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Production and evaluation of nutrient-dense complementary food from millet (*Pennisetum glaucum*), pigeon pea (*Cajanus cajan*) and seedless breadfruit (*Artocarpus altillis*) leaf powder blends

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Millet (M) and pigeon pea (P) were fermented (12, 24, 36 and 48 h) and milled into flours used in formulation of complementary foods. The 0 h sample served as the control. These flours and their blends were analysed for functional properties, chemical composition and microbiological count using standard methods. The flours were blended as B_{55} (M+P flours + breadfruit leaf powder (A) blends, 55:30:15), C_{60} (M+P flours + breadfruit leaf powder blends, 60:30: 10), D_{65} (millet + pigeon pea flours + *Artocarpus altilis* blends, 65:30: 10) and E_{70} (M+P flour blends, 70: 30). The best blend was obtained from the nutritional composition and used for the incorporation of 0 to 15% *A. altilis* powder. The best flours were used for the formulation of the complementary diet. Results showed 36 h samples had the highest protein value (11.84 and 30.88 %) compared to the other flours. Based on this, the flours were blended together and fortified with graded levels of dry milled seedless breadfruit leaf (5, 10 and 15%). The blends showed high protein content B_{55} (11. 84 %), C_{60} (16.91 %), D_{65} (14.59 %) and E_{70} (15.78 %) compared with the single millet flours Mo (9.65%), M_{12} (9.82%), M_{24} (11.57 %), M_{36} (11.84 %) and M_{48} (8.37), and with FAO standard protein value of 10%. The composite flour had very high vitamin A, and calcium content due to the incorporation of the breadfruit leaf powder. The breadfruit leaf powder had 13111.07 IU of vitamin A, and 9.10 mg/100g of calcium. Fermentation increased the bulk density, oil absorption capacity, water absorption capacity, swelling index and least gelation concentration of single flours of M+P flours unlike the blends. The total viable and mould counts were within the same range for both the single and composite flours, and are safe for human consumption when compared with <10^6cfu/g as recommend by microbiological standards.

Key words: *Artocarpus altilis* leaf extract, complementary foods, fermentation, millet, pigeon pea.

INTRODUCTION

Breast milk is the ideal food for infants during the first six months of life. It contains still undiscovered substances that cannot be reproduced artificially and its overall nutrient composition is superior to any alternative, including infant formula. Breast feeding is considered best for infants from nutritional and immunological points of view as well as for protection against *Campylobacter*-associated diarrhoea (Nout and Ngoddy, 1997). In developing countries, most infants show satisfactory growth for the first four to six months when breast milk solely meets the nutritional needs but after this period, it may become increasing inadequate as the nutritional demands of the infant increases (Nkama et al., 2001). In spite of its superiority, breast milk cannot provide all of the nutrients and calories that allow infants to thrive after the first six months, more nutritious foods should gradually be introduced to different types of semi-solid, solid or complementary foods as they gradually transition from a diet-centered on breast milk.

Complementary foods are foods that are readily consumed and digested by the young children, and that provide additional nutrition to meet all growing child's needs. Complementary foods (commonly known as weaning foods) are formulated to satisfy nutritional needs of infants and young children. A true complementary food would add to the diet nutrients such as iron and zinc, which breast milk has not evolved to provide for older infants as the child gradually outgrows her birth stores (Gabrielle, 2009). Weaning is a gradual process during which breast milk increasingly complemented with other foods that fully meet the young child's needs. It is a process of gradual introduction of other foods into a baby's diet to complement breast milk and progressively replace it and eventually adapting the child to adult diets (Nkama et al., 2001).

In Nigeria, as in most developing parts of the world, most people depend on plant foods for dietary needs particularly cereals and legumes. Such legumes like pigeon pea, cowpea, African yam bean, soya bean among others, serve as good sources of dietary protein. These play important role in the diets of many people including children. Many countries have exploited cheap locally available plant materials from cereals and legumes to developed weaning foods (Nkama et al., 2001).

In Nigeria, the usual first weaning food is "pap" referred to as "akamu" by Igbos, "ogi" by Yorubas or "koko" by Hausas. It could be made from maize *(Zea mays),* millet *(Pennisetum americamum)* or guinea corn (sorghum species) or a combination of the cereals (Onofiok and Nnanyelugo, 1998). Fermented cereal has been popularly used as complementary infant food in Nigeria, where it is referred to as "ogi." "Ogi" is a smooth creamy, free flowing thin porridge obtained from wet-milled, fermented maize, sorghum or millet. The preparation involves dilution of the fermented product with water and boiling with constant stirring to desired consistency (Johnanson et al., 1995). The major disadvantage of sole cereal gruel is that the starchy nature of these foods makes them bind so much water, thus yielding a bulky gruel with decreased nutrient content, and also cereals have lower protein quality compared to legumes (Marero et al., 1988).

Traditional weaning foods in West Africa are known to be of low nutritive value (Guiro et al., 1987), and are characterized by low protein, low energy density and high bulk, cereal based diets have been implicated in protein-energy malnutrition. Guiro et al. (1987) similarly noted that the traditional millet gruel used for weaning Senegalese children was not energy dense and was insufficient to cover all the nutrient needs of the infant. The problems inherent in the traditional West Africa weaning foods and feeding practices predispose the infants to malnutrition, growth retardation, infection and high mortality. The first Nigeria Nutrition Network of 2002 identified poor feeding practices and/ or shortfall in food intake, as the most important direct factors responsible for malnutrition and illness amongst children in Nigeria.

As in most other developing countries, the high cost of fortified nutritious proprietary complementary foods is always, if not prohibitive, beyond the reach of most Nigerian families. Such families often depend on inadequately processed traditional foods consisting mainly of un-supplemented cereal porridges made from maize, sorghum and millet. The amino acid compositions of the proteins in the cereal grains are generally low in the contents of lysine (Manay and Shadaksharawamy, 2006). The proteins in legumes have a well-recognized deficiency of the essential sulphur-bearing amino acids namely methionine and cysteine, but are comparatively rich in lysine (Ihekoronye and Ngoddy, 1985).

Therefore, blending cereal with legume would help to improve nutrient density of the complementary food and improve nutrients intake, which resulted in the prevention of malnutrition problem. Protein malnutrition is wide spread among the poor of developing and under developed countries. Since animal's protein is beyond the reach of this group, their primary protein supply comes from plant based products. Amongst these pigeon pea or red grain (*Cajanuscajan* (L) millspaugh) is an important food legumes that can be grown under rainfed conditions with least inputs. Pigeon pea is rich in starch, protein, calcium, magnesium, crude fiber, fat, trace elements and minerals. Beside its high nutritional value, pigeon pea is also used as traditional folk medicine in India, China and some other countries. Literature on this aspect show that pigeon pea is capable of preventing and curing a number of human ailments such as cough, pneumonia, respiratory infections, dysentery, tooth ache, wounds among others (Saxena et al., 2010).

Micronutrient deficiencies are common during infancy, and optional approaches for their prevention need to be identified. Micronutrient deficiency is a challenge, particularly in developing countries and deficiencies of iron and other micronutrients including zinc remain public health problems in these countries (Bhaskaram, 2002).

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The deleterious effects of iron deficiency on cognitive development in infants are well documented, whereas zinc deficiency has been implicated in growth faltering (Brown et al., 2002) and increase morbidity, particularly diarrhoea disease and pneumonia (Bhutta et al., 1999).

