**FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE**

Study of some physical and functional properties of the malted Temash Barley (*Hordeum Vulgare* L.) grains and its flour

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**Abstract:** Temash is one of the barley varieties and traditionally used for kolo (roasted grain) and malt. This study was conducted to generate some engineering properties of the temash grain and its malt flour. The experiment consisted of the factorial design of two factors. Each sample was steeped at room temperature (24°C) for 37 hrs and kilned at 50°C for 24 hrs. Experiment material was subjected to evaluate for physical properties of the grain and its flour, functional properties. The physical properties of native temash flour were 11.13% moisture, 40.22° angle of repose, 0.97 g/mL bulk density and are significantly (P < 0.05) different from values, which ranged from 5.88 to 7.79%, 36.55 to 37.68° and 0.82 to 0.93 g/mL of the respective attributes of malt flour. Increasing the germination temperature and

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- Effect of germination Temperature and Time on Malt Quality of Temash Barley (*Hordeum Vulgare* L.)
  - Review on Honey Adulteration and Detection of Adulterants in Honey
  - Design and development of mango peeler and pulper machine
  - Design and development of scalding and plucker of chicken machine
  - New food product development and preserving technology on low shelf life foods

Mr. Alemu Girma Tura has a great aspirations work in the front-line research areas and deliver community service of Food engineering machines to solve loss during processing and initiate food engineering students to focus on it.

**PUBLIC INTEREST STATEMENT**

Malt is the major raw material for beer production. Ethiopia has a shortage of malt barley to meet the demand of the all local breweries. This may be due to inadequate number of malt factories in Ethiopia or low local grain quality. Based on these problems Ethiopian Institute for Agricultural Researches is improving barely grain which has high extraction in beer production. Addition to this, Temash grain is one of barely variety which is not studied so far and also used as malt for tela traditionally. Malt prepared from barley is by far the most important due to its high content of enzyme and also its quality is based on malting condition (soaking, germination and kilning). So, the study of germination effect is the most malt quality decider and used to know extraction potential of temash grain. To do this knowing physical properties are basic information for all.
time resulted in reduced hectoliter weight (HLW) and a thousand kernel weight (TKW) of malted grain. However, germination did not affect angle of repose of both malted grain and malt flour. The TKW reduced from 37.29 to 32.52 g and HLW from 76.88 to 71.83 kg/HL whereas the native temash grain had TKW and HLW values of 47.17 g and 81.77 kg/HL, respectively. Statistically, the highest values of the functional properties of the malt flour, which included water absorption capacity, swelling power, water solubility index and dispersibility of flour were 2.98 g/g, 0.37%, 27.09% 74.83%, respectively for the sample germinated at 21°C for 5 days. The lowest values were 2.16 g/g, 0.06%, 6.00% and 67.67% for the respective attributes of raw temash flour.

**Subjects: Fluid Mechanics; Packaging; Chemical Engineering**

**Keywords: functional properties; germination; physical properties; temash barley grain**

1. Introduction

Temash (*Hordeum vulgare L.*) grain is also one of barely varieties available in Ethiopia (Hunduma, 2006). It is grown at different locations in the country and mainly consumed after roasting as kolo (roasted whole grain) and besso (flour of lightly roasted grain). Temash has different local names at different locations in the country. For example, in Afaan Oromo it is called gaqxee due to eating quality (Hunduma, 2006), temash in Amharic and sometimes it is called naked barely. At investigator area temash is used for kolo (eaten between meals, while having traditional coffee), besso (flour of roasted of temash grain), chuukko (mixture of besso and clarified butter) and malt for tella. Study of the physical properties of cereal grain as part of engineering properties are very important to optimize the design parameters of processing equipment, handling facilities and storage structures. The geometric characteristics of size, shape, volume, surface area, density, and porosity are important in many food materials handling and processing operations. Knowledge of the bulk density is used for determination of floor space during storage and transportation (Rahman, 1995). When mixing, transporting, storing and packaging particulate matter, it is important to know the properties of bulk materials (Lewis, 1987). To design equipment and facilities for handling processing and storage, the physical properties of crop grains must be known (Kochhar & Hira, 1993). Elfawal (2009), reported that the function of many types of agricultural machines (sifters, sowing machines, pneumatic transport systems, etc.) is influenced by the physical property of the objects participating.

