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Research Article

Effect of Blending Ratio and Fermentation Time on the Physicochemical, Microbiological, and Sensory Qualities of Injera Prepared From Maize-Sorghum and Wheat Flours

Dessie Teka Nibret[1], Tadele Andargie Wudineh[2], Mesfin Wogayehu Tenagashaw[2], Agimassie Agazie Abera[2], Degnet Teferi Asres[2], Abebaw Teshome Tiruneh[2], Takele Ayanaw Habtu[2], Sadik Jemal Awol[2], Danel Berhineb[2] and Asrat Otrub[2]*

[1]*Food and Beverage Industry Research and Development Center, Ethiopia*

[2]*Bahir Dar Institute of Technology, Ethiopia*

Abstract

Teff is commonly used to prepare injera. However, due to the higher price of teff recently, only high-income people pay for it. Hence, this work investigated the effect of blending ratios and fermentation time on the quality of injera prepared from maize-sorghum and wheat. The prepared injera showed moisture as 3.69% to 8.36% db., crude protein 11.2% to 15.73%, total ash 1.11% to 1.7%, crude fat 0.93% to 2.59%, crude fiber 1.96%t o 3.3%, carbohydrate 70.96% to 76.98%, and gross energy 354.52% to 381.17 Kcal/ 100 g. Injera prepared from all the blends was sensorially accepted; however, injera prepared from 60% wheat, 30% sorghum, and 10% maize fermented for 84 h was the most preferred. Generally, this study concluded that up to 60% wheat, 30% sorghum and 10% maize blending, and 84 h fermentation could be recommended in the preparation of nutritionally improved injera with good sensory acceptability.

Keywords: Blending ratio; Wheat; Fermentation time; Injera; Nutritional quality; Sensory acceptability

Introduction

Injera is a thin, pancake-like, flatbread and a small honeycomb-like structure on its top surface which is formed due to the production of CO_2 during fermentation and escape during baking [1]. It is a common ethnic staple food consumed in all parts of Ethiopia [2]. Even if teff is commonly used to prepare injera, other cereals such as sorghum, rice, wheat and maize are also utilized for such purposes, especially in rural communities [3].

Teff (Eragrostis tef Zucc) is known for its higher mineral content than other cereals [4]. Nowadays, injera is prepared in combination of teff with other cereals like wheat, sorghum, millet, maize, rice, barley, amaranths, and quinoa. Due to the increase in teff prices, even middle-income households tend to mix teff flour with cheaper cereals when making injera [5].

Sorghum (*Sorghum bicolor L. Moench*) is one of the gluten free cereals that prevent the occurrence of Celiac Disease (CD). According to Yetneberk [6], study, there has been very little research into technologies for improving sorghum injera's quality. Sorghum and maize, being gluten-free grains, can be used to compensate for wheat in injera for people suffering from diseases such as celiac disease [7].

Maize (*Zea mays L*) is the lowest-priced cereal among the grains that deliver both energy and good quality protein [8]. According to Demeke [9], maize is an important food security crop in Ethiopia and the most caloric source among all major cereals. According to Chandran, et al. [10], Maize grain lacks adequate levels of the essential amino acids, thus reducing the overall biological value of its protein.

Wheat (*Triticum aestivum L*) is one of the types of cereal crops mostly grown worldwide and hence also in the highlands of Ethiopia. It is a major source of starch and energy that provides substantial amounts of a number of components that are essential for health, mainly protein, vitamins (B vitamins), dietary fibre and phytochemicals.

According to Neela & Fanta [11], the best sensory injera would be rich in eyes, softer, thin, and reliable and sour tasting due to the fermentation time and process.

There are limited findings on blending maize flour with sorghum and wheat flours for injera making. As a result, an effort is needed to improve the nutrient density and sensory acceptability of injera by blending maize with sorghum and wheat flour through an appropriate fermentation time. By considering all the above gaps, this study was focused to investigate the effects of blending ratio and fermentation time on the physico chemical, microbiological, and sensory qualities of injera made from different ratios of maize, sorghum, and wheat blended flours.

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***Corresponding author:** Dessie Teka Nibret, Food and Beverage Industry Research and Development Center, Ethiopia, Tel: +251915857478

Materials and Methods

Sample collection and raw material preparation

The following experimental materials, such as white sorghum (melkam variety) were collected from Gonder Agricultural Research Center, wheat (kekeba variety), white tiff (teddy variety), and maize (BH660), were collected from Adet Agricultural Research Centre.

The collected samples were cleaned manually to remove stones, dust, lighter particles, undersized and immature grain. The samples were milled to the whole flour level, which is traditionally used for injera making. After milling, the flour was sifted to pass through a710 µm test sieve [12]. The sieved flour was packed into polyethylene plastic bags and stored at 4°C for further laboratory analysis and injera preparation.

Experimental design

The experimental design of this study had two factorial design arranged in Completely Randomized Design (CRD); fermentation time and blending ratio. Fermentation times were 36, 60, and 84 hours [13] and the flour blending ratio is considered in five levels: they are BR1 (wheat 60: sorghum 30: maize 10), BR2 (wheat 50: sorghum 35: maize 15), BR3 (wheat 40: sorghum 40: maize 20), BR4 (wheat 30: sorghum 45: maize 25), BR5 (wheat 20: sorghum 50: maize 30) and Control 100% teff [14]. The selection of the blending ratio was considered based on the observations of the preliminary studies and the fermentation time is selected based on the traditional practice and preliminary work (Table 1).

Table 1: Blending ratio combination with fermentation time.

Blending ratio	Fermentation time		
	F1	F2	F3
BR1	BR1*F1	BR1*F2	BR1*F3
BR2	BR2*F1	BR2*F2	BR2*F3
BR3	BR3*F1	BR3*F2	BR3*F3
BR4	BR4*F1	BR4*F2	BR4*F3
BR5	BR5*F1	BR5*F2	BR5*F3
Control	C*F1	C*F2	C*F3

The experiment contains two factors Blending Ratio (BR) and fermentation time (F) f1=36, f2=60 and f3=84 hours. Blending ratio contains five levels, with one control andfermentation timecontains three levels. The number of treatment combination = 15, Total run with triplication= (3*15) +9= 54 runs.

Preparation of fermented dough and preparation of injera

Irsho for each experiment was prepared from the previously prepared flour and clean water. The fermentation starter was ready for use after 60 hours of fermentation and was used for the preparation of the main dough. Injera was prepared by mixing blended flour (1 kg) with 2 L of water and 160 mL of ersho and making it into dough by hand kneading for 5 minutes. Then, the fermentation was allowed for 36 - 84 hours as indicated in the experimental design.

Abs it was cooked by taking 10% of the fermenting dough, mixing it with water (1:3 ratios), boiling it for 10 minutes. After cooling to about 46°C, abs it was added back into the fermenting vat for the second phase of fermentation, which lasted for about 12 h until bubbles formed and it became ready for baking to prepare injera.

Once the dough is ready, the Mitad surface is swapped down with rapeseed flour using a piece of clean cloth before pouring the batter. The fermented dough was allowed to be thin enough to pour 500 ml on to the hot flat pan (at a temperature of around 220°C), locally known as "Mitad." The Mitad was covered with a Mitad lid locally called "akimbalo" to prevent steam from escaping. After injera is baked, the samples were stored in a traditional storage bin known as “Missob”; a portion of injera is subjected to the sensory analysis and the remaining is dried for physicochemical analysis.

