Formulation and Assessment of Nutritious Infant Complementary Foods from Co-Fermented Maize, Millet and Pigeon Pea Blends

Abstract

Infant complementary food introduces nutritious meal to augment for deficiency at early stage of growth. This study focuses on investigating proximate, physico-chemical, functional and anti-nutritional properties of the infant food formulation from blend of maize, millet and pigeon pea. The dried co-fermented maize-millet was milled into fine flour, mixed with fine powder obtained from processed pigeon pea. Different blends of the co-fermented cereals and pigeon pea powder formulation were prepared. The Proximate, nutritional, chemical, functional property, mineral content, anti-nutritional properties and sensory evaluation of the complementary food produced were evaluated. Energy values of the formulations were in the range of 353.76 – 358.86 kca/g, obtained from co-fermented maize-millet and pigeon pea blends. Sample MSE had the highest protein content of 15.60 $\pm$ 0.95%. For functional properties, bulk density highest and lowest values were 0.70, 0.62 g/ml from MSE, MSA respectively, for swelling capacity; water absorption capacity and oil absorption capacity, the highest values were obtained from MSE, the lowest values were from MSA. For mineral composition, sample MSA had the highest value of calcium and zinc which were: 204.79 and 11.49 mg/100g $\pm$ 0.02[a] while sample MSE had the highest value of iron; 4.96 in mg/100g respectively. The anti-nutritional composition shows that sample MSA had the lowest value of saponin, phytate and oxalate and sample MSE had the highest value of saponin, phytate and oxalate. Sensory evaluation indicated that MSA is mostly valued. These formulations are cheap source of infant food, formulation obtained in MSA and MSE are most preferred for use as weaning foods as selected by sensory evaluation.

Keywords: Co-fermented, dehulled, functional food, maize-millet, blends.

Introduction

Complementary feeding is an augmentation feeding process to initiate infant with family meals and meet nutrients requirements, this process starts when breast milk is inadequate for the nutritional needs of infants. Therefore, augmentation meal is required along with breast milk. Complementary foods are used to replace breast milk gradually, and to augment infant formula, it provides additional nourishment during process of weaning (WHO 2011; USDA, 2019). There are recommendation to follow when complementary meals are to be introduced to the child, such recommendations include considerations of developmental stages and nutrients status; inherent medical condition, cultural, ethical and religion food preference of the family are very important (Castenmiller *et al.*, 2019; Dagne *et al.*, 2019).

Complementary foods are used during child transition from infant foods to family foods, at this stage infant formula which are commercial foods are used. However, for low income individual these infant formula products are mostly expensive and hence insufficiently supplied leading to malnutrition. The inadequacy is obviously as a result of increasing energy and nutrient requirement at this stage of rapid growth of the baby. At age 6 -12 months, a sufficient ration that will meet the need of rapid growing infant are necessary, therefore the augmentation with locally formulated staple food to reduce cost (Makinde *et al.*, 2012).

Exclusive breastfeeding at the early stage is safe and advised, complementary feeding comes in when the breast feeding may not be adequate to supply the needed nutritional requirement as a result of growth and health status of the infant (Maslin, 2017). At infancy, (0 - 2 years), a critical growing stage, for healthy and behavioral development good nourishment is required (Onoja, 2014; Maslin, 2017). Commonly, in low income class, there is noticeable inadequacy in growth during weaning; this may mostly be consequence of lack of adequate or insufficient supply of nourishment. Poor preparations, inadequate and low quality of local formulated weaning foods are the common occurrence, prevalent across classes and groups (Plessie, 2013; WHO, 2013; Grimshaw *et al.*, 2014).

Protein deficiency is common occurrence, mostly when infants are fed with low quality complementary foods. This is often accompanying by calories and macronutrients deficiency (Akinola *et al.*, 2014). Poor choice of complementary food blends will adversely affect child growth and development both physical and mental capability (Onyango *et al*., 2014). For adequate growth and mental development of the child, according to Wallenborn, (2021), breastmilk must be complemented adequately, commencing at 6 months old. Gradually, infant transition to family food should be introduced between 2-3 times a day as from 6-8 months, subsequently increase to 3-4 times daily from age 9-12 months, other snacks should be provided as additional nourishment between 12-24 months in between meal or as desired (Qasem *et al*., 2015; Prell and Koletzko, 2016).

