ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 15 No. 4
September 2015
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

FORMULATION OF COMPLEMENTARY FOOD USING AMARANTH, CHICKPEA AND MAIZE IMPROVES IRON, CALCIUM AND ZINC CONTENT

Zebdewos A[1], Singh P[2], Birhanu G[3],
Whiting SJ[4] * Henry CJ[5] and A Kebebu[6]

Alemselam Zebdewos

*Corresponding Author: E-mail: susan.whiting@usask.ca

[1]MSc lecturer, Anesthesia Department, Hawassa Health Science College, Hawassa Ethiopia

[2] PHD Assistant Professor School of Food Science and Nutrition Hawassa University Awassa Ethiopia

[3]MSC Hawassa University School of Nutrition, Food Science and Technology, Hawassa Ethiopia

[4]PhD Professor, College of Pharmacy and Nutrition, University of Saskatchewan, Saskatoon SK, S7N 5C9 Canada

[5]PhD Associate Professor, College of Pharmacy and Nutrition, University of Saskatchewan, Saskatoon SK, S7N 5C9 Canada

[6] MSc Research Assistant, College of Agriculture, Hawassa University, Awassa Ethiopia

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 15 No. 4 September 2015
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

ABSTRACT

Malnutrition is the cause of the majority of deaths in children under five years old in Ethiopia. Micronutrient deficiencies such as iron, zinc and calcium, often seen in malnourished children, are major public health problems throughout Ethiopia. These deficiencies have negative consequences on the cognitive and physical development of children, and on work productivity of adults. There is, therefore, a need for sustainable methods to address iron inadequacy in complementary feeding. Animal products are a good source of iron, zinc and calcium, but due to their high costs, their consumption by most children in Ethiopia has declined. The grain amaranth grows wild in areas of Ethiopia but is considered a weed. This study, conducted in rural Ethiopia, was initiated to prepare nutrient-rich complementary food using recipes that substituted the usual maize gruel with porridge made from amaranth and chickpea flours. Using a laboratory based experimental study design, four porridges suitable for complementary feeding, with different proportions of amaranth grains, maize and chickpeas were formulated in triplicate and analyzed in triplicate for minerals including iron, and phytate levels. Mother-child pairs were recruited for acceptability testing, at the community level. Results showed adding amaranth improved the content of iron and other nutrients as compared to control porridge (100% maize) and decreased phytate levels. The lowest phytate to iron ratio (0.24) was observed in the 70% amaranth and 30% chickpea blend, and the lowest viscosity measure was also observed in this same formulation. Soaking amaranth seeds in warm (50^{o}C) water then germinating in lemon juice-containing water at 32^{o}C for 72 hours resulted in the lowest phytate levels. In sensory testing, all of the formulated porridges with different proportions of amaranth flour were acceptable to mothers and their children, although the red color was disliked by mothers and their children. Flavor preference was not altered; however, overall acceptability was reduced with increasing amounts of amaranth. The study indicated that a processed 70% amaranth and 30% chickpea product can be used to produce low-cost, nutrient-rich complementary food with moderate acceptability. Increased nutritional awareness, production and consumption of grain amaranth products may be the way to address mineral deficiencies including iron, in the study area.

Key words: Micronutrients, Phytates, Complementary feeding, Amaranth grain, Chickpea, Ethiopia, Iron, Zinc.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 15 No. 4 September 2015 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

INTRODUCTION

Malnutrition is the cause of the majority of deaths among children under five years in Ethiopia [1]. Ethiopia has one of the highest rates of stunting and wasting in the world. The 2011 Ethiopian Demographic Health Survey [2] reported that 44% of Ethiopian children under five years of age were stunted, which is an indication of chronic malnutrition. Micronutrient deficiency is a major contributor to childhood morbidity and mortality in Ethiopia. Iron, Iodine, vitamin A, and zinc are recognized as problem nutrients for the children because of the challenge of obtaining adequate intake from complementary foods to meet dietary requirements [2]. Iron is one of the essential micronutrients required for children aged 6-24 months due to high metabolic demand and low content of iron levels in breast milk [3].

