Effect of mango and carrot fortification on proximate composition, β-carotene and sensory properties of teff injera

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Abstract: This work investigated the effect of mango and carrot flour and juice substitution on the quality of teff injera. The mango and carrot in two forms (flour and juice) at three substitution levels (15%, 20% and 30%) were added using factorial experiment were blended and co-fermented for injera baking using 100% teff flour as a control. The injeras were subjected to analysis of proximate composition, β-carotene, vitamin C contents and sensory evaluation. The results revealed that teff injera substituted with mango and carrot at 15%, 20% and 30% showed significant (P < 0.05) effect on the protein, crude fiber, ash, β-carotene and vitamin C contents. With an increase in mango and carrot substitution levels, a significant increase in the β-carotene and vitamin C contents of the injeras was observed. Injera with high β-carotene and vitamin C contents can be obtained by 30% flour substitution. Injera sensory attributes were significantly influenced by mango and carrot substitution levels (P < 0.05). Injera eye size and its distribution, a key sensory

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PUBLIC INTEREST STATEMENT
Teff injera is a whole grain fermented staple food for the majority of Ethiopians. Teff injera is free of wheat type gluten proteins and is desirable for celiac patients. Even though, teff injera nutrients and bioactive compounds are appreciated in the health food markets, it is limited with pro-vitamin A carotenoids, vitamin C and omega-3 fatty acids. In view of this, fortification of teff injera with mango and carrot has high potential to improve pro-vitamin A carotenoids and vitamin C contents of injera. In addition to value addition to mango and carrots, such practice can also reduce the postharvest loss of mango and carrot and thereby contribute toward food and nutrition security for resource poor community. This study provides baseline information on the possibility to use mango and carrots as a strategy to fortify injera to combat the micro-nutrient malnutrition.
attributes for injeras were reduced from control injera with mango juice and carrot flour, blending at 20% and 30%, respectively. The whiteness of injera color was changed, but no significant difference was observed on brownness of injera at bottom surface. The result showed injera with acceptable sensory attributes (softness, stickiness, fluffiness and rollability, injera eyes, sourness and overall acceptably) compared to the control injeras can be obtained with 15% mango and carrot substitution levels.

Subjects: Nutrition; Food Additives & Ingredients; Food Engineering

Keywords: carrot; β-carotene; injera; mango; sensory; teff

1. Introduction

The typical Ethiopian staple food, injera is a fermented thin pancake-like, sour, soft, circular flat bread processed from teff grain flour. Teff (Eragrostis tef) grain is a tiny, millet like grain which is superior in its injera making features as compared to other cereal grains used (Yetneberk et al., 2004). Because of the small size of teff grain (length 0.9 to 1.7 mm, diameter 0.7 to 1.0 mm and a thousand kernel mass of 0.19 to 0.42 g), it is always milled to whole grain flour and fermented consumed as injera (Bultosa, 2016). Injera provides considerable amount starches (70–73%), dietary fibers (4.5%), minerals (particularly iron = 9.5–37.7, calcium = 17–124, zinc = 2.86, magnesium = 184 in mg/100 g) and B-vitamins (thiamine, riboflavin and niacin) to consumers (Abebe et al., 2007). However, it is limited with vitamins A and C, and essential fatty acids like omega-3 fatty acids (Bultosa, 2016; Zhu, 2018). The protein content in grain teff can range from 9% to 13% with balanced amino acids as compared to major cereal grains (maize, sorghum, wheat, barley and rice) (Bultosa, 2016). Teff injera is free from the allergenic wheat type gluten proteins (Rosell et al., 2014). Because teff is always processed from whole grains, it can supply considerable nutrients for celiac patients (Bultosa, 2016; Zhu, 2018) as compared to other gluten free diets which are often processed from starchy sources (maize, rice, cassava, and potato) (Dennis et al., 2019).