Consequently, upon the noticeable inadequacies of the homemade complementary food preparation, many formulations have been suggested, feeding procedure and feeding time have been provided as a guide (Dagne *et al*., 2019; Isaac *et al*., 2022). This project work offers an alternative complementary diet, on the premix of nutrients full cereal and pulse that will meet nutritional requirement guidelines for introducing infant to complementary meals. It is important that complementary feeding is an exigencies measure to combat deficiency as a consequence of breast milk inadequacy at such stage of growth between ages 6-23 months. The nutritional requirements continue to increase, with child increasing age, beyond the breast milk supply thus gap are created. For energy need, complementary food should supply 200, 300, 550 kcal daily to augment the energy requirements for age 6-8, 9-11 and 12-24 months respectively (Relvas *et al.,* 2019). Furthermore, the micronutrients requirement such as calcium, iron, zinc, phosphorus, magnesium and vitamin B6 must also be met. Unfortunately, most stuff used for complementary foods are not significantly adequate to meet the need of these macronutrients, protein and vitamins, most importantly vitamin B1, B2, B6, B12 and vitamin C. (UNICEF, 2012; Qasem *et al*., 2015).

Complementary food is expected to contain required energy and nutrients and vitamins, it must be adequate in quantity and quality to meet the macro and micro nutrients appropriately for growing infant to achieve balance diet, it required combination of energy given raw material grains and pulse. The cost must be low to serve the purpose of been available for the low income earners as well as the middle class categories (Bari *et al*., 2019; Isaac *et al*., 2022). In some African countries, locally formulated weaning foods are produced from staple grains, these are often deficient in some minerals nutrients and some specific vitamins (Dewey, 2013; Yusufu *et al.,* 2013). There is therefore a need to make homemade food which is rich in nutrients, available for mothers because commercially formulated infant foods are often beyond the reach of the poor. (Aguayo and Menon, 2016). To enhance the nutrients of grains, other cereal combinations such as maize, millet and pigeon pea combination, and fermentation process will increase digestibility and availability of the nutrients and vitamins in the meal, it will reduce anti-nutritional constituents (WHO, 2012; Plessis *et al.,* 2013; Bari *et al*., 2019).

Fermentation process converts complex organic molecules to simpler forms. The process involves microorganisms, through metabolic process remove or reduce anti-nutrients and makes the simple molecules readily assimilated to the body. Yeast such as *saccharomysis cerevisae* convert such food molecules like starch, raffinose and maltose into simple form (glucose), while proteins are converted to peptide/amino acid. Activities of microbes and enzymes involves in fermentation lead to biochemical change that produces significant modification of food substance and give desirable and more appealing food products (Lebaka *et al*., 2018; Nkhata *et al*., 2018). Fermentation has been age long practice of improving food qualities; the appearance, flavor and aroma are enhanced. It is a natural process that makes vitamins, essential amino acid, microelements available (Ogunremi *et* al., 2015; Simwaka *et al*., 2017; Xiang *et al*., 2019).

foods Shelf life are enhanced when it is subjected to controlled fermentation and organoleptic values of food are improved. For example, yoghort is organolepticaly improved than raw milk. Fermentation enhances the bio-conversion of complex molecules of the raw food materials to safe end product, for example, during gari production, there is an elimination of hydrogencyanide content of cassava, and the anti-nutritional factors in legumes are removed by fermentation (Tsafrakidou *et al.,* 2020). Probiotics enhance nutritional properties as it developed during food fermentation, due to the presence of fermenting microorganisms. For example, yeast and lactic acid bacteria in garri and yeast in bread add to its nutritive quality and help in dough rising respectively, the fermentation process reduces the cooking time of food like locust beans. Also, West African food like Ogi prepared from fermented maize are more appealing when properly fermented, and locust bean production are enhanced by fermentation (Adeoye *et al*., 2018; Abioye *et al*., 2021).

