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Full Length Research

Assessment of Malt Quality Attributes of Barley Genotypes grown in Bekoji, Holeta and Ankober, Ethiopia

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Barley is a crop of ancient origin in Ethiopia which is an important food source and industrial crop for beer production. Sixteen malt Barely varieties (four released varieties which were in production such as Holker, Traveller, EH1847 and IBON174/03 and twelve promising Cultivars) during the year 2014-2015 main seasons the experiment were conducted and analyzed for their grain, malt and wort quality parameters. The Grain quality parameters for sixteen Cultivars such as sieve size, germination energy, moisture content, Hectoliter weight ,thousand kernel weight and protein content and malting and wort quality parameters for sixteen Cultivars ,Hot water extract, soluble protein content, friability, diastatic power, free amino nitrogen, zinc content were analyzed. Cultivars MB1, MB3, MB5, MB7, MB9, and MB4 were better result in grain and malt quality trait compared to the standard check over the three locations Bekoji, Holeta and Ankober. Among the three locations Kulumsa (Bekoji) was suitable for quality malt barley production as the grain and malt quality traits are in the acceptable range followed by Dbrebrhan (Ankober). 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).

Key words: malt barley, malt quality, standard check

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INTRODUCTION

Barley is a crop of ancient origin in Ethiopia and the country is considered as a center of diversity for barley, because of the presence of great diversity in ecology (Berhane,1991).In Ethiopia barley has a long history of cultivation in the highlands (Firdissa *et al.,* 2010). The diversity of barley types found in Ethiopia is probably not exceeded in any other region of comparable size (Bekele, 1983). Barely in Ethiopia is mainly used for making local recipes and drinks in Ethiopia such as Bread, kolo, Genfo, Animal feed, Beso, Tela and Borde. Malt is the second largest use of Barely and at the present time it is considered as one of the cash crop in Ethiopia and its demand by malt factory is increased due to expansion of breweries and beer consumption levels in the country (AMF, 2012). As reported by Mohammed and Getachew (2003) and presented by Ethiopian Barely Business (2012) malt barely is among crops demanded in good quantity and quality. Similarly in 2011, Breweries in Ethiopia imported 60% of the malt primarily from international producers (Ethiopian Barely Business case presentation, 2012).

The demand from agro industry supply of products in

quality and quantity hinder the activity of the brewing industry and their growth. Malt barely grain is mainly produced in the south eastern part of Ethiopia in Aresi and Bale administrative zone (Getachew *et al.*, 2007). Therefore, this study was conducted to generate the current methods and ways of improvement of barely with their quality attributes that are important to characterize barely grain according their physical and chemical characteristics for malting and technology needs and identifying malt barely advanced variety for varieties with respect to 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 barley variety.

MATERIALS AND METHODS

The experiment was conducted during the year 2014-2015 at three locations. These were in Arsi zone of Oromia region (Kulumsa agricultural research center), Amahara region north shewa (Deberebrhan regional research center) and west shewa at Holeta agricultural research center located in the central high land of Ethiopia. Trial planting and field management was implemented as per the standard procedure. Sixteen barley varieties were collected from the National Variety Trial (NVT) which was conducted at Holeta, Debrebrhan and Kulumsa Agricultural Research Center. Four variety (Holker, traveler, EH 1847, IBON174/03) were used as standard check (they were released varieties)and selected based on their yield.

A composite sample was prepared from three locations for analysis at Ethiopian institute of agricultural research. The grains were initially analyzed such as Grain size was performed by 2.8mm, 2.5mm and 2.20mm vibrating sieves in to four components. Germination energy was determined taking 100 Barley kernels were spread on wetted (4ml distilled water) filter paper lined on Petri dishes (90mm) and allowed to germinate at nearly 100% relative humidity set at a temperature of 16°C germination cabinet for 3 days as described in EBC (1998) method 3.6. Moisture content was measured taking a sample of about 3g flour was weighed on analytical balance and oven dried at 105^{O}C for 3 hours. The moisture lose on drying was calculated and expressed in % of the predrying sample mass as described in the EBC(1998) Method 4.2.1. Thousand kernel weights were determined by taking 100 kernel barley samples counting and calculated as percentage corn weight**.** Hectoliter weight was determined on dockage free samples using a standard laboratory hectoliter weight apparatus (grain analysis computer (GAC) 2100) as described in the AACC (2000) method no 55-10. The protein content of each barley variety was determined by Kjeldahl method as stated in the AACC (2000) Method 46-11.

