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Effects of Germination Temperature and Time on Malt Quality of *Temash* Barley (*Hordeum vulgare* L.)

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Abstract: Temash is one of barley varieties and traditionally used for kolo and malt. This study was conducted on its use for malt production. It was aimed to evaluate the effect of germination temperature and time on malt quality. The experiment consisted of the factorial design of two factors namely, germination temperature (15, 18 and 21°C) and germination time (3, 4 and 5 days), and was laid out in 3x3 completely randomized design with three replication. Each sample was steeped at room temperature (24°C) for 37 hrs and kilned at 50°C for 24 hrs. Samples subjected to treatments were evaluated for malt quality parameters. Temash grain proximate compositions were also analyzed. Regarding malt quality, germination at 18°C temperature for 4 days had better results with relatively higher hot water extraction and friability and lower weight loss. In the case of the grain quality requirements, temash grain fulfilled the acceptable range of the European Brewery Convention (EBC) and Asela Malt Factory Standard (Ethiopia).

Keywords: Germination, Malt Quality, Physical Properties, Temash Barley Grain

1. Introduction

Barley (*Hordeum vulgare* L.) is a monocotyledonous herb belonging to family of *triticeae* and its evolution is related to two other small-grain cereal species, wheat and rye. The first sign of the pre-agricultural gathering of wild barley are found in the region of Fertile Crescent in south-western Asia, 22,000 years ago, and domestication of barley has occurred independently also in Central Asia [1]. Today, barley is a significant crop plant globally, and it is mainly exploited as feed or as a raw material for malt production. However, recently due to high content of soluble dietary fiber present in barley and its proven health benefits, barley is used as a food ingredient [2]. Barley grain is an excellent source of soluble and insoluble dietary fiber, B-complex vitamins, minerals, and phenolic compounds. The effectiveness of barley β-glucans in food products for lowering blood cholesterol has been documented in a number of studies [3]. Hulled barley grain consists of about 56 to 67% starch; protein contents varied from 8.2 to 14.5%, ß-Glucan content is typically 2.5 to 5.5% [4]. Contents of fat and ash in different barley grown in Ethiopia are 3.13 to 6.4% and 1.43 to 2.27%, respectively [5].

Barley is a crop of ancient origin in Ethiopia and the country is considered as a center of barley diversity [6]. Ethiopia is the second largest producer of barley in Africa next to Morocco, accounting for about 26 percent of the total barley production in the continent [7]. Barely is the most important cereal crop with total area coverage of 960,000 hectares and total annual production of about two million (2,024,921) metric tons in Ethiopia [8]. The main barley producing regions in Ethiopia are Shewa, Arsi, Gojam, Gonder, Welo, Bale, and Tigray, where more than 85% of the country's total production comes from (Ethiopian Central Statistical Authority on Agricultural sample survey, 2001).

The history of modern malting in Ethiopia started in 1974 at St. Georege brewery. Asella malt factory was established in 1984 with the aim of supplying malt to local breweries. [5].

Barely source for this factory is from south eastern part of Ethiopia in Aresi and Bale administrative zone [9]. Ethiopia has a shortage of malt barley to meet the demand of the local breweries. This may be due to inadequate number of malt factories in Ethiopia beside Asella malt factory (older malt factory) and Gonder malt factory which is a recently established. Sometimes these factories are importing barley malt from Belgium and Holland to meet demand in the country as the local malt barely has longer germination time than imported barely [10]. Malt is the major raw material for beer production. Malt prepared from barley is by far the most important due to its high content of enzymes. However, malt from other cereals has attracted a lot of attention in recent years because of economic considerations and local availability especially rice and sorghum. [11]. Sorghum malt is the most appropriate alternative for brewing next to barley [12].

There are two types of barley that farmers grow in Ethiopia: food barley and malt barley. The majority of barley that farmers grow is food barley and it is the main ingredient for several staple dishes such as *injera*, porridge, and bread. Barely production food barely type is higher than malt barely [13]. Ethiopian Institute for Agricultural Research (EIAR) with the support from USAID at different research centers, works on the barley improvement program aims to raise the production of barley and barely breeders are developing many barely varieties for malt beverages. As a result Beka, Holker, HB-120, HB-52, HB-1533 and Miscal-21 are among the officially released, popular malt barley varieties in Ethiopia [14] and three years ago (2016) two malt barely varieties HB1963 and HB 1964 were released by Holetta Agricultural Research Center. *Temash* (*Hordeum vulgare* L.) grain is also one of barely varieties available in Ethiopia [15]. It is grown at different locations in the country and mainly consumed after roasting as *kolo (*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 *qaxxee* due to eating quality, *temash* in Amharic and sometimes it is called naked barely [15]. It is barely size and shape but different in husk properties. *Temash* grain is used for *kolo* (eaten between meals, while having traditional coffee), *besso (*flour ofroasted of *temash* grain), *chuukko (*mixture of besso and clarified butter) and malt for *tella*.

As a barely variety, it would be wise to study the potential of *temash* grain for beer production. The effect of different parameters during germination and subsequent processes need to be investigated.

