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The Mineral Content and Sensory Properties of Injera Made from the Faba Bean, Sorghum and Tef Flour Blend

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Abstract

The effects of 55-70% teff (Eragrostis tef), 20-30% sorghum (*Sorghum bicolor*) and 5-15% faba bean (*Vicia faba*) flours blending ratio and fermentation time (24, 48 and 72 h) with custom design on iron, zinc and calcium contents and sensory properties of injera were investigated using 100% teff injera as a control. The mixture of faba bean and sorghum with tef significantly increased the iron, zinc and calcium contents of the blended injera. High iron (22.66 mg/100 g), zinc (23.81 mg/100 g) and calcium (187.25 mg/100 g) contents were obtained from 55% tef, 30% sorghum and 15% faba bean blended injera fermented for 72 h. Sensory acceptability of all blended injera scored a mean rating well above the average, which is an indicative of the goodness as products. The most preferred injera by panelists was produced from tef flour combined with 20% sorghum and 10% faba bean flours fermented for 72 h.

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Introduction

Injera is a type of feremented flat bread made in Ethiopia from grain tef (*Eragrostis tef* (Zucc) Trotter) flours, free of gluten proteins the type found in wheat which originated from Ethiopia and is also at large cultivated in Ethiopia. Injera is a staple food for majority of Ethiopians, where it is served with almost every meal. Grain tef was reported to have proximate composition of about 11% protein, 73% carbohydrate, 3% crude fiber, 2.5% fat and 2.8% ash [1]. It was also reported to have a relatively higher iron content than other common cereals [2], this was in part contributed by agronomic practices used in Ethiopia [3]. Grain tef is mainly used for making injera; sometimes also used as porridge and as an ingredient for home-brewed alcoholic drinks. The grain proteins are also presumed easily digestible because is rich in digestible type proteins and relatively poor in prolamins [4] [5]. Tef grain flours has been reported to be used in diferent food products such as various breads, cookies pasta and weaning foods because is always used as whole grains, gluten free nature, high iron contnets of good proteins and starches digestibility [6].

At present *Tef* is the most expensive cereals grown in Ethiopia, because *tef injera* is the favorite diet of the nation and usually considered as a prestige food in the society. Moreover *tef* is exported to United States, Europe and other countries due to the absence of gluten and its nutritional value [7].

Grain sorghum (*Sorghum bicolor* (L.) Moench) was reported to have proximate composition of 74.7% carbohydrates, 1.8% ash, 12.3% protein, 4.2% fat and 1.7% fiber [8]. Sorghum is used as the second most preferred cereal for *Injera* preparation in Ethiopia [7]. This is because sorghum *injera* shows brittleness and dryness after storage [9]. It is also used to produce many African and Asian traditional foods like, *roti, chapatti, tuwo, tortillas* and porridges [10].

Faba bean (*Viciafaba*) was reported to have (50-60) % carbohydrate, (25-35) % protein and 1-2.5% lipid (with oleic and linoleic acid representing 75% of fats) [11]. Also [12] reported that the whole dried seeds contain (per 100 g) 344 calories, 10.1% moisture, 1.3 g fat, 59.4 g total carbohydrate, 6.8 g fiber, 3.0 g ash, 104 mg Ca, 301 mg P and 6.7 mg Fe. The bean is a common breakfast meal in the Mediterranean region, Central and East Asia, Ethiopia, America and Oceania [13]. It is used to make stew (*shiro wot* in the Ethiopian national language, Amharic) mixed with other pulses like pigeon pea and chickpea. It is served with *Injera* [14].

To get sufficient nutrition, cereals have been found to have nutrient potentials that could complement one another if properly processed and blended with legumes [15]. Fermentation also has contributed to improve the nutritional values of those cereal products. Fermented foods can have the added benefits of enhancing flavor, increased digestibility and improving the nutritional value [16]. This is due to growth and action of the bacteria during fermentation [17].

Since, Sorghum and faba bean is less expensive in Ethiopia, there is great interest to blend with *tef* flour in order to control the projected increasing demand of *tef* and improving the nutritional quality of Injera. Therefore, initiation is taken to investigate the blending ratio of faba bean and sorghum with tef grains and fermentation time on nutritional composition and sensory acceptability of Injera.

Materials and Methods

Source of Raw Materials

The experimental materials such as white tef, faba bean and sorghum were collected from Debre Zeit Agricultural Research Center (DZARC); Holeta Agricultural Research Center (HARC) and Haramaya University Research Center (HURC) respectively.

Experimental Design

The experimental design was used in this study to determine the ratio of the blends cereals (tef and sorghum) with legume faba bean, and to optimize the fermentation time using mixture design. A mixture design is appropriate when the response depends on the component proportions of the mixture and not on the component quantities. In this study the effect of three mixtures of products, namely tef (T), sorghum (S) and faba bean (F) flour was studied to determine appropriate formulation. The proportion of tef from 55 to 70%, sorghum from 20 to 30% and faba bean from 5 to 15% were used. The constrained proportion was planned after doing preliminary test. Thus to compare the blend

Injera, 100 % tef flour was used [14].

