

Effect of Kilning Temperature on Some Physico-Chemical Properties of Malt

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Abstract

The character and the quality of the malt is affected during kilning. Mashing and wort quality is also affected during kilning of malt. Accordingly an experiment was conducted on the malt quality parameters for malts kilned in different temperature. In Ethiopia, there is high demand of quality malt for new emerging beer industries. Thus, this research aims to evaluate the effect of kilning temperature of selected barley variety Holker from Kulumusa research center Ethiopia. The kilning of germinated barley was performed at four different temperatures (50°C, 70°C, 90°C and 110°C) in order to produce four different malts. The experiment contained in combination of the four kilning temperatures laid out in complete randomized design with three replications. As a result, all investigated malt quality assessing parameters which includes the hot water extract, color, pH, malting weight loss and the wort viscosity were significantly different among the different treatment temperatures. Malts treated with 50°C and 70°C gave good malt quality containing higher hot water extract (79.7 and 75.17%), a normal color (2.32 and 2.63), standard pH (6.53 and 5.99), acceptable malting weight loss (0.60 and 1.55) and appropriate wort viscosity (1.66 and 1.62cp), respectively.

Keywords: Malt, Kilning, Temperature, Physico-Chemical, Barley

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1. Introduction

Barley (*Hordeum vulgare* L.) is the most widely adapted cereal grain in the world. The annual world production reached over 141 million tons in 2016 (FAOSTAT, 2018). Barley is commonly used for malting as it has a three-celled aleuronic layer that ensures extensive and uniform breakdown of the starchy endosperm which is important in the production of good quality malt (Brennan *et al.*, 1997). The malting quality of barley is very complex and is controlled by many genes and is strongly influenced by the environment (Fox *et al.*, 2003). Due to the increasing beer consumption in the world, there is a high demand for quality malting barley (Sardana and Zhang, 2005).

There are three steps for malting procedure includes: steeping, germination and kilning. Kilning is heating of grain with increasing temperature regime above 50°C in order to obtain desired properties for the malt. The desired properties include enzyme survival, removal of moisture for stabilization, removal of raw flavours, development of malty flavours and colour (Bamforth, 2003). The kilning of malt is not simply a drying process but also a chemical process in which the character and quality of the malt are generated (Johnston, 1954). The reaction of sugars and amino acids induced by heating during the kilning process and wort boiling leads to the formation of melanoidins via the maillard reaction responsible for imparting colour to beer (Bamforth, 2003).

It was observed that malt processing like kilning temperatures can affect the quality of the malt and it also determines wort colour (Bamforth, 2006). The most important quality parameters for the malting industry include moisture content (3-5.8%), PH of wort (5.6-5.9), plump kernels (>2.5 mm), protein content in the range of (9-11.5%), high diastatic power (200-300wk) and high malt extract i.e. based on EBC standard. Malting varieties are preferred by brewing industries since the hull forms a filter bed during wort filtration, although hull-less barley could be also employed in malting (Bhatty, 1999).

Thus the aim of the present work was to study focuses on effect of drying temperature of Holker barley variety from Kulumusa research center Ethiopia, on some Physico-chemical properties of malt. Consequently, this will support in solving the familiar quality problems pointed out usually by the local brewing industries.

2. Materials and Methods

2.1 Sample Collection and Preparation

The raw material for the production of malt is the malting barley. The selected barley variety i.e. (Holker) was taken from Assela malt factory, Asela (Kulumusa) Ethiopia. The sample was cleaned to separate the foreign matters, including dust and dirty, also broken and immature grains. Barley kernels (SB) were malted in the Hawassa University Food Microbiology Laboratory.

Steeping: Three Kg of barley kernels were steeped in nylon bags with appropriate amount of tap water, following the procedures of (Weston *et al.*, 1993). The kernels were steeped for 12hrs, followed by 2 hrs aeration, 8hrs steeping, 2hrs aeration, 12 hrs steeping, 2hrs aeration and finally 10 hrs steeping (a total of 48 hrs) at room

temperature to reach moisture content of 42-44%.

Germination: The steeped barley was spread in nylon bags and placed on plastic sheet lined with aluminum shelves and were allowed to germinate at room temperature (Weston *et al.*, 1993). Known amount of distilled water were sprayed every 24 hrs for three days using hand sprayer to maintain the relative humidity. On the fourth day i.e. 96 hrs, (when the length of the acrospires is $\frac{3}{4}$ of the length of the kernels), the germinated sample were transferred to drying oven for kilning.

Kilning: The germinated sample was kilned in time and temperature controlled drying oven. The original sample was divided in to four equal parts. Each sample were then dried in four different drying temperatures (i.e. 50°C, 70°C, 90°C and 110°C) for 24 hrs in order to obtain four different malt samples (M50, M70, M90 and M110 respectively).

