

# Determination of Nutritional Composition, Functional and Pasting Properties of Wheat, Sweet Lupine and Moringa Leaf Composite Flour

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## ABSTRACT

Ethiopian cuisine has less protein and minerals on the wheat-based products resulting protein and mineral deficiency. This can be offset by the addition of nutrient rich sweet lupine and moringa leaf flour, which are both cost-effective. This study was conducted on determining of nutritional composition, functional and pasting properties of wheat, sweet lupine and moringa leaf composite flour. Standard procedures were used during experimental determination of composite flour. Completely randomized design (CRD) was used in experimental analysis. The bulk density of composite (wheat, sweet lupine and moringa leaf powder) flour was 0.45g/cm<sup>3</sup> (BR<sub>1</sub>), 0.45 g/cm<sup>3</sup> (BR<sub>2</sub>), 0.45 g/cm<sup>3</sup> (BR<sub>3</sub>) and ), 0.46 g/cm<sup>3</sup> (BR<sub>4</sub>). 0.87g/g (BR<sub>1</sub>), 0.84 g/g (BR<sub>2</sub>), 0.83 g/g (BR<sub>3</sub>), 0.86 g/g (BR<sub>4</sub>) of water absorption capacity, 1.03 g/g (BR<sub>1</sub>), 1.11 g/g (BR<sub>2</sub>), 1.04 g/g (BR<sub>3</sub>) and 1.00 g/g (BR<sub>4</sub>) of oil absorption capacity. As the lupine and moringa flour ratio increase the water absorption and oil absorption capacity of composite flour increase that indicates it contains more protein. The protein content of wheat sweet lupine and moringa flour were 9.32%, 40.03%, 31.61%, respectively. The calcium and zinc content of wheat, sweet lupine and moringa flour were 27.46 mg/100g, 174.07 mg/100g, and 1008.19 mg/100g, 0.78 mg/100g, 2.91 mg/100g, 1.54 mg/100g (zinc), respectively. The anti-nutritional composition ingredients were 53.28, 84.16, 1745.39, catechin equivalent mg/100g (tannin), and 1.47%, 3.25%, 7.66%, (alkaloid) wheat, sweet lupine and moringa leaf flour, respectively. The study found that composite flour made from 79%wheat, 20% sweet lupine, and 1% moringa flour has better nutritional values that could be used to make nutrient rich food in industrial application.

**Key words:-** Composite flour; Functional properties; Moringa; Pasting properties; Sweet lupine; Wheat

## INTRODUCTION

Wheat is a nutrient-dense food that is consumed all over the world. It is used to make a variety of dishes and has more protein, minerals, B-group vitamins, and dietary fiber than other cereal grains (Rahaie *et al.* 2014). Each of the three separate sections of the wheat grain-bran (13-17%), germ (2-3%), and endosperm (80-85%) contains all the nutrients that are necessary for life. In general, the wheat grain kernel contains 2.2% crude fiber, 1.8% minerals, 12% water, 2% fat, and 70% carbs (Johansson, Prieto-Linde, and Larsson 2021). Additionally, it contains copper, phosphorus, magnesium, manganese, zinc, selenium, iron, and potassium (Cornell and Hoveling 2020). Wheat bran contains dietary fiber that helps prevent and treat several digestive diseases as well as lower the risk of colon cancer (Caeiro *et al.* 2022).

Lupine (locally in Amharic known as “*Gibto*” in Ethiopia) is widely used to describe the seeds of different domesticated *Lupinus* species and is a good source of crucial nutrients, for health such as proteins, lipids, dietary fiber, minerals, and vitamins (Tessema 2017) (Arnoldi *et al.* 2015). However, the potential of lupine in human

nutrition has generally been underestimated worldwide and it remains underutilized and undervalued as a food source (Rumiyati, James, and Jayasena 2012).

*Moringa oleifera* member of the family of Moringaceae is a potent treatment for malnutrition. Because it contains a wide range of vital phytochemicals in its leaves, pods, and seeds, the moringa plant is extremely nutritious (Chhikara et al. 2020). Moringa is claimed to have 7 times more vitamin C than oranges, 9 times more protein than yoghurt, 10 times more vitamin A than carrots, 15 times more potassium than bananas 17 times more calcium than milk, and 25 times more iron than spinach (Rockwood, Anderson, and Casamatta 2013)(Rani and Arumugam 2017). Adding moringa to wheat-based products can enhance their nutritional profile and provide additional health benefits. Moringa, often referred to as *Moringa oleifera*, is a nutrient-dense plant known for its rich content of vitamins, minerals, and antioxidants (Rani and Arumugam 2017).

Moringa leaves are a good source of micronutrients and are concentrated with protein. The leaves are an exceptionally excellent source of  $\beta$ -carotene, vitamin C, calcium, iron, potassium, magnesium, selenium, zinc, and a good balance of all the essential amino acids (James and Zikankuba 2017). Moringa leaf proteins ranged from 29.1 to 35.3 g/100g dry weight (Fernandes *et al.* 2015) (Bichi 2013).

A protein-energy deficiency is common in a region where wheat is a staple meal (Jacob *et al.* 2013). One of the causes is that Ethiopian cuisine generally has less protein than other diets. As a result, understanding the importance of foods based on wheat can raise the amount of protein-rich goods to avoid protein deficiency (Kloos and Lindtjörn 2019) (Jacob *et al.* 2013). To compensate for the low levels of protein and minerals in wheat-based products, it is essential to supplement sweet lupine and moringa leaf flour, which are both cost-effective.

## MATERIAL AND METHODS

### Experimental Materials

Wheat flour (30 kg) was collected from a local market, sweet lupine (Sanabor variety) (15 kg) was collected from the Andassa Agricultural Research Center and selected based on its production yield, and moringa leaves (2.5 kg) was collected from residents of the Bahir Dar University staff Mary-Site hostels. It was cleaned in preparation for flour preparation. Before milling, the sweet lupine and moringa leaves were hand-cleaned. The flour was sealed in a polyethylene plastic bag and stored at 4°C until the next stage of analysis. The experiments were conducted at the food processes, food chemistry, research-grade, and post-harvest and food microbiology laboratories of Bahir Dar Institute of Technology (BiT). The sample preparations, functional properties of flour, physicochemical properties, and pasting properties were conducted at BiT laboratories, Addis Ababa University (AAU) and Addis Ababa Science, Technology University (AAST), Debre Zeit Agricultural Research Center (DZARC) and Ethiopian Public Health Institute (EPHI).

### Sample Preparation

#### Preparation of Sweet Lupine Flour

Before analyzing the physical properties and flour production, sweet lupine (sanabor variety) seed was physically cleaned to remove stalks, stones, broken seeds, light materials, and other impurities. The cleaned whole seeds were soaked in water for 36 hours at room temperature (Bellagha *et al.* 2008). The soaked sweet lupine seeds were sun-dried and dehulled with a traditional mill. In a conventional mill, the separated kernels were ground into fine flour and filtered through a 0.425mm sieve (Yunfeng and Laike 2010), (Yunfeng and Laike 2010)

#### Preparation of Moringa Leaf Powder

Moringa leaf flour is produced using the method described by (Aye 2016). Following manual removal from the stems, the moringa leaves were thoroughly cleaned with water to remove any dirt or other impurities. Moringa leaf flour was dried at 60°C for 6:00 hours, then crushed or milled to fit through a 0.425 mm sieve mesh. It was then sealed into a polyethylene bag.