Sample Preparation

The tef, sorghum, faba bean grains was manually cleaned. Then tef grain was milled by the disk attrition mill to whole flour to the finenest level traditionally used for Injera processing at Haramaya University public grain milling house. The sorghum grain was milled after debraning using mortar and pestle. Faba bean was milled after seed coat was removed on a disc attrition mill. The flour was kept in an airtight sealed plastic bucket at room temperature [18] for the duration of the analysis. The blend mixture was prepared and Injera was processed.

Dough Processing and Fermentation

Tef, sorghum and faba bean blended injera was prepared using standard recipes. The process involved dough processing and fermentation and then baking of the batter (thin fermented dough). Prior to fermentation 1 kg of the blend flour (tef, sorghum and faba bean flour) was mixed with about 2L water and about 80 ml of *ersho* (starter saved from preliminary fermentation) and then the dough was kneaded by hand for each treatment/blend [19]. The dough was kept from covering the lid/bowl at room temperature at the Food Science and Postharvest Technology (FSTP) Laboratory.

Fermentation

During 24 hrs fermentation, notably vigorous gas evolution and maximum dough expansion were observed. Acidic yellowish liquid on dough surface were observed during 48 hrs and 72 hrs fermentation time. The layer of the liquid was then removed. For Injera baking of dough fermented for 24 hrs, 48 hrs and 72 hrs, about 10% of fermenting dough was withdrawn for absit preparation. 10% of the fermented dough of the blend flour (for each fermentation time: 24 hrs, 48 hrs and 72 hrs) was taken and boiled at 100°C and then after the absit was cool at 46°C mixed back to the fermented dough. After the 2nd fermentation (2 to 3 hrs) injera was baked [19].

Baking

Injera was baked after fermentation by diluting the batter slightly with water to uniform consistency. Then it was poured using circular motion from the outer perimeter towards the center, onto a hot-round smooth baking griddle called *metad*. The *metad* was then covered with a *metad* lid called *akambalo* to prevent steam from escaping. Prior to pouring the batter, the *metad* surface was swapped down by the repeseed flour using a piece of cloth. This prevents the *Injera* from sticking to the *metad* surface. Finally Injera was baked for about 3 min [19].

Chemical Composition Analysis

Mineral contents such as Iron, Zinc and Calcium of both control and blended injera samples were carried out using the method [18]. Condensed tannin was analyzed by vanillin-HCl method of [20] using the modified Vanillin-HCl methanol method. Phytic acid was determined through phytate phosphorus (Ph-P) analysis according to [21].

Sensory Attributes of Blended Injera Products

In order to determine consumer acceptability of tef, sorghum and faba bean blended injeras, a sensory evaluation was conducted. A total of 50 male and female panelists were selected from Haramaya University Food Science and Postharvest Technology staffs and students, who have knowledge on sensory analysis. *Injera* made from the blend was evaluated for the sensory attributes after 2 hrs of *injera* was baked and stored in straw basket or *masob* covered tightly with polyethylene plastics. *Injera* was stored in *masob* by cutting/slicing into a quarter of the whole *injera* with sharp and nit knife this is to prevent contamination among the different blending ratios of *injera* products. These slices of *injera* were used for sensory within 2 hours after baking. Product sample was arranged and each panelist was instructed on the procedure of sensory evaluation. Panelists were instructed to make their own individual assessments according to their best feeling after tasting the product. The parameters tested for are flavor, aroma, Sourness, color, rollability and injera appearance (i.e. Eyes of injera and injera underneath appearance) using a seven hedonic scale ranging from 7 = very much liked to 1 = very much disliked [22].

Statistical Analysis

At least a triplicate data were analyzed and modeled using the statistical software JMP™ 8, 2008 (by SAS Institute Inc., Cary, NC, USA). Mixture response surface methodology was applied to the experimental data using JMP version 8. A polynomial equation was fitted to the data to obtain a regression equation. Statistical significance terms in the models were identified. Summary of fit, ANOVA, lack of fit and parameter estimates were generated by the JMP 8. Data were also analyzed by ANOVA and mean comparison was done using Duncan's Multiple Range Test (DMRT) by SAS 9.1.3. Significance was judged if the probability level of the *F*-statistic calculated from the data was less than 0.05. The model adequacy was checked by R^2, R^2 adj and lack of fit test. The tertiary contour plots were drawn to develop the optimum blending ratio of the mixture of tef, sorghum and faba bean that are used as an ingredient for Injera making [19].