Malts was prepared using a Phoenix Automated Micro malting system (Phoenix Bios stems, Adelaide, Australia). The mashing process was according to the EBC congress mashing method. Friability 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 tested according to EBC method 4.15 (EBC, 1998).soluble protein content was determined by taking 20 ml wort and pipated in to kjeldahl flask and 3ml of sulfuric acid was added. Antifoam was added to prevent excess foaming. After drying 20ml sulfuric acid and 10g of catalyst was added. The digestion, distillation and titration were completed as described in EBC method. The diastatic power of barley malt was determined according to ASBC (2008).The free amino nitrogen value was determined from the wort sample based on a small scale version of the IoB Ninhydrin method. Zinc concentrations were determined by reference to an appropriate metal solution made of 1000ppm standards. The wort samples were homogenized by shaking before used. It was filtered through dry zinc free filter paper and the first 4 ml filtrate was discarded before collecting. Successively pipette in a test tube 2.0 ml wort sample, 8.0ml 0.01 mol/l HCl was mixed well. The atomic absorption spectrophotometer was used to determine zinc.

RESULTS AND DISCUSSION

Grain quality

Grain size (sieve size): (Fox *et al*., 2006) demonstrated the genetic and environmental effects in improving grain size. Industry standards on large grain are based on the total percentage of grain > 2.5mm (IOB, 1997). Growing location showed significance difference (P<0.05 Table 3) in grain size. Varieties grown at Bekoji had higher mean grain size than varieties grown at Ankober and Varieties grown at Ankober had higher mean grain size than Holeta (94.07, 92.87and 72.62 %respectively) but the requirement in the brewing industry is >80 % must be above 2.8 and 2.5 mm sieve size according to Ethiopian standard requirement for malt purpose. Mean grain size in Holeta was very small compared to Bekoji and Ankober**.** The analysis of variance for grain size was not significantly different (P<0.05, Table 1) among varieties. Highest mean grain size percentage were obtained in MB15 (92.56%) and MB1 (92.66%) while varieties MB12 (78.83%) and MB11 (80.1%) had lower values (Table 1).The grain size percentage should be >90% for 2-rowed barley and >80% for 6-rowed barley (Anonymous, 2012).in this study the grain size fulfill the standard requirement of the Industry according to EBC and

Table 1. Effect of variety on grain size, germination and moisture content of grain

Genotype/Varity	Grain quality parameter		
	Grain size (%)	**Germination energy (%)**	**Moisture content (%)**
1.MB1	92.66±3.46^{c}	89.33±5.13^{e}	11.46±2.84
2.MB2	86.00±15.82^{b}	64.33±23.54^{c}	11.10±2.65
3.MB3	90.8±7.70^{b}	96.33±1.15^{f}	11.30±2.72
4.MB4	80.50±25.89^{a}	87.66±9.29^{d}	10.83±2.85
5.MB5	91.93±5.74^{c}	93.66±7.09^{f}	11.00±3.00
6.MB6	83.40±13.13^{a}	68.66±27.30^{c}	11.26±2.96
7.MB7	89.90±7.18^{b}	65.00±34.04^{c}	10.96±2.70
8.MB8	86.06±9.30^{b}	76.33±10.69^{d}	11.33±2.85
9.MB9	87.96±10.48^{b}	96.00±6.08^{f}	11.83±2.70
10.MB10	85.80±20.36^{b}	99.33±1.15^{f}	10.73±2.55
11.MB11	80.10±17.95^{a}	94.33±8.14^{f}	11.10±3.05
12.MB12	78.83±17.87^{a}	87.00±13.52^{e}	11.33±2.80
13.MB13	83.63±10.53^{a}	98.33±2.08^{f}	11.33±2.99
14.MB14	86.60±18.62^{b}	13.00±4.58^{a}	11.73±2.22
15.MB15	92.56±3.63^{c}	55.00±6.55^{b}	11.10±2.88
16.MB16	87.63±9.036^{b}	91.33±9.01^{e}	11.00±2.68

Ethiopia malt factory except variety MB12(78.83%).