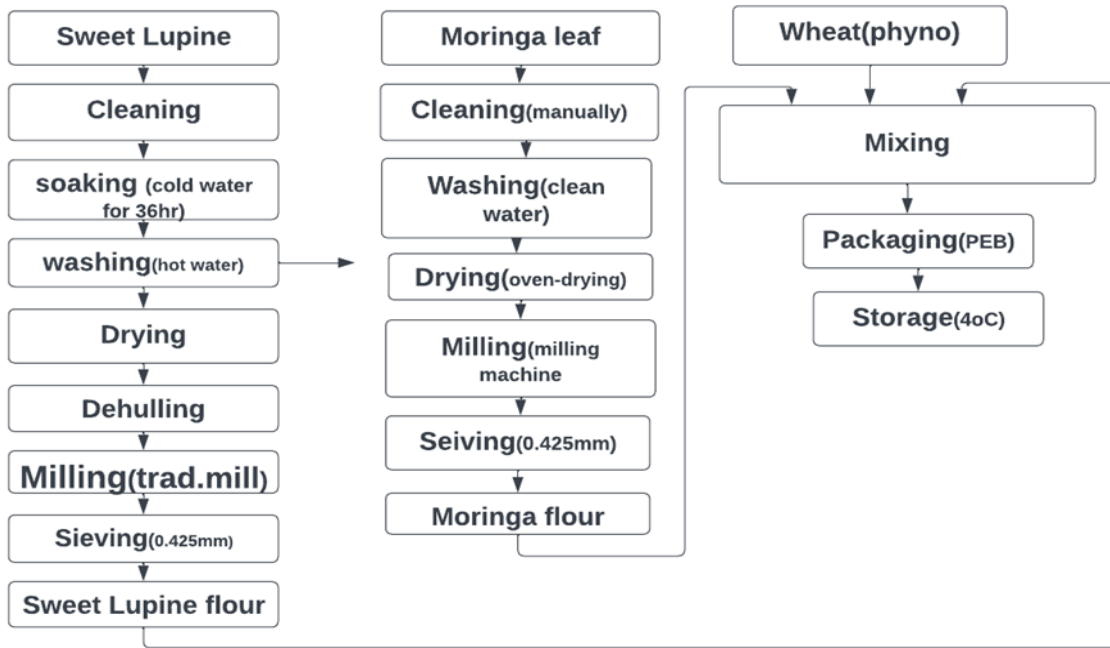


Figure 1 Flow sheet preparation of individual flours

### Experimental Design and formulation of composite flours

The experiment was carried out to determine the maximum and minimum amounts of variables. This study used both a completely randomized design (CRD) and an analysis of variance. The experiment's design included precise values for the following blending ratios as it show in table 1.

Table 1 Experimental Design and Formulation of Composite Flours

Blending ratio	Wheat (%)	Sweet Lupine (%)	Moringa (%)
BR1	79	20	1
BR2	82	15	3
BR3	85	10	5
BR4	88	5	7
Control	100	0	0

### Proximate Analysis

The flour samples made from wheat, sweet lupine, and moringa leaf powder were needed to be dried in order to remove moisture without affecting the composition of the sample and grinding into a fine powder and were analyzed using the American Association of Cereal Chemists (AAOCC, 2000) protocol to evaluate their proximate compositions (moisture content, crude protein, crude fat, crude fiber, and total ash) three times each.

### Moisture content determination

The crucibles were cleaned and dried in an oven at 105 °C for 30 minutes and placed in a desiccator to cool for 30 minutes. Weight the sample (w1) and weight the empty crucibles (w2). The moisture content was determined according to (AOAC (2005, 925.10) method (Nankya 2021) and, calculated as

$$\text{Moisture content (\%)} = \frac{(W_1 - W_2)}{W} \times 100\% \dots \text{Equation 1}$$

Where: W= weight (g) of sample, W<sub>1</sub>= weight (g) of a sample with the dish before dry

W<sub>2</sub> = weight (g) of sample with dish after dry

### Fat content determination

Using the (AOAC 2005) method, the samples' fat content was ascertained (Nankya 2021). After being cleaned with hot water, the extraction cylinder was heated to 105°C and left for approximately an hour. It was taken out of the oven and set aside in a desiccator for an hour before being weighed (W<sub>1</sub>). An extraction thimble's bottom was covered with a layer of cotton that was fat-free. A layer of cotton free of fat was placed over approximately 2 g of the sample, which had been weighed, in the thimble (W). Next, the thimble was put inside the extraction chamber. After 150 milliliters of n-hexane were added to the extraction cylinder, it was placed on the heating plank and extracted for four hours. The extraction cylinder was disconnected after four hours of extraction.

$$\text{Crude fat (\%)} = \frac{W_2 - W_1}{W} \times 100\% \dots \text{Equation 2}$$

### Ash content determination

The AOAC (2000) method was employed to ascertain the amount of ash present. After all moisture has been eliminated, the amount of ash in composite flour and bread samples represents the sample's organic and inorganic components. The porcelain crucibles will be cleaned and dried in a muffle furnace that is heated to 550 °C for 30 minutes. After cooling in a desiccator for thirty minutes, the dried crucibles will be weighed (W<sub>1</sub>). A new sample weighing roughly 3g will be weighed in crucibles (W<sub>2</sub>) that have been dried and cooled. It will then be burned on a hot plate beneath a fume hood at 370°C until the smoking ceases. Ultimately, the sample will burn for five hours at 550°C in the muffle furnace, after which it will cool, be weighed again (W<sub>3</sub>), and be computed as follows:

$$\text{Ash content\%} = \frac{W_3 - W_1}{W_2 - W_1} \times 100\% \dots \text{Equation 3}$$

Where: - W<sub>1</sub>= mass of the crucible (g), W<sub>2</sub> = mass of crucible with sample (g), W<sub>3</sub> = mass of the crucible with ash (g)

### Crude protein content determination

According to AOAC official method No. 920.87 (2000), used by (Anberbir et al. 2023) the Kjeldahl method was used to determine the crude protein content of components, composite flours, and bread samples. The steps involved in the method were as follows:

A digestion flask containing around 0.5 g of the samples was precisely weighed. The samples were treated with 1 g of a combination of catalysts (10:1) consisting of K<sub>2</sub>SO<sub>4</sub> and CuSO<sub>4</sub>.5H<sub>2</sub>O. After precisely 5 milliliters (or 98% of the concentrated sulfuric acid) were added, the flask's contents were thoroughly mixed by shaking. The flask was heated to 350°C for four hours, or until the solution turned green and clear, using a Kjeldahl digester (DK20, VELP Scientific, Italy) to facilitate the digestion process. The flask was taken out of the digester and given time to cool after digestion. After the mixture cooled, 50 mL of distilled water and 40 mL of 40% NaOH were added. The mixture was thoroughly mixed. A 25 mL solution of 4% boric acid was placed inside the receiver flask along with the distillation tube. Titration: The distillates were titrated using standardized 0.1N HCl until a pink color shift—a sign of the titration endpoint—occurred.

$$\text{N\%} = \left( \frac{(V_s - V_b) \times N \times 14.007}{ws} \right) \times 100 \dots \text{equation 4}$$

Where:  $V_s$  = volume of the standard HCl solution used in the titration of the sample,  $V_b$  = volume of the standard HCl solution used in the titration of the blank,  $N$  = Normality of standard HCl,  $W_s$  = Weight of the sample (g), 14.007 = molecular weight of nitrogen, and 6.25 = protein conversion factors.

Protein content (%) = % Nitrogen  $\times$  6.25

**Crude fiber determination**

Crude fiber will be determined by the method of (AOAC 1995) (Association of Official Analytical Chemistry) (Belachew 2019).

Weigh accurately 2 g of sample transfer to the Gooch crucible and put into a 60 mL beaker of the fiber digestion apparatus. Add 200 mL of 1.25% sulfuric acid solution place on the digestion apparatus and boil for exactly 30 minutes. Remove the beaker and filter by using a vacuum pump and rinse with boiling water. Return the Gooch crucible to a beaker and add 200 mL of 1.25% sodium hydroxide/potassium hydroxide solution return to a heater and boil for exactly 30 minutes. Remove the beaker and filter as before and rinse with boiling water and acetone. Dry the residue for 2 hours at  $130 \pm 2$  °C. Cool the dish in a desiccator and weigh ( $W_1$ ) Ignite for 3 hrs at 600 °C. Cool in desiccator and reweigh ( $W_2$ ). The results were calculated and expressed as follows

$$\text{Crude fiber\%} = \frac{W_1 - W_2}{W} \times 100 \dots\dots\dots \text{equation 5}$$

**Carbohydrates content determination:**

Total carbohydrate was determined by differences between 100 and the total sum of the percentage of crude fat, moisture, ash, crude fiber, and crude protein content.

$$\% \text{Total carbohydrate} = 100 - (\% \text{ moisture} + \% \text{ Ash} + \% \text{ crude protein} + \% \text{ fat} + \% \text{ fiber})$$

$$C\% = 100 - [M + F + A + P + F] \dots\dots\dots \text{equation 6}$$

Where: F= the mass percent of fiber, P= the mass percent of protein, F= The mass percent of fat A= The mass percent of ash, M= Moisture content (%)

**Computation of total energy value of bread samples:-**

Total energy value was determined according to AOAC, 2005) (Okereke, Igbabul, and Ikya 2021). The percent calories in selected samples were calculated by multiplying the percentage of crude protein and carbohydrate with 4 kcal/g and crude fat with 9 kcal/g. The values were then converted to calories per 100 g of the sample.