The Ministry of Health, Nigeria, 2012 emphasized that a child could get protein energy malnutrition when his food does not contain sufficient amount of protein and energy. Protein-energy malnutrition is a disease of children under 5years caused by inadequate intake of food. This disease can be associated with other communicable diseases such as diarrhoea and respiratory tract infection. Marasmus and kwashiorkor are the severe forms of this disease. A number of cereals and legumes that are readily available have been found to have nutrient potentials that could complement one another if properly processed and blended (Fernandez et al., 2002; Oguntona and Akinyele, 1995). Therefore, it is imperative that efforts to formulate composite blends and scientific studies are carried out to ascertain the nutritive adequacy of these locally available blends (cereal and legume) for possible use as complementary foods, especially by the rural and poor urban mothers during the period of weaning.

Most of the previous works on complementary food production were based on cowpea, soyabean, maize and rice. These materials have also been competitively used for different industries, researchers among others. However, millet is a cereal in which its protein and caloric content are comparable to maize and rice but people have been eating maize and rice due to the knowledge of what they derive from the food in terms of calories and proteins but little have been known about the nutritive of millet. Therefore, the knowledge (that millet's caloric and protein contents are comparable to that of maize and rice) brings millet to lime light as a good quality protein and caloric food source. Millets are group of highly variable small-seeded grasses, widely grown around the world as cereal crops or grains for both human food and feeder. They do not form a taxonomic group but rather a functional or agronomic one. Millets are important crops in the semi-arid tropics as of Asia and Africa (especially in India, Nigeria and Niger Republic), with 97% of millet production in developing countries (McDonough et al., 2000).

Millet, like sorghum is predominantly starchy. The protein content is comparable wheat and maize. Pearl millets are higher in fats. Millets are also relatively rich in iron and phosphorus (FAO, 1995). Finger millet has the highest calcium content among all the food grains. Millets are rich in B vitamins (especially niacin, B_6 and folic acid), calcium, iron, potassium, magnesium and zinc.

Legumes are the species of plants family *Leguminosae*, which are good sources of dietary protein. Examples are cowpea, pigeon pea, soyabean, groundnut, and bambara nut. Pigeon pea has been reported to contain high quality protein and is a good source of amino acids except methionine (Elegbede, 1998). Legumes are rarely used for weaning and are introduced much later (after six months of age) because of the problems of indigestibility, flatulence and diarrhea associated with their use (King et al., 1985). Pigeon peas are an important legume crop of rainfed agriculture in the semiarid tropics. Pigeon peas are both a food crop (dried peas, flour, or green vegetable peas) and a forage/cover crop. In combination with cereals, pigeon peas make a well balanced human food (Akporhonor et al., 2006). Pigeon pea contains high levels of protein and important amino acids (methionine, lysine and tryptophan).

Artocarpus altilis (seedless breadfruit) is 100 feet (30m) tall, with large, spreading branches and a straight trunk with smooth gray bark. Leaves large, 16 to 20 inches (40 to 50cm) wide and 24 to 35 inches (60 to 90cm) long, usually with 5 to 11 deeply out lobes. In Trinidad and the Bahamas, a leaf of *A. altilis* is used to lower blood pressure and relieve asthma. It is also used in the treatment of diarrhea (Zerega et al., 2004).

Cereal gruel processing methods have resulted in the loss of nutrients other than protein. Makinde and Lachance (1976) reported a 95% loss of the original tryptophan in maize during the processing of "ogi". Large losses of niacin during processing which treatment of ogi were reported which could account for the high incidence of pellagra in the area (Onofiok and Nnanyelugo, 1998). This method of processing which leads to micronutrient deficiency in complementary food could be averted by complementation of millet (cereal) with pigeon pea (legume) and fortifying it with *A. altilis* leave powder. Therefore, blending cereal (millet) with legume (pigeon pea) fortified with *A. altilis* leaves would help to improve nutrient density of the complementary food and improved nutrients intake, which resulted in the prevention of problem of malnutrition. The addition of *A. altilis* would also help in the prevention of diarrhoea since it is medicinal.

The main aim of the study is to formulate and evaluate the nutrient-dense complementary food produced from millet, pigeon pea fortified with graded level of bread fruit leaf powder for proximate, vitamin, mineral compositions and functional properties of the flours and their blends as well as the microbiological quality of the formulated complementary food.

MATERIALS AND METHODS

Procurement of raw materials

The seeds of millet and pigeon pea were purchased from Ogige market in Nsukka while the *A.altilis* leaves were obtained from Owere-Obukpa farm in Nsukka, Enugu State.

Processing of millet flour

Millet seeds (3 kg) each were manually cleaned/ winnowed,

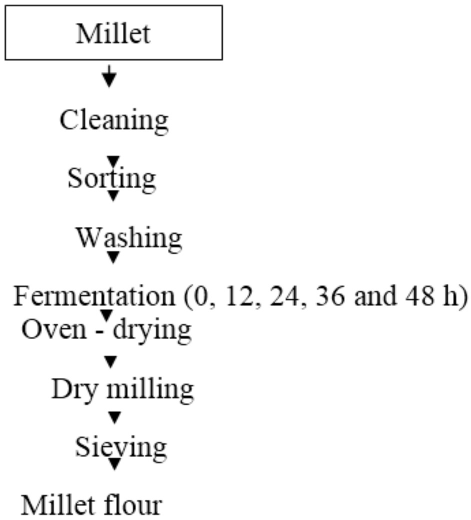

Figure 1. Flow diagram for production of millet flour (Source: Modified method of production of Ogi from Odunfa and Adeyele (1985)).

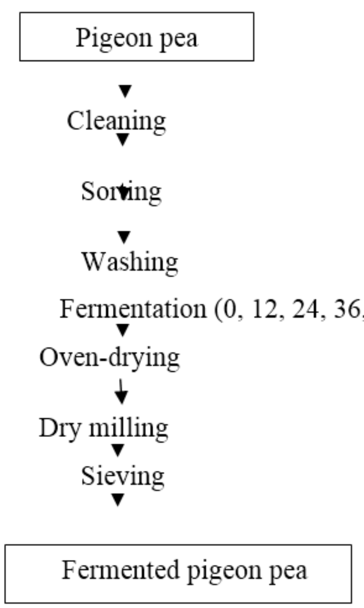

Figure 2. Flow diagram for the production of pigeon pea flour.

weighed and fermented for 12, 24, 36 and 48 h. The fermentation process was by endogenous micro flora in the seeds at room temperature as described by Onuoha and Obizoba (2001). The fermented grains were oven-dried, milled and sieved by passing through a 1mm pore size sieve to yield flour. The flour was packaged in air tight container and stored for analysis (Figure 1).

Processing of pigeon pea flour

Pigeon pea seeds (2 kg) each were cleaned, weighed and fermented for 12, 24, 36 and 48 h. The fermented seeds were oven-dried, milled and were passed through a 1 mm pore size sieve to yield flour. The flour was packaged in air tight container and stored for analysis (Figure 2).

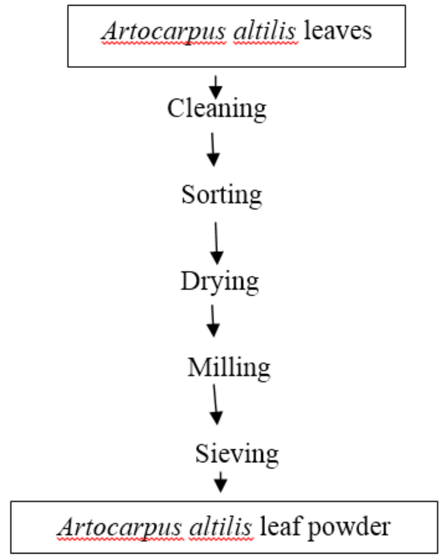

Figure 3. Flow diagram for the production of *A. alitilis* leaf powder.

Processing of leaves

A known quantity of *A. atilis* leaves (500 g) were harvested cleaned, oven-dried, milled and sieved with 1 mm sieve to yield leaf powder. The leaf powder was packaged in air tight bag and stored for analysis (Figure 3).

