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Assessment of Drying Mass Constants of Selected Nuts and Oil Seed

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Abstract: *Food materials provide nutrients to the body for growth and health of animal and human. It is therefore necessary to preserve food material for food security through the removal of moisture to a level that would minimize spoilage by microorganisms, etc. In this regard, the drying mass constant of a material could help to easily predict its mass which would correspond to the desired moisture content during drying. This study involves the use of model equation to obtain drying mass constant, for some selected nuts and oil seeds namely: kola nut, walnut and African oil bean seed. Each sample was grouped into small, medium and large sizes. Each size was subjected to drying and the mass taken at one hourly interval until constant mass of the material was observed. Moisture contents (MC) were computed and graphs were plotted for each size and the bulk sample with respect to drying time, ratio of initial mass (M_0) to mass at any given drying time, (M_t) ($i.e., M_0/M_t$); and rate of drying against drying time. Result revealed that the drying mass constant obtained for kola nut, walnut and African oil bean seed were 0.3338 ± 0.0417, 0.7641 ± 0.0044 and 0.7812 ± 0.0516, respectively.*

Keywords: *Moisture content, Drying mass constant, Kolanut, Walnut, African oil bean seed.*

I. Introduction

Food plays an important part in the life of human beings. This is because it provides nutrients and energy to facilitate growth and development for maintenance of healthy and active life. Some of the nutrient required by the body may include carbohydrate, vitamins, protein, mineral and fats including fiber and water for healthy diet [1]. One of the major groups of food that provides nutrient to the body is edible nuts and oil seeds. In most cases, they are enclosed in a hard shell and do have a great taste when eaten. They are good source of proteins, minerals, fats such as mono and poly saturated fatty acids. The fatty acids help to reduce blood cholesterol and so contribute in preventing heart attack and hardening of arteries [2, 3, 4] Generally, food is a perishable commodity and for this reason there is need for food preservation. However, the drying temperature should be such that it will not affect the quality of the food material. This is because at certain temperature the chemical components may undergo reactions that may encourage quality degradation such as odour, colour, flavour and rancidity. Therefore, to ensure the removal of moisture to avoid growth of mould and other associated negative effect, a lower temperature with long drying time may be suggested for safety of some food materials. For instance, the temperature range of 40^0C to 50^0C is recommended as optimal temperature for drying hazel nut as higher temperature would cause quality degradation [5]. More so, Filho *et al.* [6] recommended 40°C for drying of soybean seeds. In this regard, a good drying temperature for nuts and oil seeds could be suggested to be 50^0C and 40^0C, respectively

When a material is subjected to drying, it may reach a constant mass at a given time, t following the removal of all evaporable water. This constant mass is referred to as the bone dry mass denoted as M_d. The mass of the material at any given time during drying could be denoted as M_t. If a freshly harvested material has its initial mass M_o at time t = 0, then M_o and M_d could be related [7] as:

$$FM_0 = M_d \quad (1)$$

Where, F is the fraction of the initial mass that would be equal to the bone dry mass.

The moisture content of a material subjected to drying could be obtained as:

$$\text{Moisture content (MC) wet basis (wb)} = \frac{(\text{Initial mass} - \text{Final mass})}{\text{Inital mass}} \quad (2)$$

$$\text{MC (wb)} = \frac{(M_t - M_d)}{M_t} \times 100\% \quad (3)$$

Moisture content (MC) dry basis (db) = $\frac{\text{(Initial mass − Final mass)}}{\text{Final mass}}$ (4)

$$MC\ (db) = \frac{(M_t - M_d)}{M_d} \times 100\% \quad (5)$$

From equation 1, the equation 3 could be written as:

$$MC\ (wb) = \left\{1 - F\frac{[M_0]}{[M_t]}\right\} \times 100\% \quad (6)$$

Also, equation 5 may be expressed as:

$$MC\ (db) = \left\{\frac{1}{F\left(\frac{M_0}{M_t}\right)} - 1\right\} \times 100\% \quad (7)$$