Limited work has been reported so far and this project was proposed with the aim of evaluating the suitability of *temash* grain for malt extraction.

1.1. General Objective

To study impact of germination conditions on qualities of t*emash* malt at different germination temperature and time.

1.2. Specific Objectives

1) To determine the proximate composition of *temash* raw grain.
2) To study physical properties of raw *temash* grain
3) To understand the extraction potential and evaluate the quality of malt, which could be produced from *temash* as influenced by different germination temperature and time.

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 malt preparation were carried out at Haramaya University, at Food Science and Postharvest Technology and Central Laboratories. Studies on physical properties of grain were conducted at Hawassa and Wolkite Universities. Proximate analysis of *temash* grain was done at Debrezeit Agricultural Research Center, while quality evaluation ofmalted *temash* grainwas carried out at Asella Malt factory.

2.2. Experimental Materials

Temash barely variety grains were obtained from a local market in Degam wereda, in North shoa, Oromia region.

Figure 1. *Temash barley 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 threelevels 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 below.

Table 1. *Experimental layout.*

Germination time (days)	Germination Temperature (°C)		
	T_1 (15)	T_2 (18)	T_3 (21)
D_1 (3)	T_1 D_1	T_2 D_1	T_3 D_1
D_2 (4)	T_1 D_2	T_2 D_2	T_3 D_2
D_3 (5)	T_1 D_3 T_1 D_3	T_2 D_3	T_3 D_3

Where T_1, T_2 and T_3 represented 15, 18 and 21°C temperature of germination, respectively and D_1, D_2 and D_3 represented 3, 4 and 5 days, respectively of germination time.

2.4. Sample Grain and Malt Preparation

Temash (Hordeum vulgare. L) 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 (1.2kg) for each treatment was used in this study. Each sample was soaked in tap water by a ratio of 100g: 223mL for 37 hours at room temperature and water exchange with aeration was carried out at 8 hours interval. After steeping each sample was germinated at different temperatures and time in relative humidity chamber with 89.6% RH (Termaks chamber KBP 6395F, Bergen, Norway) according to time-temperature combinations in Table 1. Each sample was sprayed in a nylon bag with 100 mL of distill 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 rootlets 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.

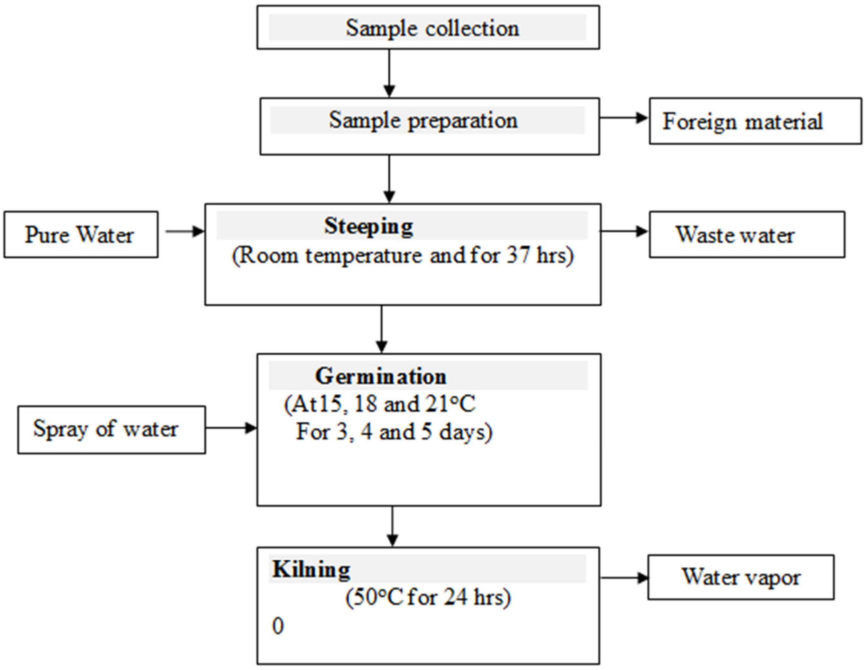

Figure 2. *Flow diagram of malt preparation [16].*

2.5. Proximate Analysis and Grain Qualities

2.5.1. Ash

Ash content was determined according to the method of [17]. Ground sample (3g) was taken into each preheated crucible. Crucible sample was placed into the muffle furnace (type ELF11, England) set at 550°C till constant weight of grayish ash was obtained. After incinerated, crucible sample was transferred to the desiccators until cool to room temperature and the ash sample was calculated by using following formula.

$$\text{Ash content (\%)} = \frac{M3 - M1}{M2 - M1} \times 100 \quad (1)$$

Where: M1= mass of crucible (g)
M2= sample mass with crucible (g) and
M3= mass of crucible and dried sample (g)

2.5.2. Moisture

Malt moisture content of sample was determined according to the [18]. *Temash* malt was milled by disc mill (Buhler, Braunschweig, Germany) after hand polishing. Sample flour (5 g) was dried in oven at 103°C till constant weight. The mass loss on dry mass was calculated as percent of moisture by using the following formula.

