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A Preliminary Study of the Comparative Malting Qualities of *Sorghum bicolor* and *Sorghum guineensis*

O. O. Lasekan

Department of Food Science and Technology, Ondo State Polytechnic, PMB 1019, Owo, Nigeria

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ABSTRACT

Malting qualities of Sorghum bicolor *and* Sorghum guineensis *grown in the same field were studied. After the different sorghum grains were steeped in water (10 ± 2°C) with a six-hourly steep liquor change schedule, they were grown on a glass sheet lined with moist blotting paper for a period of 6 days. Germinated seedlings were kilned to a moisture content of 4%.*

*Samples of sorghum (*S. bicolor *and* S. guineensis*) were collected at three different stages (steeping, germination and malt) and subjected to analysis of sugar content, diastatic activity, protein content, viability, apparent extract, water extract and sedimentation rate.*

S. bicolor, *which exhibited a significantly ($p < 0{\cdot}05$) high moisture content when compared with* S. guineensis, *also had a significantly ($p < 0{\cdot}05$) high protein content, malting loss, enzyme activity and acrospire length. However, no significant ($p > 0{\cdot}05$) difference was observed when the different sorghums were analysed for sugar and diastatic activity.*

Variations in sedimentation rates, moisture contents, protein contents, apparent extracts and cold and hot water extracts of the sorghum malts are discussed.

INTRODUCTION

In tropical countries sorghum forms a substantial part of the human diet and finds important use as a source of alcoholic beverages. Recently, Skinner (1976) produced, from sorghum, a tropical lager beer which was highly acceptable to a number of tasters. For effective utilisation of the different

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sorghum varieties for brewing, it is desirable to evaluate their malting qualities.

Previously, malting quality of barley was reliably estimated by micromalting 60 g samples and measuring the sugars produced after mashing. However, this procedure is rather lengthy, requiring at least 10 days for completion.

Recent methods (Fleming *et al.*, 1974; Bendelow, 1975; Palmer, 1975) include a rapid technique which emphasises the importance of the barley endosperm as a substrate and several tests for the estimation of barley β-glucans in assessing barley malting quality. A weakness of these tests lies in the fact that some pentosans and high molecular weight β-glucans of the cell walls are difficult to extract (Bathgate, 1975). Allison *et al.* (1975) also reported a simple comparative test based on the sedimentation rates of milled barleys.

This study is aimed, therefore, at comparing the malting qualities of *Sorghum bicolor* and *Sorghum guineensis*.

MATERIALS AND METHODS

Sample collection

The different sorghum grains *S. bicolor* and *S. guineensis*, were obtained from the Cereal Research Institute of Nigeria (CRIN).

Optimum moisture content and steeping schedule

The initial moisture contents of the grains were determined by weighing 100 g of samples and drying to constant weight in an oven maintained at 65°C.

To determine the optimum moisture content, grains were kept in a fine wire mesh basket and then steeped in water (10 ± 2°C). Samples were taken every 6 h for moisture determination. The steeping was allowed to continue for 48 h with a six-hourly change of steep water.

Malt production

A hundred grams each of the two different sorghum grains were steeped in water (10 ± 2°C) with a six-hourly steep liquor change schedule. They were evenly spread at room temperature (28 ± 2°C) on a glass sheet lined with moist blotting paper and allowed to germinate for 6 days. Germinated seedlings were kilned in a hot air oven at 55°C until the moisture content was 5·8%. Temperature was next raised to 65°C until the moisture content was 4%.

Determination of germination energy and germinative capacity

This was determined by the ASBC (1958) method.

Estimation of malting losses and acrospire length

Different samples of steep sorghum grains were spread on a glass sheet lined with blotting paper and were allowed to germinate. Grains were sprinkled with water at approximately six-hourly intervals. A sample was taken daily and the length of the acrospire measured before the grains were dried to constant weight.

Assay of amylases

A hundred millilitres of 0·2% (w/v) CH_3COOCa at pH 4·6 were used to extract the amylases from 10 g each of the ground sorghum malts for 3 h (Dube & Nordin, 1961). The extract was centrifuged at 12 000 rev min^{-1} for 30 min at a temperature of between -1 and $+1$°C. The clear supernatant extract was assayed at 37°C using the modified method of Street and Close (1956). After preliminary experiments, it was considered essential to dilute the extract ten times.