The equations 6 and 7 are developed as model equations based on basic drying principle. In this work, the drying mass constants of some selected nuts and oilseed were determined so as to provide a data bank. The empirical equation 6 could be used to predict the mass of the drying material at a given moisture content, once the initial moisture content of the fresh harvested sample is known. The following are some selected nuts: kolanut and African oil beans seed. Nut with the most packed energy is the walnut and has high percentage of poly unsaturated fatty acid, folate, mineral e.g. copper, manganese and zinc. It contains large quantity of omega 3 fatty acid (α- linolenic acid) and antioxidants such as gallic acid, ellagic acid; tannin; flavonol, quinine, etc. Some of these components help to reduce the risk of breast and prostate cancer; and immune system [8, 4, 9]. In Nigeria, walnut is locally known as 'ekom' in Ibibio, 'asala' in Yoruba, and 'udo' in Igbo. Kola is of two common species, namely: *Cola acuminate* and *Cola nitida*. It could be chewed to ease hunger pangs and could be used for treatment of asthma and whooping cough; flavouring of beverages; production of kola wing and chocolate. It is also a source of alkaloids and caffeine; essential oils [10, 11, 12]. In Nigeria, kolanut is locally known as efiat (Ibibio), Oji-igbo (Igbo) and gworo (Yoruba). Oilseeds produced in most of the countries are for oil extraction [13]. The African oil bean, locally known as 'ugba' in Southeastern Nigeria, 'ukana' in Ibibio, and 'apara' in Yoruba, belongs to family *Leguminosae* (*Mimosoideae*). It has a green coloured pod as its fruit containing up to 10 flat shaped and hard seeds which darkens with maturity. It contains about 44% protein and about twenty amino acids, fatty acid, mineral e.g. magnesium, calcium, iron, manganese, phosphorous, copper, vitamins [14, 15].

II. Materials And Methods

2.1 Materials and Equipment

The materials and equipment used were oven, weighing balance, kolanut, walnut and African oil bean seed.

2.2 Sourcing of Materials

The fresh samples of nuts and oil seeds were obtained from farm land in Uyo, Akwa Ibom State, Nigeria.

2.3 Preparation of Sample

Each sample to be used was cleaned, sorted and grouped into three sizes ranges, namely: large, medium, and small. The samples were then dried in a hot air conventional oven.

2.4 Determination of Moisture Content (MC)

The prepared fresh nuts were oven dried at drying air temperatures 50°C while the oil seeds were dried at 40°C. The experimental run was carried out in triplicates. The weight reduction in the samples during drying was monitored at an interval of 1 hour until constant mass was achieved. A 0.01g precision digital/ electronic weighing balance was used for measuring the weight of the samples.

2.5 Experimental Procedure

The equation 3 was used in obtaining the moisture content of the samples. A graph or plot of the moisture content with drying time was done for the three sizes and bulk samples. The drying rate (DR) of the samples at each time (t) interval was calculated; and a graph of drying rate versus drying time was plotted for all the size ranges per sample. Bulk sample drying rate against drying time was also plotted for all samples. The standardized values of MC and M_o/M_t were calculated for the three size ranges and bulk samples [7]. These calculated values were plotted for each of the sample based on the model equation 6. The drying mass constant F values were obtained for each plot as the slope of the graph.

III. Results And Discussion

3.1 Determination of Drying Mass Constant of Kolanut

The graph of moisture content against drying time for the various size ranges of kolanut dried at 50°C till bone dry mass is given Fig. 1 and 2

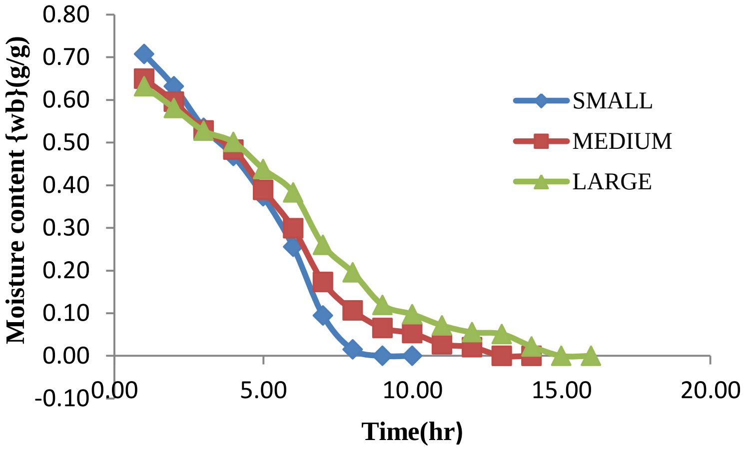

Figure 1: moisture content variation against time of drying different size ranges of kolanut

