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Effect of Belending Semolina with Red Teff on Nutritional Quality of Short Cut Pasta

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Abstract: The use of red teff as a food ingredient in foods like short cut pasta helps to reduce cardiovascular disease and improves glycemic control. Teff has more fiber and minerals than wheat. Although there is study towards improving the nutrients and functional food character of macaroni products around the world, there isn't much going on in Ethiopia. As a result, this research was carried out in order to increase the nutritional status of macaroni products by substituting teff flour for semolina flour in part. The influence of four different teff flour ratios (10%, 15%, 20%, and 25%) compared to a control (100% semolina) on the quality of macaroni was tested. The macaroni was put to the test. Except for moisture content and protein, the macaroni products were significantly ($p<0.05$) increased for the selected proximate composition of macaroni. As the proportion of teff in macaroni grew, the mean values of ash content (0.73 to 1.80), fat content (1.39 to 1.89), fiber content (0.73 to 3.49), and utilizable carbohydrate (72.33 to 77.56) increased. Moisture and protein levels, on the other hand, were lowered from 10.81 to 7.85 percent and 14.02 percent to 7.86 percent, respectively. As the proportion of teff grew, so did the mineral content. With the addition of teff, iron, calcium, and zinc levels rose from 49.23 to 56.95 mg/100g, 219.74 to 233.25 mg/100g, and 6.93 to 8.11 mg/100g, respectively.

Keywords: Macaroni, Semolina, Teff Flour

1. Introduction

People all across the world consume pasta products such as macaroni, spaghetti, vermicelli, and noodles [3]. It is made up of a sophisticated multi-component system. Because of its ease of preparation, sensory appeal, low cost, and storage stability, it is a popular dish. According to experts, pasta is highly digestible and has a high number of complex carbohydrates, low sodium, and total fat. According to studies, however, it is lacking in dietary fiber, minerals, and essential fatty acids. As a result, pasta products must meet nutritional standards in order to meet the nutritional needs of consumers. A variety of ingredients are employed to fully address this nutritional gap in order to overcome it.

Teff is a minor cereal crop in the rest of the world, but it is a major food grain in Ethiopia, where it is mostly used to make injeran. Teff is high in complex carbohydrate, which accounts for 80% of the grain's nutritional value. Teff has an average crude protein composition of 8 to 11 percent, which is comparable to other common cereals like wheat, and a relatively high lysine concentration, which is a primary limiting amino acid in cereals. Red teff's crude fiber content is 3.1 percent, while its total and soluble dietary fiber content is several. Red teff contains more total and soluble dietary fiber than wheat, sorghum, rice, and maize, with a crude fiber level of 3.1 percent [2]. Teff contains more iron and calcium than other cereal grains [1].

Semolina fortification the protein and mineral content of the final product can be improved by red teff flour, which are lacking in durum semolina pasta. The use of red teff in pasta boosts red teff production and demand, bringing it into the market chain while also boosting the nutritional value of the pasta. In Ethiopia, the use of red teff for pasta manufacture is quite limited. The main goal of this research was to provide direction to individuals working in this field and to demonstrate the effect of red teff flour addition on semolina. The macaroni's cooking quality, sensory qualities, and chemical composition.

2. Materials and Methods

2.1. Experimental Materials

The durum wheat (Triticum turgidum ssp) semolina flour and red teff flour utilized in this study were obtained from Dire Dawa Food Complex Share Company and Dire Dawa local market, respectively.

2.2. Wet Gluten Determination

Hand washing with weak salt (2 NaCl) solution was used to determine the wet gluten content of the sample, as stated in AACC (2000) technique No. 38–10. The sample (approximately 5.0 g) was placed in a porcelain cup, and 2 ml of distilled water was added to form a firm ball dough, which was then baked at 25°C for 30 minutes. The dough was then kneaded gently over nylon cloth in a stream of washing water until all starch and other soluble materials was removed. Squeezing 2–3 drops of white clean wash water from gluten mass was continued till 2–3 drops of white clean wash water were obtained. The gluten was placed in the washing water for roughly an hour. Then pushed between the sheets as dry as possible.

2.3. Dry Gluten Determination

The dry gluten content was evaluated by drying the wet gluten for 24 hours at 100 degrees Celsius in an oven (Scientific series 2000, Model 220, South Africa) according to AACC (2000) technique No. 38–10. The dried gluten was weighed in a weighing dish with a flat bottom, and the mass was calculated as dry gluten.

