Production of pasta from Moringa leaves – oat – wheat composite flour

Marido Getachew and Habtamu Admassu

Abstract: The objective of this study was to produce pasta from the composite flour of wheat, oat, and moringa leaves and to evaluate the effect of blending proportion of the individual flour on the physico-chemical properties and sensory qualities of pasta products. Pasta products were produced from 100% wheat flour (WF), which was used as control and composite flour in which wheat flour was substituted as BF₁ (2.5% of oat and 2.5% moringa flour), BF₂ (5% of oat and 5% moringa flour), BF₃ (10% of oat and 10% moringa flour), BF₄ (15% of oat and 15% moringa flour), and BF₅ (25% of oat and 25% moringa flour). The proximate composition of the blended pasta extrudes, rheological properties of dough, water activity, and cooking quality were analyzed. The sensory attributes of pasta products like color, aroma, taste, texture, appearance, and overall acceptability were evaluated by panelists. Increasing in the levels of moringa leaves powder showed in increasing of proximate composition (protein, fiber, fat, and ash), however, reduced in moisture content of pasta. The protein content progressively increased from 10.7% in 100% WF to 20.56% in pasta with 25% oat and moringa leaves flour (powder).
1. Introduction

Pasta is an ancient food widely consumed in the world and represents one of the staple foods of the Mediterranean diet. There are many theories concerning its origin. Some researchers place its origin in the thirteenth century by Marco Polo, who introduced pasta in Italy in 1271. Pasta is mainly produced with wheat flour and water, eggs, and/or other optional ingredients can also be added (Giacco, Vitale, & Riccardi, 2016).

Pasta mainly made from coarse semolina milled from durum wheat, *Triticum durum*, which is mixed with water and then extruded through a metal die under pressure. Pasta can be made into dried and filled products including spaghetti and macaroni, ravioli, and tortellini (Alemayehu, Desse, Abegaz, Desalegn, & Getahun, 2016; Fuad & Prabhasankar, 2010).

In recent days, pasta formulation including non-wheat ingredients like sweet potato flour, tapioca starch, and flour from certain other cereal grains are also used and mixed with water and/or eggs to make the dough. Pasta is economical, easy to prepare, have longer shelf life, and are consumed all over the world in many different ways (2016).

Nowadays, with continuously changing socio-economic status, people in Ethiopia have showing new tendencies in food habits. This might be depending on due to individual energy and nutrient needs, health factors, economic influence, food availability and preferences, advertisement and information, political influence, and environmental consideration. Specially, currently Ethiopian people become more concerned about their health. As a result of this, utilization of natural products of plant and animal origin having lesser side effects in health and economy has gained popularity (Sahay, Yadav, & Srinivasamurthy, 2017; Sterna, Zute, & Brunava, 2016).

Health considerations generally recommend that it is necessary to consume at least a minimum amount of wheat and nonwheat cereals, such as oats as part of daily diets. Oat is nutritious and calorie-proper food ingredients, because it contains a good amount of fiber (β-glucan), proteins, vitamins, and mineral substances, such as iron and zinc than the other whole grains (Kebede et al., 2016).

Moringa oleifera and oat are crops having enormous nutritional and medicinal benefits. They are rich in proximate composition helping in a healthy food product development which is important for normal functioning of the body. Using composite flour for food product development is a good new approach in utilizing underutilized food sources, such as moringa in various food products.

2. Materials and methods

2.1. Source of raw materials and sample preparation

Durum wheat (DW) Fetan28, used for this study was purchased from the Ethiopian agricultural research institute, Debrezeit agricultural research center, moringa leaves were collected from Shewa Robit agricultural research center, and oat was purchased from the local market of Addis Ababa. The collected samples were then brought to laboratory. Durum wheat was thoroughly cleaned with laboratory sieve; very course impurities were handpicked, soaked in water for 30 minutes to facilitate dehulling, and then sun dried. Moringa leaves were washed and dried in sun, then dried in oven at 40°C for 6 hours.
Oat sample was thoroughly cleaned with laboratory sieve, very coarse impurities were hand-picked and finally sun dried.

### 2.2. Milling and blending formulation

Durum wheat and oats were milled using laboratory mill 120 perten instrument, moringa leaves were milled by FRITSCH and then each milled flour was sieved by 180 µm sieve size separately. Blended flour for pasta production was prepared as follows: durum wheat flour of 100%, 95%, 90%, 80%, 70%, and 50% were blended with Oat and moringa leaves powder together to constitute (0%, 5%, 10%, 20%, 30%, and 50% ratio’s) as shown in Table 1 on the basis of primarily trial and error based on the extrusion time and temperature of the pasta. The three types of flours were blended to the required mixing ratio and the quality characteristics of the blended and the control (pure wheat flour without blend) flours were analyzed.

