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Textural and Eye Qualities of *Injera* Prepared from Quality Protein Maize and Teff Blended Flours

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Abstract: *Injera* is fermented, leavened, flat and round pancake-like Ethiopian traditional bread, and made from cereals like teff, wheat, barley, sorghum, maize or a combination of some of these cereals. This study was conducted to investigate the effect of blending ratio and fermentation times on the textural and eye /hole/ characteristics of *injera* prepared from quality protein maize (QPM) and teff composite flours. Factorial design of two factors in CRD arrangement was used. The factors were blending ratio of teff flour (20%, 30%, and 40%) and fermentation times (48hr, 60hr, and 72hr). The sensory acceptability scores for eye-size, texture, and rollability were ranged from 5.08 to 5.50, 5.01 to 5.76, and 4.61 to 5.69 due to blending ratio, respectively and from 5.18 to 5.41, 5.28 to 5.48, and 5.08 to 5.29 due to fermentation times, respectively tested for fresh *injera*. The peak force, which indicate the firmness level of *injera* samples also varied significantly ($p<0.05$) and the values ranged between 2.23 to 3.13 N (first day) due to blending ratio and from 2.59 to 2.69 N (first day) due to fermentation times. Increasing the blending proportions of teff flour in the composite was found improving the texture, firmness, and eye qualities of QPM-teff composite *injera* samples.

Keywords: Quality Protein Maize, Teff, *Injera*, Texture, Firmness

1. Introduction

Native to Ethiopia and Eritrea, *injera* is a traditional sourdough flatbread with teff as a major ingredient [7]. However, depending on the agroecology of the area concerned different cereals (sorghum, wheat, finger millet, maize, and barley) and their blends are used to make *injera* [11, 5]. A good *injera* is soft, fluffy, and able to be rolled without cracking. It should retain these textural properties after 2 to 3 days of storage. *Injera* made from teff is most preferred due to its softer texture, preferred taste, its color and can be rolled without cracking. The front side of a good quality *injera* has uniformly spaced honeycomb-like pores traditionally called "*eyes*", formed due to the penetration of escaping gas that is produced during fermentation and baking, whereas the bottom surface of *injera* is smooth and shiny [10].

Injera prepared from quality protein maize are only preferred in their fresh state and softness does not last as long as teff *injera*. Upon storage, it firms rapidly and becomes friable. Because of this, the use of quality protein maize for *injera* making received little attention [13]. Quality protein maize (QPM) is nutritionally enhanced maize developed through conventional breeding method. It contains nearly twice the quantity of lysine (>4.0%) and tryptophan (>0.8%) present in the conventional maize [6, 8, 12]. Increasing the consumption of food products prepared from QPM is the ideal solution to problems related to malnutrition [13]. Therefore, the study planned to improve textural, rollability, and firmness qualities of *injera* prepared from quality protein maize flour through compositing with teff flour and identifying the fermentation time required to maximize the utilization of QPM by the consumers in the country.

2. Materials and Methods

2.1. Flour Preparations

Quality protein maize (Melkassa-6Q) and teff (Magna) grains were collected from Melkassa Agricultural Research Center and Debre Zeit Agricultural Research Center of Ethiopian Institute of Agricultural Research, respectively. The grains were sorted and cleaned, and separately milled

(UDY3010-019, USA) to a sieve size of 0.50 mm [13].

2.2. Injera Making

About 200 g of flour was mixed with 180 ml of water and kneaded for 2 mins. Then, 10 ml of (5% on flour weight basis) pre-prepared starter yeast (*irsho*) was poured on the dough and left to ferment for 48, 60, and 72 hrs at room temperature. After the primary fermentation, about 10% of the fermented dough was taken and mixed with three parts of boiling water and then mixed thoroughly for 1 min (*absit*). The mixture was left at room temperature until the temperature dropped and then, the mixture was added back on the fermenting dough and mixed well. To this, 100 ml of water was added and the mixture was let to ferment for about 3 – 4 hrs at room temperature until a foamy slurry was formed. Then, the slurry was poured on an electric clay stove in circular motions and covered to cook for 2 mins [14].

2.3. Sensory Evaluation

Sensory evaluation of *injera* samples were carried out by 30 panelists composed of male and female. The evaluation was carried out for freshly baked *injera*, on the second and third days, respectively. The panelists were requested to test the *injera* samples in terms of eye-size, texture, and rollability using seven-point hedonic scale (1=dislike extremely, 2=dislike moderately, 3=dislike slightly, 4=neither like nor dislike, 5=like slightly, 6=like moderately, and 7=like extremely) [16].

