Maize Based Food Products in Ethiopia: A Review of Traditional Practices and Research Outputs

Senayit Yetneberk,[1] Mulugeta Teamir[2] and Adefris Teklewold[3]

Abstract

Maize (Zea mays L.) has a diverse form of utilization for human food and as a raw material for industrial processing. In Africa, a greater proportion of maize grains are used for human food whereas industrial processing of the bulk of maize grains are carried out in developed countries. This review is intended primarily for documenting the existing maize based Ethiopian traditional foods and associated research outputs. The report is organized in sections. The introductory section provides the food uses of maize and the rationale for the exercise. Other sections deal with the nutritional values of common and quality protein maize and traditional methods of processing. Research output on composite flours, supplementary infant food formulations and some industrially food products are highlighted. These are explored by briefly summarizing available publications from different research centers, higher learning institutions and developmental organizations pertaining to the traditional and modern practices of maize uses for food through a desk review. The review identified different types of traditional maize foods prepared at household level and some locally processed industrial food products. Finally, research gaps were pointed out. The article provides you with an overview of Ethiopian traditional maize based foods and research outputs that has been completed as well as a future view of what may still need to be done.

Keywords: Quality protein maize, common maize, traditional processing, traditional foods and supplementary foods

---

Introduction

Maize (Zea mays L.) has a diverse form of utilization for human food and feed and as a raw material for industrial processing. In Africa, a greater proportion of maize grains produced is used for human food whereas industrial processing of the bulk of maize grains are carried out in developed countries. It is the cheapest cereal among food grains which provide both energy as well as good quality protein (Rai *et al.,* 2012) and an important food security crop in Ethiopia, with the cheapest caloric source among all major cereals (Demeke, 2012).

[1]Program officer, Nutritious Maize for Ethiopia (NuME) Project, SG 2000-Ethiopia.
E-mail: Senayit@saa-safe.org or syetneberk@yahoo.co
[2]Researcher, Melkassa Agricultural Research Center, Melkassa
E-mail: muluteam@gmail.com
[3]Leader, Nutritious Maize for Ethiopia (NuME) Project CIMMYT-Ethiopia Office
E-mail: A Teklewold@cgiar.org

A Household Income, Consumption and Expenditure Survey conducted by the Central Statistics Agency (CSA) revealed that maize consumption per household was 62.88 kg for rural areas and 9.33 kg for urban areas, annually. The total consumption per household for rural and urban areas was 145.53 kg and 41.30 kg, respectively (CSA, 2000). This data indicates that the rural population in Ethiopia consumes more maize compared to the urban population.

In terms of its utilization for human food, each country has one or more maize dishes that are unique to its culture. For example, in Central and Latin America, maize is consumed in the form of flat bread or *tortillas*. Some staple foods prepared from maize in different African countries include *ogi* (Nigeria), *kenkey* (Ghana), *koga* (Cameroon), *tô* (Mali), *injera* (Ethiopia), and *ugali* (Kenya), *sadza* (Zimbabwe and South Africa). (Diet.com http://www.diet.com/g/corn-or-maizebased-diets#). Most of these food products are processed at household level.

This review briefly summarized available publications from different research and higher learning institutions and developmental organizations pertaining to the traditional and modern practices of maize uses for food in Ethiopia through a desk review to help indicate research areas on identified gaps.

Nutritional values of common maize (CM)

Maize is one of the major food crops in Ethiopia and plays an important role in the livelihood of the farming community. The nutritive value of common maize is quite similar to other cereal grains characterized with low protein quality and high carbohydrate content. Low protein quality of normal maize emanates mainly from deficiency in the essential amino acids lysine and tryptophan and excess of leucine, leading to poor growth and kwashiorkor in young children and pellagra in adults (Graham *et al*., 1990). For those consuming >50% of their daily energy from maize, pandemic protein malnutrition may exist (Nuss and Tanumihardjo, 2011). Normal maize kernels are also deficient in vitamin C, B-vitamins, iron, and iodine (Nuss and Tanumihardjo, 2010). It is reported that the germ contains nearly 80% of the kernel's minerals and the endosperm has less than 1% (Nuss and Tanumihardjo, 2010). Sustained consumption of conventional maize without supplementing with other protein and micronutrient sources puts consumers at risk of malnutrition that manifests itself in weakened immune systems, stunting and mental retardation (Mduruma *et al*., 2013).

