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Nutritional and Sensory Evaluation of Complementary Food Prepared from Blends of Pumpkin Seed, Pumpkin Flesh (Cucurbita pepo), Maize (*Zea mays*), and Soybean (*Glycine max*)

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ABSTRACT

Vitamin A, iron, and Zinc deficiencies are three of the common nutritional problems of children in Ethiopia. Nutritious, packed commercial complementary foods are beyond the reach of many Ethiopian households, especially the rural poor. Therefore, an attempt was made to improve zinc, iron, and vitamin A contents of local complementary foods without compromising sensory quality. Porridge samples were prepared from composite flours of germinated maize, pumpkin pulp, its seed, and soybean flour with ratios of 75%:5%:5%:15, 60%:10%:10%:20, 45%:15%:15%:25, and 30%:20%:20%:30% respectively. The control sample was prepared from 100% ungerminated maize. Iron, Zinc, and vitamin A (β-carotene) contents, other proximate compositions, and sensory analysis were conducted following standard procedures. The result indicated that Blending ratio of 30%:20%:20%:30% was significantly increased($p<0.05$) Iron, zinc, Calcium, Magnesium, Vitamin C, Vitamin A (ß- carotene), Omega -3 fatty acid, Omega-6 fatty acid, Protein, Fat and Energy contents from 3.97 to 11.00 mg, 1.86 to 2.98 mg, 29.9 to 52.2 mg, 21.89 to 26.72 mg, 8.41 to 47.24 mg,0.06 to 574 µg, 0 to 7.92 mg, 0 to 20.18, 10.98 to 20.26%, 1.7 to 17.22% and 374.18 to 436.87 k calorie respectively than control. The complementary food prepared from composite flours showed very much acceptable (> 5) in overall sensory quality using hedonic scale. In conclusion, blending germinated maize, pumpkin pulp, its seed and soybean flour improved iron, zinc and vitamin A(ß-carotene) contents without reducing other nutritive value, energy requirement as codex almentareous acceptable recommend Value for 6-23-month age children without compromising sensory quality of the complementary food and the proportion, 30% maze + 20% pumpkin pulp + 20% pumpkin seed + 30% soybean was recommended for small and micro industry Enterprise of complementary food processing or preparing at household level.

1. INTRODUCTION

The childhood period, especially from birth to two years of age, truly determines the direction of a child's life since rapid growth and brain development occur during this time. This period is often marked by growth faltering, which is difficult to reverse after two years. Poor nutrition during this critical growth period affects vital functions and compromises motor and cognitive development (Michaelsen et al., 2000). Childhood malnutrition caused by the consumption of complementary foods having less nutrient density is still a major problem in several low and middle-income countries (Black *et al*., 2008).

Out of 667 million children under age 5 worldwide, 159 million (23.84%) are too short for their age (stunted), 50 million (7.5%) do not weigh enough for their height (wasted), and 41 million (60.15%) are overweight. Among 7 billion the world's population, about 2 billion (28.57%) people suffer from micronutrient malnutrition, and nearly 800 million people (11.43%) suffer from energy (calorie) deficiency (WHO, 2018). Under-nutrition accounts for 45% of all under-5 deaths (WHO, 2019; USAID & GAIN, 2009). In Ethiopia, 37% of children under the age of five are stunted, 7% are wasted, and 21% are underweight (Hailegebriel et al., 2019; EMDHS, 2019). The situation is particularly severe in the Amhara Region, where 46% of children under five are stunted, 10% are wasted, and 28% are underweight (EMDHS, 2019). In addition to macro nutrient deficiency, Vitamin A, iron, and zinc deficiencies are three of the common nutritional problems in children of developing countries, including Ethiopia. About 50% and 56% of children under 5 years showed vitamin A and iron deficiency, respectively, in Ethiopia (Hailegebreal et al., 2019; EDMHS, 2019). About 36.2% of children below two years of age had subclinical vitamin A deficiency (VAD) in Ethiopia (Demissie et al., 2009). About 37.6% of children under five had serum retinol concentration of less than 0.7µmol/L (Haidar, 2011)

VAD compromises immune systems and causes premature death for one million young children each year in the developing world (USAID & GAIN, 2009). VAD in children may impair vision and cause xerophthalmia, which leads to blindness (Sommer *et al*., 1996); weaken immune function, and increase the severity of infectious diseases like measles and diarrhoea, leading to child mortality (Demographic & Nigeria, 2012). Zinc deficiency may lead to poor growth in childhood, reduced immune competence, and increased morbidity from infectious diseases such as diarrhoea, pneumonia, and elevated childhood mortality rates in developing countries (Salgueiro *et al*., 2002). Due to zinc deficiency alone in 2011, about 35.6% of children in Africa were stunted, leading to 116,000 child deaths (WHO, 2018). These micronutrients have special benefits due to their impact on the physical and cognitive development of children (Neumann *et al*., 2002).

Chronic low intake of zinc and vitamin A-rich food is the primary cause of their deficiencies. Food-based approach is the best way to combat malnutrition of vitamin A, zinc, and others among infants and young children in the developing world (Faso & Bassole, 2011). Incorporating high ß-carotene foods like pumpkin is a cost-effective food-based approach to improve vitamin A intake of young children and tackle vitamin A-related health problems (Hashim *et al*., 2000; Berteram *et al*., 1995). It was also noted that pumpkin seed flour supplemented a complementary mix is an economically nutritious food with highly acceptable sensory properties in addition to rich minerals (Fe, Zn, and Mg) and essential fatty acids (Omega-3 and 6) (Dhiman *et al*., 2009).

Complementary foods, introduced to children between the ages of 6 to 36 months, are liquids and semisolid foods, which are later substituted by solid foods (Balasubramanian *et al*., 2014). Complementary foods of good quality possess several key properties, including High nutrient density, low bulk density, low viscosity, and appropriate texture. They also have high energy content, balanced protein and micronutrient contents, and a consistency that facilitates easy consumption (Krut *et al*., 2013). However, complementary foods with appropriate quality did not reach the consumers in low and middle-income countries since raw materials were expensive and processing technologies were underdeveloped too.