Bulk density is weight per unit volume of sample. Bulk density gives information on the porosity of a product and can influence the choice of package and its design (Lee et al., 2008). The higher bulk density observed for the malted grain or flour implies a denser packaging material may be required for that product. According to (Tavakoli et al., 2010), bulk density of barley malt at different moisture levels varied from 0.71 to 0.66 g/mL. The angle of repose is important parameter in determining the inclination angle of the machine hopper tank (Kaleem et al., 1993). Angle of repose of grains depends on properties like size and shape of kernels, moisture content, fines and foreign material content, presence of mould, and submerging, pouring, piling or emptying method, and can vary greatly (Al-Hashemi & Al-Amoudi, 2018). The angle of repose is used in the design of equipment for the processing of particulate solids for example, it may be used to design an appropriate hopper or silo to store the material, or to size a conveyor belt for transporting the material. It can also be used in determining whether or not a slope will likely collapse the slope is derived from angle of repose and represent the steepest slope a pile of granular material will take (Bhople et al., 2017). According to (Tavakoli et al., 2010) the values of malt barely angle of response is varying between 31.16 to 36.90° in range of 7.34 to 21.58% (db) moisture content. Thousand kernel weight (TKW) is the weight of the 1,000 kernels. It is the weight in grams of 1,000 seeds. Seed size and the TKW can vary from one crop to another, between varieties of the same
crop and even from year to year or from field to field of the same variety. The thousand kernel weight barley increased linearly from 44.48 g to 51.30 g based on grains moisture (Tavakoli et al., 2010). Functional properties indicate the ability of protein material to hold oil and water, to emulsify the same and to form products having firm consistency upon heating and cooling. Functional properties are those parameters that determine the application and use of food material for various food products. Functional properties are significantly influenced by the processing of grain flour (Mirhosseini & Amid, 2013).

As a temash is barely variety, it would be wise to study the effect of different parameters during germination of temash grain and flour. Limited work has been reported so far due to less concern and this project was proposed with the aim of studying the functional and engineering properties of its flour.

1.1. General objective
To study physical and functional of malted temash grain and its flour produced at different germination temperature and time.

1.2. Specific objectives
• To know physical properties of temash malt grain
• To determine physical properties of temash malt flour.
• To study functional properties of temash malt flour.

2. Materials and methods

2.1. Experimental site
The experiments were conducted at Wolkite, Haramaya and Hawassa Universities, Asella Malt Factory, and Debre Zeit Agricultural Research Center. Works like determination of functional properties and malt preparation were carried out at Haramaya University, at Food Science and Postharvest Technology and Central Laboratories. Studies on physical properties of grain and malted flour were conducted at Hawassa and Wolkite Universities.

2.2. Experimental materials
Temash barely variety grains were obtained from a local market in Degam wereda, in North shoa, Oromia region Figure 1.

Figure 1. Malted temash grain used in the study.
2.3. Experimental design
The experiment was conducted in a factorial design with two factors. Factor one represented the germination temperature with three levels of 15, 18 and 21°C and the second factor was time of germination with three levels of 3, 4 and 5 days. The experiment was done in a completely randomized design (CRD) for preparing of Temash malt samples. Treatments were replicated three times. The experiment was organized as shown in Table 1.

2.4. Sample grain and malt preparation
Temash (Hordeum vulgare) grain sample was cleaned manually by removing broken, damaged kernels and foreign materials. After cleaning some grain sample was sealed in polyethylene plastic bags and stored at room temperature for further laboratory analysis. The remaining cleaned grain was used to prepare malt. Temash malt preparation process and malting condition were adapted from that of barley malt within the slight modification. The temash grain sample (1.2 kg) for each treatment was used in this study. Each sample was soaked in tap water by a ratio of 100 g: 223 mL for 37 hours at room temperature and water exchange with aeration was carried out at 8 hours interval (Galano et al., 2011). After steeping each sample was germinated at different temperatures and time in relative humidity chamber with 89.6% RH (Termaks chamber KBP 6395 F, Bergen, Norway) according to time-temperature combinations in Table 1. Each sample was sprayed in a nylon bag with 100 mL of distilled water using hand sprayer to avoid decrease of relative humidity.

After germination time was over each sample was dried by drying oven (model PF120 (200) England) at 50°C for 24 hours. Dried malt was polished to remove rootslets and acrospires. Lastly, each sample was milled by attrition mill (Buhler, Braunschweig, Germany) to pass through 0.2 mm mesh size and packed in airtight polyethylene bag for further laboratory analysis. Malt preparation process was summarized as follows in Figure 2

2.5. Determinations of physical properties

2.5.1. Thousand kernel weight
Thousand kernel weight (TKW) for raw and malted temash grain was determined by weighing the counted (Numigral II Chopin grain counter, France) 1000 kernels according to (EyoeI, 2013).

