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Evaluation and Characterization of selected varieties of sorghum for malting purpose in Ethiopia

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Abstract

Background

Sorghum is staple cereal crop in Ethiopia which is used as a food source and traditional beverage. Seven sorghum varieties were used, planted malted, and extracted under similar conditions to assess their quality for brewing. The experiment was performed and analyzed their physicochemical, malting, biochemical and wort quality parameters investigated employing standard procedures. The grain quality parameters for seven sorghum varieties such as ash, moisture, protein, tannin, starch, amylose, iron and zinc, malting, and wort quality parameters were analyzed. Data were analyzed utilizing ANOVA [at 95% significant level] and correlations using SPSS 14 software.

Result

Results showed the two cultivars ESH-1 and ESH-4 had a protein percentage greater than 12%. While the highest starch value was recorded in Melkam (65.39 %) variety. Debra grain recording the highest zinc (38.86 ppm) content and ESH-4 was recorded the highest iron (38.66 ppm) content. All the cultivars had good germinative capacities more than 80% and more than 90% were recorded at 24 and 48 hours respectively. The varieties Debere and Melkam have recorded the highest germinative energy values of 88 and 67 % at 12 hours respectively and while 100% of germination energy values were recorded at 24 hours. Varieties with high friability were Debere and Melkam which indicates high lautering performance. Varieties with low friability were Argity and ESH-4 indicated that under modification can lead to poor mash conversion and more high viscosity. The cross correlations between amylose, starch and protein were showed the significant difference at $p < 0.05$. The correlations between the amylose pairs of amylose-starch (0.686) and amylose-protein (0.685) were found to be high and positive. Yield was negatively significantly correlated to amylose, starch, protein, ash and moisture content ($r = -0.705, -0.590, -0.441, -0.201$ and $-0.0.178$) respectively. However, most of the cultivars fulfilled the quality requirements and within the acceptable range of the European Brewery Convention (EBC) and Asela Malt factory standard (Ethiopia).

Conclusion

This study showed that the cultivars have good potentials for use as malting materials in beverage making. Some of the sorghum varieties have been identified to be useful as nutritious source of food and for use in the malting industry.

Key words: sorghum, varieties, grain, malt and wort

1. Introduction

Sorghum is a warm short cycle annual, adapted to withstand higher average temperatures than most other cereal crops. Sorghum (*Sorghum bicolor* L. Moench) is one of the most staple food. Sorghum is the fifth most produced grain globally (MacCarthy, Sommer, and Vlek 2009; Kimani et al. 2014; Rhodes et al. 2014). In Ethiopia, sorghum is the third (3rd) most important staple cereal crop after teff and maize (Taffesse, Dorosh, and Gemessa 2012). Its productivity in the regions of Ethiopia could be enhanced through effective breeding programmers using locally adapted and well-characterized germplasm (Opole 2019). Kinds of literature have shown that improved agricultural inputs, population growth/economic development, and climate change have a substantial influence on sorghum production although at varying degrees of certainty depending on the country and/or region (Sheldon 2016).

In Africa, sorghum is still largely a subsistence staple food crop. Nowadays, It is increasingly the demand and forming the raw materials of successful food and beverage industries (Taylor 2003; Isaac, Demuyakor, and Awuni 2012). In Africa, sorghum grain is the major raw material cereal crop used to produce the traditional “opaque” beers (Lyumugabe et al. 2012; Owuama 1997). However, the sorghum grain of the raw materials for beer production needs to be identified and specified. Only certain sorghum varieties are specifically used to produce sorghum beers (Lyumugabe et al. 2010; Polycarpe Kayodé et al. 2005). Additionally, the Sorghum crop is grown in almost all regions of Ethiopia as a staple food crop on which the lives of millions of poor Ethiopians depend. It has tremendous uses for the Ethiopian farmer and all parts of the sorghum plant used for a different purposes. They are using for multiple purposes such as food (injera & bread mostly), animal feed, and used as the basic ingredient in some local beverages like tella (Adugna 2007).

Research studies into sorghum are progressing rapidly and making a great impact in brewing despite the earlier misunderstanding that malted sorghum developed insufficient hydrolytic enzymes. The increased use of white grain sorghum by breweries in Africa has resulted in competition in the market between grain food and grain for brewing purposes. This problem led to the undertaking of these studies to identify varieties specific for food and other malting and brewing purpose (Ikediobi 1990). Sorghum, like other cereals, is an excellent source of starch and protein and can be processed into starch flour, grits, and flakes which can be used to produce a wide range of industrial products (Palmer 1992). It is in line with the above reason

some of the recently developed (released) varieties from EIAR were characterized for food and industrial utilization.

Therefore, this study was conducted to generate the current methods and ways of improvement of sorghum with their quality attributes that are important to characterize sorghum grain according to their physical and chemical characteristics for malting and technology needs and identifying malt sorghum advanced variety for varieties concerning. Concerning the quality preference for breeders, malt factory and breweries as well as small scale farmers for appropriate selection, effective quality control, and their economic development respectively by growing appropriate and acceptable malt sorghum variety. Also, as in barley, the development of sorghum varieties suitable for malting and brewing purposes has been a major area of research and development. This paper presents the results of investigations on the performance of selected sorghum varieties malted under similar conditions, intending to assess their brewing potentials in the absence and presence of commercial enzymes. This provides a good indication for superior quality malt quality profiles for the new improved varieties with the old varieties. Therefore, this activity was aimed to evaluate and characterize selected sorghum varieties for malting purposes in Ethiopia.

2. Materials and Methods

2.1. Sample collection and preparation

A total of seven popular sorghum varieties such as Melkam, Dekeba, Aregetti, ESH-1, ESH-4, Debere, and ESH-5 were planted at Melkassa Agricultural Research Center in National Sorghum Breeding Research Program in the same environmental and soil type, and Debere (known malt sorghum variety) was used as a control. The sorghum grain samples were harvested and transported into Melkassa Agricultural Research Center food science and nutrition research laboratory. The collected samples were cleaned by hand to remove any foreign matters that come along with the sorghum and visually inspected to remove any physically damaged sorghum, and rinsing with tap and distilled water. The grain samples were spreader on a clean surface layered with soft absorbent paper and allow dried at room temperature overnight. For each variety about 2kg cleaned and pure seed, the sample was taken and packed in plastic bags. All the necessary materials for this study such as standard chemicals were purchased.

