Available online at www.worldscientificnews.com

World Scientific News

An International Scientific Journal

WSN 136 (2019) 159-172 EISSN 2392-2192

Efficiency of Locally Available Spices to Improve Shelf Life and Sensory Attributes of Teff *Injera*

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ABSTRACT

Injera is one of the fermented foods that is made from different cereals, including sorghum, teff, maize, wheat, barley, or a combination of some of these cereals. Despite the fact that *injera* is a favorite staple food, mould spoilage caused by *Aspergillus*, *Penicillium*, *Mucur* and *Rhizopus* spps is a serious problem that affects the shelf life of *injera*, the staple Ethiopian fermented bread. There were no reports on the efficiency of spices on shelf life and sensory attributes of any of the traditional Ethiopian fermented foods especially in teff *injera*. Therefore, this study was carried out to evaluate the efficiency of locally available spices to enhance the shelf life and sensory attributes of teff *injera*. Isolation and identification of fungi that spoiled *injera* was carried out by standard procedures. The efficiency of spices to increase shelf life of injera was evaluated in *vivo* and sensory attributes of preserved *injera* was evaluated by 30 panelists. The results revealed that four types of fungal species belonging to the genera of *Penicillium, Aspergillus, Rhizopus* and *Mucur* species were isolated from spoiled teff *injera*. Teff *injera* containing powder and water extract of 2% *N. sativa* were the most preferred in terms of taste with mean rating of 6.9; ethanol extracts of 2% *N. sativa* was the most preferred in terms of colour and allover acceptance with mean rating of 6.9and 6.93 respectively. On the basis of the current findings, tested spices could be a good candidate to improve the shelf life and sensory attributes of teff *injera*. Therefore, further studies are needed to study their toxicology and isolate the bio-active components responsible for shelf life and sensory improvement from these plants.

***Keywords*:** *Injera*, Spices, Moulds, Shelf life, Sensory evaluation, Debre Tabor, fermented foods

(Received 21 September 2019; Accepted 09 October 2019; Date of Publication 10 October 2019)

1. INTRODUCTION

Food preparation is predominantly a household phenomenon in Ethiopia. In cases where 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 (Askal and Kebede, 2013). These fermented foods are prepared using various techniques, raw materials and microorganisms, which vary from place to place (CI-ROFA, 2002).

The outcome and quality of spontaneous food fermentation may not be predictable and it is a major problem in African fermented foods (Achi, 2005). Generally, food fermentation relies on chance inoculation (that is either natural contamination or back slopping) which results in a product of inconsistent quality (Kimaryo *et al*., 2000). In order to maintain and sustain African indigenous fermented foods and beverages, controlled fermentation (Sadeghi *et al*., 2009; Agarry *et al*., 2010) and product quality characteristics (Kabeir *et al*., 2004; Theodore *et al*., 2007 and Taiwo, 2009) are strongly recommended.

A wide variety of fermented foods and beverages are consumed in Ethiopia. These include *injera, kocho, tella, awaze, borde* and *tej*. *Injera* is one of the fermented foods that is made from different cereals, including sorghum, teff, corn, wheat, barley, or a combination of some of these cereals. *Injera* from teff (*Eragrostis tef*) is much more relished by most Ethiopians, than that from any other source. *Injera* is a pancake-like food usually obtained after the flour of cereals has been subjected to 24 to 96 hrs of traditional fermentation depending on the ambient temperature (Askal and Kebede, 2013). It has a high nutritional value, as it is rich in calcium and iron. Unfortunately, *injera* has a shelf life of only 3-4 days essentially due to microbial spoilage. It is a common practice to discard mouldy *injera*. However, in times of food scarcity, mouldy *injera* is sun dried and prepared for consumption. This may cause many food borne diseases because fungal spores can resist sun ray.

Food spoilage is a serious issue in developing countries because of inadequate processing and refrigeration facilities. Food spoilage microorganisms are those, which upon growth in a food, produce undesirable flavour (odour), texture and appearance, and make food unsuitable for human consumption. Among microbial spoilage, mould spoilage is a serious problem that affects the shelf life of *injera*, the staple Ethiopian fermented bread. *Aspergillus niger*, *Penicillium* sp. and *Rhizopus* sp. were found to be responsible for *injera* spoilage (Ashagrie and Abate, 2012). The use of weak organic acid as preservative is allowed in acidic foods, primarily as mould inhibitors (Ashagrie and Abate, 2012).

