# *Original Research Article*

## NUTRITIONAL QUALITY OF COMPLEMENTARY PORRIDGE MADE FROM YELLOW MAIZE, PUMPKIN SEEDS, SOYBEANS AND CARROTS FOR FEEDING CHILDREN AGED 6-24MONTHS.

**Abstract**

Flours from yellow maize, pumpkin seeds, soybeans and carrots were blended in different proportions. Formulated flour samples were; MPSC1 (55:15:20:10), MPSC2 (60:17:15:8), MPSC3 (65: 20:15:5) and control samples were MP (75:25) and MS (75:25). Extruded flour samples were assessed for proximate, minerals (magnesium, iron, zinc) and vitamin A content and data obtained were analyzed statistically. Protein content results of the formulated flour samples ranged from 18.45 g/100g in to 14.08 g/100g. Vitamin A content in formulated flours ranged from 324.5 µg/100g to 21 µg/100g. Zinc amount, results ranged from 22.58 mg/100g to 9.41 mg/100g. Magnesium amount, results ranged from 281.33 mg/100g to 31.08 mg/100g. Iron content from the formulated samples ranged from 13.22 mg/100g to 45.54 mg/100g. Based on the targeted nutrients of interest of this study results showed that, soybeans contributed to protein level, carrots contributed to high beta carotene amount, while pumpkin seeds contributed to zinc, magnesium and iron.

**Keywords;** Yellow maize, formulation, proximate composition, minerals



### 1.0 Introduction

Around the age of 6 months, an infant's need for energy and nutrients starts to exceed what is provided by breast milk alone, and complementary foods are required to meet those needs. An infant of this age is also developmentally ready for other foods (Masuke *et al.,* 2021). This transition is referred to as complementary feeding. If complementary foods are not introduced around the age of 6 months, or if they are given inappropriately, an infant's growth may falter (Taghizade *et al*., 2015).

According to PAHO/WHO, 2003 in order to meet infant's nutritional needs complementary food should be timely, be introduced when the need for energy and nutrients exceeds what can be provided through exclusive breastfeeding. Adequate, able to provide sufficient energy, protein and micronutrients to meet a growing child's nutritional needs. Safe, should be hygienically stored and prepared, and fed with clean hands and clean utensils. And lastly they should be properly fed meaning that they are given consistent with a child's signals of satiety and appetite, and that meal frequency and feeding are suitable for age.

Tanzania's complementary feeding practices are suboptimal as they do not meet WHO recommended complementary feeding indicators such the introduction of solid, semi-solid, and soft foods, a minimum level of nutritional diversity, a minimum number of meals per day, and a minimal standard of diet (Ogbo *et al.,* 2018).

In developing countries, a high rate of malnutrition in children under the age of five is linked to the selection of complementary foods and inappropriate feeding practices (Sen *et al*., 2017). Most of the families from several developing countries cannot afford the high cost of fortified complementary foods because of poverty (Abamecha, 2020). As a result, many families rely on low quality, inadequately processed traditional complementary foods for their children. Because of this, protein energy malnutrition is a significant issue for infants in developing countries (Taghizade *et al.,* 2015).

Low cost indigenous and underutilized legumes that can be processed and appropriately combined with widely accessible carbohydrate sources will provide relatively affordable and nutrients dense complementary foods that will help to minimize malnutrition and enhance children's nutrition in order to reduce these issues (Obinna *et al.,* 2018).

In this study locally sourced raw materials were used for the formulation of complementary foods for feeding children. Several materials ranging from cereals, plant protein sources, as well as vegetables have been found to be highly nutritious and were able to serve as cheap substitutes for diet formulation (Chamba *et al.,* 2021). This study also aimed at production and analyzing nutritional, physical properties and consumer acceptability of formulated complementary flour made from yellow maize, pumpkin seeds, soybeans and carrots.