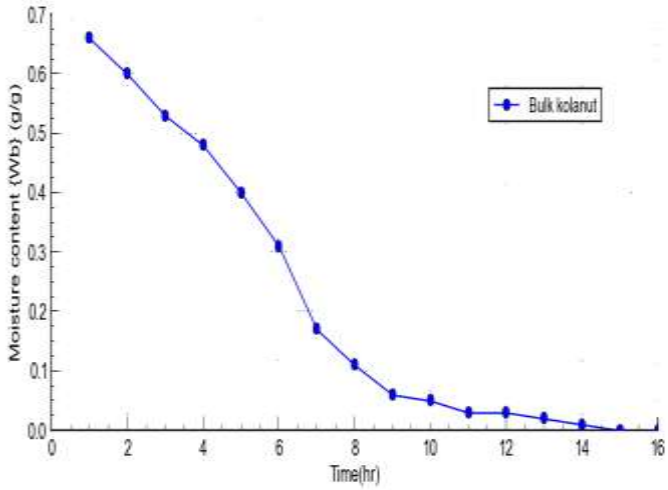

Figure 2: moisture content variation of against time of drying the bulk of kolanut

As their drying time increased, their moisture contents decreased. It was also noted that drying time increased with increase in size which implies that drying time depends on size of the sample. A plot of drying rate against drying time for each size is given in Fig. 3 and 4.

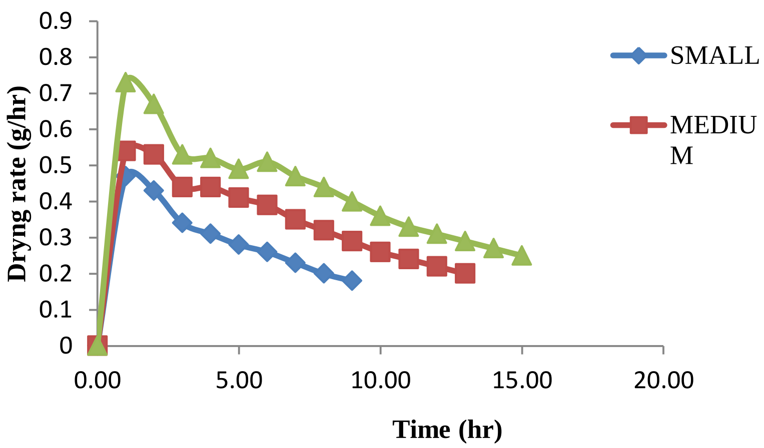

Figure 3: Drying rate against drying time for the different size ranges of kolanut

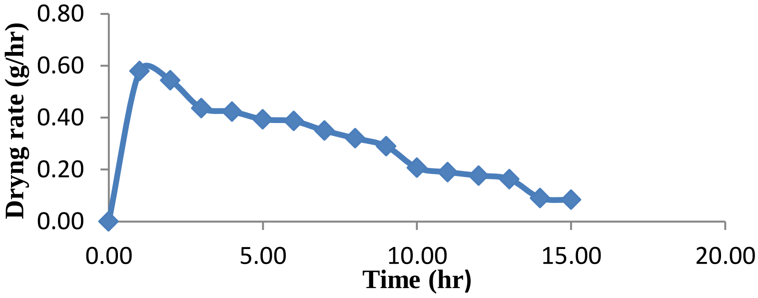

Figure 4: Drying rate against drying time for bulk kolanut

The drying rate of the bulk kolanut was computed as the average of the drying rate of the small, medium and large sizes. Their drying curves obtained followed an ideal drying rate curve pattern. It was also observed that for the medium size, the drying rates at the third and fourth hour were constant such that it had a short constant rate period and the drying rate for all the kolanut sizes decreased with increase in drying period. The standardized values of MC and M_o/M_t were plotted as presented in Fig. 5 and 6.