Results and Discussions

Effect of Blending Ratios and Fermentation Time on Proximate Compositions of Injera

The effect of tef, sorghum and faba bean blending ration and fermentation time had significant ($P<0.05$) effect on the proximate composition of the blend Injera. [19] reported that significant ($p<0.05$) increased in moisture and protein content was observed from the blend Injera made by blending 55% tef, 30% sorghum and 15% faba bean and fermented for 72 hrs. High fat, carbohydrate and energy content were obtained on the blend Injera made by blending 70% tef, 20% sorghum and 10% faba bean and fermented for 24 hrs. The long fermentation time was increased the moisture and protein content, on the other hand ash, fat, fiber,carbohydrate and energy was observed maximum in short fermentation time [19]. Generally, the addition of more sorghum and faba bean with long fermentation time is playing a vital role in proximate composition of blended injera as compared to the control.

Effect of Blending Ratios and Fermentation time on Mineral Content of Injera

Iron

The iron content of the blend injera made by blending sorghum and faba bean flour in to tef flour was shown in Table 1. Blending of tef, sorghum and faba bean had a significant effect ($P<0.05$) on the iron content of injera. The high iron content was obtained when 55% tef, 30% sorghum and 15% faba bean were blended and fermented for 72 hrs while the lowest value of iron content was obtained when 65% tef, 30% sorghum and 5% faba bean were blended and fermented for 24 hrs. The result revealed that the addition of more faba bean and sorghum has a positive impact on iron content of the blend injera. Fermentation time had significantly ($P<0.05$) increased the iron content of the blend injera. This is probably due to long fermentation period enhances the removal of antinutritional factors which are believed to be responsible for unavailability of both proteins and minerals [23].

The control 100% tef injera had the lowest iron content 18.83 mg/100 g as compared to the blend injera.The result has shown that the addition of more faba bean and sorghum flour into tef flour is important to boost the iron content of the blend injera as compared to the control (100% tef injera). All the interaction terms (tef and faba bean) and (tef and sorghum) had significant ($P<0.05$) effect on the iron content of the blend injera. Thus, when the proportion of faba bean and sorghum flour increased in the mixture the iron content was also increased. The following model (Eq. 1) was developed to predict the iron content.

$$Fe=0.253T+0.219S-1.869FB-0.008(T*S)-0.028(T*Fb)+0.134FT[x] \quad (1)$$

Where Fe = predicted iron (mg/100g), T =the proportion of raw tef flour (%), S =is the raw sorghum flour (%), and FB =is the raw faba bean flour (%), and FT [x] = is the batter fermentation time at (x=24, 48 and 72hrs).

When the proportion of tef, sorghum, and faba bean flour and fermentation time substituted into equation 19 the predicted iron content would be determined. For example the predicted value of the blend injera obtained by blending 15% faba bean and 30% sorghum into 55% tef flour was 22.22%, which is equivalent to the actual data (22.66±4.48). This indicates that the model was sufficient enough in describing the data.

The shaded region of Figure 1a was the optimum area for iron content. The optimum value (20.0 - 25.86) mg/100 g was obtained when 55% tef, 30% sorghum and 15% faba bean were blended and

Table 1. Mineral and Antinutritional content of the blended injera

Blending Ratio	FT	Fe (mg/100g)	Zn (mg/100g)	Ca (mg/100g)	Tannin (mg/kg)	Phyticacid (mg/100g)
55% T + 30% S + 15% FB	24 h	16.74±0.04^{h}	18.33±0.04^{g}	172.89±0.01^{d}	0.606±0.00^{a}	203.86±0.03^{f}
	48 h	17.62±0.02^{g}	21.44±0.04^{d}	173.17±5.79^{c}	0.595±0.00^{c}	174.99±0.00^{j}
	72 h	22.66±4.48^{a}	23.81±0.01^{a}	187.25±0.02^{a}	0.581±0.00^{e}	120.76±0.02^{o}
65% T + 20% S + 15% FB	24 h	15.34±0.01^{j}	18.14±0.05^{h}	166.44±0.02^{g}	0.603±0.00^{b}	208.65±0.03^{e}
	48 h	16.45±0.01^{i}	21.35±0.01^{e}	170.26±0.04^{f}	0.584±0.00^{d}	195.59±0.28^{g}
	72 h	21.65±0.05^{b}	22.88±0.01^{b}	182.57±0.02^{b}	0.576±0.00^{f}	140.12±0.01^{k}
65% T + 30% S + 5% FB	24 h	11.56±0.04^{m}	15.66±0.04^{j}	129.55±0.02^{l}	0.110±0.00^{g}	190.56±0.01^{h}
	48 h	13.73±0.04^{k}	21.15±0.04^{f}	152.42±0.02^{j}	0.074±0.00^{i}	132.56±0.05^{l}
	72 h	18.55±0.01^{f}	21.75±0.03^{c}	170.43±0.02^{e}	0.066±0.00^{j}	124.54±0.02^{n}
70% T + 20% S + 10% FB	24 h	13.44±0.03^{l}	17.85±0.04^{i}	149.56±0.01^{k}	0.098±0.00^{h}	290.84±0.02^{b}
	48 h	16.76±0.02^{h}	21.13±0.02^{f}	165.45±0.04^{h}	0.066±0.00^{j}	179.73±0.02^{i}
	72 h	18.83±0.01^{e}	21.75±1.79^{c}	162.25±0.01^{i}	0.061±0.00^{k}	130.65±0.04^{m}
Control	24 h	18.83±0.04^{e}	14.27±0.03^{m}	123.86±0.04^{o}	0.015±0.00^{l}	295.46±0.03^{a}
	48 h	19.05±0.01^{d}	14.55±0.03^{l}	126.97±0.03^{n}	0.008±0.00^{m}	282.24±0.04^{c}
	72 h	19.18±0.01^{c}	14.66±0.02^{k}	136.86±0.03^{m}	0.008±0.00^{m}	234.46±0.03^{d}