The Amhara region, which contributes the second largest agricultural product in the country, but with the highest vulnerability of under nutrition and micronutrient deficiencies such as Vitamin A, zinc, and iron (Haddad *et al*., 2015). Therefore, it is important to develop complementary foods that aim to combat malnutrition. Hence, the objective of this study was to formulate and assess the nutritional impact of different blending ratios of germinated maize, pumpkin pulp, pumpkin seeds, and soybean on the zinc, iron, and vitamin A contents. Additionally, the study aimed to analyse the proximate compositions and sensory properties of a locally produced complementary food. Therefore, the aim of this study was to formulate and evaluate the nutritional effect of blending ratio of germinated maize, pumpkin pulp, and its seed and soybean on zinc, iron, and vitamin A contents, and to analyze proximate compositions and sensory properties of local complementary food.

2. MATERIALS AND METHODS

2.1. Sample Preparation

Maize (BH- 545) variety and Soybean *(*Pawe-II variety) which were brought from Adet Agricultural Research Center and Pumpkin prurchesed from North Achefer district, west Gojjam, Ethiopia were used for the experiment. Five kg of maize was sorted, cleaned, soaked for 24 hrs, rinsed with clean tape water, and then germinated for 48 hrs and sun-dried. Pumpkin pulp and seed were manually separated. The pulp was chopped into pieces of 2cm diameter (Abebe *et al.,* 2006) and shed-dried to prevent loss of beta-carotene. After a manual removal of the hull, pumpkin seed was sun-dried and semi-roasted at 60 ^{0}c for 20 minutes. Similarly, five kg of Soybean seed was sorted, washed, and cleaned then soaked in hot water at 60 ^{0}c for 20 minutes to deactivate enzymes for beany flavour and reduce anti-nutritional contents(Jideani, 2011). The soya bean samples were then decorticated, dried with sun drying method, and semi-roasted in a hot air oven for 20 minutes at 150°C (Emmanuel & Omale, 2019). Treatment and control samples were separately milled into flour passing 1mm diameter sieve using laboratory mill (Thomas Wiley Mill Model 4, USA). The flour was packed in a polyethylene bag and stored in the laboratory at room temperature.

2.2. Experimental Design

The experiment consisted of one factor (blend ratio) with six levels, including the control. Each level had germinated maize, pumpkin pulp, semi-roasted pumpkin seed, and Soybean flour in different proportions and 100% un-germinated maize flour for control. A completely randomized design (CRD) was employed for the treatments with three replications. A randomized complete block design (RCBD) was used for the sensory evaluation test.

2.3. Complementary Food Blend Formulation

Five composite flours were formulated using Germinated Maize and dried Pumpkin Flesh, roasted and ground Pumpkin Seed, and Soya Bean flour in different proportions. These proportions were selected by reviewing various literature (Onabanjo *et al.,* 2009; Onwurafor *et al.,* 2017; Emmanuel & Omale, 2019). Ingredients were weighed and blends were formulated in proportions as follows:

F1 (100% germinated maize flour + 0% pumpkin flesh flour+0% dehulled pumpkin seed flour +0% soybean flour)

F2 (75% germinated maize flour + 5% pumpkin flesh flour +5% dehulled pumpkin seeds flour +15% soybean flour)

F3 (60% germinated maize flour + 10% pumpkin flesh flour +10% dehulled pumpkin seed flour +20% soybean flour)

F4 (45% germinated maize flour + 15% pumpkin flesh flour +15% dehulled pumpkin seeds flour +25% soybean flour)

F5 (30% germinated maize flour + 20% pumpkin flesh flour +20% dehulled pumpkin seed flour + 30% soybean flour) and

F6 (100% non-germinated maize flour as control)

These flours were thoroughly mixed, packaged, and kept at ambient temperature until needed for analysis.

2.4. Porridge Preparation and Sensory Evaluation

Complementary food porridge samples were prepared with the assistance of mothers (Abebe *et al*., 2006). The flours were blended following the aforementioned ratios. A local clay pot (*Masero*) was used for porridge cooking. Salt was added to the taste in boiling water (100°C). Oil was added in the ratio of 4ml per 100g flour. The porridge samples were continuously stirred on fire till ready (for 10 minutes). Ready porridges were transferred to identical aluminium plates coded with three digit random numbers. Fifteen panellists were randomly selected for sensory evaluation. Taste, Colour, Flavour, Texture and overall acceptance of porridge samples were evaluated by mothers using a 5-point hedonic scale: 5 = like very much, 4 = like, 3 = neither like nor dislike, 2 = dislike and 1 = dislike very much. The samples were served in duplicate (Stone & Side, 1992).

2.5. Proximate Composition Analysis

Proximate composition analysis was conducted at laboratories of Bahir Dar Institute of Technology and Ethiopian Agricultural Research Institute (EIAR). Proximate compositions were analysed using the methods of AOAC (2000). Moisture content was determined by drying the samples for 3 hours. at 105°C with a drying oven (Memmert, Germany). Crude protein content was analysed by the Kjeldahl method in three steps (digestion, titration and distillation). Then percent nitrogen obtained was multiplied by 6.25. Crude fat content was determined by exhaustively extracting the samples with diethyl ether using a Soxhlet extractor. Crude fiber content was determined in four steps (digestion, filtration, washing and drying, and combustion). Complementary porridge samples were digested by refluxing 1.25% boiling sulphuric acid and 28% boiling potassium hydroxide. Total ash was determined by ashing the samples at 550°C using a muffle furnace. Total carbohydrate content was determined by subtracting the moisture content, crude protein, total ash, and fat from the total dry weight of the sample. Gross energy was determined by calculating energy from fat, carbohydrate, and protein contents using Atwater's conversion factors considering protein and carbohydrate each gives 4 kcal and fat yields 9 kcal per 100 grams.

2.6. Mineral Analysis

Iron, zinc, magnesium, and calcium content was determined according to the AOAC (2000) procedures by the use of UNICAM, 919 Atomic Absorption Spectrophotometer (AAS). Samples will dry and then ash at 450 ^{0}C under a gradual increase of 50 ^{0}C temperature per hour. The ash samples were then dissolved in 5.0ml 6N HCl and diluted to 50ml with deionized water. Iron, Zinc, magnesium and calcium concentration of an aliquot was determined using an atomic absorption spectrophotometer.