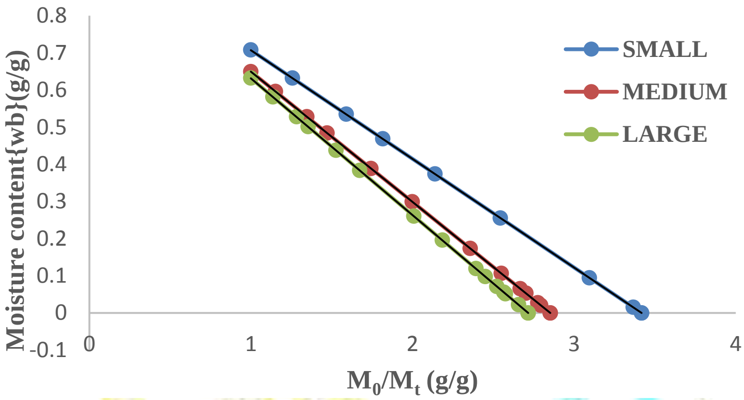

Figure 5: moisture content against M_o/M_t for the different size ranges of kolanut

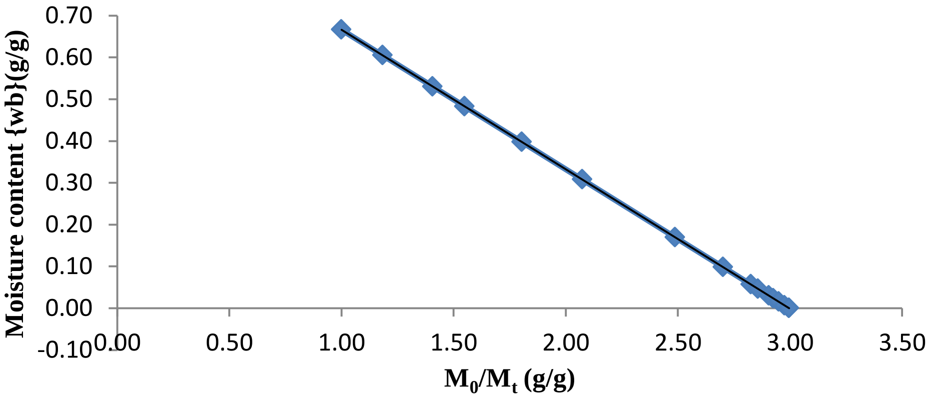

Figure 6: moisture content against M_o/M_t for bulk kolanut

The drying mass constants of 0.2926, 0.3505, 0.3682 and 0.3338 were obtained for the small, medium, large and bulk samples, respectively, with a standard deviation of 0.0417 with reference to the bulk sample. The value of standard deviation is low which means that the mean drying mass constant which is that of the bulk can be used as a representative for the drying constant of the other sizes. The equation gave a coefficient of determination (R^2) of 1 for all the sizes.

3.2 Determination of Drying Mass Constant of Walnut

The Moisture content variation against time of drying the three size ranges of walnut nut dried at 50°C is shown in Fig. 7 and 8.

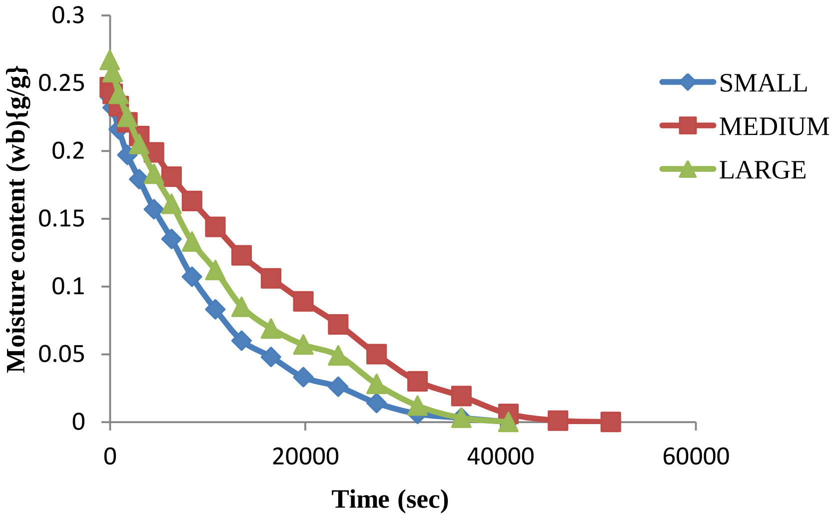

Figure 7: moisture content variation against time of drying the different size ranges of walnut

