Effect of Barely (*Hordeum Vulgare L.*) and Potato (*Solanum Tuberosum L.*) Blending Ratios on Injera in North Shewa Zone, Ethiopia

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Research Article

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Abstract

Background

Ethiopians are dependent on teff flour to make injera as staple food. In Ethiopia, although injera could be made from different cereals, The price of teff is high and the yield is low. Thus finding alternative cheaper grain and developing blend potato and barley improved variety in different ratio with acceptable and improved nutritional value would be important.

Methods

This study was conducted to determine effects of blending ratios on Proximate, mineral composition and sensory acceptability of barley and potato composite injera. Proximate and mineral analysis of injera was done using standard methods, and sensory evaluation was made using 5-point hedonic scales. Seven parameters were prepared to evaluate the effect of blending ratio on color, taste; texture, appearance, flavor, roll ability and sourness of Injera.

Result

From the study result injera proximate quality ranked B1 to B3 could be used as an alternative option for injera utilization and provide nutritional benefit to consumers ,minerals like iron, zinc, magnesium and calcium were increased as proportion of potato flour increased for both potato barely composite injera, High iron (70.89ppm), zinc (37.53 ppm) and calcium (684.65ppm and magnesium (663.59ppm)) contents were obtained from B3 for iron and zinc and B4 for calcium and magnesium of potato barely blended injera. The sensory quality such as color, taste, appearance and flavor of injera became unacceptable beyond B3.

Conclusion

In general from proximate composition, minerals and sensory quality perspective blending ratios from B1 to B3 could be used as an alternative option for injera utilization and provide nutritional benefit to consumers. The outcome of the research has a significant implication in food security and nutrition security

Background

Globally, more than two billion people are affected by one or more Micronutrient deficiencies (MNDs) and the risks of deficiency are greater in sub-Saharan Africa (SSA) than in most other regions (Joy et al., 2014, Kumssa, et al., 2015 and Gödecke et al., 2018). Causes of MNDs, which are also known as 'hidden hunger', include the inadequate intake of micronutrients —in particular, calcium (Ca), iron (Fe), iodine (I), selenium (Se), zinc (Zn) and vitamin A, especially in regions in which diets are dominated by cereals and where access to foods from plant and animal sources that are richer in nutrients is limited (Bouis, et al., 2017).

Foods prepared from different cereal blends and from root and tuber crops could provide better nutritional and dietary diversity, besides food security. It is a priority of Ethiopian government to increase agricultural production to improve food and nutrition security of the increasing population.

Blending improves nutrient composition and overall acceptability of food products. Using barely flour as an ingredient for other easily available and relatively low-cost cereal-based products could be important for food security, especially in the developing countries. Since malnutrition is a major problem in Ethiopia, improving the nutritional quality of injera can help to reduce the problem. Nevertheless, limited information is available on potato flour use as an ingredient of injera preparation with other common grains. Thus, the purpose of this research was to prepare injera form blends of potato and barley flour and evaluate the proximate, mineral composition and sensory characteristics of injera.

Methods

Sample collection, Transportation and Preparation

Barely grain and potato tuber was purchased from Debre Berhan Agricultural Research Center, The test samples was cleaned manually to remove husks, damaged grains, stones, dust, light materials, glumes, stalks, undersized and immature grains and other extraneous materials. Cleaning was done by winnowing, hand sorting and passed through 1mm mesh size laboratory sieve. The cleaned grains were divided into two sub-portions. The first sub-portion not subjected to any treatment, was served as a control. All samples were then packed in airtight plastic bags until further analysis.

Potato flour preparation Uniform sized potatoes having no signs of infection or infestation was thoroughly washed in running tap water and removed any adhering soil, dirt, and dust. Then the sliced tubers were blanched with 80oc for 10 minutes. After blanching of potato, it was dried by sunlight it friable to the mill. After completely dried, the slices was milled and passed through 80 mesh sieves to obtain fine flour of uniform size and finally weighted the flour and packed in airtight plastic containers until further use (Misra and Kulshrestha,2003) Potato flour preparation as the following.