Values in the column are means of three replicates and same column with different letters are significantly different at 0.05 probability level according to Duncan Multiple Range Test. T - Tef, S - Sorghum, FB - Faba bean, FT - Fermentation time, h – hours, Control - 100% Tef flour.

fermented for 72 hrs.

Zinc

The zinc content of the blend injera was shown in Table 1. Blending of tef, sorghum and faba bean had significant ($P<0.05$) effect on the zinc content of the blend injera. The value had a mean of (19.32 mg/100 g). The highest Zn content (23.81 mg/100 g) was observed in the blend 55% tef, 30% sorghum and 15% faba bean and fermented for 72 hrs while the lowest value (15.66 mg/100 g) was observed in the blend 65% tef, 30% sorghum and 5% faba bean and fermented for 24 hrs. The result has found that the addition of faba bean and sorghum flour into tef flour was significantly ($P<0.05$) increased the zinc content of the blend injera. This might be due to that faba bean flour had more zinc content 14.58 mg/100g. Significant difference was also existed on fermentation time among the data. The high zinc content (23.81 mg/100 g) was found at 72 hrs fermentation time while the lowest zinc content (14.27mg/100g) was observed at 24hrs fermentation time. This could be due to fermentation that enhances the removal of antinutritional factors [23].

The addition of both sorghum and faba bean flour in to tef flour had significantly ($P<0.05$) increased the zinc content of blend injera. This might be attributed to more zinc content in faba bean and sorghum flour. The interaction effect of sorghum and tef had no significant ($P>0.05$) effect on the zinc content of the blend injera. This indicates that the blend of sorghum and tef flour has not an important contribution for the increment of zinc content. However, the interaction effect of tef and faba bean had a significant ($P<0.05$) effect on the zinc content of the blend injera.

With respect to fermentation time, the zinc content of the blend injera was significantly ($P<0.05$) affected by fermentation. By increasing the fermentation period there was a gradual increase in zinc content. This is due to the reduction of antinutritional factors present in the raw flour. The model used to predict zinc content was presented in the (Eq. 2) as follows.

$$Zn=0.312T+1.678S-1.438Fb-0.029(T*S)+0.021(T*Fb)+0.115FT[x] \quad (2)$$

Where: Zn is zinc predicted (mg/100g), T is the proportion of raw tef flour (%), S is the proportion of raw sorghum flour (%), FB is the proportion of raw faba bean flour (%), and FT [x] is the batter fermentation time at (x= 24, 48 and 72 hrs)

The range of tef, sorghum and faba bean was depicted in the shaded region of the contour plots (Figure 1b). The maximum value of zinc (23.88%) was obtained when 30% sorghum and 15% of faba bean flour was blended into 55% tef flour and fermented for 72 h.

Calcium

The calcium content of the blend injera was shown in Table 1. Blending of sorghum and faba bean flour in to tef flour had a significant ($P<0.05$) effect on the calcium content of the blend *injera*. The highest value (187.25mg/100g) was obtained when 55% tef, 30% sorghum and 15% faba bean were blended and fermented for 72 hrs while the lowest value (129.55mg/100g)was obtained when 65% tef, 30% sorghum and 5% faba bean were blended and fermented for 24 hrs. The addition of faba bean in the blend had significantly ($P<0.05$) increased the calcium content of the blend *injera*. This is probably due to the presence of more calcium content in faba bean and sorghum flour. [24] reported that the calcium content of faba bean was 427.2 mg/100g. The control sample had significantly small amount of calcium than that of injera made from the blend. This is due to least amount of calcium in tef grain as compared to the faba bean.