$$\text{Gross energy (\%)} = (9 \times \text{crude fat \%}) + (4 \times \text{crude protein \%}) + (4 \times \text{crude carbohydrate \%}) \text{ Kcal/100g}$$

$$\text{Gross energy (\%)} = (9 \times F) + (4 \times P) + (4 \times C) \text{ Kcal/100g} \dots\dots\dots \text{equation 7}$$

**Functional Properties of Ingredients and their Composite Flour**

**Water absorption capacity (WAC)**

The centrifugation method employed by (Yusuf, Mofio, and Ahmed 2007) with a slight modification was utilized to determine the water absorption capacity of sweet lupine, wheat, moringa, and their composite flour. The centrifuge tube ( $W_1$ ) was clean, dry, and filled with 25 mL of distilled water after 2.5 g of flour sample was weighed into it ( $W_2$ ). For one minute, a vortex mixer gently shook the tube containing the sample and distilled water. After that, the tubes were spun at 3300 rpm for 10 minutes ( $W_3$ ). The results were calculated and expressed as the percentage of water absorbed per gram of sample.

$$\text{WAC (g/g)} = \% = \frac{W_3 - W_2}{W_1} \dots\dots\dots \text{equation 8}$$

Where: -  $W_3$  = weight of centrifuge tube with sample after centrifuge,  $W_2$  = weight of centrifuge tube with sample before centrifuge, and  $W_1$  = weight of dry sample

### Oil absorption capacity (OAC)

The ability of sweet lupine, wheat, moringa, and their composite flour to absorb oil was determined using the centrifugation technique used by (Yusuf et al. (2007) with a minor modification. After 2.5 g of flour sample were weighed into the centrifuge tube ( $W_1$ ), it was clean, dry, and filled with 25 mL of sun flour oil ( $W_2$ ). The tube containing the sample and sunflower oil was gently shaken for one minute using a vortex mixer. The tubes were then spun for 10 minutes at 3300 rpm ( $W_3$ ). Calculated and reported as a percentage of sun flour oil per gram of material, the results were obtained.

$$\text{OAC (g/g)} = \% = \frac{W_3 - W_2}{W_1} \dots\dots\dots\text{equation 9}$$

Where: -  $W_3$  = weight of centrifuge tube with sample after centrifuge,  $W_2$  = weight of centrifuge tube with sample before centrifuge, and  $W_1$  = weight of dry sample

### Water activity ( $a_w$ )

The water activity was determined by Aqua Lab Life water activity measurement. Decagon  $a_w$  meter, (2004 in USA)(Carter et al. 2015)

### Bulk density

Bulk density (BD) of ingredients and composite flours were determined according to methods (Shirkole, (2011). The flour sample was transferred to a pre-described weight measuring cylinder and the new weight was recorded. The volume occupied by the measuring cylinder was also recorded. The bulk density was calculated from the equation:-

$$\text{Bulk Density (g/ml)} = \frac{\text{Mass of sample}}{\text{volume of cylinder}} \dots\dots\dots\text{equation 10}$$

### Color analysis

A Hunter colorimeter (CM-600d model) Based on  $L^*$ ,  $a^*$ , and  $b^*$  values, the color of component of flours and bread samples was evaluated using an optical sensor (KONICA MINOLTA, INC.). Under the light source, in a glass cell containing flour and a piece of bread, the color values  $L^*$ ,  $a^*$ , and  $b^*$  were noted.

### Rheological Properties Flours

#### Farinographic properties

Using the AOAC method (2000), the Brabender farinograph method was applied to wheat flours both with and without improvers. Every flour sample's water absorption was evaluated using the titration curve. After the sample was weighed at 300 grams (14% moisture content), it was put into a cleaned mixer. After 30 seconds of 63 rpm farinograph operation, distilled water was added from the burette (the deviation can be used to calculate the correct water absorption; 20 units of deviation equals 0.5% water; if the consistency is greater than 500 FU, more water is required, and vice versa (Abubaker, MUSTAFA, and AHMED 2013). The device was turned off when the consistency remained constant, and the water extracted from the burette showed the percentage of water absorbed by the flour. The cleaning of the measuring mixer was done completely. After weighing a 300-gram sample, it was added to the mixer, and the farinograph was turned on as before. The titration curve was used to determine the water quantity, which was fed all at once. After observing a noticeable decline in the curve, the instrument was operated for an additional 20 minutes before being turned off.

## Pasting properties

The phenomena of granular cooking, swelling and total disruption of granules are known as starch's pasting properties. It's been used to measure the cold-swelling of 'cooked' components, raw component paste during testing, and overall viscosity, which shows the degree of starch dextrinization. The Rapid Viscos Analyzer (RVA) was used to determine the pasting properties of flours (Maninder, Sandhu, and Singh 2007). The pasting properties of samples were tested using a Rapid Visco-Analyzer (RVA-4500, Perten Instruments Australia Pty. Ltd., Macquarie Park NSW, Australia) following AOAC procedure 76-21 (Fan *et al.* 2019). A required amount of distilled water (25 mL) was automatically supplied into the canister already containing about 3.5 g of flour. The content was agitated at 960 rpm, 50°C for 10 seconds, and then the mixing continued at 160 rpm, for 13 min while the temperature gradually increased to 95 °C and decreased to 50 °C.

## Determination of Mineral Content

### Determination of calcium content

The calcium content was determined according to (AOAC 999.15 2005) using the approved method of Flame Atomic Absorption Spectrophotometry used by (Cherie et al. 2018). Wash all crucibles with 6N HCl and glass wares with 10% nitric acid and place the crucibles in an oven for 30 minutes at 100 °C. Cool in desiccators for 30 minutes and weigh 2.5 g of sample chare at hot plate starting from low temperature under a hood. Ashes the samples in a muffle furnace at 550 °C for 1 hour then cool, and moisten it with a few drops of deionized water. Evaporate the water on a hot plate, and ash for 30 minutes at 550 °C, cool the crucible; add some drops of deionized water and 5 drops of concentrated HNO<sub>3</sub>. Weigh and apply 5–10 mL of 6N HCl to the ash to completely wet it, and then carefully transfer it to a low-temperature hot plate to dry it out. 10 mL of 3N HCl are added to the crucible, and it is heated on a hot plate for 15 mL of 3N HCl until the solution just boils. Filter into the graduated flask after cooling. Wash the crucible at least three times with deionized water and filter the washings into the flask. Add 5 mL of lanthanum chloride solution per 100 ml of solution. Cool the flask's contents and use deionized water to dilute them to the appropriate amount. Create a blank by following the directions with the same quantity of reagents and move the test liquids into a polypropylene container. The residue is dissolved in diluted acid following the dry ashing process that removes organic material. After spraying the solution into the FAAS, the metal's absorbance at a particular wavelength was determined.

$$\text{Calcium content (mg/100g)} = \frac{(C_s - C_b) \times V}{10W} \dots \dots \dots \text{equation 11}$$

Where: Cs = concentration of the sample in ppm, Cb = concentration of blank in ppm, volume = (ml) of extract, W = weight (g) of samples

### Determination of iron

After cleaning all of the crucibles with 6N HCl and the glassware with 10% nitric acid, put them in the oven at 100°C for 30 minutes. Weighed 2.5 g of the sample charcoal at a hot iron under a hood, commencing at a low temperature and heating the samples to 550 °C for an hour in a muffle furnace, remove the crucible, allow it to cool, and moisten it with a few drops of deionized water. Add five drops of concentrated HNO<sub>3</sub> and a few drops of deionized water. Evaporate on a hot plate as above. Apply 5–10 mL of 6N HCl to the ash to completely wet it, and then carefully transfer it to a low-temperature hot plate to dry it out. After adding 15 mL of 3N HCl, place the crucible on the hot plate and heat it until the solution just boils. Add 10 mL of 3N HCl to the crucible, let it cool, and then filter the mixture through filter paper into a graduated flask. Heat the mixture until it just boils. Filter into the graduated flask after cooling. Wash the crucible at least three times with deionized water. After the removal of organic material dry ashing, the residue is dissolved in dilute acid. The solution was sprayed into the FAAS and the absorption of the metal was measured at a specific wavelength.