2.7. Vitamins Analysis

Vitamin A (ß-carotene) was determined according to Delia & Kimura (2004) where 0.2- 0.3 g of flour and 5 g of porridge was measured and homogenized 4 times using 50 ml cold acetone before extract. The extract was transferred into the separating funnel containing petroleum ether (40-60°C Bp) followed by a thorough washing with about 300 ml of distilled water until the extract was acetone free. During the washing process, the distilled water was put along the walls of the glass separating funnel to avoid formation of emulations (Waterstones) in the carotenoid extracts. The washed samples were then pass through anhydrous sodium sulphate to make it free from any trace water. The dried carotene extracts were then 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 dilutes

serially to obtain 0, 0.25, 0.5, 1.0, 2.0, 4.0, 6.0, 8.0, 10.0 and 12.0 µg/ml concentrations. The extract and diluted standards were then read under a UV-Visible Spectrophotometer Wagtech, CECIL 2021 at 450 nm to obtain 40, which is its optical density (OD) that able to estimate the Beta carotenes in the sample. Linear regression equation obtained from the standard plot and the beta carotene content of the unknowns was calculated (Rasaki *et al*., 2020).

To determine vitamin C (Ascorbic acid), 2 g of porridge was measured using weighing scale and then 10 ml of 10% Trichloroacetic acid (TCA) solution was add. The mixture was shaken for a few minutes and left to extract the contents. The extracted solution was then diluted to 50 ml with an excess 10% TCA solution and filtered using No. 1 Whatman filter papers. Ten ml of the filtrate was taken into a 250 ml conical flask and titrated with a standard solution of 2,6-Dichlorophenolindophenol, Sodium salt until a faint pink colour was obtained which persisted for 10 seconds (Tomohiro et al., 1990). The vitamin C content was then calculated using the formula: Vitamin C content in mg/100g of sample = (A- B) * C * V *100/ (D * S). Where; A is the volume in ml of the indophenol solution used for the sample, B is the volume in ml of the indophenols solution used for the blank, C is the mass in mg of ascorbic acid equivalent to 1.0 ml indophenols solution, S is the mass of sample in g taken for analysis, and V is the total volume of extract in millilitres.

2.8. Fatty Acid Analysis

The essential fatty acids (omega-3, a-linolenic acid (ALA), n-6 (omega-6, linoleic acid)) were determined according to AOAC (2000) by using HPLC for the determination of omega fatty acids in oil/food samples using a dual-gradient method and charged aerosol detection. All standards were dissolved and diluted to 2500 µg/mL in alcohol and diluted serially to a concentration of 6.25 µg/mL. All solid fat samples (50 - 100 mg) were extracted in 1.2 mL methanol: chloroform (1:1) for 15 minutes using vortex mixing. Extracts were then centrifuged to remove solids, and 1.0 mL of extract was added to 4 mL of isopropanol: water (3:2) and 1 mL of 5 M KOH. All liquid oil samples (50 µL aliquot) were dissolved/ dispersed in 5 mL isopropanol: water (3:2) and 1 mL of 5 M KOH. All samples were heated in an 80 °C water bath for 1 hr with occasional stirring. After samples were cooled, a 500 µL aliquot was removed and 25 µL formic acid was added to neutralize the sample. Then samples were hydrolysed to separate the fatty acids from their glycerol backbone and analysed directly using HPLC with charged aerosol detection.

2.9. Contribution of Complementary Foods to Recommended Dietary Allowance (RDA)

The average contribution of CFs to the RDA of each nutrient was calculated as a percent of the RDA (Agbemafle *et al.*, 2020).

$$\%\, RDA \;=\; Amount\ of\ nutrient\ analysed \;/\; RDA\ for\ a\ given\ nutrient \;\times 100$$

2.10. Data Analysis

Statistical Analysis System (SAS) version 9.0 was used for data analysis. A one-way analysis of variance was conducted to test the significance of mean differences between treatment and control groups. Tukey test was employed to determine significant mean differences at a P-value of < 0.05.

3. RESULTS AND DISCUSSIONS

Proximate compositions showed a significant increase in carbohydrate and fiber of the blends, except for moisture, (Table 1). With the increase in the amount of pumpkin pulp, its seed, and soya bean flours in blends, Iron, Zinc, Magnesium, Calcium, Omega-3 fatty acid, Omega-6 fatty acid, Vitamin C and Vitamin A (beta carotene) contents increased highly significantly from 3.98 to 12.23 mg, 1.86 to 2.93 mg, 21.89 to 26.71 mg, 2.99 to 5.22 mg, 0 to 7.92 mg, 0 to 20.18 mg, 8.41 to 47.24 mg and 0.06 to 574 µg respectively (Table 2 and Table 3). The mean moisture content value for the complementary food was not significantly varied ($P>0.05$) from 4.5 to 4.81% for all treatments (Table 1). Moisture content monitoring in foods and food products is crucial because high moisture content can reduce shelf life by increasing microbial degradation activity, resulting in bad odor and unacceptable taste of

the product (Unuabonah *et al.,* 2007). In general, the moisture contents of all the tested blends were within the recommended level (less than 5%) recommended by the Codex standard (1991) for infant formula.

Table 1. Proximate Composition (%) and Gross Energy Content(Kcal/100g) of Complementary Foods (Mean ±SD).