In addition to weak organic acids antimicrobial properties of spices have been documented in recent years and interest continues to the present (Shami *et al*., 1985; Akgul and Kivanç, 1988; Cosentino *et al*., 1999; Domans and Deans, 2000; Radhakrishanan and Velusamy, 2003). A spice is a dried seed, fruit, root, bark or vegetative substance used in nutritionally insignificant quantities as a food additive for the purpose of flavoring, and sometimes as a preservative by killing or preventing the growth of harmful bacteria. Many of these substances are also used for other purposes, such as medicine, religious rituals, cosmetics, perfumery, or eating as vegetables (SSSCC, 2010).

Despite the fact that antimicrobial properties of spices have been documented and the use of spices has both economic and health contribution to prevent food related diseases caused by spoilage fungi, still little information is available emphasizing the preservative and antimicrobial role of spices in the prevention of foods of the microbial action (Arora and Kaur, 1999). Moreover, there are no reports on the efficiency of spices to improve shelf life and

sensory attributes in any of the traditional Ethiopian fermented foods especially in *injera*. Therefore, this study was designed to evaluate the efficiency of locally available spices to enhance shelf life and sensory characteristics of *injera*.

2. MATERIALS AND METHODS

2. 1. Study site

Experiments were carried out from December 2017 to July 2018 in the Microbiological Laboratory of the Biology Department; Debre Tabor University at ambient temperature of 9.5-23 ºC during the study period.

2. 2. Study Design

Cross sectional experimental design was used to evaluate the efficiency of locally available spices to improve shelf life and sensory attributes of *injera*.

2. 3. Cereal Sampling

Ten kg of teff samples were bought from Debre Tabor town open market. It was cleaned of dust, other seeds and foreign matter. On the day of fermentation, the cereals were grounded into fine powder in a local flourmill and sieved in sieve before the start of batter preparation and fermentation.

2. 4. Preparation of *Injera*

The teff *injera* samples were prepared at home in the same way as done traditionally in every household. Accordingly, teff flour was mixed with clean water in the ratio 1:2 (w/v) and 16 % of starter (*ersho*) by the weight of the flour and kneaded by hand in a bowl in the traditional way. The resultant dough was allowed to ferment for 3 days at ambient temperature. After this primary fermentation, the surface water formed on the top of the dough was discarded. For every 1 kg of original flour, 200 ml of the fermented mixture was mixed with 400 ml of water and brought to boil (traditionally known as '*absit*' making). It was cooled to about 45 ºC before it will be added into the main part of the dough. The main dough was thinned by adding water equal to the original weight of the flour and stirred for 15 minutes. The batter was left covered for 2 hours for secondary fermentation. After 2 hours, the *absit* was added to the thinned dough and mixed very well (known as batter making). The batter was left for about 30 min to rise (the second fermentation), before baking was commenced. Some more water was added to thin down and form the right batter consistency. Finally, about half a litter of batter was poured onto the hot clay griddle in a circular motion from the outside, working towards the centre. After 2-3 minutes of cooking using traditional baking equipment (*metad*), the *injera* was removed and stored in a traditional basket container *messob* (Fellow, 1997). The *injera* was then transported from home to the laboratory for further study.

2. 5. Isolation and Identification of Fungi that Spoil *Injera*

The *injera* samples were kept in the laboratory at ambient temperature for at least 3 days until mould colonies started to appear visually on its surface. After three days of storage at ambient temperature of 9.5-23 ºC, depending upon their difference in color and other colony

morphology, the spoilage moulds were directly transferred into potato dextrose agar (PDA) that contained 60 mg/L chloramphenicol as an antibacterial agent. The cultures were then incubated at room temperature to induce the growth of the fungi for five days. To get a pure culture, each of the emerging colonies was transferred aseptically to fresh PDA agar plates for identification.

The fungi will be maintained on PDA agar slants in the refrigerator (4 ºC).

Identification to the genus level of the fungal isolates was based on morphological characterization that places emphasis on colony characteristics, spore size and shape and vegetative morphology of isolates within genus and species level (Barnett and Hunter, 1972). For this purpose, slide cultures were prepared for each of the isolates.

