Food and Public Health 2015, 5(4): 103-107
DOI: 10.5923/j.fph.20150504.01

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

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Abstract Zinc and Vitamin A deficiencies are two of 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 and vitamin A contents of local complementary food porridge without reducing its nutritive value and compromising sensory property. Porridge samples were prepared from composite flours of 48hrs germinated maize, pumpkin pulp and its seed with ratio of 80%:10%:10%, 60%:20%:20% and 40%:30%:30% respectively. Control sample was prepared from 100% ungerminated maize. Zinc and vitamin A contents, proximate compositions and sensory analysis were conducted following standard procedures. SPSS version 20.0 was used for data analysis. Blending significantly increased zinc and vitamin A contents, energy, protein, fat and fiber from 1.86 to 8.23 mg, 0.08 to 199.03 µg, 344.72 to 400.79 Kcal, 11.1 to 14.80 gm, 1.71 to 10.2 gm and 2.20 to 2.96 gm respectively in control and treatment group with blending ratio of 40%:30%:30%. Complementary food porridge prepared from composite flours showed acceptable sensory property. In conclusion, blending 48hrs germinated maize, pumpkin pulp and its seed improved zinc and vitamin A contents without reducing nutritive value and compromising sensory quality of the local complementary food porridge.

Keywords Blending, Germinated maize, Pumpkin pulp and its seed, Complementary food, Zinc, Vitamin A

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 [1].

Vitamin A and zinc deficiencies are two of common nutritional problems in children of developing countries. About 36.2% of children below two years of age had subclinical vitamin A deficiency (VAD) in Ethiopia [2]. About 37.6% of under five children had serum retinol concentration < 0.7µmol/L [3].

VAD compromises immune systems and causes premature death to about one million young children each year in developing world [4]. VAD in children may impair vision, causes xerophthalmia leading to blindness [5], weaken immune function and increase severity of infectious diseases like measles and diarrhoea leading to child mortality [6]. In 2011, about 35.6% children in Africa were stunted leading to 116,000 child deaths attributable to zinc deficiency alone [7]. These micronutrients have especial benefits due to their impact on physical and cognitive development of children [8].

Zinc deficiency may lead to poor growth in childhood, reduced immunocompetence and increased morbidity from infectious diseases such as diarrhoea, pneumonia and elevate childhood mortality rates in developing countries [9].

Chronic low intake of zinc and vitamin A rich foods is primary cause for their deficiencies. Food-based approach is the best way for combating malnutrition of vitamin A, zinc and others among infants and young children in developing world [10]. Incorporating high ß-carotene foods like pumpkin is cost effective food-based approach to improve vitamin A intake of young children and tackle vitamin A

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Published online at http://journal.sapub.org/fph

related health problems [11, 12]. It was also noted that pumpkin seed flour supplemented complementary mix is an economical nutritious food with highly acceptable sensory property [13].

Therefore, this study was conducted to evaluate the effect of blending 48hrs germinated maize, pumpkin pulp and its seed on zinc and vitamin A contents, proximate compositions and sensory property of a local complementary food porridge.

2. Materials and Methods

2.1. Sample Preparation

Maize (*Zea mays L.*) and pumpkin (*Cucurbita pepo*) were procured from Sodo Zuria woreda of Wolayta zone, Southern Ethiopia. Maize was sorted and cleaned. Then, it was soaked for 24hrs, rinsed with clean tape water, germinated for 48hrs and sun dried. Pumpkin pulp and seed were manually separated. The pulp was chopped into pieces of 2cm diameter [14] and shed dried to prevent lose of beta-carotene. After a manual removal of the hull, pumpkin seed was sun dried. Treatment and control samples were separately milled in to flour passing 1mm diameter sieve using laboratory mill (Thomas Wiley Mill Model 4, USA). The flours were packed in polyethylene bag and stored in laboratory at room temperature.

