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The Fermentation Methods for Production of Injera and Dabo in Ethiopia: A Review

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ABSTRACT

Fermented food and beverage products are made globally using different practices of fresh materials with microbes. Fermented foods have sample sources of essential vitamins, minerals, enzymes and antioxidants that are all enhanced through the process of fermentation. The advantageous effects related with fermented products have a special prominence during the production of these products in less industrialized countries like Ethiopia. In the country, fermented food and beverage products have practiced in a long history. During the production of traditional fermented food natural fermentation process with the absence of starter cultures are used to initiate the fermentation process Ethiopia. The use of yeast is also common with the popularization of modern baking and pastry in the country. Moreover, the preparation of much traditionally fermented food is still practiced in a household art even though there are electric ovens and other accessories have been introduced in the restaurants and business centers. The bread can be prepared from various cereals but for Injera tef [*Eragrostis tef* (Zucc.) Trotter] is the most preferred ingredient. The traditional bread locally called hamasha has also been prepared with various modified ingredients and fermentation techniques.

Key words: Antioxidants, *Eragrostis tef,* Vitamins, Yeast.

Fermentation is the process of controlling microbes (bacteria, yeast and moulds) to modify food, producing a desired product with nutritional qualities. The presences of microorganisms are generally referred to as negative impacts causing food spoilage but they can be used as efficient live factories to produce health beneficial food. Without some microorganisms, production of certain food items may not be possible or may be costly. Microbes are cheap resources that consist of numerous enzymes which can convert complex chemical structures into simple digestible molecules with a high efficiency. Microorganisms can use the nutrients in the food as the substrate to produce energy and other required precursors for their growth resulting in the fermented food. Many types of ethnic fermented cereal foods are widely consumed across the world. Compared with foods cooked directly from raw materials, fermented cereal foods are generally more tasteful, easily digested and richer in various nutrients, such as vitamins, organic acids and free amino acids (Blandino *et al.,* 2003). Almost all types of cereals have been prepared into many kinds of foods in various natural fermented processes. Diverse microorganisms, mainly comprised of a number of bacteria and yeast species originated from the cereal grains and local environments, have been identified from foods that have been produced with diverse techniques (Tamang *et al*., 2016a). In the traditional fermented food prepared from plant and animal materials in which microbes play an important role by altering the material physically and nutritionally. African raw plant and animal materials are predominated by many lactic acid bacteria (LAB) and yeasts (Christoph *et al.,* 2017).

Not until the late 1950's studies on oriental food fermentation begun in the United States, Heseltine (1965) compiled the first list of traditional food fermentations. Different bacterial and yeast species are present in each case, which contribute to the unique flavors and textures present in fermented food (Chilton *et al*., 2015). The main purpose of this review is to access available information on the Injera and Bread preparation practices in Ethiopia and the studies carried out on their method of production, technological, microbiological, nutritional quality and economic assessments based on the literature survey.

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The teff (*Eragrostis tef*)

Injera is thin, fermented spongy flat bread and dotted with tiny holes, served in both Ethiopia and Eritrea made from the grain *Eragrostis tef* locally known as Tef. Injera is served alongside various meat and vegetable stews and is used to scoop up pieces of food with your hands, as well as soak up the sauces part of every Ethiopian and Eritrean meal. Tef [*Eragrostis tef* (Zucc) Trotter] is the most widely used grain for making injera, although other grains such as sorghum, maize, barley, wheat and finger millet are sometimes used. Tef has the largest part of area (23.42%, 2.6 million hectares)

under cereal cultivation and third (after maize and wheat) in terms of grain production (18.57%, 29.9 million quintals) in Ethiopia (CSA, 2008). Due to its nutritional value, there is an increasing concern in Tef grain utilization. In Tef, the amount of gluten is very less. Gluten is insoluble protein found in wheat, rye, barley and some lesser known grains. However, people with celiac disease or allergies find the benefits of a gluten free diet to be life sustaining. Therefore, about 66% of Ethiopian nutrition covers of injera and it accounts for about two-third of the daily protein consumption of the Ethiopian population (Arogundade, 2006). Tef is rich in a number of essential vitamins, including many from the vitamin B group and vitamins A and K (Michelle, 2017) which are essential for good health.