Sedimentation

Ten grammes of sorghum malt were milled in a microhammer mill (Glen Creston Co. Ltd) to a flour fine enough to pass through a 1-mm sieve. The sedimentation rates of the sorghum flour in ethanol were measured according to the method described by Palmer (1975) and the units were expressed as optical density values read on an Eel Unigalvo connected to a nephelometer head.

Chemical analysis

Nitrogen content was estimated by the micro-Kjeldahl method and the protein was determined by multiplying the nitrogen content by 6·25 on a dry weight basis. Maltose was determined by the Lane and Eynon method (Osborne & Voogt, 1978). The diastatic power, cold water and hot water extract and apparent extract were determined as reported by Okafor and Aniche (1980).

Statistics

Significance was tested using the Student's *t*-test.

RESULTS AND DISCUSSION

Germinative qualities of *Sorghum bicolor* and *Sorghum guineensis*

Figure 1 shows the plots of the percentage moisture contents of steeped *S. bicolor* and *S. guineensis* as functions of time for a six-hourly steep liquor change schedule. An initial rapid moisture uptake profile was obtained between the 6th and 36th hours of steeping. This was followed by a saturation moisture content (SMC) of 43–45%. This SMC is in agreement with that of Okoli (unpublished report) who reported values of 42–45%. Further steeping equalises water distribution throughout the grain; this was, however, attained earlier in *S. guineensis* than in *S. bicolor*, a factor which is related to the temperature at which the different Sorghum grains attained SMC. The rate of moisture uptake was significantly ($p < 0{\cdot}05$) higher in *S. bicolor* than *S. guineensis*, a condition which appears to be related more to varietal size than to grain viability (Adamic, 1981).

Similar correlations between % moisture content and germinative capacity of the grains were observed. *S. bicolor*, which had the highest rate of moisture uptake, produced the highest germinative percentage (capacity) and germination energy (98 and 66%, respectively) (Table 1). The 98% germinative capacity of *S. bicolor* agreed with that reported by Okafor and Anichie (1980) and was higher than the value of 93·4% reported by Solomon

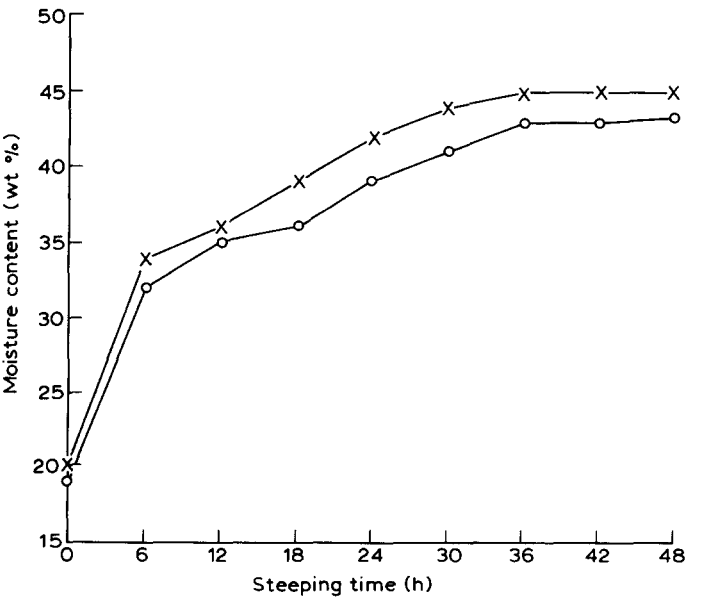

Fig. 1. Water uptake of *S. bicolor* (×) and *S. guineensis* (○) during a 6-hourly steeping (10 ± 2°C) schedule.

TABLE 1

A Comparative Analysis of the Germinative Qualities of *S. bicolor* (*b*) and *Sorghum guineensis* (*a*) Based on a Six-hourly Steeping Schedule (10 ± 2°C)