2.2. Sorghum grain characterization

The physicochemical and mineral properties of sorghum samples were determined with the following methods.

2.2.1. Moisture content determination

The moisture content was determined through the standard method of AOAC 925:10. Two (2g) of well-mixed ground sorghum samples were measured in the pre-weighted clean crucible and placed in the oven at 130 ± 2 °C for 1 hrs. Then samples were removed and allowed to cool in desiccators, finally re-weighted the sample. The moisture content was calculated as follows:

$$\text{Moisture content} = \frac{(\text{Weight before} - \text{Weight after})}{\text{Total weight}} * 100 \quad \text{-----(1)}$$

2.2.2. Ash content determination

The ash content was determined by the official method of AOAC 923.03. Five grams (5) of sorghum flour was measured in the pre-weighed crucible and then the samples were placed on a muffle furnace at 550 °C for 5 hours. Then samples were removed and allowed to cool in desiccators for 30 minutes and reweighed. Total ash content was determined using the formula :

$$\% \text{Ash} = \frac{W_3 - W_1}{W_2 - W_1} \text{-----(2)}$$

Where: %Ash = percentages ash content

W_1 = weight of the empty dishes

W_2 = weight of the dishes plus weight of the fresh sample

W_3 = weight of the crucible plus weight of the sample after oven-dried

2.2.3. Grain protein

Standard methods of AOAC 2005 was used -Kjeldahl method. One-gram ground well-mixed sorghum sample was measured and transferred into a completely dry Kjeldahl flask and 7g of catalyst (K_2SO_4 & $CuSO_4$) was added to the sample containing flask. Then 10 milliliters of concentrated sulphuric acid was mixed with the sample and the digestion was going on until the solution become clear or white. After completed digestion the sample has cooled the mixture, 100 ml of distilled water and 70 ml of sodium hydroxide (45%) were added. Then, the distillation process was conducted into 25 ml of excess boric acid containing 3ml of the

mixed indicator. The distillate was titrated with 0.1N hydrochloric acid until the red color was converted into blue color (the endpoint).

$$\text{Total Nitrogen (N \%)} = \frac{(T-B) * 14}{W (100 - Mc)} \text{-----(3)}$$

T is the volume of HCl used for titration; B is blank used as control; W is the weight of the sample taken for analysis; Mc is a moisture correction factor

$$\text{Crude protein (CP \%)} = N * 6.25$$

2.2.4. Tannin content determination

The tannin content of sorghum grain was determined through the standard method of vanillin with HCl assay (Dykes and Rooney 2006). 1g of sorghum flour sample was measured with the centrifuge tube and added 10 mL 1% HCl/Methanol solution. Then, the sample solution was placed on a mechanical shaker for 24 hours at room temperature. After 24 hours the samples are centrifuged (tabletop universal centrifuge, Model: PLC-012 E), U.S.A) at 1000g for 5 minutes. Then after 1 mL of supernatant was taken and mixed with 5 mL of Vanillin-HCl reagent in a clean centrifuge tube. Samples were incubated for 20 min at 30 °c before reading sample absorbance at 500 nm using a UV-Vis spectrometer. The tannin content of sorghum in the sample was calculated using the following formula:

$$\text{Tannin in mg/g} = \frac{(As - Ab) - \text{Intercept}}{\text{Slope} \times D \times W} \text{-----(4)}$$

Where: As = Sample Absorbance Ab = Blank Absorbance

D = Density of solution (0.791g/ml) W = Weight of sample in gram

2.2.5. Total starch content

The total starch content of sorghum grain was determined through the standard method of the Megazyme Total Starch kit. Measurement of the starch content of commercial starches. An improved enzymic method for the determination of native and modified starch (Karkalas 1985). One hundred milligrams (100 mg) sample (100 mg ± 1 mg) was weighed and added into a 15 mL centrifuge tube and record the weights. A centrifuge tube without a sample as an analytical blank was used. The sample was mixed with 200 µL of aqueous ethanol (80 % v/v) and stirred on a Vortex mixer to aid dispersion with this 2 mL of DMSO to each sample was added and

stirred. Sample containing tube was placed in a boiling water bath for 5 min and 3 mL of thermostable α -amylase solution was added in a boiling water bath for 12 minutes with stirring. Then, 4 mL sodium acetate buffer (200 mM, pH 4.5) was added and incubated with 0.1 mL amyloid glucosidase at 50°C for 30 minutes with shaking. Finally, adjusted the volume to 100 mL (or adjust to 10 mL then take 0.1 mL to dilute to 1 mL) and then 1 mL was taken from the diluted digested sample containing solution and centrifuge at 4000 rpm for 10 minutes. Transferred a 0.1 mL supernatant to a 15-mL centrifuge tube and added 3.0 mL GOPOD reagent to the tube and incubate at 50°C for 20 minutes with shaking. Prepared glucose control (0.1 mL D-Glucose standard, 1 mg/mL) and blank control (0.1 mL distilled water) and incubated them with 3.0 mL GOPOD reagent at 50°C for 20 minutes with shaking. After prepared the solution read the absorbance of the sample and Glucose control at 510 nm against the blank control. The total starch content of sorghum flour (mg starch/mg dry flour) was calculated as follows:

$$\text{Starch (mg/mg flour)} = A \times F \times \frac{FV}{0.1} \times \frac{1}{1000} \times \frac{1}{FW} \times \frac{162}{180} = \frac{A \times F \times 0.9}{FW} \text{-----(5)}$$

Where:

A = Absorbance read against the blank control

F = Conversion from absorbance to μg

$$= \frac{100 (\mu\text{g of D - Glucose})}{\text{absorbance for } 100 \mu\text{g of D - Glucose}}$$