2.4. Firmness Test

The firmness of the *injera* samples were measured following the procedure described by Senayit *et al.* with slight modification [10]. The peak force was determined using texture analyzer (TA.XT *plus*, Stable Micro Systems, Godalming, UK) in a compression mode with a sharp blade cutting probe and TA-90 heavy duty platform. The settings were: pre-test speed~4.0 mm/s, test speed~2.0 mm/s, post-test speed~5 mm/s, distance~3.5 mm, load cell~5 kg, and operating software (*Exponent, version 5.1.10*). The firmness was measured for freshly baked *injera*, on the second and third days, respectively.

2.5. Determination of Number of Eyes and Color

The number of eyes on the surface of *injera* and color (surface and hole) were determined using software (*Injera-Eyes,* version 1.0.0.0). Photo images were taken for each *injera* samples using digital color camera form similar height and with uniform light intensity. Then, to fit the software, the image of *injera* samples were cropped into 1550 pixels by 1550 pixels (width by height) [1, 13].

2.6. Experimental Design and Analysis

The experiment was carried out in triplicates for all the measured parameters. A factorial design of two factors in completely randomized design arrangement was used. The factors were blending ratio of teff flour (20, 30, and 40%) and fermentation time (48, 60, and 72 hrs). The experimental data was statistically analyzed using SAS software (version 9.4) following PROC ANOVA procedure. Means were separated by Fisher's least significant difference (LSD) test at $p<0.05$ level of significance. The results were expressed as mean ± standard deviation.

3. Results and Discussions

3.1. Eye-Size and Textural Qualities of QPM-teff Blended Injera

The results for eye-size, texture, and rollability scores of QPM-teff composite *injera* samples are presented in Table 1. The mean scores for eye-size ranged from 5.08 – 5.50, and blending ratio had significant effect ($p<0.05$). The eye-size of *injera* prepared from composite flour ratio of 60% QPM and 40% teff obtained the highest score and *injera* prepared from QPM (100%) flour obtained the lowest score. Fermentation times also had significant effect ($p<0.05$) on the eye-size and the mean scores ranged from 5.18 – 5.41. The number of eyes and the distribution on the surface of *injera* is a good indicator of *injera* quality. Ideally, eyes should neither be too few nor too numerous, they must be rather deep, interlocked with thin cross walls between them and be evenly distributed [11].

Table 1. *Eye-size and textural qualities of QPM-teff blended injera.*

Blending ratio (%)	Eye-size	First day		Second day		Third day	
		Texture	Rollability	Texture	Rollability	Texture	Rollability
100: 0	5.08±0.86^{c}	5.01±0.86^{d}	4.61±1.17^{d}	4.53±0.93^{d}	4.59±1.13^{d}	4.34±0.81^{d}	4.27±1.04^{c}
80: 20	5.20±0.94^{bc}	5.24±0.64^{c}	4.94±0.81^{c}	4.94±0.81^{c}	4.88±0.95^{c}	4.79±0.94^{c}	4.62±1.01^{b}
70: 30	5.37±0.77^{ab}	5.46±0.71^{b}	5.42±0.76^{b}	5.38±0.71^{b}	5.30±0.76^{b}	5.17±0.86^{b}	4.81±0.98^{ab}
60: 40	5.50±0.78^{a}	5.76±0.72^{a}	5.69±0.71^{a}	5.58±0.78^{a}	5.57±0.78^{a}	5.40±0.91^{a}	4.97±1.12^{a}
CV (%)	15.00	12.80	15.11	13.06	15.88	15.42	20.30
LSD	0.23	0.20	0.23	0.20	0.24	0.22	0.28

Fermentation time (hrs)	Eye-size	First day		Second day		Third day	
		Texture	Rollability	Texture	Rollability	Texture	Rollability
48	5.27±0.76^{ab}	5.28±0.76^{b}	5.08±0.82^{b}	5.00±0.82^{b}	5.02±0.87^{a}	4.73±0.98^{b}	4.53±1.01^{b}
60	5.41±0.88^{a}	5.35±0.82^{ab}	5.16±1.14^{ab}	5.08±0.94^{ab}	5.06±1.10^{a}	5.00±0.90^{a}	4.64±1.17^{ab}
72	5.18±0.90^{b}	5.48±0.77^{a}	5.29±0.92^{a}	5.24±0.93^{a}	5.18±0.98^{a}	5.06±0.99^{a}	4.83±1.00^{a}
CV (%)	15.00	12.80	15.11	13.06	15.88	15.42	20.30
LSD	0.20	0.17	0.20	0.17	0.21	0.19	0.24

Data: mean ± SD, means with the same letter in the column are not significantly different, QPM flour= 60, 70, and 80%, teff flour= 20, 30, and 40%.