All fermentation time had a significant ($P<0.05$) effect on the calcium content of the blended injera. Thus, fermentation had significantly ($P<0.05$) increased the calcium content of the blend injera. This is probably due to fermentation, which reduces the content of antinutritional factors such as phytates and tannins and is therefore likely to enhance mineral absorption [25]. The model (Eq. 3) used to predict calcium content was presented in the as follows.

$$Ca=1.829T+5.456S+1.409Fb-0.086(T*S)+0.115(T*Fb)+0.508FT[x] \quad (3)$$

Where: Ca is calcium predicted (mg/100g), T is the proportion of raw tef flour (%), S is the proportion of raw sorghum flour (%), FB is the proportion of raw faba bean flour (%), and FT [x] is the batter fermentation time at (x= 24, 48 and 72 hrs).

The range of tef, sorghum and faba bean was depicted in the shaded region of the contour plot (Figure 1c). The maximum value of calcium (187.25%) was obtained when 55% tef, 30% sorghum and 15% of faba bean was blended and fermented for 72 hrs. The addition of more faba bean and sorghum flour into tef flour increased the calcium content of the blend injera.

Effect of Blending ratios and Fermentation time on Antinutritional content of Injera

Condensed Tannin

The condensed tannin of the control and the blend was presented in Table 1. There was a significant (P<0.05) difference among the blend injera. The blend injera had a mean of (0.0099 mg catechin eq/kg). The highest value (0.606 mg catechin eq/kg) in the blend injera was obtained when 55% tef, 30% sorghum and 15% faba bean were blended and fermented for 24 hrs while the lowest value (0.061 mg catechin eq/kg) was obtained when 70% tef, 25% sorghum and 5% faba bean were blended and fermented for 72 hrs. The addition of faba bean and sorghum was significantly (P<0.05) increased the tannin content of the blend product. The least amount of tannin in faba bean is due to the fact that faba bean was dehulled. Because the tannins are found usually in the hulls of faba beans [26]. Thus condensed tannin content of the dehulled beans was very low.Tannin content in the white tef grain was virtually absent [1] and similar trend was observed since the control injera (100% tef) had insignificant levels of condensed tannins. All the interaction terms had significantly (P<0.05) increased the tannin content of the blend *injera*. This could be due to the higher tannin content of sorghum grain and faba bean.

The result revealed that fermentation time had a significant (P<0.05) effect on the tannin content of the blend *injera*. This means, when fermentation time increased, the tannin content of the blend injera was found to be reduced. The result agreed with [8] who reported that fermentation of millet grains at 12 hrs and 24 hrs reduced the antinutritional factors **(**phytic acid and tannins). The following model was developed to predict the condensed tannin content of the blend *injera* (Eq. 4).

$$CT=-0.056T-0.347S+0.372FB+0.0069(T*S)-0.0034(T*FB)-0.0007FT[x] \quad (4)$$

Where: CT is predicted condensed tannin (mg catechin eq/kg), T is the proportion of raw tef flour (%), S is the proportion of raw sorghum flour (%), and FB is the proportion of raw faba bean flour (%), and FT [x] is the batter fermentation time at (x=24, 48 and 72 hrs).

The range of tef, sorghum and faba bean was depicted in the shaded region of the contour plot (Figure 1d). The lowest value (0.061mg/kg) of condensed tannin (optimum region) of the blend injera was obtained when 25% sorghum and 5% faba bean were blended into 70% tef flour and fermented for 72 hrs.

Phytic Acid

The phytic acid content of the blend injera was shown in Table 1. Blending of tef, sorghum and faba bean had a significant (P<0.05) effect on the phytic content of the blend *injera*. The blend injera had a mean value of (112.0mg/100g). The highest value (290.84mg/100g) was obtained when 70% tef, 20% sorghum and 10% faba bean were blended and fermented for 24 hours while the lowest value (30.76mg/100g) was obtained when 55% tef, 30% sorghum and 15% faba bean were blended and fermented at 72 hrs. More phytic acid was obtained in *injera* made from tef, sorgum and faba bean mixture and light fermentation because of the combination of the three mixtre components. [27] reported that tef grain had 842mg/100g. However, as the result has shown the control (100% tef) injera had less phytic acid than the blend injera.

There were also significant differences between fermentation time (P<0.05) on phytic acid content of the blend injera as well as the control injera. The highest phytic acid (295.46mg/100g) was obtained at 24h while the lowest phytic acid was obtained at 72 hours.This might be attributed to enzymatic hydrolysis of phytic acid by endogenous phytase of sorghum and/or by phytase, which was produced by the microorganism, may account for most of the reduction of phytic acid during fermentation [28].

The results also found that fermentation time had a significant reduction effect on the phytic acid content of the blend *injera* (P<0.05). This is in full agreement with [29] who reported that injera processed from 2-3 days fermented dough was found to contain low level of phytate. The following model (Eq. 5) was developed to predict the phytic acid content of the blended Injera.