Extrusion cooking was used in the production of complementary porridge because is one of the most popular methods for processing food since it produces huge amounts of food with greater nutrient retention over a longer period of time while also eradicating dangerous microorganisms and antinutrient (Choton *et al.,* 2020). Also extrusion process reported to improves the protein digestibility and iron bioavailability of cereals through reductions in antinutritional factors such as tannins or phytates (Rathod *et al.,* 2016). Extruders have grown increasingly specialized for culinary applications since extrusion cooking creates a variety of foods (Vivian, 2019). It is important to regulate the extrusion process operations and have knowledge of the impacts of operational factors, such as temperature, screw speed, and feed moisture content so as to get products with a variety of required physicochemical characteristics (Harper and Clark, 2019).
One of the most ecologically friendly and energy-efficient methods for a variety of food items is extrusion processing, which has gained popularity over time (Deenanath *et al.*, 2017).Additionally, extrusion may be used to create wholesome foods that are tailored to social demands in order to solve issues like malnutrition and food insecurity (Egal *et al.,* 2020).

## 1.1 Materials and Methods

### 1.1.1 Raw samples

Yellow maize, soybeans, pumpkin seeds, and carrot were utilized as raw materials to make composite flour. These ingredients were obtained at Chief Kingalu Market in the Morogoro municipality. These raw materials were chosen because they were rich in the desired nutrients which were vitamin A precursor (beta carotene), Zinc, Iron, Magnesium and Protein. In addition these foods are also readily available and affordable locally are grown across Tanzania. The nutritional analysis of the composite flours were done at Sokoine University of Agriculture in the laboratory of Department of Food Science and Agro-Processing.

### 1.1.2 Preparation of yellow maize, pumpkin seeds, soybeans and carrots composite flour

Yellow maize were sorted, washed then sundried and milled into fine flour, then packed into clean sealed polyethylene bags and stored at room temperature. Pumpkin seeds were sorted, washed, soaked in water for one day for sprouting so as to convert the stored carbohydrate to consumable and for softening to ease the milling process. The seeds were roasted in the oven at 150 ℃/45min then dried at 37 ℃ in an incubator. Then dried pumpkin seeds were milled into fine flour, packed into clean sealed polyethylene bags and stored at room temperature.

Soy beans were sorted and washed then boiled for 30 minutes to remove anti nutritional factor such as phytate, thereafter the soybeans were sprayed on the tray then roasted in the oven for at 110 ℃/80min, the dried soybeans were milled into fine flour then packed into clean sealed polyethylene bags, and stored at room temperature. Carrots were washed with clean water, then scraped, grated and dried at 50 $^{0}$C/8hrs. Then the dried carrots were blended and sieved into fine flour. The flour was packed and sealed with food grade polyethylene bags for analysis.

### 1.1.3 Formulations of composite flour

Flours from yellow maize, pumpkin seeds, soybeans and carrots were blended in different proportions as presented in Table 1, to develop varieties of complementary flour of composite mixtures. However, in this study, NutriSurvey (2007) software was utilized to design and assess complementary flour blends. In order to prevent the issue of malnutrition during the early stages of child growth, these formulations developed must provide at least half of the recommended daily intake of the targeted nutrients, which are protein at 15 mg, 210 g of vitamin A, 3 mg of iron, 2.5 mg of zinc, and 54 mg of magnesium for children aged 6 to 24 months.

**Table 1**: **Formulations for complementary flour**

| Samples | Yellow maize (%) | Pumpkin seed (%) | Soybean (%) | Carrot (%) |
|---|---|---|---|---|
| MPSC1 | 55 | 15 | 20 | 10 |
| MPSC2 | 60 | 17 | 15 | 8 |
| MPSC3 | 65 | 20 | 10 | 5 |
| MPS | 75 | 25 | - | - |
| MS | 75 | - | 25 | - |

### 1.3 Extrusion cooking process

Extrusion cooking was carried out in the Bio process engineering laboratory at Sokoine University of Agriculture, using a twin screw extruder where by the pre-conditioned feed mixture was measured into the extruder by a twin-screw volumetric feeder. The extrusion process was done under the following conditions: screw speed of 30.45 rmp, feeding rate of 8.20 kg/hr and barrel temperature was set at 62 °C and 109 °C in the first and second zones respectively. The extruded materials were collected, cooled to room temperature under natural convection conditions, milled into fine flour using milling machine then, cooled, packed in polythene bags and stored at room temperature prior to porridge preparation and analysis.

