Malt Quality Parameters of Finger Millet for Brewing Commercial Opaque Beer

T. Usai[1], B.C. Nyamunda[2], B. Mutonhodza[3]

[1, 3]Midlands State University, Department of Food Science and Nutrition,
Private Bag 9055 Senga, Gweru, Zimbabwe

[2]Midlands State University, Department of Chemical Technology,
Private Bag 9055 Senga, Gweru, Zimbabwe

Abstract: ***This study compares malt quality parameters of finger millet and sorghum. The quality of malt consequently affects the quality of opaque beer produced. Certain parameters are analyzed before the malt is accepted for beer brewing. Grain samples of finger millet and sorghum were tested for germination energy before malting. The resultant malts were analyzed for moisture, diastatic power and free amino nitrogen. Finger millet achieved 100% germination while sorghum attained 99% germination in 3 days. After 5 days malting finger millet had higher moisture content (44%) than sorghum (48%). In terms of free amino nitrogen, finger millet had an average of 114.3 mg/L whilst sorghum had an average of 138.6 mg/L. Diastatic power for finger millet malt was lower (13.6 SDU/g) than that of sorghum malt (30.3 SDU/g). Finger millet has demonstrated a great potential to be used in the brewing of commercial opaque beer.***

Keywords: brewing, diastatic power, finger millet, malt, opaque beer, quality parameter, sorghum.

1. Introduction

Sorghum, finger millet and other cereals have been used to brew traditional opaque beer since time immemorial in Africa. The brewing process involves fermentation of malted grains. Currently sorghum is the main raw material used to brew opaque beer at commercial level in Zimbabwe. Sorghum (*Sorghum bicolour*) and finger millet (*Eulicine coracana*) grains thrive in areas of low rainfall and are cultivated in drought stricken areas in East and Southern Africa [1], [2]. Finger millet grain is resistant to rot and insects' damage and can be stored for as long as five years if kept dry [3]. Sorghum and millets are both usually grown without application of fertilizers or other special inputs.

Brewing of local traditional opaque beer using finger millet malt is significant in many countries. Opaque beer production involves both lactic acid and alcoholic fermentation stages and takes about 5 to 7 days to brew depending on temperature [4]. It is an opaque, alcoholic, effervescent, pinkish-brown beverage with a sour flavor resembling yoghurt and the consistency of a thin gruel [5]. Its opaque appearance is due to the high content of suspended solids and cells such as undigested starch residues, yeasts and other microorganisms. The pinkish-brown colour of opaque beer is due to the solubilisation of reddish anthocyanin pigments during souring and mashing [6]. Its sour flavor is brought about by the lactic acid formation which lowers the pH down to 3.2 [7]. The opaque beer is distributed and consumed while still actively fermenting, thus it is held in vented containers so as to allow escape of carbon dioxide. In contrast to European brewing, opaque beer is not pasteurized and it has a short shelf life ranging from one to five days depending on how hygienic the condition is during preparation and fermentation [8].

Opaque beer is rich in carbohydrates and has an alcohol content ranging from 1-4% [9]. It is also rich in mineral salts and vitamins, such as thiamine, riboflavin and niacin. It was reported that pellagra, which is relatively common in people subsisting on maize diets, was never found in people consuming small amounts of opaque beer [10].

The quality of opaque beer depends on the malt quality [11]. The quality of malt depends upon several parameters such as free amino nitrogen content [12], diastatic power [13] and germination energy [14]. Malting is a biological process that turns grain into malt. Malting of finger millet and sorghum is a common technique in India and Africa and malted finger millet is considered superior to malted sorghum and malted maize [15]. Malting results in mobilization of hydrolytic enzymes such as amylases and proteases which are essential for the solubilisation of starch and proteins in the grains [16]. This makes the grains easy to ferment. Performance of finger millet in the brewing of opaque beer by locals is commendable. This study compares the malt quality parameters of finger millet with that of sorghum which is currently being used commercially to investigate whether it can be used as its alternative in the commercial brewing of opaque beer. The use of finger millet as an alternative for sorghum will reduce or eliminate losses incurred by Delta beverages when sorghum yields are low since this would increase availability of malt at all times. Commercial sales of finger millet will financially boost people living in rural areas who produce this crop.

