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Enrichment of Fermented Sorghum Flour with Pumpkin Pulp and Seed for Production of a Vitamin A and Iron Enhanced Supplementary Food

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Abstract

Vitamin A and iron deficiencies are prevalent in preschool children being a public health concern. The study aimed at developing a flour blend formulation made of sorghum, pumpkin pulp and seeds and examining its contribution to the daily nutrient requirement for iron and vitamin A among preschool children. Three flour blends were formulated using a mixture of fermented sorghum flour, pumpkin seed flour and pumpkin pulp flour with the following ratios 80:10:10 (FP1), 70:15:15 (FP2) and 60:20:20 (FP3), respectively whereas control was made of 100% fermented sorghum flour. The flour blends and the control were analyzed for moisture content, protein, crude fiber, crude fat, ash, carbohydrate, beta-carotene and iron content. Further, sensory tests were conducted using a nine-hedonic scale to evaluate consumers acceptability of porridge made of the flour samples. Microbial analysis was conducted to establish the safety of developed flours. The results show that as the proportion of pumpkin pulp and pumpkin seed flours increased the protein content, ash, vitamin A and iron content significantly ($P<0.05$) increased. The flour blend FP3 recorded the highest amount of protein (22.87%), vitamin A (875.00 µg RAE/100g) and iron (27.51 mg/100g). The FP2 flour blend was the most preferred with sensory score of 7.91 and had ability to meet >70% of daily protein, iron and vitamin A requirements of preschool children thus most suitable for a feeding trial. The findings of this study demonstrate that pumpkin pulp and pumpkin seed can be used to enhance the nutritive value of sorghum and as such meet the protein, iron and vitamin A requirements of preschool children aiding in the eradication of nutritional deficiencies.

Keywords: iron, preschool children, pumpkin, sorghum, vitamin A

1. Introduction

Malnutrition in the form of micronutrient deficiencies is the main contributor of preventable childhood mortality and morbidity (Aires, 2018). Developing countries including Kenya bears the highest burden of micronutrient deficiencies. Vitamin A and iron deficiencies are the most prevalent forms of micronutrient deficiencies in Kenya mainly affecting preschool children Kenya National Bureau of Statistics and Macro International (KNBS and ICF Macro, 2014) and these nutritional problems are a public health concern. Preschool children are the most affected by iron and vitamin A deficiency World Health Organisation (WHO, 2011) consequently they have weakened immune system being prone to infection, impaired cognitive and physical growth (Faber et al., 2014). A micronutrient survey in Kenya (Ministry of Health, 2011) reported that 52.6 % of preschool children are vitamin A deficient while 36.6% are iron deficient. Vitamin A and iron deficiencies in under-fives are more prevalent in rural arid and semi-arid land (ASAL) areas due to food insecurity and high poverty levels, and in general these factors affect food availability, food quality and food quantity (Ferguson et al., 2015; Eberwein et al., 2016). The prevalence of anemia in Kitui County among preschool children was reported to be at 29.5% (Maina, 2011) while vitamin A deficiency is at 35.1% (WHO, 2006)' because of inadequate food nutrient intake.

In most rural ASAL areas children are mostly fed on cereal based foods such as sorghum in the form of porridge, most times, these types of foods naturally have very low levels of micronutrients (Pelto & Thuita, 2014). More so, cereals have high levels of anti-nutritional factors that hinder the absorption of iron. Cereal-based diets in children have been found not to meet their daily nutritional requirements hence they have been implicated in the aetiology of nutrient deficiencies and hindering growth. Studies have shown that where sorghum is a staple crop, vitamin A and iron deficiencies are common nutritional problems in vulnerable groups especially in preschool children (Eze et al., 2020; Tufa et al., 2016). Exploring strategies to improve the nutrient quality of cereal based foods is one important strategy to address vitamin A and iron deficiencies in preschool children.

Sorghum (*Sorghum bicolor* (L.) Moench is an important drought resistant cereal crop in Kitui County that is commonly processed into flour and utilized in children feeding. However, similar to other cereals sorghum has low nutritive value because it is deficient in essential amino acids and has anti-nutrients including phytate and tannins (Tamilselvan & Kushwaha, 2020). These antinutritional factors interact with minerals, vitamins and proteins forming insoluble compounds hindering absorption of essential nutrients and their utilization in the human body (Makawi et al., 2019). Fermentation has been identified as a simple food processing technique with potential to improve the nutritional bioavailability. Microorganisms produced during fermentation degrade antinutritional factors lowering anti-nutrients consequently increasing the level of iron, calcium and zinc (Almaiman et al., 2021). Digestibility of protein is enhanced with fermentation due to a reduction of antinutrients and activity of microbial proteases that are released breaking down the food matrix (Rashwan et al., 2021). Aromatic compounds are produced during fermentation and this enhances the sensory properties of food products (Ogodo et al., 2017; Onyango et al., 2013). The shelf life of sorghum flour is extended with fermentation due to production of lactic acid that lowers the pH hindering microbial growth (Tsafrakidou et al., 2020). Fermentation therefore enhances food safety and shelf life, aiding in food preservation.

Food enrichment by addition of micronutrient rich foods to staple foods is a strategy to address nutrient inadequacies which is a relatively low-cost approach with potential for wide spread utilization and adaptation (FAO/WHO, 2017). Improvement of the nutrient content of sorghum by incorporating underutilized nutrient rich foods such as pumpkin is a cost-effective and an efficient method to address micronutrient deficiencies whereas promoting the quality of staple foods. Pumpkin belongs to the family of cucurbitaceous, *Cucurbita moschata* variety is commonly grown in Kitui County (Mutie et al., 2020). In this County pumpkin is cultivated for its leaves and included in human diets, pumpkin pulp is used for animal feeding while pumpkin seeds are discarded as waste (Mutie et al., 2020). Some research show that pulp and seeds have better nutritional quality when compared to cereals. Incorporation of pumpkin pulp and seed flour into regularly consumed cereal-based foods might have a nutritional advantage in reference to minerals and vitamins (Akinola, 2016; Černiauskiene et al., 2014).

