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Malt Quality Profile of Malt Barley Varieties Grown in the Central Highlands of Ethiopia

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The bio chemical composition of barley is highly affected the beer quality and the economic efficiency of the brewing process. A large number of parameters had been important to define malting quality. In the study Twelve (12) Samples were collected from barley breeding research center at Holeta which were verified and released malt barley varieties. Varieties were Holker, Bekoji-1, EH-1847, Bahati, Sabini, Grace, Travller, Beka, Ibon 174/03, Miscal -21, HB-1533 and HB-1307 were used for the study ,Grain and malt quality parameters were evaluated according to the European brewery convention methods and the value were in the range grain size (88.5-97.5), germination energy(96-98.5), malt moisture content(3.6-6.7),protein content (10.1-13.5), soluble protein (3.9-7.7), kolbach index (35.5-48.8), thousand kernel weight (34-42.8), extract (73.8-80.9), color of wort (3.7-7), PH of wort (5.5-6.1) and friability (31.6-90.2).From all the varieties Holker, Travller, Sabini, Bekoji-1, Grace, Bahati and Beka were acceptable grain and malt quality traits according to the brewing specification.

Key word: malt, malt variety and malt specification

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INTRODUCTION

Barley (*Hordeum Volgare L*.) is a highly adoptable cereal grain that is produced in climate region from sub-arctic to sub-tropical. Historically, barley is an important food source in many parts of the world. At present only 2% of barley is used for human food worldwide (Baik and Ulrich, 2008). The greatest use of barley for malting purpose mostly for brewing industry. The increased competition within the brewing industry needs maximizing the raw materials. Barley is the basic raw material for brewing. Its chemical and composition is highly affected the beer quality and the economic efficiency of the brewing process. A large number of parameters have been important to define malting quality. The texture of endosperm influences the malt modification process by affecting water uptake and enzyme synthesis within the endosperm (Chandra and others, 1999).

The malting of hull less barley presents a number of challenges due to difference in chemical and physical changes (Shewry, 1993). The structural changes and biochemical degradation of the endosperm components referred to as endosperm modification (Gunkel and others,2002). Therefore different modification of different kernel properties have been identified as a factor affecting water uptake during stepping of barley, protein, starch granule size and distribution of enzymes are factors affecting the hardness of the endosperm.

This paper presents the results of the released varieties quality profile and way of improvement in the breeding strategy. The target was to select the appropriate varieties for malting and brewing barley. This provides good indication for superior quality malt quality profile for the new improved varieties with the old varieties. For further improvement of variety the data is reliable for breeder as well as malsters and breweries to be used as row material.

MATERIALS AND METHODS

Samples were collected from highland barley breeding research center at Holetta which were verified and released malt barley varieties.

Sampling of barley

A sample representing the quality of lot obtained by reduction of the bulk sample up to 1kg of were used for analysis.

Sieving test of malt barley

Hundred gram of the grain sample was placed at the top of the sieve (>2.8mm,>2.5mm,>2.2mm and <2.2mm sieve sizes) and the grain was sieved into four fractions within five minutes. The four fractions were weighted at each sieve sites.

Germination energy

Five hundred grains was distributed evenly on the whole surface of germination plate. The plate was moistening with distilled water. The germinated grain was removed after 48,72 and 96 hour and counted.

$Germination\ energy(\%) = \frac{500-\mathrm{n}}{5}$, where **n** is the number of germinated grain

Moisture content

five gram of ground sample in a clean dry moisture crucible were placed in oven at 105^{o}c for three hour and the sample were allowed to cool in a desiccators to maintain the sample temperature to room temperature for 30 minute.

$$MC = \frac{\text{Weightt before} - \text{Weight after} * 100}{\text{Total weight}}$$

Total protein of barley –kjeldhal method

One gram ground sample of malt barley measured and transferred into completely dry kjeldhal flask. Ten gram of kjeldhal tablet was added to the sample inside the flask. Twenty milliliter of 98% concentrated sulphuric acid was mixed with the sample. The sample digestion was started by connecting the kjeldhal flasks with the digestion rock (2000 FoodALYT SBS). And the digestion was completed when the brown color of the sample was completely disappeared.

After the digested sample was cooled, 250 ml of distilled water and 70 ml of sodium hydroxide (32%) were added and distilled into 25ml of excess boric acid containing 0.5ml of screened indicator. The distillate was titrated with 0.1N hydrochloric acid to the red end point.