The texture acceptability of *injera* samples were significantly influenced ($p<0.05$) by blending ratio and fermentation times. The scores ranged between 5.01 to 5.76, 4.53 to 5.58, and 4.34 to 5.40 due to blending ratio and ranged between 5.28 – 5.48, 5.00 – 5.24, and 4.73 – 5.06 due to fermentation times for the first, second, and third days, respectively. *Injera* samples prepared from QPM (100%) flour and QPM-teff composite flour (80: 20) were rated below 5 in the second and third days, and the response indicated lower degree of liking compared to *injera* samples having 30 and 40% teff flour. Textural properties are key drivers in food acceptability. Previous work of Senayit *et al.* reported that teff *injera* is relatively soft compared to sorghum *injera* [10]. The work of Zewdu *et al.* also reported that an increasing trend of liking the texture of teff-rice-maize composite *injera* when the proportion of teff and rice are increased, and texture score decreased when the proportion of maize is increased [16]. The relative softness of teff *injera* could be related to starch granule size. Teff starch have smaller granule size (2 – 6µm) compared with maize (20µm) and sorghum (20µm) starch granule sizes [2].

The rollability of *injera* samples significantly influenced ($p<0.05$) by blending ratio of teff flour and fermentation times. The mean scores varied from 4.61 to 5.69, 4.59 to 5.57, and 4.27 to 4.97 due to blending ratio for the first, second and third days, respectively. Only *injera* samples prepared from QPM-teff composite flour ratio of 70: 30 and 60: 40 (QPM: teff) were liked in the first and second days and the other *injera* samples were rated below 5, and they were not liked by the panelists.

3.2. Effect of Blending Ratio and Fermentation Time on Firmness of QPM-teff Blended Injera

Table 2 indicates the firmness of QPM-teff composite *injera* samples tested in the first, second and third days. Blending ratio significantly affected ($p<0.05$) the firmness of the samples and the values ranged from 2.23 to 3.13 N. The highest peak force was recorded for QPM (100%) *injera* and the lowest peak force was recorded for QPM-teff composite *injera* (60: 40). As the fermentation time varied from 48 to 60, and 72 hrs, maximum force values of 2.69, 2.65, and 2.59 N were also recorded, respectively. Peak force values ranged from 2.35 to 3.24 N, and 2.46 – 3.37 N were also recorded in the second and third days due to blending ratio. The values were greater than the peak force required for cutting teff *injera* (2.01, 2.12, and 2.23 N). From the result it was observed that, as the level of teff flour increased in the composite, the force required for cutting (*injera*) decreased. It has been reported that the hardness that develops in starch-based products during storage is due to the retrogradation of starch molecules [3]. Onyango *et al.* reported that, bread prepared from wheat-maize composite flour having higher proportion of maize flour required the maximum force of cutting [9]. The authors recorded the peak force values of 1.27, 1.52, 2.68, and 7.62 N for bread samples prepared from the wheat-maize composite flour ratio of 100: 0, 90: 10, 80: 20, and 70: 30, respectively.

Table 2. *Effect of blending ratio and fermentation time on firmness of QPM-teff blended injera.*

Blending ratio (%)	First day (N)	Second day (N)	Third day (N)
100: 0	3.13±0.04^{a}	3.24±0.08^{a}	3.37±0.08^{a}
80: 20	2.70±0.07^{b}	2.81±0.07^{b}	2.97±0.09^{b}
70: 30	2.49±0.09^{c}	2.60±0.11^{c}	2.73±0.09^{c}
60: 40	2.23±0.13^{d}	2.35±0.08^{d}	2.46±0.10^{d}
CV (%)	1.99	1.52	1.61
LSD	0.05	0.04	0.05

Fermentation time (hrs)	First day	Second day	Third day
48	2.69±0.35^{a}	2.82±0.35^{a}	2.94±0.35^{a}
60	2.65±0.36^{a}	2.73±0.34^{b}	2.88±0.36^{b}
72	2.59±0.35^{b}	2.70±0.34^{b}	2.82±0.36^{c}
CV (%)	1.99	1.52	1.61
LSD	0.04	0.04	0.04
Teff *injera*	2.01±0.07	2.12±0.08	2.25±0.07

Data: mean ± SD, means with the same letter in the column are not significantly different, QPM flour= 60, 70, and 80%, teff flour= 20, 30, and 40%, N=Newton.

3.3. Interaction Effects of Blending Ratio and Fermentation Time on Firmness of QPM-teff Blended Injera

Table 3 shows the interaction effects of blending ratio and fermentation time on the firmness of QPM-teff composite *injera*. The highest values (3.16, 3.31, and 3.42 N) were recorded for *injera* sample prepared from QPM (100%) flour and the lowest values (2.19, 2.30, and 2.41 N) were recorded for *injera* sample prepared from QPM-teff composite flour (60: 40). Texture analysis is primarily concerned with the evaluation of mechanical characteristics where a material is subjected to controlled force from which deformation curve of its response is generated [9].