$$\text{Iron content (mg/100g)} = \frac{(C_s - C_b) \times V}{10W}$$

Where: Cs = concentration of the sample in ppm, Cb = concentration of blank in ppm, V = volume (ml) of extract, W = weight (g) of samples

### Determination of zinc

Wash all crucibles with 6N HCl and glass wares with 10% nitric acid and place the crucibles in an oven for 30 minutes at 100°C. Let the crucible cool in desiccators for 30 minutes then weigh 2.5 g of sample chare at hot plate starting from low temperature under a hood. Ash once more for 30 minutes at 550°C and Cool the crucibles; add some drops of deionized water and 5 drops of concentrated HNO<sub>3</sub>. Evaporate on a hot plate as above. Finally ash the sample as above for 30 minutes at the same temperature as previously described. Weigh apply 5–10 mL of 6N HCl to the ash to completely wet it, and then carefully transfer it to a low-temperature hot plate to dry it out. 10 mL of 3N HCl are added to the crucible, and it is heated on a hot plate for 15 mL of 3N HCl until the solution just boils. The crucible is then cooled and filtered through filter paper into a graduated flask. Filter into the graduated flask after cooling. Use deionized water to wash the crucible three times or more, and then strain the washings into a flask (Cherie *et al.* 2018).

$$\text{Zinc content (mg/100g)} = \frac{(C_s - C_b) \times V}{10W}$$

Where: Cs = concentration of the sample in ppm, Cb = concentration of blank in ppm, V: =volume (ml) of extract, W = weight (g) of samples

### Determination of the Anti-nutritional Content of Flours Made from Wheat, Sweet lupine, and Moringa Leaf Powder

#### Determination of phytic acid

Phytic acid (phytate) was determined calorimeter to measure (Olagbemide and Philip 2014). A weighing balance was used to quickly weigh each sample, which was then divided into 15 mL centrifuge tubes and recorded. Add 10% of (0.64N) HCl to the sample and combine with vortex vigorously for 10 seconds and set the tubes in a container on a platform shaker at 300 rpm for 16 hrs (overnight) at ambient temperature centrifuged at 3000 rpm 10 °C for 20 min. weight 1.0±0.5 g of NaCl and transfer into another 15 mL falcon tubes and keep them closed. The supernatant is transferred to another falcon or test tube containing previously weighed NaCl after being filtered through what man grade 1 filter paper, and the combination is thoroughly agitated on a vortex to cause the salt to dissolve. Continue platform shaking at 300 rpm for another 20 minutes, and then allow the sample to settle at 4 °C for 60 minutes before centrifuging it for 20 minutes at 10 °C at 3000 rpm. 1 mL of supernatant should be placed in a 25 mL volumetric flask and diluted with deionized water to the desired level before being transferred to a broader mouth tube, such as a 50 mL falcon tube. Place 3mL of the diluted sample, and 1mL of Wade Reagent, and fully mix on a vortex in a 16\*100 borosilicate test tube. Centrifuge at 300 rpm and 10°C for 10 minutes and then read the absorbance of the color reaction in a spectrophotometer at 500 nm wavelength and record. Finally, using distilled water to zero the spectrophotometer for both standard assayed sample readings, the phytate content was estimated from the difference between the absorbance of the blank or control (3 mL of water plus 1 mL of Wade reagent) and that of the assayed sample.

$$\text{Phytic acid in } \mu\text{g/g} = \frac{(A_b - A_s) + I}{\text{Slope} \times w} \dots \dots \dots \text{equation 12}$$

Where As = sample absorbance, Ab = blank absorbance, W = weight of sample

#### Determination of alkaloid content

Gravimetric analysis was used to determine the alkaloid content Harborne 1973) (Mir et al. 2016). The filter paper that contained the precipitate was dried for 30 minutes at 60°C in an oven and then moved to desiccators to cool, and the weight was measured again until it was consistently determined. It tracked the consistent weight. The weight of the alkaloid was determined by calculating the weight difference of the filter paper and then represented as a percentage of the weight of the sample that was analyzed. The experiment was conducted three

times for each food sample, and the reading was recorded as the mean of the three repetitions. The precipitate-containing filter paper was dried in an oven at 60°C for 30 minutes, transferred to desiccators to cool, and reweighed until a constant weight was obtained.

$$\% \text{Alkaloid} = \frac{w_2 - w_1}{w} \times 100 \dots \text{equation 13}$$

$$(W_2 - W_1) / W * 100$$

Where, W1 = wt of filter paper, W2 = wt of filter paper + Alkaloids, W = wt of sample

### Determination of condensed tannin content

The determination of condensed tannin by the spectrophotometric method using vanillin reagent by Burns (1971) as modified by Maxson and Rooney (1972) weigh of sample in a screw cap test tube add 10ml 1% HCl in methanol to the tube containing the sample, lid then put the tube on a mechanical shaker for 24hrs at room temperature. Centrifuge the tube 1000G for 10 min take 1 mL supernatant and mix with 5 mL of vanillin – HCl reagent in another test tube at intervals of 15 seconds. Run blank by taking 1 mL of test solution and mix with 5 mL of distilled water the en wait for 20 minutes to complete the reaction.

$$\text{Tannin in mg/gram} = \frac{(A_s - A_b) - I}{\text{Slope} \times d \times w} \dots \text{equation 14}$$

Where, As = sample absorbance, Ab = blank absorbance, W = weight of sample

D = density of solution (0.791 g/mL)

## RESULT AND DISCUSSIONS

### Proximate Composition of Individual Flour

The moisture content of wheat, sweet lupine and moringa leaf powder flour had 11.81, 4.74, and 3.87 respectively. Wheat flour had the highest moisture content (11.81%), while moringa flour had the lowest (3.87%). The moisture content values of sweet lupine flour and 3.87 moringa flour were comparable. The low moisture indicates that the flour can be stored for an extended period without spoiling, indicating that the flour has a longer shelf life (Godswill 2019). This is an indicator of high-quality flour, which contributes to low residual moisture in baked goods. Flour quality is important because it reduces microbial growth, allowing flour to be stored in appropriate packaging material under optimal conditions. (Ocheme et al. 2018) found that adding sweet lupine and moringa flour to wheat flour significantly reduced moisture content ( $P < 0.05$ ). This is advantageous because lowering the moisture content inhibits the growth of spoilage organisms, particularly mold, thereby improving the bread's shelf stability.

The ash content of wheat, sweet lupine, and moringa leaf powder flour a significant ( $p < 0.05$ ) difference. As shown in Table 2. The wheat, sweet lupine, and moringa leaf powder had 2.02, 2.77, and 6.01 percent ash respectively. The wheat flour had the lowest ash content of 2.02 than both sweet lupine and moringa leaf powder whereas the moringa leaf powder had the highest ash content of 6.01 than both wheat and sweet lupine flours. The ash content of food products are measure of the total amount of minerals within the produced foods (Ayo *et al.* 2014).

The protein content of wheat, sweet lupine and moringa leaf powder flour had 9.32% (40.03%, and 31.61% protein respectively. Compared to many other legumes, sweet lupine had higher protein content. Similarly (Kefale and Yetenayet 2020) who was reported the protein content of lupine 38.6%. The most significant study variable was determined to be the amount of protein in lupine flour (Carvajal-Larenas *et al.* (2016). The flour's high protein content contributed to the goal of developing foods with high protein levels that could help reduce protein deficiencies.

The crude fiber content of wheat, sweet lupine, and moringa leaf powder flour had a significant ( $p < 0.05$ ) difference. The wheat, sweet lupine, and moringa leaf powder had crude fiber contents of 0.84%, 2.87, and 8.84%, respectively. Moringa leaf powder had significantly more crude fiber than wheat flour and sweet lupine flour while the wheat flour had lower fiber content than both sweet lupine and moringa leaf powder as shown in Table 2.

The crude fat content of wheat, sweet lupine, and moringa leaf powder flour had a significant ( $p < 0.05$ ) difference. The fat content of wheat, sweet lupine, and moringa leaf powder ranged between 1.56% and 7.52%. Moringa contained more fat (7.52%) than sweet lupine (7.01%) or wheat flour (1.56%). Table 2 displays the fat content of the ingredients (wheat, sweet lupine, and moringa leaf powder). Fat is an important ingredient that improves the product's overall quality, rheology, and texture (Belachew 2019).

