

Changes in Sorghum Malt During Storage

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ABSTRACT

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The diastatic power of the freshly kilned sorghum malt at 68.1°WK had a 29% drop after six months of storage. Freshly kilned sorghum malt displayed high wort turbidity (4.9 EBC) which dropped to 0.95 EBC and 1 EBC after 2 and 6 months of storage respectively. The colour of the malt worts faded slightly over the trial period from 7.6 EBC in freshly kilned malt to 6.8 EBC after six months. Extract remained fairly steady throughout the study period most likely due to the use of external amylolytic enzymes during mashing. The protein in extract/protein in grain fluctuated between 46.6% in the freshly kilned malt to 43.2% at the end of six months. The apparent extract after final attenuation (AEFA) indicates more fermentability beginning from two months after storage. Free α -amino nitrogen (FAN) dropped from 238 mg/L to 194 mg/L after six months of storage. Mash filtration with a micro-mash filter remained prolonged (86–93 min) throughout the six months of storage.

Key words: AEFA, DP, FAN, sorghum malt, wort separation, wort turbidity.

INTRODUCTION

Sorghum continues to be a major brewing raw material in Nigeria long after the ban on barley malt (imposed in 1988) was lifted. The reason being that sorghum is cheaper to source, although some of its brewing qualities cannot compare with those of barley malt. While some breweries use it at the 100% level, others do so in conjunction with barley at varying levels of substitution. To improve the utilization of sorghum in beer brewing, a lot of studies have been carried out. Such studies however were limited to morphology and ultra-structure^{2,8,9}, enzyme development and extraction^{4,6,14,15} as well as mashing features^{1,16,19}. The changes that develop during storage of sorghum have largely been overlooked. Barley malts have been reported to undergo changes during storage. A long held view is that freshly kilned barley malt has been reported to give opalescent worts, poor yeast head formation, poor fining of beer and poor colloidal stability of the finished beer^{1,16} which improved significantly over a pe-

riod of 20 days after kilning¹⁷. Changes that occur during sorghum malt storage have not been investigated. This paper aims at providing such information. Storage effects are of interest in predicting wort characteristics and could save much frustration, fruitless re-analyses of malt and re-checking of procedures.

MATERIALS AND METHODS

Sorghum malt procurement

Malt from the white sorghum, farafara, was obtained from a malting outlet in Lagos, Nigeria. The malting procedure commenced with a first steep in 0.1N calcium hydroxide for 8 h after which grains were drained and washed with water. An air rest period of 4 h was allowed before a second steeping in 0.5% formaldehyde for 8 h. Thereafter grains were drained and washed with water. Germination was done at 30°C for four days after which grains were kilned at 55°C.

Malt storage

The sorghum malts were kept in unsealed nylon bags (with Nuvan tablets to check weevils) inside plastic buckets with loosely closed lids and stored in a dry refrigerated room at 13°C. Samples were taken from here periodically for malt analyses and micro-brewing.

Sorghum malt analyses

Moisture was estimated with milled samples using the EBC⁷ oven method and calculated as the loss in weight after milled malt had been dried at 105–107°C. Protein was estimated using the IoB¹⁰ Kjeldahl method. Diastatic power was obtained using the iodometric method of the EBC⁷ to estimate the sugars formed by malt diastatic action on Merck starch (No 1252).

Micro-scale brewing

Milling of the sorghum malt was carried out using the hammer mill to obtain 1.2 kg of grits. This was mashed with water of pH 5.6 (grist-water ratio 1:4) containing calcium at 150 ppm of mash water. The brewing regime was a modification of the scheme reported by MacFadden and Clayton¹³ and included a protein rest at 50°C for 30 min. after which mash with added Termamyl (Novo) was heated to 93°C for 10 min before cooling down to 60°C for saccharification with Fungamyl (Novo). Both enzymes (Termamyl and Fungamyl) were added at 0.1% w/w of

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Table I. Sorghum malt analyses

Weeks	Moisture %	Protein (DM) %	DP:WK
0*	7.3 ± 0.15	7.5 ± 0.02	68.1 ± 3.1
2	7.4 ± 0.14	7.7 ± 0.03	67.8 ± 3.0
4	7.8 ± 0.16	7.8 ± 0.04	65.0 ± 2.9
6	7.8 ± 0.17	7.9 ± 0.04	64.5 ± 2.8
8	7.9 ± 0.18	8.0 ± 0.03	64.0 ± 2.8
10	8.1 ± 0.19	8.1 ± 0.04	63.0 ± 2.6
12	8.3 ± 0.20	8.2 ± 0.03	58.2 ± 2.1
14	8.4 ± 0.18	8.2 ± 0.05	54.2 ± 2.0
16	8.4 ± 0.19	8.2 ± 0.04	53.3 ± 1.9
18	8.5 ± 0.21	8.1 ± 0.05	51.9 ± 1.8
20	8.5 ± 0.22	8.2 ± 0.05	50.4 ± 1.6
22	8.6 ± 0.22	8.1 ± 0.04	50.0 ± 1.3
24	8.8 ± 0.23	8.1 ± 0.05	48.8 ± 1.1

*(fresh from kiln)

malt. This brewing regime was necessitated since sorghum diastatic enzymes are inactivated at the temperature during which sorghum starch gelatinizes (i.e. $\geq 72^{\circ}\text{C}$).

