

OPTIMUM SIZE DISTRIBUTION OF SORHUM GRIST FOR BREWING PURPOSES

BENJAMIN R. ETUK and IFREKE S. AKPAN

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ABSTRACT

The effect of particle size distribution of malted sorghum grist on extract yield and lautering performance was assessed. Sorghum grist particle size evaluation was carried out by sieve analysis after milling. The malted sorghum grist with proportions of coarse, fine, and flour particles in the ratio of 0.36: 0.25: 0.39 respectively gave good results in terms of extract yield and filtration rate. The values of 103.05% and $1.42 \times 10^{-4} \text{ m}^3/\text{s}$ were obtained for extract yield and filtration rate respectively.

Keywords: Size distribution, Filtration rate, Brewing

INTRODUCTION

Traditionally, sorghum grains have been in use for the production of local alcoholic drinks such as 'Kaffir beer' in South Africa and 'Burukutu' in Nigeria (Novellie, 1968; Banigo and Aina, 1987). For sometime now and until recently the grain has been used in large amounts as unmalted adjunct and as malted cereal to brew beer in Nigeria (Aisien, 1991). It is, however, low in beta-amylase, an important diastatic power enzyme, which necessitates the use of extraneous enzymes during mashing (Nout & Davis, 1982; Okon & Uwaifo, 1985; Aisien & Muts, 1987; Etokakpan and Palmer, 1992).

In the brewing industry, it has long been known that one of the factors that has a considerable influence on the filterability of wort and on extract yield obtained is the size distribution of milled grain or malt (Huige and Westermann, 1975). Setting the mill rolls is therefore critical to ensure correct particle size. Particle size must not be too small because wort run-off may be impaired, or too large because the extract yield may be reduced (Baker, 1983). Fine particles impeding flow can pre-exist in the grist, for example, due to fine milling or use of flour adjuncts (Kano, 1971). They can also be formed by aggregation of macromolecules of glucan and pentosans with the protein coat of small starch granules, resulting in an impermeable matrix (Taylor, 1988). Large starch granules, which have much less associated surface protein as in barley grain, do not form impervious aggregates in this way and do not impede wort separation (Scully & Lloyd, 1965).

Wort separation from sorghum mash is usually carried out with the mash filter or the whirlpool (centrifuge) due the absence of husk in the grains. The rate of separation using the mash filter can be described by the modified Darcy equation which is expressed as shown in Equations (1) to (3) (Huige & Westermann, 1975; Wilkinson, 1991).

$$Q = \frac{KA\Delta P}{\mu L} \quad (1)$$

where Q is wort volumetric flowrate; K is average bed permeability; A is mash bed cross-sectional area; μ is the viscosity of the wort; L is mash bed depth and ΔP is pressure drop across the mash bed.

$$K = \frac{\varepsilon^3 d^2}{(1-\varepsilon)^2 180} \quad (2)$$

and

$$\varepsilon = \sum \frac{(x_i)^{-1}}{(d_i)} \quad (3)$$

is bed porosity; d is the average particle size diameter of the grist and x is the weight fraction.

Also, for the whirlpool, the rate can be described using the Stokes Law of velocity as given in Equation (4) (Coulson et. al., 1987)

$$Q = \frac{d^2 \omega^2 (\rho_s - \rho) R V}{18 \mu h} \quad (4)$$

TABLE 1: Sorghum Grain/Malt Analysis (Variety L1499)*

	Grain	Malt
Moisture content (%)	10.8±0.10	10.40± 0.10
Germinative energy (%)	98.1±0.20	-
Germinative Capacity (%)	99.50±0.15	-
Malting loss(%)	-	19.50±0.01

*All values are means of three determinations ±SE

TABLE 2: Particle Size Analysis of Malted Sorghum Grist (L1499)

Grist Sample	FRACTIONAL PARTICLE SIZE DISTRIBUTION (%)		
	COARSE (2000-600)µm	FINE (600-75)µm	FLOUR <75µm
A	45	30	25
B	42	26	31
C	36	25	39
D*	62	27	11

*Unmalted sorghum

where ω is the angular velocity; ρ_s is density of the grist particles; ρ is the density of liquid (wort), R is the radius of the whirlpool basket; h is the depth of liquid in the basket and V is the volumetric capacity of the basket.

From Equations. (1) to (4), it can be seen that the particle size of the grist plays an important role in the rate of separation of wort from the mash, irrespective of the method used. Although wort viscosity may also affect wort separation rate, the viscosity of the wort is generally low at the operating temperature (Palmer, 1983).

