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Full Length Research Paper

Drying characteristics and engineering properties of fermented ground cassava

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The effect of variety on the drying and engineering properties of fermented ground cassava was studied in order to generate data for design and optimum performance of various dryers used in cassava processing. This research attempts to provide data on the engineering properties such as moisture content, specific heat capacity, thermal conductivity, thermal diffusivity and bulk density. One native cultivar and two high yield improved cultivars (TMS 30572 and NR 8082) were used for this study. The specific heat capacity obtained ranged from 1.40 to 1.45 KJ/Kg K and for bone dry fermented ground cassava. The average thermal conductivity obtained was 0.24 W/MK. The bulk density, specific heat capacity, and thermal conductivity increased with increase in moisture content while thermal diffusivity decreased as moisture content increased.

Key word: Density, thermal conductivity, thermal diffusivity, specific heat capacity, fermented ground cassava.

INTRODUCTION

Cassava is a root crop, a single specie dicotyledonous plant belonging to the family of Euphorbiacease and is the most important root crop grown in the tropics (Enwere, 1998; Anikwe and Onyia, 2005). Cassava (*Marihot esculenta*) represents the main source of energy for 200 to 300 million people all over the world (Ademiliyi et al., 2006). Cassava may actually have been introduced into Nigeria over 300 years ago although its cultivation was never generally accepted and practiced until the late 1890s (Hahn, 1988; Grace, 1977). Nwanekezi and Ukagu (1999) noted that engineering properties include latent heat of vaporization, thermal conductivity, thermal diffusivity, specific heat, moisture content, etc. These engineering properties are used for quality assessment and evaluation, design, operation and control of dryers.

The drying characteristics of fermented ground local variety of cassava was studied by Audu and Ikhu-Omoregbe (1982) and they obtained the heat and mass transfer coefficient of the variety, using oven, pneumatic and rotary driers. Njie et al. (1998) developed the thermal properties for cassava root. They also determined the thermal conductivity, specific heat capacity and thermal diffusivity of yam tuber and plantain. Nwanekezi and Ukagu (1999) also determined the engineering properties of some Nigerian fruits and vegetables (including a fresh cassava cultivar) with moisture content greater than 60%. They used the data obtained on moisture contents of the foods to determine thermal conductivity, thermal diffusivity, specific heat capacity and latent heat of fusion using available, model equations. Physical properties of cassava mash using a local variety was investigated by Gevaudan et al. (1989).

The objective of this research is to provide data on the engineering properties such as bulk density, specific heat, moisture content, thermal conductivity and thermal diffusivity of some cultivars, as well as determine the effect of variety on the drying and engineering properties of fermented ground cassava.

MATERIALS AND METHODS

Sample collection and preparation

The cultivars, one native cultivar (Akpu Bonny) and two high yield improved cultivars, TMS 30572 and NR 8082, were obtained from Root Crops Development Centre, Agricultural Research Institute, Igbariam, Anambra State, Nigeria. The cultivars were peeled, washed, grated and put in three different sacks for pressing. After fermenting for 72 h, the washed cassava was sieved with a mesh of 2.4 mm. The drying rates were determined using a hot circulating air oven.

Table 1. Initial and final moisture content of cultivars.

Cultivar	Initial moisture at harvest (% wet basis)	Moisture content after dewatering and fermentation for 72 h (% wet basis)	% Moisture expelled after drying
NR 8082	68.00	48.66	51.34
MS 30572	62.50	46.32	53.68
Native	63.44	45.18	54.82

Proximate composition

The proximate composition was determined after drying in an oven at 70°C for 24 h. Moisture, carbohydrate, protein, fat, fibre and ash content were determined using the method of Association of Analytical Chemists (AOAC) as reported by Odo and Ishiwu (1999).

Moisture content

The moisture content was determined before and after fermentation by drying 5 g of each sample in an air oven at 105°C for 24 h. Drying continued until the final weight of the sample became constant. The initial moisture content on wet basis is given by:

$$X_0 = [(W_1 - W_2)/W_1] \times 100 \quad (1)$$

Where, X_0 = moisture content on wet basis, W_1 = initial weight of sample, W_2 = final weight of sample after drying.

The moisture content on dry basis was calculated from:

$$X_d = [(W_t - W_2)/W_2] \times 100 \quad (2)$$

Where, X_d = moisture content on dry basis.

The moisture content on dry basis at any time, t is given by:

$$X_t = [(W_t - W_2)/W_2] \times 100 \quad (3)$$

Where W_2 is the weight of dried sample and W_t is weight of sample at any time, t.

Bulk density determination

The bulk density of the samples was determined by tampering procedure described by Ahmedna et al. (1997)

Determination of thermal conductivity

The thermal conductivities of the samples were determined using the expression developed by Sweat (1986).

$$K = 0.25 X_c + 0.155 X_p + 0.16 X_f + 0.135 X_a + 0.58 X_w$$

Where K is thermal conductivity of sample in W/m °C and X are the respective mass fractions of carbohydrate, protein, fat, ash and water present in each cultivar.