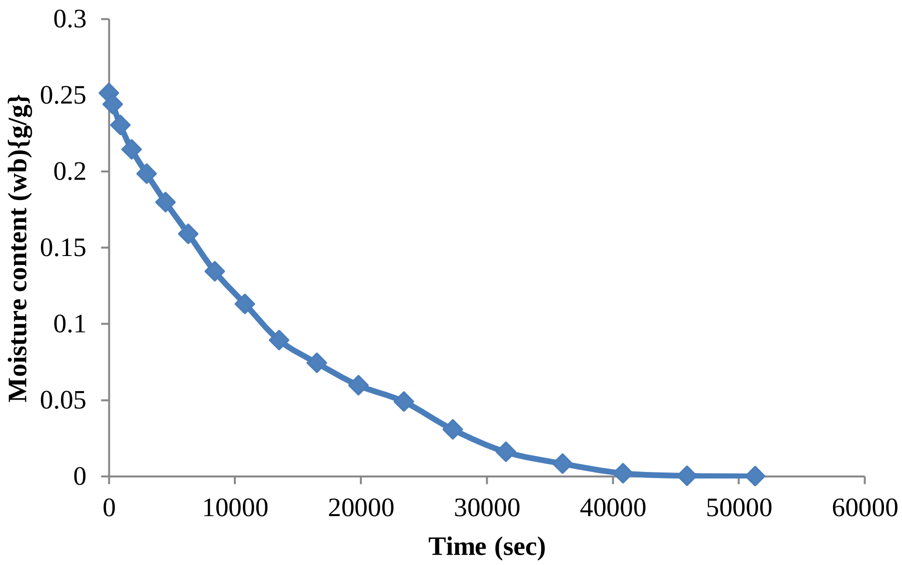

Figure 8: Moisture content variation against time of drying the walnut bulk sample

From Fig. 7, moisture content of each sample size decreased with increase in drying time with their curves similar to each other and that of the bulk sample in Fig. 8. The large size had the highest moisture content followed by the medium and small size ranges. The drying rate against drying time was plotted for each size range and bulk of the samples and presented in Fig. 9 and 10.

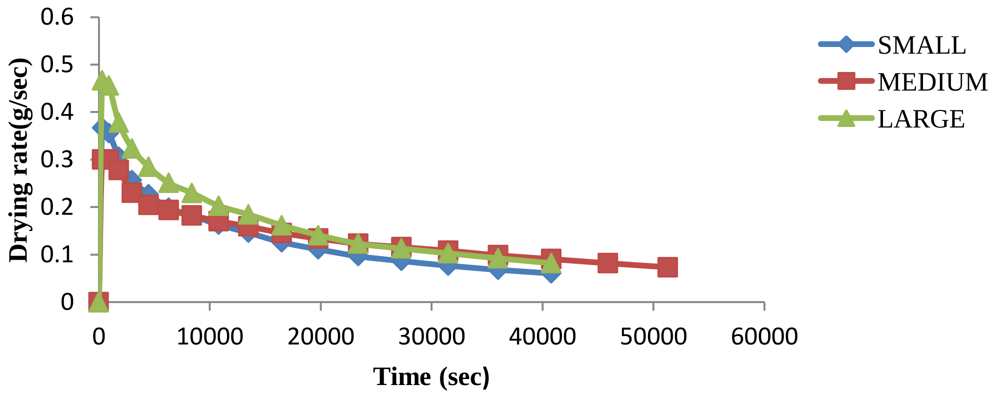

Figure 9: drying rate against drying time for the different size ranges of walnut

