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RESEARCH ARTICLE

PRODUCTION AND QUALITY EVALUATION ON NON-ALCOHOLIC SORGHUM MALT BEVERAGE

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ABSTRACT

The present study aimed to produce a non-alcoholic malt beverage using *Feterita* sorghum malt and evaluation of the product quality. Two products (A and B) of non-alcoholic sorghum malt beverage were prepared by addition of two different amounts of caramel. The quality of the products was evaluated using physical, chemical and sensory tests. The physicochemical properties of sorghum wort in terms of reducing sugars, pH, colour and original gravity were 43, 53 wort A were 39.42 and 41.67 mg/ml, 6.59 and 6.68 9 and EBC, 1.026 and 0.846 in wort A and wort B, respectively. The analysis of non-alcohol beverage indicated that the specific gravity, pH, total acidity, colour and alcohol content of product A and product B were 1.012 and 1.045 and 6.43, 6.39 and 3.4%, 3.8%, 12 EBC and 13 EBC and 0.033 v/v and 0.043 v/v, respectively. In addition, iodine reaction was negative in each of the two products. It is concluded that effective use of germination to process sorghum grain for beverage requires a control of the temperature and time. More research is needed in order to understand the adjustments made with different stages of processing of malted beverages.

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INTRODUCTION

Sorghum constitutes a significant source of protein, energy vitamin B-complex and some other minerals like phosphorous, magnesium, calcium and iron in Africa and Asia (FAO, 1995; Kimber, 2000; Yousif and ElTinay, 2001; Elkhier and Hamid, 2008; Mohammed *et al.*, 2011). Sudan produces about 4.2 million tons of sorghum annually. However, it is the only viable food grain for many of the Sudan's most food insecure people. It is grown in virtually all parts of Sudan (Mahgoub, 2014). The potential for sorghum to be an engine for economic development in Sudan is immense. It is processed into a very wide variety of attractive and nutritious traditional foods, such as semi-leavened bread, couscous, dumplings and fermented and non-fermented porridges. It is the grain of choice for brewing traditional African beers. New products such as instant soft porridge and malt extracts are great successes. Sorghum malt is used to produce local beer namely *merissa*, an opaque beer and *assaliya*, a clear beer (Algorashi *et al.*, 2016). These are products that can be found all over the country and it is not known exactly what percentage of the sorghum consumed annually in Sudan turned into malt drinks, but all

indications show that a very high percentage. Traditional sorghum beers are produced in several countries of Africa, but the differences in the manufacturing process may occur depending on the geographical location. Although the African beer has a high nutritional value, but it is less attractive than Western beers because of its poorer hygienic quality, organoleptic variations and shorter shelf life (François *et al.*, 2012). The manufacturing processes of African traditional sorghum beer essentially involves many stages such as malting, drying, milling, souring, boiling, mashing and alcoholic fermentation, however, the variations may occur depending on the geographic localization (Haggblade and Holzapfel, 2004). Traditional African sorghum beers are very rich in calories, B-complex vitamins and essential amino acids such as lysine (Chevassus-Agnes *et al.*, 1979). The beers are consumed at African ceremonies (e.g., marriage, birth, baptism, the handing over of a dowry, etc.) and constitute a source of economic return for the beer producers. From microbiological aspect, a very varied yeast and lactic bacteria acid flora has been found in African sorghum beers, although *Saccharomyces cerevisiae* and heterofermentative *Lactobacillus* usually predominate (Maoura *et al.*, 2005; Kayodé *et al.*, 2007; Lyumugabe *et al.*, 2010). In Sudan Sorghum malt is brewed as illegally due to implementation of Islamic law since 1983 and public consumption are illicit

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(WHO, 1999). Therefore it is wise to search for a way to prevent harmful alcohol consumption (about 6%) without depriving Sudanese of beneficial nutrients in sorghum malt beverages. Therefore, the present study has been initiated to use sorghum malt for purpose of producing non-alcoholic malt beverage and evaluation of the product quality.