The prevalence of anaemia in children aged 6-59 months is 44 %, and iron deficiency is the cause of half of all of these anemia cases in Ethiopia [2]. It is a serious problem causing significant morbidity and mortality in children under five and more in children less than two years. Iron deficiency anemia (IDA) can result in deficits in cognitive, behavioural and motor development, and educational achievement [4]. The typical Ethiopian complementary food is composed of starchy cereals (maize, sorghum, *teff*), tubers and/or root crops (*enset*, potatoes, sweet potatoes). These are sources of non-heme iron which is affected by phytate. Sources of heme iron and of the meat-fish-poultry factor that improves iron absorption are from meat only. Despite a large livestock population, the food supply of animal source products is very limited, as evidenced by low consumption of these products in rural areas of Ethiopia [1].

Studies conducted in Kenya [5, 6] show that amaranth grain has a good level of iron and other nutrients and may, therefore, be a choice to use for complementary food formulation at the household level to address widespread micronutrient deficiencies. Even though this prospective crop species is widely found growing in Ethiopia, it is not used as a food and food complement; rather it is considered as a weed. On the other hand, maize and sometimes chickpea are used for feeding children in the study area.

This research therefore initiated an examination of the potential use of amaranth grain in complementary foods to address the low micronutrient intake of children in a rural area of Ethiopia. The purpose was to formulate an acceptable and nutritious complementary food (porridge) using local ingredients, and modifying the 100% maize porridge that was currently in use in the study area.

METHODS

Flour Processing and Preparation

Maize and chickpea grains were purchased from local markets and then all debris was removed. The cleaned maize and chickpea was divided into two groups in each category and one group was labelled as unprocessed and the second group as processed. The second group was washed with tap water and soaked at room temperature for 24 hours in ample tap water. The water was removed after 24 hours of soaking and the seeds washed with tap water three times, and then dried by exposing them to the sun. Chickpeas were dehulled.

Then maize and chickpeas each were roasted until the grains darkened. Then both processed and unprocessed grains were milled separately, packed in plastic bags and stored until utilization for porridge preparation.

Amaranth grain flour preparation

The amaranth cultivar used was *Amaranths caudatus* which is widely grown in the Southern Nations, Nationalities Peoples' Republic (SNNPR) State, in the region of Hawassa Tulla. As shown in Figure 1, amaranth grain was collected from Tulla then sorted, steeped and germinated under different media, temperature and time. Amaranth grain was collected from the study area. It was sorted then washed (soaked) for 24 h in warm water (50°C). Then various different soakings were used: plain water at room temperature, lemon juice added to water (5 mL per 100 mL), or added salt (5 g per 100 mL). This additional soaking proceeded for either 24 or 48 hours. The water was removed and seeds were placed in a dark place at room temperature (~23°C) for 0, 3 or 6 days for germination. The grains were spread on a tray and dried in the sun. The dried seeds were first roasted until the desired colour was achieved (up to 10 minutes), then milled with an electrical mill. The flour was packed in sealed plastic bags and stored at temperatures below 15°C for further analysis [7]. For making porridges, the methods of amaranth preparation involved soaking in lemon juice-containing water and germinating for 24 h and germinating for 3 days.

The flour blend formulation

The flour blends from prepared flours were formulated for the preparation of porridge. The chickpea amount was limited to 30% as it was not normally included in complementary food. Maize and amaranth ratio varied in order to assess the combination which had the highest nutritive value in terms of iron and other micronutrients (zinc and calcium) and lowest phytate level. Four different blends were prepared for comparison. The sample from maize was used as control (100% maize). The remaining four samples with different proportion of maize and amaranth were used to compare with the control sample and with each other. The flours were blended in the ratios indicated in Table 1 [8]. Chickpea was added to provide complementary amino acids for the cereal (maize and/or amaranth). Maize was replaced gradually by amaranth grain.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 15 No. 4
September 2015
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