*Germination energy (GE):*The Germination energy is the total number of grains that germinate over 72 h of incubation under specified conditions (Woonton *et al*., 2005).The analysis result of germination energy was significantly different (P<0.05, Table 3) between locations. As it was indicated on (Table 3). GE was higher at Debrebrhan (Ankober) (85.93%) than Holeta and Bekoji (76.87%, 76.37% respectively). A minimum of 95% germination on a 3day germination test is an absolute requirement. Any factor which interferes with the uniformity of germination or reduces the vigour 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 1) among varieties. The germination energy of varieties ranged from 13-99.33% (Table 1). The highest value were for MB10(99.33%)followed by MB13(98.33) and MB3 (96.33%) while the lowest was observed in MB14, followed with MB15 .It has been indicated that varietal different showed the difference in germination energy which support this study. Thomas (cited by Swanston *et al.*, 2002) also noted differences in the genetic factors determining germination after three days and also suggested that there were environmental effects on their expression. In this study, the number of grains germinating within 24, 48 and72 hr was significant different between locations and among varieties.

Moisture content: The analysis of variance revealed significance differences between locations for grain moisture content (P<0.05, Table 3). As the mean indicated in Table 3, the moisture content of grain was higher at Bekoji than Holeta and the moisture content of grain was higher at Holeta than Ankober (13.83, 11.44% and 8.36%, respectively). Moisture levels 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. Quality and germinative capacity may also significantly deteriorate (Plankinton *et al*., 2014). The result (Table 1) showed that the moisture content were not significantly different (P<0.05, Table 1) among the varieties. The moisture content of varieties varied between 10.00-11.9%. The highest moisture content was for variety MB9 (11.83%) and the least was observed in MB10 (10.7%).According to Fox *et al.* (2003) the maximum reasonable industrial specification of malt barley moisture content for safe storage is 12.5%, whereas, the EBC standard, a moisture content of 12 -13% is accepted. In this study the moisture content were in the acceptable range.

Table 2. Effect of variety on Hectoliter weight, thousand kernel weight and protein content of grain.

Genotype/Varity	Grain quality parameter		
	Hectoliter weight	Thousand kernel weight	Protein content
1.MB1	64.36±4.350[a]	48.96±3.53[c]	10.03±1.501[a]
2.MB2	67.00±4.026[b]	46.80±5.23[b]	10.43±2.064[b]
3.MB3	66.66±3.82[b]	47.80±3.56[b]	10.80±1.41[b]
4.MB4	65.73±2.36[a]	50.13±6.21[c]	10.23±2.48[a]
5.MB5	65.86±3.34[b]	47.53±3.66[b]	10.50±1.91[b]
6.MB6	66.60±2.94[b]	50.63±4.25[c]	11.10±1.45[b]
7.MB7	66.20±3.85[b]	46.50±3.051[a]	11.50±1.45[c]
8.MB8	65.93±3.11[b]	45.40±4.51[a]	10.23±.92[a]
9.MB9	67.90±3.06[c]	47.43±4.90[b]	9.86±1.30[a]
10.MB10	65.33±3.80[a]	51.60±5.55[d]	10.46±1.27[b]
11.MB11	65.30±4.38[a]	47.83±2.61[b]	10.33±1.87[a]
12.MB12	66.56±1.98[b]	44.56±7.83[a]	10.96±2.00[b]
13.MB13	64.566±2.87[a]	50.00±5.56[c]	9.96±1.46[a]
14.MB14	64.53±3.35[a]	48.13±8.46[b]	9.66±.66[a]
15.MB15	65.43±3.16[a]	46.66±3.00[b]	11.30±1.55[c]
16.MB16	64.66±2.84[a]	51.10±1.94[d]	10.46±1.78[b]

Tables 3. Effect of location on grain size, germination and moisture content of grain.

Location	Grain quality parameter		
	Grain size	Germination energy	Moisture content
Holeta	72.62±11.38[a]	76.87±24.58[a]	11.44±.51[b]
Debrebrhan(Ankober)	92.87±4.19[b]	85.93±26.34[a]	8.36±.62[a]
Kulumsa(Bekoji)	94.07±2.96[b]	76.37±24.45[a]	13.83±.34[c]

Tables 4. Effect of location on Hectoliter weight, Thousand kernel weight and protein content of grain.

