



Improvement of Injera Quality Through Incorporation of Fenugreek in Tef Flour

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Abstract: Injera is most commonly consumed food in Ethiopia. Traditionally, injera can be made from tef and other cereals. This study was conducted to determine the effect of fenugreek (raw, roasted and germinated) incorporation (1%, 3% and 5%) on nutritional composition, sensory quality and keeping quality of tef injera. Protein content was determined by Kjeldal method. Moisture and ash content were determined with oven and Furnace, respectively. Untrained but experienced panelists were used in sensory analysis. Days of storage was recorded and compared with control injera for shelf life determination. The result showed that injera enriched with 5% raw and roasted fenugreek had the highest crude protein contents and crude fiber compared with control (100% tef flour). Injera made with 5% raw fenugreek had less mold growth, which had recorded significantly the highest shelf life (five days). Sensory evaluation (appearance, taste, aroma, texture and overall acceptability) indicated that of all injera incorporated with 1% to 5% of fenugreek flour were more preferable than the control sample except the 5% raw fenugreek which was not preferred due to its bitterness taste. Furthermore, injera made with 5% raw fenugreek incorporation level showed lower taste perception due to its bitterness. From this study, it can be concluded that 1 to 5% of roasted and malted and 1 to 3% of raw fenugreek incorporation could significantly increases sensory acceptability of injera with improvement of some nutritional contents without any change on the Iron content.

Keywords: Injera Quality, Fenugreek, Tef Flour, Sensory Quality, Shelf Life, Tef Grain

1. Introduction

Injera is made from Tef (*Eragrostis tef* (zucc) trotter) which is the stable crop and most popular grain for making injera. Injera is considered to be two-third of Ethiopian diet and two-third of the daily protein intake of the population [1]. It is fermented traditional flat bread made from tef flour, water, and starter (ersho). Sometimes, tef flour is blended with other cereals for making of injera. Traditionally, Fenugreek is also incorporated in tef flour expecting to improve its quality.

Fenugreek contains 20-25% protein, 45-50% dietary fiber, 20-25% mucilaginous soluble fiber, 2-5% steroidal saponins, 6-8% fixed fatty acid, and essential oils.

Injera storage period does not exceed 3 days at room temperature under commonly stored condition due to mould growth. Three fungal types were identified to be responsible in the spoilage of injera [2]. But, it is expected that addition

of fenugreek to injera ingredients could increase shelf life of injera which may due to its antimicrobial activities.

Fenugreek (*Trigonella foenum – graecum* L.) seeds can be a good supplement to cereals because of its high protein (25%), lysine (5.7 g 116 g N) and insoluble dietary fiber (28%) besides being rich in calcium, and iron [3]. Fenugreek helps in cholesterol reduction [4]. This may be due to high content of fiber [5, 6].

In some parts of Ethiopia, injera is prepared by adding some fenugreek flour to tef to improve its baking quality. Because of this, the injera becomes softer and has a shiny appearance [7-9] suggested that fenugreek seed, which is rich in protein, is a good supplement if used with tef flour. Commonly, it is incorporated in tef flour as roasted, malted and raw fenugreek flour. [10] observed that there was enhancement in antioxidant activities of enriched injera with fenugreek at 95:5 ratio of tef flour to fenugreek, respectively.

However, there are limited information on the usage of

fenugreek as ingredients of injera for improving sensory quality and shelf life. This study, therefore, was designed to evaluate the influence of the blend ratio and processing condition of fenugreek on injera sensory quality, nutritive value and shelf life of injera.

2. Materials and Methods

2.1. Raw Material Collection and Preparation

The sample of the fenugreek (Chala variety) and tef (Quncho variety) was taken from Debre Zeit Agricultural Research Center (DZARC). First, the whole samples of fenugreek was divided into three parts after cleaning. One part (M) was soaked in distil water for overnight and then transferred to other airtight container and stay there for three days for malting. Then the malted fenugreek was dried in an oven at 60°C. Fenugreek was prepared according to procedure of [6]. Both the malted and one other part (RO) were roasted separately until changed to deep brown color. Then all malted (M), Roasted (RO) and unroasted or Raw (RW) were milled with miller and packed into separate polyethylene bags. The tef samples were cleaned and ground by using miller and the prepared flour was sieved through 1mm sieve. All fenugreek flour were mixed with tef flour after milling at 1%, 3%, and 5% of each sample type and packed in polyethylene bags for later injera making and other analysis.