- Raw potato
- Washing Peeling Slicing
- Blanching with 80oc for 10 minute
- Drained the sliced potato Dry by sunlight
- Milling Weigh the flour
- Pack in air tight plastic

Source; - Yasin and Getu, 2019 with some minor modifications

Injera Preparation (Baking)

Injera prepared from different proportions of Barely- potato blended were prepared following the procedures described by Bultosa and Taylor (2004) with minor modifications. The flours of Barely and Potato mixed uniformly with the proportions of 100:0, 90:10, 80:20 and 70:30, respectively. Then composite flours (200g) were again mix with water (180ml) or (111%w/v) and thoroughly knead. Then ersho (starter culture) was added and the batter was leaved to be ferment for about 72hrs. After fermentation, the surface supernatant formed on the top of the dough discarded and 10% of the sediment was mixed with water (1:3) and cook for 2–3 minutes for the purpose of gelatinization (cooking) primarily to improve the cohesiveness of the batter and to provide readily fermentable carbohydrates for the microbes. This batter enhancer (also called *absit*) wasl cooled to room temperature and it was added back to the fermenting batter. After fermentation for 0.5–1 hour, a bubble was form which was an indicator of endpoint. Then, more water was added to the ferment batter to get uniform consistency. Approximately, 500g of the fermented batter was poured on a circular manner on a 50cm diameter hot clay griddle, cover, and bake for 3–4 minutes.

Treatments and Experimental Design

The experimental work was conducted using six level of blending ratios [100g whole barely as control, 90:10 (B1), 80:20 (B2), 70:30 (B3),60:40 (B4) and 50:50 (B5)] for *injera* and five levels of blending ratios [100g whole barely as control, 90:10 (B1), 80:20 (B2), 70:30 (B3) and 60:40 (B5) for bread and we used Hagerie barely variety and Gera potato variety. The treatments were arranged in Completely Randomize Design (CRD) with three Replications.

Data collected

Sensory Evaluation of potato barely composite injera

- 30 semi-trained consumer panelists, 10 males and 20 females
- Using acceptability test for seven Injera attributes such as color, appearance, texture,, taste, flavor, roll ability and sourness
- Instructed to evaluate all the randomized order labeled with three digit code using a five point hedonic scale (dislike extremely = 1, dislike 2;=; neither like nor dislike = 3; like 4; like extremely = 5)
- Instructed to cleanse their mouth before testing the next sample with odor and flavor free water
- Samples receiving an overall quality score of ≥ 3 was considered acceptable (Gizachew *et al.*, 2015).

Determination of Proximate Compositions

The proximate analysis was performed according to the following procedures given.

Determination of moisture: Moisture content was determined by the method of the Association of Official Analytical Chemists (AOAC, 2000); the Official Method 925.10, by drying the samples in an oven until a constant weight was obtained.

Determination of total ash: Ash was determined by the method of the Association of Official Analytical Chemists (AOAC, 2000), using the Official Method 923.03.

Determination of Crude Protein: Crude protein was determined by the method of the Association of Official Analytical Chemists (AOAC, 2000) using the Official Method 920.87.

Determination of crude fat: Crude fat was determined based on the Sohxlet extraction method of AOAC (2000) using official method 920.39.

Determination of crude fiber: Crude fiber was determined by the method of the Association of Official Analytical Chemists (AOAC, 2000) using the official method 962.09.

Determination of total carbohydrate: Total percentage carbohydrate was determined by the difference method as reported by Osborne *et al*., (1978).

Determination of Minerals, Digestion: Mineral and trace elements sample digestions was undertaken using a closed-vessel microwave digestion system. Sample powder was weighted (0.5 g) to proper Teflon digestion vessels. A mixture of concentrated nitric acid (4 mL), hydrogen peroxide (1 mL) and deionized water (3 mL) was carefully added, and vessels was properly closed and introduced into the microwave oven. A micro-wave program was established and optimized. Vessels were there-after cooled to room temperature and digested samples were diluted up to 25 mL with deionized water, for subsequent determination of minerals and trace elements. To assess possible contamination, a blank solution was prepared containing the same reagents and using the same procedure as the samples and standards. Determination of Iron (Fe), Zinc (Zn), Calcium (Ca) and Magnesium (Mg) by Atomic Absorption Spectrometry [AOAC 985.35 Method]

Data analyses

The experiment was carrying out using a completely randomized design (CRD) as outlined by Steel and Torrie (1980). The data was analyzed by using an Analysis of Variance (ANOVA). Where possible, mean comparisons was using the List Significance Difference (LSD) at $p \leq 0.05$. Statistical analysis was carrying out using the SAS (Version 9.0) system.