2.4. Macaroni Production Process

To promote equal distribution of water at room temperature, semolina and teff (depending on the sample proportion) were premixed in a Spar mixer model No: - (L5M-A produced in China) at speed 1 (60 rpm) for 10 minutes. The 500 g premixed dough was transferred to a laboratory macaroni machine with a single screw (Model 'Minilab '30S', Italy) and mixed and kneaded for 1 minute. According to [6], the dough was extruded through the brass die at room temperature and dried in a hot-air drying oven (Scientific series 2000, Model 220, South Africa) at 60, 75, and 90°C. (2012). the dry macaroni was placed into a polyethylene bag and stored.

2.5. Proximate Composition Analysis

2.5.1. Moisture Content

The moisture content of raw materials and products was assessed using the approved method 925.10 of the Association of Official Analytical Chemists (AOAC), (2000). A clean plate was dried in a desiccator for 1 hour after being dried in a 105°C oven. The dish's weight (W1) was calculated. Samples (5 g) were weighed in a dry dish (W2) and dried at 105°C. until they reached a consistent mass, then cooled in a desiccator to room temperature (W3). The moisture content was calculated using the following formula:

$$MC = \left(\frac{W_2 - W_3}{W_2 - W_1}\right) \times 100 \quad (1)$$

Where: - MC- Moisture content (wb)
W_1- Mass of the dish (g)
W_2- Mass of the sample and dish before drying (g)
W_3- Mass of sample and dish after drying (g).

2.5.2. Crude Protein

AACC was used to determine the amount of crude protein in macaroni AACC (2000). Using the micro-Kjeldahl method, a ground sample from each treatment was tested for crude protein. A Kjeldahl digestion flask was filled with the sample weight (1.0 g). A 1.0 g catalyst mixture (Na2SO4 mixed with anhydrous $CuSO_4$ in a 10:1 ratio) was added. The digestion flask was placed in the digester after 5 mL of H2SO4 was added and the temperature was raised to 350°C for over 2 hours until digestion was complete. The flask was taken out of the digester and set aside to cool. After cooling, the contents of the flask were diluted with 30 mL of distilled water, 25 mL of distilled water, and 40 mL of concentrated.

$$N = \frac{V_{HCl} \times N_{HCl} \times 14}{M} \times 100 \quad (2)$$

$$P = F \times N \quad (3)$$

Where: V_{HCL}: The volume consumed to the endpoint of the titration,
N_{HL}: The Normality (Used Often Is 0.1N)
M: Sample weight on dry matter basis,
14.00: Is the molecular weight of nitrogen

2.5.3. Crude Fat

The crude fat analysis was determined by the Soxhlet extraction method according to AACC (2000 method by using the Soxtec Extraction system (Foss Soxtec TM 8000 Extraction unit, Sweden). Ground sample (3 g) was weighed and added into a thimble. The thimble with the sample was placed in a 50 mL beaker and dried in an oven for 2 hours at 110°C. A 150-250 ml dried beaker was weighed and rinsed several times with petroleum ether. The sample contains in the thimble was extract with petroleum ether in a Soxhlet extraction apparatus for 6-8 hours. After the extraction was complete, the extracted fat was transferred into a pre-weighed beaker (M_i). The beaker with extract fat was placed in a fume hood to evaporate the solvent on a steam bath until no odor of the solvent was detectable. Then the beaker with content was dried in an oven for 30 minutes at 100°C. Finally, the beaker with its contents was removed, cooled in a desiccator, and weighed (M_f). The amount of fat in macaroni was calculated by using the following formula:

$$\frac{M_f - M_i}{m} \times 100 = Fat\ (\%) \quad (4)$$

Where: M_f= Dried mass of fat with beaker (g)
M_i= Mass of the beaker (g)
m= Sample mass (g, db).