Preparation of dried injera flour: The baked injera was dried by spreading on aluminum foil at 70°C for 8 to12 hours in an air oven dryer (Model: DHG-9140: Zenith Lab Inc., China) and ground with a mortar and pestle to a fine level to pass a sieve of 710 µm [15]. These injera flours were packed and sealed in polyethylene plastic bags and stored at 4°C until further laboratory analysis was done.

Data collection

Determination of physical properties:

Determination of viscosity: A rotational digital viscometer made by Thermo Scientific (model Visco Star Plus) was used to analyze the apparent viscosity of the blended flours and also the teff dough and batters. The instrument was eveled, and the appropriate spindle number was R4 with a suitable 100 RPM set.

Determination of PH: The pH of the fermented dough was determined directly by dipping the pH meter before and after absit addition and injera samples. The pH meter was standardized using pH 4.0 and 7.0 buffers. Then, after completing the calibration of pH, the sample was measured using a PH meter (model: PHS-25/3C).

Determination of total titrable acidity: The total titratable acidity of dough, batter, and injera was determined depending on the methods designated by [16]. The titratable acidity was determined by titrating a mixture of 10 g of sample and 100 ml of distilled water to pH 8.5 using a 0.1 M sodium hydroxide solution.

Texture analysis: The force-time curve was measured using a Texture Analyzer TAXT2i (Stable Micro Systems, Surrey, England). The injera strips were wrapped in polyethylene plastic and stored at room temperature (25°C) for 0, 2, and 4 days.

Color analysis: The determination of the Color of injera (surface and bottom) was determined using software which resolved by an electronic spectrophotometer Konica Minolita Cm-600d Spectrophotometer with optical sensor works based on L*, a*, and b* values.

Determination of proximate composition of injera: The moisture content of the injera samples was determined according to the AOAC, 2000; using the official method No. 925.10 by oven drying (model: DHG: 9140A; Zenith Lab Inc., China). The crude protein content was determined by the Kjeldahl method (AOAC, 2000), using the official method No. 920.87. The crude fiber content of injera was determined bythe non-enzymatic gravimetric method AOAC (2000), official method No. 920.168, using the acid and base digestion method. The total ash content of the injera samples was determined by AOAC, (2000); using the official method 923.03.

The crude fat of the injera samples was determined by the soxhelet extraction method according to AOAC (2000), using the official method No. 920.39.using the hexane as the extraction solvent. The carbohydrate content was determined by difference method according to Onyeike. The total energy content of the injera samples was determined according to AOAC (2000), by multiplying the mean value of crude fat, total carbohydrate, and crude protein by the factor 9, 4, and 4, respectively.

Determination of anti-nutritional factors and phenolic content:

Phytate content was estimated by undertaking phytic acid analysis spectrophotometrically methods according to Latta and Eskin [17]. Condensed tannin was determined using the procedure outlined by Dykes [18]. Escobedo-Flores, et al [19], Described a method for determining the TPC of each extract. According to Georgé, et al [20] the sample of injera flour (5g) was homogenized with 10 mL of 60% methanol containing 0.1% HCl before being heated in a water bath for two hours at 85°C to eliminate vitamin C.

Determination of mineral content: The Iron (Fe), Zinc (Zn) and Calcium (Ca) content of the injera sample was determined according to the methods described by AOAC, 2000, using the official methods of Flame Atomic Absorption Spectrophotometry, 923.03. The sample (2g) was digested for 420°C to 60 minutes (Kjeldahl digester, DK20, VELP Scientific, Italy) with 20 ml of concentrated 69% to 72% HNO_3 and 10 ml of 70% $HClO_4$.

Determination of microbial quality of injera:

Aerobic plate counts: The total aerobic plate count was carried out on injera samples after baking, day three, and day five storage at room temperature using the procedure of Horwitz & Latimer Jr. About 23.5 g of PCA powder was weighed and added to 1000 mL of distilled water, which was then heated to boiling to dissolve it completely.

Yeast and molds: The total yeast-mold count was carried out on injera samples on days one, three, and five at room temperature storage. About 39 g of PDA powder was weighed and added to 1000 mL of distilled water, which was then heated to boiling to dissolve it completely. The counts of visible colonies were read out by using a colony counter (JKI, Model-JKCC-30, China) and expressed as log CFU/g [21].

Sensory evaluation of injera : The acceptability and sensory profile of the prepared injera were estimated by 37 untrained panelist with the five-point hedonic scale [22].The sensory evaluation of all injera samples was carried out at the department of food engineering using regular injera consumers' panellists, lecturers, and students at Bahir Dar Institute of Technology. The panelist was evaluated for each sample sensorial parameter, including taste, eye size, top and bottom surface, rollability, eye distribution, softness, color, and overall acceptability, based on their degree of liking (1. dislike extremely; 2. dislike moderately 3. Neither like nor dislike 4. Like moderately; 5. Like extremely.

Data analysis

All analyses were subjected to ANOVA (Analysis Of Variance) to obtain the significance difference between the mean values using Turkey's pair wise comparison, the Least Significance Difference, or LSD ($p<0.05$). The statistical analysis of the data from each experiment was performed using Minitab 19 version software, and results were expressed as mean ± Standard Deviation (SD). Sigma plot version 12.5 was used to create some graphs.

Results and Discussions

Physical properties of dough, batter and injera

Viscosity of the dough and batter: The interaction of blending ratio and fermentation time had a significant ($p<0.05$) effect on the viscosity of the dough and batter. From the results, BR1 fermented for 36h was 6.53 poise, and BR5 fermented for 84h was 1.11 poise, which had the highest and lowest viscosities of the dough compared to the other treatments.

The composite flour BR1 fermented for 36h was 2.35 poise, and the composite flour BR5 fermented for 84h was 0.34 poise, had the highest and lowest viscosities of the batter. According to Attuquayefio, the amount of abs it added and the quantity of air bubbles produced during fermentation both had an impact on the viscosity values of the fermented batter.

PH and TA of dough: The interaction of blending ratio and fermentation time had a significant ($p<0.05$) effect on the pH of the dough and the results were in the range 3.21 to 3.86. The lowest pH value of the dough before absit addition (3.21) was observed from BR1, fermented for 84h while the highest pH value (3.86) was obtained from BR5, fermented for 36h. Overall, there was a rapid decay in pH in all dough samples from 36 to 60 h, a steady decline from 60 h to 84 h due to fermentation time effects.

According to Attuquayefio [23] pH indicates the amount of lactic acid produced during fermentation, and hereafter it determines the sourness of the dough.

The total Titratable Acidity (TA) of the composite formulated dough varied from 1.16 to 2.16. The highest TA values were in the dough BR1, fermented for 84h and the lowest value was measured in BR5 at the 36h of fermentation. The sourness test of traditionally fermented Ethiopian injera is one of the sensory attributes impacted by pH due to changes in lactic acid bacteria availability during fermentation, as reported by [24]. Injera dough made with tedey teff flour as well as dough made from maize flour [25] and sorghum flour [26] has all been observed to have an increase in total titratable acidity as the fermentation process increased.

PH and TA of batter: The interaction of blending ratio and fermentation time had a significant ($p<0.05$) effect on the pH of the batter and the value ranged 3.44 to 4.20. In general, there was a rapid increase in pH in all batters after the addition of a sit compared to the PH of dough. The pH decreased with increasing TA during the batter fermentation, associated with an increase in LAB count [27].