Results And Discussion

Proximate composition of injera

Moisture content: Significant difference ($p < 0.05$) was shown in moisture content of *injera* of potato barely composite products (Table 1). Within an increment in barley flour proportion from 50–100%, an increase in moisture content from 5.01–13.75% was observed in the *injera* product (Table 1). Perhaps, an increase in moisture content could be due to the high water-binding capacity of the starch in the barley flour. The low moisture content was obtained from a high proportion of potato flour. Similarly, Shevkani, Singh, Kaur, and Rana (2014) reported that amaranths flour has high water-absorption properties.

Ash content: The ash content indicates an estimate of the total mineral content in a given quantity of food substance (Mezgebo, Belachew, & Satheesh, 2018). The ash content of *injera* sample were statistically similar among the samples and this may be due to both barely and potato are rich in total ash content, but the number expressed in ash content of *injera* showed higher percentage (Table 1).

Organic matter content: Significant difference ($p < 0.05$) was shown in organic matter content of potato barely composite *injera* (Table 1). The highest organic matter content were recorded in whole barely (97.22%) which was followed by B1 (96.87%) but decreased as potato flour proportion increased and as the proportion of potato flour increased organic matter were decreased in general from this finding barely has higher organic matter than potato.

Crude protein: The protein content of injera was significantly affected by potato and barley mix (Table 1).The protein content of samples ranged from 12.87–15.22% (Table 1). Protein content of *injera* sample was increased with an increased proportion of potato flour till B3 [15.22%] and decreased as the blending ratio increased, which could be due to the high amount of protein in potato flour. This is important for Ethiopians where *injera* is the major staple food prepared mostly from sole teff flour unless it is not accessible and costly. Above and beyond, both barely and potato-based injera can be a good source of protein for those who are gluten-sensitive.

Crude fiber content: According to the Nutrient content of potato flour and Barley flour the Crude fiber content of potato flour is better compared to barely flour. Crude fiber content of *injera* from six different formulations of injera showed significantly different at ($p < 0.05$) and which was between 5.88% [B5] and 9.09% [B3] (Table 1). Relatively higher Crude fiber content was observed in a sample of injera prepared from B3 [9.09%] and which was followed by B2 [8.11%]. Therefore, the Crude fiber content of potato flour is better compared to barely flour. This is vital for many countries like Ethiopia, where potato and barely are produced in many parts of the country.

Table 1:- Shows effects of blending ratios on Proximate Composition of barely and potato composite *injera*

Treatments	MC%	ASH %	OM %	CP%	CF%
PO	11.01^{b}	3.3^{a}	87.7^{e}	14.25^{abc}	2.45^{cd}
BA	13.75^{a}	3.23^{a}	97.22^{a}	13.88^{abc}	1.79^{d}
B1	9.02^{c}	3.23^{a}	96.87^{ab}	14.39^{abc}	3.45^{bcd}
B2	7.55^{cd}	3.23^{a}	95.45^{bc}	14.85^{ab}	3.99^{abc}
B3	6.31^{de}	3.25^{a}	93.85^{c}	15.22^{a}	4.55^{ab}
B4	5.23^{e}	2.88^{a}	91.22^{d}	13.11bc	4.95^{a}
B5	5.01^{e}	2.79^{a}	90.11^{d}	12.87c	5.25^{a}
CV%	12.09	31.95	1.07	7.10	26.48
LSD%	1.75	1.75	1.75	1.75	1.75

**Mean values followed by the same letter in the column are not significantly different at 5% probability level. According to LSD test; Where;-PO:- potato flour, BA (pure barely),B1 (10:90),B2 (20:80),B3 (30:70),B4 (40:60),B5 (50:50), DM (dry matter),OM(organic matter),ASH (ash),CP (crude protein) and CF (crude fiber) , LSD=least significant difference and CV (Coefficient of variation)*

Iron, zinc, Calcium and magnesium content of potato barely composite injera and bread: Table 2 showed that, the highest iron content of injera were recorded in B3 (70.89ppm) which was followed by B2 (69.55ppm) and the least were recorded at B5 (50.99ppm), whereas highest zinc content were recorded at B4 (37.53ppm) and statistically similar with B3 (36.92ppm) and the least was recorded at B5 (25.54ppm). The highest calcium and magnesium content of injera were recorded at B4 (684.77 ppm and 517.74ppm) respectively and the least were recorded at B5 (557.99 ppm and 517.74ppm) respectively.