2. Method

2.1 Sample Preparation

Finger millet grains (2 kg) and 2 kg of sorghum grains were cleaned by handpicking and floatation to remove stones and other debris. The grains were then separately placed in mutton cloth bags and steeped for 8 h in water with formaldehyde. The grains were germinated for 5 days at 25^{o}C in a germination vessel. This was followed by kilning of the malt for 48 h at about 40^{o}C. The malts were turned

twice a day to facilitate drying. The dried malts were then separately milled to a fine powder before analyses.

2.2 Percentage Extract in Malt

Extract is defined as the percentage of dry substance in the malt which is soluble in water when extracted over a standard gradient regime. 50 g of the milled sorghum malt was transferred into a preweighed 500 ml beaker. Warm (45-46^{o}C) atemporated distilled water (400 ml) was poured into the beaker under stirring to prevent lump formation. The mixture was continuously stirred for 50 minutes in a mash bath set at 45^{o}C. The temperature of the mash bath was raised by 1^{o}C per minute for 25 minutes up to 70^{o}C. The mash temperature was maintained constant at 70^{o}C for a further 60 minutes. The mash was cooled to 20^{o}C in 10-15 minutes in an ice bath water under stirring. The mash was filtered and the filtrate was ready for analysis.

2.3 Free Amino Nitrogen

Free amino nitrogen (FAN) in wort is the measure of the quantity of amino nitrogen available to yeast during fermentation, or the quantity of amino nitrogen remaining in the beer after fermentation. Ninhydrin reacts with the free amino acids, ammonia, (and to some extent, end group α-amino nitrogen in peptides and proteins) during boiling to produce a colour.

All prepared samples were atemporated to 20°C and mixed well. A 1 ml wort sample was pippeted into a 100 ml volumetric flask. Deionised water was added to make up to the mark. Aliquots (2 ml) of this solution were pippeted into two test tubes. A reagent blank in form of deionised water were prepared for each batch. Glycine standard samples (2 ml) were prepared in test tubes for each batch. Ninhydrin colour reagent (1ml) was added into each test tube. The test tube contents were thoroughly mixed using a vortex mixer.

The test tubes were then placed in a boiling water bath (95^{o}C) for 16 minutes followed by cooling in a 20^{o}C water bath for 10 minutes. The samples were diluted with 5 ml dilution solution. The mixtures were mixed thoroughly using a vortex mixer and placed in a water bath (20^{o}C) for 25 minutes. The absorbance of the mixtures was then determined using a UV-Vis spectrometer (Shimadzu Model UV-1601) set at 570 nm.

2.4 Diastatic Power

2.4.1 Malt Preparation

Malt meal (12.5 g) was weighed into an extraction beaker followed by addition of 5 g of bacteriological peptone and 250 ml of distilled water. The mixture was placed in a 30^{o}C water bath for 1 h 45 minutes while agitating every 20 minutes. The mixture was filtered throwing away the first 50 ml of the filtrate. The Moisture content of the residue was then determined using the moisture analyzer (Ohaus MB45). Malt filtrate (20 ml) was transferred to a 100 ml volumetric flask and diluted to the mark with 0.5% sodium chloride solution. The diluted extract (10 ml) was transferred into a 250 ml volumetric flask and the mixture cooled to 20^{o}C. Buffered starch solution (200 ml) at 20^{o}C was added to the volumetric flask mixture from a fast flowing pipette and a stopwatch was instantly started under stirring. The temperature of the "starch infusion" mixture was maintained at 20^{o}C for exactly 30 min from the time of adding the starch solution.

At the end of 30 min 20 ml of 0.5 M sodium hydroxide was added rapidly and mixed by inverting the flask. The volume was made up to 250 ml at 20^{o}C with distilled water and thoroughly mixed. The blank solution was prepared by adding 20 ml of 0.5 M sodium hydroxide to the 10 ml of diluted malt extract before adding the 200 ml of starch solution. The blank solution was treated in exactly the same way as the starch solution actually undergoing diastasis.