2.5.2. Hectoliter weight (HLW)
The test weight of raw and malted temash grain sample was measured according to AACC, (AACC, 2000) method no.55–10 by using electric volume-weight apparatus (model GHCS-1000A, China). Test weight of the grain in kilograms per hectoliter (kg/hL) was calculated from grains weighed on the balance.

\[
HLW = \frac{\text{weight of sample (g)}}{\text{volume of test weight (L)}} \times 0.01
\] (1)

| Table 1. Experimental layout |
|-----------------------------|
| Germination time (days)     | Germination Temperature (°C) |
|                            | T1 (15) | T2 (18) | T3 (21) |
| D1 (3)                      | T1 D1   | T2 D1   | T3 D1   |
| D2 (4)                      | T1 D2   | T2 D2   | T3 D2   |
| D3 (5)                      | T1 D3   | T2 D3   | T3 D3   |

Where T1, T2 and T3 represented 15, 18 and 21°C temperature of germination, respectively and D1, D2 and D3 represented 3, 4 and 5 days, respectively of germination time.
2.5.3. Angle of repose of temash grain and its malt flour

The cylinder was placed over a plain surface and temash grain/malt flour was filled in. The height of heap above the surface and the diameter of the heap at its base was measured and the angle of repose (ϕ) calculated as indicated by (Shumaila Jan, 2015).

\[
\text{Angle of Response } (\phi) = \tan^{-1} \left( \frac{2h}{d} \right) \tag{2}
\]

Where: \( \phi \) = angle of repose (°)

\( h \) = height of the pile (cm) and \( d \) = diameter of the pile (cm)

2.5.4. Bulk density

2.5.4.1. Bulk density of malted grain. The bulk density of the temash malted grain was determined by filling a cylindrical container of 500 mL in volume according to Malik and Saini, (2016). Then the bulk density of temash malted grain was calculated from the mass of the malted grains and the volume of the cylinder as the following formula.

\[
\text{Bulk density } (g/mL) = \frac{MF - ME(g)}{\text{volume of measuring cup}(mL)} \tag{3}
\]

Where \( MF \) = weight of sample and measuring cylinder

\( ME \) = weight of empty measuring cylinder

2.5.4.2. Bulk density of malt flour. Determination of malted temash flour bulk density was done according to method described by (Oladele & Aina, 2007).
2.5.5. **Grain size**
Grain size was analyzed by grain size analyzer which contains four compartments with vibrating sieves (sortimalt, pfeuffer product, Germany) according to European Brewery Convection method (Analytica-EBE, 1998). Temash grain (100 g) was weighed and added to grain size analyzer. After 5 min amount of sample retained on 2.8 mm, 2.5 mm, 2.2 mm and pan (TSR) was weighed and expressed by percentage of retained

\[
\% \text{ retained} = \frac{\text{mass on sieve}}{\text{total mass}} \times 100
\]  

(5)

2.6. **Functional properties of Temash malt flour**

2.6.1. **Dispersibility**
The dispersibility of malted flour was determined by the method of AACC (2000).

\[
\text{Dispersibility} (\%) = 100 - \text{volume of settled particle}
\]  

(6)

2.6.2. **Water absorption capacity (WAC)**
Water Absorption Capacity (WAC) was determined by method of (Sze & Sathe, 2000). Water-holding capacity was expressed as gram of water held per gram of malted flour sample.

\[
\text{WAC(g/g)} = \frac{M3 - M2}{M1}
\]  

(7)

Where:—M3 is weight of empty tube + sample after centrifuged and decanted,

M2 is weight of empty tube + sample before centrifuging and

M1 is weight of sample in dry base.

2.6.3. **Swelling power and solubility**
Swelling power and solubility determinations were carried using the method of (Emire. et al., 2006).

\[
\text{Swelling Power(\%)} = \left( \frac{\text{Weight of dry sediment}}{\text{Weight of dry Sample}(100 - \text{solubility})} \right) \times 100
\]  

(8)

\[
\text{Water solubility Index (\%)} = \frac{\text{Weight of dry Supernatant}}{\text{Weight of dry solid}} \times 100
\]  

(9)

2.7. **Statistical analysis**
All data were analyzed by two-way of analysis of variance (ANOVA) model using the statistical software programs (SAS), version 9.0 for windows. The results were reported as average value of triplicate analysis of (mean ± SD) and were analyzed by Fisher’s (LSD) least significance difference and significance was at P < 0.05.

3. **Results and discussions**

3.1. **Effect of main factors germination temperature and time on physical properties of malted grains**

3.1.1. **Bulk density**
Table 2 presents data of bulk density of malted grain as affected by germination temperature and time. There was no significant difference (P > 0.05) due to germination temperature. Germination
time has its own impact on bulk density having the lowest value (0.69 g/mL) for those with the longest duration of 5 days. The next, following value was 0.72 g/mL and 0.73 g/mL statically higher than the value indicated above but have no difference between them. The result agreed with the values 0.67 to 0.73 g/mL reported by (Aregbesola et al., 2012), who found that moisture content and bulk density of malted sorghum grain had a direct relationship. To design grain hoppers for processing machinery bulk density and angle of repose data is required (Rameshbabu et al., 1996).