Materials and methods

Maize, millet and pigeon pea were sourced from local market in Ondo, Ondo state, South West, Nigeria, and all other reagents used for investigations of quality attributes were analytical grade.

Preparations of ingredients (Maize, Millet and Pigeon pea)

Flour of maize and millet were processed together after thorough sorting and cleaning, following the modified method of Nwakalor and Obi (2014) as shown in Figure 1. The grains were co-fermented after steeping for 72 h and milled into fine consistency of 250µml. The final powder was store in air tight low density polyethylene bags at room temperature.

The pigeon pea flour was also processed according Nwakalor and Obi (2014), with modification as shown in Figure 1. These involve sorting, cleaning, steeping (72 h), de-hulled and precooked. Consequently, the obtained sample was dried in cabinet drier to 12 % moisture content at 65 ^{0}C and milled to 250 µml particle size. The co-fermented maize and millet flours were mixed with pigeon pea flour appropriately in ratio 90:10; 80:20; 70:30; 60:40; 50:50. This reconstituted mixture was subjected to both physical chemical and sensory analysis to obtain the best and preferred combination.

Proximate analysis

Proximate analyses were carried out following the AOAC (2019), the analysis include: moisture content, crude protein determination, crude fat determination, ash content and crude fiber determinations.

Functional properties determination

Determination of water absorption capacity and bulk density were carried out by the methods described byMalomo *et al*., *(*2012) and Siddique *et al.*,(2012) respectively. Oil absorption capacity (OAC);swelling power and solubility were determined byAppiah *et al*. (2011),and Jude-ojei *et al.* (2017) respectively

Mineral Content Determination

The minerals; Calcium (Ca), Iron (Fe), and Magnesium (Mg) were determined by atomic absorption spectrophotometer while Sodium (Na) and Potassium (K) were determined using flame photometer (AOAC, 2019).

Antinutrients and Sensory Analysis

Antinutritional property such as oxalate was determined by methods described by Oke (2012) and Falade (2014), phytate, and saponin content of the samples were determined by the methods described by AOAC (2019) andObadoni and Ochuko (2002) respectively.

Sensory evaluation of the developed infant foods was carried out by fifteen panelists among mothers in primary health care centers in Ondo State, Nigeria. Using 9-point hedonic scale as described by Singh *et al.* (2012) and Bolarinwa *et al*., (2016).