Analysis of samples

The proximate analysis, vitamin and mineral content of each sample (single flour) were determined. This was used as the basis for selecting the best samples. After the initial analysis of each sample, the best two samples from millet flour and pigeon pea flour were blended together with *A. altilis* leaf powder. After blending, the ratios results shown in Table 1. Further analysis were carried out to determine the proximate composition, mineral content, vitamin contents, some selected functional properties and microbial content of the blended samples.

Proximate analysis of millet, pigeon pea flour, *A. altilis* leaf powder, their blends and products

Determination of crude protein

The crude protein content was determined by the micro-Kjeldahl AOAC 920.53 method as described by AOAC (2010).

Determination of moisture content

The hot air oven method as described by AOAC method 925.10 (AOAC, 2010) was used in determination moisture content.

Table 1. Proportion of millet flour, Pigeon pea, flour and *A. altilis* leaf powder used for complementary food formulation.

Millet flour	Pigeon pea flour	*A. altilis* leaf powder
70	30	0
65	30	5
60	30	10
55	30	15

Determination of fat content

This was determined using the Soxhlet extraction with petroleum ether according to AOAC 920.39 method as described by AOAC (2010).

Determination of total ash content

The AOAC 923.03 method described by AOAC (2010) was used in determining the total ash content.

Determination of crude fiber

Crude fiber content was determined by the AOAC 962.09 method described by AOAC (2010).

Determination of carbohydrate

Carbohydrate content was determined by difference as described by Oyenuga (1968) as shown: % carbohydrate = 100 – (% moisture + protein + % ash + % crude fibre)

Determination of mineral content

The mineral content was determined using Atomic Absorption Spectroscopy after wet digestion method as described by Adeyeye and Ajewole (1992).

Determination of vitamin A

Vitamin A content was determined by the procedure described by Jakutowicz et al. (1997).

Determination of vitamin B_1

Vitamin B_1 was determined by the procedure described by Koche et al. (2008).

Microbial analysis

Plate count for bacteria and yeast

Plate count for both bacteria and yeast was done using the method described by Jideani and Jideani (2006).

Determination of some selected functional properties of the blend of millet flour, pigeon pea flour and *A. altilis* leaf powder

Determination of bulk density

The bulk density was determined by the method described by Nwanekezi et al. (2001).

Determination of viscosity

The viscometer was used in characterizing the flow behavior of each of the sample respectively. The viscosity of porridges from sample flour was determined according to the method described by Sathe and Salunkhe (1981), using the Gallenkamp Universal Torsion Viscometer.

Determination of particle size distribution

The particle size distribution was determined by the method as described by Ihekoronye and Oladunjoye (1988).

Determination of wettability

The wettability of the samples was determined by the method as described by Onimawo and Akubor (2012).

Determination of water /oil absorption capacity

The method described by Onimawo and Akubor (2012) was used in determination of water absorption capacity.

Determination of least gelation concentration

The least gelation concentration was determined according to the method described by Onimawo and Akubor (2012).

Determination of swelling index

Swelling Index was determined using the method of Onimawo and Akubor (2012).

Data analysis and experimental design

The design of the experiment for the blends was done using completely randomized design (CRD). Data analysis was carried out using one-way analysis of variance (ANOVA). Mean separation was done by Duncan's New Multiple Range Test with Statistical Package for Social Sciences (SPSS) version computer software 20. The determinations were done in duplicate and significance was accepted at $p<0.05$ according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

The discussions are on dry basis.

Effect of fermentation on proximate composition of millet and pigeon pea flour

Table 2 and 3 show the proximate composition of the unfermented and fermented millet and pigeon pea flours. The crude protein content of the unfermented millet was 9.65% while for the various fermentation regimes were 9.82±0.03 % (12 h), 11.57±0.04 % (24 h), 11.84±0.04 % (36 h), 8.37±0.05 % (48 h) as shown in Table 2.

Table 2. Proximate composition (%) of unfermented and fermented millet flour.

Samples	Crude protein	Ash	Fats	Moisture	Crude fibre	Carbohydrate
M_0	9.65^c±0.00	1.06^d±0.02	2.50^d±0.55	4.20^d±0.02	3.45^a±0.05	79.19^a±0.78
M_{12}	9.82^c±0.03	1.35^c±0.20	4.60^b±0.06	5.68^b±0.05	3.43^a±0.22	75.14^c±0.11
M_{24}	11.57^b±0.04	1.67^a±0.01	4.96^a±0.03	5.22^c±0.07	2.96^b±0.15	73.65^c±0.00
M_{36}	11.84^a±0.04	1.53^b±0.00	4.82^{ab}±0.09	5.84^b±0.03	2.72^b±0.15	73.36^d±0.19
M_{48}	8.37^d±0.05	1.09^d±0.02	3.77^c±0.08	7.32^a±0.06	1.13^c±0.01	78.56^b±0.27

Values are means SEM of means of duplicate determinations. Values bearing different super-scripts in the same column are significantly different (p<0.05); Key: M0® unfermented millet flour; M12®12h fermented millet flour; M24® 24 h fermented millet flour; M36® 36 h fermented millet flour; M48 ®48 h fermented millet flour, M®millet flour.

Table 3. Proximate composition (%) of unfermented and fermented pigeon pea flour.

Samples	Crude protein	Ash	Fats	Moisture	Crude fibre	Carbohydrate
P_0	22.36^d±0.02	3.10^c±0.00	2.56^a±0.05	7.44^d±0.04	4.38^a±0.02	60.16^b±0.06
P_{12}	21.85^d±0.05	3.43^b±0.10	1.10^d±0.00	7.58^c±0.07	2.61^b±0.07	63.43^a±0.04
P_{24}	28.65^b±0.07	3.56^a±0.03	2.48^{ab}±0.07	8.26^b±0.08	2.81^b±0.03	54.70^c±0.11
P_{36}	30.88^a±0.04	3.20^c±0.01	2.29^b±0.04	8.26^b±0.08	2.81^b±0.03	52.56^d±0.05
P_{48}	27.18^c±0.21	3.12^c±0.04	2.05^c±0.04	8.99^a±0.08	4.37^a±0.08	54.28^c±0.01

Values are means±SEM of means of duplicate determinations. Values bearing different super-scripts in the same column are significantly different (p<0.05); Key: P_0 .→ Unfermented pigeon pea flour; P_{12}→ 12h fermented pigeon pea flour; P_{24} → 24h fermented pigeon pea flour; P_{36} → 36h fermented pigeon pea flour; P_{48}→ 48h fermented pigeon pea flour, P→pigeon pea flour.

Fermentation for 12 h showed a non-significant (p>0.05) increase in the crude protein level of millet by 1.76% of that originally present. Also, fermentation for 2 4h and 36 h significantly (p<0.05) increased the crude protein level of the millet by 19.89 and 22.69% respectively.

Furthermore, fermentation for 48 h significantly decreased (p>0.05) the crude protein level by 13.26%. The increase in crude protein content of the 36 h fermented millet indicates that 36 h was the optimum fermentation period for protein synthesis by the fermenting micro flora of the sample. The decrease in crude protein level of 48 h could be due to the fact that the fermenting micro-organisms have started using the nutrient in the millet. Also, the decrease in the 48 h crude protein level of the millet is not in agreement with Nwabugwu (2005), who reported increase in the protein content of millet after 48 h fermentation (72 h fermented millet 9.46%). The protein value (Table 3) for the unfermented pigeon pea was 22.36% while for the various fermentation regimes, were21.85 (12 h), 28.65 (24 h), 30.88 (36 h) and 27.18% (48 h). Fermentation for 24, 36 and 48 h increased the crude protein content of the pigeon pea by 28.13, 38.10 and 21.56%, respectively while the 12 h fermentation decrease the protein level by 2.28%. The 36 h fermentation is the optimum fermentation period for pigeon pea and it could be due to the release of free amino acids for protein synthesis (Egbekun, 1998).