Formulated foods	Moisture	Ash	Fiber	CHO	Fat	Protein	Energy value
F1	4.60^{a} ±0.04	1.51^{c} ±0.04	3.49^{ab} ±0.45	77.99^{a} ± 0.60	4.27^{e} ± 0.16	8.13^{f} ± 0.24	382.91^{e} ± 2.29
F2	4.81^{a} ±0.18	2.39^{b} ±0.25	3.55^{ab} ±0.33	66.53^{b} ± 0.19	9.15^{d} ± 0.09	13.58^{d} ± 0.19	402.73^{d} ± 0.60
F3	4.54^{a} ±0.21	2.41^{b} ±0.05	3.76^{a}± 0.29	62.99^{c} ± 1.02	11.02^{c} ±0.38	15.28^{c} ± 1.38	412.28^{c} ± 2.00
F4	4.59^{a} ±0.23	3.19^{a} ±0.05	3.58^{a} ± 0.34	55.78^{d} ± 1.31	14.29^{b} ± 0.17	18.57^{b} ± 0.92	426.01^{b} ± 1.83
F5	4.50^{a} ±0.41	3.37^{a} ±0.55	4.44^{a} ± 1.76	50.21^{e} ± 3.04	17.22^{a} ±0.23	20.26^{a} ± 1.56	436.87^{a} ± 6.76
F6	4.68^{a} ±0.07	1.72^{c} ±0.11	2.19^{b} ± 0.05	78.73^{a} ± 0.30	1.70^{f} ± 0.05	10.98^{e} ± 0.29	374.18^{f} ± 0.54
CV	4.89	10.5	22.17	2.21	2.19	6.53	0.77
RV	<5	<4	< 5	60-75	20-35	20-35	425 - 550

**Means with the same alphabet as superscript within the same columns are not significantly different at a 5% significance level. CHO: carbohydrate, CV: coefficient of variation, RV: Recommended value*

Blending germinated maize with pumpkin pulp, its seed and soya bean resulted in a significant decrease in carbohydrate content. A similar reduction was observed by Tizazu *et al* (2010) on sorghum-based complementary food preparation using germination (Tizazu *et al* (2010); Inyang *et.al* (2008)) on instant "Fura " from germinated sorghum. The decrease in carbohydrate content may be due to the germination of maize for 48hrs which increased alpha-amylase activity that breaks down the carbohydrate into simpler and more absorbable sugars that are utilized by emerging shoot during the early stages of germination (Tizazu *et al*., 2010; Inyang *et al*., 2008). Despite the decrease in carbohydrate level, the blend containing 30%:20%:20%:30% and 45%:15%:15%:25% ratio of 48 hrs germinated maize, pumpkin pulp, its seed, and soybean respectively found to provide more than 75% and 60 % of the recommended carbohydrate value for 6-12 months and 12-23 months old children correspondingly.

Energy content significantly increased on blending, with a remarkable increase in 30%:20%:20%:30% blend. The increase in energy value could be due to an increase in fat content which may result from the inclusion of pumpkin seeds and soybean which are known for their high oil content (Sara *et al*., 2008). It was recommended that 425 Kcal. and 550 Kcal. of energy should come from complementary foods for 6 -11 and 12-23 months old children respectively. The current complementary food could provide 426.01 Kcal/100g and 436 Kcal/100g for F4 and F5, respectively which was acceptable in recommended value (400 -550 Kcal/100g) in germinated maize, pumpkin pulp, and its seed and soybean blended for 6-11 and 12-23 months old children (Shanshan *et al*., 2011).

The protein content was significantly increased from 8.13 to 20.26%. The observed increase in crude protein content is supported by the reports of Tizazu *et al (*2010) and Inyang & Zakari (2008). The increase in crude protein content might be due to the net synthesis of amino acids by germinating seeds (Tizazu *et al*., 2010; Inyang, 2008). The highest increase seen in the 30%:20%:20%:30% (F5) blending ratio could be explained by the highest amount of soybean incorporated (Hamed *et al*., 2008; Pongjanta *et al*., 2006). The current complementary food could provide 13.56% to 20.26% (F2- F5) of the total energy from protein which falls within the recommended range (Huffiman *et al*., 1994). The highest protein content (20.26%) is obtained in blending formulation (F5) as compared to the control group (10.89%) which fulfilled the recommended value (10-35%)

The fat content was significantly increased from 4.27 to 17.22%. Crude fat content increased in the current study which is different from the result obtained on instant "Fura" preparation from 48 hrs germinated sorghum (Inyang, 2008) and sorghum-based complementary food preparation using germination (Tizazu *et al*., 2010). The decrease in crude fat content between the control group(F6) and 100% germinated maize(F1) might be due to increased activities of lipolytic enzymes during germination which hydrolysis fat into fatty acids and glycerol that can be used as a source of energy for developing embryo (Tizazu *et al*., 2010; Inyang, 2008). Therefore, the observed increase in crude fat content in the current study may be due to the pumpkin seed and soybean included which have high oil content (Sara *et al*.,2008). The complementary foods developed in the current study provide 14.29 - 17.22% (F4 - F5) of energy from fat meeting the recommended value (10-25%) (Brown et al., 2012). The highest fat content (17.22%) is obtained in blending formulation (F5) as compared to the control group (1.70%).

The fiber content was increased from 3.49 to 4.49%. The fiber content of the current food(F1-F5) product was also acceptable in recommended value (<5%) and fiber content increased with increasing the blending ratio of pumpkin pulp (Amuna *et al*., 2000). The highest fiber content (4.49%) is obtained in blending formulation (F5) as compared to the control group (2.19%) which fulfilled the recommended value (<4%).

The ash content was increased from 1.51 to 3.37%. The observed increase in the ash content of the blends may be due to the high mineral content in pumpkin seeds (Sara *et al*., 2008). A nearly similar value (1.51 to 3.37g) was reported by Pongjanta *et al* (2006) from Thailand on increasing pumpkin flour from 10% to 20% in bakery products. The ash content of the current food product(F2-F5) was also acceptable in the recommended value (<4%) and greater than the control group (Pongjanta *et al.,* 2006). The highest ash content (3.37%) is obtained in blending formulation (F5) as compared to the control group (1.72%) which fulfilled the recommended value (<4%).

Table 2. Mineral and Vitamin Contents of Complementary Foods per 100g (Mean ±SD).