The interaction of blending ratio and fermentation time had a significant ($p<0.05$) effect on the total titrable acidity of batter after addition of a sit, the value ranges from 1.11 to 1.98. This could explain the apparent increase in lactic acid towards the end of fermentation, accompanied by a lack of changes in PH.

PH and TA of injera: The PH of the composite formulated injera varied from 4.35 to 4.75, and the interaction of fermentation time and blending ratio had a significant ($p<0.05$) influence on the pH of injera. The pH of injera was increased compared to dough and batter. This is due to the decrease in moisture content caused by baking, which resulted in a change in pH.

The interaction of blending ratio and fermentation time had a significant ($p<0.05$) effect on the total titrable acidity of injera, the value ranges from 1.08 to 1.89. The highest TA values were measured in BR1 for fermented 84h fermentation, and the lowest value was measured in BR5 for fermented 36h of fermentation.

Color (L*, a* and b* values) characteristics of prepared injera

The interaction of blending ratio and fermentation time had a significant ($p<0.05$) effect on the surface color (L*, a* and b* values) of formulated injera. The average lightness values (L*) ranged from 27.16 to 51.92. The average redness values (a*) ranged from 1.79 to 4.25 and the average blueness values (b*) ranged from 12.70 to 18.72

in the surface color of composite flour injera.

The interaction of blending ratio and fermentation time had a significant ($p<0.05$) effect on the bottom color of injera lightness value (L*) ranged from 26 to 47.92. The average redness values (a*) ranged from 1.29 to 3.75 and the average blueness values (b*) ranged from 11.23 to 16.88 (Table 2).

Texture properties of baked injera at different storage periods

The interaction of blending ratio and fermentation time had a significant ($p<0.05$) effect on the texture of injera at zero, two, and four day storage. According to Sluková, et al [28] report alterations is staling that incurred during storage, referring to the losses of freshness that impose organoleptic change mainly in injera texture. The physical texture value for the composite flour injera measured by the texture analyzer was found to be in the ranges 11.30 to 16.8 N, 10.8 to 14.75 N, and 9.02 to12.82 N at baking 2nd and 4th day storage, respectively. In the current study, it was observed that the hardness of injera decreased with an increase of sorghum and maize flour proportions in the composite flour with elongation of fermentation time, which was cloth related (Table 3) [29].

Effect of blending and fermentation time on anti-nutritional and phenolic content of injera

Condensed tannin: The Condensed Tannin (CT) contents of injera made from different composite flour ratios ranged from 0.61 to 1.17 mg/100 g, and teff flour injera as a control showed 1.1, 1.03, and 0.59 mg/100g at 36, 60, and 84 h of fermentation. Trends of increasing tannin content in composite blends were attributed to the increased percentage incorporation of sorghum flour.

Reduction in tannin contents due to fermentation might have been caused by the action of polyphenol oxidase or tanniase of fermenting micro flora on tannins (Table 4) [30].

Total Phenolic Content: The interaction of blending ratio and fermentation time had a significant ($p\leq0.005$) effect on the total phenolic content of injera, and the values varied from 24.83 mg GAE/100g to 36.33 mg GAE/100 g, while teff flour injera as a control showed 23.9, 31.33, and 31.7 mg/100g at 36, 60, and 84 h fermentation. The total phenolic content of injera samples was found to significantly increase with an increase in the proportion of sorghum and maize flour in the blends. According to Shumoy, Gabaza, et al [31] an increase in total phenolic content ranging from 31% to 54% was seen in injera made from teff varieties and an increased fermentation time from 0 to 120 h.

Phytate content: The interaction of blending ratio and fermentation time had a significant ($p<0.05$) effect on the phytate content of injera, and the value ranged from 139.7 mg/100g to 211.5 mg/100g. As wheat composition increases, the phytate concentration also increases in the blended injera; the inverse is true for maize and sorghum compositions. According to Rahman and Osman [32] the significant reduction in phytate content during fermentation should be attributed to the enzymatic hydrolysis of phytic acid.

Effect of Blending Ratio and Fermentation Time on Mineral Contents of Injera

The interaction of blending ratio and fermentation time had a highly significant ($p<0.01$) effect on the iron content of injera and the result found to be in the range of 4.17 to 12.5 mg/100 g. The highest value was obtained from the control (13.95 mg/100g) fermented at 84 h, while the lowest value was found in BR1 (4.17) fermented for 36 h. As the fermentation time increased from 36 to 84 h, the iron content significantly increased. According to Leykun, et al [33] study, the iron content of injera made from 100% pure teff flour is significantly ($p<0.05$) higher than injera made from other composite flour injera because teff grain has high iron contents. Moreover, during fermentation, pH is reduced, which leads to an optimal environment for phytase activity to degrade phytate [34].

The interaction of blending ratio and fermentation time had a highly significant ($p<0.01$) effect on the zinc content of injera, and the result varied in the range of 1.92 to 4.92 mg/100g. The highest

Table 2: Effect of blending ratio and fermentation time on the surface color (L*, a* and b* values) of formulated injera.