FV = Final volume of the sample = 100 mL

FW = Initial dry flour weight = flour weight \times (1 - % moisture content)

0.1 = Volume size of the diluted sample that being analyzed using GOPOD reagent

$\frac{1}{1000}$ = Conversion from μg to mg

$\frac{162}{180}$ = Conversion from free D-glucose to anhydrous-D-Glucose (as in starch)

2.2.6. Amylose content

The amylose content of sorghum grain flour was determined through the standard method using a modified Megazyme total starch kit (Juliano 1971). A 20 mg of dry sorghum flour of lipid-free sample was measured and transferred into a 50mL centrifuge tube. Then, wet the sample with 0.8 mL water to each tube and added 7.2 mL DMSO. The solution was mixed vigorously for 1 min using a vortex mixer and was heated the tubes in a water bath at 85°C for 15 min with intermittent mixing. The solution was allowed in the tubes to cool at room temperature (~45 min) and 17mL water was added to each tube through shaking well. Then, 100 μL of the

diluted solution (Solution I) and 4.4 mL of distilled water were added into a 15-ml centrifuge tube. A diluted iodine solution (0.5 mL) was added and mixed vigorously. Finally, the color is developed for at least 15 min and they measured the absorbance of the sample and each of the standard mixtures at 640 nm against a reagent blank as the reference. The amylose content was calculated as followed:

$$\text{Amylose (\%)} = \left(A \times \frac{20}{\text{SW}} - \text{intercept} \right) \div \text{slope} \times 100\% \text{-----(6)}$$

Where: A = Absorbance read against the blank control

SW = Accurate dry starch weight in mg

= Wet flour weight \times (1 - % moisture content/100) \times % starch content/100

20 = 20 mg of standard AM and AP weight

2.2.7. Iron and Zinc contents determination

The mineral concentration of Iron and Zinc was determined from the absorbance of the samples using a flame atomic absorption spectrometer (Shimadzu, Japan) against the standard readings (AACC,2000). The absorbance was determined using wet digestion using hydrochloric acid from the ash which was obtained by dry ashing procedures as described in the above total ash analysis (Jahromi et al. 2007; Committee 2000).

2.3. Sorghum malting method

All the sorghum malting procedure was performed according to the recommended methods of the Institute of Brewing(Manzanares et al. 1991).

2.3.1. Grain steeping

Sorghum grain steeping was performed by measuring out 200g of each sorghum variety and immersed the sorghum seed in 400 mL of distilled water. Steeping was carried out for 24 h at room or ambient temperature of ~28-30°C. The steep water was changed at 6 h intervals to minimize microbial contamination.

2.3.2. Germination

Germinations of sorghum grains were performed at 28°C -30°C for 3–6 days using micro-malting equipment in a controlled environment. During germination, the grains were regularly sprinkled with water, mixed, and turn to achieve uniform temperature and moisture levels.

2.3.3. Kilning

Germination was terminated by drying (kilning) the seedlings in a thermostatically controlled hot-air oven, preset at 50°C until the moisture content of the malt was reached the recommended range (4.0%). Kilning was conducted for 24h, after which both the radicle and plumule were manually removed.

2.4. Sorghum malt quality analysis

2.4.1. Degree of steeping

The degree of steeping (DS) of the sorghum grain varieties was estimated according to the modified Bernreuther apparatus method reported by Kunze (2004). A grain sample of known moisture content is weighed into the apparatus and steep along with it for ease of draining excess water. At the end of the steeping process, the weight of water absorbed, X in g is first calculated from the equation below:

$$X (g) = \frac{w_1(w_0(w_2 - w_1))x^2}{w_2}$$

Where: w₁= weight of grain before steeping in g,

w₂= weight of grain at the end of steeping in g, w₀= initial weight of water in grain before steeping in g calculated as follows:

$$w_0 = \frac{\text{moisture content of sample in \%}}{100}$$

Thereafter, the degree of steeping/attained moisture level, Y in % is calculated as follows:

$$Y (\%) = \frac{X}{W_1} * 100$$

Where: X = weight of water absorbed at the end of steeping in g, w₁= weight of grain sample before steeping in g.

2.4.2. Germination energy

Two hundred grain samples were distributed evenly on the whole surface of the germination plate. The plate was moistening with distilled water. The germinated grain was removed after 48,72 and 96 hours and counted. The germination energy was calculated as follows:

$$\text{Germination energy (\%)} = \frac{(100 - n)}{1}$$

Where n is the number of non-germinated grain during germination.

2.4.3. Friability of sorghum malt

The friability of the malted sorghum sample was analyzed using a Pfeuffer Friabilimeter, which uses a pressure roller to grind the sample against a rotating screen. Low, medium, and high friability malts were selected for the test according to EBC method 4.15 (EBC, 1998). One hundred grams (100g) of the malted grain was run in the friability meter for 8 min, and the non-friable fraction was weighed and then the friability was calculated as follows.

$$\text{Friability (\%)} = (100 - R)$$

Where: R is the mass of non-friable one retained over the Friablemeter sieve from 100g sample used for the test.

2.4.4. Malt Moisture content determination (Method of AOAC 925:10)

The moisture content was determined through the standard method of AOAC 925:10. . Two (2g) of malted sorghum samples were measured in pre-weighted clean crucible and placed in the oven at 130 ± 2 °C for 1 hrs. Then samples were removed and allowed to cool in desiccators, finally re-weighted the sample containing crucible

then report flour residue as total solids and loss in weight as an indirect method.

$$\text{Moisture content} = \frac{(\text{Weight before} - \text{Weight after})}{\text{Total weight}} * 100$$

2.4.5. Malt protein content

Standard methods of AOAC 2005 -Kjeldahl method was used as above mentioned in equation no 3).

2.4.6. Soluble protein (from wort)

Soluble protein is measure by taking 20ml of wort into the Kjeldahl flask and digesting it. The wort will preheat to evaporate the excess moisture and dry it. Then start the digestion by adding 3ml of concentrated sulphuric acid 10g of catalyst and anti-foam. The digestion, distillation and titration completed according to EBC method 3.3.1

$$\text{Total (N\%)} = \frac{T * 14 * 100}{V}$$

V is the volume of wort taken and T volume of HCl taken during titration.