Pumpkin flour is an excellent source of beta-carotene, iron, ascorbic acid and protein (El-Salhy et al., 2017). Pumpkin provides pro-vitamin A that is broken down in the liver into vitamin A, and thus consuming food made of pumpkin flour can help address vitamin A deficiencies (Swar et al., 2014). Ascorbic acid promotes the absorption of iron in the body and therefore pumpkin has potential to address iron deficiencies (Černiauskiene et al., 2014). Pumpkin flour contains essential amino acids such as lysine and methionine that have been reported to be lacking in sorghum (Akinola, 2016). Enrichment of fermented sorghum flour by incorporation of pumpkin flour might improve its nutrition quality. Elsewhere, efforts have been made to utilize pumpkin seeds and pulp flour in addressing macronutrient deficiencies (Setiawan et al., 2021) but not micronutrient deficiencies. Although pumpkin seed and pulp flour has been largely used in development of bakery products (Pongjanta et al., 2006) not much attention has been given to its use in development of flour blends for use in porridge feeding of children. Porridge is frequently and widely consumed by children and therefore processing pumpkin pulp and seeds into flour has high chance of contributing to the nutrient intake of young children. Further, processing pumpkin seeds and pulp into flour extend shelf life, with high sensory qualities and as a fortifying agent of staple foods. These attributes of pumpkin seed and pulp porridge flour blends make it a most preferred vehicle to address nutrient inadequacies among children and low-income groups.

2. Materials and Methods

The materials used in this study included pumpkin (*Curcubita moschata*) and Sorghum (*Sorghum bicolor (*L.) Moench. Ten kilograms of white sorghum were purchased from Migwani market in Mwingi Sub County, Kitui County, put into a hermetic bag and transported to the Jomo Kenyatta University of Agriculture and Technology, (JKUAT) food science laboratory for analysis. About 3-5 kilograms of pumpkin that are locally grown in the area and does well in ASAL regions were purchased. Parameters that were used in the selection of pumpkins included absence of physical injuries such as cracks or abrasions, hard-outer covering, and maturity evidenced by presence of cork-like stems that appeared to be dark grey in color were selected. Other features such as uniformity in color, size and shape of the pumpkins were considered in selection. Each pumpkin was then put in a cardboard container and transported to JKUAT, food science laboratory for analysis. All the raw materials were stored in ambient conditions awaiting analysis.

2.1 Preparation of Fermented Sorghum Flour

Ten kilograms of white sorghum grains were sorted to remove foreign material including stones and broken grains. The sorted grains were thoroughly cleaned using tap water. Cleaned sorghum grains were then dried in a hot air oven at 65^0C for 24 hours. The sorghum grains were then milled using a laboratory attrition mill. To prepare fermented sorghum flour, slurries of plain sorghum flour and distilled water were prepared at the ratio of 1:3 (w/v) in a sterile beaker (Asres et al., 2018). The flour (substrate) water ratio (1:3) has been found to be optimal to enable the production of lactic acid bacteria that are involved in the fermentation process (Blandino et al., 2003; Osman, 2011). The slurries were left to ferment naturally by placing them in an incubator at 30^0C for 36 hours after which the supernatant was decanted. The resulting slurry was evenly spread into thin layers on aluminium dishes and placed in a hot air oven to dry at 65^0C for 24 hours. This was then removed from the oven and milled (Asma et al., 2006; Okpala et al., 2013a), the resulting flour was passed through a 200 µm mesh size for sieving and placed in an air tight containers and stored awaiting analysis.

2.2 Preparation of Pumpkin Flour

Ten whole pumpkins were thoroughly washed with clean water and dried. Using a stainless-steel knife, the pumpkins were then cut into halves, then, the fibrous content and seeds were scooped out. Peeling of the pumpkin fruit was done to remove the rind then washed and diced into 2 millimetres cubes (Usha et al., 2010). Shredding was then done by placing the pumpkin cubes into an automatic electric food grater, strips of about one-millimetre thickness were produced (Kiharason et al., 2017). The shredding was done to ensure that there was sufficient drying of the pumpkins (Sharma, 2017). Pumpkin shredded strips were then placed into an electric drier at a temperature of 60^0c for 48 hours as described by Joy et al. (2021) who obtained a moisture content of 6.5%. The dried strips of pumpkin fruit were then milled using a fine mill and passed through a 200 µm sieve size mill (Kiharason, 2019) and put into air tight containers awaiting analysis. The scooped pumpkin seeds from the whole pumpkin pulp were freed of any foreign material, cleaned (Abdelgadir et al., 2019) oven dried at 65^0C for 24 hours as described by Oyet & Chibor (2020) who obtained a moisture content of 3.7%. The seeds were then manually decorticated Ike et al. (2020) then ground into flour using an electric mill and passed through a sieve and put into an air tight containers awaiting analysis.

2.3 Formulation of Flour Blends

The nutritional composition data of the raw materials was input in the nutrisurvey software. The nutrisurvey software is embedded with the RDA of various nutrients as required by under-fives (FAO/WHO, 2005). Nutri-survey software is an important analytical tool that helps in determining the potential of different foods to meet daily nutrient requirements of various target groups (Amegovu et al., 2014; Onyango et al., 2020). However, there is need to validate the nutritional composition data available in the Nutri-survey software by carrying out laboratory analysis since it provides for estimated average values (Berra, 2020; Wald et al., 2019). Three flour blend formulations were developed using the raw materials of fermented white sorghum grains flour, pumpkin pulp flour and pumpkin seed flour. In all the flour blend formulations pumpkin seed and pumpkin pulp flour were incorporated at a ratio of 1:1. The control flour was made up of 100% fermented white sorghum flour. The other three flour blend formulations developed were coded randomly; - FP1, FP2 and FP3. The composition of all the developed flours are shown in Table 1.

Table 1. Flour Formulation Ratios

Sample code	Fermented sorghum flour (%)	Pumpkin pulp (%)	Pumpkin Seed (%)
FP1	80	10	10
FP2	70	15	15
FP3	60	20	20
Control	100	0	0

2.4 Chemical Analysis

The developed flours FP1, FP2, FP3 and control were analysed for moisture content, protein, crude fat, crude fibre and ash content using standard methods as described by AOAC (2006). Carbohydrate content was determined by differentiation method. The AOAC methods of 1995 (970.12) was used to determine the iron content of the developed flours. Iron was determined by wet digestion using an atomic absorption spectrophotometer (AAS AA-7000 Shimadzu Japan). Approximately 2 g of each sample was put into muffle furnace and dry-shed at 550^0c for 10 hours. Ash was then dissolved in 1% HCL acid into a conical flask and brought up to the 100ml mark using standard volumetric flask. The iron content of the different flours was then estimated from the atomic absorption spectrophotometer. Beta carotene content of the developed flours were determined using column chromatography and UV Spectrophotometer; by acetone and petroleum ether extraction method (Delia et al., 1988). First beta-carotene extraction was done by grinding about 6 grams of each fresh sample in a mortal pestle. About 3 g of the ground sample was then extracted using 0.1 g of magnesium carbonate, acetone (40 ml) and petroleum ether (60 ml) and then blended for five minutes, followed by filtration using a suction pump.