Table 1. The Level of Incorporation of Fenugreek to Tef Flour.

Usage of Fenugreek	Incorporation level of FF:TF			
	1:99	3:97	5:95	0:100
Raw	RW 1%	RW 3%	RW 5%	Control
Roasted	RO 1%	RO 3%	RO 5%	
Malted	M 1%	M 3%	M 5%	

FF – Flour of Fenugreek, TF – Tef Flour.

2.2. Compositional Analyses

The prepared Injera was used for analysis of protein, fiber, mineral analysis, sensory acceptability, and shelf life determination. Samples were taken from each injera enriched with fenugreek and the control. Crude protein, total ashes, crude fat, crude fiber, moisture and minerals (Ca, P, Fe, Zn) determination was done as procedures of [11] official methods of food analysis. Total carbohydrate content was determined by difference method.

2.3. Shelf Life Determination

The injera samples were examined for visible signs of mould growth on the crust every day. The microbial shelf life was 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 [12].

2.4. Sensory Evaluation

The appearance, taste, color, aroma and overall acceptability were analyzed. Twenty untrained but

experienced panelists were selected from the staff members. All samples were presented for them on the same trays. Water was provided to rinse their mouth before and in between the test. Five point hedonic test (5-like very much, 4-like, 3-neither like nor dislike, 2-dislike, 1-dislike very much) was used.

2.5. Statistical Analysis

Data were analyzed by analysis of variance using general Linear Model procedure of SAS software (SAS institute, 2002). Differences among means with $P < 0.05$ were accepted as representing statistically significant differences. Duncan multiple comparisons were deployed to separate treatment means.

3. Result and Discussion

3.1. Proximate and Minerals Composition

The nutritional composition of fenugreek and tef grains is presented in Table 2. Only the moisture contents of the control and injera with roasted fenugreek (1%) were significantly different ($p \leq 0.05$) which might be due to the minor difference in thickness of sampled injera which is uncontrolled. There was no significant difference in ash content of all the injera. However, there was numerical increase with increasing level of fenugreek flour incorporation. It was reported that germinated fenugreek has about 2.94% ash content [6]. [13] has reported that tef has 2.6% ash content. This shows that both fenugreek and tef have somewhat similar ash contents which may be the cause for insignificance of ash contents in this study.

The highest protein Contents were observed in injera enriched with RW 5% (11.00%) and Ro 5% (10.80%) which were significantly different from the control (9.97%). This shows that adding of 5% fenugreek flour to injera can improve its protein content. The amount of protein content was increased with increasing the percentage of the fenugreek flour. This result is in agreement with previous report that shows improvement of injera protein by addition of fenugreek flour [13]. The raw fenugreek protein content had ranged between 27.11- 29.89% [6] and 32.85% of germinated protein [14] whereas the protein content of tef is around 10-12%. This small increment of protein resulted from the high protein contents of fenugreek (20-30%) [15]. This protein in fenugreek is rich in tryptophan and lysine which is not found in cereals. Because, addition of fenugreek to injera is advantageous in having this essential amino acids in our daily foods in addition to increasing sensory acceptance of the injera (Table 4).

All injera incorporated with fenugreek had significantly higher fat content than that of control except M 1% and RW 1%. The highest fat content was obtained in M 5% followed by RW 5% and RO 5%, respectively. There was a report that the fat content of all Injera prepared with fenugreek (1, 5 and 10%) were significantly ($p < 0.05$) different from the control [13]. This is in agreement with the current study. This may be

due to high content of crude fat (7.91%,) in fenugreek [6]. This increased amount of fat may help in improving

appearance (shininess) of injera (Table 4) which is the important injera's sensory parameter.

Table 2. The proximate Composition of Injera Made of mixture of Tef and Fenugreek flour.