2.4.7. Kolbach index (ratio S/T)

Kolbach index is calculated according to ASBC (2008) by using the following formula.

$$\text{Kolbach index} = \frac{\% \text{soluble protien}}{\% \text{malt protien}} \times 100$$

2.5. Mashing of ground malted sorghum.

2.5.1. Mashing

Malt samples of sorghum were ground in a hand mill to produce grist with 2mm particle size and then Fifty grams (50 g) of the ground malted flour was extracted with 360mL of distilled water in a 500 mL Erlenmeyer flask. Mashing was carried out for 30 minutes at 45 °C and up to 70 °C (rate 1 °C/min) for 25 min to activate the enzymes, and then 100 mL of 70 °C distilled water was added to each sample and hold at 70 °C for 1 h. After 10 min and 15 min saccharification test EBC (1998) was performed with 0.02N iodine solution. After mashing, the sample was cooled at room temperature, and then distilled water was added to adjust the weight of the content in the mash vessel to 450 g. The extract was filtered through 32 cm flute filter paper in 20 cm funnel. The time elapsed by each sample to filter fully into a flask was recorded to determine filtration time.

2.5.2. Density of the clear wort

The density of the clear wort was determined using a wort hydrometer and expressed in degrees Plato (⁰P). The extract obtained was converted and expressed in percentage in wet basis (% wb) using the following equation;

$$\text{Extract wet base} = p \frac{(800 + M)}{(100 - P)}$$

$$\text{Extract dry base} = \frac{(E * 100)}{(100 - M)}$$

Where: P is g extract in 100 g wort (Plato), M is % moisture in the malt and E is extract as wet basis.

2.5.3. Filtration time

The extract was filtered through 32 cm fluted filter paper in a 20 cm funnel. The time elapsed by each sample to filter fully into a flask was recorded to determine filtration time. Filtration rate, the volume of wort recovered per unit time during the mash filtration process was measured with a measuring cylinder and the filtration rate (FR) in mL/s was calculated as:

$$\text{FR (mL/s)} = \frac{V}{T}$$

Where V is the volume of wort recovered (in mL) and T is the time of filtration (in S)

2.5.4. Color of wort

The color of the diluted sample wort estimated by a series of standards comprising colored glass discs.

2.5.5. P^H of wort

P^H of wort was measured by P^H meter after 30 minutes start of filtration.

2.6. Statistical analysis

Data were statistically analyzed using SPSS 20.0 Window evaluation version program with Duncan's multiple range test and all measurement parameters were done in triplicate form and the data was reported as mean ± standard deviation (SD) at 95% confidence level.

3. Results and discussions

3.1. Sorghum grain characterization

The biochemical composition of the six sorghum cultivars given in Table 1. The moisture content of the cultivars ranged from 11.67% (ESH-1) to 13.77% (ESH-5). The low moisture content in all the cultivars suggests good storability of the grains before processing (need references). The two cultivars ESH-1 and ESH-4 had protein percentages greater than 12% which compares favorably with that of barley (8-13%), the traditional malting crop. Thus, the suitability of wort from this sorghum malt for yeast nutrition is assumed, since this depends on the total soluble nitrogen (TSN) and free amino nitrogen (FAN) levels (Aba et al. 2005; Ogonna 2011). The embryo of sorghum is larger than that of barley and contains more

unsaturated lipids (e.g. linoleic acid)(Palmer, Etokakpan, and Igyor 1989). The ash (0.87-1.44%) contents in the cultivars were analyzed and lower than that of barley (2.496%). This seems to suggest the availability of mineral elements being sufficient for yeast nutrition and alcohol production as required by brewers (Lodolo et al. 2008). All the cultivars analyzed are low in tannin (0.00685 – 0.15573), indicating that they are safe for use either as dry grain or malted grain. The total starch content was shown in the range of 61.34-65.39%, which indicated a good range of grain quality in the brewing process.

Table 1: Some grain quality properties analysis of the sorghum varieties

Code	Amylose	Ash	Tannin	Iron	Moisture	Protein	Starch	Zinc
Argiti	19.20± 0.37 ^a	1.37± 0.10 ^a	-4918± 1.61 ^b	29.92± 6.28 ^{ab}	13.07± 1.27 ^a	11.98± 0.67 ^{ab}	64.64± 1.66 ^{ab}	30.28± 5.34 ^{bc}
Debere	18.91± 0.38 ^a	1.44± 0.74 ^a	15573± 4.10 ^a	34.07± 1.05 ^a	12.33± 3.74 ^a	11.27± 0.90 ^b	61.34± 4.50 ^b	38.86± 6.95 ^a
Dekeba	19.13± 0.33 ^a	1.28± 0.10 ^a	685± 1016.3 ^b	12.997± 3.23 ^d	13.48± 0.18 ^a	11.60± 0.48 ^{ab}	64.99± 0.44 ^{ab}	20.45± 1.21 ^d
ESH-1	19.20± 0.14 ^a	1.42± 0.73 ^a	-1344±0.96 ^b	19.83±1.08 ^{Cd}	11.69±1.97 ^a	13.09±1.06 ^a	64.42±2.07 ^{ab}	26.03±3.87 ^{b-d}
ESH-4	19.15±0.10 ^a	1.43±0.33 ^a	1813±0.93 ^{ab}	38.66±7.46 ^a	12.72±0.98 ^a	12.02±1.70 ^{ab}	63.54±1.79 ^{ab}	33.22±6.24 ^{ab}
ESH-5	19.02± 0.14 ^a	1.08±0.06 ^a	1888±0.42 ^{ab}	23.63±8.16 ^{bc}	13.77±0.09 ^a	11.57±1.09 ^{ab}	64.67±0.96 ^{ab}	25.47±5.23 ^{b-d}
Melkam	19.12± 0.02 ^a	0.87±0.03 ^a	5975±2.13 ^{ab}	12.34±1.61 ^d	13.60± 0.05 ^a	11.45±0.45 ^{ab}	65.39±0.13 ^a	22.13±1.43 ^{Cd}
Mean	19.11	1.27	2810.3	24.53	17.95	11.86	64.14	28.07
CV	1.31	2.76	18.14	20.53	9.53	8.36	3.32	17.13
Significant	ns	ns	***	***	Ns	*	*	***

ns, *, **, ***non-significant or significant at $P \leq 0.05$, $P \leq 0.01$, or 0.001, respectively; means with the same letter within columns were not significantly different at $P \leq 0.05$. The negative sign of tannin content indicated that below the detection limit of the instrument.