The sample was decanted into a separator and the residue cleaned twice with 25 ml acetone in each wash and one wash with 25 ml of petroleum ether, the extracts were then mixed together. Volume was made up to 1 to 5 ml using acetone depending upon the matrix. High performance liquid chromatography was then used to analysis the sample. The HPLC had a column of 5 µm C18, 4.6 × 250 mm for the beta-carotene determination. Acetonitrile, methanol and acetone of the rations 60, 30 and 10 respectively acted at a flow rate of about 1.2 ml per minute served as the mobile phase for the analysis. The peaks of beta-carotene were a mixture of acetonitrile (CH3 CN), methanol (CH3 OH) and acetone in the ratio 60:30:10. Peak responses of β-carotene were recorded at wavelengths 450 nm. The vitamin A content was then determined by use of WHO/FAO recommendation of retinol conversion factor of 1:12 to estimate the amount of provitamin A in the samples (François et al., 2021).

2.5 Microbial Analysis

The microbial analysis of the flour samples was done according to ISO standard methods. Stock solution was prepared by aseptically collecting 20g of each flour and placing it in a 100ml flask that contained 90 ml of sterile 0.1% buffered peptone water this was then stirred and homogenized for two minutes into a sterile stomacher bag (ISO 4833:2003). The suspensions were then diluted and serial dilutions of 10^{-1} to 10^{-5} were obtained in triplicates and used for specific medium. Aliquots, 0.1 ml and 1 ml, of each dilution were used for pour plating and spread plating respectively, into the various medias. Spread plating using potato dextrose agar with chloramphenicol (2%) were used to determine yeast and moulds, the plates were incubated for 7 days at 25^0C while for total viable count it was at 37^oC for 24 hours. *Salmonella* was determined by suspending 25g of each flour sample in 225 ml of lactose broth for two minutes and then homogenised into a stomacher bag (sterile) and enriched for 24 hours at 37^0c. Then the pre-enriched culture (1 ml) was put into selenite cysteine broth and incubation done for 24 hours at 375^0c. Thereafter the pre-enriched culture (0.1ml) was moved into Heketonic Enteric agar (10ml) plates and incubated at 37^0C for 24 hours. To identify the strains further biochemical tests were done. For, total coliforms violet red bile agar media was incubated at 37^0C for 48 hours and enumeration done. For *Escherichia coli* the colonies from violet red bile agar media were collected and inoculated into Eosinmethylene blue agar and incubated at 37^0C for 24 hours. Strains with green metallic sheen classified as *E. coli* while those with dark red colonies identified as coliforms. Acceptable levels of microbes were based on specification standards as provided by (East Africa Communities, 2011).

2.6 Consumer Sensory Evaluation

The sensory evaluation studies were conducted at DEB Migwani primary school, in Kitui County among 98 caregivers with preschool children. The sensory tests were conducted in a private designated room that was well lit. The participants were identified and recruited through home visits with the help of local administration and community health volunteers. Participation in the study was voluntary and the caregivers gave written and verbal consent to participate in the study. A research approval was received from National Commission for Science Technology and Innovation (NACOSTI) and ethical clearance obtained from Mount Kenya University Ethical review Committee. Prior to the sensory evaluation exercise the details of the evaluation tests were explained to the caregivers and they were requested not to have tasted anything an hour before the evaluation (Jacinto et al., 2020).

The four porridge samples were prepared using the method described by Rowe et al., (2009). About 400g of flour was added to 800 ml of clean cold water in a bowl and stirred using a wooden ladle until a smooth paste was obtained. After that the mixture was added into 2500 ml of boiling water stirred and brought to boil for about 15 minutes this was then removed from heat and allowed to cool to 40^0c then sensory evaluation was done. Each porridge sample was individually coded. Ceramic white plates and white plastic spoons of uniform size were randomly coded with three digits and used to serve the porridge to the panelists. The panelists were provided with the four samples of the porridge and a sensory evaluation form with a 9-hedonic scale the rankings used were 9-like extremely, 8-like very much, 7-like moderately, 6-like slightly, 5-neither like nor dislike, 4-

dislike slightly, 3-dislike moderately, 2-dislike very much and 1-dislike extremely. The panelists were asked to rank each of the four porridge samples based on color, aroma, taste, mouth feel and overall acceptability. Cold water was provided to the panelist to rinse their palates in between assessing the porridge samples to avoid cross-interactions.

2.7 Data Analysis

Genstat software package was used to analysis data for moisture, ash, protein, crude fat, crude fibre, carbohydrate, iron, beta-carotene, sensory and microbial properties. Data are presented as averages with their standard deviations. Analysis of variance was then done and mean separation obtained by performing post-hoc Duncan's Multiple Range Tests. Duncan Multiple Range Tests have been found to be suitable since they have high power in detecting significant differences in mean values (Granato et al., 2014). For all tests, a significance level of <0.05 was considered.

3. Results and Discussion

3.1 Nutritional Composition of the Raw Materials

The nutritional composition of the raw materials including pumpkin seed flour (PSF), pumpkin pulp flour (PPF) and fermented white sorghum flour (FSF) is shown in Table 2. The high amount of vitamin A and iron observed in pumpkin seeds and pumpkin pulp indicates its potential to improve the less nutritious sorghum flour.

Table 2. Nutritional Composition of Raw Materials

Parameter	PSF	PPF	FSF
Moisture (%)	4.70 ± 0.00^{c}	5.21 ± 0.02^{a}	4.62 ± 0.02^{b}
Ash (%)	7.69 ± 0.04^{c}	6.16 ± 0.59^{b}	$1.90+0.03^{a}$
Protein (g/100g)	37.48 ± 1.34^{c}	9.19 ± 0.95^{a}	7.97 ± 0.31^{b}
Crude fat (%)	15.41 ± 0.10^{c}	2.30 ± 0.00^{b}	3.28 ± 0.16^{a}
Crude fiber (%)	5.37 ± 1.02^{c}	0.10 ± 0.00^{a}	1.80 ± 0.00^{b}
Carbohydrate (%)	29.34 ± 1.17^{a}	77.04 ± 0.86^{c}	80.43 ± 0.18^{b}
Iron (mg/100g)	36.62 ± 0.30^{b}	65.69 ± 8.10^{c}	2.61 ± 0.26^{d}
Beta-carotene (mg/100g)	9.33 ± 0.01^{c}	16.0 ± 1.07^{b}	0.01 ± 0.00^{a}
Vitamin A µg RAE/100g	777.51 ± 10.01^{c}	1333.36 ± 10.00^{b}	0.83 ± 0.00^{a}

Values with different letter superscript in the same row are significantly different at p<0.05 based on analysis of variance and post-hoc Duncan range tests. Values are based on triplicate samples mean±standard deviations. All values are on dry weight basis except for moisture content.