Blending ratio	Fermentation time (hr)	L*	a*	b*	L*	a*	b*
BR1	36	27.16 ± 3.25ᶠ	4.25 ± 0.02ᵃ	18.72 ± 0.22ᵃ	26 ± 4.42ᶜ	3.75 ± 0.72ᵃ	16.88 ± 0.78ᵃ
	60	28.03 ± 2.81ᵉᶠ	4.19 ± 0.12ᵃᵇ	17.90 ± 0.96ᵃᵇ	26.41 ± 2.69ᶜ	3.69 ± 0.58ᵃ	15.37 ± 0.41ᵃᵇᶜ
	84	29.76 ± 0.63dᵉᶠ	4.11 ± 0.03ᵃᵇ	17.13 ± 0.06ᵃ⁻ᵈ	28.34 ± 2.67ᶜ	3.61 ± 0.67ᵃ	15.7 ± 2.30ᵃᵇ
BR2	36	31.43 ± 0.63dᵉᶠ	3.54 ± 0.63ᵃᵇᶜ	17.51 ± 1.87ᵃᵇᶜ	29.09 ± 1.51ᶜ	3.04 ± 0.07ᵃᵇ	16.28 ± 0.08ᵃ
	60	33.47 ± 1.71ᵈᵉ	3.24 ± 0.09ᵃ⁻ᵈ	16.27 ± 1.46ᵃ⁻ᵈ	31.88 ± 2.68ᶜ	2.74 ± 0.60ᵃᵇ	14.77 ± 0.62ᵃ⁻ᵈ
	84	34.69 ± 0.72ᵈ	3.18 ± 0.07ᵃ⁻ᵈ	16.1 ± 0.76ᵃ⁻ᵈ	33.67 ± 2.98ᵇᶜ	2.68 ± 0.63ᵃᵇ	14.84 ± 0.39ᵃ⁻ᵈ
BR3	36	42.43 ± 0.79ᶜ	2.83 ± 0.22ᵃ⁻ᵉ	16.33 ± 2.56ᵃ⁻ᵈ	40.09 ± 0.02ᵃᵇ	2.33 ± 0.48ᵃᵇ	15.2 ± 4.07ᵃᵇᶜ
	60	43.43 ± 1.38ᶜ	2.72 ± 0.16 ᵃ⁻ᵉ	16.07 ± 0.62ᵃ⁻ᵈ	42.33 ± 0.62ᵃ	2.22 ± 0.54ᵃᵇ	14.05 ± 0.86ᵃ⁻ᵈ
	84	44.99 ± 0.02ᵇᶜ	2.69 ± 0.13ᵇ⁻ᵉ	15.32 ± 1.48ᵃ⁻ᵈ	43.16 ± 1.63ᵃ	2.19 ± 0.57ᵃᵇ	13.02 ± 1.44ᵃ⁻ᵈ
BR4	36	45.81 ± 0.20ᵇᶜ	2.48 ± 0.27ᶜᵈᵉ	15.12 ± 1.33ᵃ⁻ᵈ	41.3 ± 0.33ᵃᵇ	1.98 ± 0.98ᵃᵇ	14.23 ± 2.52ᵃ⁻ᵈ
	60	46.79 ± 0.60ᵃᵇᶜ	2.43 ± 0.77ᶜᵈᵉ	15.12 ± 1.18ᵃ⁻ᵈ	43.32 ± 0.16ᵃ	1.93 ± 0.06ᵃᵇ	13.16 ± 1.17ᵃ⁻ᵈ
	84	47.15 ± 1.30ᵃᵇᶜ	2.20 ± 0.88ᶜᵈᵉ	14.84 ± 1.22ᵃ⁻ᵈ	44.05 ± 2.29ᵃ	1.70 ± 0.17ᵃᵇ	13.05 ± 1.81ᵃ⁻ᵈ
BR5	36	49.77 ± 1.90ᵃᵇ	2.026 ± 0.48ᶜᵈᵉ	14.03 ± 0.83ᵃ⁻ᵈ	46.06 ± 1.48ᵃ	1.53 ± 1.18ᵃᵇ	12.47 ± 0.57ᵃ⁻ᵈ
	60	50.55 ± 1.88ᵃᵇ	1.85 ± 0.09ᵈᵉ	13.55 ± 0.24ᵃ⁻ᵈ	46.57 ± 0.68ᵃ	1.35 ± 0.60ᵃᵇ	11.26 ± 0.24ᵃ⁻ᵈ
	84	51.92 ± 1.36ᵃ	1.79 ± 0.09ᵈᵉ	12.70 ± 0.64ᶜᵈ	47.92 ± 0.94ᵃ	1.29 ±0.60ᵃᵇ	11.23 ±0.29ᵃ⁻ᵈ
Control	36	27.39 ± 1.48ᵉᶠ	1.52 ± 0.02ᵉ	13.03 ± 1.44ᵇᶜᵈ	26.05 ± 2.59ᶜ	1.02 ± 0.68ᵃᵇ	10.16 ± 0.07ᵇᶜᵈ
	60	28.88 ± 0.76ᵈᵉᶠ	1.51 ± 0.61ᵉ	12.8 ± 2.32ᵇᶜᵈ	27.82 ± 0.68ᶜ	1.01 ± 1.32ᵃᵇ	9.71 ± 0.70ᶜᵈ
	84	29.84 ± 1.45ᵈᵉᶠ	1.29 ± 0.24ᵉ	12.01 ±0.17ᵈ	28.01 ± 0.50ᶜ	0.79 ± 0.46ᵇ	8.94 ± 1.17ᵈ
P- Value	BR	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	FT	<0.001	0.218	0.053	0.002	0.601	0.019
	BR*FT	<0.001	<0.001	0.001	<0.001	0.004	0.001

Data: mean ± SD, means with the same letter in the column are not significantly different, BR is blending ratio and f is fermentation time, L*= Lightness, a*= Redness, b*= Yellowness, and Control, teff.

Table 3: Interaction effect of blending and fermentation time on texture (hardness cutting force measured in N).

Blending ratio	Fermentation time	Zero day storage	Two day storage	Four day storage
BR1	36	16.8 ± 2.55^{bcd}	14.75 ± 0.78^{bcd}	12.82 ± 4.51^{c}
	60	15.28 ± 0.05^{bcd}	14.48 ± 0.65^{bcd}	12.29 ± 1.08^{cd}
	84	13.77 ± 2.45^{cd}	13.27 ± 1.74^{cd}	11.96 ± 0.12^{cd}
BR2	36	15.36 ± 0.09^{bcd}	14.11 ± 0.21^{bcd}	12.70 ± 0.23^{c}
	60	13.79 ± 0.56^{cd}	13.64 ± 0.77^{cd}	11.86 ± 1.99^{cd}
	84	13.28 ± 0.70^{cd}	12.79 ± 1.41^{cd}	11.37 ± 1.00^{cd}
BR3	36	14.40 ± 0.15^{bcd}	13.21 ± 1.54^{cd}	11.28 ± 0.27^{cd}
	60	13.38 ± 0.06^{cd}	13.23 ± 0.14^{cd}	11.38 ± 0.56^{cd}
	84	13.18 ± 0.70^{d}	12.53 ± 0.66^{cd}	11.01 ± 0.64^{cd}
BR4	36	13.75 ± 0.18^{cd}	12.8 ± 1.53^{cd}	10.96 ± 1.27^{cd}
	60	12.79 ± 0.07^{d}	12.49 ± 0.35^{cd}	10.14 ± 0.10^{cd}
	84	12 ± 1.34^{d}	11.6 ± 0.78^{cd}	9.68 ± 0.63^{cd}
BR5	36	12.24 ± 1.13^{d}	12.24 ± 1.13^{cd}	10.55 ± 0.29^{cd}
	60	12.20 ± 1.05^{d}	11.75 ± 0.41^{cd}	9.08 ± 0.14^{d}
	84	11.30 ± 0.31^{d}	10.80 ± 0.39^{d}	9.02±0.03^{d}
Control	36	24.12 ± 0.05^{a}	22.48 ± 0.70^{a}	20.67 ± 0.80^{a}
	60	19.86 ± 0.90^{a}	19.36 ± 0.764^{ab}	18.18 ± 1.49^{ab}
	84	19.22 ± 4.51^{abc}	17.23 ± 4.51^{abc}	17.15 ± 0.21^{b}
p-value	BR	<0.001	<0.001	<0.001
	FT	0.066	0.05	0.054
	BR*FT	<0.001	<0.001	<0.001

*Each means value ± standard deviation of triplicates. The values followed by different superscript letters within a column indicate a significant difference (p < 0.05).BR, blending ratio, and (control teff).

Table 4: Effect of Blending and Fermentation Time on Anti-nutritional and Phenolic Content of Injera.