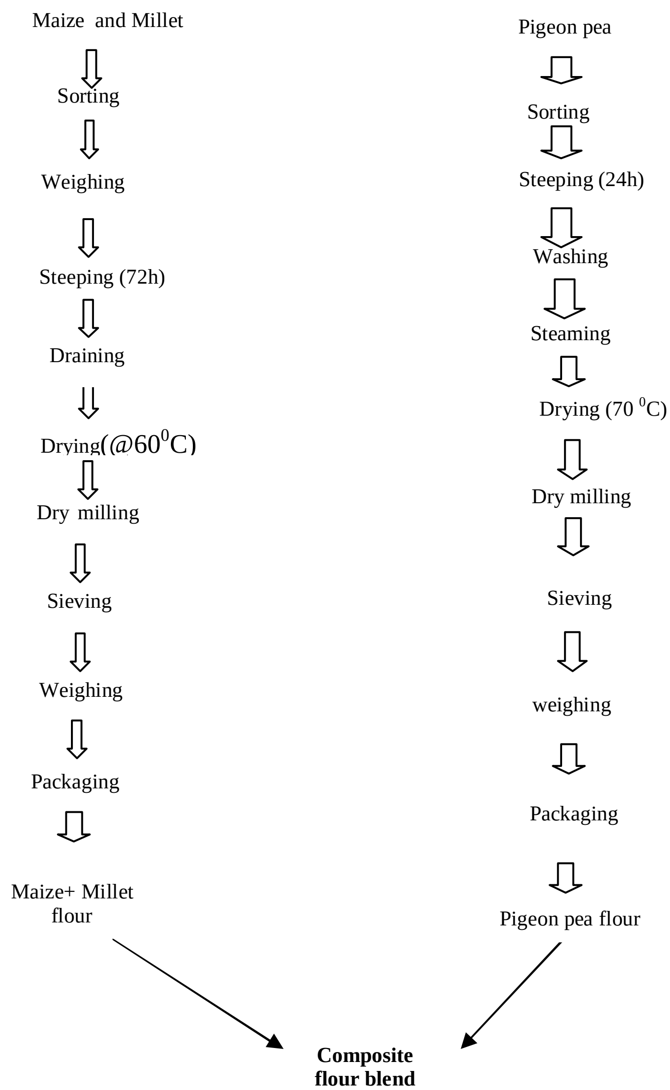

Figure 1: Co-fermented Millet-Maize flour and pigeon pea flour (Nwakalor and Obi, 2014).

RESULT

Proximate composition of the samples

The proximate composition is shown in Table 1. For crude protein, co-fermented maize-millet flour (MSF) was 11.42 %, for the for the pigeon pea flour inclusion 20.24 %. For the formulated food samples, the protein values ranged between of 12.19-15.60 % (MSA-MSE). The inclusion of pigeon pea increased the protein value, while sample MSE had the highest protein value (Table .1). Fermentation process has been proofed to increase protein value in food products (Mbaeyi-Nwaoha and Obetta, 2016). Thus high protein obtained in both co-fermented flour samples were influenced by the pigeon pea and fermentation process. Day and Marawicki, (2016) corroborated the positive effect of fermentation on protein level of fermented grain. The pigeon pea flour was higher in protein (20.24%) this shows that pigeon pea is a good complement that augments for the protein of the blends. The blends showed a crude protein content increase with increased pigeon pea addition, thus make it conforms to the minimum recommendation of 10 % protein content in complementary food for infants (Abeshu *et al.*, 2016; Arsenault and Brown, 2017). However, the formulated food could be given to infants as a protein enriched food to prevent protein energy malnutrition (PEM). The value obtained for protein content for the blends agreed with that obtained by Sodipo *et al.* (2018) which were between 11.70-14.60 % for pearl millet and germinated pigeon pea composite flour (Perrin *et al.*, 2020).

Table 1: Proximate Composition of complementary Flour Blends

Sample	Moisture (%)	Fat (%)	Fibre (%)	Ash (%)	Protein (%)	CHO	Energy (kcal/g)
MSA	9.65±0.16^{d}	0.42 ± 0.03^{f}	0.96 ± 0.03^{f}	0.22 ± 0.01^{f}	12.19 ± 0.14^{f}	76.58±0.31^{a}	358.86^{C}
MSB	9.94 ±0.05^{c}	0.45 ± 0.02^{f}	1.02 ± 0.04^{f}	0.30 ± 0.02^{f}	12.86 ± 0.16^{e}	75.44±0.05^{b}	357.25^{bc}
MSC	10.02± 0.04^{bc}	0.56 ± 0.02^{e}	1.25 ± 0.04^{e}	0.45 ± 0.04^{e}	14.42 ± 0.10^{d}	73.3±0.07^{c}	355.92^{b}
MSD	10.12 ±0.09^{ab}	0.62 ± 0.03^{d}	1.43 ± 0.08^{d}	0.51 ± 0.03^{d}	14.8 ± 0.12^{c}	72.56±0.08^{d}	355.02^{b}
MSE	10.24 ±0.07^{a}	0.68 ± 0.03^{c}	1.53 ± 0.08^{c}	0.64 ± 0.02^{c}	15.60 ± 0.95^{b}	71.31±0.09^{e}	353.76^{a}
MSF	5.92± 0.03^{f}	2.96 ± 0.07^{a}	1.54 ±0.03^{b}	1.87± 0.20^{b}	11.42 ±0.39^{g}	76.29±0.02^{f}	357.56^{bc}
MSG	7.24 ± 0.02^{e}	2.84 ± 0.02^{b}	3.95 ±0.10^{a}	3.21± 0.01^{a}	20.24± 0.02^{a}	62.52±0.07^{g}	356.60^{c}

Grain flour: pigeon pea percentage blends- MSA= 90:10; MSB= 80:20; MSC=70:30; MSD=60:40; MSE=50:50; MSF=100 % maize-millet flour, MSG= 100 % pigeon pea flour.