3.1.1 Nutritional Composition of Pumpkin Pulp Flour and Pumpkin Seed Flour

Pumpkin pulp flour (PPF) had a higher moisture content at 5.21% compared to pumpkin seed flour (PSF) and this observation concur with past studies that have reported similar findings (Kim et al., 2012; Nwofia et al., 2012). These results imply that pumpkin pulp flour may have had lower dry matter compared to pumpkin seeds flour (Karanja et al., 2013). The moisture content values obtained for pumpkin pulp flour are comparable to 5.00% reported by Pongjanta et al. (2006), however, they are lower than 5.80% reported by El Khatib & Muhieddine (2020) but higher than 4.90% reported by Bhat (2013). The moisture content of 4.70% obtained in this study for pumpkin seed flour is higher than 3.70% reported by (El Khatib & Muhieddine, 2020). Various factors may have contributed to variations in moisture content of pumpkin flour reported in the present study and other previous studies. Method of drying, drying temperatures and length of drying have an impact on the moisture content of pumpkin flour (Ikrawan et al., 2020; See et al., 2007). In this study pumpkin pulp was dried at 60^{0}c for 48 hours in an oven dryer, this correlates to Sirimu & Uwineza (2020) who observed that oven dried pumpkin pulp flour samples at 60^{0}c for 48 hours have a moisture content of 5.00- 8.90%. Pumpkin seeds that are oven dried at 65^{0}c for 24 hours and milled into flour have been found to have a moisture content of less than 5.00% (Abdelgadir et al., 2019; Oyet & Chibor, 2020) which is similar to the current findings.

The recorded ash values were 7.69% and 6.16% for pumpkin seed flour and pumpkin pulp flour respectively. The ash content values obtained for pumpkin seed flour are close to 7.28% reported by Petkova & Antova (2015) however they are lower than 8.37% obtained by Sharma and Lakhaw (2017) but higher than 5.00% reported by Elinge et al. (2012). The ash content obtained in this study for pumpkin pulp flour are however comparable to 6.70% reported by Fedha et al. (2010). Ash content is recognized as a measure of nutrition quality of food (Ooi et al., 2012; Sonkamble & Pandhure, 2015). Ash content of a food reflects its total mineral content, the higher the ash content in a food the higher the mineral content (Afify et al., 2017; Sonkamble & Pandhure, 2015). The current study therefore reveals that *C. moschata* could be a good source of minerals that are important in human nutrition.

The protein content of 37.48 g/100g and 9.19 g/100g were obtained for pumpkin seed flour and pumpkin pulp flour respectively. These protein values are comparable to 37.33 g/100g reported by Dhiman et al. (2018) for pumpkin seed flour and 9.50 g/100g reported by Pereira et al. (2020) and 9.65 g/100g obtained by Aukkanit & Sirichokworrakit (2017) for pumpkin pulp flour. The values for pumpkin seed protein were higher than 34.56 g/100g reported by Shahangir (2015) but lower than 39.22 g/100g obtained by Shemi (2014). Protein intake among children in Kenya has been reported to be insufficient both in quality and quantity in turn resulting in protein deficiencies (Kinyuru et al., 2012; Okoth et al., 2017). The utilization of locally available foods that are nutrient dense has been identified as a low cost and sustainable strategy in addressing protein deficiencies among children in low-income countries (De Jager et al., 2019; Kinyuru et al., 2015). Development of flour blends that incorporate locally available foods that are rich in protein may help in meeting the daily protein requirements of children (De Jager et al., 2019). The protein values obtained in this study reveal that the *C. moschata* pumpkin variety cultivated in Kitui county is rich in protein and can be a good source of the nutrient especially in children that have rapid growth. Pumpkin has been reported to have functional properties since it contains lysine and tryptophan that when consumed produce serotonin that lower stress levels (Nyam et al., 2013). Cereals such as sorghum have low quality protein being deficient in lysine and tryptophan (Awadalkareem et al., 2008) and therefore pumpkin can be incorporated into sorghum to improve it protein quality.

The crude fat content for pumpkin seed flour and pumpkin pulp flour were 15.41% and 2.30% respectively. The crude fat values observed for pumpkin seed flour are similar to 15.40% reported by Muchugi et al. (2017) though lower than 17.89% reported by Amin et al. (2019). The observed values of crude fat content for pumpkin pulp flour are similar to those reported in other previous studies (Abdulaali & George, 2020; Adebayo, Farombi, 2013). Zhou et al. (2007) fat enhances palatability of food, delay hunger onset and serves as a transport medium for fat soluble vitamins Despite the amount of crude fat in pumpkin seeds being high, it nutritive quality has been found to be suitable for enrichment of food products (Nyam et al., 2013). Pumpkin seeds are rich in poly unsaturated fatty acids that regulate metabolism of serum lipids hence may control obesity onset (Nyam et al., 2013; Zhou et al., 2007).

The crude fiber content for pumpkin seed flour was recorded as 5.37% which is comparable to 5.48% obtained by Tuslinah et al. (2018). Crude fiber content of pumpkin pulp flour was at 0.1 mg/100g which is similar to values obtained by Nwofia et al. (2012). However, the crude fiber content of pumpkin pulp flour reported in the current study is lower than 1.17 mg/100g reported by Pongjanta et al. (2006). Another study by Bhat (2013) observed that pumpkin pulp flour had a crude fiber content of 1.16 mg/100g.

The carbohydrate values for pumpkin seed flour seen in this study are comparable to 27.35% obtained by Karanja et al. (2013). Pumpkin pulp flour had carbohydrate content of 77.04% which is near to 76.79% reported by Abdulaali & George (2020). The high carbohydrate content in pumpkin pulp flour contribute to sweet taste in food products enhancing sensory attributes (Nwofia et al., 2012). The results in this study imply that pumpkin seed flour may not be a good source of carbohydrate as compared to pumpkin pulp flour. That in enriching food it is important to utilize both pumpkin seeds flour and pumpkin pulp flour so that they supplement each other (Konadu et al., 2021).