The decrease in protein content at 48 h could be probably that microorganisms had used up the nutrient for their growth and metabolism (Ariahu et al., 1999). This decrease did not agree with Onuoha and Obizoba (2001), who reported an increase in the protein content of lima beans after 48 h fermentation. The fat content of fermented millet flour varied from 4.60 (12 h), 4.96 (24h), 4.82 (36h) to 3.77% (48h) with 24 h fermentation having the highest value (4.96 %) and unfermented millet flour had a value of 2.5%. Fermentation significantly (p< 0.05) increased the fat content of the millet flour. The increase in the fat content of millet with fermentation could be attributed to the ability of microorganisms to break up oil cells.

According to Obizoba and Atii (1994), there is an increase in fat content of millet with fermentation. Table 3 shows the fat content of fermented pigeon pea flour. The fat contents of fermented pigeon pea flour varied from 1.10 (12h), 2.48 (24h), 2.29 (36h) and 2.05% (48 h) respectively while the unfermented pigeon pea had the value of 2.56 %. The fat contents were found to be significantly lower in the fermented pigeon pea flour than in un-fermented pigeon pea flour. This decrease in fat contents might be attributed to the increased activities of the lipolytic enzymes during fermentation which hydrolyses fat components into fatty acid and glycerol (Adebowale and Maliki, 2011).

The ash content of the fermented millet flour range

Table 4. Mineral and vitamin contents of fermented and unfermented millet flour.

Samples	Iron (mg/100 g)	Zinc (mg/100 g)	Calcium (mg/100 g)	Vitamin A (IU)	Vitamin B_1 (mg/100 g)
M_0	$7.08^a \pm 0.00$	$0.45^c \pm 0.03$	$2.00^c \pm 0.00$	$33.02^e \pm 0.01$	$0.36^e \pm 0.02$
M_{12}	$4.19^c \pm 0.02$	$0.62^b \pm 0.01$	$2.04^c \pm 0.05$	$33.29^d \pm 0.78$	$0.58^d \pm 0.01$
M_{24}	$4.31^b \pm 0.00$	$0.77^a \pm 0.01$	$5.00^b \pm 0.00$	$60.55^b \pm 0.13$	$0.61^c \pm 0.00$
M_{36}	$2.95^d \pm 0.03$	$0.77^a \pm 0.01$	$6.05^a \pm 0.15$	$48.24^c \pm 0.43$	$0.68^b \pm 0.01$
M_{48}	$7.07^a \pm 0.05$	$0.79^a \pm 0.01$	$4.50^b \pm 0.30$	$68.35^a \pm 1.76$	$0.82^a \pm 0.00$

Values are means±SEM of duplicate determinations. Values bearing different super-scripts in the same column are significantly different ($p<0.05$); Key: $M_0 \rightarrow$ unfermented millet flour; $M_{12} \rightarrow$ 12 h fermented millet flour; $M_{24} \rightarrow$ 24 h fermented millet flour; $M_{36} \rightarrow$ 36 h fermented millet flour; $M_{48} \rightarrow$ 48 h fermented millet flour, M→millet flour.

from 1.06 to 1.67%, and unfermented millet flour had a value of 1.06% while highest value was recorded (1.67 %) at 24 h fermentation. Also, the ash content of pigeon pea (Table 3) flour ranged from 3.10 to 3.56% and unfermented pigeon pea flour had a value of 3.10% while 24 h fermentation period had the highest value (3.56%). There were gradual increase in the ash content of both fermented millet flour and fermented pigeon pea flour. There were significant different ($p>0.05$) in the ash content of millet but for the pigeon pea, apart from P_{12} and P_{24}, there were no significant difference($p < 0.05$) in the other samples. However, fermentation increased the ash content of both millet and pigeon pea flours.

The fermented samples showed comparable crude fiber content, which varied from 1.13 to 3.45% in millet and unfermented millet sample had the value of 3.45% while in pigeon pea (Table 3) the sample varied from 2.61 to 4.37% and the unfermented pigeon pea had the value of 4.38%.There were slight difference in crude fibre of both millet and pigeon pea. There were decreases in crude fibre of millet as the fermentation time increased but decreased the crude fibre of pigeon pea.

The moisture content of the millet flour ranged from 4.2 to 7.32% with unfermented millet flour having the value of 4.2% and 48h fermentation recorded the highest value (7.32%). Furthermore, the moisture content of the pigeon pea (Table 3) flour ranged from 7.44 to 8.99% with unfermented pigeon pea having the lowest value (7.44%) and 48 h fermentation having the highest value (8.99%). There were gradual increases in moisture content of both millet and pigeon pea with increase in fermentation. The decrease in moisture content of unfermented samples might probably be due to its low dry matter content while the increase in moisture content of both fermented millet and pigeon pea were because of the moisture absorbed during fermentation.

The carbohydrate content of the fermented millet flour ranged from 73.36 to 78.56% while the unfermented millet had the value of 79.19 %. Also, the carbohydrate level of the fermented pigeon pea flour ranged from 52.56 to 63.43%, and the unfermented pigeon pea value is 60.16%. The carbohydrate content of the flour varied with different fermentation periods. The carbohydrate content of millet fermented for 48h showed a significantly ($p<0.05$) increase than the other fermented millet samples. There was a reduction of carbohydrate content of pigeon pea as the fermentation time increased and in millet after 24 and 36 h fermentation period. This reduction in carbohydrate content could be attributed to possible hydrolysis of complex carbohydrate to simple sugars, which were used for metabolic processes (Nnam, 2001).

Effect of fermentation on the mineral and vitamin contents of fermented millet and pigeon pea flour

Table 4 and 5 shows the mineral and vitamin content of fermented millet and pigeon pea flour. There were a lot of variations in the iron content of millet flour. Fermentation decreased the iron content of millet. The samples were significantly ($p<0.05$) different from each other, it was only the millet flour fermented for 48 h that was not significantly ($p<0.05$) different from the unfermented millet flour. In contrast, there was significant ($p<0.05$) increase in the iron content of the fermented pigeon pea (Table 4). There were gradual increases in the iron content of pigeon pea as the fermentation time increased. Similar increase has been made in fermented soybeans by Van der Riet et al. (1987).

The zinc content of the millet flour was significantly ($p <0.05$) increased by fermentation when compared to the unfermented sample. This increase could probably be due to the removal of antinutrients that might have formed complexes with zinc. A similar increase in the zinc content of the cooked fermented and sprouted millet was reported by Obizoba and Atii (1994). As for the pigeon pea (Table 5) there were variations in their values. There were a non-significant ($p<0.05$) increase after 12 h fermentation of pigeon pea but a sudden significant ($p<0.05$) decrease was observed as the fermentation periods increased.

The calcium content of the fermented millet flour ranged from 2.04 to 6.05 mg/100 g while the unfermented millet flour had 2.00 mg/100 g (Table 4). The calcium content of the fermented pigeon pea ranged from 3.91 to 8.71mg/100g and the unfermented pigeon pea was 3.05

Table 5. Mineral and vitamin content of fermented and unfermented pigeon pea flour.

