Effect of Cultivar, Steeping, and Malting on Tannin, Total Polyphenol, and Cyanide Content of Nigerian Sorghum

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ABSTRACT

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Tannin was estimated in the seeds of 15 Nigerian sorghum cultivars and found to vary between 0.25% (catechin equivalent) for SSV11 and SSV12 and 2.92% for SRN484. Total polyphenol content ranged from 0.32% (tannic acid equivalent) for KSV13 to 2.7% for SRN484. During steeping (48 hr), the extractable tannin content of SRN484, KSV7, and SSV3 decreased 33, 27, and 43%, respectively; during malting (five days) the tannin content decreased an additional 42, 24, and 10%, respectively. Total extractable polyphenol content of SRN484 and SSV3 was reduced by 41 and 20% during steeping, whereas that of KSV7 was increased by 50%. The polyphenol content also decreased by 22, 68, and 19% for SRN484, KSV7, and SSV3, respectively, after malting. Cyanide content of the grains varied from 8 μg/g for SSV3 to 38 μg/g for SRN484. After steeping, the cyanide content increased to 44 μg/g for NVW cultivar and 111 μg/g for SRN484, whereas the cyanide content of the five samples investigated increased during malting to reach 121, 99, 105, 136, and 78 μg/g for SRN484, SSV11, KSV8, KSV15, and NVW, respectively. The results suggested that all the sorghum cultivars except SRN484 could be used in the brewing industry although care should be taken about the cyanide component of the malt.

O. A. Olaniyi (*personal communication*, 1984) suggested that sorghum should be substituted for barley malt in the Nigerian brewing industry to save the country the huge foreign exchange spent annually on barley malt. Sorghum has been traditionally used to produce alcoholic and nonalcoholic beverages in Nigeria (Ogundiwin 1977) and kaffir beer in South Africa (Novellie 1977).

As a substitute for barley in brewing, sorghum has two drawbacks. The first is the polyphenol/tannin content. Nutritionally, Jambunathan and Mertz (1973) pointed out that the high tannin content of some sorghum cultivars reduced digestibility and food values expected from their analytical compositions, and Daiber (1975) and Novellie (1977) observed that the high polyphenol/tannin content of "bird-proof" sorghum grains inhibited enzyme reactions and microbial activity needed in the brewing of sorghum beer. Secondly, when sorghum is sprouted, it produces dhurrin, a cyanogenic glycoside, which on hydrolysis yields HCN. The grain contains little or no dhurrin but the coleoptile and first leaf of sorghum seedlings are reported to contain as much as 25% dhurrin on a dry weight basis (Conn 1979). The HCN concentration is highest in the shoot and lowest in the seed. If the shoot and root were removed in malted sorghum the HCN problem would be eliminated, but industrially both are milled with the grain (Novellie 1962). This could pose a health hazard, because HCN can be fatal (Conn 1979) and sublethal doses could cause blindness (Smith et al 1963), ataxic neuropathy (Osuntokun 1973), or goiter (Ekpechi 1967).

The objective of this investigation was to determine the tannin, total polyphenol, and cyanide contents of some sorghum cultivars grown in Nigeria and to monitor changes in these constituents during steeping and malting.

MATERIALS AND METHODS

The 15 locally adapted varieties of *Sorghum bicolor* (L.) Moench were grown during 1985 and 1986. The late season sorghum varieties (Table I) were planted in June (around the Zaria-Kaduna-Kano axis) after the rains had come, whereas short- and medium-season sorghums were planted from late July to early August. The crops were harvested in the dry months of December and January under excellent conditions and more than 97% of the seed germinated on steeping.

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One kilogram of each variety was washed three times and steeped in 2 L of water for 18-48 hr depending on their differential rates of water uptake. Water was changed every 6 hr during steeping. The grains were washed after the steeping period and germinated in ventilated cupboards at an ambient temperature of 28 ± 4° C. Water was sprinkled on the germinating seeds regularly, and the grain was occasionally mixed. At intervals during steeping and malting some seed was removed and kilned in an oven at 48 ± 2° C for 10 hr. The root and shoot were removed, and the malt was milled using a Brabender Quadrumat experimental mill.

Total extractable polyphenol was estimated by the method of McGrath et al (1982), tannin content was analyzed by the modified vanillin-hydrochloric acid method of Price and Butler (1977), and the HCN content was determined by the method of Gorz et al (1977) and confirmed by the method of Lambert et al (1975). Duncan's multiple range test was carried out as outlined by Steele and Torrie (1960).