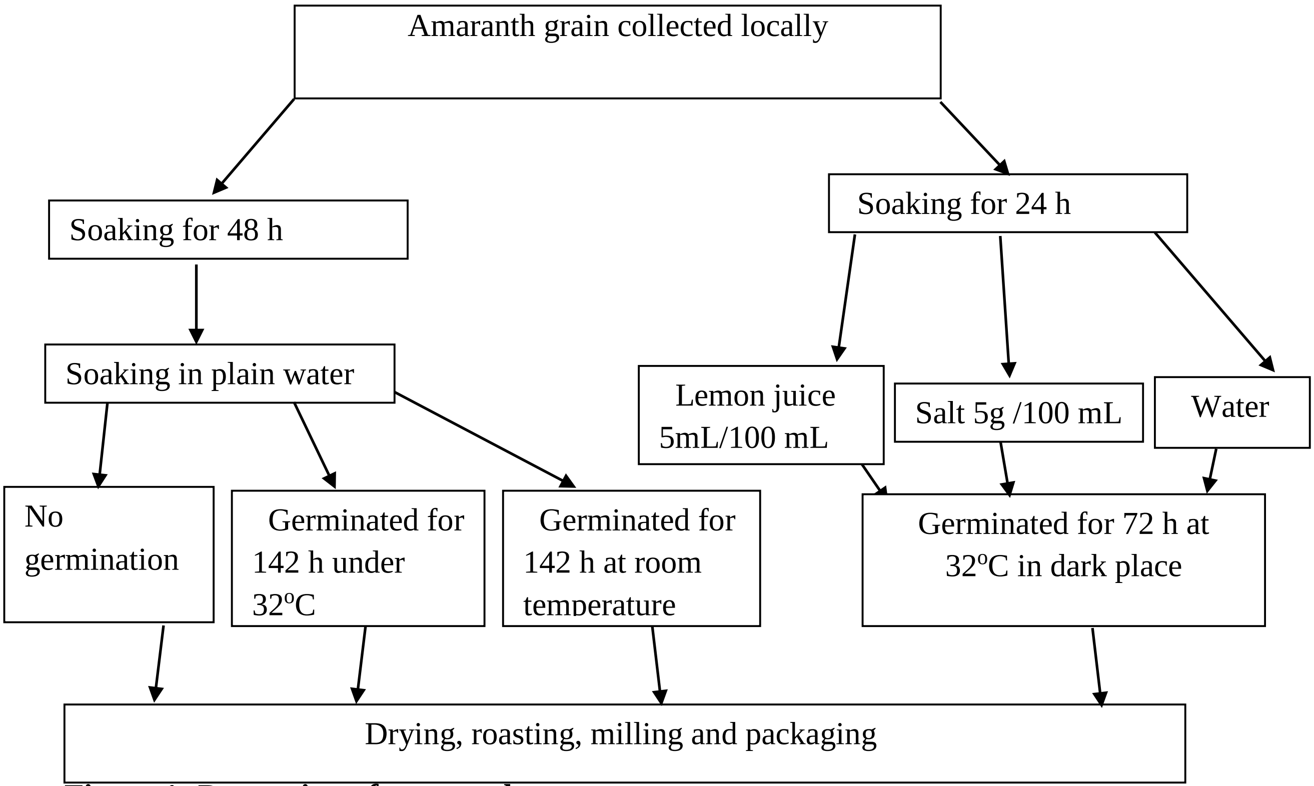

Figure 1: Processing of amaranth

Porridge preparation

All samples were prepared with similar proportion of water to flour ratio of 6:1, and all samples were made in triplicate. Before adding to boiled water, the flour was mixed properly until it became uniform as viewed with the naked eye. The blended flour was added to boiled water and cooked for 10 minutes by stirring occasionally. It was then removed from the stove and allowed to cool to 30^{o}C to make ready-to-serve porridge. Hygienic practices such as washing hands and utensils with soap and tap water were observed throughout preparation, from the selection of grains from the market, until porridges were prepared and served to children.

Nutrient analysis of formulated porridges

Analysis of each unprocessed as well as processed food constituents and fresh food samples was done using standard AOAC methods [9]: moisture content (AOAC 925.09, 2000); ash content (AOAC 923.03, 2000); crude fiber content (AOAC 962.09, 2000); crude fat content: (AOAC 4.5.01, 2000); and crude protein (AOAC 979.09, 2000). Carbohydrate content (grams) was determined by difference. Metabolizable energy was determined by calculation from fat, carbohydrate and protein content using the Atwater's conversion factors [10]. Iron and zinc contents were determined using atomic absorption spectrophotometer [10]. Phytate was determined by the method of Latta and Eskin [11] as modified by Vantraub and Lapteva [12].

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 15 No. 4 September 2015 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Acceptability trial by mothers and their children

Porridges were prepared from the five blends of maize, chickpea, and amaranth flour. Sensory evaluation was conducted for two consecutive days at field level by selecting 50 consenting mothers and their children in under 2 years age group. Porridges were prepared from the five blends shown in Table 1; this preparation was done at the community level using commonly available household tools. Sensory qualities were tested by mothers for color, flavour, taste, mouth fill and overall acceptability by their children using a five point hedonic scale [13]. The response of infants was scored by the mother by noting whether the infant liked or disliked the food by looking at the child's response. Before the test, each mother was asked not to take coffee or tea, and not to use perfume 30 minutes before taking the test and also not to give breast milk and food for at least 1 hour before the test. The tests were carried out in the morning. Each time 1-2 teaspoons of porridge were given to the child; then the mother was requested to observe the reaction of the child. The mother reported her observations of the child's reaction to each type of porridge for color, taste, and flavour. This constituted the test for acceptability.