Wort analyses

Worts for analyses were obtained from the micro-scale brewing. Wort turbidity was measured with the hazemeter (Vos 4000) which had been calibrated with formazin standards. Colour was estimated using the Lovibond comparator. Wort extract was determined using the EBC⁷ method by converting the specific gravity to extract content (sugars) by means of Plato table. Protein in extract (%) was estimated using the soluble nitrogen content method of the EBC⁷ on Kjeldahl digested wort samples. Free α -amino nitrogen (FAN) was determined using the TNBS method of the EBC⁷. Apparent extract after final attenuation (AEFA) was estimated as the extract after wort had been fermented by fresh brewery yeast for 24 h at 25°C .

Wort separation

A Resch 100 KR variable speed micro-mash filter was used with the speed regulator controlled to maintain the filtration pressure at 0.6 bar. Wort volume obtained was 6 liters.

Results of all the analyses are the means of triplicate analyses.

RESULTS AND DISCUSSION

Moisture and diastatic power

Storage of raw material is subject to the requirement that products remain unchanged. This requirement, however, is difficult to attain completely (especially in sorghum which has no protective husks) because of deterioration factors such as moisture absorption (grains are hygroscopic), fluctuating temperature from the environment and respiring grains and infestation from organisms such as moulds, insects and rodents. In this study infestation, wide temperature variations and moisture fluctuations (7.3–8.8%) were minimal (Table I). Results in Table I also show a slight drop in the DP of the sorghum malts after two months of storage (68.1 \rightarrow 64.0 $^{\circ}\text{WK}$) which was much higher (68.1 \rightarrow 48.8 $^{\circ}\text{WK}$) at the end of six months. This observation agrees with earlier reports that sorghum malt amylases are less stable than those of barley malt^{12,15}.

Wort turbidity, colour and extract

Freshly kilned sorghum malt exhibited a wort turbidity of 4.9 EBC (Table II) which dropped to 0.95 after two months of storage. These results agree with the observation of De Clerck³ that freshly kilned barley malt produced opalescent worts. A clear bright laboratory wort is usually preferred although in most cases malts that give opalescent or turbid worts in the laboratory usually give a bright wort in the brewery due to the thicker layer of spent grains that occurs when a lauter tun is used. More correlations exist when a mash filter which has a thinner bed is used. The colour of the sorghum malt worts faded slightly over the study period, dropping from 7.6 EBC in the freshly kilned malt to 7.2 EBC after two months and finally to 6.8 EBC after six months. Compared to barley lager malts, colour generally is below 3 EBC^{11,18}. Extract remained fairly constant throughout the study period most likely due to the usage of external enzymes (Termamyl and Fungamyl) for starch hydrolysis during mashing.

Protein in malt, protein in extract, FAN

The protein in extract, in relation to the total protein in grain, is indicative of the extent of modification and the total proteolytic activity of the malt. The results of these

Table II. Sorghum wort analyses

Weeks	Wort turbidity EBC	Colour EBC	Extract (DM) %	Protein in extract %	Protein in extract/ protein (DM) %	FAN (TNBS) mg/L	AEFA $^{\circ}\text{P}$
0*	4.9 ± 0.15	7.6 ± 0.21	87.7 ± 3.4	3.5 ± 0.08	46.6 ± 1.5	238 ± 3.1	2.18 ± 0.08
2	4.4 ± 0.12	7.5 ± 0.20	87.9 ± 3.2	3.5 ± 0.07	45.5 ± 1.4	231 ± 3.2	1.59 ± 0.06
4	2.8 ± 0.11	7.5 ± 0.21	87.8 ± 3.1	3.5 ± 0.07	44.9 ± 1.5	220 ± 3.1	1.54 ± 0.05
6	1.8 ± 0.09	7.4 ± 0.20	88.1 ± 3.3	3.5 ± 0.08	44.3 ± 1.3	219 ± 3.0	1.50 ± 0.03
8	0.95 ± 0.07	7.2 ± 0.18	88.3 ± 3.2	3.5 ± 0.08	43.8 ± 1.2	218 ± 2.9	1.42 ± 0.02
10	0.96 ± 0.08	7.0 ± 0.16	88.5 ± 3.1	3.5 ± 0.07	43.2 ± 1.2	217 ± 2.7	1.25 ± 0.20
12	1.0 ± 0.09	7.1 ± 0.18	88.8 ± 3.3	3.6 ± 0.08	43.9 ± 1.1	216 ± 2.6	1.20 ± 0.01
14	0.93 ± 0.07	7.0 ± 0.17	88.5 ± 3.2	3.6 ± 0.09	43.9 ± 1.3	211 ± 2.4	1.19 ± 0.02
16	0.98 ± 0.07	7.0 ± 0.16	88.4 ± 3.1	3.6 ± 0.08	43.9 ± 1.4	205 ± 2.1	1.31 ± 0.02
18	0.98 ± 0.07	6.9 ± 0.15	88.0 ± 3.3	3.5 ± 0.07	43.2 ± 1.3	201 ± 2.4	1.54 ± 0.02
20	1.0 ± 0.08	6.9 ± 0.16	89.0 ± 3.5	3.6 ± 0.07	43.9 ± 1.2	198 ± 2.3	1.51 ± 0.03
22	1.01 ± 0.09	6.9 ± 0.15	88.1 ± 3.2	3.5 ± 0.08	43.2 ± 1.3	196 ± 1.9	1.54 ± 0.02
24	1.00 ± 0.08	6.8 ± 0.12	87.2 ± 3.1	3.5 ± 0.07	43.2 ± 1.2	194 ± 1.8	1.57 ± 0.03