In this paper, the effect of particle size distribution of sorghum malt grist on the brewing process such as mashing and lautering performance is reported with a view to determining the optimum sorghum grist proportions that will give good brewing results.

EXPERIMENTAL

Sorghum Grain/Enzyme Supplement

Samples of the sorghum grain variety (Sorghum bicolor L, (L1499)) used for this study were obtained from the seed production unit of the Institute of Agricultural Research (IAR), Zaria, Nigeria. The grains were analysed according to the Recommended Methods of analysis (IOB, 1986) for viability and moisture content.

The commercial enzyme supplements used during the mashing process include Amyloglucosidase (AMG), Neutrane, Glucanase, Celluclast and fungal amylase, which were obtained from Champion Breweries Plc, Uyo, Nigeria.

Malting Procedure and Malt Analysis

The experimental malt was prepared from the grain sample by the method described by Palmer et. al. (1989). In this method, the sorghum grain sample for each variety was steeped in water at 25°-30°C for 24 hours with a 2 hour air-rest. After this it was drained and allowed to germinate for four days on moistened blotting paper in a malting tray covered with water-proof held with clips in a dark cupboard at ambient

TABLE 3: Analysis of Sorghum Malt (L1499) Extract

Grist Sample	Specific Gravity (^o P)	Apparent Extract (%)	Extract 'AS-IS' (%)	Extract 'Dry-Basis' (m ³ /s)	Filtration Rate	Saccharification Test
A	1.04356	10.84	98.5	109.2	1.065x10 ⁻¹	Positive
B	1.04533	11.26	102.6	114.4	1.0775x10 ⁻¹	Positive
C	1.04536	11.28	103.05	115.0	1.42x10 ⁻¹	Positive
D*	1.04141	10.33	93.4	104.7	1.60x10 ⁻¹	Positive

*Unmalted Sorghum

temperature of 25°-30°C. At the end of the germination, the green malt was dried in an oven (Model OVE-102) equipped with a draught fan at 50°C for 14 hours. The dried rootlets were rubbed off by hand while the malt so prepared was analysed for moisture content and malting loss (IOB, 1986; EBC, 1975).

Milling Process

About one hundred grams of the malted sorghum grain sample were each milled using the manual grinder (Corona Model GR1000), electric blender (Moulinex 530) with 1 blade, and 3 blades, to give grist samples A, B, and C respectively. The manual grinder was also used in milling the unmalted grain sample that served as a control. All milling experiments were done in triplicates.

Particle Size Analysis of Milled Samples

The particle size distribution of the milled samples of the malted and unmalted grains were each determined by the sieve method (Tyler, 1973). The weighed grist was placed on the top sieve in a stack of different sieves and shaken mechanically for 5 minutes on a Ro-Top sieve shaker. The fraction retained on or passing through each sieve was weighed and reported as percent of total grist.

Extract Preparation and Analysis

The experimental wort was prepared from the sorghum grist using the mash decoction method (Aisien, 1987) with some modifications. Exactly 100g of the grist was mashed at 50°C with 625.5ml of distilled water. The pH was adjusted from 6.5-7.0 with the addition of calcium hydroxide, and neutrase added for proteolysis. The mash was held for 30 minutes after which glucoamylase and celluclast were added and the mash temperature raised to 80°C and held for 60 minutes for maximum gelatinization of the sorghum starch. The mash was then cooled to 67°C and AMG and fungal amylase were added for amylolytic activities. The mash was held for 30 minutes, and after this period the temperature was raised to 75°C and held for another 20 minutes for full conversion (saccharification), while the saccharification test was carried out. After this, it was mashed off now ready for wort recovery and analysis.

The filtration rate of the wort was determined by measuring the volume of the wort collected per unit time during the filtration process, while the extract content of the wort was obtained from the specific gravity (SG) by means of the Official Sugar Table (Plato Table) (A.O.A.C., 1980; EBC, 1975). The wort viscosity and colour were also determined using the Recommended methods of Analysis (IOB, 1977; EBC, 1975).

RESULTS AND DISCUSSION

Grain /Malt Analysis

The results of the grain and malt analysis are given in Table 1; which shows clearly that the grains were viable with adequate moisture content and suitable for malting. (Chukwurah, 1988; EBC, 1975).