$Total\ nitrogen(N\%) = \frac{(\mathrm{T}-\mathrm{B})*14}{\mathrm{W}(100-\mathrm{Mc})}$,

W is weight of the sample taken for analysis

T is volume of HCl used for titration

B is blank used as control

Crude protein (CP%) = N*6.25

Soluble protein

Soluble protein was measured by taking 20ml of wort into kjeldal flask and digesting. The wort was preheated to evaporate the excess moisture and dry it. Then digested 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

$Total(N\%) = \frac{\mathrm{T}*14*100}{\mathrm{V}}$, V is volume of wort taken and T volume of HCl taken during titration.

Kolbach index (ratio S/T)

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

$$\textbf{Kolbach index (KI)} = \frac{\textbf{\%soluble protein}}{\textbf{\% malt protein}}\ \textbf{x100}$$

Thousand kernel weight of malt barley

The number of corn was counted by grain counter machine and the thousand counted corn was weighed and taken as thousand kernel weight.

Malt analysis

All the malt analysis was measured according to European Brewery Convection method (EBC) 3.3.1

Extract determination

Mashing procedure

The mashing process was according to the EBC congress mashing method. 55g of malt sample from each varieties were weighed (at room temperature) in to mash beaker and grinded through mill set for standardized fineness of grind. Then, ground malt was collected in same mash beaker, carefully brushing malt

particles remaining in mill in to mash beaker. Mix, and without delay, the mash beaker was placed with content on balance accurate to within ±0.05g under 750g 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℃ to 50 g of ground malt, and then the vessel was placed in a mashing apparatus. The sample was held at 45℃ for 30 min, then the temperature was raised to 70℃ by 1℃ for every 1-min increase for 25 min, and then 100 mL 70℃ distilled water was added to each sample and held at 70℃ for 1 h. After 10 min and 15 min (for late saccharified samples), saccharification test EBC (1998) was done with 0.02N iodine solution. 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 time elapsed by each sample to filter fully into a flask was recorded to determine filtration time. The density of the clear wort was determined using an wort hydrometer and expressed in degrees Plato (ºP). The extract obtained was converted and expressed in percentage on wet basis (% wb) using the following equation.

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

$$\textbf{Extract dry basis} = \frac{(\textbf{E x 100})}{(\textbf{100 - M})}$$

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

Color of malt

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

PH of Wort

PH of wort was measured 30 minute after the start of filtration with a glass electrode PH meter.

Friability of malt

Friability- Samples were 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 tested according to EBC method 4.15 (EBC, 1998). Malt sample, 50g, was run in the friability meter for 8 min, and the non-friable fraction was weighed.

$$\textbf{Friability(\%)} = 100 - R * 2$$

Where: R is mass of non friable one retained over the Friabilimeter sieve from 50g sample used for the test.

RESULT AND DISCUSSION

The finding of this study are presented and discussed in detail to address the objectives of the study. The data used for the statistical analysis were stated in wet basis.

Grain size

The analysis of variance for grain size was significantly different (P<0.05, Table 1) among the varieties. Highest mean grain size percentage were obtained for the varieties were Holker(96.5%),Bekoji-1(96.5%),Bahati(97.5%),Beka(97.5%),Miscal-21(66.5%) and HB-1307(95.5%).Varieties with high grain size implies in uniformity in size as well as high distatic activity. The lowest value was obtained for varieties HB-1533(88.5%), Ibon -174/03(93.5%) and Traveller(91.5%). The bold grain percentage should be >90% for 2-rowed barley and >80% for 6-rowed barley (Anonymous, 2012).In this study the majority of the varieties full fill the specified requirement.

Germination Energy

The analysis of variance of germination energy was not significantly different (P<0.05, Table 1) among varieties. A minimum of 95% germination on a 3day germination test is an absolute requirement. All the varieties were successful for germination test. All varieties had above 95 germination energy. The Germination energy is the total number of grains that germinate over 72 h of incubation under specified conditions (Woonton *et al.,* 2005).

Moisture content

The moisture content were significantly different (P<0.05, Table 1) among the varieties. The moisture content of varieties varied between 3.6 -6.9%.Miscal-21(9.6%), Holker(6.7%), Bekoji-1(6.1%) and sabini (6.9%) were with high moisture content. Moisture levels need to be low enough to prevent heat damage and the growth of disease microorganisms. The rest of the varieties were within the accepted range of malt moisture content. The malt moisture content for long shelf stable storage is recommended 4 to 5% (AOAC, 1990).