## 1.4 Proximate Composition

Proximate composition of the flour formulations were done to determine the amount of macronutrients present in the flours. This involved the analysis of crude protein, crude fat, ash, moisture and carbohydrates. All determinations were carried out in triplicates.

### 1.4.1 Crude protein

Crude protein content of the flour samples was determined using the micro-Kjeldahl method 920.87 (AOAC, 1999). The procedure was divided into three steps namely digestion, distillation and titration (Nielsen, 2010). The dried sample (0.5 g) was weighed and transferred into digestion tubes; 0.6 g of catalyst (mixture of 10 g $K_2SO_4$, 0.5 g $CuSO_4$) and 6 mL of concentrated $H_2SO_4$ were added to each tube with a sample. Samples were digested using Tecator digestion system 40 (Model 1016 digester, Sweden) for 3 hours to obtain a clear greenish solution. The digest was cooled and mounted in the distillation unit (Foss Tecator, Model 2200 Kjeltec auto distilling unit, Sweden). The distilled water, 70 mL was added to the digest followed by 70 mL of 40% NaOH and steam distilled for 4 min. The distillate, 50 mL was collected in conical Erlenmeyer flask containing 25 mL of 4% boric acid. The distillate was thereafter titrated with 0.105 g/100 mL hydrochloric acid. The blank volume was carried out and 0.04 mL obtained.

Titration equation was; $(NH_4)_2SO_4 + 2NaOH + H_2O \longrightarrow NaSO_4 + NH_3 + H_2O$

$$\%Nitrogen = \frac{14.01x(titre-blank\ )mL\ xconcentration\ of\ acid\ in\ n/mol}{weight\ of\ sample(g)x10}\ x10 \ldots\ldots\ldots\ldots \text{(i)}$$

$$\%\ CP = \%Nitrogen\ x \text{ nitrogen conversion factor 6.25} \ldots\ldots\ldots\ldots \text{(ii)}$$

### 1.4.2 Crude fat

Total fat was determined by using Soxhlet extraction official method 945.87 (AOAC, 1999). The dry sample (5 g) was placed into the extraction thimble and assembled to the Soxhlet apparatus. The petroleum ether (60 mL) of was used for continuous reflux for 55 min in three phases, the boiling phase for 15 min, the fat extraction phase for 30 min and the petroleum ether recovery phase for 10 min. Petroleum ether was then recovered by evaporation. Pre-weighed cups containing fat were dried in an oven at 105 $^0$C for 30 min to evaporate any remaining petroleum ether, cooled in a desiccator for 20 min and weighed. Percentage fat was calculated by using the formula:

$$\%Fat = \frac{Weight\ of\ crude\ fat\ (g)}{Weight\ of\ dry\ sample(g)}\ x100 \ldots\ldots\ldots\ldots \text{(iii)}$$

### 1.4.3 Crude fibre

Crude fibre was determined by using AOAC (1999) official method 920.86. Ankom fibre analyzer (Model ANKOM 220, USA) was used for the determination of crude fiber. Flour sample of 1.0 g was digested in the fiber analyzer by dilute sulphuric acid (0.125 M H2SO4) for 30 min and washed with hot water. The residues were then digested by dilute alkali (0.125 M KOH) for 30 min and washed by hot water. Digested residues were dried in the oven 105 $^{o}$C for 5 h, cooled and weighed. The residues were then placed in muffle furnace and incinerated at 550 $^{o}$C/2 hrs, cooled and weighed again. Total fiber content was taken as the difference between the residues before and after Incineration:

$$\% C.F = \frac{(Weight\ of\ sample\ residues\ before\ incineration - Weight\ after)g}{Weight\ of\ dry\ sample\ taken\ for\ determination(g)} \times 100 \ldots\ldots\ldots\ldots\ldots \text{(iv)}$$