2.2. Porridge Preparation and Sensory Evaluation

Thirty mothers of 6-23 months old children were randomly selected for sensory evaluation in three kebeles of Sodo Zuria woreda. The flours were blended with ratios of 80%:10%:10%, 60%:20%:20% and 40%:30%:30% respectively germinated maize, pumpkin pulp and its seed. The control was 100% ungerminated maize (Table 2.1).

Table 2.1. Blending experiment

Samples	Blending ratios			
	NGM flour	GM flour	Pumpkin pulp flour	Pumpkin seed flour
Control	100%	-	-	-
80:10:10	-	80%	10%	10%
60:20:20	-	60%	20%	20%
40:30:30	-	40%	30%	30%

NGM = non-germinated maize flour (control), GM = germinated maize flour

Complementary food porridge samples were prepared with the assistance of mothers [14], one from each kebele. 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. Then, control and composite flours were added. The porridge samples were continuously stirred on fire till ready (for 10 minutes). Ready porridges were transferred to identical aluminum plates coded with three digit random numbers. Taste, colour, flavor, mouth fullness, appearance and overall acceptance of porridge samples were evaluated by mothers using a 5-point hedonic scale where 5 = like very much, 4 = like, 3 = neither like nor dislike, 2 = dislike and 1 = dislike very much. The samples were served in duplicate [15]. Mothers also fed the porridge samples to their children and the children's facial expressions were evaluated.

2.3. Chemical Analysis

Chemical analysis was conducted at laboratories of Ethiopian Public Health Institute (EPHI), Addis Ababa. Proximate compositions were analysed using methods of AOAC [16] as follows. Moisture content was determined by drying the samples for 3hrs at 105°C with drying oven (Memmert, Germany). Crude protein content was analysed by 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 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 sulfuric acid and 28% boiling potassium hydroxide. Total ash was determined by ashing the samples at 550°C using muffle furnace. Total carbohydrate content was determined by difference (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 the Atwater's conversion factors considering protein and carbohydrate each gives 4kcal and fat yields 9 kcal per 100gram. Zinc content was determined following method of AOAC [17]. The ashed samples were dissolved in 5.0ml 6N HCl and diluted to 50ml with deionized water. Zinc concentration of an aliquot was determined using an atomic absorption spectrophotometer. ß-carotene was analysed with an open column chromatography spectrophotometer [18].

2.4. Data Analysis

SPSS version 20.0 was used for data analysis. Means and standard deviations were computed. One-way analysis of variance was conducted to test the significance mean differences between treatment and control groups. Tukey test was employed to determine significant mean differences. P-value < 0.05 was taken as a cut-off point for statistical significance test. Results were displayed using tables.

2.5. Ethical Consideration

Ethical clearance was obtained from Ethical Review Board of Hawassa University (HwU). Informed consent was obtained from sensory panel members before tasting complementary food porridge samples.

3. Results

Result of sensory evaluation indicated that mean scores of treatment group ranged from 4.32±0.77 to 4.72±0.4, meaning all sensory attributes were liked very much by the sensory panel members though appearance was tending to show a change with increasing amount of pumpkin pulp and its seed in blends (Table 3.1). Young children also less preferred the porridge with the highest pumpkin pulp and its seed substitute.

Proximate compositions showed a significant increase in blends, except for carbohydrate (Table 3.2). With increase in amount of pumpkin pulp and its seed flours in blends, zinc and vitamin A contents increased highly significantly from 1.86 to 8.23 mg 0.08 to 199.03 µg respectively (Table 3.3).