3.1.2. Angle of repose

The angle of repose values for a malted temash grains are presented in Table 2. Both germination temperature and time did not cause a significant difference (P > 0.05) on the angle of repose. The angle of repose values ranged from 29.99 to 30.94° due to germination temperature and ranged from 30.17 to 30.39° due germination time. However, the result showed a higher value when compared to the 27.15° of the raw grains. This could be because raw grains were full oval-shaped which can easily slide on each other being flowable whereas malted grains had shrunk and less became flowable. This is in agreement with the result reported by (Mohammed & Getachew, 2009), who stated that the angle of repose of grain increased with increasing moisture content. The result was also agreed with Brigg (1998), who indicated the angle of repose of malt result in range 23 to 35°. The angle of repose is an important parameter in the designing of belt conveyors because friction is necessary to hold the grains to the conveying surface without slipping or sliding backward.

3.1.3. Thousand kernel weight

Thousand kernel weight (TKW) of the malted grain values had shown significant (P < 0.05) difference due to germination time (Table 2). The highest average value, (36.43 g) was of sample germinated for 3 days but with no significant difference from the 35.17 g of sample fermented for 4 days. Malted temash germinated for 5 days exhibited 33.75 g, this having a difference from the highest value but significantly lowest from all. In respect of germination temperature values had also shown significant (P < 0.05) difference. The highest value, 36.05 g was of samples germinated at 15°C but with no significant difference from the 35.05 g of samples germinated at 18°C temperature. Malt germinated at 21°C exhibited 34.25 g having significant (P < 0.05) difference from the highest value. Germination time resulted in TKW values which ranged from 33.75 to 36.43 g. Raw grain was 47.17 g (Table 2) and this is due to the loss associated during malting condition including germination time and temperature. The result was similar to that of (Fekadu & Ayana, 2013), who studied the improvement of malting qualities of barley varieties result in range 45.80 to 53.8 g. The thousand kernel weight also decreased as moisture content of

| GT(°C) | BD(g/mL) | AR(°) | TKW(g) | HLV(kg/lL) |
|--------|----------|-------|--------|-----------|
| 15     | 0.72 ± 0.03* | 30.94 ± 0.88* | 36.05 ± 1.31* | 73.62 ± 1.35* |
| 18     | 0.72 ± 0.01* | 30.34 ± 1.16* | 35.05 ± 2.43 b | 73.33 ± 0.50 b |
| 21     | 0.71 ± 0.04* | 29.99 ± 1.22* | 34.25 ± 1.17 b | 72.90 ± 3.08 e |

*Values are means ± standard deviation. Values within the same column with different superscript letters have significant (P < 0.05) differences. GT = germination temperature, BD = Bulk density, AR = Angle of Repose, TKW = Thousand kernel weight, HLV = Hectoliter weight, CV = Coefficient of variation, LSD = least Significant difference.
malt decrease. The result was agreed with the range 43.22 to 44.68 g reported by (Mohammed & Getachew, 2009), who found that moisture content and thousand kernel weight of barely had a direct relationship. (Regosa, 2013), also reported the minimum and maximum thousand kernel weight of malt barley which is ranged from 23.00 to 39.10 g and temash grain was accepted to select for malt thus it fulfills EBC (23–35%) standard requirement. Generally speaking, temash malt with a higher thousand kernel weight can be expected to have a greater potential of grist extraction.

3.1.4. Hectoliter weight
The hectoliter weight of malted grain was significantly (P < 0.05) affected by germination temperature. The hectoliter weight values were 73.62, 73.33 and 72.90 kg/hL for samples germinated at 15, 18, and 21°C, respectively, all samples in hectar liter weight being significantly (P < 0.05) different from each other. Likewise, three germination time of 3, 4 and 5 days resulted in malt grain of significantly different values of hectoliter weight of 75.16, 73.08, 71.60 kg/hL, respectively. These values were higher than HLW of four malt barely varieties reported by (Galano et al., 2011) which ranged from 63.5 to 66.8 kg/hL. Similarly, hectoliter weights of malt barley grain were with the range of 67.4 to 70.70 kg/hL as reported by (Fekadu & Ayana, 2013). This could be because a loss in weight during malting was increased as germination time and temperature increased.