RESULTS AND DISCUSSION

From the data presented in Table I, it was apparent that tannin and polyphenol content varied significantly in the sorghum cultivars investigated. Tannin was low in 13 varieties (0.25-0.46% catechin equivalent) and high in KSV12 (0.67%) and SRN484 (2.92%). Extractable polyphenol was between 0.37 and 0.68% in all the samples except SRN484 (2.70%). As expected, the white, cream, and yellow seeds contained small amounts of tannin and polyphenol (except KSV12), whereas the red pigmented SRN484 had the highest concentration. Radhakrishnan and Sivaprasad (1980) reported similar varietal as well as locational differences in the polyphenol content of sorghum seeds grown in India. Jambunathan and Mertz (1973) also observed wide variations in the tannin and polyphenol content of sorghum seeds grown in the United States. Daiber (1975) suggested that sorghum grains containing above 1.1% polyphenol may not be suitable for brewing. In the samples investigated only SRN484 exceeded this limit (Table I) and was therefore not recommended for the brewing industry. In addition, SRN484 recorded the lowest diastatic activity (72.9 sorghum diastatic units [SDU]/g) out of all the samples investigated, and this was due to the inhibitory nature of its tannin content (Ogundiwin et al, *unpublished data*). Although the diastatic power of SRN484 was within the range of 60-80 SDU/g estimated as essential for industrial malting by Novellie (1977), the product (beer) from such malt may not be acceptable due to haze formation as a result of tannin-protein interaction.

Tannin contents were reduced by 33% in SRN484, 27% in KSV7, and 43% in SSV3 during steeping of the grains for 48 hr (Fig. 1). This decrease could have been caused if the tannins reacted with soluble sorghum proteins, rendering the tannins inextractable in

TABLE I
Maturation Period, Pericarp Color, Tannin, and Total Polyphenol Content of Sorghum Grains and the Cyanide Content of Dry, Steeped, and Malted Seeds[a]

Sorghum Varieties	Maturation Period (days)	Pericarp Color	% Tannin[b]	% Polyphenol[c]	Cyanide Content (μg/g dry weight)		
					Dry Seed	After Steeping[d]	After Malting[e]
SSV3	175	yellow	0.30 f	0.50 de	8 b	55.3 fg	98 kl
SSV9	165	cream	0.26 g	0.46 ef	10 b	50.2 fg	96 dkl
SSV10	160	cream	0.26 g	0.40 fh	12 b	53.6 f	102 k
SSV11	170	yellow	0.25 g	0.441 fg	11 b	55.8 fg	99.3 k
SSV12	175	yellow	0.25 g	0.46 e	12 b	53.3 fg	116 j
KSV4	110	cream	0.269 j	0.35 hj	12 b	50.7 fg	89.7 dlm
KSV7	145	white	0.46 c	0.63 c	12 b	49.2 g	106 k
KSV8	140	white	0.41 de	0.42 f	13 b	48.1 g	105 k
KSV11	105	creamy brown	0.46 c	0.53 d	11 b	58.1 fg	96.9 kl
KSV12	105	cream	0.67 b	0.62 c	12 b	72.6 e	82.4 lm
KSV13	100	white	0.26 g	0.32 j	27 a	56.8 f	140 hij
KSV14	100	white	0.40 e	0.35 hj	24 a	58.1 f	150 h
KSV15	90	dirty red	0.45 cd	0.68 b	27 a	92.2 d	136 hij
NVW	120	white	0.25 g	0.37 gh	11 b	43.6 f	77.5 em
SRN484	110	deep red	2.92 a	2.70 a	38 a	111.3 c	121 cij

[a] Figures followed by the same letter are not significantly different at the 95% confidence level.
[b] Catechin equivalent.
[c] Tannic acid equivalent.
[d] Steeping for 48 hr.
[e] Five-day malting period.

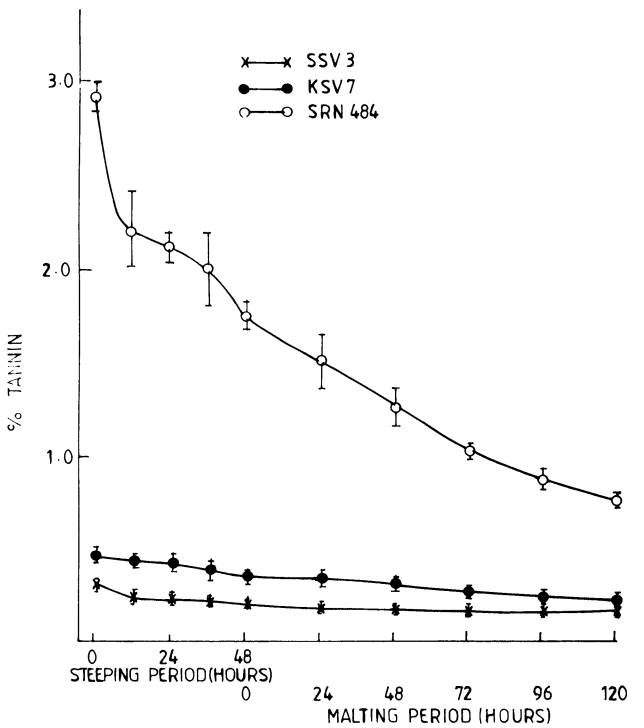

Fig. 1. Tannin (catechin equivalent) content of selected Nigerian sorghum varieties during steeping and malting.