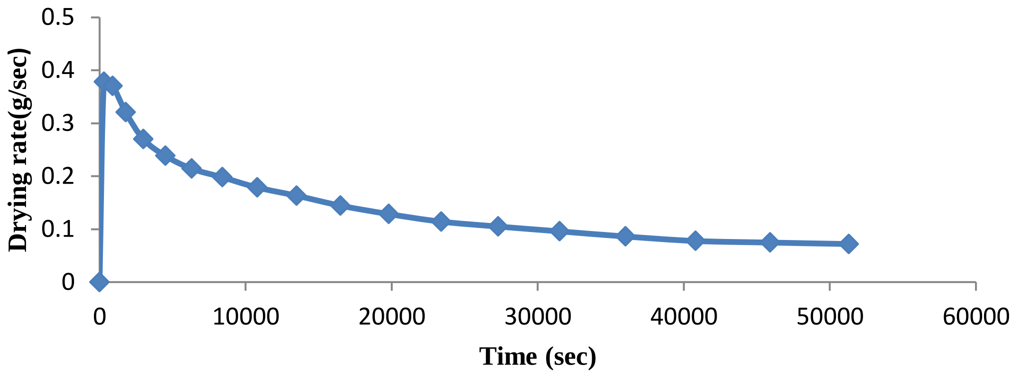

Figure 10: drying rate against drying time for bulk walnut

The rate of moisture evaporation increased drastically at the initial drying time. During this period, most of the free moisture was removed. The drying curve obtained is similar to an ideal drying curve. The drying rate for all the Walnut sizes decreased with increase in drying time. The standardized values of moisture content and M_o/M_t were plotted and presented in Fig. 11 and 12 for the three size ranges and the bulk of the samples, respectively.

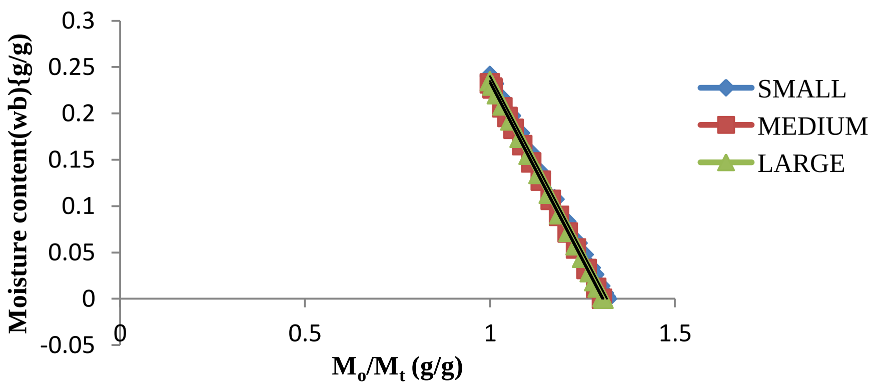

Figure 11: moisture content against M_o/M_t for the different size ranges of walnut

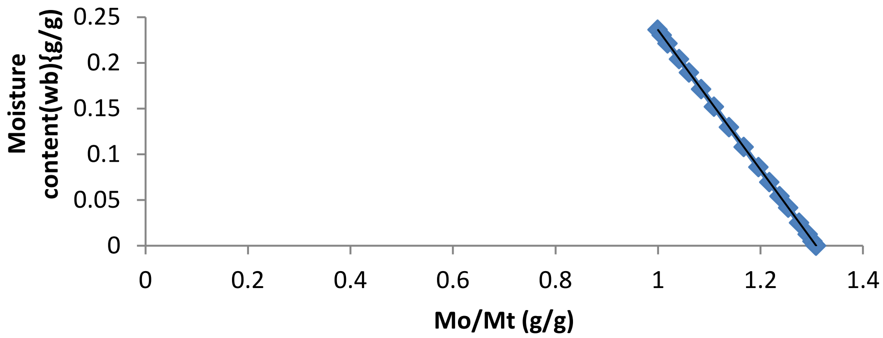

Figure 12: moisture content against M_o/M_t for bulk walnut

The drying mass constants of the small, medium, large and bulk quantities were 0.7597, 0.7675, 0.7651 and 0.7641 respectively, with R^2 of 1 for all the sizes. The graph of MC against M_o/M_t for all the sizes followed the same pattern. The standard deviation of 0.0040 was obtained with respect to the bulk sample value of drying mass constant.

3.3 Determination of Drying Mass Constant of African Oil Bean Seed
Fig. 13 and 14 show the moisture content variation against time of drying the various size ranges of African oil bean seed dried at 40°C.