3.2. Effect of main factors germination temperature and time on malted grains size
Table 3 presents the data of malted grain size as influenced by the main factors germination temperature and time. Malted grain size retained on 2.8 mm screen decreased from 18.88 to 13.33% as temperature reduced from 21 and 18°C respectively. Similarly, malted grain retained on 2.5 mm screen size significantly (P < 0.05) decreased from 45.55 to 39.83% as germination temperature increased from 15 to 21°C. Germination time did not have significant (P > 0.05) affect on the percentage of grains retained on the 2.5 mm. Regarding the percentage of retained grain on the 2.2 mm screen the three germination temperatures exhibited significant (P < 0.05) differences with values of 28.39, 30.61 and 34.43% for the 15, 18 and 21°C temperatures, respectively. As germination temperature increased size reduction of the grains increased due to higher loss content associated with increased metabolic or enzymatic activity with the grain (Analytica-EBC, 1998). Similarly, the three germination times of 3, 4 and 5 days resulted in significant (P < 0.05) increase in the percentage of grains retained on 2.2 mm screen with values of 29.85, 31.58 and 30.97%, respectively. Malted grain size retained on TSR had values 7.25 and 7.88% for the sample germinated at 15 and 18°C, respectively, with no significant difference between them but are statically (P < 0.05) lower than the 12.41% recorded for the sample germinated at 21°C. Similarly, malted grain size retained on TSR had the highest value, 10.07%, and is significantly (P < 0.05) higher than 8.45% and 9.01% recorded for those with 3 and 4 days of germination time. These two

| Table 3. Grain size data of malted grains as affected by germination temperature and time |
|---------------------------------|----------------|----------------|----------------|-----------|
| GT(°C) | 2.8 mm (%) | 2.5 mm (%) | 2.2 mm (%) | TSR (%) |
| 15   | 18.81 ± 1.51a | 45.55 ± 2.12a | 28.39 ± 2.12a | 7.25 ± 0.99b |
| 18   | 18.88 ± 0.98b | 42.63 ± 1.73b | 30.61 ± 1.39b | 7.88 ± 0.54b |
| 21   | 13.33 ± 2.22c | 39.83 ± 2.96c | 34.43 ± 2.08c | 12.41 ± 2.14c |
| Gt(days) | 3 | 18.46 ± 2.17a | 43.24 ± 2.76a | 29.85 ± 2.84a | 8.45 ± 2.18b |
|      | 4 | 16.18 ± 3.33b | 43.23 ± 4.66b | 31.58 ± 4.22b | 9.01 ± 1.96b |
|      | 5 | 16.01 ± 3.40b | 42.95 ± 2.15b | 30.97 ± 1.74b | 10.07 ± 3.67b |
| LSD | 0.99 | 1.68 | 1.34 | 1.05 |
| CV  | 5.86 | 3.97 | 4.35 | 11.53 |
| Raw Temash | 21.47 ± 1.03a | 36.37 ± 0.83a | 36.16 ± 1.78b | 6.00 ± 0.69c |

Values are means ± standard deviation. Values within the same column with different superscript letters have significant (P < 0.05) differences. GT = germination temperature 15, 18 and 21°C and Gt = germination times 3, 4 and 5 days respectively. TSR = total sieve retain, CV = Coefficient of variation, LSD = least Significant difference.
Table 4. Physical properties data of malt flour as affected by germination temperature and time

| GT(°C) | MC (%) | AR(°) | BD(g/mL) |
|--------|--------|-------|----------|
| 15     | 7.44 ± 0.38* | 37.15 ± 1.07* | 0.88 ± 0.05* |
| 18     | 7.21 ± 0.79* | 37.27 ± 1.15* | 0.86 ± 0.01b |
| 21     | 6.09 ± 0.51b | 36.69 ± 1.05* | 0.84 ± 0.01* |
| GT(days) |        |       |          |
| 3      | 6.88 ± 0.75* | 36.84 ± 0.94* | 0.86 ± 0.02* |
| 4      | 7.00 ± 0.91* | 37.14 ± 1.13* | 0.87 ± 0.04* |
| 5      | 6.85 ± 0.88* | 37.13 ± 1.26* | 0.85 ± 0.02* |
| LSD    | 0.5    | 1.22  | 0.01     |
| CV     | 7.29   | 3.33  | 1.06     |
| Temash flour | 11.13 ± 0.32* | 40.22 ± 0.18* | 0.97 ± 0.15* |

Values are means ± standard deviation. Values within the same column with different superscript letters have significant (P < 0.05) differences. GT = germination temperature, MC = moisture content, AR = Angle of Repose, BD = bulk density, CV = Coefficient of variation, LSD = least Significant difference.

values were not different from each other. Generally, it can be seen that the majority of malted grains are of sizes of 2.5 mm to 2.2 mm and smaller in size than raw temash (Regasa, 2013).