2. 6. Evaluation of the Efficiency of Spices to Improve Shelf Life of *Injera*

2. 6. 1. Preparation of spices extracts

Nigella sativa seeds, *Trigonella foenum* seeds, *Curcuma longa* rhizomes, *Carum copticum* seeds and *Coriandrum sativum* seeds were bought from Debre tabor town open market. It was clean and washed in sterile distilled water. Dry spices (10 gm each) were grind with grinder and sieved through mesh cloth to get the fine powder. Powdered spices were soaked in 100 ml of distilled water and will be kept at room temperature for 24 hours and filtered using Whatman no. 1 filter paper. The filtrate was heated at 40-50 °C using water baths, until thick paste is formed. The thick paste was considered as 100% concentration of extract. These extracts were stored at 4 °C in refrigerator. The ethanol extract also was prepared following same procedure with the exception of solvent, which will be 95% ethanol instead of sterilized distilled water (Sana and Ifra, 2012).

2. 6. 2. Preparation of spiced *injera*

Two (2%) powder, ethanol and water extract of each spice was added on the *injera* batters just before baking (Kocic and Dimic, 2013). After the baking process, the experimental and control *injera* samples were stored in the laboratory at ambient temperature.

2. 7. Evaluation of Shelf life of *Injera*

The *injera* samples were examined for visible signs of mould growth on the crust every day. The shelf life is defined as the period in days during which the spoilage caused by microorganisms was first observed. The shelf life was expressed in relation to the corresponding control (Katsinis *et al*., 2008).

2. 8. Evaluation of Sensory Attributes of *Injera*

Injera prepared from the different cereals preserved with different spices were evaluated for its sensory acceptability by using *injera* consumer panels based on the taste, aroma colour, and the overall acceptance of cereal *injera* on a 7-point hedonic scale. On the scale 1-dislike very much, 2-dislike much, 3-dislike, 4-neither like nor dislike,5-like,6- like much,7-like very much (Meilgaard *et al*., 2007).

2. 9. Data Collection and Analysis

Laboratory based experiments was involved to collect data on fungi that spoil *injera*, efficacy of spice to improve sensory and shelf life of *injera*. After completion of data collection,

each measurement of the different variables were systematically organized into tables and figures and subsequently subjected to statistical analysis. Data analysis was done using SPSS Version 20 software. One-Way Analysis of Variance (ANOVA) and Duncan test were performed to evaluate differences in shelf life and sensory attributes of *injera* samples baked with powder, water and ethanol extracts of locally available spices. P-values less than 0.05 were considered statistically significant.

3. RESULTS AND DISCUSSIONS

3. 1. Fungi isolated from *Injera*

In this study, small white fungal colonies (visible to the naked eye) appeared on *injera* starting on the 3rd day of storage in a *messob*. The *injera* moulds were isolated at different times of storage at ambient temperature and viewed their morphology using a microscope. Fungal species belonging to the genera of *Penicillium, Aspergillus (A. niger), Rhizopus* and *Mucur* spps were isolated form *injera*.

3. 2. Efficiency of Spices to Improve Shelf life of *Injera*

In the current study, the efficiency of powder, water and ethanol extracts of spices on the shelf life of *injera* were shown in Tables and it was determined as the day in which mould was visible to the naked eye. Table 1 showed that, shelf life of teff *injera* containing 2 % powder, water extract and ethanol extract of *T. foenum* were (7, 7 and 9) days; *C. sativum* were (8, 8 and 11) days; *N. sativa* were (7, 8 and 10) days; *C. copticum* were (8, 7 and 9) days and *C. longa* were (5, 5 and 6) days respectively. While shelf life of Sorghum *injera* without spice was 3 days. Ethanol extract of *C. sativum* was the best of all tested spices followed by *N. sativa* which prolonged the shelf life of teff *injera* up to 11 and 10 days respectively. Ethanol extracts of *T. foenum* and *C. copticum* were also prolonged the shelf life of sorghum *injera* up to 9 days. The statistical analysis of the data showed that there were significant differences ($P < 0.05$) among the *injera* samples prepared with powder, water and ethanol extracts of spices on shelf life. The results also indicated that there were no significant differences ($P < 0.05$) among powder, water extract and ethanol extracts with the exception of *C. sativum* on shelf life of *injera*

Table 1. Shelf life of teff *injera* containing spices.