Protein content

The protein content,soluble protein content and kolbach index of the malt result showed that there were

Table 1. sieve test, germination energy, moisture content, protein content, soluble protein kolbach index and thousand kernel weight of the varieties.

varieties	Malt Quality parameters						
	Sieve test	Germination energy	Moisture content	Protein content	Soluble protein	Kolbach index	Thousand kernel weight
1.Holker	96.5±0.7^{fg}	96.5±2.1^{a}	6.7±0.3^{f}	9.6±0^{a}	7.7±0^{a}	38.5±0^{ab}	36.7±0.4^{bc}
2.Bekoji-1	96.5±0.7^{de}	97±1.4^{a}	6.1±0^{e}	11.6±0.2^{cde}	4.4±0de	38±1.2^{ab}	40.0±0.04^{cd}
3.EH-1847	91.5±0.7^{c}	97±0^{a}	4.1±0.1^{ab}	11.1±0^{bcd}	4.4±0.1^{de}	39.6±1.2^{bc}	26.7±0.4^{a}
4.Bahati	97.5±0.7^{g}	97.5±0.7^{a}	3.9±0.07^{a}	10.2±0.2^{ab}	4.7±0^{f}	46±1.3^{de}	33.4±7.0^{b}
5.Sabini	94.5±0.7^{a}	97.5±2.1^{a}	6.9±0.14^{f}	10.5±0.2^{abc}	5±0^{g}	48.8±0.4^{e}	26.6±0.5^{a}
6.Grace	94.5±0.7^{a}	98.5±0.7^{a}	4.4±0.07^{bc}	10.2±0.4^{abc}	4±0.2^{bc}	39.1±1.2^{abc}	26.0±0.08^{a}
7.Traveller	91.5±0.7^{c}	96.5±0.7^{a}	3.8±0.1^{a}	10.1±0.07^{ab}	4.3±0.2^{de}	42.9±1.9^{cd}	33.3±0.2^{b}
8.Beka	97.5±0.7^{g}	96.5±0.7^{a}	5.5±0.3^{d}	12.5±0.07^{ef}	4.6±0^{ef}	36.6±.2^{ab}	33.8±0.2^{b}
9.Ibon-174/03	93.5±0.7^{d}	97.5±2.1^{a}	3.6±0.2^{a}	12.1±0.9^{de}	4.4±0de	36.4±.2.9^{ab}	42.8±0.2^{d}
10.Miscal-21	96.5±0.7^{fg}	97.0±0^{a}	9.6±0.1^{g}	13.5±0.1^{f}	4.8±0^{fg}	35.5±0.4^{a}	41.7±0.4^{cd}
11.HB-1533	88.5±0.7^{b}	96.5±2.1^{a}	3.9±0.07^{a}	11.0±1.1^{bcd}	3.9±0^{ab}	35.5±3.5^{a}	34.5±0.7^{b}
12.HB-1307	95.5±0.7^{ef}	96.0±0^{a}	4.7±0.1^{c}	10.7±0.2^{abc}	4.2±0^{cd}	39.2±1.0^{abc}	34±0.0^{b}

Table 2. malt extract, extract difference, color of wort, PH of wort and friability of the varieties.

varieties	Malt Quality parameters					
	Fine grind extract	Course grind extract	Extract difference	Color of wort	PH of wort	friability
1.Holker	80.9 ±0.0^{a}	78.1±0.0^{a}	1.8±0.0^{a}	4.0±0.0^{a}	5.9±0^{a}	74.9±0.1^{bc}
2.Bekoji-1	77.07±0.7^{a}	76.7±0.0^{a}	1.0±0.0^{a}	4.0±0.0^{a}	5.6±0.1^{a}	59.1±0.1^{cd}
3.EH-1847	75.50±0.7^{a}	73.0±1.4^{a}	2.5±0.7^{a}	3.7±0.3^{a}	6±0.2^{a}	54.6±0.5^{a}
4.Bahati	78.03±4.2^{a}	76.2±0.5^{a}	2.1±0.1^{a}	3.7±0.3^{a}	6±0.2^{a}	67.5±0.7^{b}
5.Sabini	78.50±0.0^{a}	77.5±0.0^{a}	1.0±0.0^{a}	4.0±0.0^{a}	5.9±0.1^{a}	86.5±0.7^{a}
6.Grace	77.70±3.2^{a}	75.8±3.8^{a}	1.9±0.7^{a}	3.7±0.3^{a}	5.7±0.3^{a}	90.2±0.2^{a}
7.Traveller	80.50±5.9^{a}	78.8±6.1^{a}	1.7±0.1^{a}	5.0±1.4^{ab}	5.5±0.1^{a}	63.1±0.1^{b}
8.Beka	78.90±0.0^{a}	76.8±0.0^{a}	2.1±0.0^{a}	5.5±2.1^{ab}	5.9±0.4^{a}	38.5±0.7^{b}
9.Ibon-174/03	78.23±1.7^{a}	75.7±3.8^{a}	2.5±2.1^{a}	7.0±0.0^{ab}	6.1±0.4^{a}	44.6±0.4^{d}
10.Miscal -21	73.85±1.6^{a}	71.2±2.4^{a}	2.6±0.8^{a}	4.0±0.0^{a}	5.9±0.3^{a}	31.6±0.5^{cd}
11.HB-1533	76.80±3.6^{a}	74.0±3.3^{a}	2.7±0.3^{a}	5.2±2.4^{ab}	5.8±0.07^{a}	33.7±0.3^{b}
12.HB-1307	78.60±3.2^{a}	77.0±2.9^{a}	1.6±0.2^{a}	4.0±1.2^{a}	5.9±0.2^{a}	57.5±0.7^{b}