Tr	Proximate Composition (g/100g)						Energy (kcal)
	Moisture	Ash	Protein	Fat	Fiber	Carbohydrate	
Control	4.90±0.23 ^a	2.63± 0.04 ^{ab}	9.97±0.09 ^c	1.27±0.09 ^c	3.97 ± 0.26 ^a	77.38±0.45 ^a	360.52±2.19 ^b
RO 1%	4.97±0.04 ^a	2.50±0.09 ^b	10.23±0.08 ^{bc}	1.7± 0.11 ^{abcd}	4.21 ±0.30 ^a	76.42±0.16 ^{ab}	361.65±2.26 ^{ab}
M 1%	4.47±0.15 ^{bc}	2.60± 0.09 ^{ab}	10.03±0.09 ^c	1.43±0.04 ^{dc}	5.00±0.87 ^a	76.46±0.69 ^{ab}	360.78±2.69 ^b
RW 1%	4.23±0.14 ^{cd}	2.60±0.02 ^{ab}	10.10±0.04 ^c	1.43±0.06 ^{de}	4.93±0.33 ^a	76.72±0.52 ^{ab}	360.20±1.65 ^{ab}
RO 3%	4.70±0.00 ^{ab}	2.73± 0.03 ^a	10.43±0.23 ^{abc}	1.73±0.10 ^{abc}	4.220±0.43 ^a	76.39±0.28 ^{ab}	363.04±1.27 ^{ab}
M 3%	4.63±0.05 ^{ab}	2.63±0.02 ^{ab}	10.10±0.07 ^c	1.60±0.06 ^{bcd}	5.12±0.03 ^a	75.80±0.05 ^b	358.12±0.51 ^b
RW 3%	4.43±0.03 ^{bc}	2.67± 0.01 ^a	10.27±0.03 ^{bc}	1.50±0.01 ^{cde}	5.03±0.22 ^a	76.26±0.24 ^{ab}	359.02±0.95 ^b
RO 5%	4.00±0.05 ^{de}	2.73± 0.05 ^a	10.80±0.51 ^{ab}	1.70±0.10 ^{abcd}	4.34±0.43 ^a	76.61±0.74 ^a	364.66±1.27 ^a
M 5%	4.43±0.1 ^{bc}	2.67± 0.02 ^a	10.63±0.09 ^{abc}	1.90±0.12 ^a	5.13±0.39 ^a	76.27±0.32 ^{ab}	364.64±1.30 ^a
RW 5%	3.87±0.03 ^e	2.67±0.04 ^a	11.00±0.25 ^a	1.80±0.10 ^{ab}	5.07±55 ^a	75.60±0.92 ^b	362.67±2.21 ^{ab}
CV	4.09	3.02	3.38	9.09	16.34	1.161	0.841

Results were interpreted as Mean ± SE, Treatments that share the same letters are not significantly different (p<0.05). RW=Raw, RO= Roasted, The M=Malted, Tr =treatment, Kcal=kilocalorie.

The highest and lowest crude fiber contents were recorded from malted fenugreek (M 5%) flour and the control, respectively. With increasing, the proportion of fenugreek, the crude fiber content of injera was somewhat increased. [13] has reported that all fenugreek-incorporated Injera (1, 5 and 10%) were significantly from the control. However, in this study, there is only increment in number with no significance increase. This small increment can be due to high content fiber in fenugreek [5, 6] which may further increase with increasing its percentage which is not economical and also sensorially may not acceptable. For instance, in this study, the injera with 5% fenugreek was less preferred by panelists due to its bitterness that may be caused by tannins and other polyphenol compounds.

The total carbohydrate contents of blended *Injera* were (p<0.05) decreased as compared to control. The significance difference was seen in M 3% and Rw 5%. This could be due to higher carbohydrate content of tef than fenugreek. The increased fenugreek inclusion showed lower carbohydrate content of *Injera*. The energy contents of all fenugreek incorporated *Injera*

of RO 5% and M 5% were significantly (p<0.05) increased as compared to control. This could be due to higher content of fat in fenugreek than in tef. The increased fenugreek inclusion showed higher energy content of *Injera*. This may come from the increased amount of fat in the treatment injera.