Statistical analysis

The sensory, proximate and mineral analysis data was analyzed using analysis of variance (ANOVA). Fisher least significance difference (LSD) at $p < 0.05$ was used to determine the significance of mean difference of sensory attributes.

RESULTS

Effect of processing on phytate level of amaranth grain

The results indicated that soaking amaranth grain in water decreased the phytate level significantly (Table 2). The minimum phytate level result was achieved for soaking period of 24 hours and germination period of 72 hours. Further increase in soaking and germination time, and increasing temperature did no significantly reduce the phytate level. However, soaking with lemon juice and salt water resulted in further decrease of the phytate level.

Nutrient content

Proximate and mineral content of five samples containing the same amount of chickpea flour but different proportions of maize and amaranth are shown in Table 3. The highest protein, fat, fiber and ash contents were found in the blend made up of 30% chickpea and 70% amaranth; the highest CHO (carbohydrate) and moisture contents were found in the control sample made up of 100 % maize.

The mineral analysis (Table 4) revealed that the highest iron and calcium contents were found in Sample V (30% chickpea and 70% amaranth). The lowest iron and zinc contents were found in sample II (30% chickpea+70% maize). The lowest phytate level was found in sample V porridge, (70 % amaranth and 30% chickpea) with the amount half that of the Control (maize) porridge.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 15 No. 4 September 2015 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Sensory evaluation

The highest color preference was given to the control (100% maize) formulation followed by sample II (30% chickpea and 70% maize). The lowest color preference score was given for sample V (30% chickpea and 70% amaranth); however, this porridge had the highest appearance, flavour and acceptability score.

DISCUSSION

Studies indicate that amaranth is rich in important nutrients, but it also contains high phytate levels which affect the absorption of protein, iron, zinc and other nutrients. Even though the grain has high phytate level, studies suggest that home-made processing such as soaking of grains and germinating can decrease the phytic acid [5, 14]. This study's findings showed the various ways soaking and germinating can decrease the phytate level; however, soaking under water with added lemon juice or salt were the most effective at lowering phytate [15].

Amaranth grain is rich in both macro and micro nutrients [5]. Amaranth grain is a good source of iron, calcium and zinc and other micro and macro nutrients including lysine which is unusual to find in plant source protein [5, 14]. The protein, fat, crude fibre, and ash content significantly increased when the proportion of amaranth increased in the porridge made from maize, chickpea, and amaranth flour. The mineral analysis in the present study indicated that iron and calcium level significantly increased with increasing proportion of amaranth in the blend. The nutrient level of the blend containing 30% chickpea and 70% amaranth significantly increased from 4 to 15 mg for iron, 7 to 16g for protein, and 24 to 244mg for calcium compared to the Control group (100% maize). This wide change indicates that amaranth grain is not only a good source of iron but also for calcium and protein.

The phytate level of the blend decreased significantly when the proportion of amaranth increased The least phytate to iron ratio (0.24) was observed in 70% amaranth and 30% chickpea blend compared with the control group (1.71). The ratio should fall below 1:1 and preferably below 0.4:1 to increase the bioavailability of iron in cereal and legume based foods [16]. This as well would improve availability of not only iron but also zinc and calcium.

The sensory evaluation result for this study indicated that the porridge with the highest amount of amaranth is acceptable, although less so than the 100% maize porridge that is commonly used in the study area. Subjects - Respondents found the pink colour to be unacceptable, because it was different from the usual colour.