$$\text{MMC (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \quad (2)$$

Where: MMC = Malt Moisture content
W_1 = Weight of the Petri dish
W_2 = Weight of the Petri dish and the sample before drying
W_3 = Weight of the Petri dish and the sample after drying

2.5.3. Crude Protein

The amount of crude protein in *temash* grain was determined according to [17]. The method includes digestion, neutralization and titration process. Sample was analyzed for crude protein using the micro-Kjeldahl method. Sample (1.0 g) was added in to a kjeldhal digestion flask. Catalyst mixture (Na_2SO_4 mixed with anhydrous $CuSO_4$ in the ratio of 10:1) of 1.0 g was added. After addition of 5 mL of H_2SO_4, digestion flask was placed in the digester and the temperature was brought to 350°C allowed digesting for over 2 hour until digestion is completed. The flask was removed from the digester and allowed to cool. After it cooled, the content in the flask was diluted by 30 mL of distilled water followed by 25 mL and a concentrated 40% NaOH was added into the digestion flask to neutralize the acid and to make the solution slightly alkaline. The contents was distilled immediately by inserting the digestion tube line in to the receiver flask that contains 25 mL of 4% boric acid solution and about 150 mL of distillate was collected. Finally, the distillate was titrated by a standard acid (ca 0.1N HCl). The percentage of nitrogen was converted to percentage of protein by using appropriate conversion factor (% protein = F x % N).

$$N = \frac{V_{HCl} - V_{blank} \times N_{HCl} \times 14}{M} \times 100 \quad (3)$$

Where: V_{HCl} is volume of HCl consumed to the end point of titration, V_{blank} is volume of HCl consumed for blank test, N_{HCl} is the normality of HCl (used often is 0.1N) M is sample weight on dry matter basis, 14.00 is the molecular weight of nitrogen, N is Nitrogen (%), F is conversion factor (6.25).

2.5.4. Crude Fat

The fat content was determined by soxhelet extraction method according to [17]. Sample (3g) was weighed and added in to a thimble and the thimbles with the sample was placed in 50 mL beaker and dried in an oven for 2hrs at 110°C. A 150-250mL dried beaker was weighed and rinsed several times with petroleum ether. The sample contained in the thimbles was extracted with petroleum ether in soxhlet extraction apparatus for 6-8 hours. After the extraction complete, the extracted fat was transferred in to a pre-weighed beaker (Wi), the beaker with extracted fat was placed in a fume hood to evaporate the solvent on a steam bath until no odor of the solvent is detectable. Then the beaker with content was dried in an oven for 30 minutes at 100°C. Finally, the beaker with its content was removed and cooled in a desiccator and weighed (Mf). The amount of fat in sample was calculated by using the following formula.

$$\text{Fat (g/100g)} = \frac{\text{Mf} - \text{wi}}{\text{M}} \times 100) \quad (4)$$

Where Mf: weight of fat with beaker (g) Wi: weight of beaker (g) and M: sample weight (g)

2.5.5. Crude Fiber

The crude fiber content of sample was determined by using following method of [17]. Sample of 2 g was taken and placed in 1000 ml beaker. 200 ml solution of 1.25% H_2SO_4 was added in the beaker. The sample was then digested by boiling for 30 min. Then it was filtered by using suction apparatus. The residue was washed with hot water until it became acid free. The residue was again transferred to 1000 ml beaker and boiled with 200 ml solution of 1.25% NaOH for 30 min. It was again filtered and the residue was transferred to pre-weighed crucible and dried in an oven at 100°C for 24 hr till constant weight was obtained. Then the dried residue was charred on a burner and ignited into muffle furnace at 550 ºC for 6 hours cooled in desiccators and weighed. The loss in weight during incineration represents the weight of crude fiber in sample. The crude fiber content was calculated as shown below.

$$\text{Crude fiber (\%)} = \frac{\text{Weight of residue} - \text{weghit of ash}}{\text{Weight of sample}} \times 100 \quad (5)$$

2.5.6. Utilizable Carbohydrate

Carbohydrate content was estimated by subtracting the sum of other constituents (percentages of moisture, crude fat, crude fiber, crude protein and ash contents) from 100 [19] according to the following equation.

$$\text{Utilizable Carbohydrate (\%)} = 100 - \{\text{Moisture (\%)} + \text{fiber(\%)} + \text{Protein (\%)} + \text{Fat (\%)} + \text{Ash (\%)}\}$$

2.5.7. Germination Energy

It was done by placing 100 representative grains on filter paper with 4ml water in closed petridshs and allowed to germinate at temperature of 25°C and 89% relative humidity. Germinated seeds after 72 hours was counted and expressed in percentage [20].

$$\text{GE(\%)} = \frac{\text{Number of seed germinated}}{\text{Total number of seeds set for test}} \times 100 \quad (6)$$

2.6. Determination of Temash Malt Quality

2.6.1. Malting Weight Loss

The malting weight loss during malting conditions was calculated according to the method described by [21].

$$\text{MWL(\%)} = \frac{\text{Weight of grain used for malt} - \text{weight of polished malt}}{\text{weight of grain used for malt}} \times 100 \quad (7)$$

2.6.2. Wort Viscosity

The viscosity of the wort is determined using calibrated viscometer (model D1131, Spain), Krebs stormer type in milipoise according to [18].

