Food Chemistry **49** (1994) 257–260

Studies on malting conditions for sorghum

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(Received 31 March 1993; accepted 14 April 1993)

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 (5·63 mg/ml), FFBL (5·89 mg/ml) and CHAKARA (5·57 mg/ml) sorghum varieties were obtained from malts of grains steeped for 20 h and kilned at 55/65°C. The percentage malting losses decreased with an increase in reducing sugar and the least malting loss was recorded in 20 h-stepped grains. The non-reducing sugar values varied with the kilning temperature and the variety of sorghum. The percentage moisture content of malt in all the varieties increased with reducing sugar and differed with the kilning temperatures. Kilning at 55/65°C generally produced malts of the highest percentage moisture content (9·0–13·5%). The percentage protein content of the malts increased with steeping time at all kilning temperatures.

INTRODUCTION

Kilning virtually follows germination in the malting process. It involves drying of the green malt in a kiln or oven at temperatures between 55 and 65°C until the rootlets become brittle or friable (Okafor & Aniche 1980; Briggs *et al.*, 1981). Kilning contributes to colour development which is affected by the extent of modification, duration and levels of temperature–time sequence of the kilning cycle, and the moisture content of the grain at different stages of the cycle (Briggs *et al.*, 1981; Pathirana *et al.*, 1983; Owuama & Asheno, 1993). During kilning, the reducing sugars decrease in quantity, but the sucrose level often increases, possibly due to hydrolytic enzymes working in reverse (Briggs *et al.*, 1981). Low temperature kilning yields greater survival of enzymes. Elevated temperatures also permit greater enzyme survival when the malt is less moist (Briggs *et al.*, 1981; Pathirana *et al.*, 1983). Most of the work done on kilning has been with green malt of barley. This work therefore reports on the effect of various kilning temperature regimes on the moisture, protein and sugar content of sorghum malts produced from grains steeped for different periods.

MATERIALS AND METHODS

Source of sorghum

The improved varieties of sorghum used in this work were KSV, FFBL and CHAKARA (Owuama & Asheno, 1993).

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Malting of sorghum

Six hundred-gram portions of each variety of sorghum were steeped for 12, 14, 16, 18, 20, 22 and 24 h at room temperature (28–30°C) (Okafor & Aniche, 1980). At the end of each interval, the water was drained off and the grains were allowed to germinate for 72 h following the method of Okafor & Aniche (1980). The green malts of each sample were then divided into three equal parts, A, B and C. Samples A and C were kilned in hot air ovens at 55°C and 65°C respectively, until the rootlets became friable. Sample B was maintained at 55°C in an oven for 6 h and then at 65°C until the rootlets became friable. The rootlets were removed by rubbing (Okafor & Aniche, 1980). The samples were then kept in desiccators until required for further analysis.

Determination of moisture content of malt and malting losses

The moisture content of malts and malting losses of the different sorghum varieties were determined by the procedure described by Okafor & Aniche (1980).

Determination of protein and sugars

The protein content of the malts was determined by Kjeldhal's method (Egron *et al.*, 1981) and the reducing and non-reducing sugars determined by the Lane & Eynon constant volume technique (Egron *et al.*, 1981).

RESULTS AND DISCUSSION

The percentage moisture contents of KSV, FFBL and CHAKARA sorghum varieties in relation to steeping

Table 1. Percentage malting loss of malts from sorghum grains steeped for 12–24 h and kilned at different temperature regimes

Steeping time (h)	KSV			FFBL			CHAKARA		
	55°C	55/65°C	65°C	55°C	55/65°C	65°C	55°C	55/65°C	65°C
12	7·20	7·05	7·59	5·11	5·99	6·80	6·44	6·62	7·34
14	7·70	7·46	8·20	8·53	9·32	7·09	6·58	7·55	7·68
16	7·32	7·31	8·39	8·16	9·05	9·35	6·63	7·85	7·94
18	6·45	7·06	7·12	6·42	8·60	7·44	6·48	6·34	7·45
20	4·95	6·62	7·97	5·43	7·33	7·09	5·40	6·32	7·74
22	8·71	7·24	8·02	6·50	9·40	7·52	7·81	7·66	8·30
24	8·75	7·39	8·39	6·72	10·67	7·78	8·29	9·25	8·35

time have been reported earlier (Owuama & Asheno, 1993).

Percentage malting losses from sorghum grains steeped for 12–24 h and kilned at different temperature regimes vary with the sorghum varieties, kilning temperatures and steeping time (Table 1). These observations resemble those of earlier workers (Novellie, 1962*b*; Pathirana *et al.*, 1983; Owuama & Asheno, 1993). The percentage malting loss in samples kilned at 55°C or 55/65°C decreased in 12–20 h-steeped grains in all three sorghum varieties and subsequently increased with an increase in steeping time. The 65°C-kilned malts followed the same pattern but had the least malting losses from the 18 h-steeped samples in KSV and CHAKARA varieties. This observation contradicts the report that longer steeping periods lead to higher malting losses (Pathirana *et al.*, 1983). The degree of malting loss *vis-à-vis* the kilning temperature varies from one variety to another. The highest value of malting loss was generally recorded in 55/65°C-kilned malts for FFBL but in 65°C-kilned malts for CHAKARA and KSV varieties. The least malting losses were observed in 55°C-kilned samples in all varieties. Thus, higher kilning temperatures apparently lead to higher malting losses. This agrees with the observations of Pathirana *et al.*, (1983). However, malting losses at all kilning temperatures and steeping times in this report are lower than those of Pathirana *et al.* (1983) but resemble those of other workers (Novellie, 1962; Okafor & Aniche, 1980; Owuama & Okafor, 1991). Generally, the malting loss decreased as the reducing sugar increased in all the varieties.