3.3. Effect of main factors germination temperature and time on physical properties of malt flour

3.3.1. Angle of repose
The angle of repose data of temash malt flour obtained by different germination temperature and time are shown in Table 4. The angle of repose resulted insignificant (P > 0.05) difference due to the main factors germination temperature and time. The values were 37.15, 37.27 and 36.69° for malt flour germinated at 15, 18 and 21°C, respectively. Likewise, germination time did not show a significant difference in angle of repose with values of 36.84, 37.14 and 37.13° for samples with germination duration of 3, 4 and 5 days, respectively. Recently studied reports indicated that the angle of repose of malt flour was in the range from 30 to 45°(Al-Hashemi & Al-Amoudi, 2018) and that angle repose is in direct relationship with its moisture content (Al-Hashemi & Al-Amoudi, 2018). The malt flour does not stick together which implies better stability and lower flowability than raw temash flour.

3.3.2. Bulk density
Bulk density is the amount of sample by weight that is present in a defined volume. Bulk density values of the malt flour samples had shown significant (P < 0.05) difference due to germination temperature (Table 4). The highest mean value 0.88 g/mL was of sample germinated at 15°C and the lowest value 0.84 g/mL was of sample germinated at 21°C. In respect of germination time values had also shown significant (P < 0.05) differences. The highest value 0.87 g/mL was of sample germinated for 4 days and the lowest value 0.85 g/mL was of sample germinated for 5 days. The results were similar to the report by (Cornejo & Rosell, 2015) who indicated that the bulk density of malt flour of rice decreased from 0.79 to 0.70 g/mL as germination time increased. (Ocheme & Chirma, 2008) had also reported a decrease in bulk density of malt sorghum flour from 0.77 to 0.70 g/mL with increasing germination time. Table 4 shows that malted flour with the lowest moisture content had the lowest bulk density and the highest moisture content had the highest bulk density which implied bulk density of flour had a direct relationship with its moisture contents.

3.4. Effect of main factors germination temperature and time on functional properties of temash malt flour
Table 5 presents the data of functional properties of temash malt flour as influenced by the main factors germination temperature and germination time. Functional properties were defined as
those characteristics that govern the behaviour of constituents of food during processing, storage and preparation as they affect food quality and acceptability. Functional characteristics are important factors in formulation of new food products.

3.4.1. Water absorption capacity

The water absorption capacity (WAC) varied from 2.68 g/g for sample germinated at 15°C to 2.77 g/g for those germinated at 21°C and having significant (P < 0.05) difference between them as influenced by germination temperature. Germination time also showed significant (P < 0.05) difference in WAC value of malt flour with 2.50, 2.78, and 2.92 g/g for those germinated for 3, 4, and 5 days, respectively. Table 5 displays that as germination temperature and time increased water absorption capacity also increased. These values are similar to the finding by (Ocheme & Chinma, 2008), who reported water absorption capacity of germinated sorghum flour increasing from 1.22 to 1.38 g/g as germination time increased. This could be because water-holding components were modified during germination.

3.4.2. Swelling power

Data of swelling power in Table 5 indicated that malt flour germinated at 18 and 21°C had values of 0.28 and 0.29% swelling power with no significant difference between them but are significantly (P < 0.05) higher than the 0.22% recorded for samples obtained at 15°C germination temperature. On the other hand, the swelling power of the flours increased significantly (P < 0.05) as germination time increased with swelling power of 0.22, 0.26 and 0.32% for germination times of 3, 4 and 5 days, respectively. (Cornejo & Rosell, 2015) also reported an increase in the swelling power of millet flour as a result of the increase in germination time. Similarly, (Ocheme & Chinma, 2008), reported swelling power of germinated sorghum flour was increased from 0.22 to 0.23% as germination time increase.

3.4.3. Water solubility index

Table 5 also shows the water solubility index data of malt flours as influenced by germination temperature. The highest values were 24.17%, which belonged to samples germinated at 21°C and the 23.19% of malt flour germinated at 15°C with no difference (P > 0.05) between them. In respect of germination time, malt flour germinated for 4 and 5 days showed 23.95 and 22.41%, respectively, of water solubility index with no difference (P > 0.05) between them. Sample which germinated for shortest duration had the lowest (19.07%) water solubility index. The result agreed with the finding of (Cornejo & Rosell, 2015), who reported water solubility index of germinated rice flour which increased from 6 to 15% as germination time increased. This is confirmed with the action of enzymes in malted flour release water-soluble compounds.