### 1.4.4 Ash content

Ash content was determined according to AOAC (1999), method 923.03. Five grams of dry sample was oven dried at 105 $^{o}$C /24 h. The weight of crucible and dried sample were recorded. The dried samples in crucibles were incinerated in a muffle furnace at 550 $^{0}$C for 3 h, grey ash was obtained. Ash content was calculated as the difference between the weight of sample before and after incineration Percentage ash was calculated from the relationship:

$$\%Ash\ (DM) = \frac{Weight\ of\ ash\ (g)}{weight\ of\ dry\ sample\ (g)} \times 100 \ldots\ldots\ldots\ldots\ldots \text{(v)}$$

### 1.4.5 Carbohydrate content

Carbohydrate was calculated as a percentage difference using the formula:

% Carbohydrate = 100 % – (% protein + % crude fiber + % crude fat + % Ash) …….. (vi)

## 1.5 Vitamin A

Beta carotene determination was done according to Delia and Mieko (2004) whereby 5g of porridge triplicate samples in a test tube were measured and homogenized 4 times using 50mL proportions of cold acetone before extraction. The extracts were then transferred into the separating funnel containing petroleum ether (40-60 $^{o}$C), followed by a thoroughly washing with about 300mL of distilled water until the extracts is acetone free. During the washing process, the distilled water was kept along the wall of the glass separating funnel to avoid formation of emulations (water stones) in the carotenoid extracts. Then washed sample was allowed to pass through anhydrous sodium sulphate to dry it. The dried carotene extracts were collected into a clean and dry volumetric flask. Beta carotene stock standard solution with the concentration of 100 µg/mL was prepared. This stock solution was diluted to obtain 0, 0.25, 0.5, 1.0, 2.0, 4.0, 8.0 and 16.0 µg/mL concentrations.

The extract and diluted standards was then read under UV-Visible Spectrophotometer Wagtech, CECIL 2021 at 450nm to obtain its optical density (OD) which was able to estimate the beta carotenes in the sample. Linear regression equation obtained from the standard plot and the beta carotenes content of the unknown calculated as described by (Rasaki *et al*., 2009).

## 1.6 Mineral Content (Zinc, iron and Magnesium)

The analysis of minerals (zinc, iron and magnesium) were done according to AOAC (1999) method number 968.08 procedures by the use of UNICAM, 919 Atomic Absorption Spectrophotometer (AAS). For each sample 5 g was measured in a pre-dried and weighed crucibles then incinerated at 550 $^{o}$C overnight to ash. The ash was dissolved in 6 N HCl and left for 12hrs to allow extraction of minerals. The results were presented as an average of the duplicate determination.

### 1.7 Statistical Analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) version 16.0 software statistical package. All values for chemical properties were presented as Mean ± SD. Statistical differences between extruded porridge samples were determined by Univariete and Tukey comparison post hoc test; P < 0.05 was considered statistically significant.

## 1.8 RESULTS AND DISCUSSION

### 1.8.1 Nutritional quality

Proximate composition results are shown in Table 2, and results of vitamin A, iron, zinc and magnesium content of the complementary porridge are shown in Table 3.

**Table 2**: **Proximate compositions (%dwb) of the formulated complementary porridge**

| Samples | Moisture | Crude protein | Crude fibre | Ash | Fat | Carbohydr ate |
|---|---|---|---|---|---|---|
| MPSC1 | 3.40± 0.35 | 17.42± 0.01 | 5.14± 0.28 | 2.70± 0.03 | 11.89± 0.21 | 59.45± 0.56 |
| MPSC2 | 3.59± 0.35 | 17.27± 0.04 | 5.25± 0.42 | 2.46± 0.01 | 9.04± 0.35 | 62.39± 0.42 |
| MPSC3 | 3.86± 0.77 | 18.45± 0.01 | 5.38± 0.14 | 2.52± 0.02 | 4.41± 0.14 | 65.38± 0.35 |
| MP | 4.66± 0.98 | 14.08± 0.01 | 5.56± 0.49 | 2.31±0.03 | 3.83± 0.49 | 69.56± 0.14 |
| MS | 4.74±0.49 | 15.04± 0.03 | 4.09± 0.28 | 2.20± 0.01 | 1.51± 0.56 | 72.42± 0.21 |
| FAO/WHO | <5 | >15 | <5 | <3 | 10-25 | 60-75 |