For iron pumpkin pulp flour had iron content of 65.69 mg/100g which is comparable to 68.30 mg/100g obtained by Liomba et al. (2018), however this was higher than 53.67 mg/100g reported by Paiko et al. (2014). In this study pumpkin seed flour had a significant amount of iron at 36.62 mg/100g comparable to 35.65 mg/100g reported by Karanja et al. (2013). World Health Organization (2011) iron deficiency is a major problem in Africa specifically in Kenya and more so among preschool children. The findings of this study imply that pumpkin pulp and pumpkin seed flour are a good source of iron and can be used to enrich food products that are low in iron to meet nutritional needs of vulnerable groups.

The observed beta-carotene values in pumpkin seeds flour of 9.33 mg/100g are lower than 11.70 mg/100g reported by Echessa et al. (2013) but higher than 5.70 mg/100g obtained by Malkanthi et al. (2018). However, the values are comparable to 9.00 mg/100g obtained by Syed (2019). A study by Das & Banerjee (2015) reported that pumpkin pulp flour had a beta-carotene of 7.30 mg/100g which is lower than 16.00 mg/100g observed values in the current study though comparable to 16.10 mg/100g obtained by Eleiwa et al. (2014).

From, the results obtained in the current study and other mentioned studies it is clear that the nutritional composition of pumpkin seed flour and pumpkin pulp flour vary. The variations maybe as a result of geographical differences (Elinge et al., 2012; Mohammed et al., 2019) with indications that even analysis of pumpkins within the same country may give different nutritional composition results. A review of literature reveals a paucity of data on studies that have evaluated the nutritional content of pumpkin seeds and pumpkin pulp in Kenya and specifically in Kitui County. The current study sought to fill this research gap. Moreso very few studies have utilized both pumpkin pulp and pumpkin seed flour in the development of food products.

3.1.2 Nutritional Composition of Fermented Sorghum Flour

Geremew et al. (2016) reported that fermented sorghum flour had a moisture content of 4.80%, these results are consistent with the current study findings. Similarly, Badi (2004) reported that fermented sorghum flour had a moisture content of 4.90% which is close to the current study observations. The obtained results for ash of 1.90% are comparable to values of 1.98% reported by Adebiyi et al. (2005) for fermented sorghum flour. More-over Okpala et al. (2013) reported that fermented sorghum flour had a ash content of 1.96%. The values for protein of 7.97 g/100 g in this study for fermented sorghum flour are comparable to 7.60 g/100 g reported by Oboh & Amusan (2009), however they are higher than 6.90 g/100 g obtained by Tamilselvan & Kushwaha (2020) though lower than 9.77 g/100 g and 8.08 g/100 g reported by Afify et al. (2012) and Okpala et al. (2013) respectively.

The crude fat, crude fiber and carbohydrate content of fermented sorghum flour in this study were at 3.28%, 1.80% and 80.43% respectively. The obtained values for crude fat are almost similar to 3.27% found by Mariod et al. (2016) however they are lower than 3.58% obtained by Ogodo et al. (2017) and higher than 2.28% reported by Afify et al. (2012). The crude fiber value of 1.80% is higher than 1.58% reported by Tufa (2016), however the value is lower than 2.05% reported by Ojokoh & Eromosele (2015). The carbohydrate content of fermented sorghum flour reported in this study is similar to values obtained by Tamilselvan & Kushwaha (2020). In this study fermented sorghum flour had iron content of 2.62 mg/100g which is higher than 3.95 mg/100g obtained by Afify et al. (2012). Another study by Abah et al. (2020) observed that fermented sorghum flour had iron content in the range of 0.9-20 mg/100g which supports the current study findings.

The beta-carotene content a precursor of vitamin A in fermented sorghum flour was found to be negligible which concurs with past studies (Adebo, 2020; Nkhata et al., 2018). The results of this study show that sorghum has negligible amounts of vitamin A and iron yet Vitamin A and iron deficiency are a public health concern especially in children. Further, the present study observed that sorghum may be suitable for young children feeding due to its energy content. There is therefore need to explore ways of improving the nutrient quality of sorghum especially in micronutrient composition since it is frequently consumed in order to meet the dietary requirements of children.

3.2 Nutritional Composition of Flour Blend Formulations

The results on the nutritional composition of all the developed flour formulations are presented in Table 3.

Table 3. Nutritional Composition of Flour Blend Samples

Sample	**FP1**	**FP2**	**FP3**	**Control**
Moisture %	4.83 ± 0.04^{b}	5.05 ± 0.04^{c}	5.14 ± 0.03^{d}	4.62 ± 0.02^{a}
Ash mg/100g	2.32 ± 0.03^{b}	2.53 ± 0.05^{c}	2.69 ± 0.02^{d}	$1.90 + 0.03^{a}$
Protein g/100g	19.07 ± 0.11^{b}	20.48 ± 0.53^{c}	22.87 ± 0.99^{d}	7.97 ± 0.31^{a}
Crude fat g/100g	4.65 ± 0.06^{b}	4.70 ± 0.02^{b}	4.09 ± 0.07^{c}	3.28 ± 0.16^{a}
Crude fiber g/100g	1.13 ± 0.07^{c}	0.91 ± 0.05^{b}	0.51 ± 0.01^{a}	1.80 ± 0.00^{d}
Carbohydrate g/100g	68.00 ± 0.02^{c}	66.33 ± 0.09^{b}	64.71 ± 0.01^{a}	80.43 ± 0.18^{d}
Energy content Kcal	380.12 ± 6.1^{a}	379.54 ± 7.2^{a}	313.52 ± 5.1^{b}	393.12 ± 3.5^{c}
Iron mg/100g	23.59 ± 0.01^{b}	25.42 ± 0.00^{c}	27.51 ± 0.01^{d}	2.61 ± 0.26^{a}
Beta-carotene mg/100g	8.51 ± 0.10^{b}	9.74 ± 0.12^{c}	10.50 ± 0.10^{d}	0.01 ± 0.00^{a}
Vitamin A µg RAE/100g	709.17 ± 0.10^{a}	811.68 ± 0.13^{b}	875.00 ± 0.10^{c}	0.83 ± 0.00^{d}

-Values with different letter superscript in the same row are significantly different at $p<0.05$ based on analysis of variance and post-hoc Duncan range tests. Values are based on triplicate samples mean±standard deviations. All values are on dry weight basis except for moisture content.

-FP1=10%PSF+10%PFF+80%FSF;FP2=15%PSF+15%PFF+70%FSF;FP3=20%PSF+20%PFF+60%FSF and Control=100%FSF. PSF-PUMPKIN SEED FLOUR; PFF-PUMPKIN PULP FLOUR; FSF-FERMENTED SORGHUM FLOUR.