Injera samples	Shelf life			P
	Water	Powder	Ethanol	
Teff (Control)	3.33 ± 0.33^{a1}	3.33 ± 0.33^{a1}	3.33 ± 0.33^{a1}	1
Teff + 2% *T. foenum*	7 ± 0.58^{b1}	7.33 ± 0.33^{c12}	9 ± 0.58^{c2}	0.066
Teff + 2% *C. sativum*	8 ± 0.00^{b1}	7.67 ± 0.33^{c1}	11 ± 0.58^{c2}	0.002
Teff + 2% *N. sativa*	8.33 ± 0.9^{b12}	7.33 ± 0.33^{c1}	10.33 ± 0.9^{c2}	0.072

Teff + 2% *C. copticum*	8±0.58^{b1}	7±0.58^{c1}	9.33±0.9^{c1}	0.135
Teff + 2% *C. longa*	5±0.58^{a1}	5±0.58^{b1}	6.33±0.33^{a1}	0.183
p	0.000	0.000	0.000	

Values are expressed as mean of three replicates± S.E.M. Values with different letters in the same row at each extract and numbers in the same column at each injera sample indicate statistically significant differences (Duncan's test, $p < 0.05$).

3. 3. Efficiency of Spices to Improve Sensory Attribute of *Injera*

In the current study, panels of 30 judges were used to describe the degree of consumer acceptance and satisfaction to different cereals *injera* prepared using different spices. The sensory responses of the panels to *injera* prepared from different spices blends of flours of sorghum, barley, wheat, maize and teff were provided in Tables.

Table 2 showed that the results of sensory analysis of teff *injera* containing 2 % powder, water extract and ethanol extract of five spices. It was observed that, *injera* sample prepared from 2 % powder of *N. sativa* was the most preferred in terms of taste, aroma, colour and all over acceptance with mean rating of 6.9, 6.93,6.73 and 6.97 respectively. *Injera* sample containing 2 % powder of *C. longa* was the least preferred in terms of all sensory attributes.

Table 2. Mean score for hedonic sensory attributes of teff *injera* samples.

Injera samples	Powder			
	Test	Aroma	Colour	Overall acceptance
Teff (Control)	6.53±0.1^{ab}	6.6±0.1^{ab}	6.57±0.1^{b}	6.7±0.08^{ab}
Teff + 2 % *T. foenum*	6.53±0.1^{ab}	6.63±0.1^{ab}	6.7±0.08^{b}	6.83±0.07^{ab}
Teff + 2 % *C. sativum*	6.37±0.12^{a}	6.6±0.12^{ab}	6.6±0.1^{b}	6.83±0.07^{ab}
Teff + 2 % *N. sativa*	6.9±0.06^{b}	6.93±0.05^{b}	6.73±0.11^{b}	6.97±0.03^{b}
Teff + 2 % *C. copticum*	6.57±0.14^{ab}	6.77±0.1^{ab}	6.63±0.12^{b}	6.77±0.08^{ab}
Teff + 2 % *C. longa*	6.5±0.13^{ab}	6.47±0.15^{a}	5.9±0.21^{a}	6.53±0.14^{a}
P	0.036	0.036	0.000	0.15
Water extracts				
Teff (Control)	6.53±0.1^{a}	6.6±0.1^{a}	6.57±0.1^{a}	6.7±0.08^{a}
Teff + 2 % *T. foenum*	6.5±0.1^{a}	6.73±0.1^{a}	6.5±0.13^{a}	6.73±0.08^{a}
Teff + 2 % *C. sativum*	6.7±0.08^{ab}	6.8±0.07^{a}	6.87±0.06^{a}	6.73±0.12^{a}
Teff + 2 % *N. sativa*	6.9±0.06^{b}	6.87±0.06^{a}	6.8±0.07^{a}	6.87±0.06^{a}