		Germination time (days)							
		0	*1*	*2*	*3*	*4*	*5*	*6*	*Mean*
Sugar (%)	*b*	1·76	1·90	2·44	2·77	3·05	3·65	4·63	2·89**
	a	1·91	2·03	2·61	2·96	3·24	4·19	4·77	3·10**
Diastatic	*b*	0·004	0·048	0·061	0·069	0·076	0·091	0·116	0·07**
Power (°L)[b]	*a*	0·048	0·051	0·065	0·074	0·081	0·105	0·197	0·09**
Protein	*b*	11·6	11·5	11·0	10·9	10·4	10·1	10·1	10·8*
(DB) (%)	*a*	11·4	11·4	10·8	10·7	10·3	10·0	9·95	10·6*
Malting	*b*	13·10	14·08	15·25	16·00	19·25	20·50	22·90	17·30*
loss (%)	*a*	13·0	14·00	15·00	15·80	19·00	20·40	22·60	17·11*
Enzyme	*b*	0·01	0·60	2·20	4·50	5·30	5·80	6·10	4·60*
Activity[a]	*a*	0·01	0·40	2·00	4·00	5·00	5·40	5·50	4·16*
Acrospire	*b*	0	3·90	8·00	13·60	18·20	23·70	28·00	20·05*
length (mm)	*a*	0	3·80	7·30	12·50	16·80	21·40	26·00	18·14*
Germination	*b*	66[c]							
Energy (%)	*a*	62[c]							
Germinative	*b*	98[c]							
Capacity (%)	*a*	96[c]							

[a] Enzyme activity, Units (100 ml extract × 50)$^{-1}$.

[b] °L, Lintner, DB (dry basis).

[c] Values determined after the sixth day of germination.

* ($p < 0·05$).

** Means within a column with similar superscripts are not significantly different ($p > 0·05$).

et al. (1987). This could be due to varietal differences, since they worked on *S. guineensis*. However, the value of 96% recorded for *S. guineensis* in this study is higher than their recorded value of 93·4%. This observation has further strengthened the hypothesis that *S. bicolor*'s viability is probably a function of moisture content.

Significant differences were observed in the acrospire length, saccharifying enzyme production, malting losses and crude protein contents of the different sorghums during the period of germination (Table 1). With increase in acrospire length (being more significant ($p < 0·05$) with *S. bicolor* than *S. guineensis*), a corresponding increase in malting losses was recorded in the different sorghum grains. The malting loss was significantly ($p < 0·05$) higher in *S. bicolor* than in *S. guineensis*; mean percentages were 17·30 and 17·11, respectively. The progressive increase in malting losses might be due to the utilisation of reducing sugars produced by saccharifying enzymes by the growing embryo (Solomon *et al.*, 1987).

This could be responsible for the progressive increase in the observed level

of reducing sugars of both grains. Contrary to expectation, the increase in sugar content of *S. bicolor* was not significantly ($p > 0.05$) different from that of *S. guineensis*.

Since it is the view of many workers that amylases effect the hydrolysis of starch to fermentable sugars, it could be rightly said that amylases were the saccharifying enzymes. However, there have been conflicting views as to when the activity of these enzymes becomes manifested. Faparusi (1970) concluded that the enzyme activity started from the second day of germination. In this study, however, appreciable activity was recorded on the first day for both grains. Overall, *S. bicolor* amylases were significantly ($p < 0.05$) more active than those of *S. guineensis*. There was also significant ($p < 0.05$) difference in their respective protein contents with a mean of 10·8 and 10·6%, respectively. However, there was no significant ($p > 0.05$) difference in their respective diastatic powers.

Sorghum malts

Table 2 shows the comparative analysis of the different sorghum malts. Sorghum malts of equal moisture contents were used. *Sorghum guineensis* gave the highest apparent extract (8·5° plate). This value agreed with the value reported by Okafor and Anichie (1980). A similar trend was obtained for both the percentage cold water extract and true hot water extract, respectively. However, the cold water extract range (67·0–69·0%) obtained for *S. bicolor* and *S. guineensis* was appreciably higher than the (17·0%) value for barley malt.

The mean ($\pm$ SE) of sedimentation rates were 64·2 $\pm$ 1·3 and 61·0 $\pm$ 0·4 for *S. guineensis* and *S. bicolor*, respectively. The observed differences in sedimentation rate are probably a reflection of the ease of release of starch

TABLE 2
Analyses of the Different Sorghum Malts *S. bicolor* (*b*) and *S. guineensis* (*a*)

	b	*a*
Moisture (%)	4·0	4·0
Apparent extract (°plate)	8·2	8·5
Cold water extract (%)	67·0	69·0
True hot water extract (kg/litre)	10·98	11·77
Protein (DB) (%)	10·08	9·92
Diastatic power (°L)	32	31
Sedimentation (Nephelometer Readings)	61·0 $\pm$ 0·4[a]	64·2 $\pm$ 1·3[a]

[a] Values of means $\pm$ standard error of four determinations made on each sample.

granules from proteinaceous and cell wall materials (Allison *et al.*, 1975) and therefore might be a measure of endosperm compactness of the sorghum grains.

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