Formulated foods	Iron (mg)	Zinc (mg)	Mg (mg)	Calcium (mg)	Vitamin - A (µg)	Vitamin – C (mg)
F1	$6.23^{d} \pm 0.14$	$1.51^{f} \pm 0.00$	$25.62^{b} \pm 0.00$	$42.3^{c} \pm 0.00$	$127^{e} \pm 0.03$	$10.95^{d} \pm 0.42$
F2	$7.60^{c} \pm 0.12$	$1.55^{e} \pm 0.00$	$26.44^{a} \pm 0.00$	$52.2^{b} \pm 0.00$	$414^{d} \pm 0.05$	$22.76^{c} \pm 9.39$
F3	$7.51^{c} \pm 0.16$	$2.63^{c} \pm 0.00$	$26.54^{a} \pm 0.00$	$52.40^{b} \pm 0.00$	$490^{c} \pm 0.01$	$24.04^{c} \pm 0.18$
F4	$10.22^{b} \pm 0.19$	$2.66^{b} \pm 0.00$	$26.61^{a} \pm 0.00$	$59.1^{a} \pm 0.00$	$523^{b} \pm 0.06$	$33.95^{b} \pm 1.55$
F5	$11.00^{a} \pm 0.08$	$2.98^{a} \pm 0.00$	$26.72^{a} \pm 0.36$	$52.2^{b} \pm 0.00$	$574^{a} \pm 0.07$	$47.24^{a} \pm 9.64$
F6	$3.97^{e} \pm 0.57$	$1.86^{d} \pm 0.01$	$21.89^{c} \pm 0.59$	$29.9^{d} \pm 0.21$	$0.06^{f} \pm 0.03$	$8.41^{d} \pm 1.17$
CV	3.33	0.19	1.10	1.77	0.94	22.62
RV	11	3	80	500	300-600	15-50

**Means with the same alphabet as superscript within the same columns are not significantly different at a 5% significance level. CV: coefficient of variation RV: Recommended Value (RDA)*

Table 3. Fatty acid contents of complementary foods in mg per 100g (Mean ±SD).

Formulated foods	Omega-6 fatty acid	Omega-3 fatty acid
F1	$0.00^{e} \pm 0.00$	$0.00^{e} \pm 0.00$
F2	$2.89^{d} \pm 0.06$	$0.23^{d} \pm 0.84$
F3	$4.80^{c} \pm 0.06$	$0.45^{c} \pm 0.18$
F4	$6.05^{b} \pm 0.08$	$0.58^{b} \pm 0.85$
F5	$7.92^{a} \pm 0.59$	$0.69^{a} \pm 0.79$
F6	$0.00^{e} \pm 0.00$	$0.00^{e} \pm 0.00$
CV	6.78	1.12
RV	7-8	0.5-0.7

**Means with the same alphabet as superscript within the same columns are not significantly different at a 5% significance level. CV: coefficient of variation RV: Recommended Value*

Vitamin A (ß-carotene) and C Content showed a significant increase as compared to the control (Table 2). Vitamin A content was increased from 1.06 µg/100g in control (F6) to 574 µg/100 gm(F5) on inclusion of each 20% pumpkin pulp and its seed in blends which 12 units of beta carotene is equivalent to 1 unit of vitamin A (WHO/FAO, 2004). The observed increase was higher than the report of Abebe *et al* (2006) and Walle et al (2017*)* in southern Ethiopia, where pumpkin supplementation raised vitamin A content in traditional corn blends by 25-folds and more than 180-folds (53.5µg. RAE (Retinol Activity Equivalents)/100 gm) in *kocho* (Abebe *et al.,* 2006). The observed high difference may be because of dried pumpkin pulp flour with concentrated vitamin A used in the current study. The highest increase seen in the 30%:20%:20% :30% blending ratio (F5) could be explained by the highest amount of pumpkin pulp, its seed, and soybean incorporated. The current complementary food could provide 414 to 574 µg/100 gm of Vitamin A content which falls within the recommended value (Abebe *et al.,* 2006). The highest vitamin A (ß- carotene) content (574.3 µg/100 gm) is obtained in blending formulation (F5) as compared to the control group (0.06%) which fulfilled the recommended value (300-600 µg/100g).

The vitamin C content was increased from 10.95 to 47.24 mg/100g. The observed increase in vitamin C content of the blends may be due to high pumpkin flesh blends and was higher than the report of Abebe *et al.* (2006*)* in southern Ethiopia, where pumpkin supplementation raised vitamin C content in *kocho* (Abebe *et al.,* 2006). The highest increase was seen in 30%:20%:20% :30% blending ratio (F5) could be explained by the highest amount of pumpkin pulp incorporated. The current complementary food could provide 22.76 to 47.24mg/100g (F2-F5) of Vitamin C content which falls within the recommended value (Abebe *et al.,* 2006). The highest vitamin C content (47.24 mg/100g) is obtained in blending formulation (F5) as compared to the control group (8.41%) which fulfilled the recommended value (15-50mg/100g).

Minerals Content showed a significant increase as compared to control (Table 2). The Zinc content was increased from 1.51 to 2.98mg/100g. The highest increase was seen in the 30%:20%:20%:30% blending ratio(F5) could be explained by the highest amount of pumpkin seed incorporated (Abebe *et al.,* 2006). The current complementary food could provide 2.63 to 2.98mg/100g (F3-F5) of zinc content which falls nearly to the recommended value. The highest Zinc content (2.98 mg/100g) is obtained in blending formulation (F5) as compared to the control group (1.86 mg/100g) which fulfilled near the recommended value (3mg/100g). Compared with the control, zinc content was improved nearly by 0.77, 0.8, and 1.12 folds in blends with pumpkin pulp and pumpkin seed respectively at 5%,10%,15%, and 20% ratios. This increase might be attributed to the high zinc content of pumpkin seeds (Abebe *et al.,* 2006). The porridge supplemented with 20% pumpkin pulp and pumpkin seed could provide 3 mg zinc which is the RDA for 6-23 months old children.

The iron content was increased from 6.23 to 11 mg/100g. The highest increase seen in the 30%:20%:20%:30% blending ratio(F5) could be explained by the highest amount of pumpkin seed and soya bean incorporated (Abebe *et al.,* 2006; Tona *et al*., 2015; Osto et al., 2015; Ocheme *et al.*, 2015). The current complementary food could provide 10.22 to 11 mg/100g (F4-F5) of iron content which falls nearly and within the recommended value. The highest iron content (11 mg/100g) is obtained in blending formulation (F5) as compared to the control group (3.97 mg/100g) which fulfilled the recommended value (3mg/100g). As compared to the control, iron content was improved nearly by 3.63,3.54,6.03 and 7.03 folds in blends with pumpkin pulp and pumpkin seed respectively at 5%,10%,15%, and 20% ratios. The porridge supplemented with 20% pumpkin and its seed and 30% soybean could provide acceptable RV for 6-23 months old children.