Teff + 2 % *C. copticum*	6.7±0.12^{ab}	6.8±0.07^{a}	6.7±0.13^{a}	6.83±0.07^{a}
Teff + 2 % *C. longa*	6.63±0.09^{ab}	6.6±0.1^{a}	6.6±0.12^{a}	6.7±0.1^{a}
P	0.041	0.108	0.128	0.652
Ethanol extracts				
Teff (Control)	6.53±0.1^{a}	6.33±0.1^{a}	6.57±0.1^{a}	6.7±0.08^{a}
Teff + 2 % *T. foenum*	6.57±0.1^{a}	6.7±0.08^{a}	6.7±0.08^{a}	6.77±0.08^{a}
Teff + 2 % *C. sativum*	6.67±0.15^{a}	6.77±0.11^{a}	6.73±0.08^{a}	6.8±0.07^{a}
Teff + 2 % *N. sativa*	6.83±0.07^{a}	6.73±0.08^{a}	6.9±0.06^{a}	6.93±0.05^{a}
Teff + 2 % *C. copticum*	6.8±0.07^{a}	6.73±0.1^{a}	6.6±0.1^{a}	6.9±0.1^{a}
Teff + 2 % *C. longa*	6.73±0.12^{a}	6.63±0.09^{a}	6.63±0.09^{a}	6.77±0.1^{a}
p	0.213	0.791	0.085	0.315

Values are expressed as mean of three replicates± S.E.M. Values with different letters in the same column at each injera sample indicate statistically significant differences (Duncan's test, $p < 0.05$).

Teff *injera* prepared with 2 % water extract of *N. sativa* was the most preferred in terms of taste, aroma and allover acceptance with mean rating of 6.9, 6.87 and 6.87 respectively. *Injera* with *C. sativum* was the most preferred in terms of color with mean rating of 6.87. On the other hand injera sample with 2 % water extract of *C. longa* and injera samples without spice (control) were the least preferred in terms of aroma and allover acceptance with mean rating of 6.6 and 6.7 respectively while injera samples without spice was the least preferred in terms of taste and color with mean rating of 6.53 and 6.57 respectively.

Regarding to ethanol extract, teff injera with 2% of *N. sativa* was the most preferred, in terms of taste, color and allover acceptance with mean rating of 6.83, 6.9 and 6.93 respectively. While *Injera* with *C. sativum* was the most preferred in terms of aroma with mean rating of 6.77, *injera* sample without spice was the least preferred in terms of all sensory attributes. Results showed that there was a statistically significant difference in the taste, aroma and colour of the six *injera* samples with powder of spices. there were no a statistically significant difference in all sensory attributes of the six *injera* samples with ethanol extracts of spices, while there were a statistically significant difference in the taste of the six *injera* samples with water extracts of spices ($P < 0.05$).

4. DISCUSSION

4. 1. Fungi Isolated from Spoiled *Injera*

In bakery products, the baking temperature is generally sufficient to destroy these organisms; contamination might arise from mould spores derived from the atmosphere or from surfaces during the cooling, finishing and wrapping procedures (Gock *et al.*, 2003). A variety

of fungal species are responsible for the spoilage of each kind of food (Filtenborg *et al*, 1996). The most common type of microbial spoilage is mould growth and in many cases it is the major factor governing shelf-life (Marin, 2005). In the present investigation four types of fungal species belonging to the genera of *Penicillium, Aspergillus, Rhizopus and Mucur* species were isolated from spoiled *injera*. This finding was in accordance with that of Guynot *et al., (*2005) and Gerez *et al. (*2009) who reported that the most wide spread and probably most important moulds, in terms of biodeterioration of bakery products are species of *Aspergillus, Penicillium, Eurotium* and *Fusarium.* (Guynot *et al.,* 2003) also reported that other species, such as those of *Cladosporium, Mucor* and *Rhizopus*, have been found less frequently in bakery products. According to Filtenborg *et al.,* (1996) each individual food type is normally infected by a limited number of fungi.

Apart from the repelling sight of visible growth, fungi are also responsible for off-flavour formation and the production of mycotoxins and allergenic compounds (Gutierrez *et al*., 2009). In this study a yellowish pigment on the surface of a spoiled injera had been observed on injera was kept for 11 days. Since both *Penicillium and Aspergillus* sp. are toxin producing moulds, a spoiled injera could also be a source of toxic compounds that might be menace to human health, although further investigation is needed to know for sure whether this yellowish pigment released by this moulds was actually a toxin or not.