The carbohydrate content of wheat, sweet lupine, and moringa leaf powder flour had significant ( $p < 0.05$ ) differences. The control flour (100% wheat) had a carbohydrate content of 75.14%, surpassing sweet lupine flour (42.53%) and moringa flour (42.14%) as shown in Table 2. Wheat flour contains more carbohydrates than sweet lupine and moringa leaf powder, which contain more protein, fat, fiber, and ash.

The computation of the total energy value of flour samples of flour samples had significant ( $p < 0.05$ ) difference. Wheat, sweet lupine, and moringa leaf powder flour had the computed total energy values of 345.78 kcal/100 g, 393.77 kcal/100g, and 362.80 kcal/100g respectively. The sweet lupine flour had a higher computation of total energy value (393.77 kcal/100g), whereas wheat flour had the lowest computation of total energy value (345.78 kcal/100g) as shown in Table 2.

Table 2. Proximate composition of ingredients

Blending ratio	Proximate compositions of ingredients in flours						
	Moisture%	Ash%	Protein%	Fiber%	Fat%	Carbohydrate	GE kcal/100g
MF	3.87±0.08 <sup>d</sup>	6.01±0.10 <sup>a</sup>	31.61 ± 0.27 <sup>b</sup>	8.84±0.19 <sup>a</sup>	7.52±0.19 <sup>a</sup>	42.14±0.29 <sup>b</sup>	362.80±1.33 <sup>b</sup>
SLF	4.74 ±0.52 <sup>d</sup>	2.77±0.09 <sup>b</sup>	40.03 ± 0.05 <sup>a</sup>	2.87±0.38 <sup>b</sup>	7.01±0.15 <sup>b</sup>	42.53±0.09 <sup>b</sup>	393.77±2.26 <sup>a</sup>
WF	11.81± 0.05 <sup>a</sup>	2.02±0.07 <sup>c</sup>	9.32± 0.03 <sup>c</sup>	0.84±0.09 <sup>c</sup>	1.56±0.12 <sup>c</sup>	75.14±0.43 <sup>a</sup>	345.78±0.42 <sup>c</sup>
P-value	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000

Note: The value expressed in mean ± standard deviation with triplicate experiment; MF= moringa flour, SLF= sweet lupine flour, WF=wheat flour. The mean was significantly different ( $p < 0.05$ ) and the mean with different superscript letters (a-d) in columns was significantly different at the level of  $p < 0.05$ .

### Mineral Composition of Ingredient

The calcium content of the wheat, sweet lupine and moringa leaf powder had a significant ( $p < 0.05$ ) difference. As Table 3 shows the calcium content of wheat, sweet lupine and moringa leaf powder was 27.46 mg/100g, 174.07 mg/100g, and 1008.19 mg/100g respectively. The calcium content of moringa leaf powder was higher than sweet lupine, and wheat flour while the wheat flour had lower calcium content than both moringa and sweet lupine flours. The concentration of sweet lupine flour raises the calcium content of the blend (Kefale and Yetenayet 2020).

The iron of the wheat, sweet lupine, and moringa leaf powder flour had a significant ( $p < 0.05$ ) difference. As Table 3 shows the iron content of wheat, sweet lupine and moringa leaf powder was 3.85 mg/100g, 4.91 mg/100g, and 14.95 mg/100g respectively. The iron content of moringa leaf powder was higher than sweet lupine and wheat flour while the wheat flour had lower iron content than both moringa and sweet lupine flours.

The zinc of the wheat, sweet lupine, and moringa leaf powder flour had a significant ( $p < 0.05$ ) difference. As Table 3 shows the zinc content of wheat, sweet lupine and moringa leaf powder was 0.78 mg/100g, 2.91 mg/100g, and 1.54 mg/100g respectively. The zinc content of sweet lupine flour had higher than moringa leaf powder, and wheat flour while the wheat flour had lower zinc content than both moringa leaf powder and sweet lupine flour.

Table 3 Mineral compositions of ingredient flour

Ingredients	Ca	Zn	Fe
MF	1008.19±5.54 <sup>a</sup>	1.54±0.02 <sup>b</sup>	14.95±0.21 <sup>a</sup>
SLF	174.07±2.56 <sup>b</sup>	2.91±0.01 <sup>a</sup>	4.91±0.04 <sup>b</sup>
WF	27.46±0.27 <sup>c</sup>	0.78±0.02 <sup>c</sup>	3.85±0.12 <sup>c</sup>
p-value	<0.000	<0.000	<0.000

Note: The values expressed in mean ± standard deviation with triplicate experiment; MF=moringa flour, SLF=sweet lupine flour, WF=wheat flour, the mean was significantly different at  $p < 0.05$ ) and with different superscript letters (a-c) in columns were significantly different at the level of  $p < 0.05$ .

### Ant-nutritional Composition of Ingredient Flour

The phytic acid content of wheat, sweet lupine, and moringa leaf powder had a significant ( $p < 0.05$ ) difference. Figure 2 shows the phytate content of wheat, sweet lupine, and moringa leaf powder. The moringa leaf powder had higher phytate content (519.89 mg/100g) than both sweet lupine and wheat flours (153.52mg/100g and 68.89mg/100g, respectively). Phytic acid has been identified as an anti-nutritional ingredient in cereals and legumes (Oatway, Vasanthan, and Helm 2001) (Kumar *et al.* 2010). Its anti-nutritional properties are associated with its ability to bind minerals, proteins, and starch (directly or indirectly) (Oatway *et al.* 2001) (Kumar *et al.* 2010)(Hurrell *et al.* 1992). Therefore, as was already said, consuming more phytic acid may result in a decrease in the bioavailability of minerals.

Condensed tannin content wheat sweet lupine and moringa leaf powder flour had a significant ( $p < 0.05$ ) difference. Figure 2 shows the condensed tannin content of wheat, sweet lupine, and moringa leaf powder. The tannin content of wheat, sweet lupine, and moringa leaf powder ranged from 53.28 mg catechin eq/100g to 1745.39 mg catechin eq/100g. Moringa leaf powder had significantly higher condensed tannin content than both sweet lupine and wheat flour, while wheat flour had the lowest condensed tannin content.

Alkaloid content wheat sweet lupine and moringa leaf powder flour had a significant ( $p < 0.05$ ) difference. Figure 2 depicts the alkaloid composition of sweet lupine, moringa, and wheat flour. Sweet lupine, moringa, and wheat flour had alkaloid contents of 3.25%, 7.66%, and 1.47% respectively. Moringa flour had significantly ( $p < 0.05$ ) higher alkaloid content than sweet lupine and wheat flour while wheat flour had the lowest alkaloid content.

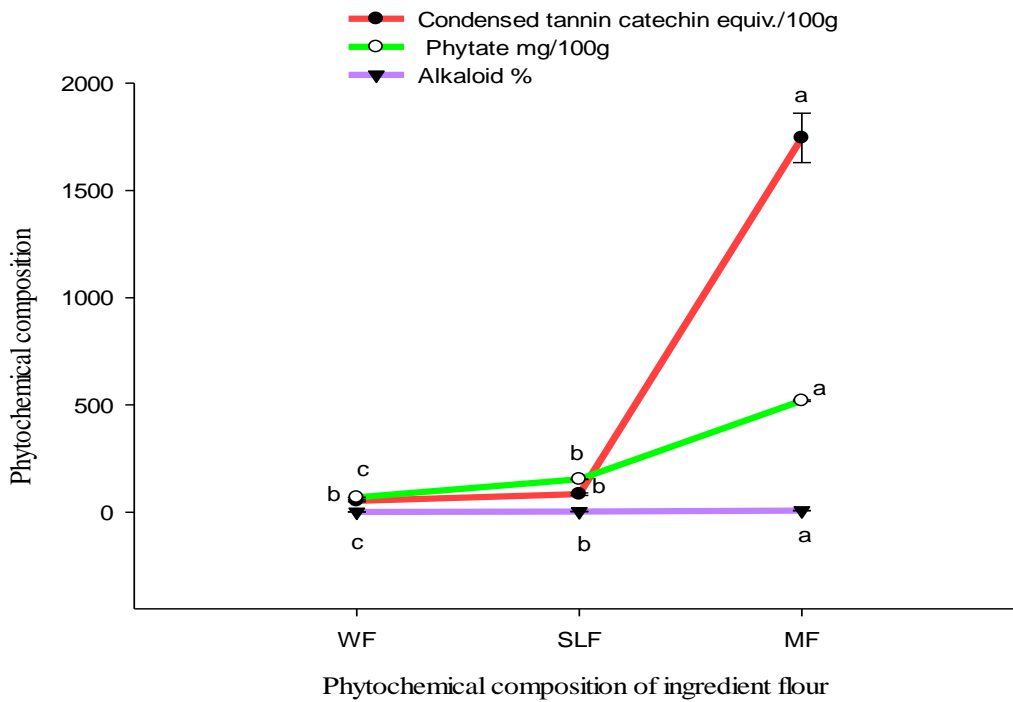


Figure 2 Ant-nutritional composition of ingredient

### Functional Properties of Ingredients and Composite Flour

The functional properties of food components govern how they are applied and used to produce various food items (Adeleke and Odedeji 2010). Table 4 shows the functional properties of wheat, sweet lupine, and moringa leaf powder flour and their composite flour. The functional characteristics of food components have a significant impact on the transportation, production, storage, stability, texture, flavor, and other aspects of food items. These characteristics are influenced directly or indirectly by variety, type, particle size, and chemical composition. The composition of flour and its processing methods are discussed. It is possible to improve the functional properties of food materials, their nutritional content, and product quality by combining various flours in the proper proportions (Igbabul, Adole, and Sule 2013).