2.5.4. Ash Content

According to AACC (2000), official method 923.03. The total ash content of the flour and Macaroni was determined by the gravimetric method. Crucible was cleaned, dry and ignited at 550°C for 1 hour, cooled in desiccator and weight (m_1). Ground samples (3 g) were weighed (m_2). The samples were dried at 120°C for 1 hour. Then the dried sample was carbonized over a blue flame and ignited in a muffle furnace at 550°C until ashing completed (over 12 hours). After that, the samples were cooled to a desiccator and weighed (m_3). Finally, total the ash content was calculated as follows:

$$\left(\frac{m_3-m_1}{m_2-m_1}\right) \times 100 = \%Ash \quad (5)$$

Where: - M_1= Mass of crucible (g),
M_2= Sampled mass with crucible (g)
M_3= The final mass of sample with crucible (g) after ashing.

2.5.5. Crude Fiber

The crude fiber was analyzed according to [4]. Ground sample (3 g) was weighed (m_1) and placed in a 500 mL beaker. These were digested with 1.25% sulfuric acid and wash with water and further digest with 1.25% sodium hydroxide, filtered in coarse porous (75µm) crucible in apparatus at a vacuum of about 25mm. The residue left after refluxing was washed again with 1.25% sulfuric acid at near boiling point. Then the residues were dried at 110°C overnight, cool in a desiccator, and weighed (m_2). After dried the sample was ashed at 550°C until ashing completed then cooled in a desiccator and weighed again (m_3). The total crude fiber was express in percentage as follows:

$$\left(\frac{m_2-m_3}{m_1}\right) \times 100 = F \quad (6)$$

Where: F=Total crude fiber (%) Total crude fiber (%),
M_1= Mass of sample (g, db),
M_2= Mass of sample before ashing (g)
M_3= Mass of the sample after ashing (g, db).

2.5.6. Utilizable Carbohydrate

Utilizable carbohydrate contents of macaroni were calculated from the equations described in (Samati and Rajagopal, 2006):

Utilizable Carbohydrates (%) = 100 − (% moisture + % protein + % fat + % ash + %fiber)

2.6. Minerals

2.6.1. Calcium

The calcium content was determined by atomic absorption spectrophotometer (AACC, 2000). Ground sample (2 g) was weighed into an ashing vessel (that was be pre-ignited at 550°C and cooled in a desiccator). The sample was carbonized over a blue flame of Bunsen burner and put in the muffle furnace at 500°C until ash was completed. Then, the ash was dissolved in 10 mL dilute 3 M HCl. The solution was boiled and evaporated nearly to dryness on a steam bath. The residue was re-dissolved quantitatively in 20 mL 2 M HCl and was filtered through coarse porosity filter paper into a 100 mL volumetric flask. The paper was washed and the residues fill to dilute to 100 mL mark. Standard solution (25 µg Ca/mL) in the range of 2-20 µg/mL was prepared from analytical grade calcium wire by dissolving 1.249 g in 30mL HCl and 50 mL distilled water and then it was diluted to 1L. Finally, calcium was measure by adding enough La stock solution to make the final dilution 1% La (i.e., 5 mL La solution to the 25 mL flask, 20 mL to 100 mL flask) this was added to the sample and final standard solution. The absorbance of a sample was read with Atomic Absorption spectrophotometric at 422.7nm.

$$\frac{\mathrm{C} \times 100}{\mathrm{S}} = \mathrm{Ca\ (ppm)} \quad (7)$$

Where: - C: Sample concentration from the plot of absorption in µg/mL
S: Sample

2.6.2. Iron

Iron content was determined by Atomic Absorption Spectrophotometer (AACC, 2000). Ground sample (2.0g) was taken into the ash vessel (that was pre-ignited at 550°C and cooled in desiccators). Ashing was done at 500°C and then the ash was dissolved in a minimum volume of HCl-H_2O (1:1); 20 mL of this solution was added and evaporated to dryness on a steam bath. After cooled to ambient temperature, absorbance was read at 248.3 nm using air-acetylene as a source of flame for atomization with Atomic Absorption standard solution (1000 µg Fe/mL) with the range of 2-20 µg/ml was prepared from the pure iron wire by dissolving 1.000g into 30 mL 6 M HCl with boiling and dilute to 1L.

$$\frac{(\mu\mathrm{g/mL})\mathrm{x}100}{\mathrm{Sample\ mass\ (db)}} = \mathrm{Fe\ (ppm)} \quad (8)$$