PA=11.835T+50.38S-29.96Fb-1.019(T*S)+0.268 (T*FB)-1.713FT[x] (5)

Where: PA is predicted phytic acid (mg/100g), T is the proportion of tef flour in percent (%), S the proportion of sorghum flour in percent (%), FB is the proportion of faba bean flour in percent (%), and FT[x] is batter fermentation time (x=24, 48 and 72 hrs).

The range of tef, sorghum and faba bean was depicted in the shaded region of the contour plot (Figure 1e). The lowest value (120.76mg/100g) of phytic acid content (optimum region) of the blend injera was found when the 30% sorghum and 15% blended into 55% tef flour and fermented at 72 hrs.

Effect of Blending Ratios and Fermentation Time on Sensory Acceptability of Injera

Sensory evaluation is used in food science to objectively analyze food quality through the evaluation of the attributes traceable by one or more of the five human senses— taste, smell, touch, sight, and hearing [30]. In many cases, it allows for the objective determination of whether or not consumers will accept a novel food product [31].

In the current study, a panel of 50 judges was used to describe the degree of consumer acceptance and satisfaction to the injera prepared using different combinations of teff flour combined with sorghum and faba bean flour, and fermentation time. Fermentation time and Blending of tef, sorghum and faba bean had a significant (P<0.05) effect on the sensory acceptability of the blend injera. Acceptability test result for flavor, aroma, sourness, color, appearance and rollability of the control and blended injera product was given in Figure 2. Scores of the products that had a mean value greater than 5 indicates the products were well liked by the panelists.

The addition of faba bean and fermentation time had a significant (P<0.05) effect on the rollability of the blend injera. Rollability is associated with the less staling property of the baked product. The staling in the product will increase crumb firmness and deterioration of the baked product during storage [32]. The addition of more faba bean in the blend increases the crumb firmness of the blend injera and similar to the result found on bread by [33]. The panelists were more like the rollability of control injera than blended injera. The rollability of blended injeras made from blending of 20% sorghum and 10% faba bean in to 70% tef followed by 30% sorghum and 5% faba bean in to 65% tef fermented at 72 hours was more liked by the panelist than 24 hrs and 48 hrs fermentation (Figure 2).

Sourness is the sharp acidic taste of fermented foods. The blending ratios and fermentation time caused significantly (P<0.05) differences on sourness; Injera from 70% tef with 20% sorghum and 10% faba bean exhibited the highest acceptability scores of 6.96 followed by 6.84 was obtained from the injera containing 65% tef, 30% sorghum and 5% faba bean fermented at 24 hrs respectively (Figure 2). All the data indicated a high degree of acceptability of the sourness of the injera with different levels of tef, sorghum and faba bean blending ratios. Generally, the trend showed that with prolonged fermentation time (72 hrs), the panelist scores reduced. This could be due to more acid production during the long fermentation.

A strong, pleasant smell (odor) usually from food is called as aroma and is sensed by receptors in the nose. The highest scores of aroma were 6.94 belonged to *injera* containing 20% sorghum and 15% faba bean with 65% tef fermented at 72hrs, while the lowest score (5.22) was obtained from the control injera fermented at 24hrs (Figure 2). The addition of faba bean and sorghum increased the pleasant aroma of the blend injera. This might be attributed to more antinutritional factors like tannins in faba bean and sorghum flour. The values have also increased as the prolonged fermentation time.

Flavor is the sense of taste and smell combined. Taste of injera is associated with the sensation of saltiness, sweetness, sourness and bitterness triggered in the mouth by contact with the injera [31]. The highest acceptability scores of the flavor (6.9) of the injera were obtained from the blend 65% tef, 20% sorghum and 5% faba bean fermented for 72hrs. The lowest score, 5.06 belonged to the injera containing 20% sorghum and 10% faba bean with 70% tef and control injera fermented with 24hrs (Figure 2). The addition of faba bean and sorghum flour into tef flour

