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The Effect of Kernel Size and Texture on the Malting Properties of Sorghum

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ABSTRACT

The effect of kernel size and texture of kernels on the malting properties of sorghum was investigated. Twelve sorghum cultivars were used for the study. The physical features of the kernels that were determined included the endosperm texture, endosperm type and kernel size. Also determined were the germination energy and germination capacity. To monitor the malting properties, the malting loss, hot water extract, cold-water extract and diastatic power were determined. The effect of duration of germination on the root and shoot lengths of kernels was also investigated. Two of the cultivars were floury while the other cultivars were corneous. All the cultivars were non-waxy. The mean percentage values of the germination energy and germination capacity were 84.92% and 91.75% respectively. As the germination period increased, root and shoot lengths of all the twelve cultivars also increased. The greatest change in the root and shoot lengths was observed between the second and third day of the germination period. The malting loss increased with the germination period and ranged between 15.5-33.0%. The malting loss for all cultivars reached its peak between the second and third day of germination. Malting loss was least for floury endosperm. The diastatic activity increased throughout the duration of germination. The diastatic

activity was positively correlated with the cold water extract ($r = 0.99$) and hot water extract ($r = 0.29$). The cold water extract increased as the diastatic activity increased. The corneous grains were relatively high in diastatic activity but no correlation was obtained between the size indices and malting properties of the cultivars.

Key Words: Sorghum, Kernel size, texture, malting properties

INTRODUCTION

The art of malting has been with the Africans for long and the malting procedure is basically the same in all parts of the continent (Rooney and Kirleis, 1980). Malting involves germination of the grain until the food store (endosperm), which is available to support the development of the germ of the grain, has suffered some degradation from enzymes (Briggs *et. al.* 1981). A primary aim of malting is to develop and activate enzymes for the conversion of the insoluble reserved foods. The activities of these enzymes are terminated by drying (Kilning) the young plant (green malt) so that the endosperms are not completely depleted through respiration of the embryo and its growth. Hence, malt is the modified cereal grain resulting from induced germination under controlled conditions of moisture, aeration and temperature. A good malt should not contain more than 4% fully unmodified grains and not less than 75% full modified grains (van Erde, 1983).

Barley is the preferred grain for malting in modern brewing. Other cereal grains such as wheat rye, oat, sorghum and maize have been used for malting, though with little success (Pomeranz and Shands, 1974; F.I.I.R.O.1984). However, sorghum seems to be the most appropriate alternative to barley malt, on the basis of cost, utilization and production level. Indeed, the size of sorghum has been reported to be similar to that of barley, though more rounded in shape (Skinner, 1976).

Various findings concerning the malting abilities of sorghum have been reported. The kernel size and shape affect the malting properties and water up take of the grain (Rooney, 1973). Ilori (1989) also reported that the kernel size index correlated significantly with the germination energy and capacity. However, correlation of the kernel size with the malting properties of the grain has not been well investigated. The reports of these workers indicate that there are varietal differences in the optimum malting conditions of sorghum. Varietal differences in sorghum indicate differences in kernel characteristics (Ilori, 1989), and these may be of importance in the malting of sorghum just as texture and size are important in barley malt.

It is therefore the aim of this paper to investigate the effect of kernel size and texture on the malting properties of

sorghum.

MATERIALS AND METHOD

Sources of materials

The international crop Research institute for the semi-Arid Tropics, Kano, supplied the sorghum cultivars used for the study.

Analyses of the physical parameters of sorghum cultivars

Endosperms texture: This was determined by cutting twenty kernels selected at random, amount of corneous and floury comparing the relative amount of corneous and floury endosperm portions (Akingbala, 1982). The scale was from 1 to 5. The rating carried from corneous (1) intermediate corneous (2-3) to floury (4-5).

Endosperm type: Twenty randomly selected kernels were cut into halves longitudinally and stained with 0.01% iodine solution. Waxy endosperm stained purplish red while non-waxy endosperm stained dark blue (Akingbala, 1982).

Kernel size: The three major axes represented the length, breadth and thickness of the kernel (Marteues-Heura and Lachnace, 1979). Size index was calculated from the sum of x, y and z axes.

Germination energy: This was done according to I. O. B. (1977).

Germination Capacity: The method outlined by Okafor and Anichie (1980) was used.

Micro malting

The malting chamber of the Department of Food Technology, at the University of Ibadan, Nigeria was used. The flow chart in [fig 1](#) was adopted for the malting process.

400g of each sorghum sample were cleaned by steeped in and washing with tap water. The kernels were then

steeped in 2000ppm limewater (1:2w/ v) for 18h, and thereafter washed and spread to 2cm layer thickness in the malting drawers, which were later placed in the malting chamber. The germinating kernels were turned once and watered two times daily.