| GT(°C) | WAC (g/g) | SP (%) | WSI (%) | DIS (%) |
|--------|-----------|--------|---------|---------|
| 15     | 2.68 ± 0.29b | 0.22 ± 0.02b | 23.19 ± 3.88a | 73.05 ± 1.35a |
| 18     | 2.75 ± 0.14a  | 0.28 ± 0.06a  | 18.05 ± 2.08b | 72.83 ± 2.04b |
| 21     | 2.77 ± 0.19a  | 0.29 ± 0.05a  | 24.17 ± 3.18a | 71.55 ± 2.73b |

| GT(days) | WAC (g/g) | SP (%) | WSI (%) | DIS (%) |
|---------|-----------|--------|---------|---------|
| 3       | 2.50 ± 0.18c  | 0.22 ± 0.01c  | 19.07 ± 2.45b | 70.61 ± 1.76c  |
| 4       | 2.78 ± 0.05b  | 0.26 ± 0.04b  | 22.41 ± 3.02a  | 72.33 ± 1.65b  |
| 5       | 2.92 ± 0.09a  | 0.32 ± 0.06a  | 23.95 ± 4.97a  | 74.50 ± 0.75a  |
| LSD     | 0.08 | 0.02 | 2.06 | 1.18 |
| CV      | 3.15 | 9.16 | 9.54 | 1.65 |
| Temash flour | 2.16 ± 0.15f | 0.06 ± 0.01* | 6.00 ± 0.64* | 67.67 ± 1.15* |

Values are means ± standard deviation. Values within the same column with different superscript letters have significant (P < 0.05) differences. GT = germination temperature 15, 18 and 21°C and Gt = germination time 3, 4 and 5 days respectively. WAC = water absorption capacity, SP = swelling power, WSI = water solubility index, DIS = dispersibility, CV = Coefficient of variation, LSD = Least Significant difference.
3.4.4. Dispersibility
The dispersibility of flour in water indicates its reconstitution ability. Dispersibility values of the malt flour samples had shown significant (P < 0.05) difference due to germination temperature (Table 5). The values 73.05 and 72.83% of samples germinated at 15 and 18°C, respectively, showed no significant difference (P > 0.05) while both values are significantly higher than the 71.55% of those germinated at 21°C. In respect of germination time values had also shown significant (P < 0.05) differences. The highest value 74.50% was of sample germinated for 5 days and the lowest value 70.61% was of sample germinated for 3 days. The results were similar to the report by (Kulkarni et al., 2001), who reported dispersibility of 63 to 79% for germinated sorghum flour. Malt flour with high the dispersibility is better in reconstitution.

4. Conclusions and recommendations

4.1. Conclusions
This study clearly showed that increasing germination temperature will result in decreased thousand kernel weight and bulk density of malt flour. Likewise prolonging germination time will decrease the HLW, TKW, and bulk density of malt flour. An increase in germination temperature and time can lead to an increase in the functional properties of malt flour water absorption capacity, swelling power, and water solubility index. Angles of repose of malted grain and flour will not be affected that much by germination. The majority of malted grains are of sizes of 2.5 mm to 2.2 mm and smaller than raw grains. The information generated regarding some engineering properties of native temash grain, malted grain, and its flour is useful in checking qualities of grains in marketing and flour processing, in the design of screens for cleaning of the grains, to design of storage and processing facilities of grains. It is also basic information to develop new products either from native temash or malt flour. Some physical parameters have shown that temash grain is suitable for malting to meet the growing shortage of malt barley in the brewing industry.

4.2. Recommendations
Temash barley is one of the best grains which such work has not been reported so far and therefore, it is recommendable to study the following for the future

- It is recommended that other researches to study the gluten content and paste properties of temash starch.
- It is recommended to study the amino acid profile of temash flours
- Study on colorimeter and oil absorption capacity of temash.
- Analyzing anti-nutrient and mineral content of temash grain
- Producing new products from temash either by blending with other flour or alone.

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Competing interests
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References
AACC. (2000). American Association of Cereal Chemists Inc. 10.
Al-Hashemi, H. M. B., & Al-Amoudi, O. S. (2018). A review on the angle of repose of granular materials. Powder Technology, 330, 397–417. https://doi.org/10.1016/j.powtec.2018.02.003
Analytico-EBC. (1999). European Brewing Convention Analysis Committee.
Aregbesola, O. A., Adedeji, M. A., & Ajibola, O. (2012). Moisture dependence of some properties of malted sorghum grains. American-Eurasian Journal of Agricultural and Environmental Science, 12(3), 365–368.
Bhople, S., Kumar, A., & Haldkar, P. (2017). Effect of moisture content on angle of repose for different cereals and pulses. JCS, 5(5), 2283–2286.