### Bulk density

The bulk density of composite flour wheat, sweet lupine, and moringa leaf powder flour decreased from 460 to 450; and the bulk density of ingredient flour (wheat, sweet lupine, and moringa) decreased from 590 to 450 kg/m<sup>3</sup>. Due to the bulk density of composite flour, which is a mixture of different ingredients such as wheat, sweet lupine, and moringa, can be affected by several factors including the properties of the individual components and their proportions in the mixture. The bulk density of a composite sample of wheat, sweet lupine, and moringa decreased as the moisture content increased, indicating that bulk volumetric expansion was less pronounced than grain mass gain due to moisture gain. According to (Muhammad, Ahmad, and Lawan 2017), bulk density—the physical characteristics of the components in dry mixes is an important factor in defining product packaging specifications. The bulk densities of lupine flour in this study were comparable to those reported by (Ratnawati *et al.* 2019), who reported that the bulk densities of soybean, mung bean, and red bean flour were, respectively. Raw sweet lupine has a higher bulk density than soaked sweet lupine due to its lower moisture content. This study's grain bulk density was comparable to lupines, albus (0.73 g/cm<sup>3</sup>) reported by (Chandra 2022), (Tizazu and Emire 2010), and (Mishra *et al.* 2012) for soybean (0.61 g/cm<sup>3</sup>) maize (0.72).

### Water absorption capacity

As shown in the Table 4 adding more sweet-lupine and moringa flour resulted in a significant ( $P < 0.05$ ) increase in the mean values of WAC reported from this study, which ranged from 0.75 to 2.92 g/g. The highest value was obtained from 100% sweet lupine flour, while the lowest value was obtained from 100% wheat flour. The ability

of flour to absorb and hold onto water or oil can improve flavor, and texture, and reduce moisture and fat loss in food preparations (Awuchi, Igwe, and Echeta 2019). The protein composition of food sources influences the ability to absorb water and oil (Appiah, Asibuo, and Kumah 2011). Protein interacts with water and oil in foods because it possesses both hydrophilic and hydrophobic properties. WAC is a measure of a protein's hydrophilic capacity. They are, however, comparable to the values obtained by (Ratnawati *et al.* 2019) for soybean, mung bean, and red bean (4.07g/g, 3.18g/g, and 1.20g/g) for which lupine flour was studied. This study's lupine flour values were higher than previously reported values for soybean (1.12%) (Adebowale and Maliki 2011), mucuna (1.20%), and flours. Flour is chosen for use in bread products due to its high capacity to absorb water (Appiah *et al.* 2011), (Kiin-Kabari, Eke-Ejiofor, and Giami 2015) assert that a greater capacity to absorb water is advantageous for baking ingredients that must be hydrated to enhance their ability to handle the dough.

### Oil absorption capacity

The OAC ranged from 1.0 to 1.28 g/g, with sweet lupine flour having the highest value (1.28 g/g), which was significantly ( $P < 0.05$ ) different from other mean values. (Olalekan and Bosede 2010) reported values for jack beans (1.13 g/g), pigeon peas (1.48 g/g), and cowpeas (1.13 g/g) that are comparable to the values found by these researchers.

### Water activity analysis of flours

The water activities of individual flours ranged from 0.26 to 0.51 for moringa and wheat flour respectively, when compared to the control (100% wheat flour). The moringa flour had lower water activity than the sweet lupine, and wheat flour. Low water activity allows for better storage conditions for the flour and goods made from them by limiting the entry of microbes in to the water. Lower water activity levels are more important for food preservation because they inhibit chemical reactions and microbial growth (Getachew and Admassu 2020). The table 4 shown that the water activity of the flours made from wheat, sweet lupine, and moringa leaves was lower when compared to the control flour.

Table 4 Functional properties of ingredients and their composite flour

Flour/ Blended flour	Functional properties of ingredients			
	BD (g/cm <sup>3</sup> )	WAC	OAC	a <sub>w</sub>
MF	0.45± 0.00 <sup>c</sup>	1.973 ± 0.08 <sup>b</sup>	1.02 ± 0.011 <sup>c</sup>	0.26 ± 0.001 <sup>d</sup>
SLF	0.59 ± 0.02 <sup>a</sup>	2.918 ± 0.24 <sup>a</sup>	1.30 ± 0.007 <sup>a</sup>	0.28 ± 0.003 <sup>d</sup>
WF	0.49± 0.00 <sup>b</sup>	0.751 ± 0.02 <sup>c</sup>	1.01 ± 0.050 <sup>c</sup>	0.52 ± 0.006 <sup>a</sup>
P-value	<0.000	<0.000	<0.000	<0.000
Functional properties of composite flour				
BR1	0.45±0.01 <sup>c</sup>	0.87 ± 0.01 <sup>c</sup>	1.03± 0.24 <sup>c</sup>	0.47 ± 0.00 <sup>c</sup>
BR2	0.45±0.00 <sup>c</sup>	0.84 ± 0.02 <sup>c</sup>	1.11 ± 0.01 <sup>b</sup>	0.50 ± 0.01 <sup>b</sup>
BR3	0.45±0.01 <sup>c</sup>	0.83 ± 0.07 <sup>c</sup>	1.04 ± 0.03 <sup>b</sup>	0.51 ± 0.01 <sup>b</sup>
BR4	0.46±0.01 <sup>c</sup>	0.86 ± 0.02 <sup>c</sup>	1.00 ± 0.02 <sup>c</sup>	0.513 ± 0.00 <sup>a</sup>
P-value	<0.000	<0.000	<0.000	<0.000

Note: The values expressed in mean ± standard deviation with triplicate experiment; BR=blending ratio, MF=moringa flour, SLF=sweet lupine flour, WF=wheat flour BD=bulk density, WAC= water absorption

capacity, OAC=oil absorption capacity, WA=water activity. The mean was significantly different  $p<0.05$ ) and the mean with different superscript letters (a-c) in columns was significantly different at the level of  $p<0.05$ .

### Measurement of the Color of Individual and Composite Flour Samples

The physical property of a hue influences the quality and acceptability of food products. It also shows how storage and processing affect product quality (Hutchings, 1999). The color of the flour is affected by the amount of pigments present, the rate at which the pigment is extracted, and the size of the wheat particle. For  $L^*$ ,  $a^*$ , and  $b^*$ , the table shows the measured amounts of sweet lupine, wheat, moringa, and blended flour. The calculated means were 32.12, 2.15, and 82.80. When compared to sweet lupine and moringa, wheat flour has the highest  $L^*$  value and the lowest  $a^*$  value. Moringa flour has the highest greenness (-11.73) among them, with a significant difference ( $p<0.05$ ). The sweet lupine flour lightness index ( $L^*$ ) is a visual representation of brightness that ranges from black to white. Depending on the presence of pigments, the color of the flour can be made redder or yellower (Van-Hal, 2000). The botanical origin of the plant, as well as the composition of the flour, influence the color of the flour (Kaur, Kaushal, and Sandhu 2013). Color is a significant physical element that has a direct impact on how well-liked food goods are. It also denotes changes in product quality caused by processing and storage (Belachew 2019).