Samples	Iron (mg/100 g)	Zinc (mg/100 g)	Calcium (mg/100 g)	Vitamin A (IU) activity	Vitamin B_1 (mg/100 g)
P_0	3.02^d±0.02	0.76^a±0.03	3.05^d±0.30	43.10^c±0.05	0.48^e±0.02
P_{12}	3.04^d±0.04	0.77^a±0.01	3.91^c±0.03	12.73^d±0.09	0.69^a±0.00
P_{24}	3.73^c±0.03	0.65^{bc}±0.01	7.95^b±0.08	94.82^b±2.09	0.62^b±0.00
P_{36}	5.92^b±0.02	0.61^c±0.02	7.98^b±0.05	130.49^a±0.05	0.56^c±0.01
P_{48}	11.29^a±0.04	0.69^b±0.02	8.71^a±0.09	126.87^a±0.19	0.54^c±0.01

Values are means±SEM of duplicate determinations. Values bearing different super-scripts in the same column are significantly different ($p<0.05$); Key: P_0→Unfermented pigeon pea flour; P_{12}→ 12h fermented pigeon pea flour; P_{24}→ 24 h fermented pigeon pea flour; P_{36}→ 36 h fermented pigeon pea flour; P_{48}→ 48 h fermented pigeon pea flour, P→pigeon pea flour.

mg/100g. Fermentation significantly ($p<0.05$) increased the calcium content of millet. There were gradual increases in the calcium content of pigeon pea (Table 5) as the fermentation period increases. The unfermented samples of millet and pigeon pea flour were lower compared with those of the fermented samples. Amoo and Jokotagba (2012) reported a similar decrease in fermentation on the nutritive value of *Aspergillus niger* and *Aspergillus fumigatus* fermented *Huracrepitans* (sandbox tree) seed flour.

The vitamin A activity (precursor of vitamin A, beta-carotene), content of fermented millet flour ranged from 33.29 to 68.35 I.U. while unfermented millet flour was 33.02 I.U. The vitamin A content of fermented pigeon pea (Table 5) ranged from 12.73 to 130.49 I.U. while the unfermented pigeon pea was 33.20 I.U. There were significant ($p<0.05$) increases in both fermented millet and pigeon pea flour. It was observed that pigeon pea fermented for 12h had a significant ($p<0.05$) decrease in vitamin A content.

The vitamin B_1 content of the fermented millet flour increased by 0.58 mg/100g (12 h), 0.61 mg/100g (24 h), 0.68 mg/100g (36 h) and 0.82 mg/100g (48 h) while the unfermented millet flour was 0.36 mg/100g. However, the values for vitamin B_1 content of fermented pigeon pea ranged from 0.54 to 0.69 mg/100g while the unfermented sample was 0.48 mg/100g. There are also a slight but significant ($p<0.05$) increase in vitamin B_1 content of both fermented millet and pigeon pea flour. FAO (1995) observed increases in thiamin (up to 90 percent) and riboflavin (to 85 percent) on fermentation of pearl millet batter. There was also a similar increase in thiamin, riboflavin, ascorbic acid, vitamin A and tocopherol in pearl millet germinated for 48h and kilned at 45^0C (FAO, 1995).

Effect of fermentation of the functional properties of the single millet flour, pigeon pea flours, breadfruit leaf powder and their blends

The functional properties of unfermented and fermented millet and pigeon pea flours, seedless bread fruit leaf powder and their blends are shown in Table 6, 7 and 8. The bulk density of fermented millet flour ranged from 0.067 to 0.71 g/ml compared with the unfermented millet flour (0.67 g/ml) (Table 6). The samples M_{24} and M_{48} were significantly different ($p < 0.05$) from other millet samples. The bulk density of the pigeon pea flour ranged from 0.64 to 0.76g/ml (Table 7).

There were significant ($p<0.05$) differences among the flour samples. The bulk density of the seedless breadfruit leaf flour and the composite flours ranged from (0.54 to 0.65 g/ml) (Table 8). Fermentation did not have any effect on the bulk density of the millet and pigeon pea. However for the blends, there were no significant difference ($p<0.05$) they all had the same value. The bulk density values obtained were generally higher (0.67 to 0.71 g/ml) for millet, (0.64 to 0.76 g/ml) for pigeon pea and (0.54 to 0.65 g/ml) for the composite flour blends than that obtained by Edema et al. (2005) for flour from commercially sold soybean (0.38g/ml). However, values obtained from this study were comparable by Okaka and Potter (1979) for cowpea (0.60g/ml) and fall in the range for Bambara groundnut (0.6 to 0.75 g/ml) reported by Onimawo et al. (1998).

The values for water absorption capacity ranges from 1.36 to 2.17 % for millet flour (Table 9), 1.65 to 2.28 % for pigeon pea flour (Table 7), 1.68 to 1.99 for the composite flour blends (Table 11) and 3.67 for the seedless breadfruit leaf flour (Table 8). The unfermented millet flour had a value of 1.52 %, the values for the fermented millet flour increased at 36 and 48 h fermentation periods. The values for pigeon pea flour gradual increased with fermentation periods. As for the composite flour, their values increased with the sample (B_{55}) that had the highest quantity (15 %) of breadfruit leaf flour. The increase in values for pigeon pea and the blends was attributed to the fact that fermentation enhanced the hydrolysis of starch, which invariably increased the water absorption capacity of the samples (Onwulata et al., 1998).

The seedless breadfruit leaf flour had the highest value in water absorption capacity. Values obtained from this study are greater than that obtained for flours from soybean (1.12%) as reported by Alfaro et al. (2004) but however, compared with the water absorption capacity

Table 6. Functional properties of unfermented and fermented millet flour.

Sample	Bulk density (g/ml)	Oil absorption capacity (%)	Water absorption capacity (g/g)	Swelling index (%)	Wettability (minutes)	Least gelation concentration	Viscosity at 60 (centipoises)	Particle size distribution
M_0	0.67^{b}±0.001	1.24^{c}±1.765	1.52^{b}±0.017	1.57^{d}±0.735	1.27^{e}±0.015	8.00c±0.000	0.22^{d}±0.002	6.11^{d}±0.009
M_{12}	0.67^{b}±0.000	1.83^{a}±2.080	1.36^{c}±0.009	1.64^{d}±0.170	2.32^{d}±0.020	10.25^{c}±0.250	0.22^{d}±0.002	10.09^{b}±0.004
M_{24}	0.71^{a}±0.003	1.75^{b}±2.560	1.44b^{c}±0.001	1.67^{d}±1.925	3.57^{a}±0.015	15.00^{b}±0.000	0.26^{c}±0.001	10.78^{c}±0.616
M_{36}	0.67^{b}±0.002	1.73^{b}±1.200	2.08^{a}±0.77	1.79^{b}±0.715	3.27^{b}±0.050	15.00^{c}±0.000	0.28^{b}±0.002	11.38^{a}±0.440
M_{48}	0.61^{a}±0.004	1.29^{c}±0.655	2.17^{a}±0.050	1.89^{a}±0.140	2.57^{d}±0015	19.25^{a}±0.250	0.31^{a}±0.000	11.35^{a}±0.0022

Values are means ± SEM of duplicate determination. Values carrying different superscript in the same column are significantly different (P<0.05); Key: M_0→ Unfermented millet flour; M_{12}→ 12 h fermented millet flour; M_{24}→ 24 h fermented millet flour; M_{36}→ 36 h fermented millet flour; M_{48}→ 48 h fermented millet flour, M →millet flour.

Table 7. Functional properties of unfermented and fermented single pigeon pea flour.