3.4. Effect of Blending Ratio and Fermentation Time on the Number of Eyes and Color of QPM-teff Blended Injera

The number of eyes and color of QPM-teff composite *injera* samples are presented in Table 4. Blending ratio had significant effect ($p<0.05$) on the number of eyes and the values ranged from 3618.22 to 6847.89. The highest value was recorded for *injera* sample prepared from QPM-teff composite flour having 30% teff, followed by 20% teff and the lowest value was recorded for *injera* sample prepared from QPM (100%) flour. Fermentation time also had significant ($p<0.05$) effect on the number of eyes and values of 5310.42, 5412.17, and 6542.92 were recorded from *injera* samples fermented for 48, 60 and 72 hrs, respectively. The number, size and distribution of holes; commonly called *eyes* on the *injera* surface represent one of the most important qualities attributes of *injera* [11]. Hayelom reported the number of eyes of teff *injera* ranged from 17764.50 to 19609.20 (area not specified) for *injera* samples prepared from different teff varieties [4]. Yoseph also reported the number of eyes of teff *injera* varied from 224 to 298

(unspecified area) for *injera* samples prepared from teff flour milled by different millers [15].

Blending ratio and fermentation time had significant effect ($p<0.05$) on the color of *injera* samples. The lightness (L*) values ranged from 64.66 to 70.32. *Injera* samples prepared from QPM (100%) and QPM-teff composite flour (80: 20) obtained the highest L* value and had no significant difference ($p>0.05$). The lowest L* value was recorded from *injera* sample prepared from 60% QPM and 40% teff composite flour. The work of Zewdu *et al.* also reported that, the L* value of teff *injera* (54.65) was lower than the L* value of *injera* (63.17) prepared from teff-maize-rice composite (70: 0: 30) flour [16]. The redness (a*) values of QPM-teff composite *injera* were varied from 0.92 – 3.81, and 2.18 – 2.61 due to blending ratio and fermentation time, and significant differences ($p<0.05$) were noted. Higher a* value was recorded for *injera* sample prepared from QPM-teff composite flour having 40% teff and lower value was recorded for *injera* sample prepared from QPM (100%) flour. *Injera* sample fermented for 48 hrs showed the highest a* value whereas those fermented for 72 hrs showed the lowest a* value.

The yellowness (b*) values of QPM-teff composite *injera* varied significantly ($p<0.05$) from 5.06 to 13.24 due to blending ratio, and from 9.18 to 11.00 due to fermentation time. As the blending ratio of teff flour increased (20, 30, and 40%) in the composite, b* values were found increase in parallel, in contrast as the fermentation time (48, 60, and 72 hrs) increased b* values were found decreasing. Significant differences ($p<0.05$) were also observed on the hole color of QPM-teff composite *injera* samples due to blending ratio and the values ranged from 41.53 – 48.01 (L*), 1.52 – 5.44 (a*), and 9.11 – 16.09 (b*). As blending ratio of teff flour increased in the blends, the lightness of the hole was found decreasing whereas the redness and yellowness values were found increasing. The fermentation time also significantly ($p<0.05$) increased the L* values from 42.17 to 44.41, but decreased the redness (3.87 – 4.28) and yellowness (13.21 – 14.95) values.

Table 3. *Interaction effects of blending ratio and fermentation time on firmness of QPM-teff blended injera.*

Blending ratio (%)	Fermentation time (hrs)	First day (N)	Second day (N)	Third day (N)
100: 0	48	3.16 ± 0.03^{a}	3.31 ± 0.07^{a}	3.42 ± 0.08^{a}
100: 0	60	3.14 ± 0.03^{a}	3.20 ± 0.07^{b}	3.37 ± 0.10^{ab}
100: 0	72	3.09 ± 0.03^{a}	3.18 ± 0.06^{b}	3.34 ± 0.06^{c}
80: 20	48	2.78 ± 0.05^{b}	2.88 ± 0.01^{c}	3.03 ± 0.07^{c}
80: 20	60	2.71 ± 0.07^{bc}	2.80 ± 0.08^{d}	2.98 ± 0.10^{c}
80: 20	72	2.65 ± 0.04^{c}	2.76 ± 0.06^{d}	2.89 ± 0.05^{d}
70: 30	48	2.53 ± 0.10^{d}	2.66 ± 0.10^{e}	2.80 ± 0.08^{e}
70: 30	60	2.51 ± 0.11^{de}	2.59 ± 0.13^{ef}	2.73 ± 0.09^{e}
70: 30	72	2.43 ± 0.05^{e}	2.56 ± 0.10^{f}	2.64 ± 0.05^{f}
60: 40	48	2.28 ± 0.16^{f}	2.41 ± 0.07^{g}	2.53 ± 0.16^{g}
60: 40	60	2.23 ± 0.14^{f}	2.34 ± 0.08^{gh}	2.45 ± 0.07^{gh}
60: 40	72	2.19 ± 0.12^{f}	2.30 ± 0.08^{h}	2.41 ± 0.03^{h}
CV (%)		1.99	1.52	1.61
LSD		0.09	0.07	0.08

Data: mean ± SD, means with the same letter in the column are not significantly different, QPM flour= 60, 70, and 80%, teff flour= 20, 30, and 40%, N=Newton.