Table 3.1. Sensory Acceptability Test of Complementary Food Porridge

GM:P:PS	Sensory attributes					
	Colour	**Taste**	**Flavour**	**Appearance**	**Mouth fullness**	**Overall acceptability**
Control	4.52±0.52^{a}	4.70±0.46^{a}	4.63±0.49^{a}	4.87±0.34^{a}	4.70±0.46^{a}	4.62± 0.56^{a}
80:10:10	4.50±0.73^{a}	4.43±0.62^{a}	4.42±0.60^{a}	4.72±0.45^{a}	4.62±0.56^{a}	4.58± 0.64^{a}
60:20:20	4.52±0.62^{a}	4.58±0.65^{a}	4.55±0.57^{a}	4.45±0.65^{b}	4.68±0.47^{a}	4.53±0.57^{a}
40:30:30	4.32±0.77^{a}	4.65±0.52^{a}	4.67±0.54^{a}	4.45±0.70^{b}	4.63±0.55^{a}	4.70±0.46^{a}
p-value	*0.28*	*0.06*	*0.61*	*<0.001*	*0.78*	*0.44*

Values are averages of duplicate measurements (mean ± standard deviation). Control = 100% ungerminated maize, GM = germinated maize, P = pumpkin pulp, PS = pumpkin seed. Means with the same superscripts in a column are not significantly different at p<0.05

Table 3.2. Proximate Composition and Gross Energy Content of Local Complementary Food Porridge

Nutrients	Blending ratio (GM:P:PS)				P-value
	Control	**80:10:10**	**60:20:20**	**40:30:30**	
Moisture	11.01±0.01^{a}	12.01±0.05^{b}	12.16±0.78^{b}	12.27±0.06^{c}	<0.001
Protein	11.10±0.09^{a}	12.20±0.13^{b}	13.21±0.16^{c}	14.80±0.27^{d}	<0.001
Fat	1.71±0.01^{a}	4.63±0.01^{b}	7.53±0.42^{c}	10.20±0.13^{d}	<0.001
Ash	1.67±0.13^{a}	2.68±0.02^{b}	3.10±0.01^{c}	3.50±0.85^{d}	<0.001
Fiber	2.20±0.01^{a}	2.46±0.01^{b}	2.49±0.08^{b}	2.96±0.78^{c}	0.001
CHO	72.32±0.21^{a}	67.96±0.19^{b}	65.93±0.01^{c}	62.28±0.18^{d}	<0.001
Energy (Kcal)	344.72±0.41^{a}	362.29±0.42^{b}	384.31±0.27^{b}	400.79±1.58^{c}	0.003

Values are averages of duplicate measurements (mean ± standard deviation). GM = germinated maize, P = pumpkin pulp, PS = pumpkin seed, control = 100% ungerminated maize, CHO = carbohydrate. Means followed by the same superscripts in a row are not significantly different at p <0.05

Table 3.3. Zinc and vitamin A contents of complementary food porridge

Nutrients	Blending ratio (GM:P:PS)				P-value
	Control	**80:10:10**	**60:20:20**	**40:30:30**	
Zinc (mg/100 g)	1.86±0.05^{a}	4.05±0.08^{b}	6.37±0.01^{c}	8.23±0.08^{d}	<0.001
Vitamin A (µg/100 g)	0.08±0.01^{a}	114.26±0.25^{b}	159.74±0.81^{c}	199.03±0.08^{d}	<0.001

Values are averages of duplicate measurements (mean ± standard deviation). Control = 100% ungerminated maize, vitamin A (µg RE) = µg.β.carotene/6 [19], GM = germinated maize, P = pumpkin pulp, PS = pumpkin seed. Means followed with the same superscripts in a row are not significantly different at p <0.05

4. Discussions

Sensory quality is more important feature of complementary foods than quantity as it influences the intake in children [20]. 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 appearance was tending to decrease on increasing amount of pumpkin pulp and its seed. This and the young children's less preference of porridge with the highest pumpkin pulp and its seed substitute could be due to the unusual colour of porridge resulted from the supplements. Findings of the study on pumpkin pulp supplemented *kocho* and maize-based complementary porridge in Southern Ethiopia supports the current result [14]. 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 [21].