Blending ratio	Fermentation time	Condensed tannin(mg catechin equiv./100g	Total phenol (mgGAE/100g)	Phytate content (mg/100g)
BR1	36	0.75 ± 0.02^{cde}	24.83 ± 0.13^{bc}	211.5 ± 19.4^{ab}
	60	0.64 ± 0.004^{e}	29.72 ± 4.47^{abc}	191.01 ± 3.31^{abc}
	84	0.61 ± 0.12^{e}	31.23 ± 1.84^{abc}	190.4 ± 2.66^{abc}
BR2	36	0.89 ± 0.01^{abcde}	27.17 ± 4.31^{abc}	206.7 ± 9.83^{ab}
	60	0.73 ± 0.12^{de}	30.73 ± 4.08^{abc}	190.84 ± 8.70^{abc}
	84	0.72 ± 0.17^{de}	32.9 ± 2.39^{abc}	187.99 ± 2.70^{abc}
BR3	36	1.13 ± 0.11^{ab}	31.89 ± 0.39^{abc}	188 ± 7.32^{abc}
	60	0.8 ± 0.07^{abcde}	32.19 ± 0.83^{abc}	183.95 ± 11.08^{abcd}
	84	0.76 ± 0.09^{bcde}	32.99 ± 1.06^{abc}	181.27 ± 2.33^{bcd}
BR4	36	1.14 ± 0.03^{a}	32.93 ± 2.43^{abc}	184.47 ± 9.93^{abcd}
	60	0.84 ± 0.09^{abcde}	33.001 ± 0.587^{abc}	182.89 ± 7.73^{abcd}
	84	0.82 ± 0.09^{abcde}	34.12 ± 1.67^{ab}	145.4 ± 20.7^{cd}
BR5	36	1.17 ± 0.05^{a}	34.99 ± 1.107^{a}	183.37 ± 10.52^{abcd}
	60	1.03 ± 0.05^{abcd}	36.27 ± 1.07^{a}	181.3±19.1^{bcd}
	84	0.95 ± 0.05^{abcde}	36.33 ± 4.37^{a}	139.7 ± 25.3^{d}
Control	36	1.1 ± 0.06^{abc}	23.9 ± 5.70^{c}	230.57 ± 5.10^{a}
	60	1.03 ± 0.13^{abcd}	31.33 ± 3.33^{abc}	210.9 ± 7.27^{ab}
	84	0.59 ± 0.10^{e}	31.7 ± 6.82^{abc}	203.2 ± 3.28^{ab}
p-value	BR	0.01	<0.001	<0.001
	FT	0.001	0.014	0.014
	BR*FT	0.001	<0.001	<0.001

*Each means value ± standard deviation of triplicates. The values followed by different superscript letters within a column indicate a significant difference (p<0.05). BR, blending ratio, and (control teff).

zinc content (6.39 mg/100g) was obtained in control injera fermented at 84 h, while the lowest zinc content (1.92 mg/100g) was obtained from BR1 injera fermented at 36 h. The increasing effect of the zinc concentration of composite flour as fermentation period increased in the present study was in agreement with the research, which reports an increment of soluble zinc in several folds as the result of phytate level reduction during fermentation by the activity of the phytase enzyme [35].

The interaction of blending ratio and fermentation time had a significant (p<0.05) effect on the calcium content of injera, and the value varied from 62.38 mg/100g to 100.06 mg/100g. Different researchers reported that composite flour injera calcium content varied from 17.97 to 187.25 mg/100g [36,37], which is in close agreement with the current study. The highest (138.4 mg/100g value was found for the control injera fermented at 84 h, while the lowest (62.38 mg/100g) was obtained in BR1 fermented for 36 h. The increase in calcium as the fermentation time increased might be due to the reduction of anti nutritional factors by fermenting microorganisms [38].

Effect of Blending Ratio and Fermentation Time on Proximate Composition of Prepared Injera

Moisture Content: The interaction of blending ratio and fermentation time had a significant (p<0.05) effect on the moisture content of blended injera, which ranged from 4-88 % to 8.36%. Throughout the mean moisture content of the 18 experimental trials of the formulation, those experimental trials containing a significant amount of wheat in the recipe showed the highest moisture content as compared to the moisture content of the other trials. Such low moisture content may be associated with the highest proportion of maize and sorghum in the recipe since the highest fat composition of maize might significantly affect the water absorption capacity of formulation BR5.

Crude protein contents of injera: The interaction of blending ratio and fermentation time had a significant ($p<0.05$) effect on the protein content of blended injera, and the values ranged from 11.22 to 15.73. The increment in protein content in the injera samples is due to the blending effect of the high protein content of wheat flour. Therefore, the total blended injera had more protein content than the control injera. Furthermore, higher crude protein contents were observed when the fermentation time of injera was increased from 36 to 84 h at all levels of blends.

Generally, it was reported that increasing fermentation time increases protein content due to the accumulation of microbial biomass, causing extensive hydrolysis of protein molecules into amino acids and other simple peptides. The protein content of injera obtained in this study is relatively comparable to the protein content of sorghum, maize, and teff composite injera, which varied from 11.27% to 14.73% [39].

Crude fat contents of injera: The interactions of blending ratio and fermentation time caused a significant change ($P<0.05$) in the crude fat contents of formulated injera, and the values ranged 0.93% to 2.59%.The crude fat contents of injera samples were found to be significantly decreasing with an increase in the proportion of wheat flour in the blends and fermentation time as well.

According to Bello et al. [40] increased activity of the lipolysis enzyme during fermentation hydrolyzes fat components into fatty acids and glycerol. A decrease in the fat content of fermenting maize samples has been reported by Adegbehingbe [41] which corresponds with the present study. According to Arotupin & Adewole [42] study, the reduction in fat content during the prolonged period of fermentation might have resulted from the use of lipids by the microorganisms to obtain energy for their metabolic processes during fermentation.

Total Ash Contents of Injera: The total cash values were found in the range of 1.11% to 1.70%. According to Bultosa [43] injera prepared from teff flour compositions showed a higher ash content due to the high amount of minerals and ash in teff flour compared to other cereals. The result of total ash content reduction due to fermentation time was in agreement with the report of Berhanu, et al. [44]. Who reported total ash content of defatted coconut flour decreased from 2.76 % at 0 to 1.02 at 72 h.

Crude Fiber Contents of Formulated Injera: The interaction of blending ratio and fermentation time had a significant ($p<0.05$) effect on the crude fiber content of blended injera, and the values ranged from 1.96% to 3.3%. The results of the current study were relatively in line with the findings of Asrat Yasin [45], who reported the crude fiber content of injera prepared from teff, and quality protein maize flour blends in the range of 2.14% to 3.22%. The reduction in crude fiber content as fermentation time increased could be attributed to the partial solubilization of cellulose and hemicelluloses types of material via microbial enzymes [46]. It also reported by Ojokoh and Bello [47] that the enzymatic breakdown of the fibre occurred during fermentation by lactic acid bacteria, which utilized the fiber as a carbon source.

Carbohydrate Content of injera: The interaction of blending ratio and fermentation time had a significant ($p<0.05$) effect on the carbohydrate content of blended injera, and the value ranged from 70.96% to 76.98%. The current result was not a line with the range value (78.71% to 81.47%) of carbohydrates prepared from teff and quality maize protein blended injera [48]. The carbohydrate content decreased as the fermentation time extended from 36 to 84 h. The reduction could be due to the degradation of primary substances by fermenting microorganisms, mainly starch and soluble sugars that caused the subsequent reduction in starch contents [49].

Gross Energy content of injera: There was a significant ($p<0.05$) difference observed in the gross energy of injera samples due to the interaction effect of blending ratio and fermentation time, and the value ranged from 354.52 kcal/100g to 381.71 kcal/100g (Table 5). There is a decrease in carbohydrate content because of the microbial degradation of starch during fermentation [50].

Microbial load analysis of injera at different storage periods

Total yeast and mold count: Formulated injera yeast-mold counts in the first, third, and fifth days of storage ranged from 2.34 to 2.61 log CFU/g, 2.42 to 2.76 log CFU/g, and 3.35 to 3.78 log CFU/g, respectively. The result also showed that formulations BR5 fermented for 84 h at 3.78 log CFU/g and BR1 fermented for 36 h at 3.35 log CFU/g had the highest and lowest yeast-mold accumulation in the formulated injera in the 5th day of storage, respectively. Overall, molds and yeasts are able to grow at a lower pH than bacteria [52]. According to Ashagrie and Abate [51] mold spoilage is a serious problem that affects the shelf life of injera.