### 2.3. Pasta preparation

Durum semolina, oat, and moringa flour blends were prepared in the ratio of 100:0:0, 95:2.5:2.5, 90:5:5, 80:10:10, 70:15:15, and 50:25:25 respectively. In each case, 300 g blended flour was taken and the required amount of water was added at a proportion of 100 gm of flour to 30–35 mL, water and mixed well for 10 min to distribute the water uniformly throughout the flour until the moisture content of dough reaches around 31%, then the dough was feed to extruder (double screw Brabender KETSE 20/40 EC, Duisburg Germany). After extrusion, the pasta samples were dried at 60ºC until the final moisture is 11% (Özyurt et al., 2015). The products were then subjected to various chemical and sensory analyses.

### 2.4. Proximate analysis of pasta

Moisture content of pasta samples was determined according to method AACC, 1999 (Dang & Bason, 2014). Fat content determined by SER 158 Solvent Auto Extractor according to method AOAC method number 920.39 (Moreau, 2005). Eight (8 g) of grounded pasta samples were used during analysis for fat. Fiber content was analyzed according to method AOAC (Lee, 1992). Protein content determined by method of AOAC, 1997 (Horwitz, 2010).

### 2.5. Pasta water activity analysis

Water activity of individual flour and produced pasta was analyzed by aqua lab 4TE according to method AOAC, 1995 (Nyambe, Chama, Siachoono, & Mubemba, 2017).

The sample was placed in a disposable sample cup (half filled) and completely covering bottom of the cup and put in drawer and analyzed for water activity (aw).

### 2.6. Cooking quality analysis

The optimum cooking time, water uptake, and cooking loss of pasta were determined as AACC, 2000 (Giuberti, Gallo, Cerioli, Fortunati, & Masoero, 2015). Twenty-five (25 g) of pasta was weighed

| Table 1. Blending formulation of wheat, oat, and moringa oleifera leaves powder |
|-----------------------------------------------|
| **Constituent flour samples** | **Blending ratio (%)** |
| WF | 100:0:0 |
| BF1 | 95:2.5:2.5 |
| BF2 | 90:5:5 |
| BF3 | 80:10:10 |
| BF4 | 70:15:1 |
| BF5 | 50:25:25 |

BF = Wheat, oat, and moringa blends, WF = 100% wheat flour, BF1 wheat = 95% oat and moringa = 2.5%, BF2 wheat = 90% oat and moringa = 5%, BF3 wheat = 80% oat and moringa = 10%, BF4 wheat = 70% oat and moringa = 15%, BF5 wheat = 50% oat and moringa = 25%.
and then cooked to the optimum cooking time in a 300 mL water using boiling container with slight agitation. Then after, the cooking water was drained and the cooked pasta was rinsed with 50 mL distilled water for 30 s and drained for 5 min before weighting, then the drained cooking and rinsing water has collected in a beaker and weighed for cooking loss analysis. Water uptake was calculated as the difference in weight of cooked pasta and uncooked pasta. Cooking loss was determined by evaporating the combined cooking and rinse water in a preweighed glass beaker in an air oven at 105ºC to constant weight. The residue was weighed and reported as a percentage of the weight of dry pasta before cooking.

2.7. Sensory analysis
Sensory evaluation of the products was carried out by using nine point hedonic scales with 1 dislike extremely and 9 like extremely. The pasta was cooked and provided to panelists. Each pasta sample was analyzed for color, aroma, texture, taste, appearance, and overall acceptability. The panelists were scored the pasta samples according to their preferences to each sensory attributes and p < 0.05 was used to determine the statistical significance of the sensory attribute.

2.8. Statistical analysis
All statistical analyses were performed using IBM SPSS version 20 statistical software. One-way analysis of variance (ANOVA) with a post-hoc Tukey HSDa significant difference (p < 0.05) test was used to investigate the effects of two groups of factors; type of temperature and blending ratios on pasta physico-chemical properties. The result was reported as mean and standard deviation method (SDM).

3. Results and discussion

3.1. Water activity analysis of flours and pasta products
Water activity is free or available water in a food that supports microbial growth, and participates in chemical and enzymatic reactions and spoilage processes. The lower the water activity is more important for food stability, by reducing chemical reaction and microbial growth.