The Magnesium content was increased from 25.62 to 26.72 mg/100g. The highest increase seen in the 30%:20%:20%:30% blending ratio(F5) could be explained by the highest amount of pumpkin pulp and its seed incorporated (Abebe *et al.,* 2006). The current complementary food could provide 25.62 to 26.72 mg/100g %(F1-F5) of magnesium content which did fall below the recommended value(80mg/100g). The highest Magnesium content (26.72 mg/100g) is obtained in blending formulation (F5) as compared to the control group (21.89 mg/100g) which did not fulfil the recommended value (80mg/100g). As compared to control, magnesium content was improved nearly by 4.55, 4.65,4.72, and 4.83 folds in blends with pumpkin seed respectively at 5%,10%,15%, and 20%

ratios. This increase might be attributed to the high Magnesium content of pumpkin seed and soybean (Abebe *et al.,* 2006; Tona *et al*., 2015; Ocheme *et al.*, 2015). The porridge supplemented with 20% pumpkin and its seed and 30% soybean blend flour could provide a high Magnesium content but could not provide acceptable RV for 6-23 months old children.

The calcium content was increased from 42.3 to 52.2 mg/100g. The highest increase seen in the 30%:20%:20%:30% blending ratio(F5) could be explained by the highest amount of pumpkin seed incorporated (Abebe *et al.,* 2006; Tona *et al*., 2015; Ocheme *et al.*, 2015). The current complementary food could provide 42.3 to 52.2 mg/100g % (F1-F5) of calcium content which did not meet the recommended value (500 mg/100g). The highest Magnesium content (52.2 mg/100g) is obtained in blending formulation (F5) as compared to the control group (29.9 mg/100g) which did not fulfil the recommended value (500 mg/100g). Compared with control, calcium content was improved nearly by 2.23,2.25,2.91and 2.23 folds in blends with pumpkin pulp and its seed respectively at 5%,10%,15%, and 20% ratios. The porridge supplemented with 20% pumpkin pulp and its seed and 30% soybean blend flour could provide a high Calcium content but could not provide acceptable RV for 6-23 months old children.

Fatty acid compositions showed a significant increase in blends as compared to the control (Table 3). Omega-3 (alpha-linolenic acid) and omega-6 fatty acid (linoleic acid) are essential fatty acids that are needed for brain and cognitive development. Their content as compared to control was improved nearly by 2.89,4.8,6.05 and 7.92 and 9.72,14.1, 16.62 and 20.18 respectively folds in blends with pumpkin seed respectively at 5%,10%,15%, and 20% ratios. This increase might be attributed to a high poly unsaturated fatty acid content of pumpkin seed (Abebe *et al.,* 2006; Tona *et al*., 2015; Ocheme et al., 2015). The porridge supplemented with 20% pumpkin seed and 30% soybean could provide acceptable RV for 6-23 months old children. The percentage contribution of micronutrients provided by complementary foods(F1-F6) which met RDA for 6-23 months is shown in Table 4. The contribution of complementary foods (F2 to F5) to the RDA of iron, zinc and vitamin A was greater than 50%. The highest iron, zinc, and vitamin A contribution to RDA was obtained in complementary food (F5) which was 100, 99.33,95.67% respectively.

Table 4. Percentage contribution of micronutrients provided by complementary foods meeting RDA

Nutrients	RDA	Percentage of RDA					
		F1	F2	F3	F4	F5	F6
Fe(mg/day)	11	56.57	69.09	68.27	92.91	100	36.09
Zn(mg/day)	3	50.33	51.67	87.67	88.67	99.33	62
Vitamin-A(µg RE)	600	21.17	69	81.67	87.17	95.67	0.01

**RDA: Recommended dietary allowance*

Results of sensory evaluation indicated that mean scores of the treatment group ranged from 4.67±0.49 to 5.33±1.4, meaning all sensory attributes were liked very much by the sensory panel members though overall acceptability tended to show a change with increasing amounts of pumpkin pulp, its seed, and soybean in blends (Table 5).

Table 5. Sensory Acceptability Test of Complementary Food Porridge

Formulated foods	Colour	Flavour	Taste	Texture	Overall acceptability
F1	$4.93^{ab} \pm 0.88$	$5.40^{a} \pm 0.91$	$5.13^{ab} \pm 0.74$	$4.80^{a} \pm 1.21$	$5.20^{a} \pm 1.26$
F2	$5.20^{a} \pm 1.21$	$4.87^{a} \pm 1.41$	$5.27^{a} \pm 1.33$	$4.87^{a} \pm 1.64$	$5.33^{a} \pm 1.40$
F3	$5.00^{ab} \pm 0.85$	$5.40^{a} \pm 0.99$	$5.20^{a} \pm 1.01$	$4.60^{a} \pm 1.18$	$5.27^{a} \pm 1.28$
F4	$4.87^{ab} \pm 1.36$	$5.00^{a} \pm 1.13$	$4.73^{ab} \pm 1.16$	$4.60^{a} \pm 1.88$	$5.27^{a} \pm 0.96$
F5	$4.53^{ab} \pm 0.92$	$4.87^{a} \pm 1.30$	$5.07^{ab} \pm 0.96$	$4.40^{a} \pm 1.35$	$5.13^{a} \pm 1.30$
F6	$4.40^{b} \pm 0.51$	$4.80^{a} \pm 0.41$	$4.47^{b} \pm 0.64$	$4.60^{a} \pm 0.63$	$4.67^{a} \pm 0.49$
CV	20.54	21.26	20.17	29.58	22.51
LSD	0.72	0.78	0.73	0.99	0.84

**Means with the same alphabet as superscript within the same columns are not significantly different at a 5% significance level. CV: coefficient of variation LSD: Least significant difference*