**Key:** MPSC; composite mixture of yellow maize, pumpkin seeds, soy beans and carrots
MP (control); composite mixture of yellow maize and pumpkins
MS (control); composite mixture of yellow maize and soybeans

**Table 3**: **Vitamin A and minerals content (%dwb) of the formulated complementary porridge**

| Samples | Vitamin A (μg) | Iron mg/100g | Zinc mg/100g | Magnesium mg/100g |
|---|---|---|---|---|
| MPSC1 | 324.5±60.10 | 13.22± 0.11 | 19.27 ±0.31 | 216.51± 0.62 |
| MPSC2 | 310±5.65 | 14.50± 0.18 | 22.58± 0.55 | 268.34± 0.43 |
| MPSC3 | 153± 0.00 | 13.53± 0.16 | 17.59± 0.23 | 281.33± 1.06 |
| MP | 21±4.24 | 45.54± 0.25 | 10.50± 0.70 | 31.08± 1.35 |
| MS | 103.5±7.77 | 17.08± 0.16 | 9.41± 0.39 | 15.49± 0.36 |
| RDI | 210-400 | 3.9-18.6 | 3-8.4 | 54-75 |

**Key:** MPSC; composite mixture of yellow maize, pumpkin seeds, soy beans and carrot flours
MP (control); mixture of yellow maize and pumpkins flours
MS (control); mixture of yellow maize and soybeans flours
Recommended dietary intake (RDI) source (WFP, 2018)

#### 1.8.1.1 Moisture content

Moisture content of the extruded flour samples were significantly lower (p < .05) than of the control samples. This is assumed to be caused by the lower moisture content of the ingredient flours, including soybean (3%) flour. The high moisture content of the generated flour was caused by the high percentage of yellow maize (12%) in the control samples. Moisture content in the flour samples ranged from 3.40 g/100g in sample MPSC1 (55:15:20:10) to 4.74 g/100g in sample MS (75:25). However, all the formulated complementary porridges had a moisture content within the acceptable FAO/WHO requirement. The low moisture content might be due to drying and roasting of the sample raw materials during preparation process. Findings of this study agrees with a work reported by Chamba *et al.,* (2021) after going through the same procedures in the preparation of flour from yellow maize, soybeans and pumpkinseeds to reduce their moisture content. Given that spoilage microorganisms thrive in environments with high moisture content, therefore samples that have been formed with lower moisture content are going to have a longer shelf lives.

#### 1.8.1.2 Carbohydrate content

Carbohydrate content in porridge samples increased with higher proportion of yellow maize (76.5%). Carbohydrate content in the flour samples ranged from 59.45 g/100g in sample MPSC1 (55:15:20:10) to 72.42 g/100g in sample MS (75:25). The complementary porridge samples can be regarded as good source of energy to support children's growth, this is because all of the flour samples had carbohydrate content within FAO/WHO requirements of 60-75. The findings of this study reflects results by Chamba *et al*., (2021) that high carbohydrate content in developed composite flour increase with the utilization of yellow maize. Carbohydrates are an infant's main fuel source, and essential for proper growth and development. Offering your infant healthy, nutrient-dense carbohydrates will help optimize child growth and maintain a healthy body weight.

### 1.8.1.3 Protein content

Protein content of complementary porridge samples ranged from 18.45 g/100g in sample MPSC3 (65:20:10:5) to 14.08 g/100g in sample MP (75:25). Similarly, all of the formulated complementary flour samples had protein content within acceptable FAO/WHO requirement 15% as can be seen in the Table 2 except for a control sample MP (70:25). This is contributed by the utilization of protein rich ingredients (soybean (34%) and pumpkin seeds (30.3%) compared with the carbohydrate rich ingredients (maize) that were utilized in the formulation of the control samples. Since most cereals such as maize have a low protein content. The findings of this study are comparable to Marcel *et al*., (2022) that high protein content in developed composite flour increases with the utilization of soybeans and pumpkin seeds.