2.6.3. Diastatic Power

The diastatic power was determined according to the [18] method 4.12. 20 gram of milled malt was dissolved in 480 mL cold distilled water and heat into a water bath at 40°C for an hour. The wort was cooled and 50 mL filtrate was used for analysis after 200 mL filtrate was rejected. Four flasks (label 1 & 2 for main analysis and 3 and 4 for blank analysis) were prepared. Starch solution (10 g starch in a small amount of water) was transferred to each four flask. Acetate buffer (5 mL) was added to main flasks and was shaken for 20 minutes. Malt extract (5mL) was added also to main flasks to deactivate diastase enzymes after 20 minutes. Sodium hydroxide of 2.5mL and 5 mL of extract was added to blank flasks respectively after gently shaking. All the four flasks are making to 200 mL with distilled water. 50 mL from each flask was transferred to four corresponding 150 mL flasks. Iodine solution (25 mL) and 3mL of NaOH was added for each. After 15 minutes solution was acidified by addition of 4.5 mL of H_2SO_4. Finally all four solutions in 150mL flask were titrated by sodium thiosulfate to disappearance of the iodine to blue color. The volume of sodium thiosulfate consumed to reach the titration end point was read from the burette and calls it "B" and Diastatic power was calculated by the following equation:

$$\text{Diastatic power (wet basis)} = (B - A) \times 23 \quad (8)$$

Where: A is the volume of sodium thiosulfate in milliliter used for direct titration,

B is the volume of sodium thiosulfate in milliliter used for blank correction,

23 is conversion factor for the specific procedure.

2.6.4. Hot Water Extract

The hot water extract was determined according to the [18] mashing method. No.4.51. Malt sample (50 g) from each treatment were weighed and added in to weighted mash beaker. The mash beaker was placed with content on balance accurate to within ±0.05 g under 750 g load and adjust weight of malt to 50 ± 0.05 g by removing excess in to tared dish for moisture determination. The mashing procedure was done by adding 200 mL of distilled water at 45°C to 50 g of ground malt, and then the vessel was placed in a mashing apparatus. The sample was held at 45°C for 30 min, then the temperature was raised to 70°C by 1°C for every 1 min increase for 25 min, and then 100 mL 70°C distilled water was added to each sample and held at 70°C for 1 h. After 10 min saccharification test was done with 0.02 N iodine solutions. At the completion of mashing, the sample was cooled to room temperature and then distilled water was added to adjust weight of the content in mash vessel to 450 g. The extract was filtered through 32 cm fluted filter paper in 20 cm funnel. The density of the clear wort was determined using density meter (model DMA35 basic, Austria) and expressed in degrees Plato (°P). The extract obtained was converted and expressed in percentage on wet basis (% wb) using the following equation.

$$\text{Extraction of malt (\%, wb)} = P\left(\frac{800+M}{100-P}\right) \quad (9)$$

$$\text{Extraction dry basis (\%)} = \frac{E*100}{100-M}$$

Where: P is g extract in 100 g wort (°P), E=extract as wet bases and M is % moisture of the malt

2.6.5. Friability

Temash malt (50 g) was used for friability test by Pfeuffer Friabilimeter according to method 4.15 [18]. After 8 minutes non-friable fraction was weighed and record as R value. Percentage of friability then expressed as shown below.

$$\text{Friability (\%)} = 100 - R \times 2 \quad (10)$$

Where: R is mass of non friable one retained over the Friabilimeter sieve

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. Proximate Composition of Temash Grains

3.1.1. Crude Protein

The proximate compositions of raw *temash* grain are given in Table 1. Crude protein content was 10.80%. The result was similar with the 10.78% report of [13] who studied improvement of malting qualities of barley varieties in Ethiopia. According to European Brewery Convention standard protein content of barley for malt production is 9 to 11.5% and not greater than 12.50% as Asella malt factory standard. Due to this result *temash* barely was in acceptable range to use as malt. According to [22] the desired protein content of malt barley lies in the range of 9 to 12%. High protein content in malt barley is not desirable because it leads to a reduction of malt extract caused by proportionally lower carbohydrate content [23]. However, if the protein content of malt is too low, brewing performance may be impaired through poor yeast amino acid nutrition. Similarly [5] reported that barley used for malt should have a grain protein concentration below 11.5%, as higher protein content will deteriorate malting produce and final beer quality.

3.1.2. Moisture Content

Grain moisture content for *temash* grain was 11.13% (Table 1). This result was similar to the result of [5] which varied between 10.00 to 11.90%, but greater than the 9.50 to 9.60% reported by [24] The variation could be due to the moisture content depends on the storage condition and hydroscopic capacity of the grain. Moisture levels for barley malt need to be low enough to inactivate the enzymes involved in seed germination as well as to prevent heat damage and the growth of disease microorganisms. According to [25] the maximum industrial specification of malt barley moisture content for safe storage is not over 12% whereas, in the EBC standard, a moisture content of 12 to 13% is accepted. In this study, the moisture content was in the acceptable range.