Sensory quality is a more important feature of complementary foods than quantity as it influences the intake in children (Lutter *et al*., 2003). In the current study, none of the complementary food porridge preparations was disliked by the sensory panel members. Almost all of the sensory attributes were liked very much by mothers. However, the mothers' liking of colour and texture tended to decrease with increasing amounts of pumpkin pulp and its seed. This and the young children's less preference for porridge with the highest pumpkin pulp and its seed substitute could be due to the unusual colour of porridge resulting from the blending. The findings of the study on pumpkin pulp-supplemented *kocho* and maize-based complementary porridge in Southern Ethiopia support the current result (Abebe *et al*., 2006; Tona *et al*., 2015). This result is consistent also with the finding of scholars from India who noted that sensory characteristics of pumpkin seed flour incorporated bakery products (bread, bun, biscuits, and cake) were highly acceptable (Tona *et al*., 2015)

4. CONCLUSIONS

This study demonstrated that blending germinated maize with pumpkin pulp, pumpkin seed, and Soybean flour at a ratio of 30%:20%:20%:30% respectively can improve iron, zinc, vitamin A (beta carotene), and essential fatty acids contents without compromising the sensory property of complementary foods. This blending proportion contributed 100% iron, 99.33% zinc, and 95.66% vitamin A (ß- carotene) of the recommended daily allowance (RDA). Thus, this can be further demonstrated for wider application to areas where these nutrients are deficient in children's diets. Additional research should be done on the functional properties, microbiological analysis of supplemental foods, and bioavailability of micronutrients.

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Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors upon reasonable request.

Conflict of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Abebe, Y., Stoecker, B. J., Hinds, M. J., & Gates, G. E. (2006). Nutritive value and sensory acceptability of corn-and kocho-based foods supplemented with legumes for infant feeding in Southern Ethiopia. *African Journal of Food, Agriculture, Nutrition and Development*, *6*(1), 1-19.

Agbemafle, I., Hadzi, D., Amagloh, F. K., Zotor, F. B., & Reddy, M. B. (2020). Nutritional, microbial, and sensory evaluation of complementary foods made from blends of orange-fleshed sweet potato and edible insects. *Foods*, *9*(9), 1225.

Amuna, P., Zotor, F., Sumar, S., & Tswelelo Chinyanga, Y. (2000). The role of traditional cereal/legume/fruit-based multimixes in weaning in developing countries. Nutrition & Food Science, 30(3), 116-122.

AOAC (2000). Official Methods of Analysis, 18th Edition, Washington DC.

Balasubramanian, S., Kaur, J., & Singh, D. (2014). Optimization of weaning mix based on malted and extruded pearl millet and barley. *Journal of Food Science and Technology*, *51*(4), 682-690.

Berteram, J. S., & Bortkiewicz, H. (1995). Dietary carotenoid inhibit neoplastic transformation and modulate gene expression in mouse and human cell. Am. J. Clin. Nutr, 62, 132S-136S.

Black, R. E., Allen, L. H., Bhutta, Z. A., Caulfield, L. E., De Onis, M., Ezzati, M., ... & Rivera, J. (2008). Maternal and child undernutrition: global and regional exposures and health consequences. The lancet, 371(9608), 243-260.

Brown, K., Dewey, K., & Allen, L. (2012). Complementary feeding of young children in developing countries: a review of current scientific knowledge. Complementary feeding of young children in developing countries: a review of current scientific knowledge, 228-228.

Codex Alimentarius Commission. (1991). Guidelines for formulated supplementary foods for older infants and young children. Rome, Italy: Codex Alimentarius Commission.

Central Statistical Authority (CSA). (2019). Ethiopia Demographic and Health Survey (EDHS). Addis Ababa, Ethiopia and ICF International Calverton, Maryland, USA.

Delia, R. B., & Kimura, M. (2004). HarvestPlus handbook for carotenoid analysis (Vol. 2, p. 63). Washington, DC: International Food Policy Research Institute (IFPRI).

Demissie, T., Ali, A., & Zerfu, D. (2009). Availability and consumption of fruits and vegetables in nine regions of Ethiopia with special emphasis to vitamin A deficiency. *Ethiopian Journal of health development*, *23*(3).

Demographic, N. (2012). Health survey 2011. Central Statistical Agency Addis Ababa. Ethiopia ICF International Calverton, Maryland, USA, 2016(1).

Dhiman, A. K., Sharma, K. D., & Attri, S. (2009). Functional constituents and processing of pumpkin: A review. Journal of Food Science and Technology, 46(5), 411.

Emmanuel, O. B. (2019). Development and Quality Evaluation of Complementary Food Formulated from Sorghum, Soybean and Sesame Flour Blends. Journal of Nutrients, 5(1), 1-10.

Faso, B. (2011). Nutritional properties of enriched local complementary flours. Advance Journal of Food Science and Technology, 3(1), 31-39.

Haddad, L. J., Hawkes, C., Achadi, E., Ahuja, A., Ag Bendech, M., Bhatia, K., ... & Flores-Ayala, R. (2015). Global Nutrition Report 2015: Actions and accountability to advance nutrition and sustainable development. Intl Food Policy Res Inst.

Haidar, J. (2011). Common micronutrient deficiencies among food aid beneficiaries: evidence from refugees in Ethiopia. Ethiopian Journal of Health Development, 25(3), 222-229.

Hailegebriel, S., Gilano, G., Seboka, B. T., Ahmed, M. H., Simegn, A. E., Tesfa, G. A., & Yehualashet, D. E. (2021). Prevalence and associated factors of caesarean section in Ethiopia: a multilevel analysis of the 2019 Ethiopia Mini Demographic Health Survey. BMC Pregnancy and Childbirth, 21, 1-9.

Hamed, S. Y., El Hassan, N. M., Hassan, A. B., Eltayeb, M. M., & Babiker, E. E. (2008). Nutritional evaluation and physicochemical properties of processed pumpkin (Telfairia occidentalis Hook) seed flour. Pakistan Journal of Nutrition, 7(2), 330-334.

Hashim, N., & Pongjata, J. (2000). Vitamin A activity of rice-based weaning foods enriched with germinated cowpea flour, banana, pumpkin and milk powder. Malaysian Journal of Nutrition, 6(1), 65-73.