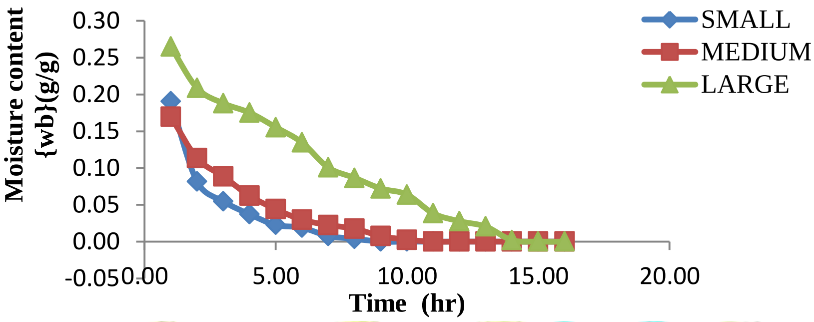

Figure 13: moisture content variation against time of drying different size ranges of African oil bean seed

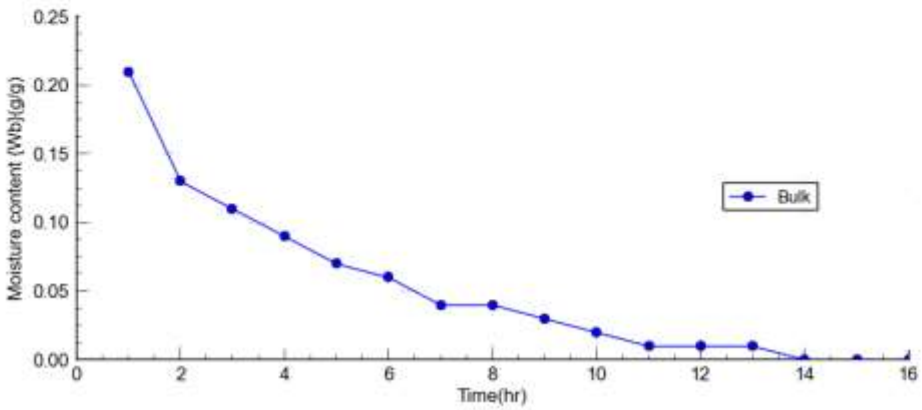

Figure 3.14: moisture content variation against time of drying the African oil bean seed

The moisture content of each sample size decreased with increase in drying time. Also, drying time increased with increase in size; which implies that drying time is also dependent on sample size. The rate of drying (DR) was plotted against the drying time as shown in Fig. 15 and 16.

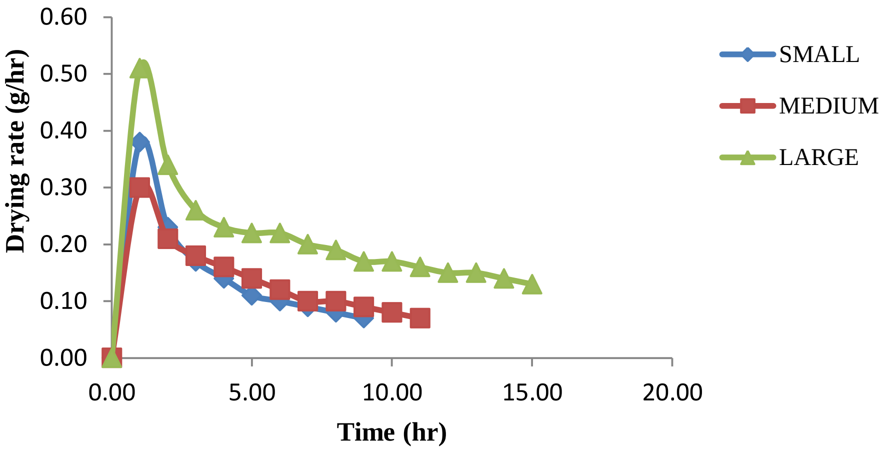

Figure 15: drying rate against drying time for the different size range of African oil bean seed