Nutritional benefits of quality protein maize (QPM)

QPM a product of conventional plant breeding and an example of bio-fortification of a maize genotype whose lysine and tryptophan levels in the endosperm of the kernels are about twice higher than in conventional maize varieties (Adefris, *et al.* 2015). Thus, consumption of QPM alleviates the problem of malnutrition manifested in the maize growing and consuming communities. These two amino acids allow the body to manufacture complete proteins (Mamatha *et al.*, 2017). It provides balanced nutrition for human consumption particularly for pregnant and lactating women infants & children.

A feeding study conducted by EHNRI has shown that QPM is superior to normal maize in terms of its palatability, weight gain as well as the efficiency of its protein (Akalu *et al*., 2001). Abiose *et al*. (2015) confirmed the fact that QPM has a biological value (>60%) and true digestibility (>60%) than the products from common maize. Similar study on nutritional impact of QPM in children's diets in western Ethiopian highlands showed that consuming QPM reduce or prevent growth faltering and may in some cases support catch-up growth in weight (Akalu *et al.,* 2010).

Maize grain processing

Cereal grains are subjected to different processes during food preparation for human consumption. Likewise, processing of maize undergoes similar steps i.e. a primary and secondary processing. Cleaning (sorting, winnowing and washing), as primary processes are important steps to remove foreign materials such as husk, straw, dust, sand, metal and stones that lowers the quality of the end product.

Pounding of the cleaned maize grain with a wooden mortar and pestle is widely used as traditional method of processing in many developing countries including Ethiopia. It is a laborious task which is generally incumbent on women. It is performed to remove the bran and or germ from cereals which in turn reduces their phytate content when it is localized in the outer aleurone layer (O'Dell and Koirtyohann, 1972). Hence, bioavailability of iron, zinc, and calcium may be enhanced, although the content of minerals and some vitamins of these pounded cereals is simultaneously reduced (Hotz and Gibson, 2007).

Traditional processing equipment

Several traditional processing equipment are used in different regions of the country. This processing equipment were used for several years to process cereals and pulses without much improvement lending themselves to labor intensive food preparations. They are operated by women who are largely responsible for household food processing. Except decortication and milling the grain to flour which is mechanically performed by milling service providers, all the operations listed in table 1 are performed manually.

Table 1. Some unit operations and associated traditional equipment used in Ethiopia

Unit operation	Equipment used
Cleaning	Straw mat *(Sefed)*
Decortication	Wooden mortar and pestle (*mukecha*) Manually operated stone grinder (*wefcho*)
Milling	Wooden mortar and pestle (*mukecha*) Manually operated stone grinder (*wefcho)*
Roasting	Metal griddle (*beret mitad*) or clay griddle (*shekla mitad)*
Sieving	Straw sieve (*wonfit*)
Fermentation	Earthenware/clay pot (*insera*)
Cooking	Clay pot (*shekla dist, minchet)*
Mixing	Wooden bowel (*gebete)*
Stirring	Wooden ladle (*mamasaya*)
Baking	Clay griddle for *injera* (*shekla mitad)* Clay griddle for *dabo (geber mitad*)

Source: Modified from Abegaz *et al*., 2002 and users' personal communications.

Traditional foods

In Ethiopia different types of traditional foods and beverages are prepared from maize and other cereals at a household level. In the early 90s a survey on food uses of maize and their preparation methods was conducted by the Institute of Agricultural Research (IAR) in major maize producing areas of Central Ethiopia covering nine woredas (Minjar, Adama, Boset, Dugda, Arsi Negele, Shashemene, Efrata and Jille and Kewot). Five traditional foods prepared from maize were identified (Senayit, 1992). These were *injera, kitta, nifro, genfo,* and *kollo.* Some of these foods were fermented and some were non-fermented.