The addition to proximate composition fenugreek flour had a significant effect on mineral composition of injera. The highest calcium (Ca) content was recorded from injera incorporated with 5% roasted fenugreek flour (65.77mg/100g) followed by 3% roasted fenugreek (60.33mg/100g) which were significantly different from the control injera. The roasted fenugreek has more increased the Ca content than the malted and the raw fenugreek. This may be due to release of bounded Ca by Phytochemicals caused by heat during roasting. Even though not significant, it was observed in all treatments that addition of raw, roasted and malted fenugreek can increase the Ca content of injera numerically. This increment may be caused by higher Ca content of fenugreek (168.88mg/100g) [6]. The Ca content of tef is 61.33mg/100g which is less when compared with fenugreek [16].

Table 3. The Result of Mineral Composition and Shelf Life Test Mineral compositions (mg/100g) and Shelf life.

Treatments	Ca	Zn	Fe	P	Shelf life
Control	49.87±2.23 ^c	2.00±0.12 ^b	16.73±0.37 ^a	147.90±1.92 ^c	3.00±0.00 ^d
RO 1%	56.10±3.40 ^{bc}	2.27±0.08 ^{ab}	17.83±0.59 ^a	184.79±7.10 ^{ab}	3.00±0.00 ^d
M 1%	52.83±0.76 ^{bc}	2.10±0.05 ^b	17.46±0.32 ^a	145.29±8.33 ^c	2.00±0.00 ^c
RW 1%	54.43±2.10 ^{bc}	2.23±0.09 ^{ab}	17.24±0.35 ^a	155.00±13.2 ^{cde}	3.33±0.33 ^{cd}
RO 3%	60.33±0.83 ^{ab}	2.77±0.37 ^{ab}	17.12±2.03 ^a	188.00±3.33 ^{ab}	3.67±0.33 ^{bc}
M 3%	56.00±3.58 ^{bc}	2.20±0.06 ^{ab}	15.40±0.25 ^a	148.89±4.21 ^{de}	2.00±0.00 ^c
RW 3%	52.13±3.38 ^{bc}	2.30±0.15 ^{ab}	17.08±0.38 ^a	171.53±3.09 ^{abc}	4.00±0.00 ^b
RO 5%	65.77±0.75 ^a	2.47±0.18 ^{ab}	18.53±1.78 ^a	192.59±11.82 ^a	4.00±0.00 ^d
M 5%	57.20±3.87 ^{abc}	2.47±0.20 ^{ab}	17.42±1.24 ^a	146.60±4.81 ^c	2.00±0.00 ^c
RW 5%	53.10±3.93 ^{bc}	2.70±0.20 ^a	17.03±1.01 ^a	170.45±7.12 ^{bcd}	5.00±0.00 ^a
CV	8.67	12.95	2.827	7.807	8.323

The results were interpreted as Mean ± SD,. Treatments that share the same letters are not significantly different (p<0.05gm). Tr=Treatment, Ca=Calcium, Zn=Zink, Fe= Iron, P=Phosphorus, RW=Raw, RO= Roasted, M=Malted.

The highest Zn content was obtained from injera made with inclusion 5% raw fenugreek (2.70mg/100g) which was significantly different from the control (2.00mg/100g). Other

treatments were not statistically different but numerically increased. Different author observed that the Zn content of tef injera ranged between 1.00 to 2.77 mg/100g [7, 17]. This

shows that increasing the level of fenugreek increased Zn content of Injera. This increase in Zn content may be because of higher Zn content of fenugreek (4.43mg/100g) [16]. Inclusion of fenugreek has a positive effect in increasing injera's Zn content which is very important for human growth and mental development. Since small amount of this element is needed for our health enough amount can be obtained from injera enriched with fenugreek. Because, injera is stable food which is consumed daily and in high amount in Ethiopia than other food types. In such type of foods, a little improvement of Zn content and other important minerals can play a great role on our health.