Where: µg/mL is the absorbance reading concentration

2.6.3. Zinc

Zinc content was determined by Atomic Absorption Spectrophotometer (AACC, 2000). Ground sample (2.0 g) was taken into the ashing vessel (pre-ignited at 550°C and cooled in desiccators). Ashing was done at 500°C and then the ash was dissolved in a minimum volume of HCl-H_2O (1:1); 20 mL of this solution was added and evaporate to dry a steam bath. After cooling to ambient temperature, absorbance was read at 213.8 nm using air-acetylene as a source of flame for atomization with Atomic Absorption standard solution (10 µg Zn/mL) within the range of 0.5-5 µg/ml was prepared from analytical grade ZnO by liquifying 1.3830 g into 10 mL 6 M HCl and diluted to 100 mL and 5 mL of the solution was taken and dilute to 500 mL mark with distilled water and a serious of standard solutions to construct the calibration curve. Zinc content was calculated by the following formal.

$$\frac{\left(\frac{\mu\mathrm{g}}{\mathrm{mL}}\right)\mathrm{x}100}{\mathrm{Sample\ mass\ (db)}} = \mathrm{Zn\ (ppm)} \quad (9)$$

Where: µg/mL is the absorbance reading concentration

3. Results and Discussion

The findings of the study were presented and discussed in this section, which included the effects of the two factors on the physical and cooking qualities, proximate composition, and sensory acceptability of macaroni products.

3.1. Chemical Composition of Durum Wheat Semolina and Red Teff Flour

Some chemical property of the main raw materials (durum wheat semolina and teff flour) that were used for this work are shown in Table 1. The moisture content of semolina was 14.2%, which is higher than the 9.5% that was reported by Bashir *et al.* [8], Such variation in the moisture content can be attributed to the difference in the drying conditions and durum wheat varietal difference (Teresa *et al*., 2009). The moisture content of teff was 8.5% and higher than the 6.74% reported by. [7]. Information on the moisture content in the semolina and teff flour was used to calculate the amount of water to be added externally in the dough-making process for macaroni products extrusion.

Table 1. *Chemical composition of semolina and Red teff flour.*

Parameters	Raw Materials	
	Semolina	Teff Flour
Moisture (%)	14.2±0.35	9.5 ±0.35
Ash (%)	0.86±0.07	3.13 ±0.35
Wet Gluten (%)	28.1±0.11	No gluten
Dry Gluten (%)	12.55±0.12	No gluten

Note: values are mean ± SD of triplicate

The ash content was 0.86% for semolina and this result was close to 0.79% reported by Szydłowska et al. [15] and to 0.94% that was reported by Sabanis *et al*., [16]. According to those researchers, the major source of the ash may be due to less efficiency of milling machinery which leads to contamination of the semolina flour with the bran. The ash content of teff was recorded table 3. 13% and this result was corroborated by [1] who reported that the ash content of 13 teff varieties ranged from 3.16–1.99 %. According to those report the ash levels in teff grain are influenced by the post-harvest and harvest practices used.

The gluten content is the most determinant component of the semolina which affects the rheology and the final product quality. The wet gluten content of semolina in this study was observed to be 28.1% and the dry gluten content was 12.55%. The dry gluten content found in this work was almost equal to the 12% reported by Dhankhar*et al*., [14], According to this report semolina with a dry gluten content of between 12-14% and >15% were regarded as medium and high-quality semolina for pasta products making, respectively.

3.2. Main Effects on Proximate Composition

3.2.1. Moisture Content

Moisture content plays a pivotal role to determine the shelf stability of the end product. The moisture content of the macaroni products indicated that there existed a significant ($p<0.05$) difference. The highest value (10.81%) was observed for macaroni without teff flour (control) whereas the lowest value (7.85%) was recorded for macaroni with 25% teff flour. The moisture content of that macaroni with 10 and 15% teff flour had no significant difference ($P>0.05$) between them. According to the result observed the moisture content of the macaroni decreased as the teff flour ratio increased and this may be due to the lower moisture content of the teff flour (Table 2). The use of different types of raw materials would influence the macaroni moisture content to decrease the moisture content and contribute toward extending the shelf life of the product.

The drying temperature also had a significant ($P<0.05$) effect on the moisture content of the product as shown in Table 2. The moisture content of samples dried at 60°C was 9.25 whereas those dried at 75 & 90°C were 9.06 and 8.93%, respectively, and with no statistical difference between them but were significantly lower than the 9.25%. This pattern was related to the effective moisture diffusivity that increases with drying temperature, following an Arrhenius-type equation [13].