4. 2. Efficiency of Spices on Shelf life of *Injera*

In the present investigation the efficiency of powder, water and ethanol extracts of spices was evaluated to increase the shelf life of some cereals *injera.* It was determined as the day in which mould was visible to the naked eye. The results showed that the all powder, water and ethanol extracts of spices were effective to increase the shelf life of *injera* by inhibiting moulds responsible for *injera* spoilage depending on the types of spices and cereals. This was shown by increase the shelf life of *injera* samples containing spices as compared to the sample without spices (the controls). The shelf life of *injera* without spices (control) was 3-4 days depending on the types of cereals. These results were supported by Ashagrie and Abate (2012) who reported that the shelf life of injera samples containing chemical preservatives was increased as compared to the sample without preservatives (the controls). Many researchers also study the efficiency of many spices against food borne pathogens using several extracts (Shelef *et al*., 1980; Akgul and Kivanc, 1988; Aureli *et al*., 1992; Conner, 1993; Al-Jedah *et al*. 2000)

According to results obtained in the present investigation Ethanol extract of *C. sativum* was the best of all tested spices followed by *N. sativa* which prolonged the shelf life of teff *injera* up to 11 and 10 days respectively. However powder and water extract of *C. longa* was the least which prolonged the shelf life of teff *injera* up to 5 days.

The unspiced (control) *injera* samples had the least shelf life indicating the potential of the spices in producing food product having long shelf life. This supports the facts that spices are believed to have medicinal value and have desirable determinative influences on the shelf life of bakery products when used. The current finding was supported by some researchers who reported that different spices can inhibit the growth of microorganisms and increased the shelf life of different foods.

Chow (1998) compared the antifungal preservative effect of ground cassia and powdered garlic on the shelf-life of bread. At 2 % concentration, cassia delayed mold growth in bread for 9.5 days and bread containing 2 % garlic had a shelf life-life of 9 days. Chomodao *et al.* (2009) studied that the addition of turmeric residue can extend the shelf life of bread for 4 days at room

temperature and 5 days at 25 ºC. Lean and Mohamed (1999) indicated that turmeric showed antioxidant and antimycotic activities in butter cake. In another study by Giuseppe *et al*. (2009), common spoilage microorganisms in bread were inhibited by water-soluble extract of *Amaranthus* spp. seeds and it was indicated that may be also exerted as sensory improving agent in wheat and gluten-free breads.

Studies done by Shelef *et al*., 1980; Aureli *et al*., 1992 and Conner, 1993 showed that cinnamon, clove, pimento, thyme, oregano and rosemary had strong and consistent inhibitory effect against several pathogen and spoiling bacteria. Similar results were seen in different studies in which positive effects of plant extracts (such as, thyme, oregano, clove and rosemary) on food (Ozyurt *et al*., 2011; Bensid *et al*., 2014). These findings support my results even if the plants and microorganisms are different.

Akgul and Kivanc (1988) also studied antifungal activity of selected Turkish spices (black cumin, coriander, cumin, dill, laurel, oregano, parsley, spearmint, white mustard) on some foodborne fungi and found that oregano ground (1.0, 1.5, 2.0% w/v) and its essential oil (0.05%, 0.025%) showed inhibitory effect on *Aspergillus flavus, A. niger, Geotrichum candidum, Mucor* sp., *Penicillim roqueforti* and oregano essential oil exhibited higher inhibitory effect than sorbic acid. Kordsardoui *et al*. (2011) studied antifungal properties of *Zataria multiflora Boiss* essential oil (ZMEO) in cake. According to this study, application of ZMEO at concentrations of 500, 1000 and 1500 ppm reduced mold counts significantly during cake batter production.

Several researchers have described the antifungal activity of limonene, a terpenoid hydrocarbon isolated from coriander, against *Aspergillus niger*. According to Darughe *et al*. (2012) this essential oil could be used as natural antioxidant and antifungal in foodstuffs was in line with the current results.

4. 3. Sensory Evaluation of Spiced *Injera*

The current study also addressed sensory evaluation of different cereals *injera* prepared using different spices. 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 analyze 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. Sensory analysis of teff *injera* containing 2 % powder, water extract and ethanol extract of five spices. It was observed that, *injera* sample prepared from 2 % powder and water extract of *N. sativa* was the most preferred in terms of taste, aroma, colour and allover acceptance. *Injera* sample containing 2 % powder of *C. longa* was the least preferred in terms of all sensory attributes.