3.2.1 Moisture Content of Flour Formulations

The FP3 sample had the highest moisture content at 5.14% while the control sample had the lowest. There was significant difference between the samples in moisture content (P<0.05), and a trend was noted, the moisture content of the formulations increased with addition of pumpkin flour. Ikrawan et al. (2020) reported that addition of pumpkin flour to sorghum flour increased its moisture content. Similarly, Usha et al. (2010) found that addition of pumpkin flour into fermented sorghum flour increased moisture content. Pumpkin has higher moisture content compared to sorghum due to it high protein content impacting on the water absorption capacity of the flour blend (Ikrawan et al., 2020). The moisture content of all the samples were within the recommended acceptable levels of less than 14.5% (FAO/WHO, 2019). This is important since it shows the flour samples have a long shelf life reducing the risk of food contamination. Variables including food processing conditions and type of food have an impact on moisture content, food products with moisture content >14 spoil easily while those with moisture content <12% have a higher storage stability (Awuchi, 2019; Victor et al., 2013).

3.2.2 Ash Content of Flour Formulations

The results of the current study show that the ash content of the flour blend formulations significantly increased with addition of pumpkin flour (p<0.05). A similar increase was reported by (Nneka et al., 2019; Ojokoh & Eromosele, 2015). Ojokoh & Eromosele (2015) ash levels in food reflects its mineral content therefore the high ash content observed in the present study in the samples with more pumpkin flour show that pumpkin has more minerals in comparison to sorghum.

3.2.3 Protein Content of Flour Formulations

The protein content of the samples significantly increased with addition of pumpkin flour at p<0.05. Incorporation of pumpkin (seed and pulp) flour in the sorghum flour therefore improved its protein content these findings are in agreement with previous studies (Bello et al., 2017; Simwaka et al., 2017; Victor et al., 2013). Bello et al. (2017) reported that addition of 20% pumpkin flour (seed and pulp) into sorghum flour increased protein content from 13.20% to 18.90%. All the developed flour blend formulations except for the control flour met the FAO/WHO (2017) recommendations that protein content should be above 15%. Incorporation of pumpkin flour into fermented sorghum flour has potential to increase it protein content.

3.2.4 Crude Fat of Flour Formulations

The control sample had the lowest crude fat content at 3.28% probably because it had no pumpkin flour. The fat content of all the samples were within the acceptable levels (<10%), fat content in flour should not be unnecessary high. Flour that has high fat content is prone to rancidity increasing the risk of development of off-flavours and decreasing the shelf-life (Akintade et al., 2019; Victor et al., 2013). Victor et al. (2013) reported that addition of 10% pumpkin flour into 90% maize increased the fat level from 3.5% to 8.3%. Another study by Akinola (2016) reported that fat level of 100% sorghum flour sample increased from 7.6% to 8.7% with addition of 10% pumpkin flour. The increase in fat content observed in the current study in the flour blends with more pumpkin flour is attributable to pumpkin flour. Fat is important in diets since it increases food palatability by absorbing and retaining food flavour whereas aiding in absorption of fat-soluble vitamins (El Hassan et al., 2008).

3.2.5 Crude Fiber of Flour Formulations

In the present study the crude fiber content of the samples decreased with increased incorporation of pumpkin flour, and this observation could be attributed to the higher fiber content in the sorghum flour when compared to the pumpkin flour. Crude fiber is known to be beneficial in improving digestion since they enlarge the inner walls of the colon easing waste passage preventing constipation and reducing cholesterol levels lowering the risk of onset of some type of cancers (Stephen et al., 2017). However, intake of high fiber diets in young children is restricted because these diets have been found to be harmful since they irritate the gut mucosa (Bello et al., 2008).

3.2.6 Carbohydrate of Flour Formulations

Significant differences in carbohydrate content of the sorghum-pumpkin flour blend samples were observed (P<0.05). The higher the amount of fermented sorghum flour in the flour blend the higher the level of carbohydrate in the sample. The control sample had the highest carbohydrate content at 80.43% while the FP3 had the lowest carbohydrate content at 64.71%. This observation could be linked to the higher carbohydrate content in sorghum compared to pumpkin flour concurring with previous studies that have reported sorghum has a higher carbohydrate content compared to pumpkin (Adejuwon et al., 2021; Akinola, 2016; Simwaka et al., 2017). The high carbohydrate content in sorghum shows that it is a good source of energy. In this study carbohydrate content of the flour formulations reduced with addition of pumpkin flour. This agrees with the findings of Ojokoh & Eromosele (2015) who reported a decrease in carbohydrate content in sorghum enrichment process with pumpkin seeds and pulp flour.

3.2.7 Iron Content

The iron content in the flour blend formulations ranged from 4.51-27.51 mg/100g. Significant difference (P<0.05) in iron content among the samples was observed. Iron content increased with the addition of pumpkin flour. The findings of this study concur with Liomba et al. (2018) who observed that addition of pumpkin flour to maize flour significantly increased the iron content of the resulting flour blend formulation. Liomba et al. (2018) formulated flour made of maize, pumpkin seed and pumpkin pulp at the ratios of 70:15:15 and reported that the resulting flour had an iron content of 21.2 mg/100g. Liomba et al. (2018) concluded that pumpkin flour is an excellent source of iron that can be used to fortify cereals crops of low nutritive value and as such a strategy to address micronutrient deficiencies. Another study by Naghii & Mofid, (2007) developed a ready to eat fortified cereal with an iron content of 23.3 mg/100g that improved the serum iron levels of adult women. The study further observed that fortifying rice flour with pumpkin seeds flour improved iron content of cereals food. Similarly, Sengev et al. (2021) reported that addition of pumpkin flour to sorghum flour improved its iron content.

3.2.8 Beta-carotene Content

In the present study beta-carotene levels were highest in the FP3 sample at 10.50 mg/100g while the control sample had the lowest beta-carotene content. The, beta-carotene content in the samples significantly (P<0.05) increased with addition of pumpkin flour. Similar observation have been made that addition, of pumpkin flour into cereal crops such as maize and sorghum significantly increases beta-carotene content (Ike et al., 2020; Sharma, 2017). A study by Zema and Bosha (2015) that blended maize and pumpkin (seed pulp) flour reported that addition of pumpkin flour into maize increased its beta-carotene content without altering its sensory properties. Zema and Bosha (2015) concluded that pumpkin had the potential to improve vitamin A content of cereal based porridge. Similarly, Tadesse et al. (2019) showed that blending corn flour with pumpkin flour (seed + pulp) at the ratios of 75% and 25% respectively increased its beta-carotene content by more than 180-folds.