Total aerobic plate count: Total aerobic plate counts of formulated injera samples conducted on the first, third, and fifth days of storage ranged from 3.48 to 3.63 log CFU/g, 3.63 to 3.86 log CFU/g and 4.13 to 4.52 log CFU/g, respectively. On the first and third days of storage, the highest total aerobic plate counts (3.63 and 3.86 log CFU/g) were recorded for injera samples prepared from BR5 fermented for 36 h, and the lowest total aerobic plate counts (3.48 and 3.63 log CFU/g) were recorded for injera samples prepared from BR1 composite flour with an 84 h fermentation time.PH is a significant factor affecting the growth of microorganisms in food because it affects the microbial energy metabolism concerning the buildup of hydrogen ion concentration gradients across membranes and the activity and stability of cellular macromolecules (Table 6) [53].

Sensory Acceptability of Prepared Injera

Rollability describes the ability of injera to be rolled without breaking. The interaction of blending ratio and fermentation time had a significant ($P<0.05$) effect on the reliability of composite flour injera, and the value varied from 2.53 to 3.57. The result showed that formulations BR1 fermented for 84 h at 3.57 and BR3 fermented for 60 h was 2.53 had the highest and lowest roll ability.

Texture is determined by touch and refers to the degree of softness or hardness of injera. Softness varies among the 18 formulations of injera, with a significant difference at ($p<0.05$) found the minimum 2.4 was found in BR3 fermented at 60 h, and the maximum 3.53 was obtained BR1 fermented at 84 h.

Taste is the most important attribute that determines the quality

Table 5: Interaction effect of blending ratio and fermentation time on the proximate compositions of maize-sorghum and wheat formulated and its control injera.

Blending ratio	Fermentation time	M.C (%db)	Protein (%db)	Fat (%db)	Ash (%db)	Crude fiber(%db)	Total Carbohydrate	Gross Energy (Kcal/100g)
BR1	36	8.34 ± 0.28^{a}	13.42 ± 0.99^{ab}	1.36 ± 0.14^{bc}	1.45 ± 0.10^{bc}	3.3 ± 0.09^{a}	72.12 ± 0.41^{bc}	355.83 ± 10.6^{b}
	60	8.35 ± 0.26^{a}	13.86 ± 0.69^{ab}	1.32±0.10^{bc}	1.43 ± 0.09^{bc}	2.89 ± 0.01^{abc}	72.11 ± 1.62^{bc}	355.23 ± 2.3^{bc}
BR2	84	8.36 ± 0.25^{a}	15.73 ± 0.56^{a}	0.93±0.30^{c}	1.11 ± 0.06^{c}	2.88 ± 0.31^{abc}	70.96 ± 0.38^{c}	354.52 ± 6.99^{c}
	36	7.36 ± 0.33^{a}	13.24 ± 1.58^{ab}	1.43 ± 0.27^{bc}	1.59 ± 0.19^{b}	3.13 ± 0.19^{ab}	73.47 ± 0.11^{b}	359.7 ± 4.24^{ab}
	60	7.45 ± 0.46^{a}	13.38 ± 0.21^{ab}	1.33 ± 0.01^{bc}	1.57 ± 0.19^{b}	2.77 ± 0.04^{abc}	73.23 ±1.36^{b}	358.87 ± 4.65^{b}
	84	7.55 ± 0.60^{a}	15.49 ± 0.36^{a}	1.26 ± 0.21^{bc}	1.55 ± 0.19^{b}	2.75 ± 0.48^{abc}	71.37 ± 0.32^{bc}	358.48 ± 4.64^{b}
BR3	36	6.35 ± 0.25^{ab}	12.45 ± 1.60^{ab}	1.49 ± 0.20^{abc}	1.59 ± 0.04^{b}	2.75 ± 0.36^{abc}	75.36 ± 1.14^{ab}	364.87 ± 2.1^{ab}
	60	6.44 ± 0.39^{ab}	13.12 ± 1.03^{ab}	1.38 ± 0.56^{bc}	1.57 ± 0.04^{b}	2.72 ± 0.02^{abc}	74.74 ± 1.18^{ab}	364.71 ± 3.7^{ab}
	84	6.45 ± 0.40^{ab}	15.39 ± 0.14^{a}	1.38 ± 0.19^{bc}	1.55 ± 0.04^{b}	2.50 ± 0.14^{abc}	72.70 ± 0.03^{bc}	363.94 ± 4.4^{ab}
BR4	36	5.9 ± 0.66^{ab}	12.2 ± 3.65^{ab}	1.97 ± 0.07^{abc}	1.66 ± 0.11^{b}	2.71 ± 0.04^{abc}	75.55 ± 4.39^{ab}	368.76 ± 3.6^{ab}
	60	5.92 ± 0.63^{ab}	12.94 ± 0.69^{ab}	1.39 ± 0.01^{bc}	1.64 ± 0.11^{b}	2.69 ± 0.45^{abc}	75.40±0.98^{ab}	367.89±1.9^{ab}
	84	6.09 ± 0.39^{ab}	14.95 ± 0.11^{ab}	1.39 ± 0.28^{bc}	1.57 ± 0.13^{b}	2.09± 0.32^{bc}	73.89 ± 1.01^{b}	365.95±1.2^{ab}
BR5	36	4.88 ± 1.28^{ab}	11.22 ± 1.95^{b}	2.59 ± 0.48^{a}	1.70 ± 0.00^{b}	2.74 ± 0.18^{abc}	76.98 ± 1.3^{ab}	381.71±0.94^{a}
	60	5.08 ± 0.59^{ab}	12.73 ± 0.32^{ab}	2.09 ± 0.27^{ab}	1.68 ± 0.00^{b}	2.14 ± 0.39^{bc}	76.26 ± 0.79^{ab}	374.84 ± 0.55^{a}
	84	5.58 ± 2.02^{ab}	13.57 ± 0.86^{ab}	1.92 ± 0.05^{abc}	1.68 ± 0.01^{b}	1.96 ± 0.07^{c}	75.28 ± 1.04^{ab}	372.74 ± 8.1^{ab}
Control	36	3.69 ± 1.42^{b}	10.46 ± 0.16^{c}	1.52 ± 0.08^{abc}	2.79 ± 0.05^{a}	2.73 ± 0.04^{abc}	78.1 ± 1.91^{a}	370.76 ± 5.2^{ab}
	60	3.69 ± 1.42^{ab}	11 ± 0.00^{b}	1.35 ± 0.23^{bc}	2.77 ± 0.05^{a}	2.24 ± 0.46^{abc}	77.78 ± 1.51^{a}	365.21 ± 7.5^{ab}
	84	5.43 ± 1.71^{ab}	11.15 ± 0.38^{ab}	1.19 ± 0.53^{bc}	2.75 ± 0.01^{a}	2.14 ± 0.32^{bc}	77.48 ± 1.51^{a}	364.6 ± 10.8^{ab}
CV (%)		6.37	1.76	1.52	13.13	2.61	0.25	0.97
p- value		0.002	0.007	0.003	<0.001	0.006	0.002	0.006

Table 6: The microbial load of composite flour injera at different storage duration.