Table 5 Color characteristics of ingredient and composite flour

Flour/Blended flour	Color characteristics of the ingredient		
	$L^*$	$a^*$	$b^*$
MF	$32.55 \pm 4.68^c$	$-11.73 \pm 1.039^f$	$33.66 \pm 1.17^a$
SLF	$82.80 \pm 3.87^a$	$2.15 \pm 0.075^a$	$32.12 \pm 1.06^a$
WF	$89.417 \pm 0.215^a$	$0.78 \pm 0.060^b$	$11.53 \pm 0.36^e$
P-value	<0.000	<0.000	<0.000
Color characteristics of composite flour			
BR1	$81.88 \pm 2.58^a$	$-0.88 \pm 0.02^c$	$19.25 \pm 0.14^d$
BR2	$72.57 \pm 1.04^b$	$-2.30 \pm 0.06^d$	$24.98 \pm 0.43^c$
BR3	$73.11 \pm 3.86^b$	$-3.39 \pm 0.45^{de}$	$26.75 \pm 0.83^{bc}$
BR4	$69.97 \pm 2.79^b$	$-3.52 \pm 0.04^e$	$28.68 \pm 0.51^b$
P-value	<0.000	<0.000	<0.000

Note: The values expressed in mean  $\pm$  standard deviation with triplicate experiment; BR=blending ratio, MF=moringa flour, SLF=sweet lupine flour, WF=wheat flour, L=lightness,  $a^*$ =red-green and  $b^*$  = yellow-blue. The mean was significantly different at  $p<0.05$ ) and the mean with different superscript letters (a-e) in columns was significantly different at the level of  $p<0.05$ .

### Farinographic Properties

The Brabender Farinograph measures and records the resistance of dough to mixing as it is formed from flour and water, developed, and broken down. This resistance is referred to as consistency. The maximum consistency of the dough can be set by varying the amount of water added. The amount of water absorbed can be used to create a comprehensive mixing curve, the different characteristics of which serve as a guide to the strength of the flour (Koceva Komleni, Slaanac, and Juki 2012)

## Water absorption

The effect of replacing wheat flour with sweet lupine flour at 5%, 10%, 15%, and 20% and moringa at 1%, 3%, 5%, and 7% on dough mixing properties were measured using a farinograph, and the results are shown in Table 6. Water absorption played a significant role in gluten distribution and the formation of a network structure of mixed dough. It was discovered that there was a relationship between water absorption and the addition ratio of sweet lupine and moringa flour, which could be attributed to the fact that sweet lupine and moringa flour contained more protein, which absorbs more water (Des Marchais *et al.* 2011)(Des Marchais *et al.* 2011) reported that increased water absorption (WA), which limits the water available for the growth of the gluten network when competing with wheat proteins, has been linked to proteins' ability to absorb significant amounts of water. According to (Kohajdová, Karovičová, and Magala 2013), the WA of mixed flours can be influenced by sugars and fiber. The mean values for WA in this study differed significantly ( $P < 0.05$ ), with the highest mean value BR1 coming from a composite flour made up of 20% sweet lupine, 1% moringa, and 79% wheat composite flour and the lowest mean value control from 100% wheat flour.

## Dough development time (DDT)

As indicated in Table 6 Dough development time (DDT) data revealed a significant ( $P < 0.05$ ) difference between wheat and wheat-sweet lupine and moringa composite flour. The highest mean value (4.13 min) was obtained from 20% sweet lupine flour and 1% moringa, while the low est (2.40 min) was obtained from wheat flour. This is consistent with the findings of (Kohajdová *et al.* 2013), who provided evidence to support the use of composite flour made of wheat and legumes. The difference in physicochemical properties between the legume and wheat flour contents may have contributed to the increase in DDT caused by legume inclusion (Mohammed, Ahmed, and Senge 2012).

## Dough stability time (DST)

Dough stability time (DST) is a measurement of protein weakening and is the amount of time that the dough can tolerate deformation after a drop in torque value after additional kneading and heating. Table 6 shows how adding sweet lupine and moringa flour to wheat flour shortened the dough's stability time. The mean time ranged from 7.40 minutes for 100% wheat flour to 1.43 minutes for 20% sweet lupine and 1% moringa flour, with 7.40 minutes being the best result. The shortest time was 1.43 minutes. When wheat gluten is substituted, the dough becomes softer and less stable. (Saeed *et al.* 2011) (Mohammed *et al.* 2012) discovered similar results.

## Degree of softening (DS)

In general, the degree of softening (DS) of flour indicates how quickly it breaks down and how strong it is. A higher DS value indicates that the flour has a lower strength (Miš *et al.* 2012). Because all flour fractions softened to varying degrees, the size of the flour particles also influenced the degree of softening. (Mansour *et al.* 2021)observed a different pattern in the degree of softening, which denotes the elastic proportion of dough. The degree of softening was lowest for BR3 treatment (85% wheat, 10% sweet lupine, and 5%) compared to the other ratios (79:20:1, 82:15:3, 85:10:5, 88:5:7 and 100% wheat) which recorded 1.58, 1.90, 1.21, 7.40, and 7.37, respectively

Table 6 Farinograph properties of wheat flour and composite flour

Flour/Flour blends	Farinograph properties of ingredient and composite flour				
	WV(ml)	WA(ml/100g)	DDT(min)	DS(min)	DST(FU)
WF	166.07 ± 4.61 <sup>c</sup>	53.00 ± 1.39 <sup>a</sup>	2.40 ± 1.91 <sup>a</sup>	7.40 ± 0.79 <sup>a</sup>	7.37 ± 2.04 <sup>a</sup>
BR1	218.57 ± 0.78 <sup>a</sup>	69.13 ± 0.31 <sup>a</sup>	4.13 ± 0.12 <sup>a</sup>	1.43 ± 0.21 <sup>c</sup>	1.58 ± 0.02 <sup>b</sup>
BR2	212.40 ± .87 <sup>b</sup>	66.93 ± 0.29 <sup>a</sup>	4.07 ± 0.12 <sup>a</sup>	1.73 ± 0.06 <sup>bc</sup>	1.90 ± 0.06 <sup>b</sup>

BR3	198.77± 0.75 <sup>c</sup>	62.33 ± 0.15 <sup>a</sup>	3.87 ± 0.12 <sup>a</sup>	2.00 ± 0.17 <sup>bc</sup>	1.21 ± 0.09 <sup>b</sup>
BR4	186.93± .25 <sup>d</sup>	58.40 ± 0.10 <sup>a</sup>	3.93 ± 0.12 <sup>a</sup>	2.63 ± 0.06 <sup>b</sup>	7.40 ± 0.17 <sup>a</sup>
P-value	<0.000	<0.660	<0.152	<0.000	<0.000

Note: The values expressed in mean ± standard deviation with triplicate experiment; WF=wheat flour, BR=blending ratio, WV= Water volume, WA= Water absorption, DDT=Dough development time, DS=Dough stability, DST=Degree of softening and the mean with different superscript letters (a-e) in columns were significantly different at the level of p<0.05

### Pasting Properties

The features of Pasting take into account the alteration in flour viscosity as it is heated in excess water while being constantly stirred. They help predict how the flour will behave during baking. Table 7 displays the findings of the pasting properties (PV, TV, BDV, SBV, FV, PT, and Pt) of sweet lupine, moringa, and wheat flour, and their composite flour is represented in Table 7.

#### Peak viscosity (PV)

Peak viscosity (PV) is the maximum viscosity that can be achieved during heating and is a good indicator of the durability of pastes formed during food processing as a result of starch gelatinization. It reveals the starch granules' ability to bind water (Belachew 2019), and it frequently correlates with the finished product's quality. Peak viscosities for 100% wheat, 79% wheat, 20% sweet and 1% Moringa, 82% wheat, 15% sweet lupine and 3% Moringa, 85% wheat, 10% sweet lupine, and 5% Moringa, 88% wheat, 5% sweet, and 7% Moringa, and composite flour were 2355.67, 2011, 1797, 1763, 1835, 308, and 501cP, respectively with significant (P<0.05) differences between them as shown in Table 7. The obtained mean value for sweet lupine flour was quite low when compared to wheat (Ratnawati *et al.* 2019) reported the peak viscosities of mung bean (909cP), red bean flour (827.67cP), and soybean flour (19.17cP), and they stated that the peak viscosity of soybean flour is the lowest due to lower starch and amylose content. Sweet lupine flour and Moringa flour have a lower value because they contain less starch than 100% wheat and flour composite flour. The protein content of legume flour can help to prevent starch granule swelling and reduce viscosity. In addition to proteins, the amount of fat in flour influences starch viscosity. Sweet lupine flour has the lowest peak viscosity because it contains the most fat. High fat content prevents starch molecules from interacting, resulting in less swelling of starch granules and lower viscosity of the paste (Jiang *et al.* 2023). The peak viscosity of sweet lupine measured in this study is higher than the results for soybean and lupine previously reported by (Ratnawati *et al.* 2019) and (Belachew 2019), respectively. The high-fat content of legumes in sweet lupine could be the cause.