Table 2. *Proximate composition, physical properties and quality of temash grains.*

Proximate composition (%)						Physical property (mm)		Grain quality (%)
CP	**MC**	**Crude fat**	**Crude fiber**	**Ash**	**UCHO**	**GMD**	**sphericity**	**Germination Energy**
10.8±0.36	11.13±0.32	1.92±0.05	2.44±0.35	1.95±0.03	71.76±0.94	4.07±0.01	0.52±0.01	96±1.00

Values are means ± standard deviation CP = crude protein, MC = moisture content, UCHO = utilizable carbohydrate, GMD = geometric mean diameter

3.1.3. Crude Fat

As shown in Table 2, crude fat of *temash* grain was 1.92%. This value was less than the crude fat contents of 2 to 3% of hullness barley reported by [26] and [27]. The crude fat content of different barley varieties in Ethiopia are in range of 2.20 to 6.40% as reported by [28] and also higher than value of crude fat content in this study. Also, other study by [29] reported crude fat contents of 3.60% in barely. These differences probably due to variety, environmental factors and management in pre and post harvest conditions that could affect the proximate composition [30].

3.1.4. Crude Fiber

The mean value for *temash* grains crude fiber was 2.44%. The result obtained from this study was higher than the 1.74% reported by [31] and lower than the 9.65% of *Andu-12-60B* barley variety reported by [5]. The differences could be due to variety or environmental variation of growing areas.

3.1.5. Ash Content

As shown in Table 2, ash content of *temash* grains was 1.95%. The result obtained agreed with the 1.50 to 2.50% reported by [27]. It was also in agreement with [5] who discovered values of the 1.5% to 2.50% for hulless barely. Furthermore, it was in close agreement with [5] who indicated ash content of different barely varieties were ranging between 1.43 to 2.34%.

3.1.6. Utilizable Carbohydrate

The mean value for *temash* utilizable carbohydrate was 71.76%. The result obtained from this study was in closer agreement with utilizable carbohydrate of wheat grains reported by [32] which was 72.73% and higher than the findings reported by [31] who noticed barely grain utilizable carbohydrate (68.9%). The variation could be due to utilizable carbohydrate value was depending on other composition present in that grain.

3.1.7. Geometric Mean Diameter and Sphericity

Geometric features of grains including barley are very important in the design of food engineering processes, such as air transport, drying, milling, and malting. In particular, kernel size and uniformity are important determinants of the malting quality [33].

The geometric mean diameter of the *temash* grain was 4.07 mm (Table 2). This value was less than the geometric mean diameter of 4.34 to 4.51 mm of different barley reported by [34] and higher than the geometric mean diameter of 3.88 mm of *PBW 621* wheat at 12% moisture content reported by [35]. Also, another study by [36] reported a geometric mean diameter of 4.23 to 4.75 mm in barely. These differences probably due to variety and moisture levels of grain.

As shown in Table 2, the sphericity of the *temash* was 0.52 mm. The result obtained from this study was in closer agreement with sphercity of wheat reported by [34] which was 0.53 to 0.59 mm and higher than the findings reported by [36] who noticed barely sphericity 0.47 to 0.49 mm. The result was also higher than the report of [34] who found the sphericity of *Oahin-91* and *Sur- 93* barely varieties result in range 0.44 to 0.46 mm. It is, therefore, *temash* is elliptical in shape rather than circular and important to design and construction of mesh sizes to handle these seeds efficiently during industrial handling and processing.

3.1.8. Germination Energy

The germination energy analyzed for *temash* grain is given in Table 2. Germination energy is the determination of the percentage of grains that can be expected to germinate fully if the sample is malted normally at the time of the test. Germination energy of grains was 96%. The result obtained was in close agreement with those of earlier values 96 to 98.50% reported by [5] who studied germination energy of different malt barely. According to the EBC standard, the minimum germination energy requirement for malt barley is 96% and [22] also reported germination energy malt barley after three days should be greater than 95%. The germination energy result of *temash* grains included in this study fulfilled minimum germination energy value and thus, the *temash* barley varieties studied to meet the germination energy requirements for the malting and brewing industries.