Cereal based complementary foods emanating from such ingredients should be augmented by protein rich (leguminous) foodstuffs to improve their nutritional significance (Kolawole *et al*., 2020). The formulated complementary flour might be regarded as a good source of protein. Protein is vital for the prevention of protein–energy malnutrition (PEM), which is frequently witnessed among children in emerging nations, particularly during weaning (Achidi *et al*., 2016; Adisetu *et al*., 2017). Protein makes important nutrient composition in complementary foods. They are major sources of essential amino acids and energy at times of energy deprivation. Adequate supply of dietary protein is vital for maintaining cellular function and integrity and for ensuring normalcy of health and growth

### 1.8.1.4 Fibre content

Fibre is not digested by the body. It passes through your stomach, intestines, colon and then out of your body. Dietary fiber, often called roughage, is the indigestible plant-derived food component. Fibre plays a major role of increasing the utilization of nitrogen and absorption of some micronutrients (Lisanti, 2019). Fibre content in porridge samples ranged between 5.56 g/100g to 4.09 g/100g. FAO/WHO recommends complementary foods to contain low fibre as high fibre products can lead to high water absorption and displacement of nutrient and energy needed for the growth of children less than two years of age.

Daily recommended allowance of crude fiber in the complementary foods is <5% (FAO/WHO). Also high-fiber foods effectively provide satiation by filling the stomach and delaying the absorption of nutrients. Such attributes of the complementary foods may also lower the child's feeding ability (Rolfes *et al.,* 2014)

### 1.8.1.5 Fat content

Crude fat contents of the extruded flour samples were significantly higher ($p < .05$) than the control sample. The results ranged from 11.89g/100g in sample MPSC1 (55:15:20:10) to 1.51g/g100 in sample MP (70:25:5). As shown in Table 2, this effect was contributed by the incorporation of pumpkin seeds (44.54% fat) and soybean (22.68% fat), which has good quantities of fats. On the contrary, the poor quantities of fats exhibited by the control samples are thought to be due to the utilization of carbohydrate rich ingredients including maize. Interestingly, all the formulated flour samples were within the FAO/WHO requirements of 10%–25%. These findings reflects results by Marcel *et al.,* (2022) that fat content in composite flour increase due to utilization of soybeans and pumpkinseeds. Fats content can affect developed food shelf life stability, this is because in the presence of oxygen fats can undergo rancidity which results in food spoilage. Therefore, flour sample with high fats content is more liable to the spoilage than the one with low fats content. Also fats constitute an important portion of nutrients obtained from foods. For infants and young children, they are source of energy, essential fatty acids, and fat soluble vitamins (A, D, E, and K). In addition, dietary fats have an important role in promoting good health and enhancing the sensory qualities of the foods

#### 1.8.1.6 Ash content

The crude ash content of the extruded flour samples were higher compared to that of the control samples (MS), but within the acceptable FAO/WHO requirement (<3%). Ash content signifies the presence of minerals in food samples (Laryea *et al*., 2018), and this denotes that the formulated complementary foods in this study are potential sources of minerals. Ash content in the formulated samples ranged from 2.70 g/100g in MPSC1 (55:15:20:10) to 2.20 g/100g in sample MS (75:25). The findings from this study are in line with the findings by Haque *et al*., (2013) that the proportion of soybean (at least 20%) resulted in high ash content of soybean flour as one of the ingredients, which could play a key role in mineral composition of the formulations.

#### 1.8.1.7 Vitamin A

Vitamin A contents in formulated flour samples ranged from 324.5 µg/100g in MPSC1 (55:15:20:10) to 21 µg/100g in MP (75:25). The highest ratio of vitamin A content in formulated samples (MPSC1 and MPSC2) was due to the utilization of carrots which has high vitamin A contents 16706 µg compared to soybeans and pumpkin seeds. This effect was expected because the main reason of selecting carrots in this study was its contribution of vitamin A in a form of beta carotene. The findings from this study were in agreement with those of Tumwine and Atukwase (2018), who reported an increase in vitamin A after supplementing millet flour with carrot powder. However, the obtained value of sample MPSC3 (65:20:10:5), MP (75:25), MS (75:25) are below RDI (210-400), also below the RDA of vitamin A of (500µg and 300µg) for children aged 6-24 months (Lwelamira *et al*., 2013; Lutter, 2013; FAO, 2011; Lutter and Dewey 2003). Vitamin A is essential for formation and maintenance of healthy skin, hair, and mucous membranes, proper vision and strengthening healthy immune and reproductive systems.