#### Trough viscosity (TV)

Trough viscosity (TV) is also known as shear thinning and hot paste viscosity. It measures the paste's resistance to breakdown during cooling and is the lowest viscosity value in the constant temperature phase of the RVA profile (Ayo-Omogie and Ogunsakin 2013). Table 7 shows that the average trough viscosity values for 100% wheat, 79% wheat, 20% sweet and 1% Moringa, 82% wheat, 15% sweet lupine and 3% Moringa, 85% wheat, 10% sweet lupine and 5% Moringa, and composite flour were 1063.33, 768.67, 703.33, 1344, 1393.67, 42, and 439.33.

The obtained mean value for sweet lupine flour was fairly low 15.32cP for 100% wheat, 79%, 20%, 1%, 82%, 15%, 3%, 85%, 10%, 5%, 88, 5% 7% wheat-sweet lupine, moringa when compared to wheat.

#### Breakdown viscosity (BDV)

Breakdown viscosity is a measure of cooked starch's susceptibility to fragmentation. The higher the breakdown viscosity, the less capable starch is of withstanding additional heating and shear stress during cooking (Adebowale, Adeyemi, and Oshodi 2005). In this study, the breakdown viscosities for wheat, sweet-lupine,

moringa, and wheat sweet-lupine-moringa composite flour were 1288, 266, 62, and 1240.67, 1089.33, 424, and 434cP, respectively. The obtained mean values differed significantly (P0.05) from one another, with moringa having the lowest mean value when compared to another sample, but it was comparable to breakdown values of legumes such as mung bean (40.00cP) and red kidney bean (85.00cP) reported by (Ratnawati *et al.* 2019). The mean value of moringa flour was comparable to the values reported by(Nicolas 2018) for yellow bean, black bean, and green bean (63-64cP).

**Final viscosity (FV)**

Indicates the starch's ability to form a viscous paste at the end of cooking, and a high Final Viscosity for legume starches indicates that their paste could easily form a more rigid gel (Kong *et al.* 2020). The final viscosity of the wheat, sweet lupine, moringa, and wheat-sweet lupine-moringa (79:20:1, 82:15:3, 85:10:5, 88:5:7cP) composite flour in this study was 2541.67, 103, 782, and 1615, 1463.33, 1753.33, 1796, respectively, with significant (P<0.05) differences. The obtained result is higher than the 32.83cP recorded for soybean flour, as well as the 55cP of starch from different legumes at 4% proportion reported by (Ratnawati *et al.* 2019).

**Setback viscosity (SBV)**

Setback viscosity is the viscosity that occurs when the temperature drops, causing the starch molecule to retrograde or reconnect. The texture of various products is related to setback viscosity. Because of the high setback viscosity, the product experiences syneresis during freezing/thawing cycles. In this study, the Setback Viscosity values of wheat, sweet lupine, moringa, and wheat-sweet lupine-moringa (79:20:1, 82:15:3, 85:10:5, 88:5:7) composite flour were 1570, 64, 343, and 861, 531, 412, and 403cP, with a significant (P<0.05) difference between them, as shown in Table 7.

Table 7 Pasting of Properties ingredient and composite flour

Flour/Flour blends	Pasting Properties of ingredients						
	PV(cp)	TV(cp)	BDV(cp)	FV(cp)	SV(cp)	PT(°C)	Pt(min)
SLF	308±9.54 <sup>g</sup>	42.33±8.08 <sup>g</sup>	266±16.09 <sup>e</sup>	103±9.54 <sup>c</sup>	64±10.82 <sup>d</sup>	5.61±0.23 <sup>e</sup>	93.58±11.38 <sup>a</sup>
MF	501±11.14 <sup>f</sup>	439.33±13.50 <sup>f</sup>	62±12.12 <sup>f</sup>	782±15.52 <sup>d</sup>	343.33±11.06 <sup>c</sup> <sub>d</sub>	6.55±0.28 <sup>a</sup> <sub>bc</sub>	87.67±10.07 <sup>a</sup>
WF	2355.67±21.59 <sup>a</sup>	1063.33±23.12 <sup>c</sup>	1288±13.45 <sup>a</sup>	2541.67±186.36 <sup>a</sup>	1570.33±13.50 <sup>a</sup>	5.8±0.19 <sup>de</sup>	87.94±8.69 <sup>a</sup>
P-value	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000
Pasting Properties of Composite Flour							
BR1	2011±6 <sup>b</sup>	768.67±13.50 <sup>d</sup>	1240.67±3.21 <sup>b</sup>	1615±14.11 <sup>bc</sup>	861±26.96 <sup>b</sup>	6.32±0.09 <sup>c</sup> <sub>d</sub>	86.47±7.46 <sup>a</sup>
BR2	1797±13.53 <sup>d</sup>	703.33±8.50 <sup>e</sup>	1089.33±6.66 <sup>c</sup>	1463.33±11.24 <sup>c</sup>	531±393.21 <sup>bc</sup>	6.4±0.10 <sup>bc</sup>	88.43±4.79 <sup>a</sup>
BR3	1763±7 <sup>e</sup>	1344±13.45 <sup>b</sup>	424±7.55 <sup>d</sup>	1753.33±16.04 <sup>b</sup>	412±14 <sup>cd</sup>	7.03±0.25 <sup>a</sup>	89.27±5.89 <sup>a</sup>
BR4	1835±8.89 <sup>c</sup>	1393.67±18.50 <sup>a</sup>	434±7.09 <sup>d</sup>	1796±16.09 <sup>b</sup>	403±13.53 <sup>cd</sup>	6.97±0.25 <sup>a</sup> <sub>b</sub>	89.71±7.80 <sup>a</sup>
P-value	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000

Note: The values expressed in mean  $\pm$  standard deviation with triplicate experiment; SLF=sweet lupine flour, MF= Moringa flour, WF= wheat flour, BR=blending ratio, PV= peak viscosity, TV=trough viscosity, BDV=breakdown viscosity, FV=final viscosity, SBV = setback viscosity, PT= pasting temperature, Pt = peak time and cP = centipoise. The mean with different superscript letters (a-d) in columns was significantly different at the level of  $p < 0.05$

## CONCLUSION

According to this study, the addition of sweet lupine and moringa leaf powder to wheat flour has been shown to improve its nutritional value. This study showed that the effect of the blending ratio is significant on the proximate composition, mineral content, and anti-nutritional content, of flours developed from the composite flours of wheat, sweet lupine, and moringa leaf powder. The blending ratio dramatically increased the proximate composition (ash, crude proteins, crude fat, crude fiber, gross energy, Fe, Ca, Zn, for the BR<sub>1</sub> flour samples (79%, 20% sweet lupine, and 1% moringa), while increased phytic acid, tannins, and alkaloids) for the flour samples (88% wheat, 5%, and 7% moringa). However, the carbohydrate content of the blended flour was significantly lower. Overall, it could be concluded that nutritionally improved flour can be prepared from the composite flour containing 20% sweet lupine, 1% moringa, and 15% sweet lupine, 3% moringa could be recommended and to be used as a wheat bread substitute. Furthermore, flour with higher moringa content was not recommended because moringa contains a high amount of anti-nutritional content, which interferes with the absorption or utilization of nutrients in the body.

## Ethical statement

The study adhered to the ethical principles outlined in Bahir Dar Institute of Technology's approved rules and regulations for conducting research.

## Consent for publication

Not applicable.

## CRedit authorship contribution statement

Yodit Fikadu Demissie: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

**Mr. Mekonen Tekliye Cherinet:-** Review & editing, Visualization, Validation, Supervision, Data curation, Conceptualization. **Admasu Fenta Worku(PhD):** Review & editing, Visualization, Validation, Supervision, Data curation, Conceptualization. **Mr. Berhanu Regassa Jima:** Writing – review & editing, Visualization, Validation, Methodology, Formal analysis, Data curation, Conceptualization. **Tadele Andargie Wudineh:** Writing– review & editing, Visualization, Validation, Methodology, Formal analysis, Data curation, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Data availability

Data will be made available on request.

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