2.2 Experimental Design

The experiment was made in complete randomized design (CRD). The different drying temperatures (i.e. 50°C, 70°C, 90°C and 110°C) were replicated and evaluated under the above experimental design. In this experimental design, the drying temperature was the independent variable and the quality parameters (i.e. hot water extract, malting weight loss, moisture content, Wort viscosity and Wort PH) were the dependent variables.

2.3 Grain Quality Analysis

2.3.1 Grain moisture content (GMC)

The selected barley variety was cleaned and samples were weighed on analytical balance and oven-dried for 2hrs at 105°C. Finally moisture loss during drying were calculated and expressed in percentage (AOAC, 1990). It was calculated as shown below:-

$MC = (W2 - W3 / W2 - W1) * 100$ Where:

- MC= moisture content of the grain
- W1= weight of the container
- W2= weight of the sample and container
- W3= weight of the sample and container after drying

2.3.2 Thousand kernel weight (TKW)

Sample of the selected barley variety was prepared and 500 kernels were counted, and then the 500 kernels were weighed and calculated as follows:

$$G = \frac{W * 1000 * D.M}{N * 100}$$

- G = Weight of a thousand kernel of dry barley in grams.
- W = Weight of 500 kernel taken in grams.
- D.M = Dry matter percentage of barley (100-Mc.)
- N = Number of kernels in lot taken.

2.4 Malt Quality Analysis

2.4.1 Malt moisture content (MMC)

It was the same procedure used for grain moisture content. The only difference being malt was used instead of barley grain.

2.4.2 Malting weight loss (MWL)

Malting weight losses of each sample were estimated by calculating as follow. Thousand kernel weight of the malt were subtracted from thousand kernel weight of the grain and divided to the thousand kernel weight of the grain. Then the result was multiplied by 100.

$$MWL = ((TKWG - TKWM) / TKWG) * 100$$

Thousand kernel weight of the sample was calculated with the same procedure used for the grain. The only difference being malt was used instead of barley grain.

2.4.3 Hot water extracts (HWE)

This was done as described in the AOAC (1990) method. 50g ground malt of each sample were mashed (mash bath), with appropriate amount of distilled water (200 ml) at 45°C for 30 min. Then the temperature was raised (1°C/min) for 25 minute raising the temperature to 70°C. This time a further 100ml of distilled water was added and saccharification was completed at this temperature marked by 2% iodine solution test.

The samples were cooled and adjusted to total mass by addition of distilled water. The samples were filtered through filter paper of diameter 320 mm and the time elapsed by each sample to filter fully into a flask were recorded as filtration time. The malt extract was determined by specific gravity method (DMA density meter) expressed in degrees Plato (P) and converted to % dry matter basis as follows:

$$E = \frac{(P(MC + 800))}{(DM(100 - P))} * 100$$

Where:

- E = % extract on sample.
- D.M = Dry mass of the malt.
- P = Grams of extract in 100g of Wort (Plato).
- MC =Moisture content of the malt.

2.4.4 Viscosity (v)

Viscosity of the Wort of each sample was measured using brookfield viscometer and were compared relative to water.

2.4.5 PH of Wort

The yield of extract is influenced by the PH of the mash and hence, consequently by the PH of the Wort. PH of the Wort of each sample was measured using a glass electrode.

2.5 Data Analysis

The experiment was done in triplicate times and the result was presented as mean plus or minus standard deviation. Analysis of Variance (ANOVA) was used to analyze data at $p < 0.05$ and the significance difference between means was determined by Fisher's LSD test. SAS, version 9.1 software was used to perform the statistical analysis.

3. Result and Discussion

3.1 Barely Grain Quality Analysis

From the different barely grain parameters for malting the two important ones for this study, thousand kernel weight and grain moisture content were assessed for the selected barley variety. The results for the assessed parameters are presented and discussed below.

Table 1 Grain Quality Parameters

| Parameters | GMC | GTKW |
|------------|--------|--------|
| Results | 12.57% | 41.44g |

Where GMC= grain moisture content, GTKW= thousand kernel weight

3.2 Grain Moisture Content

The result from Table 1 indicates that the moisture content of the selected barley variety has fallen in the range of EBC standard i.e. (10-13%) which is (<14%) safe to store and for further germination. Different conditions may affect the moisture content of the samples such as absorption of moisture by the samples before it was transferred to desiccators to cool. From the result in Table 1 indicates the thousand kernel weight of the selected barley variety is greater than a specified range of EBC (European Brewery Convention) standard (35-40gm). Thousand kernel weights can be related to the kernel plumpness and the extract yield from malt barley studied by Kunze (1996). With an increase thousand kernel weight, the plumpness and extract yield can increase and the reverse is true. From the result obtained the kernel size (plumpness) and extract yield was good as compared to the EBC standard. The selected variety (Holker) showed higher thousand kernel weight value because of its larger kernel size.