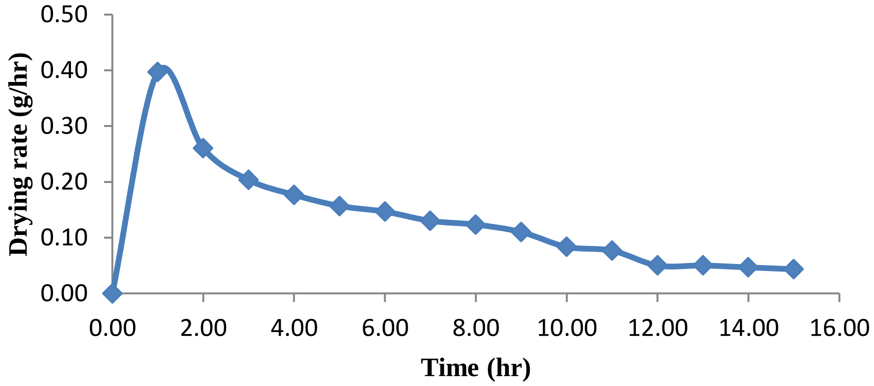

Figure 16: drying rate against drying time for bulk African oil bean seed

The rate of evaporation increased dramatically at the initial drying time. At this period, most of the free moisture was removed. The drying curve obtained is similar to an ideal drying curve. The drying rate for all the African oil bean seed sizes decreased with increase in drying time. The large size African oil bean seed had the highest drying rate at the first hour of drying. The curves for all the sizes had a similar pattern. The moisture content, M_o/M_t values and standardized for use in the model equation 6 for the different sizes and bulk of the sample were plotted and are as shown in Fig. 17 and 18.

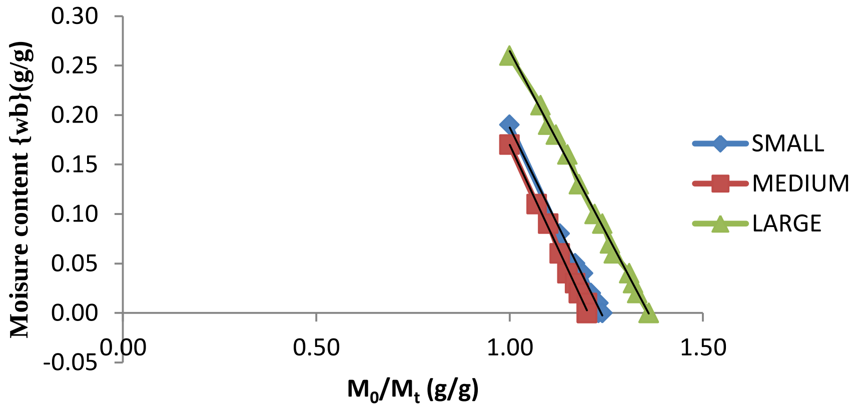

Figure 17: moisture content against M_o/M_t for the different size ranges of African oil bean seed

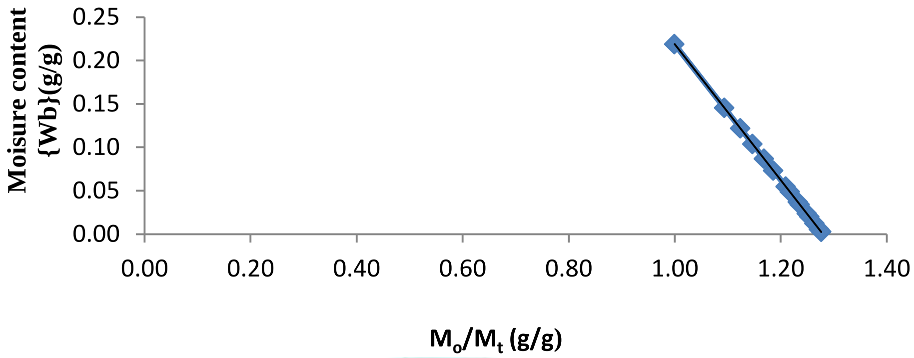

Figure 18: moisture content against M_o/M_t for bulk African oil bean seed

The slope of the graph is the drying mass constant of the model equation. The drying mass constants for the small, medium, large and bulk samples were 0.8094, 0.8301, 0.7350, and 0.7812 ± 0.0516, respectively. The values of coefficient of determination (R^2) are 1 for all the sizes. The plots of MC against M_o/M_t for all the sizes followed the same pattern.

IV. Conclusion

The drying mass constant (F) based on the model equation 6 were obtained as 0.3338 ± 0.0417, 0.7641 ± 0.0040 and 0.7812 ± 0.0516, respectively for kolanut, walnut and African oil bean seed. The F values of a particular material could be used in predicting the mass of such dried material corresponding to given moisture content if the moisture content of such freshly harvested materials is known.

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