Blending 48hrs germinated maize with pumpkin pulp and its seed resulted in a significant decrease in carbohydrate content. Similar reduction was observed by Tizazu *et al.* on sorghum-based complementary food preparation using germination [22] and Inyang & Zakari on instant "Fura" from germinated sorghum [23]. The decrease in carbohydrate content may be due to germination of maize for 48hrs which increased alpha-amylase activity that breaks down the carbohydrate in to simpler and more absorbable sugars that are utilized by emerging shoot during the early stages of germination [22, 23]. In spite of the decrease in carbohydrate level, the blend containing 40%:30:30% 48hrs germinated maize, pumpkin pulp and its seed respectively found to provide more than 70% and 50% of recommended dietary allowance (RDA) for 6-12 months and 12-23 months old children correspondingly.

Energy content significantly increased on blending, with a remarkable increase in 40%:30%:30% blending. The increase in energy value could be due to increase in fat content which may be resulted from the inclusion of pumpkin seed which is known for its high oil content [24]. It was recommended that 200 KCal, 300 KCal and 550 KCal of energy should come from complementary foods respectively for 6-8, 9-11 and 12-23 months old children. The current experimental complementary food could be provided more than the recommended vale even with least pumpkin pulp and its seed supplemented recipe for 6-12 months old children [25].

The observed increase in crude protein content is supported by the reports of Tizazu *et al.* [22] and Inyang & Zakari [23]. The increase in crude protein content might be due to the net synthesis of amino acids by germinating seeds [22, 23]. The highest increase seen in 40%:30%:30 blending ratio could be explained by the highest amount of pumpkin pulp and its seed incorporated [24, 27]. The current experimental complementary food could provide 12.25% to 14.77% of the total energy from protein which falls within the recommended range [28].

Crude fat content increased in the current study which is different from the result obtained on instant "Fura" preparation from 48hrs germinated sorghum [23] and sorghum-based complementary food preparation using germination [22]. The decrease in crude fat content 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 [22, 23]. Therefore, the observed increase in crude fat content in the current study may be due to the pumpkin seed included which has high oil content [24]. The experimental complementary foods developed in the current study could provide 11.5-22.9% of energy from fat alone which could be improved through addition of butter and meet the recommended 30-45% [26]. The fiber content of current food product was also acceptable [29].

The observed increase in ash content of the blends may be due to a high mineral content in pumpkin seed [24]. A nearly similar value (1.65 to 2.90g) was reported by Pongjanta *et al.* from Thailand on increasing pumpkin flour from 10% to 20% in bakery products [27].

Vitamin A content was increased from 0.08µg/100g in control to 199.03 µg/100 gm on inclusion of each 30% pumpkin pulp and its seed in blends. The observed increase was higher than the report of Abebe *et al.* in southern Ethiopia, where pumpkin supplementation raised vitamin A content in traditional corn blend by 25-folds and more than 180-folds (53.5µg. RAE (Retinol Activity Equivalents)/100 gm) in *kocho* [14]. The observed high difference may be because shed dried pumpkin pulp flour with concentrated vitamin A used in the current study. Blending 48hrs germinated maize with pumpkin and its seed at 40%:30%: 30% ratio respectively could provide 39.81% of RDA of vitamin A for 6-12 months and 66.67% for 1-3 years old children per 100g serving.

Compared with control, zinc content was improved nearly by 2.2, 3.4 and 4.4 folds in blends with pumpkin and its seed respectively at 10%, 20% and 30% ratios. This increase might be attributed to a high zinc content of pumpkin seed [14]. The porridge supplemented with 20% pumpkin and its seed could provide 3mg zinc which is the RDA for 6-23 months old children.

5. Conclusions

This study demonstrated that blending 48hrs germinated maize with pumpkin pulp and its seed improve zinc and vitamin A contents without reducing nutritive value and compromising sensory property of local complementary food porridge.

ACKNOWLEDGEMENTS

The authors gratefully thank USAID and ENGINE project/Save the Children-Ethiopia for funding this research. Our thanks also go to EPHI for chemical analysis and HwU for organizational and financial support. We are also thankful to our sensory panel members and lab technicians.

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