Location	Grain quality parameter		
	Hectoliter weight	Thousand kernel weight	Protein content
Holeta	67.88±1.61[c]	44.17±3.62[a]	10.60±.95[b]
Debrebrhan(Ankober)	67.16±1.63[b]	48.01±2.62[b]	9.00±.60[a]
Kulumsa(Bekoji)	62.33±1.71[a]	52.39±2.93[c]	11.87±.88[c]

Thousand grain weight: The analysis of variance of thousand kernel weight was significant difference (P<0.05 Table 4) between locations. Bekoji revealed a greater TKW than Ankober and Ankober revealed a greater TKW than Holeta (51.6 g 48.0 And 44.17 g, respectively). Between the locations, lowest values were obtained at Holeta (44.17g). However, highest values (> 46 g) were obtained at Ankober and Bekoji. Thousand grain weight (g) should be >45 g for 2-rowed barley and > 42 g for 6-rowed barley (Anonymous, 2012).The thousand kernel weight result showed that there was no significant difference (P<0.05, Table 2) among the varieties. In this study, thousand kernel weight varied between 44.55-51.6 g (Table 2). The highest Thousand kernel weight was for MB10 (51.6 g) and the least was observed in MB12(44.5 g). Lu *et al*. (2001) also reported the minimum and maximum thousand kernel weight of malt barley which is ranged from 38.6-53.0 g and this result is above to our finding and it fulfill EBC (23-35%) standard requirement for industry.

Hectoliter weight: The hectoliter weight was significantly affected by location (P<0.05) and there was effect of growing location on all the sixteen varieties (Table 4).The Hectoliter weight was relatively higher obtained at Holeta and Ankober (67.88 kg/hL,67.16 kg/hL) than Bekoji (62.33 kg/hL) (Table 4). Hectoliter weight has been shown to be influenced by growing environment (Molina-Cano et al. 1997). Test weight (TW) (bulk density or HLW) is an industry standard for classifying malt and feed barley. Barley with plumper grains and a higher test weight should have a greater percentage of starch or

energy in the grain and should be lower in fiber (Shewry and Morell, 2001).MB9 (67.9 kg/hl) followed by MB2 (67. kg/hl), MB3 (66.6 kg/hl) were highest hectoliter weight value. The varieties MB13 and MB14 were lower Hectoliter weight (64.56 and 64.53 respectively) (Table 2). Hectoliter weight is one of the best correlated parameter for malt quality and the effect of location had significant effect on hectoliter weight.

Protein content: The analysis of variance revealed significant differences between locations for grain protein content (P<0.05, Table 4). The protein content was relatively higher at Kulumsa (Bekoji)(11.87) than Holeta and Ankober(10.6 ,9.0 respectively) in (Table 4). The Grain Protein Content is influenced to a large extent by both genotype and environment (Bathgate, 1987). The protein content of the grain result showed that there was no significant difference (P<0.05, Table 2) among the varieties. In this study the protein content of the grain of barley variety varied between 9.66-11.50 (Table 2). Lowest mean protein content was obtained in MB14 (9.66%), followed by MB9 (9.86). The protein content were on higher side in MB7 (11.50) and MB15 (11.30%) (Table 2). Desirable protein content range for 2-rowed barley is 9.0-11.0% and for 6-rowed barleys 9.0-11.5% (Anonymous, 2012). Barley used for malt should have a grain protein concentration (GPC) below11.5%, as higher protein content will deteriorate malting produce and final beer quality.

Malt quality

Hot water extract (HWE): Fine grind hot water extract was significance difference between locations (P<0.05, Table 6). The extract amount was higher at Holeta (72.74%) than Bekoji and Ankober (70.04%, 68.66%, respectively) and the lowest value is found at Ankober. variation in growing conditions resulted in a wide range of malt extract values. According to Fox *et al.* (2003) the quality of the extract is influenced by several factors such as environmental, growing conditions, temperature, fertilizer, available nitrogen, or moisture.The result showed no significantly different (P<0.05, Table 5) among varieties for fine grind hot water extract. The mean hot water extract among varieties ranged from (67.18-72.91%) (Table 5). The highest (72.91) fine grind hot water extract was recorded for MB1 whereas, the lowest (67.18) value was in MB4. The extract content of promising varieties were having the same potential with released varieties. The best extract content was obtained from variety MB1 which is a promising one which is compared to the released variety MB14and MB13.The extract yield reflects the extent of enzymatic degradation and the solubility of grain components after malting and mashing (Swanston *et al.*, 2014). Low malt extract in barley seeds is ungerminated and incompletely modified seeds because High glucan content, slow filtration rate and high molecular nitrogen in extract, which result in low quality of beer. Mean EBC hot water extract value ranged from 75.0-80.7% but this result were below the EBC standard. This study result indicate low malt extract compared to EBC range for the Varieties.