3.2. Sorghum malted and malting quality

The germination energy is the total number of grains that germinate in the specific time of incubation under specified conditions(Woonton et al. 2005). Results of germination energy ere showed a direct correlation with the germination period. The analyzed results of germination energy were significantly different at 12h and 24 hrs, ($P < 0.05$, Figure 1) but in 48 hrs. and 72 hrs of germination time, germination energy was not significantly different as indicated in (figure 1). Germination energy was higher at Debre (88.00%) as a control) and Melkam (67.00%) at 12 hours. ESH-5 (21.33%) had low germination energy among the others at 12 hrs. of germination time. Any factor which interferes with the uniformity of germination or reduces the vigor of kernel growth during processing will reduce the quality of malts produced (Michael, 2014). The analysis of variance of germination energy was significantly different ($P < 0.05$, Table 3) among varieties in 12hrs and 48 hrs of germination time. . The germination

energy of varieties ranged from 21.33-88.00%, 81.33-100, 90-100.00% in 12, 24, 48 hours respectively (Figure 1). It has been indicated that varietal differences showed that difference in germination energy which supports this study. Thomas (cited by Swanston et al., 2002) (Molina-Cano et al. 2002) also noted that differences in the genetic factors are determined germination after different days and also suggested that there were environmental effects.

In this study, the number of grains germinating within 12 and 24 hours was significantly different among varieties. The germination energy of six cultivars was compared favorably with that of barley (95 and 96%) which suggests a good grain ready for malting. The low germination energy given by many cultivars seems to be discouraging for those who are interested in the malting of sorghum products. The best cultivar in terms of high germination energy within low time is Melkam. This cultivar will be used by malting industries. The unmalted of sorghum 16-22% than that of barley have been attributed to the naked nature of the sorghum grain in contrast to barley grains with husk. Low malting loss/unmalted may be indicating high extract yield in the malted grain(Smith and Lister 1983).

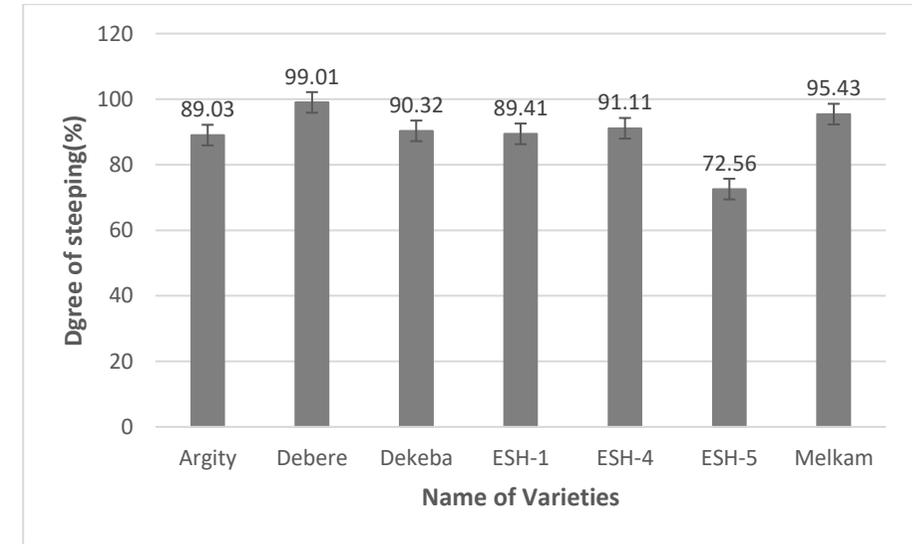
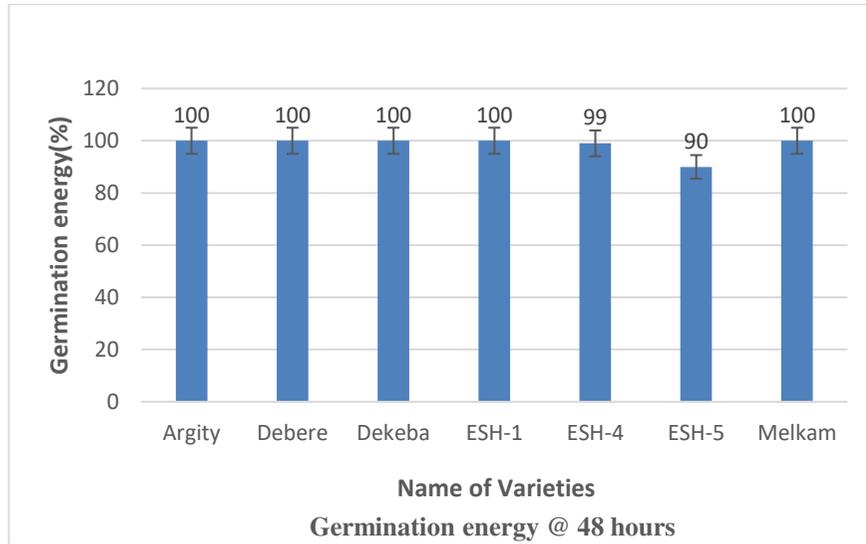
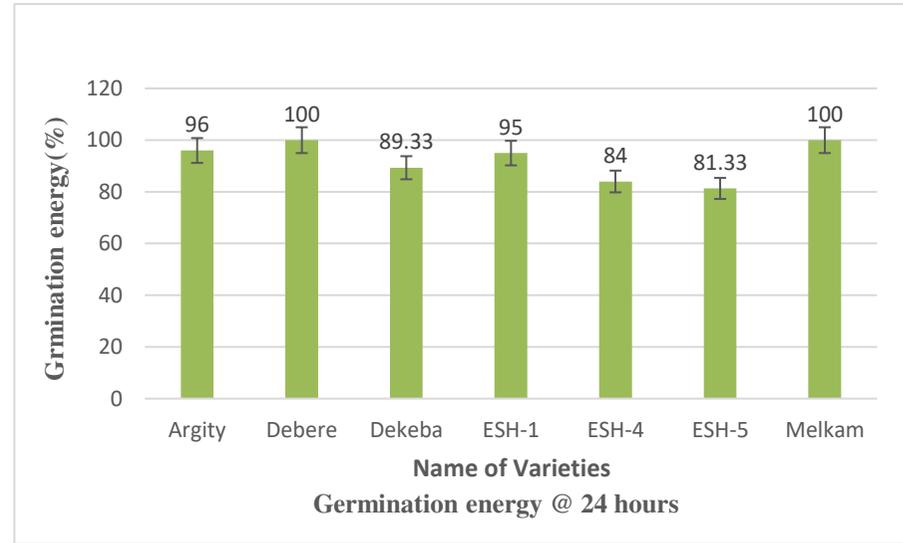
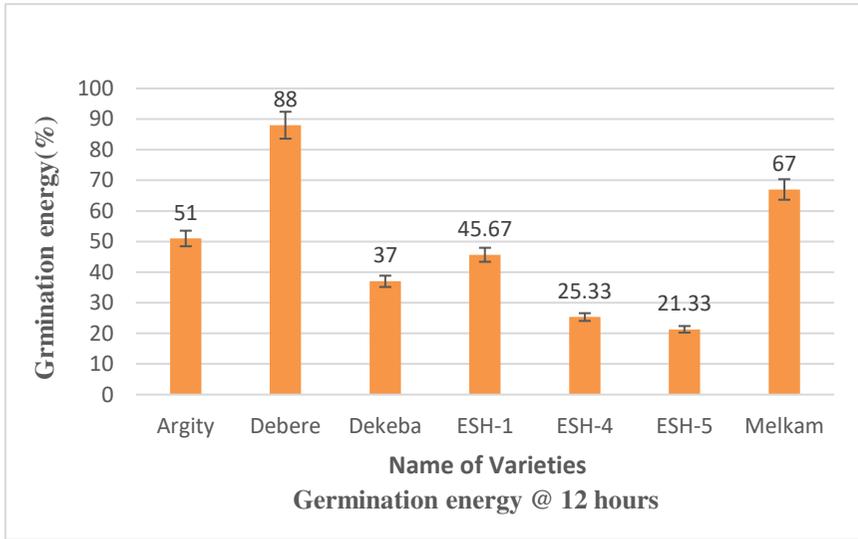