The least percentage moisture contents were recorded in 65°C-kilned malts of KSV and CHAKARA but in 55/65°C-kilned samples of FFBL (Table 2). The highest percentage moisture contents of the malts were observed in 55/65°C-kilned malts of KSV and CHAKARA but in 55°C-kilned samples of FFBL. The differences in moisture content of the malts could be attributed to the different varieties and the kilning temperatures (Novellie, 1962*a*; Pathirana *et al.*, 1983). In general, malts from the CHAKARA variety had the highest moisture contents at all the kilning temperatures. The moisture contents of the malt generally decreased with increase in steeping time up to the 20 h steeping period at all kilning temperatures for FFBL and KSV, but at 55°C and 55/65°C for CHAKARA, followed by an increase in moisture content up to the 24 h steeping period.

The reducing sugar values of the malts were observed to vary with the kilning temperatures, sorghum varieties and the steeping time (Table 3). This report agrees with those of other workers (Novellie, 1962*b*; Pathirana *et al.*, 1983; Owuama & Okafor, 1991). Reducing sugars increased from 12 to 20 h steeping times, at different kilning temperatures, for KSV (55/65°C), FFBL (55, 55/65, 65°C), CHAKARA (55, 55/65°C) and then decreased with further increase in steeping time. An increase in reducing sugars from 12 to 18 h steeping periods were observed in KSV (55, 65°C) and CHAKARA (65°C) (Table 3). Maximum reducing sugars were observed in 55/65°C-kilned samples in KSV (5·63 mg/ml), FFBL (5·89 mg/ml) and CHAKARA (5·57 mg/ml). This could be attributed to the two-step heat-treatment whereby the 55°C exposure for some time considerably reduced the moisture content of the green malt before the 65°C treatment. It has been

Table 2. Percentage moisture contents of malts from sorghum grains steeped for 12–24 h and kilned at different temperature regimes

Steeping time (h)	KSV			FFBL			CHAKARA		
	55°C	55/65°C	65°C	55°C	55/65°C	65°C	55°C	55/65°C	65°C
12	11·5	10·5	7·0	9·5	9·5	9·6	10·5	13·5	10·5
14	12·5	12·5	11·0	11·5	11·0	10·5	12·0	12·5	10·5
16	12·5	12·0	8·5	11·0	11·0	11·0	12·0	11·5	10·5
18	10·5	12·5	11·5	10·0	10·0	10·0	10·5	12·0	10·0
20	9·5	10·5	9·5	9·0	9·0	9·5	10·0	10·5	11·5
22	10·0	12·0	10·0	10·5	9·0	10·0	10·5	12·0	11·5
24	12·0	11·5	10·0	11·5	10·5	11·0	11·0	12·0	12·0

Table 3. Reducing sugar (mg/ml) content of malts from sorghum grains steeped for 12–24 h and kilned at different temperature regimes

Steeping time (h)	KSV			FFBL			CHAKARA		
	55°C	55/65°C	65°C	55°C	55/65°C	65°C	55°C	55/65°C	65°C
12	4·33	3·72	3·85	3·66	3·83	3·49	4·40	4·19	4·06
14	4·60	4·16	4·13	3·88	4·00	3·69	4·76	4·48	4·37
16	4·90	4·44	4·33	4·72	4·90	4·30	5·19	4·85	4·72
18	5·57	4·94	5·24	4·99	5·14	5·35	5·40	5·04	5·46
20	5·04	5·63	4·85	5·70	5·89	5·52	5·57	5·57	5·35
22	4·76	5·63	4·56	5·35	5·46	5·04	5·29	5·35	5·09
24	4·64	5·14	5·04	4·90	5·09	4·68	5·09	5·24	4·76

reported that when green malts with moisture contents over 10% are subjected to elevated temperature treatments, accelerated inactivation of the enzymes takes place (Pathirana *et al.*, 1983) but that greater enzyme survival can occur at higher temperatures if the malt is less moist (Briggs *et al.*, 1981). Also, kilning malts at elevated temperatures is necessary to remove the raw flavour of green malt and promote the chemical reactions responsible for the formation of components which impart the characteristic flavour to malt (Briggs *et al.*, 1981). The lowest reducing sugar values from malts were produced by 65°C-kilned malts in all varieties. Higher temperatures are known to inactivate mainly amylases, particularly β-amylases, and affect reducing sugar content of malt (Pathirana *et al.*, 1983). However, the reducing sugar levels varied with steeping time of the grains. The highest reducing sugar values were generally from the 20 h- and the least from the 12 h-steeped samples. Reasonably high moisture content during malting is essential for the maximum development of diastatic power (Novellie, 1962*b*) and diastatic power is directly proportional to the reducing sugar content of malt (Pathirana *et al.*, 1983). This may suggest that the moisture contents of green malts from 20 h-steeped grains are most adequate for producing relatively high reducing sugar levels when subjected to two-step kilning (55/65°C) process. In all cases more reducing than non-reducing sugars were produced. This observation agrees with a previous report (Owuama & Okafor, 1987).