The major unit operations performed in traditional food preparations include roasting, germination, milling, fermentation, baking and boiling. Natural fermentation had the most pronounced phytic acid lowering effect in sorghum varieties compared to other processing methods (Binyam and Kelbessa, 1995; Mohammed, *et al*., 2011) and a further reduction was observed after baking of the fermented dough to *injera*. Fermentation can induce phytate hydrolysis via the action of microbial phytase enzymes, which hydrolyze phytate to lower inositol phosphates (Hotz and Gibson, 2007).

Traditional food preparation is an art based on local knowledge and the methods employed are not controlled and standardized. Lack of measurement of added ingredients and absence of control of each unit operation renders it difficult to ensure consistent product quality to meet the demand of urban consumers. Moreover, traditional food preparations are tedious and time consuming due to use of inefficient processing equipment described elsewhere in this report.

NuME project demonstrated about ten traditional and new foods (*injera, anebabero, kitta, teresho, dabo, genfo, firfir, kurkufa, shorba* and *besso*) prepared from QPM varieties during each woreda level field day. The food preparation methods and procedures were guided by a manual on QPM based Ethiopian traditional food preparation (Sasakawa and CIMMYT-Ethiopia, 2017). These products were tasted and rated as good or better than those made from common maize. The food demonstration provides an added incentive/attraction for women to participate in the event (Adefris *et al*., 2015). Ethiopian traditional foods prepared from maize and other cereals are listed and described in table 2. This list is by no means exhaustive due to limitation of documented reports.

Table 2. Characterization and mode of consumption of Ethiopian traditional foods from cereals

Food type	Characterization and mode of consumption

Injera	Leavened flat staple bread made from flours of cereals, with tef flour preferred for the best quality attributes. A good *injera* should be soft, glossy, fluffy & rollable with an even distribution of "eyes"(a honey comb like porous structure) on the top surface. It is a staple food served with different sauces.
Anebabo	Double layered thick *injera* made from flours of cereals with tef flour preferred for best quality attributes. Smearing the top surface of *anebabero* with a mixture of butter or oil, spiced red pepper powder (*berberie*) and salt is mostly practiced. Good *anebabero* should have sweetish taste, soft and fluffy texture. Served for breakfast or as a snack food.
Dofo Dabo	Traditional sour dough bread made from cereals, wheat flour preferred for the best quality attributes. Ingredients for preparing *dofo dabo* are flour, yeast, salt and water. Good difo *dabo* should have a soft texture, porous crumb structure and raised volume with a golden-brown crust color. Served as part of the regular meal and for special occasions.
Kitta	Unleavened flat bread made from maize flour or flours of other cereals. Barley flour preferred for the best quality attributes. *chechebsa is kitta* cut into pieces & mixed with spiced butter and red pepper (*berberie*). Served for breakfast or as a snack food.
Dabo kollo	Deep fat fried crunchy snack food prepared from cereals. Ingredients of *dabo kollo* are flour, water, spice, salt and oil. Wheat flour is preferred for the best quality attributes. Composite flours of wheat & maize make acceptable product.
Kollo	Popped or roasted maize. Usually served as a snack food.
Genfo	A stiff porridge can be prepared from flour of a single cereal or a composite flour of different cereals. It is served for breakfast and to nursing mothers and young children. A good *genfo* should have a soft and smooth texture. It is consumed with butter or oil & spiced red pepper (berberie) or with milk.
Kurkufa	Cooked kale and maize flour garnished with onion, garlic and tomatoes. Maize flour preferred for the best quality *kurkufa*. It is a porridge like product with improved nutrient content from added ingredients.
Fosessie	Cooked haricot bean and maize flour garnished with onion, garlic, oil or butter. Haricot bean supplements protein and the fat improves the energy value of the product.
Nifro	Cooked green cob maize or whole maize grain. Pulses could be added to improve its protein quality. Served as a snack food or main dish.
Kinche	*Kintche* is cooked maize grist or grist of other cereals. It is high in carbohydrate specifically starch which is a source of heat and energy. It is served for breakfast.
Besso	Roasted maize flour or roasted flours of other cereals, barley preferred for best quality attributes. It is a ready to eat food consumed by wetting the flour with water or taken as a drink by adding water and sugar or milk and sugar.
Firfir	*Firfir* is normally prepared by mixing a sauce with fresh or dry *injera* and served for breakfast or as a snack food. It can also be prepared from QPM maize flour.