Figure 1: Shows germination energy at 12, 24 & 48 hours and degree of steeping sorghum grain

The steeping quality has a vital role in the germination quality of grain in brewing industries. The degree of steeping varies with genotypes and it was significantly different at $P < 0.05$ as shown in Figure 1. The degree of steeping of varieties varied between 72.56 (ESH-5)- 99.01 (Debere). This indicated that the higher degree of steeping showed a good germination quality and have its effect on malting time.

Some properties of the sorghum varieties studied are shown in Table 2. The sorghum varieties were suitable for malting because they have high germination capacities (Aisen and Muts 1987). Differences in moisture content are also presented. The malt analyses of the malted samples of sorghum are shown in Table 2. In general, all the sorghum varieties have high extract yield. High extract yield malted sorghum is caused by the high malting temperature which was used during the germination of sorghum because of the tropical nature of sorghum (Nout and Davies 1982; Agu and Palmer 1998). Extract yield remains an index of malting quality and an important measure of brewing house performance of the malt. The malting extract time of the cultivars shows that most of them gave higher extract yield than previously reported for sorghum genotype (Evans and Taylor 1990). The time of filtration values ranged from 2:50 (Melkam) -06:25 (Debere). It may then follow that most of the varieties reported here have a low protein content of the wort rather than the grain protein content. This may be the grain protein content had more in the germ rather than endosperm. The protein content (11.00 – 12.00%) range agreed with the previous research reports. The report showed that the low average protein content is 10.1% and also higher 11.0% (Bredon and Horrell 1961) and some still have protein content higher than the high average of 13.6% evaluated for normal non-opaque sorghum (Aba et al. 2005). Most of the varieties evaluated here seem to be more nutritious than those evaluated by (Murty, Bello, and Nwasike 1997). This allows the farmers to make a choice of which variety they want to grow for food or which they could grow for industry use.

Table 2: Characteristics of sorghum malt quality analysis

Varieties	Ash (%)	Moisture (%)	Wort protein (%)	Grain protein (%)	Kolbach index (ratio S/T)	Time of filtration	filtration rate (FR)%	Extract wet base	Extract dry base
ESH-5 (P#14)	1.64	7.80	1.33	11.57	11.50	04:54	3.29	65.50	71.04
ESH-5 (P#3)	1.62	7.30	1.84	11.02	16.70	04:00	4.44	60.76	65.55
Debar (P#9)	1.38	6.73	1.20	11.20	10.71	06:20	0.72	79.79	85.55
Debar (P#5)	1.03	6.60	1.19	11.27	10.56	06:25	0.65	78.02	83.53
ESH-1 (P#16)	1.41	7.12	1.47	11.00	12.56	5:00	3.42	67.00	73.40
ESH-1 (P#4)	1.42	7.20	1.67	10.96	12.09	4:48	3.58	66.12	72.31
ESH-4 (P#7)	1.40	8.13	1.49	12.02	12.40	04:30	3.89	65.52	71.32