Huffman, S. L., & Martin, L. H. (1994). First feedings: optimal feeding of infants and toddlers. Nutrition research, 14(1), 127-159.

Inyang, C. U., & Zakari, U. M. (2008). Effect of germination and fermentation of pearl millet on proximate, chemical and sensory properties of instant "Fura"-a Nigerian cereal food. Pakistan journal of Nutrition, 7(1), 9-12.

Jideani, V. A. (2011). Functional properties of soybean food ingredients in food systems. Soybean-Biochemistry, chemistry and physiology, 345-366.

Kassaw, M. W., Abebe, A. M., Kassie, A. M., Abate, B. B., & Masresha, S. A. (2021). Trends of proximate low birth weight and associations among children under-five years of age: Evidence from the 2016 Ethiopian demographic and health survey data. PloS one, 16(2), e0246587.

Krut, A. S., Ivanko, O. G., Kizima, N. V., Paschenko, I. V., Pidkova, V. Y., & Radutna, O. A. (2013). The feeding of infants and children.

Lutter, C. K., & Rivera, J. A. (2003). Nutritional status of infants and young children and characteristics of their diets. The Journal of nutrition, 133(9), 2941S-2949S.

Michaelsen, K. F. (2000). Feeding and nutrition of infants and young children: guidelines for the WHO European region, with emphasis on the former Soviet countries (No. 87). WHO Regional Office Europe.

Neumann, C., Harris, D. M., & Rogers, L. M. (2002). Contribution of animal source foods in improving diet quality and function in children in the developing world. Nutrition research, 22(1-2), 193-220.

Ocheme, O. B., Adedeji, O. E., Lawal, G., & Zakari, U. M. (2015). Effect of germination on functional properties and degree of starch gelatinization of sorghum flour. Journal of Food Research, 4(2), 159.

Oko, A. O., & Ugwu, S. I. (2011). The proximate and mineral compositions of five major rice varieties in Abakaliki, South-Eastern Nigeria. International Journal of Plant Physiology and Biochemistry, 3(2), 25-27.

Onabanjo, O. O., Akinyemi, C. O., & Agbon, C. A. (2009). Characteristics of complementary foods produced from sorghum, sesame, carrot and crayfish. Journal of Natural Sciences Engineering and Technology, 8(1).

Onwurafor, E. U., Umego, E. C., Uzodinma, E. O., & Samuel, E. D. (2017). Chemical, functional, pasting and sensory properties of sorghum-maize-mungbean malt complementary food. Pakistan Journal of Nutrition, 16(11), 826-834.

Osto, E., Doytcheva, P., Corteville, C., Bueter, M., Dörig, C., Stivala, S., ... & Lüscher, T. F. (2015). Rapid and body weight–independent improvement of endothelial and high-density lipoprotein function after Roux-en-Y gastric bypass: Role of glucagon-like peptide-1. Circulation, 131(10), 871-881.

Pongjanta, J., Naulbunrang, A., Kawngdang, S., Manon, T., & Thepjaikat, T. (2006). Utilisation of pumpkin powder in bakery products. Songklanakarin Journal of Science and Technology, 28(1), 71-79.

Rasaki, S. A., Thomas, T., & Yang, M. (2020). Iron based chalcogenide and pnictide superconductors: from discovery to chemical ways forward. Progress in Solid State Chemistry, 59, 100282.

Salgueiro, M. J., Zubillaga, M. B., Lysionek, A. E., Caro, R. A., Weill, R., & Boccio, J. R. (2002). The role of zinc in the growth and development of children. Nutrition, 18(6), 510-519.

Shanshan, N. M., & Bushuty, D. H. E. Research Journal Specific Education.

Sommer, A., & West, K. P. (1996). Vitamin A deficiency: health, survival, and vision. Oxford University Press.

Tizazu, S., Urga, K., Abuye, C., & Retta, N. (2010). Improvement of energy and nutrient density of sorghum based complementary foods using germination. African Journal of Food, Agriculture, Nutrition and Development, 10(8).

Tomohiro, T., Uoto, K., & Okuno, H. Y. (1990). Electrochemical reduction of carbon dioxide catalysed by macrocyclic Fe 4 S 4 iron–sulphur clusters. Journal of the Chemical Society, Chemical Communications, (2), 194-195.

Tona Zema, T. Z., Tafese Bosha, T. B., & Tefera Belachew, T. B. (2015). Blending germinated maize, pumpkin pulp and its seed improves zinc and vitamin A without compromising nutritive value and sensory attributes of local complementary food porridge.

Tona Zema, T. Z., Tafese Bosha, T. B., & Tefera Belachew, T. B. (2015). A baseline survey on household cultivation and dietary consumption of vitamin A and zinc rich foods by 6-23 months of old children in Sodo Zuria Woreda of Wolayta Zone, Southern Ethiopia.

Unuabonah, E. I., Adebowale, K. O., & Olu-Owolabi, B. I. (2007). Kinetic and thermodynamic studies of the adsorption of lead (II) ions onto phosphate-modified kaolinite clay. Journal of hazardous materials, 144(1-2), 386-395.

USAID, G. (2009). Investing in the Future: A United Call to Action on Vitamin & Mineral Deficiencies. USAID, GAIN, WORLD BANK, Micronutrient Initiative, UNICEF & Financial Support-Govt of Canada.

Walle, H., & Moges, D. (2017). Optimization of cereal-legume blend ratio to enhance the nutritional quality and functional property of complementary food. Ethiopian Journal of Science and Technology, 10(2), 109-122.

WHO/FAO, Vitamin and Mineral Requirements in Human Nutrition, vol. 2, National Academy Press, Washington, DC, 2004.

World Health Organization. (2018). Reducing stunting in children: equity considerations for achieving the Global Nutrition Targets 2025.

World Health Organization. (2019). Meeting report: WHO technical consultation: nutrition-related health products and the World Health Organization model list of essential medicines–practical considerations and feasibility: Geneva, Switzerland, 20–21 September 2018 (No. WHO/NMH/NHD/19.1). World health organisation.