3.2. Effect of Main Factors Germination Temperature and Time on Temash Malt Qualities

Table 3. *Quality attribution of temash malt as affected by germination temperature and time.*

	WL (%)	**MC (%)**	**HWE (%, db)**	**Viscosity (mp)**	**Friability (%)**	**DP (WK°)**
GT(°C)						
15	$10.70±2.13^b$	$7.44±0.38^a$	$79.43±2.79^b$	$1.73±0.29^a$	$61.61±8.64^b$	$162.95±12.75^c$
18	$10.77±2.54^b$	$7.21±0.79^a$	$81.87±3.24^a$	$1.82±0.10^a$	$64.16±11.39^a$	$202.72±5.63^a$
21	$12.44±1.67^a$	$6.09±0.51^b$	$81.00±2.64^a$	$1.59±0.16^b$	$64.25±5.93^a$	$188.05±11.20^b$
Gt(days)						

	WL (%)	MC (%)	HWE (%, db)	Viscosity (mp)	Friability (%)	DP (WK°)
3	9.00±1.25[c]	6.88±0.75[a]	78.32±2.16[b]	1.86±0.15[a]	54.44±3.61[c]	176.98±22.18[b]
4	11.24±1.13[b]	7.00±0.91[a]	81.78±3.19[a]	1.73±0.17[b]	67.23±8.41[b]	185.27±18.82[ab]
5	13.67±0.92[a]	6.85±0.88[a]	82.20±1.92[a]	1.54±0.20[c]	68.34±5.15[a]	191.47±16.26[a]
LSD	0.64	0.5	1.78	0.09	0.99	8.82
CV	5.71	7.29	2.23	5.53	1.58	4.82

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. WL = weight loss, MC= moisture content, HWE= hot water extract, DP = Diastatic power, WK = Windich Kolbach, mp = milipoise, CV = Coefficient of variation, LSD = Least Significant difference.

3.2.1. Malt Weight Loss

Table 3 presents data of *temash* malt weight loss as affected by germination temperature and time. Malt weight loss can be attributed to the loss of soluble substances in the steeping, respiration during germination and the removal of rootlets from malt. The weight loss of malt varied from 10.70% for the sample germinated at 15°C to 12.44% for those germinated at 21°C and having significant (P<0.05) difference between them. Germination time also showed significant (P<0.05) differences in malt weight loss with the values 9.00, 11.24 and 13.67% for those germinated for 3, 4, and 5 days, respectively. As germination temperature and time increased malt weight loss also increased. These values are similar to the finding by [24] who studied malt qualities on four malt barley varieties grown in Ethiopia the loss of which ranged from 10.46 to 13.14%. Malt weight loss of 10 to 20% is expected for the industrially prepared desirable barley malt [23] but, lower malting loss is an economic consideration. The loss associated with malting increased as germination time and temperature increased. This could be due to the respiration of grain during steeping and starch loss during germination.

3.2.2. Malt Moisture Content

The malt moisture content of *temash* data obtained by different germination temperature and time are shown in Table 3. The moisture content of the *temash* malt also showed significant (P<0.05) difference attributed by germination temperature. The highest value of 7.44% belonged to samples germinated at 15°C whereas the next higher value was 7.21% of *temash* malt germinated at 18°C, with no significant difference between them. Malt moisture content was not affected by germination time with values of 6.88, 7.00 and 6.85% for duration 3, 4 and 5 days, respectively. The result agreed with range 3.60 to 9.60% reported by [5]. Similarly malt moisture of barley varieties which ranged from 6.40 to 7.10% were reported by [24]. The variation in malt moisture content may be probably due to grains type, drying temperature and drying methods.

3.2.3. Hot Water Extract

It measures soluble materials from the malt when some hydrolytic enzymes have acted optimally. The hot water extract varied from 79.43% for samples germinated at 15°C to 81.87% for those germinated at 18°C and having significant (P<0.05) difference between them. Germination time also showed significant (P<0.05) difference in hot water extract and varied from 78.32% for sample germinated for 3 days to 82.20% for the sample germinated for 5 days. There was no significant (P>0.05) difference between the samples germinated for 5 days as compared to those which had average value of 81.78%. These values are similar to the finding by [37], who indicated that hot water extract ofsorghum grains malt germinated for 2 to 6 days increased from 66.50 to 85.05%. It is also supported by hot water extract of barley malt reported by [5] which values were in the range 73.85 to 80.9%. This finding also agreed with the result reported by [24] who stated the fine hot water extract of malted barley ranged from 76.60 to 79.70%.

3.2.4. Wort Viscosity

Data of wort viscosity in Table 3 indicated that malt germinated at 15 and 18°C had values of 1.73 and 1.82 mp wort viscosity with no significant difference between them but are significantly (P<0.05) higher than the 1.59 mp recorded for samples obtained at 21°C germination temperature. On the other hand, the viscosity of wort decreased significantly (P<0.05) as germination time increased with wort viscosity of 1.86, 1.73 and 1.54 mp for germination time of 3, 4 and 5 days, respectively. The decrease may be due to further breakdown of the larger molecules of the starch by enzymes to smaller molecules as germination time extends. According to [38], high levels of viscosity reduce the efficiency of breweries. Due to this difficulty with beer filtration, low viscosity is a desirable attribute of the wort is important.

3.2.5. Friability

Similarly, malt germinated at 18 and 21°C had values of 64.16 and 64.25% friability with no significant difference between them but are both significantly (P<0.05) higher than the 61.61% recorded for samples obtained at 15°C germination temperature. On the other hand, the friability of the malt increased significantly (P<0.05) as germination time increased with values of 54.44, 67.23 and 68.34% for germination time of 3, 4 and 5 days, respectively. [5] reported that the friability of barley malt varied from 33.70 to 90% and the low value indicted under modification. The result of the *temash* malt friability value agreed with the result obtained by [39] and disagreed with EBC standards. This could be probably due to the drying temperature and moisture content of the final malt.