Modified and compiled from: Senayit, 1992; Asrat *et al*., 1998; Abegaz *et al.,* 2002; Asrat, 2011; EHNRI, 2013; Sasakawa and CIMMYT-Ethiopia, 2017.

For each food product there are preferred crop species that could give a product with the best quality attributes as indicated above. However, the farming community prepares them from what they produce. For example, compared to tef maize is not a preferred cereal grain for making *injera.* It becomes dry and brittle shortly after baking due to retrogradation of its starch. Good *injera* is characterized as soft and rollable to wrap and hold the sauce (*wot*) (Gebre Kidan and Gebre Hiwot, 1982). Consumer taste of *injera* from QPM had acceptable and even preferable taste to conventional maize (De Groote *et al.,* 2014).

Products from composite flours

The Ethiopian Health and Nutrition Institute (EHNRI) conducted trials with composite flours of cereals and cassava to prepare four traditional food products i.e. *injera, dabo, anebabero,* and *genfo* (Asrat, 2011). The end products were evaluated on a 1-5 scale.

The overall acceptability of *injera* prepared from 100% *tef* scored 3.9 while that of QPM and local maize were 3.7 and 2.9, respectively. *Injera* prepared from blends of 90% QPM flour and 10% rice flour had an overall acceptability of 4.4 showing a better score than the standard check (100% tef flour). On the other hand, substitution of 5% and 10% cassava flour improved the overall acceptability to 3.8 and 3.9 respectively. Compositing different flours at optimum proportion produces acceptable product due to additive effect of functional properties.

Dabo from 100% wheat flour was used as a standard check. Non-gluten cereals such as maize normally produce a bread with low volume due to the absence of gluten network for holding the gas produced during fermentation and baking (Gallagher, *et al.,* 2003). Although substitutions of non-gluten flours can be expected to alter both the rheological properties of the dough and the quality of the baked product, substitution of wheat up to 60% QPM flour gave acceptable bread (Asrat, 2011). Furthermore, substituting maize for wheat will greatly reduce the cost of production.

Mixing QPM with soybean flour up to 10 to 15% and cassava flour at 10% could improve the nutritional qualities of bread (Mesfin and Shimeles, 2013). The workers did not measure the quality attributes of the bread (volume, color, texture, crumb structure and crust color). Further studies on evaluation of these quality attributes and analysis on the level of nutritional improvement is required to come up with an optimum level of blending.

Acceptability score of *anebabero* from 100% QPM and 100% common maize gave similar results 3.12 and 3.11 respectively. *Anebabero* from 100% wheat flour gave an overall acceptability score of 3.9. Substituting barley flour above 50% decreased the scores for appearance, texture and flavor progressively and resulted in rejection of the products by the taste panels. Blending of flours of 80% QPM and 20% wheat; and 80% QPM and 20% sorghum gave acceptable *anebabero* (Asrat, 2011).

Genfo prepared from 100% QPM had smoother texture and an overall acceptability of 3.4, while *genfo* made from common maize gave a lower score (2.6*).* With respect to blending QPM with other cereals, the overall acceptability of *genfo* prepared from 30% and 20% sorghum flour substitution of QPM flour resulted in a lower score 2.7 and 2.9 respectively indicating the effect of crop species on food making qualities. Further research on functional properties of each flour may help explain the observed quality differences.