2.4.2 Titration

Five millilitres of the digested starch solution were transferred into a 125 ml Erlenmeyer flask. Alkaline ferricyanide reagent (10 ml) was added to the mixture and the flask was immersed in a vigorously boiling water bath for 20 min. The level of the boiling water was slightly above the level of the mixture in the flask. After 20 min in the bath the flask was removed and cooled to room temperature under running water. This was followed by addition of 25 ml of acetic acid-salt solution and 1 ml of potassium iodide solution. The mixture was titrated with 0.05 M sodium thiosulphate solution until complete disappearance of the blue colour.

For blank correction, 5 ml of the blank correction solution was added to a 125 ml Erlenmeyer flask and 10 ml of 0.05 M alkaline ferricyanide solution. The flask was immersed in boiling water for 20 min, cooled and titrated in exactly the same way as for the direct titration of digested starch solution. Diastatic power (D) was then calculated in degrees using equation 1.

$$D = (V_{blank} - V_{malt}) \frac{2300}{(100 - M)} \quad (1)$$

Where V is the sodium thiosulphate volume used for the titrations and M is the percentage moisture in the malt.

3. Results and Discussion

3.1 Germination Energy

Fig. 1 shows variation of the germination energy of grains with time. Germination is a critical factor to the malting process. If the grain does not germinate, it cannot be processed into malt. This process is important since it results in the solubilisation of hydrolytic enzymes that are important in the brewing process [14]. The germination energy of both sorghum and finger millet shot up within the first 24 hours (89 and 86% for sorghum and millet respectively). The germination energy increased steadily in the next 2 days with sorghum attaining 99% while finger millet exhibited 100%. Finger millet showed higher germination energy than sorghum. According to Morrall *et al* [17], a minimum of 95% germination on a 3 day 4 ml germination test is an absolute requirement. The results are also confirmed by Dewar *et al* [18] who reported that after 72 hours of germination 90% of finger millet grain should have germinated for it to be accepted for malting purposes.

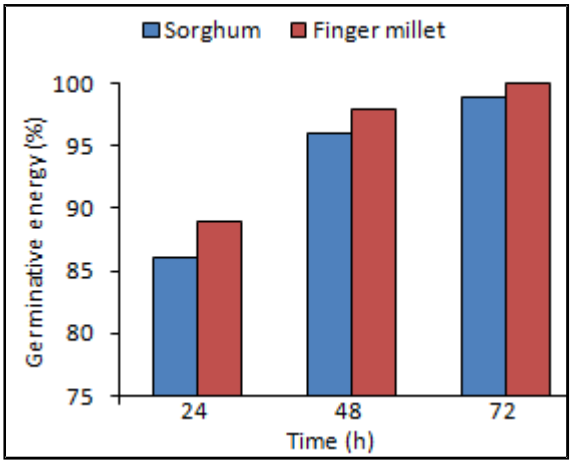

Figure 1: Germination energy of grains

3.2 Moisture Content

Fig. 2 shows the variation of moisture in the grains with time. The moisture content of both sorghum and finger millet increased steadily from day one to the fifth day. Sorghum had higher moisture content than finger millet. The highest moisture content attained in five days was 44 and 48% for finger millet and sorghum respectively. The maximum moisture content of finger millet falls within recommended values of at least 44% [19]. Increase in moisture content is important during the malting process since the grain needs to absorb enough water for activation of enzymes and initiation of germination which ultimately affects the quality of beer produced from the malt.