Sample	Bulk density (g/ml)	Oil absorption capacity (%)	Water absorption capacity (g/g)	Swelling index (%)	Wettability (minutes)	Least gelation concentration	Viscosity at 60 (centipoises)	Particle size distribution
P_0	0.65^{c}±0.003	1.08^{d}±7.470	1.87^{c}±0.565	1.41^{d}±0.245	2.99^{b}±0.045	10.25^{d}±0.250	0.22^{a}±0.001	13.85^{b}±0.033
P_{12}	0.76^{a}±0.004	1.67^{c}±0.225	2.25^{a}±0.430	3.10^{a}±0.075	1.33^{a}±0.000	12.00^{b}±0.000	0.23^{a}±0.005	14.04^{a}±0.008
P_{24}	0.69^{b}±0.000	1.75^{bc}±0.225	2.28^{a}±0.014	3.07^{a}±0.475	1.58^{d}±9.010	12.25^{b}±0.0250	0.18^{b}±0.001	14.55^{b}±0.182
P_{36}	0.65^{c}±0.000	1.81^{b}±0.805	2.03^{b}±0.014	2.94^{a}±0.400	2.12^{c}±0.300	14.25^{b}±0.250	0.16^{c}±0.0001	12.81^{c}±0.078
P_{48}	0.64^{c}±0.002	2.26^{a}±2.615	1.65^{d}±0.012	2.19^{c}±0.015	3.22^{a}±0.10	18.00^{a}±0.000	0.15^{c}±0.003	13.04^{c}±0.069

Values are means ± SEM of duplicate determinations. Values carrying different superscript in the same column are significantly different (P<0.05).
Key: P_0→Unfermented pigeon pea flour; P_{12}→ 12 h fermented pigeon pea; P_{24}→ 24 h fermented pigeon pea flour; P_{36}→36 h fermented pigeon pea flour; P_{48} → 48 h fermented pigeon pea flour , P →pigeon pea flour.

Table 8. Functional properties of single breadfruit (*Artocarpus altilis)* leaf powder and the blends of millet, pigeon pea flour and breadfruit leaf powder.

Sample	Bulk density (g/ml)	Oil absorption capacity (%)	Water absorption capacity (g/g)	Swelling index (%)	Wettability (minutes)	Least gelation concentration	Viscosity at 60 (centipoises)	Particle size distribution
A_0	0.54^{b}±0.150	3.17^{a}±2.615	3.67^{a}±0.020	3.03^{ab}±1.285	12.96^{a}±0.040	33.50^{a}±0.000	0.15^{bc}±0.000	10.76^{a}±0.0333
B_{55}	0.65^{c}±0.000	2.76^{b}±1.379	1.99^{b} ±0.005	3.16^{a}±4.876	3.59^{b}±0.000	25.00^{b}±0.000	0.61^{a}±0.003	10.98^{a}±0.118
C_{60}	0.65^{a}±0.000	2.27^{c}±0.720	1.91^{c}±0.005	2.63^{ab}±0.080	3.14^{c}±0.020	20.25^{c}±0.250	0.12^{c}±0.001	5.17^{b}±0.056
D_{65}	0.65^{a}±0.000	1.97^{d}±0.970	1.72^{d}±0.0001	2.63^{ab}±0.020	3.09^{c}±0.015	18.00^{cd}±0.000	0.14^{c}±0.002	5.61^{b}±2.609
E_{70}	0.65^{a}±0.001	1.32^{e}±0.090	1.68^{e}±0.003	2.25^{b}±0.695	2.51^{d}±0.015	17.25^{d}±0.750	0.13^{c}±0.003	8.85^{ab}±0.040

Values are means ± SEM of duplicate determinations. Values carrying different superscript in the same column are significantly different (P<0.05). Key: A_0→ Bread fruit leaf powder; B_{55}→ Millet + pigeon pea flours + breadfruit leaf powder blends (55:30:15); C_{60}→ Millet + pigeon pea flours + breadfruit leaf powder blends (60:30:10); D_{65}→ Millet + pigeon pea flours + breadfruit leaf powder blends (65:30:5); E_{70} → Millet + pigeon pea flour blends (70:30).

Table 9. Proximate composition (%) of millet and pigeon pea flour blends and seedless breadfruit (*Artocarpus altilis*) leaf powder.

Samples	Crude protein	Fats	Ash	Moisture	Crude fibre	Carbohydrate
A_0	24-27^a±0.580	1.21^c±0.020	4.46^a±0.245	3.74^c±0.320	11.51^a±0230	54.87^e±0.295
B_{55}	23.45^a±0.000	2.77^b±0.035	3.48^b±0.040	3.55^{cd}±0.040	10.75^a±0.030	55.99^d±0.015
C_{60}	16.91^b±0.030	4.29^a±0.025	3.01^c±0.000	4.78a±0.090	5.03^{bc}±0.350	65.98^c±0.015
D_{65}	14.59^d±0.250	4.85^a±0.035	3.20^c±0.030	3.91b±0.090	4.76^c±0.135	68.68^b±0.075
E_{70}	15.78^c±0.173	2.00^c±0.200	2.51^d±0.015	3.39d±0.060	5.17^b±0.035	71.17^a±0.015

Values are means ± SEM of duplicate determinations. Values bearing different superscripts in the same column are significantly different ($p< 0.05$). Key: A_0 →Breadfruit (*Artocarpus altilis*) leaf powder; B_{55}→ millet + pigeon pea flours + breadfruit leaf powder blends (55:30:15); C_{60}→ Millet + pigeon pea flours + breadfruit leaf powder blends (60:30:10); D_{65} →Millet + pigeon pea flours + breadfruit leaf powder blends (65:30:5);E_{70}→ millet + pigeon pea flour blends (70:30).

for pigeon pea by Adebowale and Maliki (2011). This result suggests that fermented pigeon pea flour may find application in the production of some baked products.

The values for oil absorption capacity (OAC) ranges from 1.24 to 1.83% (millet flour in Table 6), 1.08 to 2.26% (pigeon pea flour in Table 7), 1.32 to 2.76 % (the blends of millet, pigeon pea flour and seedless breadfruit leaf powder in Table 8 and 3.17% for breadfruit leaf powder (Table 8). The OAC of fermented millet flours are higher than the unfermented millet flour (1.24 %), but there is a gradual decrease in value as the fermentation time increased. However, oil absorption capacity of pigeon pea increase with the increase in fermentation time. As for the blends, the values gradually increased with the increment in the addition of seedless bread fruit leaf powder. Therefore, fermentation increased the oil absorption capacity of the samples. The highest value (3.17%) of seedless breadfruit leaf powder was because of excess fiber in the leaf.

Least gelation concentration is very important in food preparations. Least gelation concentration of millet flour ranged from 8.00 to 19.25% (Table 6), with highest value recorded with 48 h fermentation period of millet flour. Also, the least gelation concentration for the seed flour of pigeon pea ranged from 10.25 to 18.00% (Table 7), with highest value recorded with 48 h fermentation period of pigeon pea. Thus the least gelation concentration increased with fermentation periods for both millet flour and pigeon pea flour. These values are similar to that reported for great northern bean flour (10 %), cowpea (16%) by Sathe and Salunkhe (1981) and soyabean flour (10 %) by Alfaro et al. (2004). Such variation in the gelling properties of different legume flours may be ascribed to the relative rations of different constituents, proteins, carbohydrates and lipids that make up the flours, suggesting that interactions between such components may also have a significant role in the functional properties (Sathe et al., 1982).

This increase in the least gelation concentration of fermented millet and pigeon pea flours suggest that there was a decreased ability of the fermented millet flour and pigeon pea flour to form a stable gel. This observation was also noted by the Ihekoronye (1986). However, the values for the blends ranged from 17.25 to 25.00 % with bread fruit leaf powder having the highest value of 33.5 % (Table 8). The values gradual increase with the addition of seedless bread fruit leaf powder to the blends. This increase could probably be because of the low or no starch content of the breadfruit leaf powder.