General, increase in crude fibre of co-fermented millet-maize flour and of the composite flour were established after fermentation. Crude fibre of the pigeon pea flour (MSG) was 3.95 %, fibre content of 1.54 % was also noticed for co-fermented millet-maize flour (MSF) and the blends ranged between 0.96-1.53 %, sample MSE had the highest value among the blends. Crude fibre had dietry value, and plays a good role in healthy living, hence it is appreciable for digestive system which is important and needed for the child health (Asuk *et al.*, 2015). Increase in the values of crude fibre is in agreement with Sodipo *et al.* (2018) finding. It implies' s that the crude fiber contents of the fermented products in this study is approximately in line with the recommended allowance for infants according to Recommended Dietary Allowance (RDA) for infants (Forsido *et al.*, 2019).

The moisture content of the samples was in the range of 9.65-10.24 %, this moisture content was safe for the product storage. The moisture content was higher than that obtained by Mbaeyi and Obetta (2016) which was 7.05-9.50 %. The fat content of sample MSE of 0.68 % was the highest of the values ranged between 0.42-0.68 %, for the co-fermented millet-maize flour the value was 2.96 %, the result obtained was in range commonly obtained in literature, but different from Mbaeyi-Nwaoha and Obetta (2016). The fat RDA for infants is ≥2.0 mg/100 g. the result is within the acceptable limit (Ajanaku et al., 2013; Omoba *et al.*, 2013). Ash content values obtained were between 3.21- 0.22, the blends varied from 0.22- 0.64 %, MSG was 3.21 % while MSF was 1.87 %. The inclusion of the pigeon pea influenced the increase in the value of ash content of the samples thus, there were significant difference in the ash content of the samples. The energy values of the samples were within the range of 353.76-358.86 kcl (Perrin *et al.*, 2019).The energy needed to complement breast milk according to UNICEF (2015) are in categories depending on age, 200 kcal per day (6-8 months); 300 kcal per day (9-11 months) and 550 kcal per day (12-23 months) respectively, the result obtained was within the recommendation (UNICEF, 2015; Lutter *et al.*, 2021).
However, RDA of 3000 kcal as complementary food formulation is a very good source of energy with values ranging from 353.76 to 358.86 kcal/100g for infants. The energy values for samples of these range 353.76 and

358.86 % respectively is adequate for a complementary food, this is also in accordance with the recommended daily allowance for daily intake by children, since energy requirement for infant is relatively dependent on age, weight and health statues of the child (Lutter *et al.*, 2021).

Functional properties of complementary flour blends

The result of the complementary blend samples were shown in Table 2, the bulk density were in the range of 0.67-0.70 g/ml, these were similar to some previously reported values in literature (Sodipo and Fashakin (2011); Floriam *et al*. (2020). Infant' feeds required high bulk density, it will give good pasting value and thickness, and these attributes make infant formula desirable. The flour combinations aside from being a complementary food could serve as a functional food for a convalescent (Sodipo *et al.*, 2020; Lutter*et al.*, 2021). The swelling capacity of the flour blends ranged between 112-142 %, sample MSE was the highest (142 %) while SMA was the lowest (112 %). The gradual additions of pigeon pea flour from initial value, 10 % to 50 % increased the swelling capacity. The values obtained were between the range obtainable in literature (Sodipo *et a*l., 2018; Lawrence *et al*., 2023). The water absorption capacity of the food blends ranged between 304-348 %, the values were higher than the value presented by Lawrence *et al.* (2023) of a steamed processed pigeon pea flour ((Atuna *et al*., 2023).