Table 4. *Effect of blending ratio and fermentation time on number of eyes and color of QPM-teff blended injera.*

Blending ratio (%)	Number of eyes	Surface color			Hole color		
		L*	a*	b*	L*	a*	b*
100: 0	3618.22 ± 538.76^{d}	70.32 ± 0.98^{a}	0.92 ± 0.19^{d}	5.06 ± 0.32^{d}	48.01 ± 0.32^{a}	1.52 ± 0.42^{c}	9.11 ± 0.82^{b}
80: 20	6359.00 ± 604.13^{b}	70.09 ± 0.89^{a}	1.57 ± 0.17^{c}	10.70 ± 0.40^{c}	42.56 ± 0.39^{b}	4.32 ± 0.48^{b}	15.89 ± 0.65^{a}
70: 30	6847.89 ± 632.50^{a}	65.61 ± 0.84^{b}	3.30 ± 0.11^{b}	11.97 ± 0.44^{b}	42.13 ± 0.49^{b}	5.28 ± 0.53^{a}	16.07 ± 0.48^{a}
60: 40	6195.56 ± 595.56^{c}	64.66 ± 0.93^{c}	3.81 ± 0.13^{a}	13.24 ± 0.33^{a}	41.53 ± 0.41^{c}	5.44 ± 0.59^{a}	16.09 ± 0.89^{a}
CV (%)	0.67	0.55	8.26	2.50	1.06	4.79	2.78
LSD	37.52	0.36	0.19	0.25	0.44	0.19	0.39

Fermentation time (hrs)	Number of eyes	Surface color			Hole color		
		L*	a*	b*	L*	a*	b*
48	5310.42 ± 771.06^{c}	66.91 ± 3.51^{c}	2.61 ± 1.49^{a}	11.00 ± 4.06^{a}	42.17 ± 2.51^{b}	4.28 ± 1.57^{a}	14.95 ± 3.18^{a}
60	5412.17 ± 834.02^{b}	67.63 ± 2.74^{b}	2.41 ± 1.23^{b}	10.55 ± 3.50^{b}	44.10 ± 2.67^{a}	4.27 ± 1.58^{a}	14.69 ± 3.40^{a}
72	6542.92 ± 775.25^{a}	68.45 ± 2.87^{a}	2.18 ± 1.11^{c}	9.18 ± 3.42^{c}	44.41 ± 2.50^{a}	3.87 ± 1.39^{c}	13.21 ± 3.23^{b}
CV (%)	0.67	0.55	8.26	2.50	1.06	4.79	2.78
LSD	32.50	0.31	0.17	0.22	0.38	0.17	0.34
Teff *injera*	9488.33±109.91	59.41±1.35	0.26±0.08	4.88±0.26	43.12±2.55	0.51±0.27	6.56±0.61

Data: mean ± SD, means with the same letter in the column are not significantly different, QPM flour= 60, 70 and 80%, teff flour= 20, 30 and 40%, L*= lightness, a*= redness, b*= yellowness.

3.5. Interaction Effects of Blending Ratio and Fermentation Time on Number of Eyes and Color of QPM-teff Blended Injera

The interaction effects of blending ratio and fermentation time on the number of eyes and color of QPM-teff blended *injera* are shown in Table 5. The number of eyes of *injera* samples ranged from 3103.33 – 7775.67, and significant differences ($p<0.05$) were observed. The maximum numbers of eyes were recorded for *injera* sample prepared from QPM-teff composite flour (60: 40) fermented for 72 hrs and the values were lower than teff *injera* (9488.33). The minimum value was recorded for *injera* sample prepared from QPM (100%) flour fermented for 72 hrs. As the fermentation time extended from 48 to 72 hrs for preparing QPM (100%) *injera*, the number of eyes was found deceasing. The interaction effect of blending ratio and fermentation time on the lightness (surface) of *injera* was significant ($p<0.05$) and the values ranged from 62.64 – 70.38.