Carrot (Daucus carota) is a good source of pro-vitamin A carotenoids (particularly β-carotene), dietary fibers, sugars, minerals (calcium, phosphorus, iron and magnesium) and B-vitamins (thiamine, riboflavin and niacin) (Sharma et al., 2012). Carrot is dried to reduce postharvest losses, to overcome seasonal supply variations and for use as functional ingredients in various foods such as bread, cake, dressings and biscuits (Alam et al., 2013; Vu Nguyen & Nguyen, 2015).

Mango (Mangifera indica L.) is one of the affordable fruits in the tropical and subtropical regions. The use of mango fruits in food formulations is increasing importantly because it provides nutrients (pro-vitamin A carotenoids, vitamin C, B6 and dietary fibers, amino acids) and phytochemicals (Agatonovic-Kustrin et al., 2018), but are limited in saturated fats, cholesterol and sodium (Guiamba et al., 2015).

Both carrots and mango are produced in Ethiopia (Central Statistical Agency [CSA], 2016/2017), but their postharvest loss is very high particularly in mango fruits (Dessalegn et al., 2016). Blending of moderately ripe mango mesocarp and carrot into teff flour for injera making can have a potential to enrich injera with micronutrients such as pro-vitamin A carotenoids, vitamin C and other bioactive compounds (phenolic compounds and dietary fibers). In addition, of contribution toward value addition, nutrients and bioactive compounds, such blending can also provide an alternative color to injera imparted from mango and/or carrots.

The most documented forms of malnutrition in Ethiopia are protein energy malnutrition and deficiencies of iodine, iron, zinc, and vitamins A and C (CSA and ICF, 2016). Since injera is a staple diet in Ethiopia, enriching injera through the blending as diet-based strategy can have a potential
toward malnutrition reduction. In the past, to overcome challenges in the teff grain price increase, and to improve nutrient and functional properties for injera, blending of teff flour with sorghum, wheat, maize & barley (Cherinet, 1993), flaxseed (Girma et al., 2013), sorghum & faba bean (Mihrete & Bultosa, 2017), maize, barley, barley & sorghum, barley & maize, sorghum & maize (Abraha & Abay, 2017), cassava tuber flour (Desalegn & Desta, 2017), maize and rice (Cherie et al., 2018), quinoa (Agza et al., 2018), amaranths & barley (Woldemariam et al., 2019) have been studied. Even though there has been an improvement in some nutrients such as protein and fat contents of injera, in some of those studies (Girma et al., 2013; Mihrete & Bultosa, 2017; Woldemariam et al., 2019), some sensory properties of injera were shown to be inferior in all studies as compared to injera baked from 100% grain teff flour particularly when replacement to teff grain flour exceeds 30%. However, studies toward the blending of teff flour with vegetables and fruits for processing of injera are limited (virtually absent). Therefore, in this work, the effect of mango mesocarp and carrot juices and dried flours at 15%, 20% and 30% substitution levels for teff flour on injera quality are reported.

2. Materials and methods

2.1. Samples source

Moderately ripe mango variety (Keitt) and carrot (Nantes) variety were bought from the local market of the Bahir Dar City, Ethiopia. An improved variety of teff (Degu) was bought from Adet Agricultural Research Center, Ethiopia.

2.2. Sample preparation

The teff grain was cleaned by sifting and sieving to remove all contaminants and then milled using a disk attrition miller (cottage teff grain-milling house, Bahir Dar City, Ethiopia) to whole flour to the fineness level used traditionally for injera making. The mango fruit was cleaned, sorted, washed in clean tap water, blanched at 90°C for 2 min, and cooled in an ice water bath for 5 min (Guiamba et al., 2015). Then, after the epicarp and nuts were removed with a clean sharp kitchen knife, the mesocarp obtained were sliced and dried on a metal tray in the oven (DHG-9140 Drying oven, China) at a temperature of 60°C for 72 h to a moisture level of 10.0–10.5% (Ogori, 2013). The dried slices were milled using a mortar grinder (Mortar Grinder PULVERISETTE 2, Germany), sieved through 500 µm pore sieve, stored in low-density polyethylene bag until used for the blending experiments of injera making process.