Fermentation procesess

Baker's yeast is a commercial preparation consisting of dried cells of one or more strains of the fungus *Saccharomyces cerevisiae*, a small single cell with a doubling time of 30°C of 1.25-2 h and importantly can be cultured easily. Bakers use yeast as a leavening agent in the rising of dough for baking. A secondary contribution of yeast to bread is flavouring and aroma. Bakers yeast is a high volume, low value product, with 1574 × 106 kg being produced per annum on a global scale (O'Shea, 2005). Baker's yeast is marketed in two ways, either as compressed cakes or as a dry powder, however there is also a saleable intermediate of the process known as 'cream yeast'. Process considerations include media formulation (which has to be cost effective) and the limited respiratory capacity of yeast, which inhibits the production of biomass in favour of ethanol production. The fermentation of baker's yeast is strongly directed towards maximum biomass production, no byproducts such as ethanol are desired and so the fermentations are sectioned to obtain this maximum biomass (Van Hoek *et al.,* 2003).

Starter culture preparation

Fermentation of the teff flour is the first step in the production of Injera. In this process the teff flour is mixed with water into a duff and to this the baker's yeast or the starter culture or 'Ersho (Ethiopian name)' is added. However, in the recent times baker's yeast is widely used for fermentation. The presence of the fermentative bacterium Lactobacillus was reported from the Injera batter prepared from Tef indicating the role of LABs (Latic acid bacteria) in the quality assurance of the Injera (Askal and Kebede, 2013).

The preparation of Tef injera comprises of two stages of natural fermentation, which last for about 1 to 3 days (Primary fermentation) depending on ambient temperatures. The supernatant water is discarded and fresh water is added to thin out and allow standing for an hour (Secondary fermentation. The starter culture is typically added at a ratio of 1:1.6 w/v (Yetneberk *et al*., 2004; Baye *et al*., 2013). As soon as the liquid layer is poured off, about 10% of the fermenting dough is mixed with three parts of water and boiled for 5 min (Ashenafi, 2006). This is called Absit (a dough enhancer) and mixed with the rest of the dough in the fermentation (Sahlin and Nair, 2012). Maximum dough rising, which normally takes 30 min to 2 hr, signals the termination of the second stage of the fermentation process depending on the nature of the starter organisms, pH and ambient temperature. At this stage, the dough is thinned with water into a batter before baking on an open platter. Finally, Injera (Ethiopian flatbread) is baked on open platter, which is called Eelee or Mixad in Ethiopian language. Baking is performed for 2-3 min at about 200-250°C (Chala and Tizaz, 2019). The batter is poured on hot greased clay griddle metal or earthen plate till holes begin to form on top (Gebrekidan and Gebrehiwot, 1982). The main quality attribute of a good injera is its Slights our taste due to low pH nature of injera with large number of tiny eyes. The injera is preserved for consumption in the traditional containers in the household in the ambient room temperatures for two to three days without the addition of any preservatives. The storage period of injera does not exceed three days at ambient temperature (temperature in the highlands of Ethiopia is between 17 and 25°C.

Sensory evaluation

Sensory evaluation is defined as the examination of a product (*e.g.*, foods and beverages) through the evaluation of the attributes traceable by one or more of the five human senses-taste, smell, touch, sight and hearing (Piana *et al*., 2004). It is used in food science to objectively analyse food quality. In many cases, it is an indispensable tool because it allows for the objective determination of whether or not consumers will accept a novel food product. Texture is another important parameter often used to measure the quality of breads (Bekele and Lester, 1981). It is determined by touch and refers to the degree of fluffiness, roughness, smoothness, hardness or softness. The paste and gel properties and *in vitro* digestibility of tef [*Eragrostis tef* (Zucc.) Trotter] starch studies revealed that Tef starch gel texture was short and in most varieties was slightly firmer than that of maize starch (Bultosa and Taylor, (2004). The appearance of injera is one of the most important parameters, which refers to the quality of the eyes (cells) of the honeycomb-like structure on the top surface of injera formed during cooking due to escaping CO_2 bubbles (Yetneberk *et al.,* 2005). The color of injera also affects the appearance of the injera in relation to its aesthetic appeal. In areas where injera is consumed as a staple food, (Eritrea and Ethiopia), people prefer their injera be white in color (Gebrekidan and Gebre Hiwot, 1982).