Injera prepared from QPM (100%) flour and QPM-teff composite flour (80: 20) and fermented for 48, 60, and 70 hrs were statistically similar ($p>0.05$). Similarly, the redness of *injera* samples due to the interactions of blending ratio and fermentation time was significant ($p<0.05$) and the values varied from 0.87 – 4.10. *Injera* samples prepared from QPM-teff composite flour having 30 and 40% teff, when fermented for 48 and 60 hrs compared to 72 hrs showed higher a* values. The yellowness of *injera* samples were varied significantly ($p<0.05$) from 4.87 to 15.48 due to the interactions of blending ratio and fermentation time. *Injera* samples having 30 and 40% teff flour in the composite and fermented for 48 and 60 hrs showed higher b* values. The interaction effect of blending ratio and fermentation time on the hole color of QPM-teff composite *injera* was significant ($p<0.05$) and the values ranged between 48.22 – 39.37 (L*), 1.01 – 7.25 (a*), and 8.26 – 17.50 (b*).

Table 5. *Interaction effects of blending ratio and fermentation time on number of eyes and color of QPM-teff blended injera.*

Blending ratio (%)	Fermentation time (hrs)	Number of eyes	Surface color			Hole color		
			L*	a*	b*	L*	a*	b*
100: 0	48	4309.33±15.50^{j}	70.25±0.16^{a}	0.95±0.18^{f}	4.87±0.35^{g}	47.79±0.27^{a}	1.01±0.09^{i}	9.86±0.37^{f}
100: 0	60	3442.00±18.89^{k}	70.32±0.16^{a}	0.93±0.18^{f}	5.11±0.28^{g}	48.03±0.33^{a}	1.72±0.30^{h}	9.20±0.71^{f}
100: 0	72	3103.33±14.93^{l}	70.38±0.25^{a}	0.87±0.28^{f}	5.21±0.33^{g}	48.22±0.38^{a}	1.82±0.12^{h}	8.26±0.46^{g}
80: 20	48	5312.67±19.81^{h}	70.09±0.10^{a}	1.47±0.18^{e}	11.03±0.30^{d}	41.57±0.51^{ef}	2.93±0.11^{g}	15.49±0.27^{c}
80: 20	60	6160.67±18.33^{f}	70.08±0.11^{a}	1.61±0.13^{e}	10.70±0.29^{de}	44.25±0.55^{b}	4.79±0.27^{e}	15.47±0.17^{c}
80: 20	72	7603.67±14.84^{c}	70.07±0.13^{a}	1.63±0.22^{e}	10.36±0.34^{ef}	41.87±0.81^{e}	5.25±0.16^{cd}	16.70±0.44^{b}
70: 30	48	6391.33±19.74^{e}	64.65±0.33^{d}	3.93±0.22^{ab}	12.60±0.10^{c}	39.96±0.62^{g}	5.94±0.17^{b}	16.98±0.45^{ab}
70: 30	60	6463.33±15.10^{d}	65.69±0.29^{c}	3.40±0.16^{c}	12.41±0.34^{c}	43.05±0.38^{d}	5.11±0.12^{de}	16.97±0.35^{ab}
70: 30	72	7689.00±19.12^{b}	66.48±0.36^{b}	2.57±0.17^{d}	10.89±0.21^{d}	43.40±0.40^{cd}	4.78±0.10^{e}	14.28±0.22^{d}
60: 40	48	5228.33±12.37^{i}	62.64±0.19^{e}	4.10±0.21^{a}	15.48±0.10^{a}	39.37±0.36^{g}	7.25±0.18^{a}	17.50±0.47^{a}
60: 40	60	5582.67±10.46^{g}	64.43±0.09^{d}	3.69±0.34^{bc}	13.97±0.26^{b}	41.09±0.25^{f}	5.47±0.19^{c}	17.13±0.28^{ab}
60: 40	72	7775.67±18.18^{a}	66.92±0.08^{b}	3.65±0.20^{bc}	10.26±0.12^{f}	44.13±0.43^{bc}	3.61±0.16^{f}	13.61±0.40^{e}
CV (%)		0.67	0.55	8.26	2.50	1.04	4.79	2.78
LSD		64.99	0.62	0.34	0.43	0.76	0.34	0.67

Data: mean ± SD, means with the same letter in the column are not significantly different, QPM flour= 60, 70 and 80%, teff flour= 20, 30 and 40%, L*= lightness, a*= redness, b*= yellowness.