3.2.6. Diastatic Power

Diastatic power, the total activity of starch degrading enzymes in barley malt, is considered to be an important quality characteristic for malting and brewing [40]. The diastatic power of *temash* malt also showed significant (P<0.05) differences as affected by germination temperature and time. The highest value (202.72 WK°) of the sample germinated at 18°C and lowest value (162.95 WK°) for those germinated at 15°C temperature. Generally, an increase in germination temperature increases diastatic power. Increase in temperature increases chemical reaction by providing more activation energy. This actually by enzymes is a biochemical action. Germination time also showed significant (P<0.05) difference in diastatic power and varied from 176.98 WK°for sample germinated for 3 days to 191.47 WK° for the sample germinated for 5 days. The intermediate value 185.27 WK° obtained for samples germinated for 4 days is not statistically different (P>0.05) from both the highest and lowest values indicated. [37], reported the diastatic power of sorghum malt which having much lower values from current finding ranged from 66 to 108 WK° as germinated time varied from 2 to 3 days.

3.3. Interaction Effect of Germination Temperature and Time on Temash Malt Qualities

3.3.1. Malt Weight Loss

Table 4 presents data of *temash* malt weight loss as affected by the interaction of germination temperature and time. Values of malt weight loss were significantly (P<0.05) different from each other. Statistically, the highest (14.24%) was of the sample germinated at 21°C for 5 days whereas the lowest value (8.67%) is of sample germinated at 15 for 3 days. The weight loss affect is dominated by germination time in the interaction of the two factors. Within each group of germination temperature values increased significantly as the time increased from 3 to 4 and 5 days. The changes across the temperatures were not that much conspicuous to be noticed especially for the 15 and 18°C. The result obtained was similar to [41] who indicated that sorghum malt had value in range 7.1 to 10.6%. According to their report malt weight loss of barley is higher than the other cereals and supports this finding.

3.3.2. Moisture Content Temash Malt

The moisture content data of the malted flours is presented in Table 4. The highest average moisture content values of malted flour varied numerically between 7.25 and 7.79% with no statistical difference among them. These values belonged to the combination of the 15 and 18°C temperatures with the 3 and 4 days. The lowest mean temperature value *i.e* 5.88 to 6.45%, were of the remaining treatment combinations characterized by long germination time. They did not show significant (P>0.05) difference among them. These values are similar to the finding by [37], who reported the moisture content of sorghum malt dried at 50°C for 24 hours ranged from 7 to 7.13%. According to the quality standards of Asella Malt Factory, the maximum industrial specification of barley malted moisture content is 5.8%, whereas, in the EBC standard, a malt moisture content of 3 to 5.8% is accepted. In this study, the malt moisture content in all combinations was above the acceptable range. However, at this moisture level the *temash* malt can be stored as shelf-stable for certain duration since moisture 6.40 to 7.10% is still regarded low enough to prevent mold infestations as reported by [42].

Table 4. *Malt qualities data of malted grains as affected by interaction of germination temperature and time.*

GT*Gt	WL (%)	MC (%)	Friability (%)	HWE (%, db)	DP (WK°)	Viscosity (mp)
15*3	8.67±0.58^{d}	7.25b±0.47^{ab}	51.63±0.65^{e}	76.71±1.34^{d}	151.00±4.69^{f}	2.03±0.11^{a}
15*4	10.07±0.40^{c}	7.33±0.15^{a}	61.72±0.97^{c}	79.20±0.49^{cd}	163.92±11.96^{ef}	1.75±0.10^{b}
15*5	13.37±0.46^{ab}	7.73±0.35^{a}	71.48±1.25^{b}	82.37±2.26^{b}	173.94±9.45^{de}	1.45±0.10^{c}
18*3	7.81±0.29^{d}	7.40±0.50^{a}	52.53±0.80^{e}	79.27±2.82^{cd}	181.66±14.40d^{c}	1.76±0.06^{b}
18*4	11.13±0.32^{c}	7.79±0.52^{a}	78.36±1.32^{a}	85.58±0.56^{a}	190.04±11.17^{bc}	1.90±0.10b^{a}
18*5	13.39±1.42^{ab}	6.45±0.74^{bc}	61.58±1.14^{c}	80.77±1.14^{bc}	192.46±8.53^{bc}	1.78±0.12^{b}
21*3	10.52±0.32^{c}	6.01±0.25^{c}	59.16±0.55^{d}	78.99±1.76^{cd}	198.28±3.68^{ab}	1.78±0.07^{b}
21*4	12.54±0.52^{b}	5.88±0.27^{c}	61.61±1.35^{c}	80.56±2.50^{bc}	201.86±4.34^{ab}	1.55±0.05^{c}
21*5	14.24±0.67^{a}	6.38±0.84^{c}	71.96±0.05^{b}	83.47±1.71^{ab}	208.02±4.63^{a}	1.40±0.10^{c}
LSD	1.11	0.86	1.72	3.08	15.27	0.16
CV	5.71	7.29	1.58	2.23	4.82	5.53

Values are means ± standard deviation. Values within the same column with different superscript letters have significant (P<0.05) differences. GT*Gt = interaction of germination temperature and 15, 18 and 21°C and germination time 3, 4 and 5 days respectively. WL= malt weight loss, MC = moisture content, HWE = hot water extract, DP = Diastatic power, WK = Windich Kolbach, mp = milipoise, CV= Coefficient of variation, LSD = Least Significant difference.