The viscosity at 60°C of the fermented and unfermented millet and pigeon pea flours are shown in Table 6 and 7. The viscosity of the fermented millet ranged from 0.22 to 0.31 cp while the unfermented was 0.22 cp (Table 6). There was a small but significant ($p<0.05$) increase in the viscosity started from the 24 h fermented millet. This was not in agreement with Mensah et al. (1991), who observed reduction in viscosity of fermented maize. However, there was a reduction in the viscosity of fermented pigeon pea flour from 24 h (0.18 cp), 36 h (0.16 cp) and 48 h (0.14 cp) while there was no significant ($p<0.05$) different in the unfermented pigeon pea (0.22 cp) and 12 h fermented pigeon pea flour (0.23 cp in Table 7). This reduction in viscosity of pigeon pea flour is due to the activities of amylase that broke starch down into simpler sugars, thus reducing viscosity (Mensah et al., 1991). Also, for the blends, the values ranged from 0.12 cp (C_{60}), 0.13cp (E_{70}), 0.14 (A_0), 0.14 (D_{65}) and 0.16 cp (B_{55}) (Table 8). The sample B_{55} had higher viscosity value than other samples and this could be due to the higher quantity of seedless breadfruit leaf powder in the blends. There was also reduction in the viscosity of other blends. This reduction in viscosity would produce thin porridges, which would be good for infant formula.

The swelling indices of fermented and unfermented millet, pigeon pea flours and their blends are presented in Tables 6, 7 and 8 respectively. The fermented millet ranged from 1.64 to 1.89% while the unfermented millet was 1.57% (Table 6). The value for unfermented pigeon pea was 1.41% while the fermented pigeon pea flour ranged from 2.19 to 3.10% (Table 7). There were significant ($p<0.05$) increase in the values of both fermented millet and pigeon pea flours. The swelling index of the blends ranged from 2.25 to 3.16% (Table 8).

Table 10. Mineral and vitamin contents of millet and pigeon pea flour blends.

Samples	Zinc (mg/100 g)	Calcium (mg/100 g)	Iron (mg/100 g)	Vitamin A (1U) activity	Vitamin B1 (mg/100 g)
A0	5.54a±0.000	9.01c±0.055	5.54c±0.011	1311.07a±6.173	0.69a±0.003
B55	0.68b±0.000	1.98e±0.108	11.54b±0.350	839.53b±2.236	23.61c±0.170
C60	0.37d±0.003	2.97d±0.020	2.92e±0.100	645.21c±4.305	25.98b±0.075
D65	0.42c±0.008	49.96b±0.0195	23.54a±0.505	69.72d±0.160	28.51a±0.160
E70	0.23e±0.004	53.89a±0.945	4.91a±0.184	38.44a±0.320	23.05d±0.070

Values are means ±SEM of duplicate determination values carrying different superscripts in the same column are significantly different ($p<0.05$); Key: A_0 → Breadfruit (*Artocarpus altilis*) leaf powder; B_{55}→ Millet + pigeon pea flours + Breadfruit leaf powder blends (55:30:15);C_{60}→ Millet + pigeon Pea flours + Breadfruit leaf powder blends (60:30:10); D_{65}→ Millet + pigeon pea flours + Breadfruit leaf powder blends (65:30:5) ; E_{70}→ Millet + Pigeon Pea flour blends (70:30).

The swelling index for the blends varied, and did not follow a particular trend. This could probably be due to the various quantity of seedless breadfruit leaf powder in the blends. These increases in swelling indices of millet, pigeon pea flour and their blends as the fermentation time increases, made the bond relax, thereby causing starch granules to imbibe water in swell and a low molecular weight amylase solubilize and leach out into the aqueous medium (Oke and Bolarinwa, 2012).

The time for wettability of fermented and unfermented millet, pigeon pea, seedless breadfruit leaf and their blends are shown in Table 6 to 8. It ranged from 2.32 to 3.57 min (fermented millet) and 1.27 minutes (unfermented millet, Table 6), 1.33 to 3.22 minutes, (fermented pigeon pea flour) and 2.99 minutes (unfermented pigeon flour Table 10) 2.51 to 3.59 minutes for the blends and 12.96 for the seedless breadfruit leaf powder in Table 8. There were significant ($p<0.05$) different in the samples. This could probably be due to the effect of fermentation period which have affected the flour. As for the seedless breadfruit leaf powder (which had the highest value), it could be probably due to the fact that it is a leaf and cannot absorb moisture very fast in the water. It affects other blends which had had the high value of wettability.

The particle size distribution of the fermented and unfermented millet, pigeon pea and their blends are shown in Table 6, 7 and 8 respectively. The fermented millet increased gradually as the fermentation period increased while the value for the unfermented millet (6.11) was lower than the fermented samples (Table 6). There was also significant ($p<0.05$) increases in the value of pigeon pea flour from P_{12} (14.04) and P_{24} (14.55) but a sudden decrease as the fermentation period increase P_{36} (12.81) and P_{48} (13.04) while the value for the unfermented pigeon pea was 13.85 (Table 7). There was significant increase and decrease in the value of the blend which ranged from 5.17 to 10.98 (Table 8) while the seedless breadfruit leaf powder was 10.76 (Table 8). This could probably be due to the varying amounts of incorporation of the seedless bread fruit leaf powder in the blends.

Effect of the incorporation of the seedless breadfruit (*A.altilis*) leaf powder on the proximate composition of millet, pigeon pea flour blends

Table 9 presents the proximate composition of millet flour pigeon pea flour and seedless breadfruit leaf powder blends. The protein content of the blends ranged from 23.45 (B_{55}), 16.91 (C_{60}), 14.59 (D_{65}) and 15.78% (E_{70}), respectively while the seedless breadfruit leaf powder had 24.27% in Table 9. There were significant ($p<0.05$) increases in the protein level of the blends with respect to the samples that had the highest quantity of breadfruit leaf powder. This protein level of seedless breadfruit powder was high (24.27%) compared to the protein level (16.91%) of the blends. This showed that the leaf had an appreciable amount of protein. This result agreed with Badra (1993) who recorded crude protein values of between 21.03 and 29.70% for *Celosia laxa, Corchorus olitorius (Ewedu)* and *Amaranthus caudatus* (velvet flower or foxtail amaranth) according to Dike (2010).

Sample D_{65} had the highest level of fat content while the seedless breadfruit leaf powder had the lowest level of fat content. The fat content of the breadfruit leaf powder did not agree with the fat content of the *Gnetaceae* leave (7.52 %) according to Dike (2010). The ash level of seedless breadfruit leaf powder was 4.46% and it was higher compared to the ash level of the blends. There was significant ($p<0.05$) difference of the ash content of the blends. The ash content of sample B_{55} was higher than others. This was probably due to high level (15%) of seedless breadfruit leaf powder in the sample.

There were significant ($p< 0.05$) differences in the moisture level of the blends and the breadfruit leaf powder respectively. This could probably be due to the various levels of millet and bread fruit in the blends. The moisture content of the samples were low A_0 (3.74%), B_{55} (3.55%) C_{60} (4.78%), D_{65} (3.91%) and E_{70} (3.39%). A similar result was obtained from weaning food produced from the blends of pearl millet, cowpea and groundnut which recorded (4.5 %) moisture content.

The crude fibre of the sample B_{55} (10.75%) was higher than the other blends because it contained the highest quantity of the breadfruit leaf powder (11.51%) crude fibre. There were significant ($p<0.05$) increases in the carbohydrate content of the blend starting from sample E_{70} (71.17%), D_{65} (68.68%), C_{60} (65.98 %) and B_{55} (55.99 %) while the breadfruit leaf (A_0) had the lowest level of 54.87%. Sample E_{70} had the highest level of carbohydrate. This was probably due to the highest level of millet and increment followed a particular trend. Sample E_{70} (millet 70 % + pigeon pea 30 %) appeared to be rich in carbohydrate. The possible reason for this is that the flour is sediment of starch, proteins and other nutrients which are concentrated in the residue. A similar result was obtained with sorghum traditional complementary food and its composite flours (Nnam, 2001). The proximate values for the blends were higher than the millet flour which was normally used as a traditional complementary food.