MATERIALS AND METHODS

Materials

Seeds of local sorghum (*Sorghum bicolor* (L) Moench) cultivar known as *Feterita* were procured from a retail outlet Wad medani market, Sudan. The grains were carefully cleaned and freed from broken seeds and extraneous matter.

Production of sorghum malt

The various steps for preparation of sorghum malt were accomplished according to the manual of Laboratory Procedures for Quality Evaluation of Sorghum and Pearl Millet (Gomez *et al.*, 1997). The procedure has been described as follows:

1-Steeping

Samples of sorghum grains (25 g), in nylon mesh bags (150 mm x 100 mm), were steeped in 0.2% NaOH at pre-determined temperature (25 and 30°C). After the first hour, the steeping vessels were drained and refilled with fresh tempered tap water. Grain at each pre-determined temperatures was steeped for 24 hours, under one of two conditions of aeration, air-rest (AR) was achieved by draining steeping water from the grain, and it was given a 30 min air-rest six times within steeping period. Non-aerated (NA) was achieved by steeping the grain for the full steeping period in non-aerated water. At the end of steeping, the grain was centrifuged in spin dryer for one min at 300xg to remove the surface film of moisture and then the samples were weighed (steeped weight) (Gomez *et al.*, 1997; Mathoto, 2007).

2. Germination

The grains were spread evenly on trays lined with a single layer of moist filter paper and the trays were then covered loosely with cotton layer and stored at 25°C and 30°C for 96 and 120 h to allow germination to occur. The seeds were watered twice a day to prevent dehydration and turned daily to avoid root matting. At the end of the malting period green malt was weighed.

3. Kilning

Sorghum grains were dry-kilned at 50°C for 24 h in hot air oven (automatic electronic drying oven model OSK 6286). Dry malt was weighed. The malt was polished by manually rubbing samples with a dry muslin cloth and then polished malt was weighed.

4. Milling

Malted grains were ground in mill to pass through a 0.4 mm screen.

5. Wort Production

Wort was produced from the sorghum grains, non-aerated (NA) germinated for 5 day at 30°C by two different mashing procedures according to Igyor *et al.* (2001) procedure as described below:

a. Decantation mashing at 80°C (wort A)

This mashing procedure is a slight modification of the infusion process. Briefly, 50 g of the grist were mashed in 360 ml distilled water at 45°C for 30 min. Thereafter, 150 ml of the clear “enzymic supernatant” were removed while the remaining mash was heated at 80°C and held at the same temperature for 30 min and cooled below 50°C at which the clear “enzymic supernatant” was re-added. The mash was stirred and temperature raised to 65°C as above. After 1 h at 65°C, the mash then heated to 75°C for 10 min and cooled, and the volume adjusted to 515 ml with distilled water were stirred well and filtered using filter paper.

b. Decantation mashing at 100°C (wort B)

This procedure is similar to that reported above except that the enzymic wort was removed after mashing at 45°C and the residue was boiled at 100°C instead of being heated at 80°C. The total volume raise up to 515 ml with distilled water stirred well and filtered using filter paper.

6. The production process

Wort extracted by decantation mashing at 100°C (wort B) was boiled. Two different amounts of caramel were added- instead of hops - after boiling the wort as mentioned below: Two and half grams caramel were added for 1000 ml of wort (product A). Five grams caramel were added for 1000 ml of wort (product B). The method of addition of caramel was adapted according to the American Society of Brewing Chemists (ASBC) recommendations.

Physicochemical properties of sorghum wort

Sorghum wort samples were analyzed to determine several physicochemical properties using standard methods, these included:

- i- The reducing sugars values which were determined using Lane and Eynon (1923).
- ii- pH of wort was determined according to AOAC (1980) using a pH meter model (PHSJ-4A) standardized with buffer solution of pH 7.
- iii- Wort colour determination using spectrophotometer (Spectrumlab 22 pc No. 22pc 08370).
- iv- Determination of original gravity by using an electrical balance (Fellows, 2005).

Non-alcoholic malt beverage analysis

The produced non-alcoholic malt beverage was subjected to many analyses. The specific gravity was determined by using an electrical balance. 50 cm³ of product A and B were weighed in density bottles and the same volume of distilled water was weighed.