Table 2. Effect of kilning temperature on some physicochemical properties of malt

| Treatment | HWE | Color | pH | MWL | W-viscosity |
|-----------|-------------------------|------------------------|------------------------|------------------------|------------------------|
| M50°C | 79.70±1.01 ^a | 2.32±0.02 ^d | 6.53±0.09 ^a | 0.60±0.01 ^d | 1.66±0.02 ^a |
| M70°C | 75.17±0.57 ^b | 2.63±0.01 ^c | 5.99±0.03 ^b | 1.55±0.00 ^c | 1.62±0.01 ^b |
| M90°C | 69.57±0.96 ^c | 4.97±0.05 ^b | 4.95±0.03 ^c | 2.19±0.01 ^b | 1.52±0.02 ^c |
| M110°C | 64.60±0.54 ^d | 9.11±0.16 ^a | 4.64±0.04 ^d | 4.24±0.0 ^a | 1.48±0.02 ^d |

Where: HWE= hot water extract, MWH= malting weight loss W-Viscosity= wort viscosities

The results in Table 2 showed that there is a significant difference in hot water extract among all different temperature treated barley malts as analyzed using analysis of variance at ($P < 0.05$). Minimum hot water extract was obtained from barley malt sample M110°C which is 64.60% and a maximum of it was obtained for malt sample M50°C resulting in 79.70%. Hot water extract (HWE) is one of the key quality attributes considered when determining the malting performance of barley. The international malting and brewing industries utilise standard procedures for measuring HWE, including European Brewery Convention (Analytica - EBC 1998). Good to brew barley varieties HWE falls in the range from 73.3% to 80.6% (Weston *et al.*, 1993). The European Brewery Convention recommends that HWE of malt should in the range 79% to 82% (EBC 1998). According to this study the samples hot water extract from M50°C meet the the European Brewery Convention (EBC, 1998). The lowest hot water extract was observed in both M90°C and M110°C samples 69.57% and 64.60%, respectively (Table 2). This might be due to the applied high temperature which results in two types of common reactions known as caramelization and maillard reaction.

According to Table 2, there was significant difference at ($P < 0.05$) for the wort color among all treatments, noticing that the color was read at the wave length of 430nm and the results are in terms of absorbance. The

maximum wort color (9.11) absorbance was observed in malt sample M110°C and the minimum (2.32) was observed for M50°C. According to EBC recommendation all treatments resulted in color of wort in standard range. Because the maximum absorbance is a standard for black beer while the minimum absorbance is a standard for light beer. It was observed that malt processing can have a large impact on colour development; increasing modification or kilning temperatures can lead to more intense wort colour (Bamforth, 2006). Increasing the kilning temperature increased the color of the wort (Table 2).

According to Table 2 there was significant difference in pH among all treatments at ($P < 0.05$). Maximum pH of the wort was observed from malt sample M50°C which is 6.53 and a minimum pH was observed in malt sample M110°C resulting in 4.64. According to EBC standard pH of wort falls in a range (5.5-6.6). Therefore malt sample M50° and M70°C were in the range of to EBC standard (EBC 1998).

As perceived in Table 2 there was a significant difference in malting weight loss between the differing treating temperatures at ($P < 0.05$). Minimum malting weight loss was obtained from malt sample M50°C which is 0.60% and a maximum of it was observed in M110°C resulting in 4.24%.

As shown in Table 2 that there was a significant difference ($P < 0.05$) in the wort viscosities among all treatments. Viscosity was a measure of the “thickness” of the wort solution. It was expressed in centipoises units (cP), a measure of the breakdown of beta-glucans. According to EBC 1998, the acceptable wort viscosity range (1.55-1.65cP). In this study wort viscosity of malt sample M50°C and M70°C are within the range of wort viscosity of EBC standard. Malt samples M90°C and M110°C showed a slight decline wort viscosity from the range of the standard. This may be due to milling effect and treatment in case kilning temperature difference. The higher the wort viscosity the longer it takes to filter and hence reduced the wort yields and the lower the wort viscosity would be the sign of poor malt quality.

3.3. Conclusion

This study clearly identified and investigated that there was difference in physico-chemical parameters between all barley based brewing malts treated in different temperature ranges. All evaluated malt quality assessing parameters showed a significant difference among all treatments, some values were found to be within the acceptable limit according to EBC standard. From different temperature ranges for malt treatment, malt treated with 50°C (M50 °C) and 70°C (M70 °C) showed a good malt quality: better hot water extract (79.7% and 75.17%), color (2.32 and 2.63), pH (6.53 and 5.99), malting weight loss (0.60 and 1.55) and wort viscosity of (1.66 and 1.62) respectively. Generally, all investigated parameters hot water extract, color, pH, malting weight loss and wort viscosity showed significant differences among all different kilning temperatures at ($P < 0.05$).

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BIOGRAPHIES

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