The results of water activity analysis of individual flours were presented in Figure 1 below. The results presented in Figure 1 indicated that the water activity of both dried moringa leaves and oat flours were lower compared to the control flour. The water activity of individual flour was ranged from 0.32 moringa flour to 0.5 wheat flour. Both moringa and oat flour have lower water activity compared to control, means, which enables for good storage conditions for flours and products produced from such flours by restricting the access of microorganisms to water.

The results presented in Figure 2 indicates the water activity of pasta products produced from wheat flour composite with both dried moringa leaves powder and oat flour. are lower compared to the control flour. The water activity of blended pasta was ranged from 0.42BF5 (25% blend) to 0.48BF1 (2.5% blend).
The result is higher than result reported by RV (Manaois, Morales, & Abilgos-Ramos, 2013) (below 0.4). As the supplementation level of dried moringa leaves and oat flour increased, the water activity decreased. Conclusively, it could be observed that the incorporation of dried Moringa oleifera leaves and oat flour slightly decreases the water activity (aw), so the blend pasta can be stored for longer compared to the control pasta.

3.2. Gluten analysis

The wet gluten test provides information on the quantity and estimates the quality of gluten in flour samples. Gluten is responsible for the elasticity and extensibility characteristics of flour dough.

The values of wet and gluten index content of WF (100% wheat flour) and blends are indicated in Table 2. Maximum value for wet and gluten index content of wheat flour (WF) was found to be 37.2% and 96.5% respectively, while the minimum values were 21 and 76.79 in BF5 (25%) blend. The wet and gluten index content were decreased with increasing in substitution level of dried moringa leaves and oat flours). Gluten index (GI) is a criterion defining whether the gluten quality is weak (GI < 30%), normal (GI = 30–80%), or strong (GI > 80%) (Oikonomou, Bakalis, Rahman, & Krokida, 2015).

Wet gluten content is determined by washing the flour with a salt solution to remove the starch and other soluble matter from the sample. The residue remaining after washing is the wet gluten. During centrifugation, the gluten is forced through a sieve. The percentage of gluten remaining on the sieve is defined as the Gluten Index, which is an indication of gluten strength. A high gluten index indicates strong gluten. WF showed higher wet gluten (37.2%) and strongest gluten index (96.5%). The content of wet gluten and strength of gluten decreased as blending ratio’s increased. This indicates that the oat and moringa may have lower or no gluten component.

3.3. Proximate composition of control and blend pasta

The analysis results of the proximate of composite flours are presented in Table 3. As presented in Table 3, increasing the substitution levels of oat and moringa leaves flours showed effects on

| Table 2. Gluten content analysis for control and blended flour |
|---------------------------------------------|-------------------|-------------------|
| Flour samples     | Wet gluten (%)    | Gluten index (%)  |
| WF              | 37.2              | 96.5              |
| BF1             | 35.6              | 95.78             |
| BF2             | 33.4              | 92.81             |
| BF3             | 30.02             | 90.72             |
| BF4             | 23.7              | 89.03             |
| BF5             | 21                | 76.79             |
moisture content of composite flour pasta. The highest value of moisture content was found in WF (11.49%, control flour) and lowest was in BF5 (9.49%). The decreasing in moisture contents in the blend might be due to lower moisture contents of the substituent dried moringa flour as compared to wheat and oat flour.

The decreasing in moisture content was observed when the percentage of the substitution of dried moringa leaves and oat flour were increased into wheat flour pasta, which is a good indicator of their potential to have longer shelf life. It is believed that materials such as flour and starch containing more than 12% moisture have less storage stability than those with lower moisture content. For this reason, a water content of 10% is generally specified for flours and other related products (Offia-Olua, 2014). The control pasta sample has the highest and significant (p < 0.05) moisture content differences than others blended pasta samples. Determining moisture content is an essential first step in analyzing wheat or flour quality since this data is used for other further tests.

The total ash content was increased from 1.31% in the pure wheat flour (control) to 4% with increasing in dried moringa leaves (DML) and oat flour (BF5), which might be increasing the mineral contents of the pasta, resulted from relatively higher mineral contents of moringa leaves. These findings were in agreement with the other works (Kolapo & Sanni, 2005). Improvement in the nutritional characteristics, such as minerals, dietary fiber, protein, and shelf life with the use of green leaves vegetables in cookies and biscuits have also been reported (Dachana, Rajiv, Indrani, & Prakash, 2010).