Friability: Friability is a measure of the breakdown of malt endosperm cell wall components. Malt friability should be >60% (Anonymous, 2012).The variation for friability was not significant (P<0.05, Table 6) between locations. The mean value for locations was 56.95%, 57.65% and 63.46which were at Holeta, Ankober and Bekoji respectively. The friability at Bekoji was highest. The lowest friability were observed at Holeta. 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 (Chapon *et al*., 1979).The analysis results showed that, there was no significantly different (P<0.05, Table 5) among varieties for friability content. The mean friability content of the varieties ranged from (50.9-71.7) (Table 5). The highest malt friability content was for MB16 (71.7), while the least was observed in MB15 (50.9) the range is in between the standard check. But most of the varieties also had friability percentage of <60%, When barley endosperm is properly modified during malting, the resulting malt is soft and friable. Factors that interfere with endosperm modification, such as poor germination, large kernels and high protein, are expected to reduce malt friability (Edney, 2014).in this study the friability contradict the required standard. Since the friability of the variety need modification.

Soluble protein content: Soluble Protein of malt was not significantly different (P<0.05, Table 6) between growing locations. As it was presented in (Table 6) the higher soluble protein content was at Bekoji (4.85%) than Holeta and Ankober (4.40 versus, 4.41% respectively).The analysis results showed that, there was not significance difference (P<0.05,Table 5) among varieties for soluble protein content. The mean soluble protein content of the varieties ranged from (3.51-5.43%) (Table 5). The highest malt soluble protein content was for MB7 (5.43), while the least was observed in MB11(3.51%).In protein protein linkages, the stabilize foams and are responsible for mouth feel and flavor stability, and in combination with polyphenols, they are thought to form haze. As amino acids and peptides they are important nitrogen sources for yeast (Steiner *et al.,* 2009).

Diastatic power:The variation for Diastatic power was not significant (P<0.05, Table 3.7) between locations. The mean value for locations was higher at Ankober (372.01WK) than Holeta and Bekoji (370.69 and

Table 5. variety effects on malt quality of Fine grind Hot water malt extract (%), Friability and soluble protein content (%).

Genotype/Varity	Malt quality parameter		
	Fine grind malt extract	Friability (%)	Soluble protein content of wort
1.MB1	72.91±3.475[c]	54.73±7.5[b]	4.66±1.18[c]
2.MB2	71.70±4.978[c]	62.56±7.88[c]	3.94±0.60[b]
3.MB3	70.91±1.940[b]	69.60±10.71[d]	4.21±0.62[b]
4.MB4	67.18±4.69[a]	61.00±3.29[c]	4.80±0.39[d]
5.MB5	71.21±2.23[b]	52.96±15.02[a]	4.25±0.69[b]
6.MB6	71.90±1.20[c]	51.80±0.91[a]	4.79±0.68[d]
7.MB7	71.86±2.71[c]	53.23±11.47[a]	5.43±0.86[e]
8.MB8	68.67±4.614[a]	54.00±9.6[a]	4.61±0.38[c]
9.MB9	71.98±1.88[c]	60.50±0.7[c]	5.06±1.28[d]
10.MB10	72.19±4.96[c]	60.60±0.72[c]	4.46±1.22[c]
11.MB11	69.75±3.28[b]	55.92±4.53[b]	3.51±0.83[a]
12.MB12	68.59±4.37[a]	61.40±4.97[c]	5.29±1.45[e]
13.MB13	70.77±3.16[c]	61.65±1.81[c]	4.82±0.42[d]
14.MB14	71.70±1.52[c]	67.16±10.42[d]	4.09±0.22[b]
15.MB15	68.74±6.11[a]	50.90±14.16[a]	4.38±0.82[c]
16.MB16	67.65±3.40[a]	71.70±5.99[e]	4.56±1.29[c]

Table 6. Location effect on malt quality of Fine grind Hot water malt extract (%),Friability (%)and Soluble protein content of wort