For mango juice extraction, similar techniques described above were followed to the stage of mesocarp slicing. After which the mesocarp slices were blended using a blender (Vertical cutter-mixer, France). Then, the mango flour and juice at each blending ratio were blended with teff flour for injera making process.

Carrot was sorted, washed in clean tap water, blanched at 96°C for 2 min, cooled in ice water for 5 min, peeled, grated, chopped and dried at a temperature of 50°C in an oven dryer for 48 h the almost brittle constituency. The dried samples were milled to flour, sieved (500 µm) and stored in low-density polyethylene bags until used. For carrot juice extraction, similar techniques described above were followed to the stage by an outer layer of carrots were peeled off. The peeled carrot was diced into small pieces and blended using a blender (Vertical cutter-mixer, France), after addition of a little water, filtered using muslin cloth to obtain the carrot juice. The carrots flour and juice were blended with teff flour to each of the blending ratio for the injera making process.

2.3. Experimental design

The experiment was set as 2x2x3 factorial design of two factors of mango mesocarp/carrot (flour and juice) and three substitution levels (15%, 20% and 30%) in three replications with 100% grain teff flour as a control.
2.4. Injera preparation
The injera was prepared by mixing teff flour and mango mesocarp/carrot flour or juice in the ratio of flour/juice: potable water (1 kg: 2 L) along with about 160 mL of irsho (leftover batter from the previous baking session usually used as starter culture). The dough was made by hand kneading, fermented for 72 h. at room temperature. After fermentation, 10% of the fermented dough was thinned with 100 mL of water and cooked in 200 mL of boiling water for 1 min. The gelatinized batter was cooled to about 45°C at room temperature and added back to the fermenting dough. About 200 g of the fermented batter was poured in a circular manner onto a 45 cm diameter hot clay griddle, covered, and baked for approximately 2 min as it is done traditionally (Girma et al., 2013; Yetneberk et al., 2004). The fresh baked injera was dried for 24 h. at 40°C in an oven (DHG-9140 Drying oven, China) and ground on a disk attrition mill to pass 500 µm sieve. This sample was kept in a low-density polyethylene bag at room temperature for further analysis.

2.5. Proximate composition
The injera moisture, ash, crude-fiber, -protein and -fat contents were determined following the AOAC (2005) Method Nos: 925.10, 923.03, 962.09, 979.09 and 920.39, respectively. The total carbohydrate content (CHO) was calculated by difference: 100- (% moisture + % ash + % fiber + % protein and % fat) (Monro & Burlingame, 1996).

2.5.1. β-carotene content
β-Carotene content was determined after extraction from the sample (about 1 g) with about 15 mL acetone in the presence of a few crystals of anhydrous sodium sulphate. The supernatant was decanted into a beaker. The process was repeated twice and the supernatant was combined and transferred to a separating funnel to which about 15 mL of petroleum ether was mixed thoroughly. Two layers separated out on standing, the lower layer is discarded and upper layer was collected into a 100 mL volumetric flask and the volume was made to 100 mL with petroleum ether. The absorbance of the extracts was measured using a UV-Vis spectrophotometric (Agilent Cary 60 UV-Vis Spectrophotometer, USA) at 452 nm using petroleum ether as blank (Salehi et al., 2015). The β-carotene content was calculated using the following formula:

$$\beta\text{carotene} \text{ (mg/100g)} = \frac{\text{Optical density of sample} \times 13.9 \times 10^4 \times 100}{\text{Sample weight (db)} \times 560 \times 10000}$$

2.5.2. Vitamin C content
Vitamin C content was determined by an iodometric titration method as described in Nweze et al. (2015).

2.6. Sensory acceptability
Sensory acceptability of injeras was conducted using 20 volunteer panellists (10 female and 10 male) of those accustomed of injera eating as staple, 25–30 years old and were recruited from the postgraduate students and staff at the faculty of the Bahir Dar Institute of Technology. The coded injera samples were presented to panellists at random for likeness scores on whiteness of the bottom surface, the brownness of the bottom surface, eye size, eye evenness and distribution, softness, stickiness, fluffiness, rollability, grittiness in the mouth, sourness and overall acceptability on a seven point hedonic scale (1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = neither like nor dislike, 5 = like moderately, 6 = like very much, 7 = like extremely) (Yetneberk et al., 2004).