Injera enriched with 5% roasted fenugreek had the highest Fe content (18.12) followed by 3% roasted (17.83) and raw fenugreek (17.24) with no significance difference among the treatments and the control samples. The report by [18] has shown that the Fe contents of tef are 19.60mg/100g and 11.5mg/100g for two tef cultivars. There are reports that fenugreek has Iron content of about 11.6mg/100g to 25.8mg/kg [19, 20]. The current study shows that the white tef has 16.73mg/kg which is in range of Iron content of fenugreek. This may be why inclusion of fenugreek flour had no made significant difference from the control sample.

The Injera enriched with 5% roasted fenugreek had the highest phosphorus contents (192.90mg/100g) as compared with the control sample (147.90mg/100g) and the 5% malted fenugreek flour (146.60mg/100g). Generally, the injera made with different processing conditions and different inclusion levels of fenugreek were significantly different ($p \leq 0.05$) from the control. Previous work shows that fenugreek phosphorus content ranged between 200 to 296mg/100g [21]. The phosphorus content of control injera (Quncho variety) contains 147.90mg/100g. The addition of fenugreek flour can increase *Injera's* phosphorus contents whereas the malted fenugreek has not shown any significant change. The P in malted fenugreek may form other complex compounds during germination accelerated through enzyme activation

that may decrease the amount of P found in injera samples in this study.

3.2. Shelf Life

The result recorded for injera made with 5% raw fenugreek flour has the highest shelf life (5 days) followed by injera enriched with 3% fenugreek flour (4 days) and they are significantly different ($p \leq 0.05$) from each other. The injera samples enriched with malted fenugreek flour (1%, 2%, and 5%) were found to decrease the average shelf life of normal injera from 3 days to two days. This may result from the activated enzyme during germination and degradation of polymers to disaccharides and monosaccharide, which may support microbial growth. It was reported that no any yeast and mold growth found in 60 days in cookies enriched with fresh and germinated fenugreek [22]. However, in current study the malted fenugreek inclusion decreased the shelf life of injera that may be due to degradation of large molecules to simple sugars that are easily available for microbial growth. The difference may be due to product difference in moisture content and other factors.

3.3. Sensory Evaluation

The results from sensory panelist shows that texture of injera with 1% malted fenugreek is 4.50 followed by injera with 5% and 3% malted fenugreek which are 4.35 and 4.30, respectively. They are significantly different ($p \leq 0.05$) from the control (100%tef). But, the results of the injera with roasted and raw fenugreek are not significantly different from the control injera. The injera with malted fenugreek has a more acceptable texture that may be due to activated enzymes of malted fenugreek flour that has its own effect during fermentation. It was seen that the dough with fermented fenugreek was pre-fermented than dough with roasted and raw fenugreek flour. This may be used in future to decrease fermentation time in addition to using starter culture in dough making.

Table 4. Sensory Acceptance of Fenugreek Incorporated Injera.

Treatments	Color	Appearance	Taste	Aroma	Texture	OAA
Control	4.10 \pm 0.15 ^a	3.7 \pm 0.11 ^b	3.50 \pm 0.14 ^c	2.90 \pm 0.15 ^b	3.80 \pm 0.14 ^c	3.60 \pm 0.11 ^b
M 1%	4.25 \pm 0.15 ^a	4.35 \pm 0.13 ^a	4.45 \pm 0.17 ^{ab}	4.30 \pm 0.14 ^a	4.50 \pm 0.14 ^a	4.55 \pm 0.11 ^a
RO 1%	4.15 \pm 0.19 ^a	4.40 \pm 0.13 ^a	4.10 \pm 0.18 ^b	4.40 \pm 0.11 ^a	4.05 \pm 0.12 ^{abc}	4.40 \pm 0.15 ^a
RW 1%	4.15 \pm 0.17 ^a	4.40 \pm 0.22 ^a	3.90 \pm 0.22 ^{bc}	4.65 \pm 0.18 ^a	4.05 \pm 0.19 ^{abc}	4.35 \pm 0.22 ^a
M 3%	4.45 \pm 0.16 ^a	4.35 \pm 0.15 ^a	4.45 \pm 0.10 ^{ab}	4.50 \pm 0.13 ^a	4.30 \pm 0.14 ^{ab}	4.45 \pm 0.13 ^a
RO 3%	4.20 \pm 0.17 ^a	4.50 \pm 0.20 ^a	4.75 \pm 0.13 ^a	4.55 \pm 0.15 ^a	3.95 \pm 0.13 ^{bc}	4.60 \pm 0.17 ^a
RW 3%	4.50 \pm 0.21 ^a	4.50 \pm 0.17 ^a	4.10 \pm 0.17 ^b	4.60 \pm 0.17 ^a	4.10 \pm 0.18 ^{abc}	4.40 \pm 0.18 ^a
M 5%	4.35 \pm 0.16 ^a	4.50 \pm 0.18 ^a	4.45 \pm 0.23 ^{ab}	4.45 \pm 0.15 ^a	4.35 \pm 0.16 ^{ab}	4.50 \pm 0.15 ^a
RO 5%	4.25 \pm 0.15 ^a	4.50 \pm 0.18 ^a	4.40 \pm 0.20 ^{ab}	4.70 \pm 0.18 ^a	4.20 \pm 0.19 ^{abc}	4.55 \pm 0.15 ^a
RW 5%	4.45 \pm 0.12 ^a	4.50 \pm 0.15 ^a	3.10 \pm 0.19 ^d	4.65 \pm 0.15 ^a	4.00 \pm 0.12 ^{bc}	4.45 \pm 0.14 ^a
CV	17.19	17.08	19.00	15.38	16.37	15.92