Effect of the incorporation of the seedless breadfruit (*A. altilis*) leaf powder on the mineral and vitamin contents of millet and pigeon pea flour blends

The mineral and vitamin contents of millet, pigeon pea flour and seedless breadfruit leaf powder blends are shown in Table 10. The zinc content of the blend ranged from 0.23 to 0.68 mg/100 g while the seedless breadfruit leaf powder had 5.54 mg/100 g. Sample B_{55} with the highest quantity of breadfruit leaf powder had the highest value of 0.68 mg/100g while E_{70} (without no seedless breadfruit leaf powder) had the lowest value of 0.23 mg/100 g. There were significant ($p<0.05$) among the samples. The calcium level of the blends ranged from 1.89 to 53.89 mg/100g while the breadfruit leaf powder was 9.01 mg/100 g. There were significant ($p<0.05$) different among the samples. Sample E_{70} (which contains no seedless breadfruit leaf powder) had the highest level of calcium content (53.89 mg/100g).

The iron content of the blends ranged from 2.92 to 11.45 mg/100g while the seedless breadfruit leaf powder had 5.54 mg/100 g. However, sample B_{55} had the highest level of iron. The levels of zinc, calcium and iron of the breadfruit leaf powder were low. Few scientists, Badra (1993) and Dike (2009), also recorded low concentration of these minerals in *Amaranthus caudatus* (velvet flower), *Celosia laxa* (silver spinach or woolflower) among others.

Table 10 also presents the vitamin composition of millet flour, pigeon pea flour and bread fruit leaf powder. The vitamin A activity content of the blends ranged from 38.44 to 839.53 IU while the value of vitamin A activity content of seedless breadfruit leaf powder was 1311.07 IU. Also, the vitamin B_1 content of the blends ranged from 23.05 to 28.5 mg/100g while seedless breadfruit leaf powder had 0.69 mg/100g. There were significant ($p<0.05$) differences in both vitamin A and B_1 contents of the blends. The vitamin A contents followed a particular trend. It was observed that the incorporation of the seedless breadfruit leaf powder increased the vitamin content. However, the vitamin B_1 content had increases in its value as the quantity of the breadfruit leaf powder was reduced. Therefore, the vitamin A content of breadfruit leaf powder was very high 1311.07 1U while that of vitamin B_1 was very low 0.69 mg/100g. Blending of M_{36} and P_{36} increased the vitamin A content and lowered vitamin B_1 content.

Table 11. Total viable counts (TVC) and mould count of fermented unfermented pigeon pea flour, millet flour, breadfruit (*Artocarpus altilis*) leaf powder and the blends.

Sample	TVC (cfu/g)	Mould count (cfu/g)
P_0	$3.5x10^4$	-
P_{12}	$4.3x10^4$	$2.0x10^3$
P_{24}	$3.4x10^4$	$2.0\ x10^3$
P_{36}	$2.7x10^4$	$2.0\ x10^3$
P_{48}	$1.9x10^4$	$1.0\ x10^3$
M_0	$4.4x10^4$	$1.0\ x10^3$
M_{12}	$4.8x10^4$	$1.0\ x10^3$
M_{24}	$3.6x10^4$	$3.0\ x10^3$
M_{36}	$2.9x10^4$	$1.0\ x10^3$
M_{48}	$1.9x10^4$	-
A_O	$2.1x10^4$	$1.0\ x10^3$
B_{55}	$2.9x10^4$	$2.0\ x10^3$
C_{60}	$2.0x10^4$	$2.0\ x10^3$
D_{65}	$2.9x10^4$	$1.0\ x10^3$
E_{70}	$3.2x10^4$	$3.0\ x10^3$

Values are means $\pm$ standard of error of means of duplicate determination. key:–→ No growth; P_0→ Unfermented pigeon pea flour; P_{12}→ 12 h fermented pigeon pea flour P_{24}→ 24 h fermented pigeon pea flour; P_{36}→ 36 h fermented pigeon pea flour P_{48}→ 48 h fermented pigeon pea flour; M_0→ Unfermented millet flour M_{12}.→ 12 h fermented millet flour; M_{24}→ 24 h fermented millet flour; M_{36}→ 36 h fermented millet flour; M_{48}→ 48 h fermented millet flour; A_0→ Bread fruit leaf powder; B_{55}→ Millet + pigeon pea flours + bread fruit leaf powder blends (55:30:15) ; C_{60} → Millet + pigeon pea flours + bread fruit leaf powder blends (60:30:10); D_{65}→ Millet +pigeon pea flours + bread fruit leaf powder blends (65:30:5); E_{70} → Millet + pigeon pea flour blends (70:30).

Total viable and mould counts of fermented and unfermented pigeon pea flour, millet flour, breadfruit (*A.altilis)* leaf powder and the blends

The total viable count of the fermented and unfermented pigeon flours, millet flours, unfermented breadfruit leaf powder and the blends of millet (M_{36}), pigeon pea (P_{36}) and breadfruit leaf powder are shown in Table 11.

The total viable count for the fermented pigeon pea flour ranged from 4.3×10^4 (P_{12}), 3.4×10^4 (P_{24}), 2.78×10^4 (P_{36}) and 1.9×10^4cfu/g (P_{48}) while the unfermented pigeon pea was 3.5×10^4 cfu/g (P_0). Also, the values for fermented millet flour ranged from 5.8×10^4 (M_{12}), 3.6×10^4 (M24), 2.9×10^4 (M_{36}), 1.9×10^4cfu/g (M_{48}) while that of unfermented millet flour was 4.4×10^4 cfu/g (M_0). It was observed that P_{12} and M_{12} had the highest values 4.3×10^4 cfu/g and 5.8×10^4 cfu/g, respectively.

This may be because the 12 h fermentation was favourable for the microorganisms to thrive on. After 12 h fermentation period, the microbial count of both pigeon pea and millet flours started decreasing gradually as the fermentation time was increasing. This could probably be due to increase in acidity and other metabolites which made the environment unbearable for the microorganisms to survive thereby leading to decrease in the microbial count with progression of fermentation.

The seedless breadfruit leaf powder (A_0) was 2.1×10^4 cfu/g while the values for the blends varied from 2.0×10^4 cfu/g to 3.2×10^4 cfu/g. There were significant ($p<0.05$) differences in the microbial count of the blends and this could probably be due to varying ratio of millet and seedless breadfruit leaf powder in the blends. The International Microbiological Standard recommended that the limit of bacteria contaminants for food of less than 10^6 cfu/g (Anonymous, 1974).

Mould count for the fermented millet flour is shown is Table 11. The fermented millet ranged from 1.0 x 10^3cfu/g to 3.0 x 10cfu/g while the unfermented millet flour had 1.0 x 10^3cfu/g. Also, the fermented pigeon pea flour ranged from 1.0 x 10^3cfu/g to 2.0 x 10^3cfu/g while the unfermented pigeon pea flour had 1.0 x 10^3cfu/g. There was no growth in P_0 and M_{48}. However, for the blends, they were also at the same range of 1.0 x 10^3 to 3.0 x 10^4cfu/g.

CONCLUSION

Based on the proximate composition, it was observed that M_{36} (millet fermented for 36 h) and P_{36} (pigeon pea fermented for 36 h) had high protein 11.84 and 30.88% respectively, and was selected for formulation of complementary food. The composite flours (M_{36}/P_{36}) showed appreciable amounts of protein, ash, crude fibre, calcium, iron, vitamin A and B_1 over the single flours used in the preparation of traditional complementary food. The low microbial count (below the acceptable safe level) was reported. From the bulk density, oil absorption capacity, wettability and viscosity, it was observed that single flours could be used for weaning formulation. This study showed that nutrient dense complementary food could be produced from millet and pigeon pea fortified with seedless breadfruit leaf powder than using millet flour alone.

Conflict of interests

The authors have not declared any conflict of interests.

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