2.7. Statistical data analysis
A triplicate data except for the sensory evaluation (n = 20) were subjected to an Analysis of Variance (ANOVA) using SAS version 9.1.3 program. Duncan’s Multiple Range Test was used to determine means significance difference (p < 0.05). The results are given as mean ± standard deviation.
3. Results and discussion

3.1. Proximate composition, β-carotene and vitamin C contents of teff, mango and carrot flours and injera

There was a significant difference (p < 0.05) among teff, mango and carrot flour on the proximate composition (Table 1). The moisture content was varied from 10.02% (teff) to 11.53% (dried carrot flour). Teff flour has high protein (11.28%) and fat (2.38%) contents than mango flour (6.20% and 1.02%, respectively). Whereas no significant difference (p < 0.05) in fat content was found between teff and dried carrot flour. The highest ash (6.08%) and fiber (9.42%) contents were found in carrot flour. The total carbohydrate (CHO) content was high for dried mango flour (77.16%), followed by teff flour (71.35%) and carrot flour (61.57%). Similar proximate composition for grain teff (Bultosa, 2016; Girma et al., 2013), mango pulp (Noor Aziah et al., 2011) and carrot flour (Porto Dalla Costa et al., 2016) were reported. The proximate analysis showed that high protein content can be contributed by teff and carrot flour, high carbohydrate content of mango flour, high ash and crude fiber contents by carrot flour to the injera processed by partial substitution of teff flour with carrot or mango flour.

There was a significant difference (p < 0.05) in the β-carotene and vitamin C contents among teff, mango and carrot flour samples. The carrot flour had the highest β-carotene (43.79 mg/100 g) and vitamin C (8.64 mg/100 g) contents followed by mango (31.10 and 7.42 mg/100 g, respectively) and teff (10.37 and 6.25 mg/100 g, respectively) flour. The result shows the addition of carrot and mango flour to the teff flour can potentially increase the β-carotene and vitamin C contents of teff injera.

The proximate composition of mango substituted teff injera is shown in Table 2. The moisture content was ranged from 5.16% to 6.16% and significant difference (p < 0.05) was observed for

| Table 1. Proximate composition of teff, mango and carrot flours |
|---------------------------------------------------------------|
| Sample            | Moisture (%) | Protein (%) | Ash (%) | Fiber (%) | Fat (%) | CHO (%) | β-Carotene (mg/100 g) | Vitamin C (mg/100 g) |
| Teff flour        | 10.02 ± 0.15<sup>a</sup> | 11.18 ± 1.26<sup>a</sup> | 3.13 ± 0.11<sup>b</sup> | 1.90 ± 0.10<sup>c</sup> | 2.38 ± 0.04<sup>d</sup> | 81.35 ± 1.55<sup>b</sup> | 10.37 ± 0.30<sup>c</sup> | 6.25 ± 0.01<sup>c</sup> |
| Mango flour       | 10.06 ± 0.15<sup>b</sup> | 6.20 ± 0.98<sup>b</sup> | 2.28 ± 0.46<sup>c</sup> | 3.28 ± 0.05<sup>b</sup> | 1.02 ± 0.01<sup>c</sup> | 87.22 ± 0.05<sup>b</sup> | 31.10 ± 0.24<sup>b</sup> | 7.42 ± 0.01<sup>b</sup> |
| Carrot flour      | 11.53 ± 0.14<sup>c</sup> | 9.13 ± 1.00<sup>c</sup> | 6.08 ± 0.25<sup>c</sup> | 9.42 ± 0.22<sup>c</sup> | 2.26 ± 0.13<sup>c</sup> | 72.78 ± 1.72<sup>c</sup> | 43.79 ± 0.28<sup>a</sup> | 8.64 ± 0.02<sup>a</sup> |