Complementary foods

For infants up to the age of six months breast feeding is recommended since it is adequate both in quantity and quality to meet the nutrient and energy requirements of the child (MOH, 2006). Beyond this period, complementary or weaning foods are required to fill the calorie, protein and micronutrient gap between the total nutritional needs of the child and amount provided by breast milk. Inadequate nutrient in complementary food is a major cause for the high incidence of child malnutrition, morbidity and mortality in many developing countries (WHO, 2015). This calls for formulations of complementary foods with adequate nutrient content to support infant growth.

Some studies have been carried out on formulation of supplementary infant foods from locally available food crops to meet the nutrient and energy requirements of infants. Two complementary foods formulated by Yewelsew *et al.,* (2006) to improve the quality of children's diets in Southern Ethiopia were based on corn and an indigenous root crop product called *kocho* (*Enset ventricosum*). Kidney beans and pumpkin pulp were added to improve the protein and vitamin A values, respectively. The authors justified that addition of kidney beans and pumpkin has a potential to increase the nutritive value of traditional

Ethiopian complementary foods prepared from corn or *kocho.* They suggested addition of other crops such as kale, yellow sweet potatoes, avocado, and papaya as alternative carotenoid sources.

Meseret (2011) studied the effect of fermentation and blending of QPM with soybean for the production of nutritionally improved weaning food and reported a reduction of 46.7% of phytate and an increment of 47.4% phosphorous, 47.9% calcium, 44.7% iron and 38% zinc. Additionally, a maximum of 24.3% increment of protein value and 3% improvement of calorific value was observed. The worker concluded that fermentation and blending of soybean with QPM improves the bioavailability of minerals and protein quality.

The effect of formulations of QPM with beans and carrot on animal model using two diets was studied by Dilnesaw (2011). Diet 1 was a blend of 61.5% QPM and 27.04% haricot bean (Roba1) and 11.5% carrot flour, while diet 2 was a mix of 62.5% QPM, 26.8% haricot bean (Gofta) and 10.8% carrot flours. These blends improved mineral and vitamin A content of the diet.

A common maize and white haricot bean were blended to produce porridge by Berhanu *et al.,* (2014). Processes such as germination and roasting were employed to reduce the phytate content and enhance the bioavailability of iron and zinc. The product had acceptable taste with improved flavor, viscosity and nutritional quality.

Fermented cereals-soya bean blend was formulated for nutritional improvement of complementary food (Betre, 2013). He reported that fermentation decreased anti-nutritional factors. A cereal based complementary food from maize, soya bean and moringa with a proportion of 65% maize, 20% soya bean, 10% moringa and 5% sugar improved nutrient composition and is believed to solve problems associated with protein-energy and micronutrient malnutrition in young children (Berhanu, 2014). Similarly, broad bean containing maize porridge had a higher protein content and acceptable sensory characteristics compared to the customary cereal-based porridge (Kebebu *et al.,* 2013).

There is limited work reported on germinated cereals as ingredients in complementary food formulations. Addition of germinated cereals favors low viscosity and high nutrient density porridge that allows increased nutrient intake.

Snack foods

Snack foods are generally ready to eat (RTE) food products served between meals. In Ethiopia, most traditional snack foods are popped or roasted cereals and pulses including peanuts. Few new snack foods are developed and documented.

A protein enriched ready to eat (RTE) extruded product was developed by combining 589 g/kg maize flour, 291 g/kg defatted soy flour and 120 g/kg chickpea flour using different processing conditions. A product extruded at 140°C barrel temperature and screw speed of 200 rpm gave a high expansion ratio with good sensory and nutritional qualities (Abyneh, 2013).

Nutritionally improved cookies from composite flours of wheat, QPM and carrot was developed as a snack food (Biniyam, 2010). Cookies made from blends of 80% wheat flour, 10% carrot flour and 10% QPM flour baked at a temperature of 175 °C scored high in all sensory attributes. As the proportions of carrot and QPM flours increased the spread of the dough reduced leading to a decrease in the diameter of the cookies.