Due to the increasing price of this grain in the recent times as well as the decline in its production the people started using other compatible grain flour for making Injera. Also the new research findings have shown that incorporation of other food grains also increase the nutritious value. Research on injera preparation from composite flours for nutritional enhancement and sensory quality improvements have been reported (Ghebrehiwot *et al*., 2016). The effects of milling Teff on quality of injera has not been reported much. Addition of wheat flour can greatly

reduce the gluten content to safe levels, such as Sourdough, dominant with Lactobacillus species and Saccharomyces cerevisiae (Asahara *et al*., 1992; Settanni *et al*., 2005).

Effects of microorganisms on tef fermentation

Fermentation is one of the best efficient techniques of producing and preserving foods. It is fairly a low-energy requiring conservation technology that improves shelf life of food products. In cases fermentation is important to obtain a certain food, the microorganisms present on the raw ingredients or in the containers spontaneously take care of the process. In most of these products the fermentation is spontaneous and involves different microorganisms. Traditional fermentation of the grains brings changes on the proximate composition, soluble sugars, amino acids, enzymes inhibitor activities, phytic acid and tannins. The study carried out by Bemihiretu Boka (2013) showed that partly fermented tef injera (18 hrs of fermentation) had high antioxidant capacity than fully fermented tef injera (72 hrs of fermentation) among the tef varieties. However, partly fermented tef injera extracts showed lower antioxidant activities than raw tef flour. Antioxidant terminates these chain reactions by removing free radical intermediates and inhibits other oxidation reactions by being oxidized themselves (Sies, 1997). Antioxidants play a major role in the prevention and treatment of a variety of diseases. Antioxidants are also widely used as ingredients in dietary supplements in the hope of maintaining health and preventing diseases (Nikolova *et al.,* 2007). The biological activities of many phyto-chemicals are attributed to their antioxidant properties (Kelawala and Ananthanarayan, 2004).

A review on the application of Yeast in traditional African food is given by Jespersen (2003). The main influence of fermentation on dough structure appears to be explained by mechanical stretching and modification of the dough protein (Gluten) caused by the CO_2 evolution (Reed *et al*., 1991). This is obviously linked directly to the fermentation capacity of the yeast as well as the amount of yeast present and hence the amount of CO_2 formed. Yeast excretions may also affect the structure of the dough. It has been reported that excreted glutathione and cysteine could affect protein disulphide bonds in gluten (Stear, 1990). Yeast quality and hydrolysis of yeast with release of proteolytic enzymes may also influence dough structure. Predominance of specific yeast species seems to be largely product specific (Christoph *et al.,* 2017). In comparison with the role of the yeast strain used for the fermentation and formation of flavour compounds in beer and wine, the influence of baker's yeast on bread flavour appears to be limited (Rose and Vijayalakshmi 1993; Jenson 1998), the process lasted about 3 hr, with the microorgansisms producing the organic acids, alcohol, CO_2 and other compounds important for the flavor quality of the bread. Few studies on the flavour characteristics of baker's yeast have been published and the search for strains with special flavour properties does not seem to be given much attention. In addition, the less well defined yeasty flavour is often noticeable. This may occur in particular in the case of active dry yeast where a relatively higher concentration of yeast dry matter may be applied. Trials have been reported showing that *S. cerevisiae* and *C. guilliermondii* produced larger amounts of volatile flavour components than the lactic acid bacteria.

Factors affecting the quality of injera

About two-third of Ethiopian diet consists of injera and it accounts for about two-thirds of the daily protein intake of the Ethiopian population. Injera has a high nutritional value, as it is rich in calcium and iron (Neela and Fanta, 2020). Unfortunately, injera has a shelf life of only 3-4 days essentially due to mould spoilage. The use of weak organic acid as preservative is allowed in acidic foods, primarily as mould inhibitors. Mould spoilage is a serious problem that affects the shelf life of injera, the staple Ethiopian fermented bread. Injera is made from teff (*Eragrostis tef*) but other cereals may also be used in combination with teff. It is a common practice to discard moldy injera, however, in times of food scarcity, moldy injera is sun dried and prepared for consumption (Gashe, 1985). The effect of chemical preservatives such as benzoic acid, sodium benzoate and potassium sorbate and calcium propionate were investigated to prolong shelf life of injera (Ashagrie and Abate, 2012). These preservatives inhibit yeast and mould growth, being also effective against a wide range of bacteria as these chemicals are active in foods of low pH value and essentially in effective in foods at neutral pH values (Santini *et al*., 2009). These three compounds tend to be highly specific against moulds, with the inhibitory action being primarily fungi static rather than fungicidal. This acid and its calcium and sodium salts are permitted in breads, cakes, certain cheese and other foods. Potassium salt is commonly used because it is more stable than the acid form (Venturini *et al*., 2002). The inclusion of sorbates or benzoates in the right proportion after completion of fermentation and immediately before baking may reduce the spoilage of injera that is due to mould. The combined action of two or more preservatives is more effective in inhibiting the growth of microorganisms, which could be due to a synergistic effect among the preservatives. (Ashagrie and Abate, 2012) and are permissible in foods at up to 0.1% level (Dougharie*t et al.,* 2007; Jay, 2000). Consumption of fermented foods has a beneficial health effect for human beings as well as animal. The earlier studies on the injera and/or (breads made from various species of teff showed positive sensory attributes (taste, texture, appearance and over all acceptability) similar to those of the traditional injera made using the common tef species flour (Ghebrehiwot *et al*., 2016; Leykum *et al*., 2020).