3.2.2. Total Ash

The ash contents of the product from the composite flour had significant ($P<0.05$) differences from that of the control (0% teff). The values for samples with 10 and 15% teff flour had no significant ($P>0.05$) difference between them while those with 20 and 25% teff were statistically, higher but with no difference between themselves as shown in Table 2. The ash content had increment as the ratio of teff flour increased and this was because of the higher (3.13%) ash content in the teff flour than the 0.86% in semolina (Table 2). This result agrees with Bashir *et al*. [8], who reported increment of ash in pasta fortified with chickpea flour, defatted soy flour, and Spaghetti Fortified with Soy flour, respectively.

Table 2. *Main effect on proximate composition of macaroni.*

Teff ratio (%)	Proximate Composition					
	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Fiber (%)	UCHO
0	10.81±0.3^{a}	0.73±0.05^{c}	1.39±0.0^{e}	14.02±0.49^{a}	0.73±0.05^{e}	72.33±0.52^{c}
10	9.18±0.1^{b}	1.36±0.12^{b}	1.57±0.0^{d}	9.68±1.10^{b}	1.5± 0.16^{d}	76.49±1.24^{b}
15	9.00±0.3^{b}	1.41±0.1^{b}	1.69±0.01^{c}	8.97±0.54^{c}	1.82±0.08^{c}	77.01±0.61^{ba}
20	8.56±0.40^{c}	1.75±0.1^{a}	1.82±0.0^{b}	8.39±0.57^{d}	2.31±0.14^{b}	77.25±1.05^{a}
25	7.85±0.1^{d}	1.80±0.10^{a}	1.89±0.03^{a}	7.86±0.57^{e}	3.49±0.11^{a}	77.56±0.88^{a}
CV	2.48	5.95	3.88	4.13	8.78	0.83
LSD	0.22	0.08	0.06	0.39	0.17	0.61

Note: values= are mean ± SD CV= coefficient of variance, LSD= least significant difference, UCHO= Utilizable carbohydrate. All Values followed by different letters within the column indicate a significant difference ($P<0.05$).

3.2.3. Crude Fat Content

Fat is an important factor that helps to improve the texture, rheology, and overall quality of the product. The mean values obtained for fat contents were shown in Table 2 and increased significantly (P < 0.05) with an increased level of substitution of semolina flour by teff. In this work, the highest mean value (1.89%) was observed in macaroni containing 25% teff flour, and the lowest mean value 1.39% was observed in macaroni without teff flour (control). Increasing the fat content is due to the presence of germ, not separated during milling. According to [12]) who was working by substituting with wheat bran to develop fiber reach pasta. On other hand, the fat content of teff is higher than wheat [12] the 4.4% and 3.36% for teff and wheat grain respectively. Another study by [2] discussed that the fat content of teff is higher than that of wheat and rice, but lower than maize and sorghum.

3.2.4. Crude Protein Content

The protein content of all macaroni products with different teff blending ratios shown in Table 2 significantly (P<0.05) decreased among the treatments themselves. The highest (14.02%) protein content was observed for the control (0% teff) and the lowest (7.86%) for the macaroni which had 25% teff flour. As the teff ratio increased, the protein content of the macaroni decreased and this may be due to lower protein in teff flour than in the semolina. According to [2] the average crude protein content of teff was in the range of 8 to 11%. In contrast, semolina protein levels ranged from 10.7 to 17.3 % as reported by [11].

3.2.5. Crude Fiber Content

The fiber contents of all macaroni samples of composite flours had increased significantly (P<0.05) as shown in Table 2. The highest fiber content 3.42% was recorded for macaroni which had a 25% teff flour blend whereas the lowest value 0.73% was for control (macaroni without teff flour). This result is supported by the work of [10] who reported an increment of fiber in spaghetti fortified with Soy Flour. The crude fiber, total and soluble dietary fiber content of teff is several-fold higher than that found in wheat, sorghum, rice, and maize according to a report by [2].

Several reasons can be given for this. First, whole grains have higher fiber content than decorticated ones. Second, small grains have a relatively high proportion of bran, high in fiber [1]. The high percentage of fiber may lead to an excessive cooking loss.