An expanded food product was formulated from lentil-corn flour mixes by extrusion cooking with the objective of enriching the protein and mineral content of corn. A blend of 47.8% lentil flour, 52.2% corn flour on dry weight basis processed at 15.82% moisture content and a barrel temperature of 181.97°C was selected as the best formulation to yield a protein rich extruded product with desirable physical and functional attributes (Tadesse, 2014).

Industrially processed products

Cereal processing industries that produce enriched corn-soya blends directly supply their products to the World Food Program (WFP) of the United Nations with strict standards and certification schemes. As reported by Soethoudt *et al*., (2013), Faffa, Healthcare Foods, Guts and Hilina Enriched Food Products are professional enterprises that meet the standards imposed by the relief agencies. On average, these companies produce between 5,000 and 10,000 tons of Corn-Soya Blends for WFP.

Recently demand for enriched products has dropped significantly, as a result, the companies are diversifying into the production of commercial products like instant baby foods, breakfast cereals, bread improvers, and extruded snacks (Soethoudt *et al*., 2013). The industrial utilization of maize in Ethiopia is focused on production of flours and weaning foods (Diriba *et al.,* 2001).

The most innovative food company Faffa producing Cerifam has a 40% market share in the instant baby food segment (Soethoudt *et al*., 2013). On the other hand, Lifeline Solution a Share Company imports maize glucose in powder form and produces glucose for pharmaceutical uses. The starch could have been produced locally in order to promote the value chain of maize and save hard currency.

Research gaps and way forward

Ethiopian traditional foods are cereal based and mostly fermented. The effect of fermentation and associated traditional processing practices on nutrient improvement or loss and the scientific basis needs to be addressed. Furthermore, baked products from maize including *injera* has a staling problem shortly after baking due to starch retrogradation. End-use varietal selection, compositing with other cereals, use of some additives mainly hydrocolloids and waxy wheat flours (WWF) that could positively influence the texture and keeping quality of baked products is suggested.

The use of composite flours in most traditional food products and supplementary foods are noted in this review. Blending can contribute different functionalities to the food systems. In-depth studies on the effect of composite flours on functional properties, nutritional benefits and improvement of product quality should be well understood.

Traditional or village level maize processing are tedious and time consuming. Introducing appropriate technologies at community and household level will help reduce the drudgery imposed on rural women. Alternatively, industrial production of maize flour could alleviate this problem and eventually promote its utilization.

Although maize is known to make different types of snack foods worldwide, this review identified limited number of snack food formulations. The use of QPM for snack food production would have an added nutritional advantage for consumers and may command higher market price.

Acknowledgements

The authors would like to thank CIMMYT-Ethiopia for providing fund for this desk review. We appreciate the contribution of researchers and institutions who worked on maize and maize based food products in Ethiopia for whom we have given due acknowledgment in this report. We sincerely thank Dr Dennis Friesen for reviewing this document.

Reference

Abayneh, T. 2013. Development of Ready to Eat Protein Enriched Extruded Product. MSc. thesis. Addis Ababa Institute of Technology. School of Chemical and Bio Engineering. Addis Ababa, Ethiopia.

Abegaz, K., Beyene, F., Langsrud*, T.* Narvhus, J. A. 2002. Indigenous processing methods and raw materials of borde, an Ethiopian traditional fermented beverage. The Journal of Food Technology in Africa. 7(2): 59-64.

Abiose, S. H., Ikujenlola, A. V., Abioderin, F. I. 2015. Nutritional quality assessment of complementary foods produced from fermented and malted quality protein maize fortified with soybean flour. Pol. J. Food and Nutr Sci. 65 (1):49–56.

Adefris Teklewold, Dagne Wegary, Abraham Tadesse, Berhanu Tadesse, Kassahun Benti, Dennis Friesen and B.M. Prasanna. 2015. Quality Protein Maize (QPM). A Guide to the Technology and its Promotion in Ethiopia. CIMMYT: Addis Ababa, Ethiopia.