Location	Malt quality parameter		
	Fine grind malt extract (%)	Friability (%)	Soluble protein content of wort
Holeta	72.74±1.74[b]	56.95±9.95[a]	4.40±0.69[a]
Debrebrhan(Ankober)	68.04±2.77[a]	57.65±7.31[a]	4.41±1.19[a]
Kulumsa(Bekoji)	70.66±3.99[a]	63.46±9.37[b]	4.85±0.61[b]

352.97WK) respectively. The Diastatic power at Ankober (372.01WK)was highest. The lowest Diastatic power was observed at Bekoji (352.97WK).Diastatic power, the total activity of starch degrading enzymes in barley malt, is considered to be an important quality characteristic for malting and brewing (Allison, 1986). The conversion of barley into beer represents mankind's oldest and most complex example of applied enzymology. Indeed, historically some of the most significant advances in enzymology have been linked to the world of brewing, such as Eduard Buchner's extraction of enzymes from brewing yeast and Adrian Brown's kinetic analysis of invertase (Brown, 1902).The analysis results showed that, there was no significant difference (P<0.05) among varieties for Diastatic power content. The mean Diastatic power content of the varieties ranged from (288.80-428.60WK) (figure 1). The highest malt Diastatic power content was for MB16 (428.60WK), while the least was observed in MB11 (288.80WK).The desirable range for diastatic power is 90-110^{o}L or 200-300WK for 2-rowed cultivars and 90-120^{o}L for 6-rowed ones. The mean values of DP were not in optimum range. Mean DP value was however higher compared to the standard. The development of improved varieties for quality purposes always requires identification of important traits affecting quality. In this study the result were showed higher which indicate active enzymatic activity for fermentation to be fast.

Free amino nitrogen: The analysis results showed that, there was no significant difference (P<0.05, Table 7) between location. The free amino nitrogen value in location Holeta were highest (275.29ppm) and the lowest value were kulumsa (bekoji) (235.71ppm). The analysis results showed that, there was no significant difference (P<0.05) among varieties for FAN. The vale was ranged

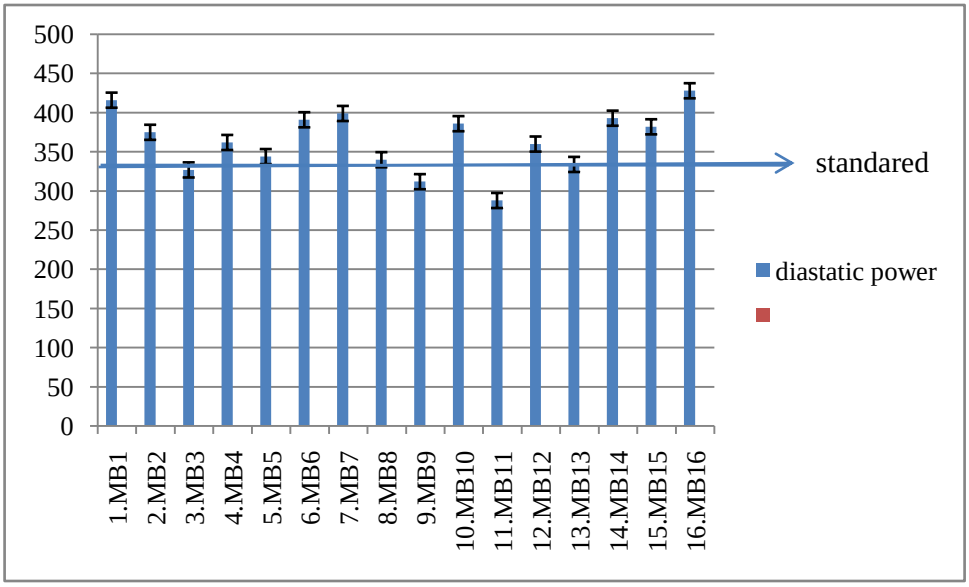

Figure 1.diastatic power in the barley malt (wort)