Table 2: Functional Properties of the Samples

Sample	Bulk Density g/ml	Swelling Capacity %	WAC %	OAC %
MSA	0.62 ± 0.02^{b}	112 ± 2.0^{e}	304 ± 0.58^{c}	213 ± 1.73^{d}
MSB	0.64 ± 0.01^{b}	119 ± 1.53^{d}	313 ± 1.73^{c}	217 ± 3.21^{d}
MSC	0.64 ± 0.01^{b}	123 ± 2.08^{c}	327 ± 1.73^{b}	226 ± 3.46^{c}
MSD	0.67 ± 0.01^{a}	136 ± 1.53^{b}	329 ± 2.08^{b}	235 ± 4.62^{b}
MSE	0.70 ± 0.03^{a}	142 ± 2.08^{a}	348 ± 3.5^{a}	245 ± 1.53^{a}

Water Absorption Capacity- WAC, Oil Absorption Capacity -OAC. MSA- 90:10 %; ; MSB- 80:20; MSC- 70 30 %; MSD- 60:40 %; MSE- 50:50 % co-fermented millet-maize flour: pigeon pea flour respectively.

Oil absorption capacity value obtained from the complementary food were between 213-245 %, sample MSE had the highest value of 245 % while MSA had the lowest value; 213 %, the inclusion of pigeon pea led to gradual increase in OAC of the samples. The mouth feel of the foods are usually improves by presence of fat and oil. The value obtained in this study falls within the range of previous publications (Sodipo *et al.*, 2018; Lawrence *et al.*, 2023).

Mineral composition of complementary food samples

Mineral content of the complementary food samples is presented in Table.3. The value of calcium in mg/ml were between 204.79-167.97, MSA had the highest value while MSE was the lowest. Calcium plays significant role in body building especially bone and teeth development, it aids muscle contraction and clothing of blood (Pravina *et al.*, 2019). The content of calcium was influenced by the inclusion of pigeon pea flour which reduced the level of calcium probably due to oxalate complex formation with the calcium. However, the values obtained for calcium were high enough to meet the nutritional needs of the infant. The value obtained in the study (167.97-204.79) were higher than those reported from previous works of Mbaeyi-Nwoha and Obitta, (2016) which were 1.98-53.89 from the production of complementary foods, however it was similar to those obtained by Atamgba *et al.* (2020) who studied the effect of different malting periods on the nutritional composition of malted sorghum-soy composite flour. Sample MSA is closed to the RDA, the RDA of calcium in infants' food is 295 mg/100 g (FAO/WHO, 1998; Oyarekua 2011). Iron content of the complementary food in this study showed an increase pattern ranging from 2.57-4.96 %. This occurrence was similar to previous report of Sama and Urooj, (2014), also it was comparable to result published by Mbaeyi-Nwoha and Obetta, (2016). Phytate has a binding affinity for iron, thus the decreasing value experienced here was as a result of leaching of iron with phytate during soaking process (Zhang *et al.,* 2022). Hence, soaking process was used to reduce the phytate as an antinutrients factors but was detrimental to availability of iron. The RAD requirement of iron in infant foods is ≥10.0 mg/100 g (Zhang *et al.*, 2022) and all the samples did not have iron contents within this range, this required supplementation. The zinc content of the blends was significantly, though, decreased from 11.49-7.88 %. This decrease could probably be due to some level of antinutrients that might have formed complexes with zinc, this trend was also reflected with other mineral such as Calcium and iron in this study, phytate also has a strong binding affinity with calcium and iron (Abdulwaliyu *et al*., 2019). However, Mbaeyi-Nwoha and Obetta. (2016) reported an increase in the value of zinc content (0.23-5.54 mg/100) during processing, but in contrast, the value of zinc obtained in this study are higher. Hence, the complementary food produced could be a good source of zinc for children. Zinc is important in the body enzymes metabolic activities. The availability may be enhanced by fermentation (Castillo-Gonzalez *et al*., 2018).