Determination of specific heat capacity

The specific heat capacities of the samples were obtained from the method of Choi and Okos (1986).

$$C_p = 4.180X_w + 1.711X_p + 1.929X_f + 1.547X_c + 0.908 X_a$$

Where Cp is the specific heat capacity in KJ/Kg K and X are the respective mass factions of water, protein, fat, carbohydrate and ash present in each cultivar and obtained from proximate compositions.

Determination of thermal diffusivity

Thermal diffusivities of the samples were determined using the method below:

$$\varphi = K/PC_p \ (m^2/s)$$

Where φ is thermal diffusivity, K is thermal conductivity, P is density and Cp is specific heat capacity.

RESULTS AND DISCUSSION

Moisture content

Moisture content obtained before and after fermentation by drying the cultivars with a circulating air oven is shown in Table 1. The cultivars used for this experiment were harvested in the month of April, 2008. NR 8082 had the highest moisture content of 68% at harvest followed by native cultivar with moisture content of 63.44%. However, the native cassava had the highest moisture expelled after drying, indicating that the native cassava was porous than the improved cassava.

Drying rate

The drying curves for the cultivars are shown in Figure 1. The moisture content (dry basis) decreased as drying time increased for all the cultivars. The drying rate decreased as the drying time increased. TMS 30572 and NR 8082 had the longest drying time of 60 min while ative cassava had a drying time of 50 min. All the cultivars exhibited different drying characteristics. This is attributed to the differences in the chemical composition of the cultivars. The native cassava had the highest drying rate and shortest drying time.

Proximate composition

The proximate composition of the cultivars is shown in Table 2. NR 8082 and TMS 30572 had a higher percentage of carbohydrate than native cassava. All the cultivars did not contain fat. All the cultivars had low pro-

Table 2. Proximate composition of cultivars on dry basis.

Cultivar	% Ash	% fat	% Protein	% Fibre	% Moisture	% Carbohydrate
NR 8082	1.05	Nil	0.22	3.20	1.80	93.73
TMS 30572	1.50	Nil	0.44	2.55	2.15	93.36
Native	0.15	Nil	0.44	4.60	1.95	92.86

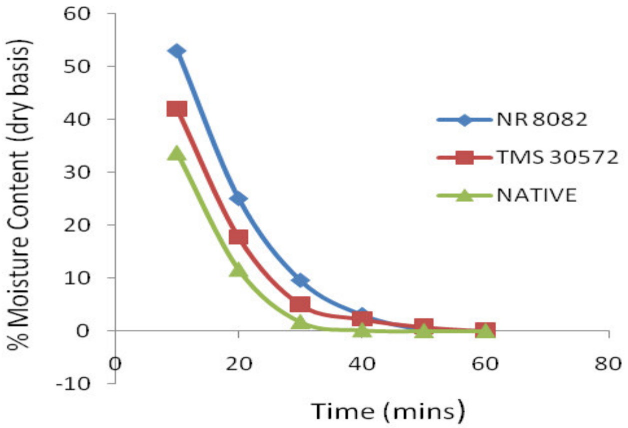

Figure 1. Drying curve for the cultivars.

protein content. The difference in drying rate can be explained by difference in the chemical composition of the cultivars.

Bulk density

Figure 2 shows that the bulk density of each cultivar decreased as the moisture content (dry basis) decreased during drying. The bulk density differed for each cultivar with the same moisture content under the same drying condition. The bulk density obtained for native cassava ranged from 171.3 to 551.2 kg/m^3. Audu and Ikhu-Omoregbe (1982) obtained a value of 370 – 620 kg/m^3 while drying a native cassava.

Specific heat capacity

The model equation of Choi and Okos (1986) was used to calculate the specific heat capacity of the cultivars in order to determine the effect of moisture content on specific heat capacity. The specific heat capacity increased with increase in moisture content for all the cultivars (Figure 3). The cultivars had very close specific heat capacity at the same moisture content. The specific heat capacity obtained ranged from 1.40 to 1.45 KJ//KgK for bone dry fermented ground cultivars. This is higher than that of Gevandan (1989), who obtained 1.205 KJ/KgK using scanning calorimeter, for bone dry native cassava mash at 206. Ademiliyu et al. (2006) obtained a range of 1.085 to 1.284 KJ/KgK for bone dry fermented ground cultivars. The difference may be attributed to the difference in carbohydrate content of the cultivars used.