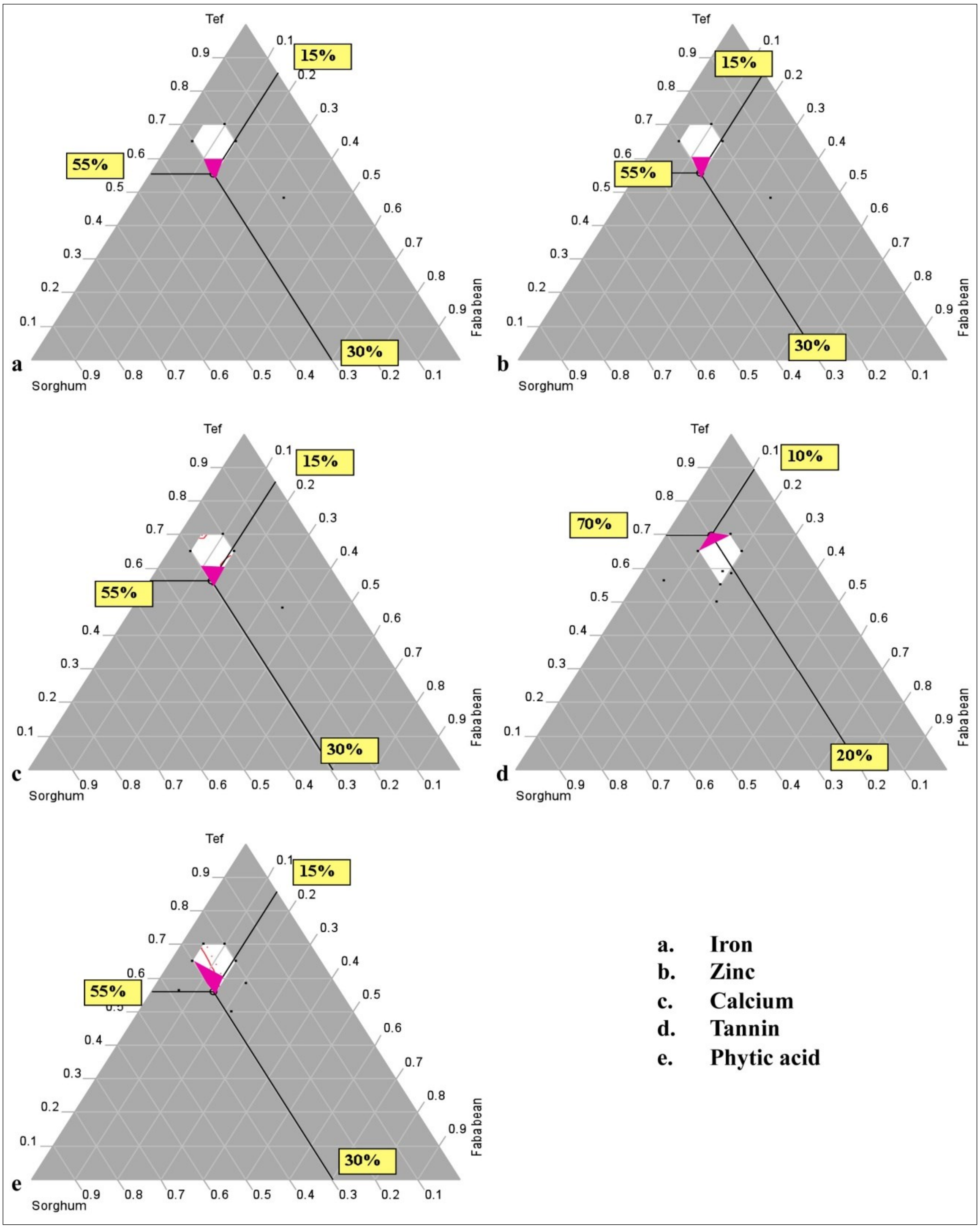

Figure 1. Mixture contour plot of Mineral and Antinutritional content of the blend injera