3.3 Contribution of Flour Formulations to Nutrient Requirements of Preschool Children

The results on the contribution of the flour samples to the daily nutrient requirements of preschool children are shown in Table 4. The estimation on intake was based on WHO guidelines on young children feeding (FAO/WHO, 2017). According to Okoth et al. (2017) the ratio of 1:2 (flour: water) in preparation of porridge for young children is considered appropriate in achieving the right consistency to encourage intake.

Table 4. Contribution of Flour Formulations to Nutrient Requirements of Preschool Children

Parameter	1-3 years old	4-5 years old
Nature of Servings		
Quantity of serving	160 ml	240 ml
Number of servings	1	1
Quantity of solid in porridge	80 g	120 g
Iron	**RDA 8 mg/day**	**RDA 8 mg/day**
FP1	5.66 (70.75)	8.50 (106.25)
FP2	6.10 (76.25)	9.14 (114.25)
FP3	6.60(82.5)	9.90 (123.75)
Control	0.06 (0.75)	0.08 (1.00)
Vitamin A	**600 RAE/day**	**700 RAE/day**
FP1	567.34 (94.56)	851.0 (121.57)
FP2	649.34 (108.22)	974.02 (139.19)
FP3	700.00 (116.67)	1050 (150.00)
Control	0.66 (0.11)	0.98(0.14)
Protein	**14 g/day**	**22.2 g/day**
FP1	15.26 (109.00)	22.88 (103.06)
FP2	16.38 (117.00)	24.58 (110.72)
FP3	18.30 (130.71)	27.44 (123.60)
Control	6.38 (45.57)	9.56 (43.06)
Energy	**1022 kcal/day**	**1352 kcal/day**
FP1	304.10(29.76)	456.14 (33.74)
FP2	303.63(29.71)	455.45(33.69)
FP3	250.82(24.54)	376.22(27.83)
Control	314.50(30.77)	471.74(34.89)

- The numbers on the table represent amount of nutrients in porridge while those in brackets represents the %RDA met. Iron levels are derived with an assumption of moderate absorption (30%). Iron, Vitamin A and energy RDA based on FAO/WHO (2005) and protein RDA based onBurgess&Glasauer,2004).

FP1=10%PSF+10%PFF+80%FSF;FP2=15%PSF+15%PFF+70%FSF;FP3=20%PSF+20%PFF+60%FSF and Control=100%FSF: PSF-PUMPKIN SEED FLOUR; PFF-PUMPKIN PULP FLOUR; FSF-FERMENTED SORGHUM FLOUR

All the developed flour blend formulations including FP1, FP2 and FP3 were acceptable since they met at least > 70% of the iron, vitamin A and protein RDA for the target group as provided by FAO/WHO (2017) while complementing energy intake with average of 30% of the RDA. The flour blend formulations could therefore be utilized in a feeding trial. In this study the control sample (100% fermented sorghum flour) had negligible amounts of iron, vitamin A and protein and therefore there was a huge gap in its capacity in meeting the RDA for children for different nutrient needs.

Iron from plant sources is in the form of non-heme iron that is not easily absorbed when compared to heme iron (Naghii & Mofid, 2007). Recommendations have been made that in estimating iron absorbed in fortified cereal based flours the assumption should be 10% absorption level (Klemm et al., 2010; Ruel & Alderman, 2013). Samtiya et al. (2021) reported a maximum iron absorption of up to 30% from fortified cereal-based flours can be achieved by utilization of food processing techniques such as germination and fermentation. In this study a 30% iron absorption was assumed. The FP3 sample contributed the highest amount of iron RDA at 82.5% and 123.75% for 1-3 years old and 4-6 years old children respectively. However, the control sample contributed negligible amounts of iron RDA for the children. Prolonged intake of diets low in iron could predispose children to iron deficiency. Mbogoh & Sudi (2017) observed that majority of children in Kitui County had iron deficiency due to diets primarily based on cereals that are deficient in iron.

The high vitamin A content in the flour blend formulations is due to the high micronutrient concentration in pumpkin flour. High levels of provitamin A in the flour blend formulations is not a concern since no toxicity has been reported as a result of consumption of beta-carotene (Franca, 2012; Kulkarni & Joshi, 2013). Grune et al. (2010) observed that it was not possible to have toxicity as a result of consumption of diets high in beta-carotene since feedback mechanism regulates its metabolism with only the required amount being converted to retinol in the liver. No dangers of high intake of beta-carotene diets as high as 30,000 µg (4167 RAE) per day has been reported in infants and young children Adetola et al. (2020). The promotion of intake of foods incorporated with pumpkin flour is a strategy to address vitamin A deficiency especially in poor households that may not afford animal foods to meet dietary requirements.

The current study found that the control sample (100% fermented sorghum flour) had the highest potential of meeting the RDA energy needs of children at 30.77% and 34.89% for 1-3 years old and 4-6 years old respectively. On the other hand, the sample that had the highest amount of pumpkin flour FP3 (60% fermented sorghum: 20% pumpkin pulp: 20% pumpkin seed) contributed the least amount of RDA of energy for the children. The implications of these results are that the flour samples were not good sources of energy for preschool children, however these may not be a major problem. Studies have shown that majority of under-fives in Kitui County mainly consume starchy staple foods that are more readily available and cheap (Kigaru & Milelu, 2017; Ndiku et al., 2010). According to Serrem et al. (2020) these foods are high in carbohydrate and provide significant amount of energy. More so, to meet the energy nutritional needs requirements of children using the flour samples developed in the current study, it is possible to adjust the amounts of feeds and frequency of feeding (FAO/WHO 2017; Okoth et al., 2017). In regard to protein the formulations FP1, FP2 and FP3 contributed more than 100% of the RDA whereas the control sample was not able to meet at least 50% of the RDA for the preschool children. These results show that pumpkin seed and pumpkin pulp flour can be used to improve the protein content of sorghum. Protein is important for growth and development of children.

3.4 Sensory Evaluation for Porridge Samples

The sensory scores of porridges produced from sorghum and pumpkin flour are shown in Table 5.