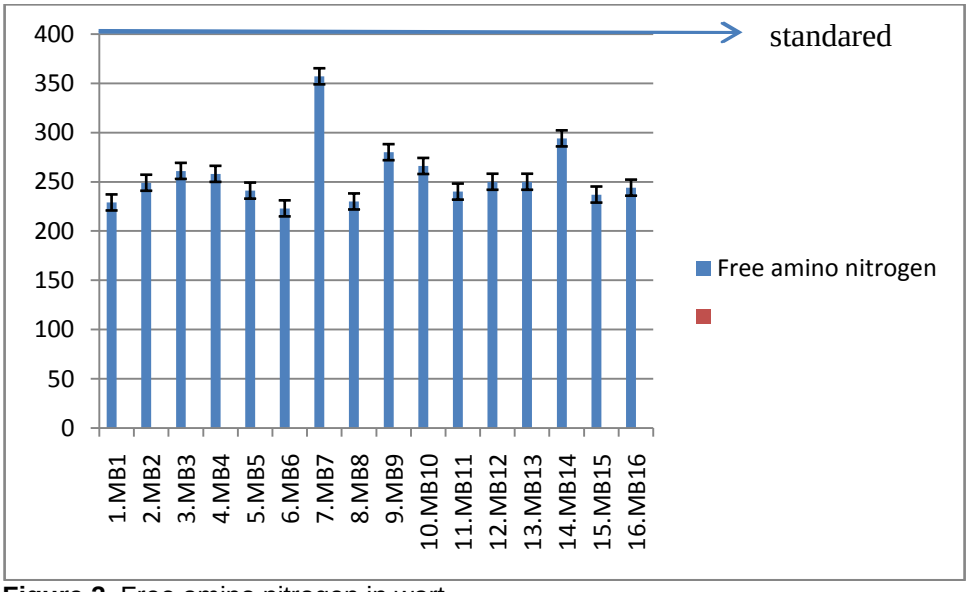

Figure 2. Free amino nitrogen in wort.

(223.48 -357.06 ppm). The variety B7, MB14, MB9 (357.06, 294.59, 280.86 ppm) were highest in free amino nitrogen content. High FAN Value is considered to be a good index for potential yeast growth and fermentation. Protein modification also involves the production of wort amino acids and small peptides (dipeptides and tripeptides), collectively known as free amino nitrogen (FAN). Adequate levels of FAN in wort ensure efficient yeast cell growth and, hence, a desirable fermentation performance. MB1, MB6, MB8 were lowest in FAN Value (229.27,223.48,230.5ppm) Enari in 1975 concluded that barley variety, nitrogen content and the malting technique all influence the FAN level of the wort generally the specifications for a normal fermentation require FAN levels between 140-160 mg/L(250-400ppm).in this study the FAN value have comparable value in the standard requirement indicating rich in free amino nitrogen content for yeast nutrition. See Figure 2 & Table 7)

Zinc content: The analysis results showed that, there was

Table 7. Effect of location on Diastatic power, Free amino nitrogen

Location	Malt quality parameter	
	Diastatic power	Free amino nitrogen
Holeta	370.69±57.68[a]	275.29±54.06[b]
Debrebrhan(Ankober)	372.01±69.77[a]	260.90±40.57[b]
Kulumsa(Bekoji)	352.97±49.87[a]	235.71±49.74[a]

no significance difference (P<0.05) among the variety for zinc content in the wort. The mean value for variety MB1 and MB4 were higher in zinc content 5.07mg/L, 5.08mg/L respectively. The lower value in zinc content were for variety MB9 and MB3 1.72mg/L,1.75mg/L respectively. The zinc content was ranged 1.72-5.08 mg/L. Zinc ions are essential for an effective and vigorous fermentation. The presence of zinc is essential for the structure and function of many enzymes, where it can be involved in the active site (zinc-metalloenzymes). However, zinc can inhibit yeast growth and fermentation at higher concentrations under certain circumstances. Zinc additions during fermentation have also shown to increase the levels of higher alcohols and esters but to reduce acetaldehyde levels. Volatile organic compound levels were higher, this may however also cause an increase of medium fatty acids responsible for undesired soapy, fatty and rancid tastes (Nicola, 2009). Figure 3

CONCLUSION

The result of this study showed that the varieties MB1,MB3,MB5,MB7,MB9,MB10 and MB4 were acceptable grain quality (grain size, germination energy, moisture content, Hectoliter weight, thousand kernel weight, protein content) and malt quality (Hot water extract amount, soluble protein, free amino nitrogen, diastatic power ,Zinc content) results compared to the standard checks (MB13,MB15,MB14 and MB16).These varieties will be usefull for the breeding program in the future for the development of malt barley Varieties. The result of this study also showed that among the three locations Kulumsa (Bekoji) was suitable for quality malt barley production as the grain and malt quality traits are in the acceptable range followed by Dbrebrhan (Ankober).

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