Specific gravity was expressed mathematically as:

$$\rho_{\text{wort}} / \rho_{\text{water}}$$

Where ρ_{wort} is the density of the wort and ρ_{water} is the density of water (Fellows, 2005). pH of product A and B were determined according to AOAC (1980) using a pH meter model (PHSJ-4A) standardized with buffer solution of pH 7. Approximately 25 mL of product A and B were placed into a 50 ml beaker. The probe was inserted into the liquid and gently stirred until a stable pH was displayed. The titratable acidity of product A and B were determined according to the AOAC (1980). Ten milliliters of product were pipette into conical flask; drops of phenolphthalein indicator were added. The sample was titrated against 0.1 NaOH while stirring constantly, until a final pink colour was formed. The acidity was calculated from the following equation:

$$\text{Titratable acid (\%)} = \frac{\text{Titre} \times \text{Normality}}{\text{Volume of sample}} \times 100$$

Result can be expressed as citric acid by applying equivalent factor (0.064) to the calculation. Determination of product A and B colour were carried out using spectrophotometer (Spectrumlab 22 pc No. 22pc 08370) which was set at 430 nm with the visible light on, and zeroed using distilled water as blank. The samples were placed into a 10 mm silica cell, wiped clean and the intensity values recorded. The samples colour were compared to Lovibond scale colour chart (Jean, 1957). The product colour results were obtained using the following formula:

$$\text{Product colour (EBC)} = \text{Optical density (OD)} \times 25$$

For iodine reaction, the saccharification time was determined by transferring 5 ml of the samples onto a test tube for the iodine test. Twenty milliliters of methanol were added followed by three drops of 20 % perchloric acid and 2 drops of N/100 iodine solution. The test was repeated every 15 min until it became negative (Nandwa *et al.*, 2013). For determination of alcohol content, 30ml of product was filtrated with filter paper then the filtrated product was injected into Alcoalyzer plus instrument according to the instrument manual (Anton Paar Model 1988). The result was a digital reading (Jacques *et al.*, 1999).

RESULTS AND DISCUSSION

Sorghum wort characteristics

Reducing sugar of wort A and wort B were 39.42 mg/ml and 41.67 mg/ml, respectively. Igyor *et al.* (2001) studied the effect of malting temperature (20°C and 25°C) and mashing method (infusion mash at 65°C, decantation/mash boiled at 80°C and decantation/mash boiled at 100°C) the reducing sugars of sorghum worts ranged between 186 and 422 µg/l. Owuama and Adeyemo (2009) reported the effect of exogenous enzymes sources, sweet potato (*Ipomeabatatas*) and yellow yam (*Discoreacayenesis*) concluded that an increase in the amounts of reducing sugar compared with the untreated malt on the sugar content of wort of a four sorghum varieties. Reducing sugar of untreated malt were 20, 20, 21 and 21 g/l for wort and *Ipomeawere* 23, 31, 36 and 43 g/l and for wort and *Discorea* were 128, 97, 119 and 120 g/l. Avicor *et al.* (2015) recently reported that reducing sugar of sorghum wort at zero time of fermentation was 86 when the quality characteristics of wort pitched with single and mixed Culture