Table 5. Sensory Evaluation Scores for Porridge Samples

Sample	Color	Aroma	Taste	Mouth feel	Overall Acceptability
FP1	5.92 ± 0.07^{b}	6.00 ± 0.06^{d}	7.24 ± 0.01^{c}	7.21 ± 0.01^{c}	7.57 ± 0.06^{c}
FP2	6.11 ± 0.02^{c}	5.91 ± 0.00^{c}	7.85 ± 0.01^{d}	7.30 ± 0.01^{c}	7.91 ± 0.00^{d}
FP3	6.30 ± 0.01^{d}	5.70 ± 0.01^{b}	6.60 ± 0.02^{b}	6.30 ± 0.02^{b}	6.40 ± 0.01^{b}
Control	5.78 ± 0.01^{a}	5.50 ± 0.02^{a}	4.62 ± 0.04^{a}	5.21 ± 0.01^{a}	5.20 ± 0.01^{a}

Results are based on mean of hedonic scores of porridges (mean±standard deviations). Values with different letter superscript in the same column are significantly different at p<0.05 based on analysis of variance and post-hoc Duncan range tests.

In regard to color the FP3 formulation had the highest score at 6.30 while the control sample had the lowest score. There was significant variation (P<0.05) in color preference of the flours, this variation could be attributed to the components of the raw materials as while as the ratio of substitution of the individual flours in the formulations. The results of this study on color scores are in line with (See et al., 2007; Usha et al., 2010) who reported that color scores increased with greater incorporation of pumpkin flour into cereals flour. The enhanced color of pumpkin-sorghum flour blend can be attributed to the beta-carotene present in pumpkin pulp giving it a yellowish color that is appealing to consumers Usha et al. (2010).

The aroma ratings show that the FP1 flour was highly rated with a score of 6.00. This shows that the panelist preferred the flour blend with little substitution of pumpkin flour. This could be attributed to their familiarity with flour made of only sorghum. High substitution of pumpkin flour into cereals has been reported to increase odour that leads to a general dislike of resulting flour blend formulations (See et al., 2007; Wongsagonsup et al., 2015). The liking of porridge with more fermented sorghum flour in this study could be attributed to release of aromatic compounds during fermentation that are further enhanced with cooking (Ogodo et al., 2017).

In terms of taste the FP2 flour was ranked highest at 7.85, all the samples significantly differed from each other in terms of taste at p<0.05. The low taste scores in FP3 could be due to strong smell from pumpkin that impair taste of cereal based porridge, a similar observation was made by (Asaam et al., 2018; Tadesse et al., 2019). Another study by Fathonah et al. (2020) reported that pumpkin contains curcubitasm that gives a bitter after taste and this may explain the low ranking of porridge with higher proportions of pumpkin flour observed in this study.

The scores on mouth feel show that the FP2 sample was the most preferred while the control sample was the least preferred with a score of 5.21. The samples FP1 and FP2 all had a score of 7.00 (like moderately). These samples had substitution of pumpkin flour at 20%, 30% respectively this then shows that pumpkin flour imparts a good mouth feel on flour blends and can be used to enhance sensory properties of fermented sorghum flour.

George (2020). pumpkin pulp flour has been reported to have a smooth mouth feel and this may explain the high mouth feel scores obtained in this study. In this study it was observed that addition of too much pumpkin flour (pulp and seed) into fermented sorghum flour led to a decrease in the mouth feel scores.

The overall acceptability scores show that the flour blend formulations FP1 (7.51) and FP2 (7.91) samples were the most preferred by the panelists while the control sample was the least liked. These results imply that inclusion of high proportion of pumpkin flour into fermented sorghum flour decrease sensory rating of resulting flour blend formulations. These results concur with Kiharason et al. (2017) who reported that inclusion of pumpkin flour into wheat above or equal to 40% led to a bitter taste and pungent smell resulting in a general dislike of bakery products. Kiharason et al. (2017) observed that substitution of pumpkin flour at 20% and 30% produced food products that were acceptable to consumers. Usha et al. (2010) observed that in development of flour blends using pumpkin and sorghum too much or too little addition of pumpkin resulted in food products with low acceptability, the study recommended 30% inclusion of pumpkin as the optimal level for high sensory attributes.

3.5 Microbial Analysis-of Flour Blend Formulations

The results on the microbial properties flour are shown in Table 6.

Table 6. Microbial Properties of Flour Samples

Sample	Coliforms/g	E. coli/g	Salmonella	Total viable count cfu/g	Yeasts & molds cfu/g
FP1	Absent	Not detected	Not detected	204	358
FP2	Absent	Not detected	Not detected	150	364
FP3	Absent	Not detected	Not detected	592	350
Control	Absent	Not detected	Not detected	515	644
Maximum Levels	Shall be absent	$1.0X\ 10^2$	Shall be absent	$1.0X\ 10^4$	$1.0X\ 10^3$

Acceptable levels based on (East Africa Communities, 2011).

That coliforms, Escherichia Coli and Salmonella were not detected in the analyzed flour samples. The absence of these microorganisms in the flour samples could be due to hygiene practices in the production process (Ibeanu et al., 2015; Makawi et al., 2019). The total viable count, yeast and molds were within acceptable levels. Drying of food materials lowers moisture content inhibiting microbial growth and prolongs shelf life (Ali., 2009; Ike et al., 2020) Thus the current study results show that the developed flour samples were therefore safe for human consumption.

4. Conclusion

The findings of this study have shown the nutritional effect of incorporation of pumpkin pulp and pumpkin seed flour into sorghum flour. The protein, iron and beta-carotene content of the flour blend formulations improved with addition of pumpkin flour. The resulting flour blend formulations were of high nutrition quality with ability to meet the daily protein, iron and vitamin A nutrient requirements of preschool children. This then shows that pumpkin pulp and pumpkin seed flour can be used as a fortifying agent to enhance the nutrient quality of low nutrition value cereal foods and as such address protein, vitamin A and iron deficiencies among children. Sensory studies showed that pumpkin flour significantly increased the color, aroma taste and overall acceptability sensory attributes of the flour blend formulations hence pumpkin flour has potential to enhance acceptability of sorghum-based products. Further, research should be done to evaluate the efficacy of pumpkin-sorghum flour blend in improving the iron and vitamin A status of preschool children. That in the event of a feeding trial the FP1, FP2 and FP3 flour blend formulations would be nutritionally suitable since they are all able to contribute to at least 70% of RDA for protein, iron and vitamin A of preschool children. However, the sensory properties scores showed that the FP2 flour formulations (70% fermented sorghum flour; 15% pumpkin pulp flour; 15% pumpkin seed flour) was the most preferred and would therefore be the most suitable for a feeding trial. Additionally, there is need to conduct absorption studies so as to examine the actual amounts of nutrients absorbed in the body following consumption of porridge made of pumpkin-sorghum flour blend.

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