<sup>a,b,c</sup>Values with the same superscript in the column are not significantly different (p < 0.05) and are means ± standard deviations (n = 3). Where CHO = total carbohydrate.

| Table 2. Proximate composition of mango substituted teff injera |
|---------------------------------------------------------------|
| Sample            | Moisture (%) | Protein (%) | Ash (%) | Fiber (%) | Fat (%) | CHO (%) |
| Control           | 5.91 ± 0.07<sup>a</sup> | 10.29 ± 1.77<sup>c</sup> | 3.01 ± 0.26<sup>c</sup> | 2.68 ± 0.08<sup>a</sup> | 1.20 ± 0.08<sup>a</sup> | 76.91 ± 1.47<sup>a</sup> |
| MF 15%            | 5.51 ± 0.15<sup>b</sup> | 12.01 ± 1.72<sup>bc</sup> | 3.13 ± 0.25<sup>c</sup> | 2.91 ± 0.02<sup>c</sup> | 2.42 ± 0.06<sup>a</sup> | 74.02 ± 1.70<sup>b</sup> |
| MF 20%            | 5.16 ± 0.29<sup>c</sup> | 11.42 ± 0.98<sup>bc</sup> | 3.71 ± 0.18<sup>c</sup> | 3.64 ± 0.15<sup>c</sup> | 2.19 ± 0.01<sup>a</sup> | 73.88 ± 0.95<sup>c</sup> |
| MF 30%            | 5.84 ± 0.21<sup>c</sup> | 11.44 ± 0.99<sup>bc</sup> | 4.33 ± 0.35<sup>c</sup> | 4.15 ± 0.14<sup>c</sup> | 1.15 ± 0.10<sup>c</sup> | 73.09 ± 0.89<sup>c</sup> |
| MJ 15%            | 6.16 ± 0.08<sup>a</sup> | 15.45 ± 1.72<sup>a</sup> | 4.78 ± 0.26<sup>a</sup> | 2.09 ± 0.17<sup>a</sup> | 1.89 ± 0.08<sup>c</sup> | 69.63 ± 1.68<sup>c</sup> |
| MJ 20%            | 6.14 ± 0.17<sup>a</sup> | 13.67 ± 1.77<sup>ab</sup> | 4.72 ± 0.29<sup>a</sup> | 2.55 ± 0.12<sup>a</sup> | 1.17 ± 0.10<sup>c</sup> | 71.75 ± 1.83<sup>cd</sup> |
| MJ 30%            | 6.09 ± 0.08<sup>a</sup> | 13.71 ± 1.72<sup>ab</sup> | 4.61 ± 0.20<sup>a</sup> | 2.14 ± 0.12<sup>a</sup> | 1.44 ± 0.06<sup>a</sup> | 72.01 ± 1.44<sup>cd</sup> |

<sup>a,b,c,d</sup>Values are means ± standard deviations (n = 3). Means with different superscripts within a column differ significantly (P < 0.05). Where: Control 100% teff flour, MF15% = 15% mango flour, MF20% = 20% mango flour, MF30% = 30% mango flour, MJ15% = 15% mango juice, MJ20% = 20% mango juice, MJ30% = 30% mango juice and CHO = total carbohydrate.
injera made with 15% and 20% mango flour substitutions. The dried injera has low moisture contents and along with low pH 4.39 to 4.49 of injeras (Girma et al., 2013), the potential of dried injera for long storage could be high. The highest crude protein content was recorded among 15% to 30% mango juice substituted injera (p < 0.05) and the lowest was for the control injera. The ash content in the injeras increased with increasing levels of mango flour in the composite flour, while carbohydrate contents decreased with increasing levels of mango flour. The crude fiber content increased with increasing levels of mango flour but decreased with increasing levels of mango juice probably due to dilution effect. There was a significant difference (p < 0.05) between injera made from 100% teff control and mango composite (flour and juice) in terms of the proximate composition. The control injera had low protein, ash, fiber and fat contents, but high in its carbohydrate contents. Fiber and ash contents increased with increasing levels of mango flour and juice while the carbohydrate content decreased as compared to the control injera. Injera processed with 15% mango juice substitution showed the highest protein and ash contents. Even though injera processed by mango flour substitution showed higher protein content than the 100% teff control injera, there was no significant difference (p < 0.05) with an increase in levels of mango substitution. There was a significant difference (p < 0.05) on the injera proximate compositions due to the two forms of substitution. Moisture, protein and ash contents were high among mango juice substituted injera, whereas fiber, fat and total carbohydrate contents were high among mango flour substituted injera.