The result were interpreted as Mean \pm SE, treatments that share the same letters are not significantly different ($p \leq 0.05$); OAA= Overall acceptance RW=Raw, RO= Roasted, M=Malted.

This experiment shows that the incorporation of raw fenugreek flour at 5% was not acceptable in taste but at 3%. However, for malted and roasted fenugreek powder, the addition level up to 5% was acceptable. The injera with 5% fenugreek flour has recorded low acceptance results (3.10)

than the control sample (3.50) in which significant difference was seen. Both injera with roasted and malted fenugreek were significantly different from the control sample.

As it is seen from the table 4, the appearance of all injera enriched with fenugreek are significantly different ($p \leq 0.05$)

from the control. The panelists indicated this that it more increased the shininess of the injera, which is attractive for consumption as indicated by [7-9] suggested that fenugreek is a good supplement if used with tef. It was reported that women usually prepare injera by adding some fenugreek flour to tef to improve its baking quality (a shiny appearance). This study is in agreement with this current study by increasing the shininess and its flavor (aroma).

There is no statistically significant difference ($p \leq 0.05$) in color between the injera enriched with fenugreek and the control (100tef). The report by [13] has shown that there was significant ($p < 0.05$) difference between control and fenugreek incorporated *Injera* in color. Though it shows that there is no statistical difference, the injera made by inclusion of roasted and germinated fenugreek were somewhat different in color. The injera made with roasted fenugreek was changed to light dark whereas the injera made with germinated fenugreek was changed to shiny color.

Unlike the result of the color, the aroma of all the injera added with fenugreek powder at different level shows significant difference ($p \leq 0.05$). The panelists indicated their suggestion that the addition of fenugreek flour improves its flavor (aroma). Also, the surrounding women using fenugreek expressed their experience that fenugreek flour increases the aroma and shininess of injera. The overall acceptability of the injera enriched with fenugreek flour and the control is also conducted to observe the difference. All the injera samples made from tef and fenugreek flour are statistically different from the control and based on this, it can be concluded that enriching the injera with fenugreek has a positive effect on its sensorial quality and in addition to this it increases the compositional quality to some extent.

4. Conclusion and Recommendation

This study was conducted with objective to identify the effect of fenugreek incorporation on injera quality. It was identified from the experiment that inclusion of fenugreek increased some nutritional contents of injera like protein, fat and fiber to some extent without affecting its Fe content. It was observed that it improves sensory quality of injera such as flavor (aroma) and shininess significantly. In addition to these, addition of raw fenugreek (only) has increased the shelf life to five days. It is advisable to use fenugreek flour for enriching injera, especially to make the injera more acceptable in sensory quality without any significant change in its Fe contents. It would be better if other research will be designed to assess whether addition of fenugreek can improve the qualities of injera made from other cereals.

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