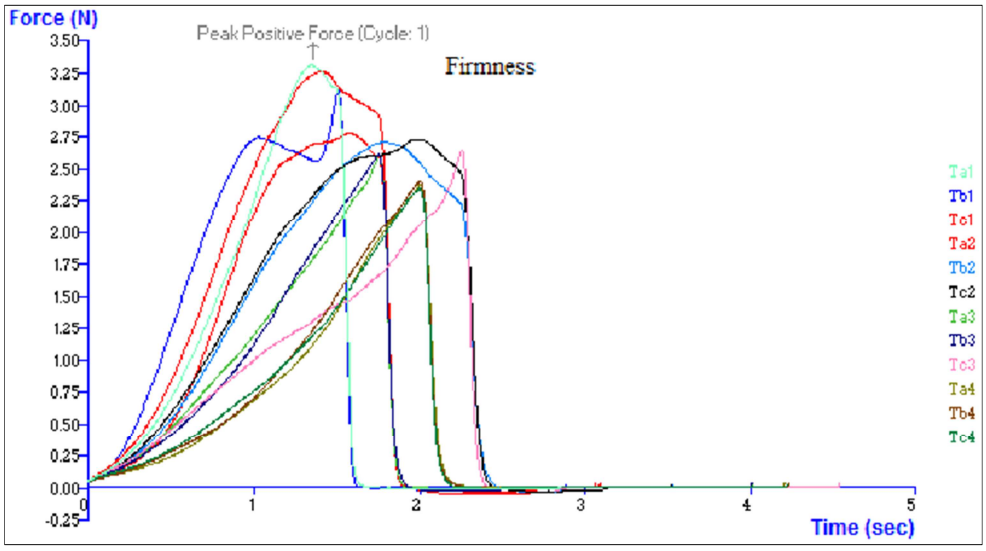

Figure 1. *Firmness graph of QPM-teff composite injera samples fermented for 48 hr.*

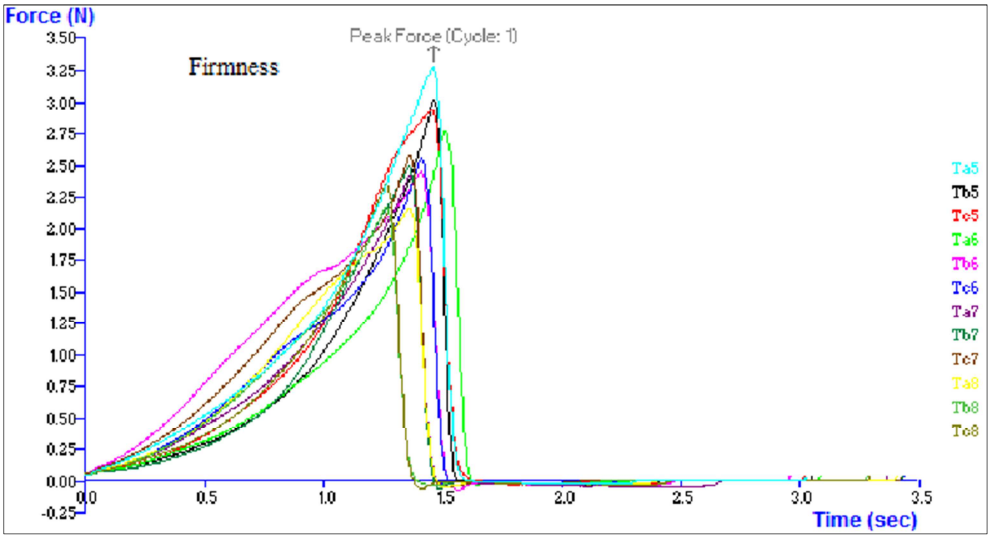

Figure 2. *Firmness graph of QPM-teff composite injera samples fermented for 60 hr.*

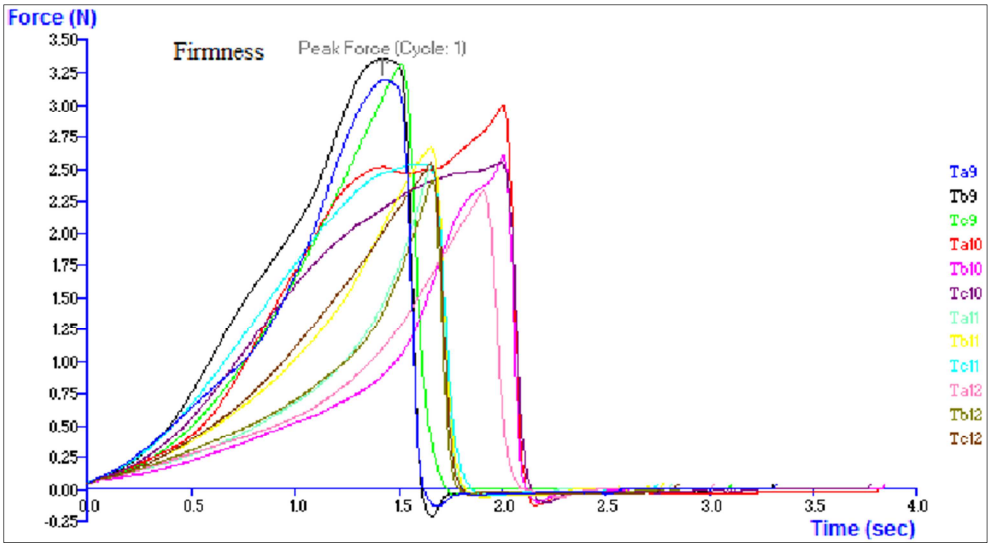

Figure 3. *Firmness graph of QPM-teff composite injera samples fermented for 72 hr.*