The proximate composition of carrot substituted teff injera is shown in Table 3. The moisture contents of the injeras were ranged from 4.58% to 5.91%. The moisture contents of carrot substituted injeras were low which indicate the possibility of long shelf life storage can be high if injera is dried. The crude protein contents were found high among 15% to 20% carrots (flour and juice) substituted injera. The ash and fiber contents of injera increased with increasing levels of carrot flour substitution because dried carrot flour is high in its ash and fiber contents. There was also an increase in the crude fat content with carrot flour substitution level increase. The ash and carbohydrate contents of injeras increased with increasing levels of carrot juice from 20% to 30% in the blend, while protein and fat content decreased. The ash and fiber contents were low among carrot juice substituted injera. Injera from carrot flour with a substituted level of 30% showed the highest ash and crude fiber contents because carrot flours bear high ash and fiber contents. There was a significant difference (p < 0.05) between the two forms (flour and juice) of carrot substituted injeras in terms of moisture, ash, fiber and fat contents with the exception of carrot flour substituted at 15% of protein and fat contents. The result shows with an increase in the carrots substitution to 30% as compared to 100% control injera, an increase in the ash, fiber and fat contents and a decrease in the total carbohydrate contents in the injeras were observed. This shows carrots have a high potential to increase the ash mineral and fiber contents of injeras and a similar effect is reported in the carrot powder substituted wheat pan bread (Hussein et al., 2013).

| Samples   | Moisture (%) | Protein (%) | Ash (%) | Fiber (%) | Fat (%) | CHO (%) |
|-----------|--------------|-------------|---------|-----------|---------|---------|
| Control   | 5.91 ± 0.07a | 10.29 ± 1.77c | 3.01 ± 0.26f | 2.68 ± 0.08a | 1.20 ± 0.08f | 76.91 ± 1.47a |
| CF 15%    | 4.61 ± 0.07d | 13.09 ± 1.91ab | 6.62 ± 0.25a | 3.32 ± 0.11c | 1.54 ± 0.08c | 70.82 ± 2.01bc |
| CF 20%    | 4.58 ± 0.15d | 11.41 ± 1.00bc | 6.34 ± 0.08b | 4.40 ± 0.04b | 2.09 ± 0.03b | 71.19 ± 0.89bc |
| CF 30%    | 5.25 ± 0.14c | 10.85 ± 1.00bc | 6.80 ± 0.04a | 5.46 ± 0.14a | 2.61 ± 0.01a | 69.03 ± 1.01c |
| CJ 15%    | 5.51 ± 0.11b | 14.94 ± 0.99cd | 4.05 ± 0.02a | 2.39 ± 0.14a | 1.74 ± 0.03a | 71.37 ± 1.03b |
| CJ 20%    | 5.79 ± 0.25b | 13.14 ± 1.00bc | 4.64 ± 0.07bc | 2.46 ± 0.03b | 1.61 ± 0.01a | 72.37 ± 0.82b |
| CJ 30%    | 5.83 ± 0.07a | 9.14 ± 1.00c  | 5.73 ± 0.04c  | 2.32 ± 0.01c  | 1.35 ± 0.02a  | 75.63 ± 0.96a |