Traditional bread

The bread Ambasha, other unique foods/beverages are predominantly in use and the culinary art has been inherited for centuries (Lyons 2007). The Ethiopian traditional bread Dabo is a thick, spiced wheat bread. There are many variations, some including cardamom, rosemary, dry ginger powder or other spices are added and fermenting the raw

and refined wheat flour and sometimes mixed with starch prepared from the root of Ensete (the false banana). Foods prepared from Ensete include bread, ferfer (a type of flatbread or injera). The fermentation of bread was achieved by using a mixture of yeast and lactic acid bacteria maintained in a dough medium. European tradition for consumption of bread seems to spread over the world, including regions like South-East Asia and Africa, as a result of the strong impact of European eating habits. Yeast-fermented breads in Europe and the United States are mostly based on wheat, although rye is commonly used for some popular bread types in Scandinavia and other northern European countries. Ambasha, relatively thin circular bread Ehbist are the traditional breads known in the Tigray region. Ambasha is triangularly sliced to serve while Ebist, thick celebrity bread is sliced into cubes by elder after praying in a religious way. Both Ambasha and Ebist are fermented traditional way commonly prepared from wheat flour. In Africa strong traditions exist for fermentation of cereals, with yeast playing a significant role in bread. In Ethiopia a large variety of bread is prepared during festivals as well as for breakfast. The fermented duff is placed on top of metal plate and covered with Ensete leaves and baked on the fire. This bread is also preserved inside baskets without addition of any preservatives and usually consumed with within two to three days. Ethiopia has immense indigenous knowledge associated with traditional fermented food preparation including the bread varieties which can be upgraded in technology to enhance production efficiency, food security and livelihood of people (Negussie *et al*., 2017). In order to improve the trade of the traditional foods the factors contributing to lack of consumer appeal and preference of indigenously manufactured foods need to be upgraded and strategies should be in the production system especially on the use of starter cultures, stabilization of spontaneous fermentations, production of food processing enzymes fuel efficiency presentation, preservation and marketing (Achi, 2005).

The consumption of Ethiopian indigenous food contributes to the prevention of many diseases and conditions that can result from an unbalanced diet. The consumption of Injera (Ethiopian flatbread) as a staple food contributes to the prevention of many diseases like anemia, obesity, bone disease and diabetes. According to Bultosa and Taylor (2004), the proximate composition of Tef is reported to be 9.4%-13.3% protein, 73% carbohydrate, 1.98%-3.5% crude fiber, 2.0%-3.1% fat and 2.7%-3.0% ash. It is rich in calcium, iron and protein and possesses an impressive set of amino acids. Furthermore, its sodium, saturated fat and cholesterol contents are low as compared to other cereals. Additionally, it does not contain gluten and is an increasingly important dietary component for individuals who suffer from gluten intolerance (Boka *et al.,* 2013). Furthermore, a study on antioxidant capacity, total phenolics and nutritional content in selected Ethiopian staple food ingredients revealed that Tef has a potential for developing value added food products (Forsido *et al*., 2013) with nutritional and health benefit components.

CONCLUSION

The Ethiopian staple foods Injera and Bread have been known as the healthy foods due to their nutritive value and digestibility. The rising cost of the food grains in the country force the families to choose better alternatives for the production of these foods and hence the taste and nutritive value may vary form the traditional preparation and also the fermentation organisms and their efficacy in imparting the quality aspects. There is necessity to validate the suitability of the combinations of raw materials and the starters and their preservation to produce tasty, appealing and healthy traditional foods of Ethiopia.

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