#### 1.8.1.8 Zinc

Zinc results ranged from 22.58 mg/100g in sample MPSC2 (60:15:17:8) to 9.41 mg/100g in sample MS (75:25). Similarly, results show that all formulated flour samples are more than the DRI12 (3–8.40 mg/100 g) according to World Food Program (2018). Therefore, the complementary porridges might be good sources of zinc because they can provide more than 50% of zinc DRI, which is considered sufficient. Thus, the porridges are considered suitable for use by the targeted groups which include children and also can be recommended to women of reproductive age. Similar to iron, zinc deficiency is also associated with stunting, anemia, and higher disease susceptibility (Agbemafle *et al.,* 2020; Bhutta *et al*., 2013).

Also zinc is a component of many enzymes in the body and is involved in most metabolic processes. Zinc plays a role in the following bodily functions such as formation of protein in the body and thus assists in wound healing, blood formation and taste perception.

#### 1.8.1.9 Magnesium

Magnesium amount in the formulated flour samples were significantly higher ($p < .05$) when compared to both the control samples and the DRI (54–75 mg/100 g). The results ranged from 281.33 mg/100 g in sample MPSC3 (65:20:10:5) to 31.08 mg/100 g in sample MS (75:25). Higher magnesium content of formulated samples is evidently due to the raw materials utilized in complementary food formulation especially utilization of (soybeans 289 mg and pumpkin seeds 592 mg). Magnesium is crucial good for child's health as it keeps the heart rhythm steady, strengthens the bones, supports a healthy immune system, and maintains normal muscle and nerve function (Ndife *et al.,* 2020). Findings of this study corresponded with those of Chamba *et al*., 2021, who reported an increase in magnesium content after supplementing yellow maize flour with soybeans and pumpkinseeds.

#### 1.8.1.10 Iron

Iron content in the formulated flour samples ranged from 13.22 mg/100 g in sample MPSC1 (55:15:20:10) to 45.54 mg/100 g in sample MP (75:25). It is further noted that all formulated samples were able to meet RDI (3.9- 18.6 mg/100 g), therefore the formulated samples can be recommended as a good source of iron because it provides 50% of the iron RDI for feeding children. Iron is essential for all tissues in a young child's developing body, blood formation and help to preserve the health of young children (Beard, 2001).

This mineral is a vital component of hemoglobin, the part of red blood cells that carries oxygen. The symptoms of iron deficiency include anemia, malabsorption of food, irritability, anorexia, pallor, and lethargy. Studies have also shown that iron deficiency in infants and older children may be associated with irreversible behavioral abnormalities and abnormal functioning of the brain.

## 1.9 CONCLUSION

Formulated flour samples MPSC1(55:15:20:10), MPSC2 (60:17:15:8) and MPSC3 (65:20:10:5) of this study were able to meet recommended daily intake for feeding children aged 6-24 month, compared to the reference samples (control). Sample MPSC3 is the best one as it contain high amount of protein and minerals and can be recommended for children diet to support their growth and health. Based on the targeted nutrients of interest of this study, results showed that soybeans contributed to protein level, carrots contributed to high beta carotene amount, while pumpkin seeds contributed to zinc, magnesium and iron. This study proves that we can use extrusion to change lives by helping mothers to get nutritious foods to support the health of their growing babies, by producing baby foods using raw materials that are locally available in our markets. Also these foods can be used as a solution to children suffering from malnutrition and stop depending on commercial foods. These foods are highly nutritious and provide sufficient energy to support the children immunity, body growth and brain development.

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