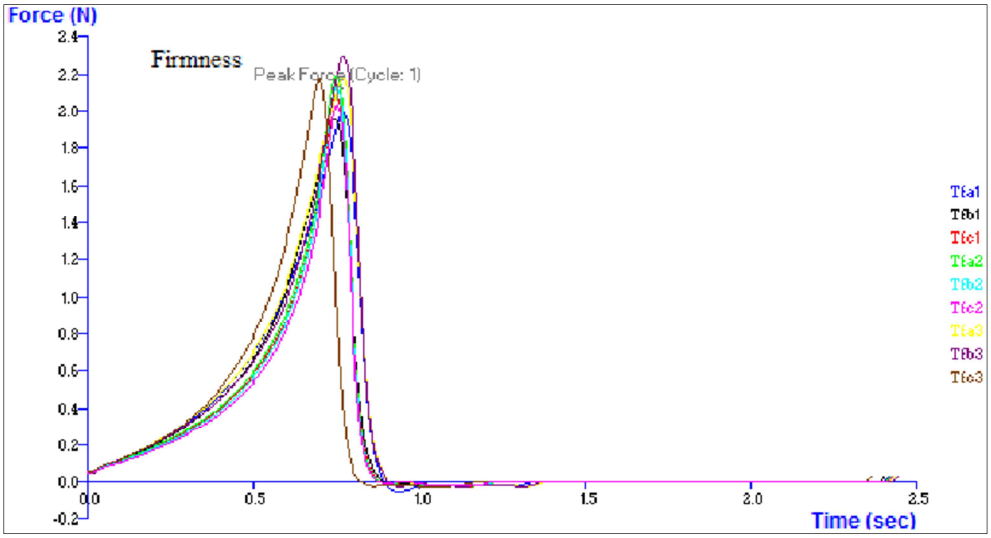

Figure 4. *Firmness graph of teff injera samples.*

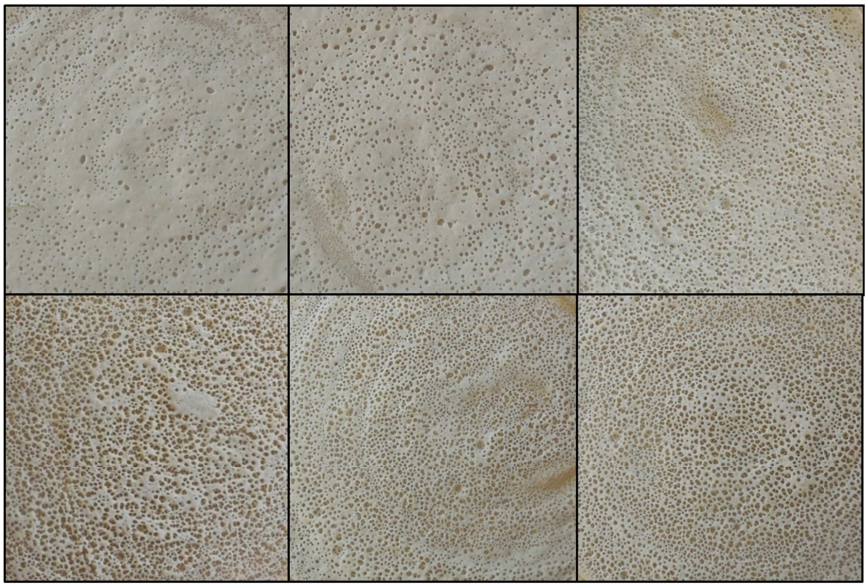

Figure 5. *QPM-teff blended injera samples.*

4. Conclusions

Quality protein maize is nutritionally enhanced variants of maize, and preparing *injera* from QPM has considerable advantages both nutritionally and economically over teff. However, *injera* prepared from QPM are only preferred in their fresh state and softness does not last as long as teff *injera*. Fermentation time is important factor that affects the eye qualities and distributions of *injera*. The study showed that, blending ratio of teff flour and fermentation times had significant effect ($p<0.05$) on the eye-size, texture, rollability, firmness, number of eyes and color (surface and hole) of *injera*. As the blending proportion of teff flour increased, better preference was observed for texture and rollability. Lower stalling and firmness were also observed with increasing in teff proportions.

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