The protein content was increased from 10.7% in control pasta (WF) to 15.56%, 15.6%, 16.75%, 17.65%, and 20.57% with addition of 2.5%, 5%, 10%, 15% and 25% dried moringa leaves and oat flours, respectively (Table 3). Moyeyinka reported (17.63% protein, 3.37% fiber, 3.37% fat, and 3.1% ash content) in incorporation of up to 15% of moringa leaves powder into moringa fortified maize ogi (Oyeyinka & Oyeyinka, 2018). Improvement in the nutritional characteristics, such as minerals, dietary fiber, protein, and shelf life with the use of green leaves vegetables in cookies and biscuits have also been reported (Dachana, Rajiv, Indrani, & Prakash, 2010).

The dietary fiber for control pasta was WF (2.1%), BF1 pasta (2.32%), BF2 pasta (2.58%), BF3 pasta (2.91%), BF4 pasta (3.08%), and BF5 pasta (3.67%). The fat content ranged from 1.64% in WF to 4.92%BF5, which indicates incorporation of moringa leaves and oat flour into wheat increased the fat content in pasta. As it can be seen in Table 3, as percentage of substitution of dried moringa leaves and oat flour increased the percentage of crude fiber has also increased. This indicated that dried moringa leaves and oat flour supplementation to wheat flour improved the crude fiber content.

In general, the pasta supplemented with dried moringa leaves and oat was found to possess higher nutritive profile than the control pasta. This result indicated that the aim of supplementation to produce nutritious and more shelf stable pasta was achieved.

| Pasta samples | Moisture  | Protein | Fiber  | Fat    | Ash     |
|---------------|----------|---------|--------|--------|---------|
| WF            | 11.49 ± .31 | 10.7 ± .11 | 2.1 ± .02 | 1.64 ± .13 | 1.31 ± .03 |
| BF1           | 10.99 ± .21 | 15.56 ± .12 | 2.32 ± .05 | 1.89 ± .12 | 2 ± .02     |
| BF2           | 11.00 ± .18 | 15.60 ± .20 | 2.58 ± .03 | 2.13 ± .13 | 2.3 ± .04   |
| BF3           | 9.498 ± .14 | 16.75 ± .17 | 2.91 ± .05 | 2.6 ± .15 | 2.6 ± .03   |
| BF4           | 9.50 ± .16 | 17.651 ± .16 | 3.08 ± .04 | 3.85 ± .17 | 2.85 ± .02  |
| BF5           | 9.49 ± .19 | 20.569 ± .21 | 3.67 ± .07 | 4.92 ± .16 | 4 ± .03     |

WF = 100% wheat flour, BF1 wheat = 95% oat and moringa = 2.5%, BF2 wheat = 90% oat and moringa = 5%, BF3 wheat = 80% oat and moringa = 10%, BF4 wheat = 70% oat and moringa = 15%, BF5 wheat = 50% oat and moringa = 25%.
3.4. Pasta cooking quality analysis
The cooking quality of pasta is generally regarded as the capacity of the product to maintain its shape when cooked in boiling water and to retain a good texture after cooking without becoming a thick, sticky mass. The Cooked Control pasta, 50% wheat and 25% of both dried moringa leaves and oat flour pasta, 80% wheat and 10% of both dried moringa leaves and oat flour pasta, 70% wheat and 15% of both dried moringa leaves and oat flour pasta as a sample has displayed in Figure 3(a–d).

The amount of residue in the cooking water is commonly used as an indicator of pasta cooking quality. Low amount of residue indicates high-quality pasta. For high-quality pasta, the residue should not exceed 7–8% of the dry weight of pasta. The cooking loss observed in this research for different flour blend combinations of pasta products varied from 7.2% for BF1 to 12% for BF5. Cooking loss of control pasta was in line with the result reported by (Sobota & Zarzycki, 2013) (5.8 ± .36%). As shown in Table 4 cooking loss was increased as incorporation level of dried moringa leaves and oat flour is increasing. This could be due to weak bonding network formation occurred in chemical composition which encapsulate them during cooking as oat and moringa leaves flour have lower gluten content.

| Pasta samples | Water uptake (%) | Cooking loss (%) | Cooking time (min) |
|---------------|------------------|------------------|-------------------|
| WF            | 48               | 6                | 8                 |
| BF1           | 48.8             | 6.7              | 8                 |
| BF2           | 50               | 7.2              | 8                 |
| BF3           | 51.4             | 9.6              | 8                 |
| BF4           | 55.1             | 10.7             | 8                 |
| BF5           | 56.3             | 12.4             | 8                 |

Figure 3. (a–d) Cooking quality analysis of pasta. (a) Control pasta boiling, (b) 50% wheat and 25% of both dried moringa leaves and oat flour pasta, (c) 80% wheat and 10% of both dried moringa leaves and oat flour pasta, (d) 70% wheat and 15% of both dried moringa leaves and oat flour pasta.
Water uptake index is the amount of water that a known dry pasta weight absorbs during cooking and holds after draining. Water uptake increased as blending ratio increased, BF₅ had higher water uptake percent while control pasta had lower. Water absorption analysis indicated that BF₅ flour had lower water absorption compared to control and blend flours, but after producing pasta it had higher water uptake percentage; this can be the effect of temperature during extruding and cooking on the binding behavior of pasta elements among themselves and with water.