Akalu, G., Wondimu, A., Fuffa, H., Kidane-mariam, T., Bisrat, A. 2001. Utilization and quality assessment of maize. In: proceedings of the second National Maize Workshop of Ethiopia. Addis Ababa, Ethiopia. pp. 184-186.

Akalu, G., Taffesse, S., Gunaratna, N. S., and De Groote, H. 2010. The effectiveness of quality protein maize in improving the nutritional status of young children in the Ethiopian highlands. Food and Nutrition Bulletin. 31(3):418-430.

Asrat, W. 2011. Development of suitable processes for some Ethiopian traditional foods using quality protein maize: Emphasis on enhancement of the physico-chemical properties. In: Meeting the Challenges of Global Climate Change and Food Security through Innovative Maize Research. Proceedings of the Third National Maize Workshop of Ethiopia. Addis Ababa, Ethiopia. Pages 261-267. Eds. Worku, M., Twumasi-Afriyie, S., Wolde, L., Tadesse, B., Demisie G., Bogale, G., Wegary, D. and Prasanna, B.M.

Asrat, W., Achamylesh, A., Bogalech A., Tenagne, K., Senayit, Y. 1998. Preparation of maize and maize-based dishes (a manual). Ministry of Agriculture Department of Agricultural Extension and Sasakawa-Global 2000. Addis Ababa, Ethiopia.

Berhanu, G., Mesfin, A., Kebebu, A., Whiting, S. J. and Henry, C. J. 2014. Household food processing methods to enhance iron and zinc bioavailability in formulated haricot bean and maize complementary food. African Journal of Food Science. 8(4): 190-195.

Betre, G. 2013. Studies on microbiological, nutrient composition and anti-nutritional contents of fermented maize/sorghum/tef flour blended with soybean. MSc. Thesis. Addis Ababa University. Addis Ababa, Ethiopia.

Binyam, K. and Kelbessa, U. 1995. Effects of traditional food preparation methods on phytic acid content of sorghum grain. SINET: Ehiop. J. Sci.18(2):207-220.

Binyam, T. 2010. Development of ready to eat protein enriched extruded product. MSc. Thesis. Addis Ababa Institute of Technology, School of Chemical and Bioengineering. Addis Ababa, Ethiopia.

CSA. 2000. Household Food Consumption and Expenditure Survey. Addis Ababa, Ethiopia.

De Groote, H., Gunaratna, N. S., Okura, J. G., Wondimu, A., Chege, K. C. and Tomlins, K. 2014. Consumer acceptance of quality protein maize (QPM) in East Africa. J. Sci. Food Agric. 94: 3201-3212.

Demeke, M. 2012. Analysis of incentives and disincentives for maize in Ethiopia. Technical notes series, MAFAP, FAO. Rome.

Diet.com. Corn or maze-based diets. http://www.diet.com/g/corn-or-maizebased-diets#. Referred in June 2015.

Dilnesaw, Z. 2011. New complementary food from quality protein maize supplemented with beans and carrot: Assessing nutritional effect on animal model. MSc. Thesis. Addis Ababa University. Addis Ababa, Ethiopia.

Diriba, G., Tessema, A., Shimelis, A., Demekash and Senayit, Y. 2001. Enhancing the Utilization of Maize as Food and Feed in Ethiopia: Availability, Limitations and Opportunities for Improvement. Addis Ababa, Ethiopia.

Gallagher, E., Gormley, T. R. and Arendt, E. K. 2003. Crust and crumb characteristics of gluten-free breads. J Food Eng. 56:153-161.

Gebrekidan, B., and GebreHiot, B. 1982. Sorghum injera preparation and quality parameters. in: Proceedings of the International Symposium on Sorghum Grain Quality. L. W. Rooney and D. S. Murty, eds. ICRISAT: Patancheru, India. Pages 55-66.