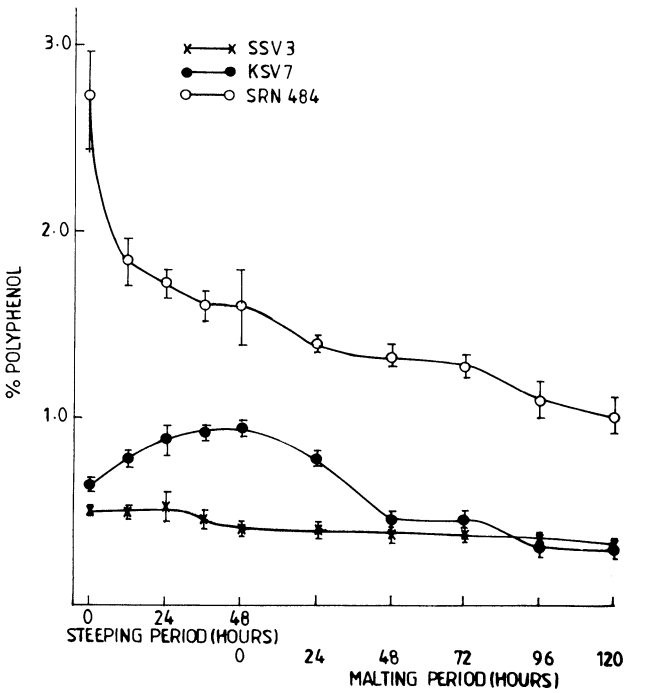

Fig. 2. Total polyphenol (tannic acid equivalent) content of selected Nigerian sorghum cultivars during steeping and malting.

methanol and therefore undetectable by the vanillin-HCl assay, and/or if further polymerization of the tannins rendered them insoluble in methanol again (Reichert et al 1980). The reduction in the total polyphenol content during steeping was 41% in SRN484 and 20% in SSV3 (Fig. 2). The 50% increase in the polyphenol content of KSV7 was accompanied by the development of a pink-reddish coloration on the seed. A similar observation was reported earlier for sorghum seedlings (Stafford 1965). The tannin content of SRN484 decreased by 42%, KSV7 by 24%, and SSV3 by only 10% during the five-day malting period (Fig. 1). The total polyphenol content decreased by 22% in SRN484, 68% in KSV7, and 19% in SSV3 (Fig. 2). A general decrease in tannin/polyphenol content of germinating sorghum was reported by McGrath et al (1982) and Rao and Deosthale (1982) for germinating pulses. This decrease in the tannin/polyphenol contents could be attributed to the increased activity of polyphenol oxidase and other catabolic enzymes as observed by Kruger (1976) for wheat.

The cyanide content of dry sorghum seeds was generally low and varied from 8 μg/g for SSV3 to 38 μg/g for SRN484 (Table I). Panasiuk and Bills (1984) observed that dry sorghum seeds contained from 1 or 2 to 29 μg of cyanide per gram. During steeping, the seeds presumably synthesized dhurrin and contained between 43–58 μg cyanide/g dry weight, with the notable exceptions of KSV12 (72.6), KSV15 (92.2), and SRN484 (111 μg/g). The cyanide content of the seed during malting followed an irregular pattern, as observed in sorghum seedlings grown under fluorescent light in the growth chamber (Adewusi 1983) or in the sun (Gorz et al 1977). The cyanide content of each cultivar

increased during steeping and malting compared with the original grain (Table I). The seeds contain the protein reserve, and during malting proteolytic enzymes develop and amino acids are released (Adewusi 1983). Since tyrosine is the precursor of dhurrin biosynthesis, there is the possibility that dhurrin was also synthesized in the seed. The cyanide content of the malt is small and should not pose a problem, especially when it could be reduced during processing. The health hazard would occur when the plumule and radicle are milled together with the malt as practiced in the kaffircorn brewing industry (Novellie 1962) or if their removal is incomplete. The plumule can contain up to 1,400 μg/g of HCN, and the radicle has as much as 860 μg/g in the early stages of growth (Adewusi 1983). Panasiuk and Bills (1984) reported a mean value of 61.3 mg of HCN/100 g of sprouted seeds and reported that neither drying at 50° C nor milling to produce meal or grist reduces the HCN content. This means that a 100-g of sprouted sorghum meal may be hazardous, because Conn (1979) estimated 50 mg of HCN as the fatal dose for a 70-kg man.

Values of HCN obtained by the method of Gorz et al (1977) agreed substantially ($r = 0.95$) with those of Lambert et al (1975) for grain, malted sorghum, and crude dhurrin samples. For whole seedlings, however, the Lambert method gave 25–40% higher values.

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