72$	$5.05^c \pm 0.63$	$5.15^c \pm 0.67$
D	70:	20:	10	$5.25^d \pm 0.61$	$5.15^d \pm 0.67$	$4.95^d \pm 0.60$	$4.95^d \pm 0.60$	$4.65^d \pm 0.62$
E	60:	25:	15	$5.05^e \pm 0.63$	$4.65^e \pm 0.62$	$4.55^e \pm 0.73$	$4.35^e \pm 0.75$	$4.42^e \pm 0.69$
F	50:	30:	20	$4.85^f \pm 0.65$	$4.20^f \pm 0.77$	$4.25^f \pm 0.72$	$4.22^f \pm 0.77$	$4.20^f \pm 0.59$

Values are mean $\pm$ standard deviation of twenty (20) semi-trained judges. Means in the same column with different superscripts are significantly different ($p<0.05$).
MF- Malted millet flour, PPF- Malted pigeon pea flour, CF- Crayfish flour.

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