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

Senayit Yetneberk,1 Mulugeta Teamir2 and Adefris Teklewold3

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).

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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>
<thead>
<tr>
<th>Unit operation</th>
<th>Equipment used</th>
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<tr>
<td>Cleaning</td>
<td>Straw mat <em>(Sefed)</em></td>
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| 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>
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<th>Table 2. Characterization and mode of consumption of Ethiopian traditional foods from cereals</th>
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<td>Food type</td>
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| **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** | *Ffir* 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. |


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.

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Reference