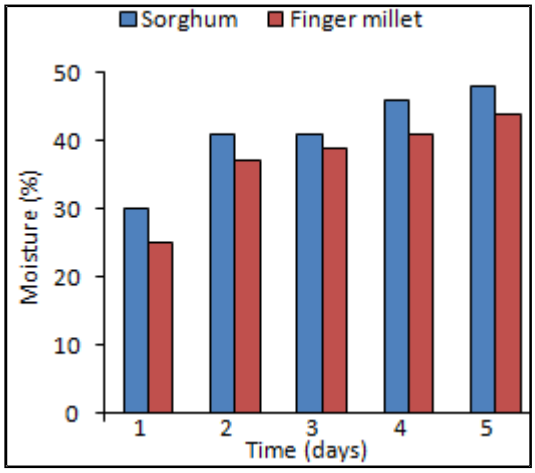

Figure 2: Moisture content of grains

3.3 Free Amino Nitrogen

The FAN in the grains is shown in Fig. 3. The FAN results for finger millet were very low as compared to those for sorghum. The highest FAN values for sorghum and finger millet were 141 and 118 mg/L respectively. These values are higher than the sorghum FAN values reported for Tanzanian varieties by Shayo *et al* [20] which ranged from 96 to 102 mg/L. Shayo *et al* [20] reported that the value for FAN in finger millet ranged from 87 to 155 mg/L.

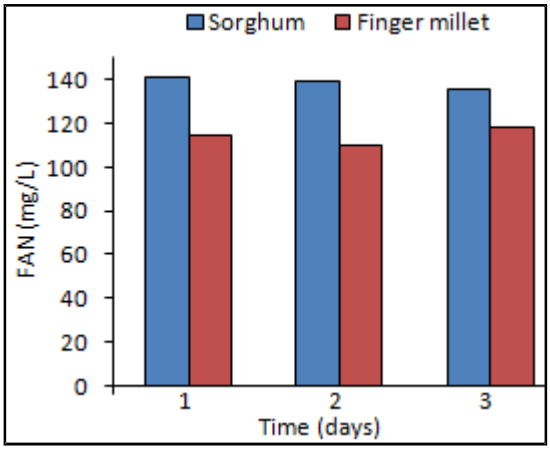

Figure 3: FAN values of grains

3.4 Diastatic Power

The diastatic power of sorghum and finger millet grains is shown in Fig. 4. The diastatic power of finger millet was very low as compared to that of sorghum. The diastatic power values of finger millet were lower compared to those for sorghum. The highest value for sorghum was 33 SDU/g whilst that for finger millet was 15 SDU/g. The diastatic values for finger millet were lower compared to those reported for Tanzanian varieties which ranged from 34.7 to 45.1 SDU/g [20]. According to Dewar *et al* [18], a minimum specification of diastatic power of 28 SDU/g for malt derived from sorghum or millet is widely recommended for commercial beer brewing. The values obtained for sorghum showed some conformance to the specification while those of finger millet were lower.

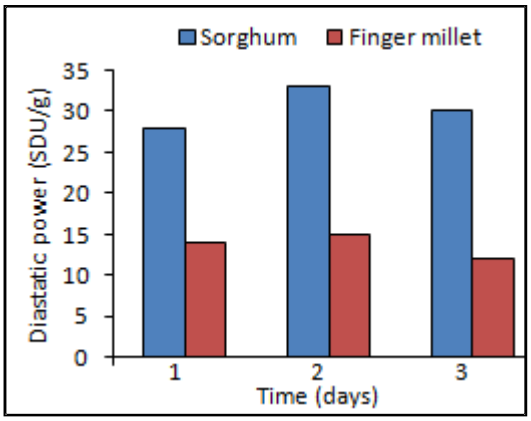

Figure 4: Diastatic power of grains

4. Conclusion

The comparison of malt quality parameters of finger millet sorghum was achieved in this study. The finger millet is inferior to sorghum in terms of diastatic power and FAN but exhibited superior germination energy. Finger millet showed good maltability. The quality of opaque beer can be improved by mixing sorghum and finger millet to exploit good quality parameters from both malts. The use of finger millet for brewing malt will vastly improve income levels of people in rural areas as well as eliminate any income loss incurred by local beverage companies when sorghum is in short supply.

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Author Profile

Mrs Tecklah Usai is a specialist in Food Science and Nutrition. She holds an MSc Degree in Food Science.

Mrs Beuala Mutonhodza is a nutritionist. She holds an MSc degree in Nutrition.

Dr Benias C. Nyamunda has research interest in Chemical Technology.