		Yeast-mold load			Total bacteria load		
Blending ratio%	Fermentation time	Day 1 log ($cfug^{-1}$)	Day 3 log ($cfug^{-1}$)	Day 5 log ($cfug^{-1}$)	Day 1 log ($cfug^{-1}$)	Day 3 log ($cfug^{-1}$)	Day 5 log ($cfug^{-1}$)
BR1	36	2.34 ± 0.03^{f}	2.42 ±0.03^{b}	3.35 ± 0.06^{ab}	3.54 ± 0.08^{hi}	3.69 ± 0.01^{hi}	4.48 ± 0.02^{a}
	60	2.48 ± 0.04^{b-f}	2.44 ± 0.01^{b}	3.47 ± 0.2^{a}	3.51 ± 0.00^{jk}	3.66 ± 0.01^{ij}	4.26 ± 0.2^{a}
	84	2.39 ± 0.02^{ef}	2.45 ± 0.01^{b}	3.58 ± 0.18^{a}	3.48 ± 0.00^{l}	3.63 ± 0.01^{j}	4.13 ± 0.05^{a}
BR2	36	2.37 ± 0.01^{ef}	2.45 ± 0.00^{b}	3.61±0.00^{c}	3.56 ± 0.01^{fg}	3.74 ± 0.02^{efg}	4.5 ± 0.01^{a}
	60	2.38 ± 0.01^{ef}	2.53 ± 0.00^{b}	3.61 ± 0.00^{c}	3.52 ± 0.00^{ij}	3.69 ± 0.01^{ghi}	4.43 ± 0.03^{a}
	84	2.48 ± 0.07^{b-f}	2.51 ±0.01^{b}	3.69 ± 0.00^{c}	3.49 ± 0.00^{kl}	3.66 ± 0.01^{ij}	4.31 ±0.01^{a}
BR3	36	2.35 ± 0.03^{f}	2.47 ± 0.04^{b}	3.63 ± 0.00^{c}	3.57 ±0.00^{f}	3.76 ± 0.01^{de}	4.5 ± 0.00^{a}
	60	2.42 ± 0.02^{def}	2.44 ± 0.19^{b}	3.67 ± 0.01^{c}	3.55 ± 0.00^{gh}	3.74 ± 0.01^{ef}	4.48 ± 0.01^{a}
	84	2.5 ± 0.09^{b-f}	2.57 ± 0.09^{b}	3.70 ± 0.00^{c}	3.52 ± 0.00^{ij}	3.71 ± 0.01^{fgh}	4.35 ± 0.03^{a}
BR4	36	2.46 ± 0.03^{c-f}	2.53 ± 0.02^{b}	3.68 ± 0.01^{c}	3.61 ±0.01^{cd}	3.82 ± 0.01^{bc}	4.51 ± 0.78^{a}
	60	2.36 ± 0.02^{ef}	2.55 ± 0.04^{b}	3.69 ±0.01^{c}	3.58 ± 0.00^{ef}	3.79 ± 0.01^{cd}	4.51 ± 0.02^{a}
	84	2.59 ± 0.07^{b-f}	2.66 ± 0.07^{b}	3.71 ± 0.00^{c}	3.56 ± 0.00^{fg}	3.77 ± 0.01^{de}	4.36 ± 0.03^{a}
BR5	36	2.46 ± 0.02^{c-f}	2.58 ± 0.04^{b}	3.68 ± 0.00^{b}	3.63 ± 0.01^{c}	3.86 ± 0.01^{ab}	4.52 ± 0.04^{a}
	60	2.49 ± 0.06^{b-f}	2.68 ± 0.11^{b}	3.70 ± 0.09^{c}	3.62 ± 0.01^{c}	3.85 ± 0.01^{ab}	4.48 ± 0.01^{a}
	84	2.61 ± 0.1^{a-e}	2.76 ± 0.06^{b}	3.78 ± 0.04^{c}	3.59 ± 0.00^{de}	3.82 ± 0.01^{bc}	4.36 ± 0.03^{a}
Control	36	2.65 ± 0.16^{abcd}	2.72 ± 0.15^{b}	3.52 ± 0.05^{c}	3.69 ± 0.00^{a}	3.89 ± 0.00^{a}	4.54 ± 0.05^{a}
	60	2.72 ± 0.06^{ab}	2.79 ± 0.05^{ab}	3.57 ± 0.01^{c}	3.68 ± 0.00^{a}	3.88 ± 0.00^{a}	4.42 ± 0.04^{a}
	84	2.85 ± 0.066^{a}	3.28 ± 0.45^{a}	3.88 ± 0.00^{c}	3.66± 0.01^{b}	3.85 ± 0.01^{ab}	4.26 ± 0.01^{a}
CV%		2.49	2.6	3.62	3.57	3.77	4.39
P- value		<0.001	0.001	<0.001	<0.001	<0.001	0.711

of baked cereal products and the most energetic parameter that influences the acceptance of consumers. The taste response of the blending-formulated injera was determined in a range of 2.53 to 3.47, but the highest taste result was discovered in teff fermented for 36 h (4.7), and the minimum taste score was 2.53 in BR3 fermented for 60 h using a five-point hedonic scale. Taste is associated with the sense of sweetness, sourness, saltiness, and bitterness triggered in the mouth through contact with the injera [54]. Fermentation time significantly influenced the taste of injera, sourness increased with increased fermentation time; this might be due to lactic acid bacteria, which synthesized flavor compounds [55].

The visual appearance or the color of a food is the main quality parameter that the consumer observes and uses as a tool to either accept or reject it. The result showed that formulations BR5 fermented for 36 h was 3.8 and BR3 fermented for 60 h was 3.07 had the highest and lowest color of formulated injera, respectively.

The interaction of blending ratio and fermentation time had a significant (P<0.05) effect on the eye size of composite flour injera, and the value varied from 2.37 to 3.63. Blending ratios and fermentation time had a significant impact on the top and bottom surface results of all composite flour injera (p<0.05), and the value ranged 2.57 to 3.5.

Overall acceptability refers to the combination of evaluations by consumers or panellists of a product. The overall acceptability of injera samples was significantly influenced (p<0.05) by blending ratio and fermentation times. Injera prepared from BR1 composite flour and fermented for 84 h had the highest overall acceptability (3.56%), whereas the lowest overall acceptability (2.57%) was obtained in BR3 fermented for 60 h. Injera fermented for 84 h showed better acceptance as compared to injera fermented for 60 h and 36 h. The reaction of panellists to the overall acceptability of injera was greater than 2.5, which indicates that the blended injera was acceptable.

The poor quality injera with fewer gas holes was found in some sorghum, which indicates the poor quality injera in sorghum was due to its sticky texture and bitter taste [56].The score of products that had a mean value greater than 2.5 except BR3, which ferments for 60 h, indicates the products were liked by the panelists. The most preferred blended injera was produced from wheat flour combined with 30% sorghum and 10% maize flour Fermented at 84 h. A similar reflection was made by Mihrete and Bultosa [57] who reported that increasing fermentation time improves sensory characteristics such as reliability, sourness flavour, and the appearance of blended injera (Table 7).

Conclusion

Consumers benefited from the use of injera made from these blending ratios of maize-sorghum and wheat flour due to their improved nutritional content as well as the economic advantage due to lower prices compared to teff.