In general, the Magnesium, zinc, iron and calcium content of injera showed significant difference at ($p < 0.05$) in potato and barley composite blend (Table 2). In the samples from the different blends, Magnesium, zinc, iron and calcium contents of injera increased with the increment of potato proportion, which may be due to the higher amount of Magnesium, zinc, iron and calcium in the potato flour. Incorporation of underutilized crops like amaranthus and potato to different grains for improving mineral content was reported (Bultosa, 2007; Emire & Arega, 2012) to improve the mineral composition both for injera and bread of potato barely composite product.

Table 2:- Showed effects of blending ratios on Fe, Zn, Ca and Mg content of barely and potato composite injera

Treatments	Fe[ppm]	Zn [ppm]	Ca [ppm]	Mg[ppm]
Po	33^{f}	28^{d}	648.99^{d}	630.41^{f}
BA	66.98^{c}	22.86^{f}	678.56^{d}	622.99^{f}
B1	68.99^{bc}	30.99^{c}	680.24^{c}	635.41^{d}
B2	69.55^{ab}	34.6^{b}	682.33^{b}	642.82^{c}
B3	70.89^{a}	36.92^{a}	683.65^{ab}	655.84^{b}
B4	60.55^{d}	37.53^{a}	684.77^{a}	663.59^{a}
B5	50.99^{e}	25.54^{e}	557.99^{e}	517.74^{g}
CV%	1.66	3.23	0.17	0.16
LSD%	1.75	1.75	1.75	1.75

**Mean values followed by the same letter in the column are not significantly different at 5% probability level. According to LSD test; Where;- PO:- potato flour BA (pure barely),B1 (10:90),B2 (20:80),B3 (30:70),B4 (40:60),B5 (50:50),CV (Coefficient of variation), Fe[iron],Zn[zinc],Ca [calcium] and Mg [magnesium]and ppm[parts per million] and LSD=least significant difference*

Sensory analysis of Potato- barely composite injera

Potato- barely composite injera sensory result

Color: The color of bread and injera tells about the appearance of the bread, how it looks like, if it is appealing to eyes, inviting, and bright. The sensory scores for injera color are presented in Table 3 . The highest mean score of potato barely composite injera were recorded on whole barely (4.17) and this result was similar to that reported by Sanful (2011) where 100% of the panelists prefer the control (100% wheat) compared wheat–taro flour composite bread.

Taste: The results of the sensory taste scores are presented in Table 3. There was a significant difference ($p < .05$) in the taste of injera due to blending ratio. The highest score was 3.83 (close to extremely like) for whole barely and which was statistically similar with B1 and B2 (3.82) ,The least scores were for B5(2.67) . There was a general decrease in the taste score with increase in potato flour proportion. Similar studies reported a decrease in the taste scores of wheat–taro flour composite bread with increased proportion of taro flour (Ammar et al., 2009). This might be due to poor potato flour odor.

Flavor: The flavor of barely potato composite injera was significantly ($p < .05$) affected by the blending ratio (table 3). Composite injera from whole barely flour proportion of resulted in the highest score (4.08, moderately like) and the least were recorded at B5 (2.75 moderately dislike). The flavor scores decrease with increase in potato flour proportion which could be attributed to the high starch contents of potato flour with bland flavor. This result was in harmony with earlier studies (Ammar et al., 2009).

Appearance: Appearance is the surface characteristics of food materials which attracts the consumer perception. The appearance of potato barely injera was significantly ($p < .05$) affected by blending ratio

.The appearance score for most of the treatment groups from whole barely , B1 and B2 was around moderately like(3.67) and had higher appearance score.

Texture : The texture of barely potato composite injera was significantly ($p < .05$) affected by the blending ratio (table 3). Composite injera from whole barely flour proportion of resulted in the highest score (4.33, moderately like) and the least were recorded at B5 (2.75 moderately dislike). The texture scores decrease with increase in potato flour proportion.

Roll ability : The roll ability of barely potato composite injera was significantly ($p < .05$) affected by the blending ratio (table 3). Composite injera from whole barely flour proportion of resulted in the highest score (4.33, moderately like) and the least were recorded at B5 (3, neither like nor dislike). The roll ability scores decrease with increase in potato flour proportion.

Sourness : The Sourness of barely potato composite injera was significantly ($p < .05$) affected by the blending ratio (table 3). Composite injera from whole barely flour proportion of resulted in the highest score (3.83, near to moderately like) and the least were recorded at B5 (2.92, near to moderately neither like nor dislike). The sourness scores decrease with increase in potato flour proportion and acceptable until B4.