In a study of complementary food preferences, mothers in a woreda in SNNPR indicated that they preferred a light colour for complementary foods and had rejected use of red haricot beans [17]. The tastes of all the porridges with added chickpeas (samples II-V) were rated slightly lower than the Control, which contained no chickpea. A separate study found that mothers in SNNPR did not use pulse crops in complementary foods even if the pulses were regularly used at the household [14]. A limitation of this study is that did not add amaranth without chickpea.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 15 No. 4 September 2015
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

CONCLUSION

The nutrient content of amaranth complementary porridge containing 70% amaranth, and 30% chickpea had higher amount of iron, zinc, and calcium; with increased protein and fat; and a low phytate level compared with the control. The porridge containing processed amaranth and chickpea at the ratio of 70:30, respectively, was as acceptable in terms of sensory characteristic as a nutritious porridge made with maize and chickpea which would contain a complete protein mixture. Further research is necessary to document effectiveness of this type of complementary food formulation on the mineral status of young children.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 15 No. 4
September 2015
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 1: Combination of samples for preparation of complementary food from amaranth, chickpea and maize

	Maize %	Chickpea%	Amaranth%
Sample I (control)	100	0	0
Sample II	70	30	0
Sample III	45	30	25
Sample IV	20	30	50
Sample V	0	30	70

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 15 No. 4
September 2015
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 2: Effect of soaking and germination of amaranth grain on the phytate level

Soaked on	Temperature	Soaking Time (h)	Germination Time/day	Phytate mg/100g
Control (none)	--	0	0	395±3.5[a]
Water	Room temperature#	48	0	210±4.3[b]
Water	Room temperature#	48	6	105±5.8[c]
Water	32^o C	48	6	105±0.7[c]
Water	32^oC	24	3	104±0.8[c]
Lemon Juice (5 mL) per 100 mL waster	32^oC	24	3	64±0.7[d]
Salt (5 g) per 100 mL water	32^oC	24	3	80±0.3[e]

Mean ± SD. Values in column with different letters are significantly different ($p < 0.05$).

Room temperature was not measured but was approximately 23 ^oC

Table 3: Proximate composition of formulated porridge blends (g/100g)

Sample	Protein	CHO	Fat	Moisture	Fibre#	Ash
I	7.58±0.07[a]	78.9±0.06[d]	4.4 ±0.01[a]	8.18±0.02[e]	2.09±0.06[a]	0.94±0.04[a]
II	11.31±0.01[b]	74.6±0.01[c]	5.4 ±0.07[b]	7.19±0.02[d]	1.99±0.05[a]	1.42±0.06[b]
III	12.94±0.02[c]	72.3±0.01[b]	6.4 ±0.02[c]	6.32±0.02[c]	4.09±0.07[b]	2.02±0.04[c]
IV	14.85±0.01[d]	70.7±0.13[ab]	6.4±0.02[c]	5.65±0.03[b]	6.05±0.02[c]	2.36±0.02[d]
V	16.39±0.07[e]	68.8±0.04[a]	7.1 ±0.08[d]	5.02±0.02[a]	7.51±0.02[d]	2.67±0.01[e]
P	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

Mean ± SD. Values in column with different letters are significantly different ($p < 0.05$).

I=Control (100% maize)
II=30% chickpea+70% maize
III=30% chickpea+25% amaranth+45% maize
IV=30% chickpea+50% amaranth+20% maize
V= 30% chickpea+70% amaranth

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 15 No. 4 September 2015
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 4: Mineral and phytate content of formulated porridges (mg/100g)

Sample	Iron	Calcium	Zinc	Phytate	Phytate to iron ratio
I	4.31±0.04[a]	24.8 ±0.02[a]	2.47±0.02[b]	87.7±0.4[a]	1.71[a]
II	3.31±0.02[b]	37.6±0.01[b]	1.98±0.01[a]	86.7±0.01[a]	2.2[b]
III	8.67±0.01[c]	33.5 ±0.19[c]	2.59±0.04[b]	79.8 ±0.02[b]	0.77[c]
IV	13.67±0.02[d]	209±0.3[d]	2.83±0.01[b]	74.9 ±0.11[c]	0.46[d]
V	15.16±0.03[e]	245 ±0.2[e]	2.59±0.01[b]	44.9 ±0.14[d]	0.24[e]
P	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

Mean ± SD. Values in the same column with different letters are significantly different ($p < 0.05$).