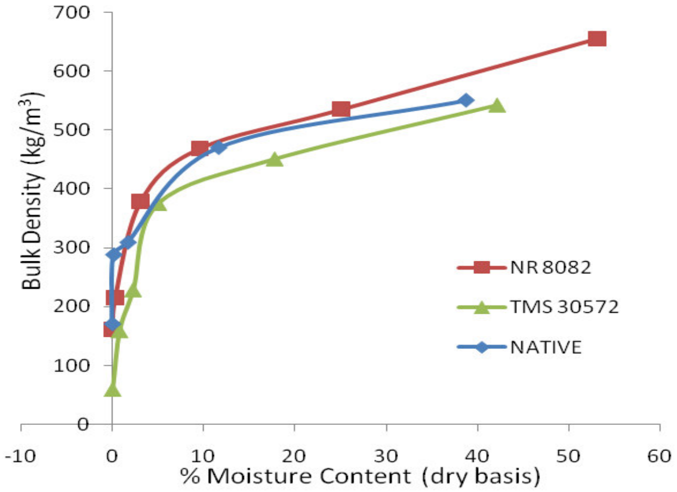

Figure 2. Bulk density variations with moisture.

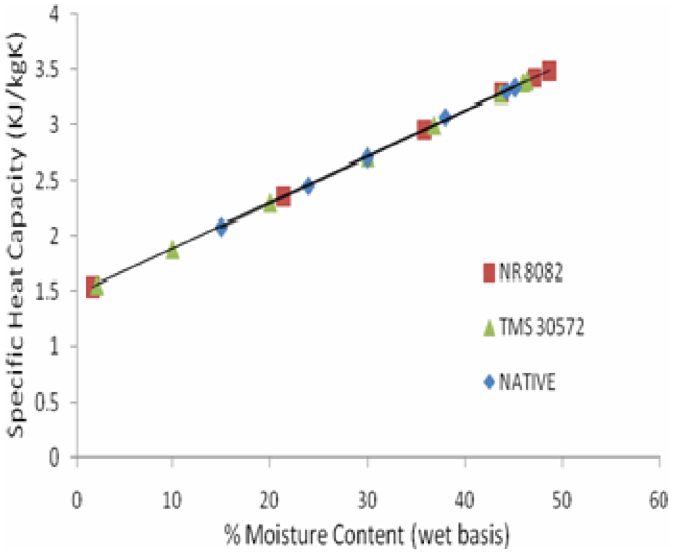

Figure 3. Specific heat capacity of the cultivars at various moisture contents.

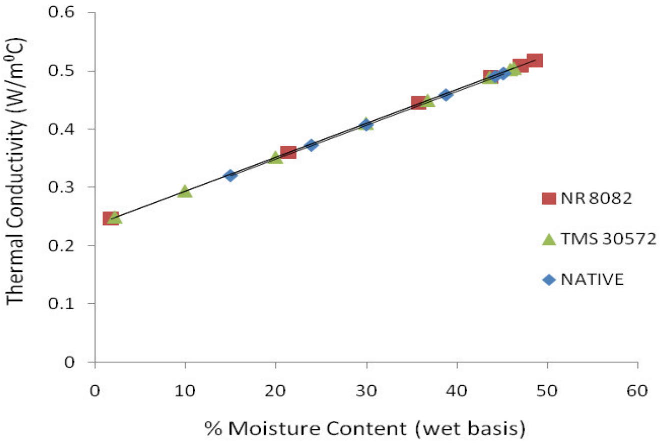

Figure 4. Thermal conductivity of cultivars at various moisture contents

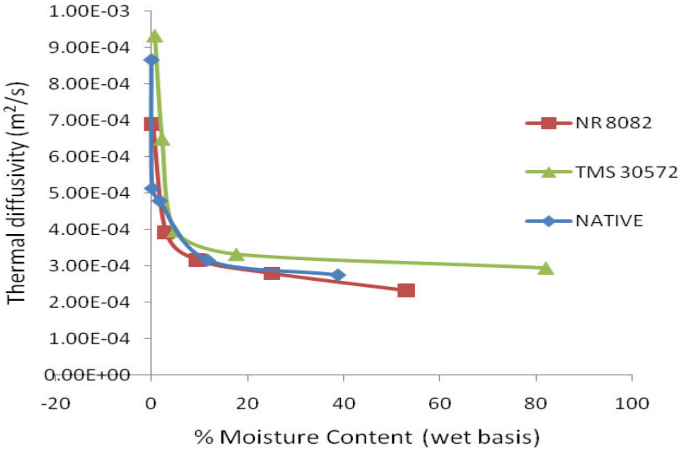

Figure 5. Thermal diffusivity variations with moisture content.

Thermal conductivity

The thermal conductivity of each cultivar increased as moisture content increased (Figure 4). The cultivars had very close thermal conductivities as depicted in the shape of Figure 4. The average thermal conductivity obtained for born dry air was 0.24.W/mK.

Thermal diffusivity

Thermal diffusivity is a measure of how fast heat propagates or diffuses through a material. The thermal diffusivity of the cultivars increased with decrease in moisture content (Figure 5) .The thermal diffusivity obtained for each cultivar was slightly different at the same moisture content. TMS 30572 exhibited the highest thermal diffusivity.

Conclusion

The proximate composition of the different cultivars considered in this study had serious impact on the engineering properties. Equally the drying rate is a function of the chemical composition of the cultivars. The drying time is a function of the moisture content. Bulk density, specific heat capacity, and thermal conductivity increased with increase in moisture content while thermal diffusivity decreased as moisture content increased.

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