yeast strains during 24, 48 and 72 hours alcoholic fermentation. In early study Owuama and Asheno (1994) reported that three temperature regimes, 55°C, 55/65°C and 65°C, were used to kiln green malts of three varieties of sorghum, produced from grains steeped for different periods at 30°C. Maximum reducing sugar values for KSV variety (5.63 mg/ml), FFBL variety (5.89 mg/ml) and CHAKARA variety (5.57 mg/ml) were obtained from malts of grains steeped for 20 h and kilned at 55/65°C. The pH which is the level of either acidity or alkalinity of any substance are very important as the body intake of either acid or alkaline are monitor and regulated, to avoid any excess take a disorder. The pH of wort A and wort B were 6.59 and 6.68, respectively. The decantation mashing at 80°C (wort A) generally gave lower pH than the decantation mashing at 100°C (wort B). However, there was no clear difference of mashing procedures on pH of wort. The results were near to those reported by Odibo *et al.* (2002) who found that the pH of wort produced from two Nigerian sorghum varieties (SK 5912 and Farafara) were 6.2 and 6.3, respectively. Malomo *et al.* (2012) found that the effect of commercial enzymes on pH of wort developed from replacement of malted barley (100%) with sorghum as adjunct 50%, 60%, 70%, and 80% were in range of 5.6 and 6.0 with no significant changes at all levels of replacements. Avicoret *et al.* (2015) reported that both the fermentation time and inoculum type influenced pH of the fermenting wort. The decrease in pH value obtained by Nkiko *et al.* (2006) who found that pH of malted and un-malted sorghum wort were 5.62 and 5.73, respectively compared with malted barley and malted barley/sorghum adjunct which were 5.06 and 4.70, respectively. However, fermentation time decrease pH value of wort (Raji *et al.*, 2014) who found that pH of Pre-fermentative wort of two local Nigerian varieties, red and white were 5.6 and 5.7, respectively.

Table 1. Physicochemical properties of sorghum wort

Wort properties	Wort A ^a	Wort B ^b
Reducing sugar (mg/ml)	39.42	41.67
pH	6.59	6.68
Colour (EBC)	9	11
Original gravity	1.026	1.025

Table 2. Physicochemical properties of non alcohol sorghum malt beverage

Product properties	Product A	Product B
Specific gravity	1.012	1.045
pH	6.39	6.43
Titratable acidity (%)	3.8	3.45
Colour (EBC)	12	13
Iodine reaction	negative	negative
Alcohol content (v/v)	0.033	0.043

Original gravity of wort A and wort B were 1.026 and 1.025, respectively. These results were less than that achieved by Aniche and Anih (1994) who reported that specific gravity of wort samples from two malted sorghum varieties (SK5912 and KSW3) and barley were the same (1.04). Also the results were less than that of Odibo *et al.* (2002) who found that original gravity of mash of two sorghum varieties were 1.042 and 1.045, respectively. Avicor *et al.* (2015) recently reported that original gravity of sorghum wort at zero time of fermentation was 1.0416. Nkiko *et al.* (2006) found that original gravity of wort made with un-malted sorghum, malted sorghum, malted barley and sorghum/barley malt adjunct were 1.004394, 1.04406, 1.04415 and 1.04412, respectively.

Non- alcoholic malt beverage characteristics

Product A and B were analyzed to know the effect of boiling and addition of caramel on properties of the products. The specific gravity (Table 1) of the non-alcohol products A and B were 1.012 and 1.045, respectively. Specific gravity of product B was more than that of product A, that may be due to amount of caramel added to product A. However, the results were near of that obtained by Ratnavathi (2012) who found that specific gravity of lager beer made from sorghum malt and sorghum adjunct was 1.03. Agu (1995) found that specific gravity of experimental beers brewed from millet, sorghum and barley malts were 1.012, 1.015 and 1.017, respectively. The results were more than that obtained by Odibo *et al.* (2002) who found that the specific gravity of the beers made from two sorghum varieties were 1.008 and 1.003, respectively. Knowledge of the density of foods is imperative in separation processes and differences in density can have important effects on the operation of size reduction and mixing equipment. Density of liquids is a measure of mass per volume at a particular temperature can be expressed as specific gravity which is found by dividing the density of a liquid by the density of an equal volume of pure water at the same temperature. Specific gravity is widely used instead of density in brewing and other alcoholic fermentation where the term original gravity is used to indicate the specific gravity of the liquor before fermentation (Fellows, 2005). The concept of specific gravity of alcoholic beverages refers to the relative density compared to water, of the wort or must at various stages in the fermentation. During alcohol fermentation, yeast converts sugars into carbon dioxide and alcohol. The decrease in the sugar content and the presence of ethanol (which is considerably less thick than water) drop the density of the wort. By checking the decrease in specific gravity after some time the brewer gets data about the health and progress of the fermentation and verifies that it is finished when gravity quits declining ([https://en.wikipedia.org/wiki/Gravity_\(alcoholic_beverage\)](https://en.wikipedia.org/wiki/Gravity_(alcoholic_beverage))).