The non-reducing sugars vary with the varieties, kilning temperature and steeping time (Table 4). During kilning, sucrose levels often increase, possibly due to hydrolytic enzymes working in reverse (Briggs *et al.*, 1981). It is expected that the reverse enzymic action would be proportional to the amylase content/diastatic power (Novellie, 1962*a*) and reducing sugar (Pathirana *et al.*, 1983); i.e. the non-reducing sugar content would follow the same pattern as the reducing sugar of the malts as described earlier; but it does not seem to follow any pattern. This suggests that, in addition to the effect of kilning on reversing enzyme action, there may be some other factors, which affect the amount of non-reducing sugar produced and these apparently vary in the degree of their contribution from one sorghum variety to another. Enzymes other than α- and β-amylases are known to play certain roles in the degradation of starch *in vivo* (Briggs *et al.*, 1981). The highest non- reducing sugar values were generally observed in FFBL (55/65°C), KSV (65°C) and CHAKARA (55°C) but the least in FFBL (65°C), KSV (55°C) and CHAKARA (55/65°C) (Table 4).

The percentage protein of malts differed from one sorghum variety to another and also with the steeping time and kilning temperature (Table 5). It decreased in all varieties as the steeping time for the grains increased from 12 to 24 h, regardless of the kilning temperature. Generally, the greatest protein levels were recorded in KSV (55/65°C) and in 55°C-kilned malts of FFBL and CHAKARA varieties. The lowest protein contents were found in 65°C-kilned malts of FFBL and CHAKARA, and in 55°C-kilned KSV malts. The percentage proteins of the malts resemble those of other workers (Aisien & Ghosh, 1978; Okafor & Aniche, 1980). The difference in percentage protein between the 12- and 20-h steeped samples in all varieties and at all

Table 4. Non-reducing sugar (mg/ml) content of malts from sorghum grains steeped for 12–24 h and kilned at different temperature regimes

Steeping time (h)	KSV			FFBL			CHAKARA		
	55°C	55/65°C	65°C	55°C	55/65°C	65°C	55°C	55/65°C	65°C
12	1·15	1·81	1·55	1·62	1·88	1·09	1·17	1·17	1·38
14	1·10	1·63	1·62	1·73	2·02	1·20	1·22	1·13	1·25
16	1·09	1·45	1·60	2·18	2·03	2·00	1·28	1·42	1·26
18	1·27	1·26	1·74	1·65	2·08	1·82	1·70	1·48	1·06
20	1·31	1·01	1·79	0·71	1·07	1·10	1·52	1·13	1·68
22	1·94	1·20	1·37	0·79	0·89	0·93	2·25	1·01	1·30
24	1·60	1·33	1·00	0·72	1·21	0·57	1·62	1·06	1·27

Table 5. Percentage protein contents of malts from sorghum grains steeped for 12–24 h and kilned at different temperature regimes

Steeping time (h)	KSV			FFBL			CHAKARA		
	55°C	55/65°C	65°C	55°C	55/65°C	65°C	55°C	55/65°C	65°C
12	15·9	15·9	14·9	13·4	13·0	12·7	14·9	14·1	14·1
14	14·1	15·9	14·1	12·7	12·1	11·5	13·4	13·4	12·7
16	12·1	13·4	12·7	11·5	10·6	11·0	11·5	11·0	11·5
18	11·5	12·7	12·7	10·2	10·2	9·76	11·0	10·6	10·2
20	11·0	11·5	11·0	9·40	9·40	9·06	10·2	9·39	9·39
22	10·2	10·6	10·6	8·75	8·75	8·46	9·40	9·06	8·75
24	9·76	9·39	9·13	8·40	8·45	8·19	8·75	8·75	8·18

kilning temperatures is between 3·61 and 4·85% which is relatively high compared to 0·64 and 2·13% from malts of grains steeped between 20 and 24 h. The percentage proteins of malts from 12 h-steeped grains are virtually the same in each variety irrespective of the kilning temperature. In general, the 65°C-kilned malts produced the lowest percentage protein in their malts. Low protein contents in malts are desirable as high protein levels lead to the formation of hazes in beer (Okafor & Aniche, 1980; Briggs *et al.*, 1981).

The observations in this report therefore suggest that the 20-h steeped samples, kilned at 55/65°C, which gave high reducing sugar values and relatively low protein content be recommended for malting of sorghum

ACKNOWLEDGEMENT

We are grateful to the Adamawa State Agricultural Development Programme for providing the sorghum varieties.

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