significance difference (P<0.05, Table 1) among varieties. Lowest mean protein content were obtained in Holker (9.6%), followed by Traveller(10.1%).Miscal-21(13.5%), Beka (12.5%) and Ibon-174/03(12.1%) protein content which were very high and indicates low extract yield. The rest of the varieties were in the range 9.6-11% protein content which were in the accepted range. Desirable protein content range for 2-rowed barley is 9.0-11.0% and for 6-rowed barley is 9.0-11.5% (Anonymous, 2012).Soluble protein for the Varieties were ranged from 3.9-7.7% which showed that good amino acids sources for yeast growth. Amino acids and peptides they are important nitrogen sources for yeast growth. Varieties which had high Kolbech index

Were Travller (42.9), Grace(39.1), EH-18-47(39.6) and HB-1307(39.2) which indicates high protein modification that gives the degree of solubility of barley protein during malt production should be between 39-44 %(Allosio *et al*. 2000).

Thousand kernel weight

The thousand kernel weight result showed that there were significance difference (P<0.05, Table 1) among the varieties. Varieties Bekoji-1(40.0), Ibon174/03(42.8), Holker (36.7) were high in grain size. Thousand grain weight (g) should be >45 g for 2-rowed barley and > 42 g for 6-rowed barley (Anonymous, 2012). These results for most varieties were low according to the standard requirement for industry.

Extract content of malt

The fine grind, coarse grind extract and extract difference of the malt result showed that there were no significance difference (P<0.05, Table 2) among varieties. Varieties

with high malt extract were Holker(80.9), Travller(80.5), Beka(78.9), Sabini(78.5) where as varieties with low malt extract were Miscal-21(73.8), EH-18-47(75.5) and HB-1533(76.8). Extract difference were poor for most of the varieties which indicates low malt modification .The extract yield reflects the extent of enzymatic degradation and the solubility of grain components after malting and mashing (Swanston *et al*., 2014). Mean EBC hot water extract value ranged from 75.0-80.7% but this result were indicated most of the varieties in the specification of the EBC standard. This study result indicates high malt extract result compared to EBC range for the Varieties.

Color of wort

Color of wort was significantly different among the varieties (P<0.05, Table 2). The mean color of wort among varieties ranged from (3.7-7.0 EBC unit) (Table 2).Varieties which were not in the EBC specification were Travller(5.0), Beka(5.5), Ibon 174/03, HB-1533(5.2) where as the other varieties were in the specification range. 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 determining the resulting flavor and color (Guerrero, 2009).In this study most of the varieties were in the specification range according to brewing industry.

PH of wort

PH of wort was significantly different among the varieties (P<0.05, Table 2).The PH range for the varieties were 5.5-6.5 which were in the specific range of European brewery convention. Varieties with appropriate PH were Bekoji-1(5.6), grace(5.7), Sabini(5.9), Miscal-21(5.9) and Holker (5.9). 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 limit the growth of microorganism in this case the growth of fermenting yeast is influenced within the variation of PH .but in this study the PH of wort is in the specified range.

Friability

The analysis results showed that, there were significantly different (P<0.05, Table 2) among varieties for friability content. Varieties with high friability were Grace(90.2), Sabini(86.5), Holker(74.9), Bahati(67.5), Traveller(63.1) which indicates high lautering performance. Varieties with low friability were Miscal-21(31.6), Beka(38.5) HB-1533(33.7) indicated that Under modification can lead to poor mash conversion and more high viscosity polysaccharides such as beta glucan. Factors that interfere with endosperm modification, such as poor germination, large kernels and high protein, are expected to reduce malt friability (Edney and Mather, 2004).

CONCLUSION

The result of this study showed that the varieties Holker,Travller,Sabini,Bekoji-1,Grace,Bahati and Beka were acceptable malt quality (grain size, germination energy, moisture content, thousand kernel weight, protein content) and malt quality (extract amount, malt protein content, PHof wort, Color of wort, soluble protein, kolbach index and friability) results compared to the European brewery convention specification. These varieties will be useful for row material for brewing industry as well as for the breeding program in the future for development of malt barley Varieties.

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