a,b,c,d,e Values are means ± standard deviations (n = 3). Means with different superscripts within a column differ significantly (p < 0.05). Where: Control 100% teff flour, CF15% = 15% carrot flour, CF20% = 20% carrot flour, CF30% = 30% carrot flour, CJ15% = 15% carrot juice, CJ20% = 20% carrot juice, CJ30% = 30% carrot juice and CHO = total carbohydrate.
The β-carotene and vitamin C contents of injera significantly increased ($p < 0.05$) with increasing levels of mango and carrot flour and juice in the composite flour injera (Figure 1) as compared to the control injera because mango and carrot bear high β-carotene and vitamin C contents. The β-carotene content of injeras varied significantly ($p < 0.05$) with increasing levels of mango flour and juice. However, the vitamin C content of injeras varied significantly only with increasing levels of mango flour in the composite flour. There was a significant difference ($p < 0.05$) between the two forms (flour and juice) of mango substitution on β-carotene and vitamin C contents. With an increase in the mango substitution level, an increase in the β-carotene and vitamin C contents of the injeras was shown. There is a subtle change in β-carotene and vitamin C contents on dough making, fermentation and injera steam baking even though the reduction of vitamin C contents is likely due to steam baking (Figure 1).

The carrot injera with a substitution level of 30% had the highest β-carotene and vitamin C contents. Flour substituted injera had higher β-carotene and vitamin C contents than juice substituted injera. The β-carotene contents of injera from carrot substitution were generally high because carrots are rich in beta-carotene.

β-Carotene is the major pro-vitamin A component of the most carotenoid containing foods and is essential to combat vitamin A deficiency. β-Carotene conversion to retinol equivalent (RE) is considered. One microgram beta carotene = 0.167 microgram RE. As indicated in Figure 1, injera processed can supply pro-vitamin A in the range 2345-3644 microgram RE for mango substituted injera whereas for carrot substituted injera from 2729 to 4045 microgram RE. The values of β-Carotene (RE) were much higher in mango and carrot substituted injeras as compared to the control injera (1212 microgram RE). The daily vitamin A requirement as RE for adolescent 10 to 18 years old is 600 micrograms (World Health Organization and Food and Agricultural Organization of the United Nations [WHO and FAO], 2004). Therefore, with this regard, the injera processed of this experiment could contribute significant RE; hence, it will enhance the intake of pro-vitamin A to reduce the vitamin A deficiency burden.

The slight increase in the moisture content of injera as a proportion of the mango juice increase in the blends is probably attributed to the mango sugar residuals which contribute for injera to be
more hygroscopic. Even though protein content was high in grain teff flour, the protein content was found low in the control injera as compared to those injera processed by mango or carrot substitution. This is most probably related to the protein proteolysis and solubilization degree differences by fermenting microorganisms as a result of substrate change on blending (Poutanen et al., 2009) which might lead to the subsequent loss of degraded protein material through the yellowish liquid called *irsho/raacitii* that accumulate on the surface of fermenting batter and discarded at the end of the first phase fermentation on injera baking (Bultosa, 2016). The decrease in the total carbohydrate contents from control injera on carrot and mango substituted injera is most probably a manifestation of their high sugar content utilization from carrot and mango on fermentation (Septembre-Malaterre et al., 2018). The increase in protein, ash, fiber, β-carotene and vitamin C contents of injera with the increasing substitution level of mango and carrot flour/juice could be a possibility to enrich injera with minerals, dietary fibers, pro-vitamin A carotenoids and vitamin C. In other study done on carrots fortified bread (Hussein et al., 2013), β-carotene rich defatted soy fortified biscuits (Mridula, 2011) and mango fortified cakes (Noor Aziah et al., 2011) an increase in fiber, ash and β-carotene were reported.