The temperature of the germinating kernels was $28 \pm 2^\circ\text{C}$ and growth was terminated at 24, 48, 72, 96 and 120hr of germination by kilning (48hr) in a forced air oven at $48 \pm 2^\circ\text{C}$. Thereafter, the kilned malts were cleaned and stored for analysis ([fig. 1](#)).

RESULTS AND DISCUSSION

Tables [1](#), [2](#) and [3](#) give the results of the experimental work. Twelve different types of sorghum cultivars were used for this study. According to [table 1](#), only two cultivars (Naga white and ICSH 89002) were found to be floury while the remaining ones were intermediate (or corneous). The size index obtained for the kernels ranged between 5.7 and 6.49mm. White mutant cultivar had the highest value while the ICSV 210 cultivar had the lowest. The average kernel size obtained for all the twelve cultivars was 6.23mm. Cannales and Sierra (1976) obtained an average kernel size of 9.00mm while Ilori (1989) obtained a size index range of 11.00 and 11.50mm. The non-conformation of the kernel size to a uniform size index may be as a result of differences in the cultivar and the place of cultivation (Hulse *et al.*, 1980). According to Rooney and Miller (1981), the shape, size, proportion and nature of the endosperm, germ and pericarp, the presence or absence of subcoat and colour of the pericarp are all genetically determined.

The intermediate texture grains were generally higher in germination energy and germination capacity than the floury ones, with the exception of ICSH 89002 and ICSV 247. The fact that ICSH 89002, despite being floury, had the highest germination energy and capacity may indicate that varietal differences occur among sorghum cultivars of the same texture. The deviation observed in ICSV 247 which had the lowest germination energy and capacity may be the resultant effect of the gross infestation of the grain. Rooney and Murty (1981) confirmed this in their findings that infestation affects pericarp colouration, kernel filling and germinability of grains.

The effect of the duration of germination on the root and shoot lengths is given in [table 2](#). It was observed that as the germination period increased, the lengths of both the root and shoot increased. ICSV 401 had the longest rootlet while ICSV 89002 had the shortest. ICSV 401, ICSH 507 and Isiad dorado had longer shoot, other cultivars in this group include ICSV 89002, white mutant and ICSV III. Earlier works by Adeola (1991) showed that ICSH 507, ICSV 401 and Isiad dorado were high-N sorghum grain. The fact that ICSH 507, ICSV 401 and Isiad dorado

were high-N sorghum may be responsible for the effect observed on the lengths of roots and shoots. According to Briggs *et. al.* (1981), high N-barleys were observed to respire and grow vigorously. Lengths of root and shoots indicate growth and probably the hydrolysis of high molecular structures within the kernel. It may also indicate the rate of loss of dry matter during germination period. It may also be pointed out that the behaviour of root and shoot lengths during germination could be affected by the pericarp thickness. The reports of Adeola (1991) indicated that the thickness of the pericarp influences the growth of the root of sorghum kernels, and hence, the germination behaviour.

The greatest change in the root and shoot lengths was observed between the second and third day of germination. This may be that the activities in the endosperm occur mostly during this period. Palmer and Bathgate (1976) reported that enzyme activity is highest during the early stages of germination since the first 2-3 days coincide with the movement of the growth hormone (gibberellins).

The malting properties of sorghum that were examined in this study are shown in [table 3](#). The malting loss was observed to increase with the germination period. The malting loss ranged between 15.5% and 33.9%. Malting loss could be between 10.9% and 35.0%, depending on the malting conditions (Novellie, 1962; Pathirana *et. al.*, 1983). Malting loss is incurred as a result of dry matter loss, mainly due to the growth and respiration of the embryo (Pollock, 1962). The increase in malting loss was highest mostly in the first and third day of germination. This, therefore, confirms the earlier submission in the previous paragraph that enzyme activity occurs most during the early period of germination. Malting loss was least for floury endosperm ICSH 89002, probably suggesting that embryo activity may be more in the corneous grains than the floury types. ICSV 247 had the lowest malting loss, but was characterized by mould infestation.

The diastatic activity increased throughout duration of germination, with ICSH 89002 having the highest while white mutant had the lowest. The intermediate (or corneous) grains were relatively high in diastatic activity. The low value obtained for ICSV 247 was due to infestation and weathering which are known to affect the germinability and hence, enzyme activity of the grain. Kernels having high germination energy were also characterized by high diastatic activity. The diastatic activity was positively correlated with the cold-water extract ($r = 0.99$) and hot water extract ($r = 0.29$) The cold water extract increased as the diastatic activity increased; enzyme activities are responsible for both the cold and hot water extract.

CONCLUSION

The kernel size index of sorghum grains cannot be tied down to a particular range, as this varies from cultivar to cultivar, and from one place to another. The germination energy, germination capacity, root length and shoot length were generally found to be high in the corneous grain. The diastatic activity, the cold water extract, the root length and shoot length increased as the duration of the germination increased. The sorghum grains with intermediate endosperms were found to be more suitable for malting than those with floury endosperm.