In the blended injera, the interaction effects of fermentation time and blending ratios had a significant (P<0.05) effect on physicochemical, microbiological and sensory qualities of injera. The blending ratio had significantly increased the crude protein, crude fat, crude fiber, gross energy, carbohydrate, condensed tannins, and total phenolic content of injera. However, total ash, phytic acid, Zn, Fe, and Ca of the blended injera were reduced significantly. The fermentation time also had considerably increased the moisture content, protein content, total phenolic, Zn, Fe, Ca, and sensory quality attributes of injera while significantly reducing the crude fat, crude fiber, carbohydrate, energy and total ash of the injera, the reduction was very small and not that considerable. Fermentation of maize-sorghum and wheat-blend injera also decreased anti-nutritional factors (phytic acid and tannins), thus improving the availability of nutrients for the consumer.

With an increase in blending proportion of wheat, better preference was observed especially for texture, rollability, and taste. Moreover, the preference of color, eye size, eye distribution, top and bottom surface, texture, and rollability of injera improved as the fermentation time increased. With regard to sensory acceptability, the acceptability of injera from 100% teff injera was superior in preference over injera from the three formulations for its sensorial quality. According to the present research finding, using 60% wheat, 30% sorghum, and 10% maize) fermented for 84 h was acceptable in its major sensory attributes and its some nutritional value.

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Table 7: Interaction effect of blending ratio and fermentation time on sensory acceptability of maize-sorghum and wheat composite injera.

BR	Fermentation	Color	Eye size	Taste	Eye distribution	Rollability	Softness	TBS	OAA
BR1	36	3.59 ± 0.84^{abcd}	3.37 ± 0.84^{bc}	3.44 ± 0.85^{b}	3.37 ± 0.88^{bc}	3.33 ± 0.83^{bc}	3.04 ± 1.02^{bc}	3.26 ± 1.02^{bc}	3.5 ± 1.07^{b}
	60	3.57 ± 1.07^{abcd}	2.8 ± 0.76^{bcd}	2.83 ± 0.87^{bc}	3.03 ± 0.85^{bcd}	3.17 ± 0.70^{bc}	3.13 ± 0.78^{bc}	3.07 ± 0.87^{bc}	3.3 ± 0.84^{bc}
	84	3.77 ± 0.97^{abcd}	3.53 ± 1.17^{bc}	3.47 ± 0.86^{b}	3.5 ± 1.07^{b}	3.57 ± 1.01^{b}	3.53 ± 1.01^{bc}	3.5 ± 1.22^{b}	3.56 ± 0.75b
BR2	36	3.76 ± 0.87^{abcd}	3.63 ± 0.81^{b}	3.2 ± 0.92^{bc}	3.43 ± 0.97^{bc}	3.2 ± 0.89^{bc}	3.1 ± 1.03^{bc}	3.4 ± 0.89^{bc}	3.47 ± 0.82^{b}
	60	3.33 ± 1.21^{d}	2.77 ± 1.01^{cd}	3.07 ± 0.98^{bc}	2.93 ± 1.14^{bcd}	2.97 ± 1.10^{bc}	2.9 ± 1.18^{bc}	2.8 ± 1.19 ^{bc}	3.03 ± 1.03^{bc}
	84	3.5 ± 1.07^{cd}	3.13 ± 0.86^{bcd}	3.07 ± 1.01^{bc}	3 ± 0.91^{bcd}	3.13 ± 1.04^{bc}	3.2 ± 1.03^{bc}	3.07 ± 1.11^{bc}	3.1 ± 1.06^{bc}
BR3	36	3.53 ± 1.04^{bcd}	3.28 ± 1.03^{bc}	2.93 ± 1.20^{bc}	2.83 ± 1.09^{bcd}	3.03 ± 1.00^{bc}	3.03 ± 1.00^{bc}	3.23 ± 1.01^{bc}	3.23 ± 0.90^{bc}
	60	3.07 ± 1.26^{d}	2.37 ± 1.03^{d}	2.53 ± 1.01^{c}	2.37 ± 1.25^{d}	2.53 ± 0.82^{c}	2.4 ± 0.89^{c}	2.57 ± 0.97^{c}	2.57 ± 1.01^{c}
	84	3.67 ± 1.21^{abcd}	3.13 ± 1.14^{bcd}	3.27 ± 0.98^{bc}	2.83 ± 1.15^{bcd}	3.3 ± 0.95^{bc}	3.16 ± 1.11^{bc}	3.17 ± 0.99^{bc}	3.13 ± 1.11^{bc}
BR4	36	3.2 ± 1.06^{d}	2.4 ± 0.93^{d}	2.83 ± 0.95^{bc}	2.6 ± 0.97^{cd}	2.9 ± 1.03^{bc}	2.67 ± 1.03^{c}	2.83 ± 0.95^{bc}	3.03 ± 0.93^{bc}
	60	3.57 ± 0.90^{abcd}	2.7 ± 1.15^{cd}	2.8± 1.16^{bc}	2.63 ± 1.00^{bcd}	2.62 ± 1.18^{c}	2.66 ± 1.08^{c}	2.62 ± 1.05^{c}	2.88 ± 1.06^{bc}
	84	3.47 ± 1.22^{cd}	2.97 ± 0.89^{bcd}	2.93 ± 1.01^{bc}	2.83 ± 0.99^{bcd}	3.03 ± 0.93^{bc}	2.9± 1.06^{bc}	2.93 ± 1.01^{bc}	3 ± 0.95^{bc}
BR5	36	3.8 ± 0.96^{abcd}	3.37 ± 1.16^{bc}	3.27 ± 0.87^{bc}	3.3 ± 0.99^{bc}	2.83 ± 1.26^{bc}	2.8 ± 1.00^{bc}	2.9 ± 0.99^{bc}	3.13 ± 0.94^{bc}
	60	3.5 ± 1.11^{cd}	2.87 ± 0.97^{bcd}	2.73 ± 0.87^{bc}	2.87± 0.90^{bcd}	2.6 ± 1.04^{c}	2.53 ± 0.97^{c}	2.6 ± 0.97^{c}	2.8 ± 0.81^{bc}
	84	3.63 ± 0.85^{abcd}	3.07 ± 1.01^{bcd}	3.27 ± 0.98^{bc}	3.07 ±1.11^{bcd}	3.3 ± 0.94^{b}	3.53 ± 1.01^{b}	3.33 ± 1.06^{bc}	3.3 ± 0.84^{bc}
Control	36	4.43 ± 0.82^{ab}	4.6 ± 0.62^{a}	4.7 ± 0.47^{a}	4.67 ± 0.55^{a}	4.73 ± 0.52^{a}	4.8± 0.41^{a}	4.7 ± 0.47^{a}	4.73 ± 0.45^{a}
	60	4.47 ± 0.68^{a}	4.5 ± 0.63a	4.37 ± 0.96^{a}	4.47 ± 0.82^{a}	4.5 ± 0.68^{a}	4.5 ± 0.63^{b}	4.47 ± 0.68^{a}	4.48 ± 0.62^{a}
	84	4.27± 0.87^{abc}	4.57 ± 0.86^{a}	4.57 ± 0.68^{a}	4.7 ± 0.70^{a}	4.67 ± 0.61^{a}	4.7 ± 0.60^{a}	4.73 ± 0.64^{a}	4.57 ± 0.77^{a}
CV (%		3.66	3.27	3.29	3.24	3.3	3.25	3.28	3.37
p- value		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

*The data is expressed as mean ± standard error and any two means in the same column not followed by the same letters are significantly different at (p<0.05).TBS means the top and bottom surface, BR, blending ratio, and control teff, OAA means over all acceptability.

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