3.3.3. Hot Water Extract

Hot water extract is one of the most important malt qualities. It determines the amount of beer that can be produced from a known quantity of malt. The hot water extract of *temash* malt also showed significant (P<0.05) differences due to combinations of treatments as displayed in Table 4. However, the values did not show any trend that can be related to the factors. The hot water extract of malt values ranged from 76.71% for malt germinated at 15°C for 3 days to 85.58% for germinated at 18°C for 4 days. The data do not show distinctive trend related to any factor within the interaction. The results were similar to the report by [42] who studied that quality parameter requirement and standards for malt barley was minimum 78.00%. This finding agreed with hot water extract values of sorghum malt reported in range 71.1 to 85.2% [43]. According to the quality standards of Asella Malt Factory, the minimum industrial specification of barley malt hot water extract is 76.00% and the mean of EBC standard value ranges from 79.00 to 82.00%. This finding indicates hot malt extract result fulfill Asella factory standard but not EBC standard.

3.3.4. Diastatic Power

The diastatic powervalues of *temash* malt exhibited significant (P<0.05) differences as displayed in Table 4 due to the interaction of germination temperature and time. The role of germination temperature is highly pronounced as its effect is highly noticed in the data. Statistically the highest values, for instance, are the three values 198.28, 201.86 and 208.02 WK° obtained when the highest temperature, 21°C, is combined with all three germination times of 3, 4 and 5 days, respectively. Like the second three higher values are those of samples subjected to germination temperature of 18°C combined with all three germination times. The remaining three lowest values are results of the lowest germination temperature 15°C. No significance difference was noted in each of the three values categorized as the highest and also among those categorized as the second higher values. Generally speaking, an increase in germination temperature for each germination time tended to increase the diastatic power of *temash* malt. The results obtained in the study were lower than the 352.97 to 372.01 WK° reported by [39]. According to quality standards of Asella Malt Factory, the minimum industrial specification of barley malt diastatic power is 200 WK° and those of EBC standard value ranged from 200 to 300 WK°. Study result indicates diastatic power of *temash* malt does not fulfill both Asella factory standard and EBC standard except the sample germinated at 21°C for 4 and 5 days.

3.3.5. Friability

Friability is a measure of the breakdown of malt endosperm cell wall components. The friability of *temash* malt also showed significant (P<0.05) differences due to the interaction of germination temperature and time. The friabilityof malt values ranged from 51.63% for malt germinated at 15°C for 3 days to 78.36% for germinated at 18°C for 4 days. An increase in friability reflects thus a more extensive modification of the endosperm during malting, mostly with respect to the degradation of the protein matrix and cell walls [39]. According to the quality standards of Asella Malt Factory, the maximum industrial specification of barley malt friability is 70%, whereas, the EBC standard, a malt friability of 70 to 100% is accepted. In this study, the malt friability in most combinations was below the acceptable range. This may probably due to the moisture content of the malt and drying apparatus.

3.3.6. Wort Viscosity

It measures the wort ability to resist flow and linked to wort β-glucan. Significant differences were noted in wort viscosity because of the interaction of the germination temperature and time. The highest value 2.03 mp is of the samples germinated at 15°C for 3 days. It was followed by 1.90 mp of the sample germinated at 18°C for 4 days. The lowest value 1.40 mp belonged to malt germinated at 21°C for 5 days. In general, an increase in germination temperature and time tended to decrease the wort viscosity of *temash* malt. This implies that at low temperature and short time there is a little enzyme which is not enough to degrade starch thus increases wort viscosity. The result obtained in the current study agreed with wort viscosity of hulless barley malt value 1.7 mp reported by [44] and is also similar to [38] who reported wort viscosity value of 1.5 mp for barley malt. According to the quality standards of Asella Malt Factory and EBC standard barley wort viscosity ranged from 1.45 to 1.70 mp. This finding indicates wort viscosity of *temash* malt almost higher than both standards.

4. Conclusions

This study clearly showed that *temash* barely grains has good composition and meet standard for malting. The study also has lead to conclusions that increasing germination temperature will result in decreased thousand kernel weight. Increase in germination temperature and time can lead to increase the malt qualities (weight loss, friability, diastatic power and hot water extract). Sample germinated at 18°C for 4 days fulfilled most malt quality standard and this germination temperature and duration can be used for *temash* malting to meet the growing shortage of malt barley in the brewing industry.

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