### 3.5. Sensory characteristics analysis

Sensory evaluation of the products was carried out by using 9-point hedonic scales with 1 dislike extremely, dislike very much, 3 dislike moderately, 4 dislike slightly, 5 neither like nor dislike, 6 like slightly, 7 like moderately, 8 like very much, and 9 like extremely. The pasta was cooked and provided to panelists. Each pasta sample was analyzed in triplicate for color, aroma, texture, taste, appearance, and overall acceptability. Thirty semitrained panelists; 20 males and 10 females of age between 24 and 30 were involved for sensory test. The three-letter coded samples were randomly provided to the panelists on the same sample plate and the panelists were scored the pasta samples according to their preferences to each sensory attributes on score card.

The summary of the sensory attributes of wheat, oat, and moringa oleifera leaves composite flour pasta samples are presented in Table 5. Color of control flour pasta, scored maximum points (6.86) followed by BF₂ (5% blend pasta) (6.81) and the lowest (6.33) was being for BF₅ (25% blend pasta). Color variations in pasta products were significant which may be due to supplementation of dried moringa leaves and oat flour (Table 5). The color of pasta changed from yellow white to greenish as dried moringa leaves incorporated. The color of the pasta products were most liked moderately expects BF₅ which was liked slightly.

Aroma, the quality perceived by the sense of smell, plays a primary role in creating consumer appeal. The aroma of dried moringa leaves and oat flour supplemented pasta samples scored maximum (6.9) in BF₃ (pasta with 10% dried moringa leaves and oat flour) followed by BF₄ (pasta with 15% dried moringa leaves and oat flour) (6.71) and lowest (6.52) being for BF₁ (pasta with 2.5% dried moringa leaves and oat flour) and WF (100% wheat flour pasta).

The taste was significantly (p<0.05) affected at 2.5% level substitution of pasta. The overall acceptability score for the control was 7.43, on a 9-point hedonic scale. No significantly different occurred in overall acceptability of pastas. Aroma, texture, overall acceptability and appearance of all pasta were liked moderately as summarized in Table 5. The taste of BF₃, BF₄, and BF₅ pasta was liked slightly while WF, BF₁, and BF₂ were liked moderately.

### 4. Conclusion

Wheat flour supplemented with composite blends of dried moringa leaves and oat flour exhibited desirable physicochemical and functional characteristics to produce acceptable pasta products. The proximate analysis showed that the supplementation of wheat flour with dried moringa leaves and oat flour was satisfactory in producing nutritious pasta product. However, the gluten content decreased with increasing proportion of dried moringa leaves and oat flour resulted in weak bonding of constituents. The protein, fiber, and ash as well as minerals content of products increased as a result of the addition of dried moringa leaves and oat flour.

The sensory evaluation of pasta products produced from wheat flour incorporated with dried moringa leaves and oat flour has exhibited acceptable quality pasta products.

On the basis of present study it was concluded that Incorporation of both moringa leaves powder and oat in pasta up to 25% in wheat flour would be successful in producing pasta with improved physicochemical properties along with acceptable sensory attributes. Consumption of such functional
Table 5. Sensory attributes analysis summary

| Blended flour ratio (%) | Color  | Aroma | Taste | Texture | Appearance | Overall acceptability |
|-------------------------|--------|-------|-------|---------|------------|-----------------------|
| 100:0:0                 | 6.80b  | 6.52b | 6.71b | 7.29c   | 7.43c      | 7.43c                 |
| 95:2.5:2.5              | 6.62b  | 6.52b | 6.67b | 7.14c   | 7.14c      | 7.14c                 |
| 90:5:5                  | 6.81b  | 6.71b | 6.67b | 7.14c   | 7.14c      | 7.14c                 |
| 80:10:10                | 6.62b  | 6.71b | 6.67b | 7.14c   | 7.14c      | 7.14c                 |
| 70:15:15                | 6.71b  | 6.90b | 6.52b | 7.38c   | 7.38c      | 7.38c                 |

*Mean values of sensory attributes in the same column with different letters are significantly different (p < 0.05).*

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