I=Control (100% maize)
II=30% chickpea+70%maize
III=30% chickpea+25% amaranth+45% maize
IV=30% chickpea+50% amaranth+20% maize
V= 30% chickpea+70% amaranth.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 15 No. 4
September 2015
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 5: Sensory scores of porridge blends by mothers and their children

Sample	Color	Appearance	Flavor	Taste	Overall acceptability
I	4.9±0.27[a]	4.7±0.43[b]	4.7±0.43[a]	4.2±0.77[a]	3.2±0.65[a]
II	4.7±0.45[a]	4.6±0.56[b]	4.6±0.56[a]	3.4±0.86[bc]	2.5±0.07[b]
III	3.6±0.89[b]	4.5±0.61[b]	4.5±0.61[a]	3.8±0.96[ab]	2.5±0.12[b]
IV	2.5±0.95[c]	3.8±1.33[a]	3.8±1.30[b]	3.1±1.04[c]	2.2±0.18[b]
V	2.2±1.47[c]	4.7±0.66[b]	4.7±0.66[a]	3.4±0.19[bc]	2.6±0.15[ab]
P	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

Values are mean ± SD of Likert scale (5 = liked best; 1 = liked least); Letters with the same column with different superscript are statistically different (P<0.05)

I=Control (100% maize)
II=30% chickpea+70%maize
III=30% chickpea+25% amaranth+45%maize
IV=30% chickpea+50% amaranth+20%maize
V= 30% chickpea+70% amaranth.

REFERENCES

1. **Government of the Federal Democratic Republic of Ethiopia.** National Nutrition Program June 2013-June 2015. Available at http://www.unicef.org/ethiopia/National_Nutrition_Programme.pdf. Accessed July 27, 2014.

2. **Central Statistical Agency [Ethiopia] and ICF International** Ethiopian Demographic and Health Survey 2011. Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ICF International.

3. **Dewey KG** Nutrition, growth and complementary feeding of the breastfed infant. *Ped Clin N Amer* 2001;**48**:87-104.

4. **Magnus D** Iron requirements in infancy. *Annals Nutr Metab* 2011; **59**(**1**):59-63.

5. **Ochola S** Effect of steeping and germination on the diastatic activity and sugar content in amaranth grains and viscosity of porridge. *J Agric Food Tech* 2013; **3**(**1**):1-7.

6. **Mugalavai VK** Effect of amaranth maize flour ratio on the quality and acceptability of ugali and porridge (Kenyan cereal staples). *ARPN J Agric Biol Sci* 2013; **8**(**1**):1-12.

7. **Okoth J, Kanensi S, Ochola N and A Gikonyo** Optimization of the period of steeping and germination for amaranth grain. *J Agric Food Tech* 2011; **1**(**6**): 101-105.

8. **Macharia-Mutie CW, Van de Wiel AM, Moreno-Londono AM, Mwangi AM and ID Brouwer** Sensory acceptability and factors predicting the consumption of grain amaranth in Kenya. *Ecol Food Nutr* 2011;**50**:375–392.

9. **AOAC**. Official Methods of Analysis. (Vol. II 17th ed.), of AOAC Association of Official Analytical Chemists, Washington, DC, USA. 2000.

10. **FAO.** Food and Agriculture Organization. Food Energy – Methods of Analysis and Conversion Factors. FAO Food and Nutrition paper 77, 2002. Available at ftp://ftp.fao.org/docrep/fao/006/y5022e/y5022e00.pdf. Accessed May 2015.

11. **Latta M and M Eskin** Simple and rapid colorimetric method for phytate determination. *J Agric Food Chem* 1980; **28**: 1315–1317.

12. **Vaintraub IA and NA Lapteva** Colorimetric determination of phytate in unpurified extracts of seeds and the products of their processing. *J Anal Biochem* 1988; **175**: 227-230.

13. **Kebebu A, Whiting SJ, Dahl WJ, Henry CJ and K Abegaz** Formulation and acceptability testing of a complementary food with added broad bean (*Viciafaba*) in southern Ethiopia. *Afr. J. Food Ag.Nutr. Dev*. 2013;**13(3**). 15 pages. http://www.ajfand.net/Volume13/No3/index3.html.

14. **Colmenares R and R Bressani** Effect of germination on the chemical composition and nutritive value of amaranth grain. *J Cereal Chem* 1990; **67**(**6**):519-522.

15. **Hurrell RF, Reddy MB, Juillerat MA and JD Cook** Degradation of phytic acid in cereal porridges improves iron absorption by human subjects. *Am J Clin Nutr* 2003;**77(5):**1213-1219.

16. **Hurrell RF** Phytic acid degradation as a means of improving iron absorption. *Int J Vitam Nutr Res* 2004;**74(6):**445-452.

17. **Berhanu G, Mesfin A, Kebebu A, Whiting SJ and CJ Henry** Household food processing methods to enhance iron and zinc bioavailability in formulated haricot bean and maize complementary food. *Afr J Food Sci.* 2014; **8(4):** 190-195.