ESH-4(P#2)	1.58	9.00	1.81	11.96	15.13	05:30	2.93	60.89	66.91
Argity(P#1)	1.52	9.23	1.50	11.98	12.52	03:50	4.71	60.91	67.10
Argity(P#11)	1.06	8.33	1.22	11.45	10.66	02:49	9.94	60.84	66.37
Melekam(P#6)	1.42	7.40	1.44	11.45	12.58	02:59	5.97	72.60	78.40
Melekam(P#8)	1.41	7.47	1.52	11.00	13.82	02:50	6.67	75.01	81.07
Dekeba-10	1.19	6.63	2.37	11.60	20.43	04:37	3.52	60.71	65.03
Significant	*	**	*	ns	***	***	***	***	***
CV	0.43	0.91	0.45	0.23	2.10	2.49	0.97	1.23	1.00

ns, *, **, ***non-significant or significant at $P \leq 0.05$, $P \leq 0.01$ or 0.001 , respectively

The correlation between the yield and grain quality analysis was used to calculate the Pearson cross-correlations which were given in Table 3. The cross-correlations between amylose, starch, and protein were showed a significant difference at $p < 0.05$. The correlations between the amylose pairs of amylose-starch (0.686) and amylose-protein (0.685) were found to be high and positive. The ash content with iron and zinc were high positive correlations indicate the same behavior which means increasing or decreasing together in the sorghum grain. The correlations of high extract yield with tannin contain. This indicated that the tannin content highly affected the malt extraction process may be through chelating and reducing fermentation and extraction rates.

Table 3: Correlation's between yield components and their biochemical components

	Amylose	Ash	Tannin	Iron	Moisture	Protein	Starch	Zinc	Extract wet base	Extract dry base
Amylose	1.000									
Ash	0.060	1.000								
Tannin	-0.872	-0.058	1.000							
Iron	-0.242	0.650	0.181	1.000						
Moisture	-0.093	-0.742	-0.108	-0.376	1.000					
Protein	0.685	0.427	-0.595	-0.007	-0.671	1.000				
Starch	0.686	-0.605	-0.722	-0.713	0.533	0.216	1.000			
Zinc	-0.469	0.635	0.487	0.907	-0.514	-0.111	-0.909	1.000		
Extract wet base	-0.705	-0.201	0.917	0.118	-0.178	-0.441	-0.590	0.445	1.000	
Extract dry base	-0.679	-0.202	0.892	0.151	-0.185	-0.422	-0.583	0.469	0.997	1.000

The yield and grain chemical composition within the correlations ≥ 0.5 were boldfaced

3.3. Mashing quality

Sorghum malts were mashed at 65°C with addition of commercial enzyme and the results obtained are shown in Table 4. Again, the iodine starch test of the mash was positive because this mashing temperature was not high enough to gelatinize the sorghum starch, even though commercial enzymes were present. However, the addition of commercial enzymes was significant in reducing the wort viscosity, suggesting that, like in barley, beta-glucanase enzymes of malted sorghum are not active during mashing (Palmer and Agu 1999). The analysis

results showed that there were significantly different ($P < 0.05$, Table 4) among varieties for friability content. Varieties with high friability were Debere and Melkam which indicates high lautering performance. Varieties with low friability were Argity and ESH-4 indicated that under modification can lead to poor mash conversion and more high viscosity. The polysaccharides such as beta-glucan affected that interfere with endosperm modification, such as poor germination, large kernels, and high protein, are expected to reduce malt friability (Mather and Edney 2004).

Table 4: Some properties of sorghum malt mash values of malted sorghum

Code	Friability (%)	Plato (°P) reading	PH of wort	Colour of wort	Volume (ml) of wort
Argity(11)	47.38 ^{de}	7.00 ^b	5.49 ^a	2.00 ^b	650 ^{ab}
Argity(p#1)	50.30 ^c	7.00 ^b	5.50 ^a	2.00 ^b	650 ^{ab}
Melkam(P#8)	72.86 ^{ab}	8.50 ^a	5.41 ^a	3.00 ^a	680 ^a
ESH-4(melthaat)	68.00 ^b	7.50 ^b	5.67 ^a	3.00 ^a	580 ^d
ESH-5(P#3)	56.60 ^c	7.00 ^b	5.67 ^a	2.50 ^{ab}	640 ^b
ESH-4(melthaat)	42.26 ^e	7.00 ^b	5.69 ^a	2.50 ^{ab}	630 ^c
ESH-5(p#14)	54.16 ^c	7.50 ^b	5.95 ^a	2.50 ^{ab}	580 ^d
Dekeba(10)	51.32 ^{cd}	7.00 ^b	5.71 ^a	2.50 ^{ab}	585 ^d
Melkam(p#6)	69.10 ^b	8.25 ^{ab}	5.74 ^a	3.00 ^a	645 ^b
Debere(p#9)	73.00 ^a	9.00 ^a	5.61 ^a	3.00 ^a	165 ^e
Debere(p#5)	77.54 ^a	8.82 ^a	5.80 ^a	2.00 ^b	150 ^{ef}
Significant	***	*	ns	*	***
CV (0.95)	4.31	0.76	0.59	1.54	7.12

ns, *, **, ***non-significant or significant at $P \leq 0.05$, $P \leq 0.01$ or 0.001 , respectively; means with the same letter within columns were not significantly different at $P \leq 0.05$.

The color of wort was significantly different among the varieties ($P < 0.05$, Table 4). Color variation in wort is due to non-enzymatic browning reactions, the Maillard reaction, that take place during kilning in the malting process, and wort boiling in the brewing process. In this case, the sugars interact with the amino acids, producing a variety of odors and flavors. This reaction is the basis of the flavoring industry with the type of amino acid involved in determining the resulting flavor and color (Guerrero et al. 2009). In this study, most of the varieties were in the specification range according to the brewing industry. The other wort quality is the pH value of wort. The pH of wort was not significantly different among the varieties ($P < 0.05$, Table 4). The pH range for the varieties was covered 5.41-5.95 which were in the specific range of European brewery convention. It was shown that over the pH range 5

to 6.6, the photolytic activity of malt can vary (Jones and Budde 2003). pH variation limits the growth of microorganisms, in this case, the growth of fermenting yeast is influenced within the variation of pH but in this study, the pH of the wort is in the specified range.