Cornejo, F., & Rosell, C. M. (2015). Influence of germination time of brown rice in relation to flour and gluten free bread quality. Journal of Food Science and Technology, 52(10), 6591–6598. https://doi.org/10.1007/s13197-015-1720-8

Elfawal, Y. (2009). Study on physical and engineering properties for grains of some field crop. Misr Journal of Agricultural Engineering, 26(4), 1933–1951.

Emire, S., Mersha, M., & Rakishit, S. (2006). Physicochemical properties, pasting behavior and functional characteristics of flours and starches from improved bean (Phaseolus vulgaris L.) varieties grown in East African. CIGR E- Journals, 8, 1–18.

Eyob, L. (2013). effect of processing on quality characteristics of pearl millet (pennisetum glaucum) based value added products. formulation: Preparation, functional properties and nutritive valu. Food and Nutrition Bulletin, 13, 324–327.

Fekadu, W., & Ayana, A. (2013). Improvement in grain yield and malting quality of barley (Hordeum vulgare L.) in Ethiopia. Ethiopian Journal of Applied Science and Technology, 4(2), 37–62.

Galano, T., Bultosa, G., & Fininsa, C. (2011). Malt quality of 4 barley (Hordeum vulgare L.) grain varieties grown under low severity of net blotch at Holetta, west Shewa, Ethiopia. African Journal of Biotechnology. Hunduma, T. (2006). Local crop genetic resource utilization and management in Gindeberet, west central Ethiopia.

Kaleem, F. H., Ismail, Z. E., & Abd Hakim, G. R. (1993). Grain straw mixture and blower characteristics. Misr Journal of Agricultural Engineering, 10, 369–382.

Kochhar, A., & Hira, C. K. (1993). Nutritional and cooking evaluation of greengram (Vigna radiata L. Wilczek) cultivars. Journal of Food Science and Technology, 34(6), 328–330.

Kulkarni, K. D., Kulkarni, D. N., & Ingle, U. M. (2001). Sorghum malt-based weaning food formulations: Preparation, functional properties, and nutritive value. Food and Nutrition Bulletin, 13(4), 1–7. https://doi.org/10.1177/016364126589101300401

Lee, D. S., Yam, K. L., & Piergianni, L. (2008). Food packaging. Food Packaging Science and Technology.

Lewis, M. J. (1987). Physical properties of foods and food processing systems Ellis Horwood, England and VCH Verlagsgesellschaft.

Mirhosseini, H., & Amid, B. T. (2013). Effect of different drying techniques on flowability characteristics and chemical properties of natural carbohydrate-protein gum from durian fruit seed. Chemistry Central Journal, 7(1), 1. https://doi.org/10.1186/1752-153X-7-1

Mohammed, H., & Getachew, L. (2009). An overview of malt barley production and marketing in Arsi. In Proceedings of the Workshop on Constraints and Prospects of Malt Barley, Production, Supply, and Marketing, Arsi (Vol. 15, pp. 1–25).

Mussatto, S. I., Dragone, G., & Roberto, I. C. (2006). Brewers spent grain: Generation, characteristics and potential applications. Journal of Cereal Science, 43(1), 1–14. https://doi.org/10.1016/j.jcs.2005.06.001

Ochene, O. B., & Chinma, C. E. (2008). Effects of soaking and germination on some physicochemical properties of millet flour for porridge production. Journal of Food Technology, 6(5), 185–188.

Oladele, A. K., & Aina, J. O. (2007). Chemical composition and functional properties of flour produced from two varieties of Tigernut (Cyperus esculentus). African Journal of Biotechnology, 6(21), 2473–2476. https://doi.org/10.5897/AJB2007.000-2391

Rahman, M. S. (1995). Food properties handbook. CRC Press.

Rameshbabu, M., Jayas, D. S., Muir, W. E., White, N. D. G., & Mills, J. T. (1996). Bulk and handling properties of hulless barley. Canadian Agricultural Engineering, 38(1), 31–35.

Regosa, T. (2013). Effect of production sites and seed age on yield components, yield and seed quality of malt barely varieties in Arsi highlands [M.Sc. Thesis]. Haramaya University.

Shumaita Jan, S. I. (2015). Effect of Physical properties on flowability of commercial rice flour/powder for effective bulk handling. International Journal of Computer Applications, 975–8887.

Sze, T. K., & Sathe, S. K. (2000). Functional properties and in vitro digestibility of almond (Prunus dulcis L.) protein isolate. Food Chemistry, 69(2), 153–160. https://doi.org/10.1016/S0308-8146(99)00244-7

Tavakoli, M., Tavakoli, H., Rajabipour, A., Ahmadi, H., & Gharib-Zahedi, S. M. T. (2010). Moisture-dependent physical properties of barley grains. International Journal of Agricultural and Biological Engineering, 2(4), 84–91.