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Fig 1: Flow diagram of Sorghum micro-malting process

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Table 1: Physical Parameters of Sorghum Cultivars

	ICSV 210	ICSH 89002	ICSV 247	ICSH 566	ICSV 89009	ICSH 507	CSV 401	Isiad Dorado	Naga White	ICSV 400	White mutant	ICSV 111
Endosperm texture	2.5	4.0	2.5	3.0	3.5	2.5	2.5	2.5	5.0	2.5	3.0	2.5
Endosperm type
Kernel size index (mm)	5.70	6.16	6.39	6.46	6.27	5.83	6.07	6.34	6.32	6.33	6.49	6.40
Germination Energy (%)	93.0	98.0	21.0	89.0	90.0	95.0	91.0	95.0	82.0	84.0	88.0	93.0
Germination Capacity (%)	93.0	98.0	90.0	90.0	91.0	95.0	93.0	97.0	85.0	86.0	89.0	94.0

Table 2: Effect of duration of germination on root and shoot lengths

	ICSV 210	ICSH 89002	ICSV 247	ICSH 566	ICSV 89009	ICSH 507	ICSV 401	Isiad Dorado	Naga White	ICSV 400	White mutant	ICSV 111
Day 1 (mm)												
R	1.1	1.0	0.5	1.0	0.7	0.4	0.7	0.7	1.0	0.8	1.2	1.0
S	0.3	0.2	0.1	0.1	0.1	0.1	-	-	0.1	-	0.2	0.2
Day 2 (mm)												
R	2.8	2.0	2.2	2.2	2.7	2.6	2.0	2.3	2.5	1.9	3.3	1.5
S	0.7	0.3	0.3	0.4	0.7	0.8	0.1	0.8	0.5	0.6	0.8	0.2
Day 3 (mm)												
R	3.6	2.7	2.5	3.2	3.5	3.0	3.4	4.1	4.4	3.2	4.8	3.0
S	1.0	0.3	0.5	0.8	1.0	3.2	0.2	1.4	2.2	0.8	2.6	0.4
Day 4 (mm)												
R	4.0	3.0	3.1	3.8	4.4	4.4	5.2	4.4	5.0	5.4	5.4	4.0
S	1.9	0.6	0.5	0.9	2.9	3.2	2.2	3.0	3.7	2.0	3.0	2.9
Day 5 (mm)												
R	4.3	3.5	4.0	4.3	5.8	5.3	7.3	5.6	6.1	5.6	5.8	6.6
S	2.0	1.4	2.1	1.7	3.9	4.2	3.5	5.1	4.4	2.5	3.8	3.8
R	=	Root length										
S	=	Shoot length										

Table 3: Malting Properties of sorghum cultivars

	ICSV 210	ICSH 89002	ICSV 247	ICSH 566	ICSV 89009	ICSH 507	ICSV 401	Isiad Dorado	Naga White	ICSV 400	White mutant	ICSV 111
Day 1												
C.W.E	12.6	13.5	9.0	17.1	17.3	16.4	10.9	11.6	8.9	13.8	10.0	16.2
H.W.E	73.1	107.2	59.5	260.9	221.5	212.8	180.3	280.3	178.5	246.3	189.0	122.5
D.A.	13.6	14.1	9.4	17.4	18.0	17.2	11.8	12.9	9.0	14.9	10.7	16.0
M.L.	11.5	4.6	5.8	9.1	7.1	13.1	5.5	10.8	4.5	11.9	3.2	7.9
Day 2												
C.W.E	12.6	15.5	11.4	18.5	19.4	19.1	16.2	17.5	9.2	17.3	11.0	17.3
H.W.E	240.5	277.7	120.3	268.9	281.6	283.6	202.8	439.8	263.2	292.8	262.5	146.4
D.A.	19.0	15.7	12.4	21.1	21.3	21.3	16.4	18.1	10.9	17.7	11.6	17.7
M.L.	17.6	4.8	11.4	12.4	9.2	15.7	15.7	19.2	7.0	16.5	5.9	12.1
Day 3												
C.W.E	20.0	21.1	17.0	19.6	19.7	20.0	18.8	18.4	12.1	18.0	11.7	18.1
H.W.E	290.2	288.4	171.1	272.6	305.9	264.6	237.2	452.2	276.6	339.2	274.4	225.8
D.A.	22.2	23.3	17.4	21.8	22.1	21.4	21.2	20.5	13.5	19.5	12.6	18.8
M.L.	17.9	9.8	13.6	15.3	14.2	18.0	21.0	25.2	13.7	19.9	7.7	15.8
Day 4												
C.W.E	19.8	31.8	17.8	19.5	21.0	19.7	24.0	19.6	13.5	18.6	14.0	19.0
H.W.E	306.8	372.4	220.8	317.9	317.9	299.8	271.6	472.8	316.3	397.0	311.4	257.5