Table.3 shows potato- barely composite injera sensory result

Treatments	Color	Taste	Appearance	Flavor	Texture	Roll ability	Sourness
A	4.17^{a}	3.83^{a}	3.67^{a}	4.08^{a}	4.33^{a}	4.33^{a}	3.83^{a}
B1	4.08^{a}	3.82^{a}	3.67^{a}	3.75^{b}	3.83^{b}	3.75^{b}	3.5^{b}
B2	3.92^{b}	3.82^{a}	3.67^{a}	3.45^{c}	3.75^{c}	3.67^{b}	3.42^{b}
B3	3.56^{c}	3.25^{b}	3.58^{b}	3.42^{c}	3.75^{c}	3.44^{c}	3.25^{c}
B4	2.67^{d}	2.83^{c}	2.67^{c}	2.9^{d}	3.33^{d}	3.33^{d}	3.17^{c}
B5	2.5^{e}	2.67^{d}	2.58^{d}	2.75^{e}	2.75^{e}	3^{e}	2.92^{d}
CV %	1.52	0.58	0.6	1.77	0.55	1.62 1.47	1.58
LSD	0.08	0.14	0.035	1.11	0.03	0.09	0.09

**Mean values followed by the same letter in the column are not significantly different at 5% probability level. According to LSD test; Where, A=Barely, B1=90:10, B2=80:20, B3=70:30, B4=60:40, B5 (50:50), CV= coefficient of variance and LSD=least significant difference*

Conclusion

From the study, injera proximate quality ranked B1 to B3 could be used as an alternative option for injera utilization and provide nutritional benefit to consumers. Within an increment in barley flour proportion from 50–100%, an increase in moisture content from 5.01–13.75% was observed in the injera product and similar trend with bread product that an increment in barley flour proportion from 40–100%, an increase in moisture content from 5.23–12% was observed The ash content of injera sample were statistically similar among the samples and this may be due to both barely and potato are rich in total ash content(minerals),

The highest organic matter content were recorded in whole barely (97.22%) which was followed but decreased as potato flour proportion increased as the proportion of potato flour increased organic matter were decreased. In general from this finding barely has higher organic matter than potato.

Protein content of injera sample was increased with an increased proportion of potato flour till B3 [15.22%] and decreased as the blending ratio increased, which could be due to the high amount of protein in potato flour. This is important for Ethiopians where injera is the major staple food prepared mostly from sole teff flour unless it is not accessible and costly. Above and beyond, both barely and potato-based injera can be a good source of protein for those who are gluten-sensitive.

According to the Nutrient content of potato flour and Barley flour the Crude fiber content of potato flour is better compared to barely flour. Crude fiber content of *injera* from six different formulations of injera showed significantly different at ($p < 0.05$) and which was between 5.88% [B5] and 9.09% [B3]. Relatively higher Crude fiber content was observed in a sample of injera prepared from B3 [9.09%] and which was followed by B2 [8.11%]. Significant difference ($p < 0.05$) was shown in Crude fiber content of bread products. There was an increase content of Crude fiber from 7.25–9.89% as we increased potato flour proportions from 10–40%. Therefore, the Crude fiber content of potato flour is better compared to barely flour. This is vital for many countries like Ethiopia, where potato and barely are produced in many parts of the country.

In the samples from the different blends, Magnesium, zinc, iron and calcium contents of injera increased with the increment of potato proportion, which may be due to the higher amount of Magnesium, zinc, iron and calcium in the potato flour. High iron (70.89ppm), zinc (37.53 ppm) and calcium (684.65ppm and magnesium (663.59ppm)) contents were obtained from B3 for iron and zink and B4 for calcium and magnesium of potato barely blended injera and the sensory quality such as color, taste, appearance and flavor of injera became unacceptable beyond B3 and similar with potato barely composite bread.

In general from proximate composition, minerals and sensory quality perspective blending ratios from B1 to B3 could be used as an alternative option for injera utilization and provide nutritional benefit to consumers. The outcome of the research has a significant implication in food security and nutrition security.

Declarations

Authors' contributions

Lamrot Woldemariam contributed to the conceptualization and designing of the experiments and preparing the manuscript and with Gosa Mamo carried out the sensory and laboratory studies, statistical analysis and interpretation and final write-up. Fikirte woldeyes defended the proposal at regional level of ARARI, she is now PhD candidate. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

All available data are shown in tables.

Consent for publication

All authors give their personal consent for publication.

Ethics approval and consent to participate

Not applicable.

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