Table3: Mineral Composition of Co-Fermented Millet-Maize and Pigeon Pea Flour

Sample	Calcium (mg/100g)	Iron (mg/100g)	Zinc (mg/100g)
MSA	204.79 ± 0.12^{a}	2.57 ± 0.04^{e}	11.49 ± 0.02^{a}
MSB	192.49 ± 0.28^{b}	2.99 ± 0.00^{d}	10.06 ± 0.02^{b}
MSC	184.79 ± 0.11^{c}	4.21 ± 0.08^{c}	9.78 ± 0.03^{c}
MSD	175.20 ± 0.05^{d}	4.53 ± 0.04^{b}	8.08 ± 0.03^{d}
MSE	167.97 ± 0.03^{e}	4.96 ± 0.02^{a}	7.88 ± 0.03^{e}

MSA- 90:10; MSB- 80:20; MSC-70:30: MSD- 60:40; MSE- 50:50, co-fermented millet-maize flour: pigeon pea flour respectively.

Antinutritional composition of complementary flour blends

Ant-nutritional factor of the complementary food produced form the grains, pigeon pea blends is presented in Table 4. There was low value for saponin (0.76-0.99); phytate content higher compared to saponin and oxalate (0.53-0.57) mg/100ml respectively. Low value obtained generally in all was a result processing methods applied which involved germination of the pigeon pea sample and soaking before drying and millig, this was corroborated by Atamgba *et al.* (2020); Sodipo *et al.* (2018). Removal of seed coat and soaking enhance the reduction of antinutritional factors of pigeon pea (Dong *et al.*, 2019). Sample MSA with lowest pigeon pea had the lowest level of saponin content (0.76 mg/100g) lower appreciably than that of Oyarekua *et al.* (2023). It was observed that as the level of inclusion of the pigeon pea flour increased the saponin content increased which is an indication that though the soaking process reduced the saponin content of pigeon pea to a permissible and acceptable level, there still remain some contents in the pigeon pea which contributed to the increase in its content in the blends. The values obtained are within the rage obtained by Sodipo *et al.* (2018) for composite flour of pearl millet and germinated pigeon pea flour blends.

The phytate content also increased as the quantity of pigeon pea flour increased from 10- 50 %. The phytate content of the blendsis lower than that of Oyarekua *et al.* (2023). It also gave an indication that some amount of the phytate still remained in the pigeon pea flour. Phytic acid also has some health benefit and the content in the blends is still safe for consumption. From all samples, it showed that Sample MSA has the least phytate and the most desirable as regard the phytate content. It is known that 10–50 mg phytate per 100 g will not cause a negative effect on the absorption of zinc and iron (Pikuda and Ilelaboye, 2013; Gupta *et al.*, 2015).

Table 4: Anti-nutritional Composition of Complementary Food Produced from Co-fermented Millet-Maize and Pigeon Pea Flour

Sample	Saponin (mg/100g)	Phytate (mg/100g)	Oxalate (mg/100g)

MSA	0.76 ± 0.01[c]	3.47 ± 0.02[c]	0.53 ± 0.00[c]
MSB	0.77 ± 0.00[c]	3.57 ± 0.12[c]	0.54 ± 0.01[bc]
MSC	0.95 ± 0.01[b]	3.58 ± 0.13[c]	0.54 ± 0.00[b]
MSD	0.97 ± 0.01[b]	3.99 ± 0.03[b]	0.56 ± 0.01[a]
MSE	0.99 ± 0.02[a]	4.25 ± 0.11[a]	0.57 ± 0.01[a]

MSA- 90:10; MSB- 80:20 ; MSC- 70:30; MSD- 60:40; MSE- 50:50, co-fermented millet-maize flour: pigeon pea flour respectively.

The oxalate content of the blends was lower than Oyarekua *et* al. (2023), sample MSA had the lowest value. The increase in the level of pigeon peas caused the oxalate content to increase. However, the values are low and this may be due to the processing methods employed.