4. Conclusion

The results of this study indicate that the malting quality of sorghum is somewhat inferior to that of barley. There is adequate reason to make further investigations to improve the quality of sorghum as a malting grain. It is evident from this study that the grain quality is an extremely useful criterion in selecting sorghum for malting. The result of this study showed that the varieties Deber, Melkam, and Argity were acceptable malt quality (germination energy, moisture content, protein content, degree of steeping) and malt quality (extract amount, malt protein content, P^H of wort, Color of wort, soluble protein, kolbach index, and friability) results compared to the European brewery convention specification. These varieties will be useful for raw material for the brewing industry as well as for the breeding program in the future for the development of malt sorghum varieties.

Ethics approval and consent to participate

The article I have submitted to your journal for review is original, has been written by the stated authors, and has not been previously published. The Article was not submitted for review to another journal while under review by this journal and will not be submitted to any other journal.

Consent for publication

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Data availability statement

All data generated or analyzed during this study are included in this manuscript. The authors' can prove all necessary raw data presented in this results sections for any person/s need for this publication process.

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Competing interest

We declare that no competing interest.

Authors Contribution

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Mulate Zerihun; was involved in proposal development, laboratory work, data analysis, and interpretation, and full write-up. Segedu Belew; She involved in laboratory work and data refinement and full write up. Kebede Dida; was involved in laboratory and data analysis. Masresha Minuye; was involved in proposal development and full write up. All authors read and approved final manuscript.

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development and as well as nutrition-related areas, fortification, Food quality, and nutrition analysis.

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Figures

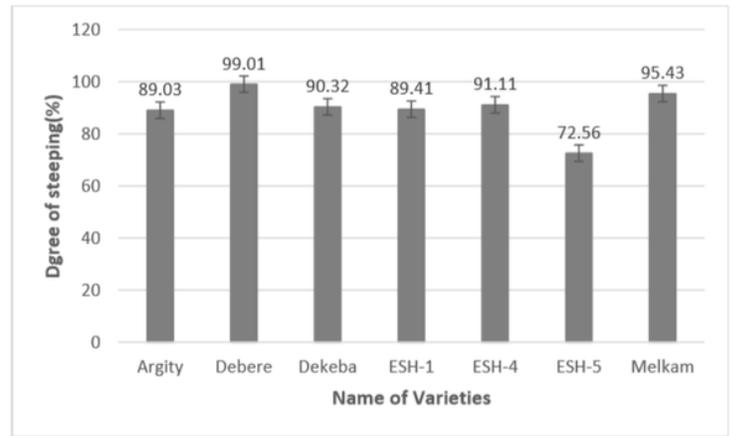
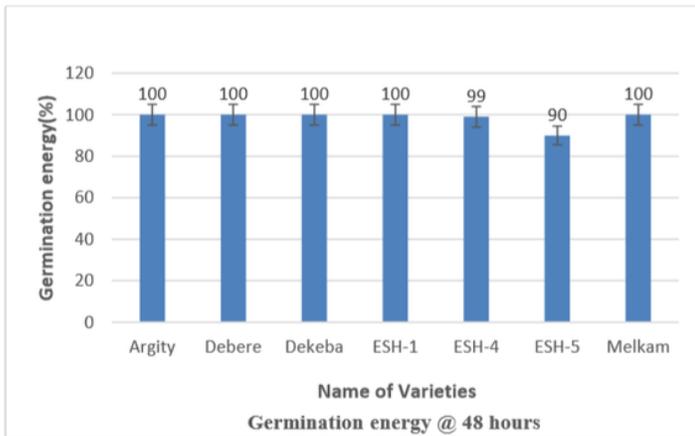
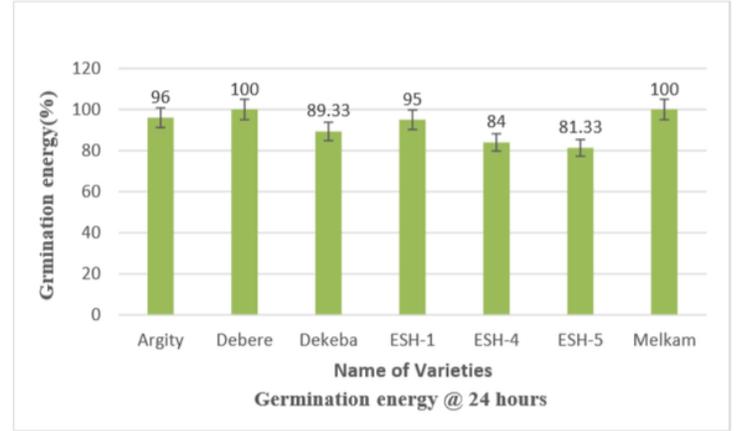
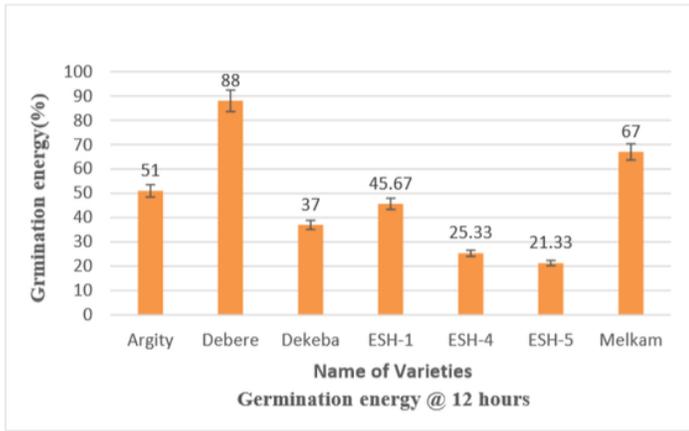


Figure 1

Shows germination energy at 12, 24 & 48 hours and degree of steeping sorghum grain