3.2.6. Utilizable Carbohydrate

The mean values of utilizable carbohydrate of macaroni of composite flours as indicated in Table 2 showed a significantly higher (P< 0.05) difference from that of the control. The highest values were 77.01, 77.25 and 77.56% recorded for macaroni products having 15, 20 and 25% teff flour ratio with no statistically differences among them. In Contrast, the lowest value of 72.33% was observed for macaroni without teff flour (control sample).

3.3. Main Effects on Minerals Content of Macaroni

The blending of semolina with teff flour resulted in an increment in the mineral content of the macaroni product as shown in Table 3. All the three minerals contents (Fe, Ca, and Zn) of macaroni product showed statically higher values than the control as the *teff* flour ratio increased. The mineral content increment in the product was due to the higher amount of iron, calcium, and zinc in teff flour than in semolina flour according to [2, 9] who reported teff that flour was not only gluten-free but also naturally contained higher iron content.

3.3.1. Iron Content

Iron (Fe) content of the macaroni products showed significant increment as the teff ratio increased. The lowest values 49.23 was of samples having no teff blend and the values kept increasing to 51.67, 53.69, 56.56 and 56.95mg/100g for those having 10, 15, 20 and 25% teff blends, respectively. This is attributed to the higher iron content of the teff flour than that of semolina. Many researchers had already indicated that teff is rich in iron content.

3.3.2. Calcium Content

The calcium content of macaroni products varied from 219.74 mg/100g of samples having no teff blend to 233.25 mg/100g of those with 25% teff blend, each increasing as the teff blend increased.

Table 3. *Main effect on the mineral content of macaroni.*

Teff ratio (%)	Mineral content (mg/100g)		
	Iron	Calcium	Zinc
0	$49.23{\pm}0.30^{d}$	$219.74{\pm}2.90^{d}$	$6.93{\pm}0.39^{c}$
10	$51.67{\pm}1.67^{c}$	$227.41{\pm}1.18^{c}$	$7.50{\pm}0.42^{b}$
15	$53.69{\pm}1.46^{b}$	$231.29{\pm}1.98^{b}$	$7.77{\pm}0.58^{ba}$
20	$56.56{\pm}0.76^{a}$	$232.72{\pm}1.64^{ba}$	$7.92{\pm}0.79^{a}$
25	$56.95{\pm}1.44^{a}$	$233.25{\pm}1.18^{a}$	8.11±0.76a
CV	1.94	0.70	0.41
LSD	1.00	1.54	0.41

Note: values are mean ± SD, CV= coefficient of variance, LSD= least significant difference. All Values followed by a different letter within the column indicate a significant difference (P<0.05).

3.3.3. Zinc Content

The zinc content of macaroni products of composite flours showed significant (P>0.05) difference from that of the control but macaroni products containing 15, 20 and25% teff flour had no statistically different among them with values of 7.77, 7.92 and 8.11 mg/100g. In general it can be concluded that addition of teff to semolina resulted significant increase in the zinc content of the macaroni products.

4. Conclusion

In conclusion, partial substitution of teff flour in macaroni products had more or less a significant effect on the physico-chemical, cooking property and sensory acceptability of the product.

The physical property of the macaroni such as bulk density, expansion ratio and color were determined. The value of expansion ratio were decreased as teff flour ratio increased; whereas the bulk density increased. The Color parameters indicated that the macaroni product from composite flour were slightly, darker, redder, and less yellow when compared to the control macaroni. The result also suggested that as drying temperature increased hardness also increased and darker color in dry macaroni. Textural analysis (hardness) of dry macaroni decreased as the teff blend increased, however there is linear relationship with drying temperature.

The progressive enrichment of the macaroni with teff flour resulted in significantly higher, ash, fat, fiber, utilizable carbohydrate and mineral content while, moisture and protein were decreased. The drying temperature had no statistical change.

The water holding capacity and cooking losses of macaroni were increased with the teff flour ratio. The reverse is true for optimum cooking time. Unlike teff flour, all selected cooking properties decreased as the drying temperature of macaroni increased.

All the four-level of semolina to teff flour proportions were tested for macaroni quality acceptability and the result revealed that the control had the highest quality acceptability than teff enriched macaroni. Apart from control, the highest quality acceptability of macaroni was obtained from teff flour proportions of 10%. Except for flavor and color, the sensory quality acceptability attributes of macaroni were increased with drying temperature.

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Conflicts of Interest

The authors declare no conflicts of interest.

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