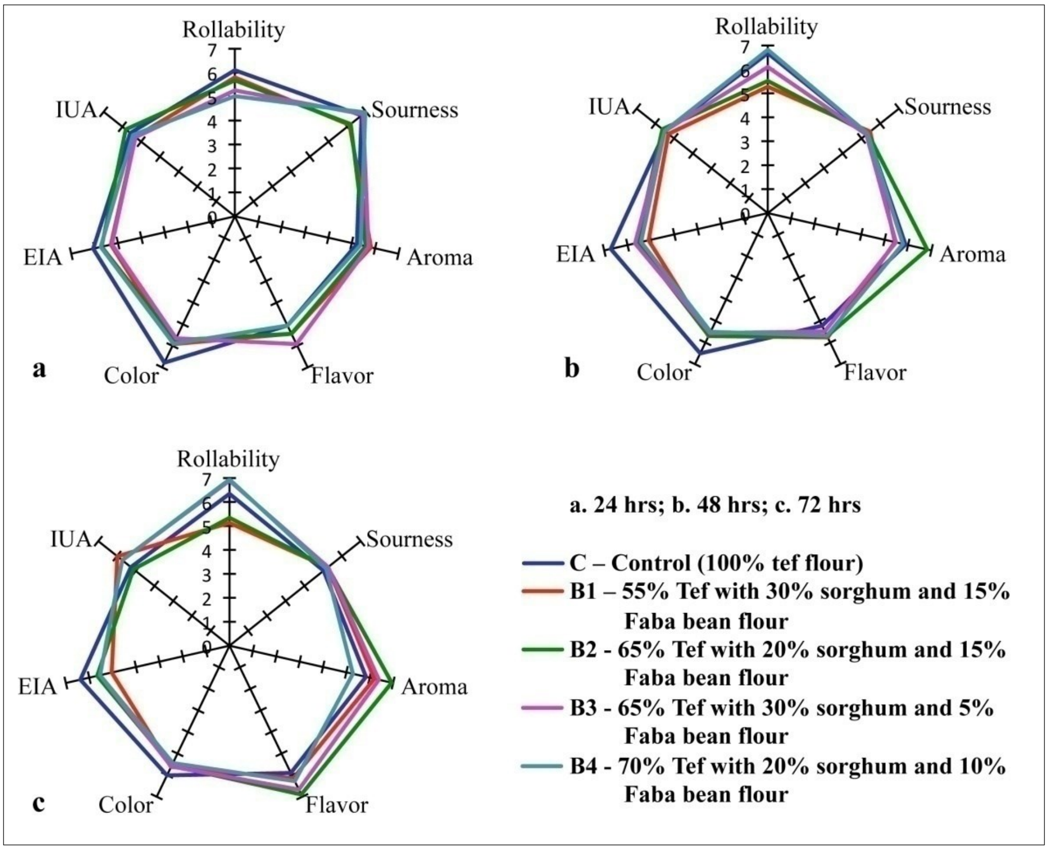

Figure 2. Effect of fermentation time and blending ratios on sensory acceptability blended *injera* product.

was found to improve the flavor of the blend injera than control. This could be due to flavor compounds, which are available in sorghum and faba bean flour. Additionally, the fermentation time had significantly influence the flavor of injera. Generally, the trend showed that with prolonged fermentation time (72 hrs), the scores increased. The increased flavor at a longer fermentation time could be due to lactic acid bacteria, which synthesized flavor compounds [34]. Fermentation improves the flavor of food [35].

The color of injera also affects the consumer acceptability of the injera. People mostly prefer the white color injera is consumed as a staple food [7]. Highest score of color (6.98) was recorded in control injera samples fermented 24hrs (Figure 2). The addition of sorghum and faba bean had significantly ($P<0.05$) reduced the color score of the blend injera. This might be attributed to more tannin content in sorghum and faba bean, which could change the color of the blend injera to brown. The result was agreed with [33] who reported that the addition of more faba bean in the blend leads to browning of the bread produced but increases the acceptable taste. The control injera fermented for 24hrs had most preferable color, which is a bright color [7]. Increased fermentation time had significantly reduced the color score of injera.

The appearance of injera is one of the most important parameters, which refers to the quality of the eyes and underneath the appearance of injera. The eyes of injera are the honeycomb-like structure of the top surface formed during cooking due to escaping CO_2 bubbles [36]. The highest panelist scores of the eyes of the injera were recorded in control samples. The addition of more faba bean and sorghum flour was decreasing the score of injeras eye's appearance given by the panelists (Figure 2). It might be due to less carbon dioxide production during fermentation. [14] reported that increased eyes formation of injera due to the more carbon dioxide gas produced during fermentation time.

The maximum acceptability scores recorded for underneath appearance of the *injera* from 55% tef, 30%

sorghum and 15% faba bean blends (Figure 2). It appeared that increasing in the proportion of sorghum and faba bean significantly increasing the underneath appearance scores of injera. The values of color and underneath the appearance of injera were significantly not affected by fermentation time.

Based on the present findings, the addition of sorghum and faba bean with tef, and fermentation time significantly increased sensory score of rollability, sourness, aroma, flavor and underneath the appearance, and decreased the score color and eyes formation of injera. All blends scored a mean rating well above average, which is an indicative of the goodness as products (Figure 1). The most preferred injera was produced from tef flour combined with 20% sorghum and 10% faba bean flour fermented 72 hours. Similar observation was made by [37] who reported that long fermentation improves sensory characteristics such as loaf volume, evenness of eyes, color, aroma, taste and texture of the breads.

Conclusion

The injera made from 55% tef with 30% sorghum and 15% faba bean had the maximum amount of moisture, protein, ash, fiber, iron, zinc and calcium content. The high amount of ash, fat, fiber, carbohydrate, energy and sensory score were obtained from 70% tef, 20% sorghum and 10% faba bean blended injera. Significant ($P<0.05$) increased in moisture, protein, iron, zinc, calcium and sensory attributes were shown on long fermentation time (72 hrs). However, ash, fat, fiber, carbohydrate and energy were shown at short fermentation time. On the two dimensional mixtures contour plot the optimum value of chemical composition of injera was observed when 55% tef, 30% sorghum and 15% faba bean were blended and fermented at 72 hrs.

The present findings revealed that the optimum value of all chemical composition and sensory acceptability of blended injera was obtained when 30% sorghum and 15% faba bean were mixed in to tef flour and fermented for 72 hrs. The blending of sorghum and faba bean with tef is not only increased the nutritional properties and sensory acceptability of injera and also reduces the utilization of expensive cereal such as tef for injera making. Generally, this study demonstrated the potential of incorporating sorghum and faba bean flour into sour bread injera, thereby creating opportunity for food producers to provide more healthy nutritional enriched products.

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