*(fresh from kiln)

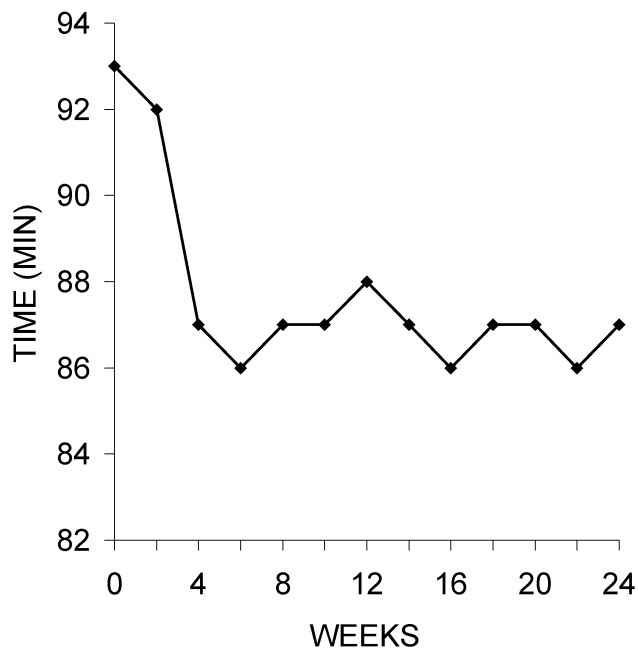


Fig. 1. Effect of storage time on sorghum mash filtration. ■—■ Mash filtration time.

indices are given in Table I (protein in malt) and Table II (protein in extract and FAN). A slight increase (1.6–8.1%) in total protein of grain is observed at the end of the six month storage period (most likely due to depleted carbohydrate from grain respiration and minimal microbial growth). The protein in extract/protein in the grain dropped from 46.6% to 43.8% after two months of storage and finally to 43.2% at the end of six months. Similarly the α -amino nitrogen (FAN) levels (Table II) dropped from 238 to 194 mg/L during the six month storage period. Since all these features are indicative of proteolytic activity in the malt, it therefore suggests that the proteolytic enzymes were probably denatured during storage resulting in lower FAN. However the decreased FAN levels were still within the range of 150–200 mg/L optimum for yeast fermentation^{19,21}.

AEFA

Freshly kilned sorghum malt had an apparent extract after final attenuation (AEFA) of 2.18°P which dropped to 1.42°P after two months of storage and rose irregularly thereafter to 1.57°P at the end of a six month storage period (Table II). AEFA is indicative of the degree of fermentation that can be expected from a malt²⁰. The less the extract after attenuation, the better the fermentability of the wort. It is therefore apparent that storage of sorghum malt leads to better fermentability. This is consistent with earlier reports that ‘fiery’ (fresh malt just off kiln) barley malt is not good for brewing.

Wort separation

Using the micro-mash filter which usually gives results similar to what one obtains in the brewery, the results of wort separation per storage time are shown Fig. 1. A longer filtration time (86–93 min) was observed in the

sorghum wort relative to the barley wort (45–60 min) at a corresponding storage time. The results are equally not consistent with earlier reports¹⁷ where barley wort separation using freshly kilned or ‘fiery’ malts was poor but improved on storage over a three week period. Prolonged filtrations of sorghum malt wort had earlier been reported by Aisien and Muts¹ and later attributed by EtokAkpan⁵ to lack of the β -D-glucan degrading endo 1-3, 1-4 β -glucanase enzyme in sorghum malts.

CONCLUSION

Further changes take place in sorghum malt during storage. Wort turbidity and apparent extract after final attenuation showed marked improvement after storage for two months. Drops in both DP and FAN were noticed during this period, but not at levels that would adversely affect brewing. Since the merit of sorghum malt storage is found only in wort turbidity and AEFA, there would appear to be no need for long storage of the malt if a modern mash filter is available. The mash and lauter tuns which give clearer worts are not workable with sorghum because of its huskless nature and the fine milling usually employed before a good yield of extract can be obtained. Again, with the high ambient storage temperatures of 25–30°C (compared to 13°C in this study) used by breweries in Nigeria, faster deteriorative changes in the malt can be expected.

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