Particle Size Analysis

The particle size distribution of the malted samples (A - C) and unmalted (sample D) plotted as percentage

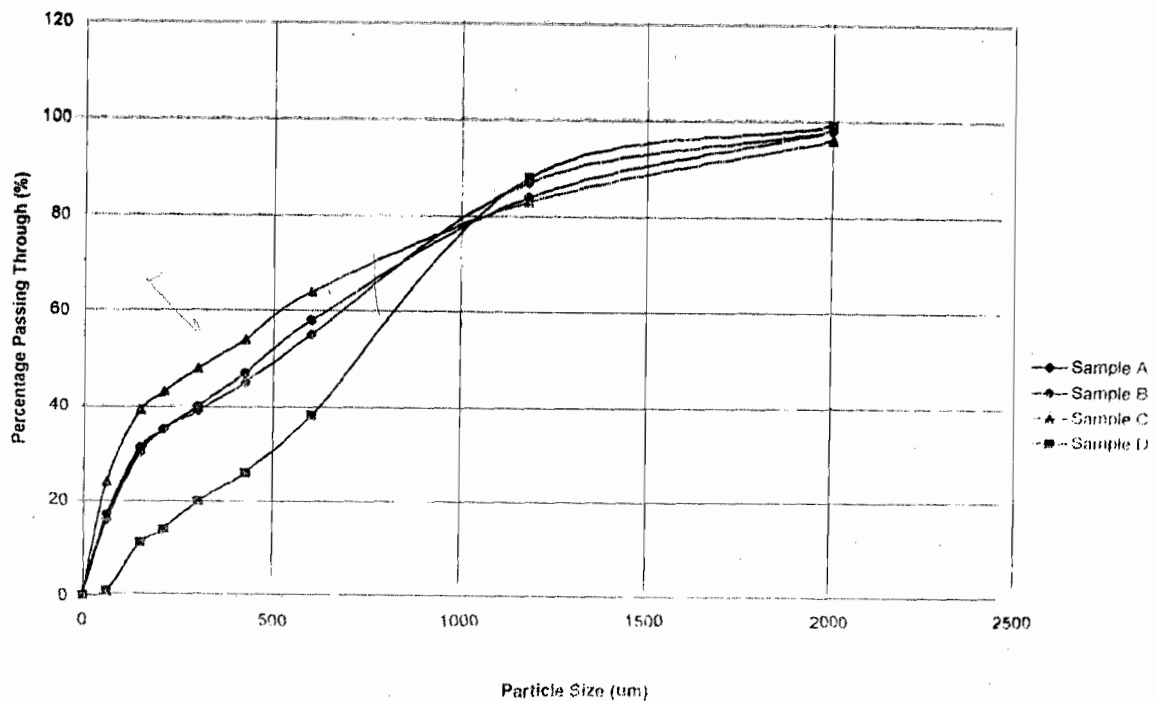


Fig. 1: Particle Size Distribution of Sorghum Malt Grist (Sorghum Variety L1499)

passing through against particle size is presented in Figure 1. These results which are summarised in Table 2 show a gradual decrease in the proportions of coarse and fine grists and an increase in the flour grists in samples A to C. These variations may be due to an increase in the milling efficiency of the systems used. For the unmalted sample (D) there are more coarse particles and less flour particles compared to sample A which was milled by the same equipment. This may be due to the fact that sample A is malted and thus friable than the unmalted sample (D).

Extract Yield

The extract content of the wort as presented in Table 3 shows an increase with a decrease in the proportion of the coarse particles and an increase in that of the flour particles. This trend should be expected since the smaller particle size of the flour proportions is accompanied with greater area for mass transfer and hence greater extraction efficiency (Huige and Westermann, 1975). Also due to the high proportion of the coarse particles in the unmalted grain sample, there is a decrease in the mass transfer area resulting in a low extract yield for grist sample D.

Filtration Rate

The wort filtration rate results are given in Table 3. Eventhough sample C has the highest and lowest proportions of the flour and coarse particles respectively, it gave the highest filtration rate. This would be attributed to the fact that the enzymes were able to act more on these particles because of the greater exposed surface in the mash of this sample thus reducing the viscous substances like beta-glucans which are one of the main causes of low run-off, thereby giving a significant improvement in wort filtration. However, the high filtration rate obtained in the unmalted sample is a direct consequence of the high proportion of the coarse particles in the sample.

CONCLUSION

The results of this investigation reveal that for the malted sorghum studied (sorghum variety, L 1499) the proportions of the particle size that give the best brewing results in terms of extract content and filtration rate would be at a ratio of 0.36: 0.25: 0.39 for coarse, fine, and flour particles respectively.

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