Sensory evaluation of complementary flour samples

Sensory evaluation of the food samples is presented in Table.5. In terms of colour for the novel product, sample MSE had the highest value of 5.2. The colour for the blends ranged from 4.64- 5.2 and 8.6 for the control (MSF) following an increase in the inclusion of pigeon pea flour. There were decrease in the taste values as the quantity of pigeon pea flour increased. Sample MSA recorded to have the highest value of 7.1. The taste values for the blends ranged from 4.5-7.1. An increase pattern were observed for texture and appearance. The values ranged from 4.2-6.3 and 4.4- 6.1 respectively. Sample MSA had 6.9 the highest value for the level of acceptability among the blends on the scale of 9.0. While the control sample (Sample MSF) had the highest value of 7.8. There were no significant difference between MSA and MSE, but there were differences with the control sample MSF regarding colour, taste, texture, flavour and overall acceptability. However, there were significant differences in appearance which possibly was a result of increased addition of pigeon pea.

Table 5: **Sensory Evaluation of from Co-Fermented Millet-Maize and Pigeon Pea Flour**

Sample	Colour	Taste	Flavour	Texture	Appearance	Acceptability
MSA	4.64 ± 2.68[b]	7.1 ± 2.6[b]	6.0 ± 1.76[a]	6.3 ± 1.57[b]	6.1 ± 0.13[bc]	6.9 ± 2.76[a]
MSB	4.50 ± 2.44[b]	6.2± 2.49[b]	5.3 ± 2.49[a]	5.4 ± 2.27[b]	5.8 ± 2.29[bc]	6.3 ± 2.67[b]
MSC	4.80 ± 2.2[b]	6± 2.54[b]	5.1 ± 2.77[a]	4.8 ± 1.43[b]	5.8 ± 2.57[c]	5.3 ± 2.91[b]
MSD	4.80 ± 2.2[b]	5.5 ± 2.7[b]	5.0 ±2.31[a]	4.2± 2.15[b]	5.4 ± 2.26[bc]	4.6 ± 3.2[b]
MSE	5.2 ± 2.29[b]	4.5 ± 0.42[b]	5.0 ± 2.49[a]	4.7 ±2.26[b]	4.4 ± 1.89[b]	4.3 ± 2.45[b]
MSF	8.6 ± 0.5[a]	8.1 ± 1.59[a]	7.99 ± 0.02[a]	8.6 ± 0.5[a]	8.7 ± 0.67[a]	7.8 ± 2.15[a]

MSA- 90:10; MSB- 80:20; MSC- 70:30: MSD- 60:40; MSE- 50:50 co-fermented millet-maize:pigeon pea flour, MSF – maize-millet control.

CONCLUSION

This study demonstrated the values inherent in co-fermented millet-maize and pigeon pea flour blends, there were significant improvement in nutritional and mineral properties of the complementary food produced. The inclusion of pigeon pea flour improved the nutritional composition of the blends. Sample MSA had the highest Zinc and Calcium value and lowest values in anti-nutritional composition. However, sample MSA can be recommended for children as these essential nutrients are required by babies. In terms of acceptability, protein, ash, fibre and iron content, Sample MSE had the highest value and this can also be recommended for children. There is evident reduction due to soaking and fermentation in anti-nutrient content of all the complementary foods produced. The study revealed, the value of the complementary foods produced based on the blend' formulation, met the RDA for nutrients and minerals requirements for infant's food. Therefore, the blends may be a good complementary weaning diet. And in line with United Nation goal number 3; good health and well-being, the use of fortified complementary food will promote child healthy growth and prevent child mortality as a result of poor complementary food. Therefore, grain blends, maize: pigeon pea products 50:50 and 90:10 are acceptable as the most preferred with the sensory evaluation carried out. The inclusion of pigeon pea to the food blends also showed improvement in functional and reconstitution properties of the formulations. Also, the supplementation or complementation of co-fermented millet-maize with pigeon pea enhance proteins quality, and should be advocated for as one of the vital ways of improving nutrient content in cereals aimed at addressing malnutrition in certain groups of local communities, especially in developing countries.

CONFLICT OF INTERESTS

There is no conflict of interest of any form.

We appreciate the use of Lautech Laboratory in carrying out some of the analysis

Disclaimer (Artificial intelligence)
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1.
2.
3.

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