### 3.2. Sensory acceptability of injera

The sensory acceptability of mango and carrot flour or juice substituted teff injera is shown in Figure 2. A significant difference ($p < 0.05$) was observed among injera made from composite flour or juice and 100% teff flour with respect to injera color, eye size, eye evenness and distribution, injera softness, stickiness, fluffiness, rollability (excluding injera processed from mango flour blending), grittiness in the mouth, sourness, and overall acceptability. When the proportion of mango and carrot flours or juices increased in the blends, the panelists score changed from like very much toward like moderately and neither like or dislike for most sensory attributes evaluated. The whiteness of injera bottom surface decreased from 100% control teff injera with either mango or carrot (flour or juice) blending at all levels, in part because of color contributed from carrot or mango and in part by degree of variation in the maillard and/or caramelization reactions that were observed as pale brown on the bottom side of injera (Girma et al., 2013). On injera brownness of the bottom surface, the only significant difference was observed in the injera processed from 30% carrot juice blending which appeared more brown than the control injera. The significant difference ($p < 0.05$) in injera eye size and eye evenness distribution of the control 100% teff injera were
observed when mango juice and carrot flour were blended at 20% and 30%, respectively. *Injera* eye and its evenness distribution on the top surface are one of the most sensory attributes to which communities that traditionally consume *injera* as staple are attracted (Agza et al., 2018; Girma et al., 2013). In this respect, the result shows blending up to 15% will not lead *injera* eyes to be significantly different from the control *injera*. The eye size of juice substituted *injera* in both mango and carrot was too small as compared to flour substituted *injera* (see Figure 3). The softness, stickiness, fluffiness, rollability and grittiness in the mouth of the *injeras* were appeared inferior with *injera* processed from 20% mango juice and 15% carrot juice blending. Mango flour up to 30%, carrot flour up to 15% and carrot juice from 20% to 30% substitution levels did not significantly influenced the texture of *injera* softness, stickiness, fluffiness and rollability as compared to 100% *injera*. Softness of *injera*, non-stickiness, rollability without fracture are the desirable attributes of *injera* (Yetneberk et al., 2004). As compared to 100% control *injera*, a significant difference in the sourness was found only with the mango flour substitution. The sourness of *injera* is at large influenced by the duration of fermentation and it appeared mango flour substitution has suppressed the sourness degree most probably due to the presence of residual sweet sugars from mango for the duration of fermentation in the *injera* making were similar in the study. Mild sour *injera* are preferred among communities that eats *injera* as a staple, and the result shows that the overall acceptability of *injera* has increased by the mango flour substitution in part are probably

Figure 3. Eye size of carrot and mango substituted teff *injera* with 15% substituted level and control *injera*. a) carrot and mango flours substituted *injera*, b) carrot and mango juice substituted *injera* and c) control *injera*. 
because of reduced injera sourness. There was no significant difference in the sweetness and bitterness of injera between control 100% teff injera and with mango or carrot (flour or juice) blended injeras. In general, the sensory attributes of injeras made were acceptable by consumers with the value of “like moderately” and “like very much” except for carrot flour 30% injera followed by mango juice 20% injera. The injera softness, injera stickiness and rollability made from composite flours were acceptable by consumers with the value of “like moderately” and “like very much” except when mango juice 20% blended injera, followed by mango juice 15% blended injera. Overall, injera made by substitution of mango and carrot (flour and juice form) was accepted by consumers except carrot flour 30% and mango juice 20% substituted injera in almost all sensorial attributes. Besides, substitution up to 15% level was not significantly different from 100% teff injera.

4. Conclusions
This study has shown acceptable injera could be obtained from composite flour made of teff, mango and carrot flours and juices since these injeras competed favorably with 100% teff injera. The findings showed that mango and carrot flour or juice forms; and mango and carrot substitution levels had significantly influenced protein, crude fiber, ash, β-carotene and vitamin C contents of the injera. With mango and carrot substitution in the injeras as compared to the control 100% teff injera, the protein, ash, β-carotene, and vitamin C contents were increased, whereas total carbohydrate content decreased significantly. Most sensory attributes of injera processed by substitution of mango and carrot (flour and juice forms) up to 15% were accepted with no significant difference as compared to the control 100% teff injera.

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Competing Interests
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Authors’ contributions
AT participated in the conception of the study, sample collection, laboratory analysis, compiling results, statistical analysis and contributed to discussion and revision of the manuscript. TA and AA participated in the interpretation of the findings, material and technical support. GB participated in the interpretation and description of the finding and edited the manuscript. All authors read and approved the final manuscript.

Ethical approval and consent to participate
The panellist’s voluntary agreement were taken for sensory evaluation of the product.

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