The pH of product A and B were 6.39 and 6.43, respectively. The pH value of product B was slightly higher than that of product A. However, there was no clear difference between the products and wort (B). In addition, Table (1) indicates that there were non- significant effects of wort boiling and caramel on pH of the products. However, the results were much more than that obtained by Omidiji and Okpuzor (2002) who found that pH of wort from cold trub (Cold trub meant to be purged from the bottom of a cold storage tank in a malt beverage plant) treated with amylase and gluconate was 4.5, lower pH obtained by Omidiji and Okpuzor might be as a result of fermentation. Titration is a chemical process used in ascertaining the amount of constituent substance as acids in a sample by using a standard counter-active reagent. Titratable acidity of product A and B were 3.8 % and 3.45 %, respectively. The percentages were converted to citric acid by applying equivalent factor (0.064) to the calculation. The results were 0.24 and 0.22, respectively. The results were less than that obtained by Avicor *et al.* (2015) who found that the acidity as lactic acid of single and mixed yeast cultures during *pito* wort fermentation were 0.64 and 0.71 at beginning of fermentation. The average product A and B colours were 12 and 13 EBC. The values were slightly higher compared to that of wort B. The products showed the effect of boiling and addition of caramel with colour intensity. In addition, product colour value may be affected by sorghum type since it was

produced from red type grain. However, the results were near of that of Ilori (1991) who mentioned that colours of commercial and two malted sorghum beers produced from the laboratory were 11.5, 12.0 and 11.5 EBC, respectively. The results were less than that obtained by Avicor *et al.* (2015) who found that the colours of single and mixed yeast cultures during *pito* wort fermentation were 22 EBC at beginning of fermentation and became 12.5 and 16.5 EBC for single yeast and mixed cultures respectively after 72 hours of fermentation. Iodine reaction of product A and B was negative after 75 minutes. Nandwa *et al.* (2013) found that the average conversion time for sorghum was wide between 75-90 minutes compared to that of barley malt which is between 15- 25 minutes. The results indicate reduction or slow disintegration of starch due to low level of α and β enzymes produced in sorghum malt compared with barley malt. Aniche and Anih (1994) found that iodine reaction of wort samples from malted sorghum and barley produced from three-mash decoction mashing scheme were positive for sorghums and negative for barley.

As seen in Table (2) the averages of alcohol contents of product A and B were 0.033 v/v and 0.043 v/v respectively. Alcohol contents of products were negligible. Ogunbanwo *et al.* (2013) found that the range of alcohol content of *burukutu* -a type of sorghum beer which is a traditional alcoholic beverage produced and consumed in Nigeria and some African countries- fermented by different types of starter cultures were 1.90 to 2.65 (v/v). Roger *et al.* (2013) found that alcohol content of "Amgba": A sorghum-maize based beer, brewed in Cameroon was 4.5%. Lyumugabe *et al.* (2010) also found that ethanol content of production of traditional sorghum beer "Ikigage" using *Saccharomyces cerevisiae*, *Lactobacillus fermentum* and *Issatckenkiaorientalis* as starter cultures were 4.34, 1.49 and 2.25 (v/v%), respectively. Merissa contains about 6% alcohol (FAO, 1999). For considerable length of time ethyl alcohol has been omnipresent among societies. The various properties of alcoholic beverages have contributed to their longstanding presence, a significant number of which originate from its psychoactive properties. The different properties of alcohol in a particular beverage gets be distinctly essential underway, distribution and consumption of an alcoholic product.

Conclusion

The outcomes got from this study affirmed that malting as a processing technique can be utilized to effectively upgrade the nutritional status of sorghum based foods while diminishing their against their anti-nutritional factors. It is highly recommended to utilize procedures, such as vacuum evaporation and pasteurization in production of non-alcoholic fermented beverage by using procedures, and to study its nutritional quality. Further research is required to understand the adjustments made with various phases of handling of malted beverages and to study its nutritional quality.

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