Teff injera prepared with 2 % water extract of *N. sativa* was the most preferred in terms of taste, aroma and allover acceptance with mean rating of 6.9, 6.87 and 6.87 respectively. *Injera* with *C. sativum* was the most preferred in terms of colour with mean rating of 6.87. On the other hand injera sample with 2 % water extract of C. *longa* and injera samples without spice (control) were the least preferred in terms of aroma and allover acceptance with mean rating of 6.6 and 6.7 respectively while injera samples without spice was the least preferred in terms of taste and colour with mean rating of 6.53 and 6.57 respectively.

Regarding to ethanol extract, teff injera with 2% of *N. sativa* was the most preferred, in terms of taste, color and allover acceptance with mean rating of 6.83, 6.9 and 6.93 respectively.

While *Injera* with *C. sativum* was the most preferred in terms of aroma with mean rating of 6.77, *injera* sample without spice was the least preferred in terms of all sensory attributes teff *injera* containing 2 % powder of *C. longa* was the least preferred in terms of colour, This could be due to the main bioactive components (curcumin) present in turmeric, which is responsible for the yellow color of turmeric (Tokusoglu *et al*, 2015). Most of spiced *injera* samples had highest ratings in all most the sensory attributes indicating the potential of the spices in producing acceptable food product. This supports the facts that spices are believed to have medicinal value (especially in African settings) and have desirable determinative influences on the overall organoleptic analysis when used.

Chomdao (2009) developed healthier bread by adding turmeric (*Curcuma longa*); whole turmeric powder (TP), turmeric essential oil (TEO) and turmeric residue (TR) from the essential oil extraction. The 0.10 per cent turmeric adding TP, TEO and TR were the most liked with the moderate score (6.08-6.90 overall liking score) from 25 panelists.

Drewnowski & Gomez- Carneros, 2000 reported that the crumb colour of bread with 8% turmeric powder had the lowest liking score. Since the colour of turmeric powder was light yellow, 2% substitution of turmeric powder did not interfere with the original colour of the bread made with wheat. The taste and overall acceptability of breads with turmeric powder at substitution levels of 0–4% had the highest liking score. The sensory characteristics liking results pointed out that a partial replacement of wheat flour with up to 4% turmeric powder in breads gives satisfactory overall consumer acceptability. However, bread which contained 6% or 8% turmeric was rated comparatively lower, which might be due to excessive amounts of volatiles and phenolic compounds, which can negatively affect the taste of food.

The essential oil contents in spices are noted for flavour and taste enhancer (Ekanem and Achinewhu, 1998). Spices add six basic tastes to finished products such as sweet, salty, bitter, sour, spicy and hot (Jay, 2017) Spices are not only used for flavouring food but are also used to enhance latent flavour of food (Hui *et al*., 2005). The results from the study showed that all the treatments were within the same range. A study by (Carraro *et al*., 2012) reported that the addition of spices and herbs in a reduced sodium content of bologna sausage resulted in better sensory attributes.

Adedeji and Ade-Omowaye (2013) reported that fried bean cake samples with *Aframomum danielli* and *Zingiber officinale* in different concentrations ranging from 0.2-1% concentration were well acceptable by the panelists in terms of appearance, taste, texture, flavour and overall acceptability. The unspiced (control) samples had the least ratings in all the sensory attributes indicating the potential of the spices in producing acceptable food product. This supports the facts that spices are believed to have medicinal value (especially in African settings) and have desirable determinative influences on the overall organoleptic analysis when used (Wood *et al*., 2000).

5. CONCLUSION

Fungi are the most common spoilage microorganisms in *injera* products. The spices used in this study had prolonged the shelf life of *injera* for up to 11 days. However, further study on bioactive compounds of spice contributes to prolong shelf life of *injera* and effect of nutrients on *injera* shelf life and sensory attributes should be investigated. The outcome of this research has a significant implication in food security, economical and health aspects.

ACKNOWLEDGEMENTS

Author would like to thank DTU for providing financial support and Department of Biology for permit the laboratory to conduct this research. I am extremely indebted to my wife W/ro Hana Ayenew, my brother Yimesgen Geta and my friend Adissu Anteneh for their devotion and enormous contribution for this research by encoding the data. I am also grateful to Mr. Teshager Zerihun for assisting me during data entry and analysis. My heartfelt thanks go to staffs of Debre Tabor University for evaluating the sensory attributes of *injera.* Finally, I would like to thank Kindey Abate for his assistance during the laboratory works.

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