Graham, G. G., Lembecke, J. and Morales, E. 1990. Quality protein maize as the sole source of dietary protein and fat for rapidly growing young children. Pediatrics. 85(1):85-91.

Hotz, C. and Gibson, R. 2007. Traditional food-processing and preparation practices to enhance the bioavailability of micronutrients in plant-based diets. J. Nutr. 137:1097-1100.

Kebebu, A., Whiting, S. J., Dahl, W. J., Henry, C. J. and Kebede, A. 2013. Formulation of a complementary food fortified with broad beans (vicia faba) in southern Ethiopia. African Journal of Food, Agriculture, Nutrition and Development. 13(3):7789-7803.

Mamatha, H., Meena, M.K., Kumar, P.C. 2017. Quality Protein Maize (QPM) as Balance Nutrition for Human Diet. Advances in Plants Agriculture Research. 6(2): 00205.DOI:10.15406/apar.2017.06.00205.

Meseret, B. 2011. Effect of fermentation on quality protein maize-soybean blends for the production of weaning food. MSc. thesis. Addis Ababa Institute of Technology. School of Chemical and Bio Engineering. Addis Ababa, Ethiopia.

Mesfin, W. and Shimelis, A. 2013. Effect of soybean/cassava flour blend on the proximate composition of Ethiopian traditional bread prepared from quality protein maize. African Journal of Food Agriculture Nutrition and Development (AJFAND). 13 (4): 7985-8003.

MOH. 2006. Complementary feeding recipes for Ethiopian Children 6-23 months old: A practical cooking and feeding guide. Federal democratic Republic of Ethiopia, Ministry of Health. Addis Ababa, Ethiopia.

Mohammed, A. N., Isam, A., Ahmed, M. and Babiker, E. E. 2011. Nutritional evaluation of sorghum flour (sorghum bicolor L. Moench) during processing of injera. World Academy of Science, Engineering and Technology. 5:3-22.

Mduruma Z., Asea, G., Apio, S., Ubwe, R., Tende, R., Ngunjiri, P.W., Rwomushana, I and Opio, F. 2013. Quality Protein Maize Cookbook for Eastern and Central Africa. ASARECA (Association for Strengthening Agricultural Research in Eastern and Centeral Africa), Entebe.

Nuss, E. T. and Tanumihardjo, S. A. 2010. Maize: A Paramount staple crop in the context of global nutrition. A comprehensive review in food science and safety. 9:417-436.

Nuss, E. T. and Tanumihardjo, S. A. 2011. Quality Protein Maize for Africa: Closing the Protein Inadequacy Gap in Vulnerable Populations. Advances in Nutrition. 2: 217-224.

O'Dell, B.L, de Bowl and, A.R., Koirtyohann, S.R. 1972. Distribution of phytate and nutritionally important elements among the morphological components of cereal grains. J Agric Food Chem. 20:718–23.

Rai, S., Kaur, A. Singh, B. and Minhas, K. S. 2012. Quality characteristics of bread produced from wheat, rice and maize flours. J Food Sci Technol. 49(6):786–789.

Sasakawa Global 2000 and CIMMYT-ETHIOPIA. 2017. Quality Protein Maize Based Ethiopian Traditional Food Preparation Manual.

Senayit, Y. 1992. Survey on Maize Utilization. In: Proceedings of the First National Maize Workshop. Addis Ababa, Ethiopia. Page 160-162.

Soethoudt, H., Van Der Riet, J., Yared, S. and Groot, J. 2013. Food processing in Ethiopia. ISBN 978-94-6173-696-3.

Tadesse, F. 2014. Effects of processing conditions and optimization of gluten free lentil-corn blend extrudates. MSc. Thesis. Addis Ababa University. Addis Ababa, Ethiopia.

WHO. 2015. Complementary Feeding of Young Children in Developing Countries: A review of current scientific knowledge. World Health Organization. WHO/NUT/98.1.

Yewelsew, A., Barbara, S. J., Hinds, J. M., Gates, J. 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 (AJFAND). 6 (1):1-12.