Thin Layer Drying Characteristics of Amaranth Grains in a Natural Convection Solar Tent Dryer

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ABSTRACT

Amaranth plants are indigenous in most semi-arid areas of Kenya. However, the communities in these areas are ignorant of the importance of the grains from these plants in their contribution to health and food security. Amaranths are susceptible to partial shatter losses especially when harvested at a moisture content less than 30% dry basis (d.b). Thus harvesting must be done at moisture content of 30% d.b or higher which requires necessary artificial drying to safe storage moisture level. The grains are traditionally dried in thin layers under the open sun. The open sun drying has disadvantages such as lack of temperature control, intensive labour and contamination from dust, foreign materials, rodents and bird droppings. A natural convection solar tent dryer would be a useful drying technique for safe preservation of these grains. This study aimed at analyzing thin layer drying characteristics of amaranth grains in a natural convection solar tent dryer. More specifically, temperature distribution in the dryer and the effect of colour of cover material of the dryer on thin layer drying of the grains were studied. The study also focused on modeling the thin layer solar drying process and determining the effect of the cover material on hardness, colour and crude protein content of the grains.

The distribution of temperature was analyzed using nine discrete points spread in two planes in the dryer. The effect of colour of cover material was determined by drying the grains in experimental dryers with different coloured PVC materials. Drying of grains in the actual dryer (1.85 m wide, 2.73 m long and 2.55 m high) was carried out at two levels (Layers 1 and 2). Thereafter, non-linear regression analysis was conducted to evaluate the performance of six thin layer drying models (viz., Newton, Page, Modified Page, Henderson & Pabis, Logarithmic and Wang & Singh) for amaranth grains. The models were compared using the coefficient of determination (R^2), root mean square error (RMSE), reduced chi-square (χ^2) and prediction performance (η_p). Finally, the grains that were dried under different cover materials were evaluated for hardness, colour and crude protein content.

An analysis of variance at 5% level of significance showed that there was no significant difference in temperature distribution within and between the planes. In addition, the results showed that the dryer with the clear cover material achieved highest temperatures (44.5±5.8^{o}C) and drying rates, and lowest relative humidity values (23.5±6.5%) as compared to those with yellow and nectarine diffused materials. However, the temperatures and relative humidity values were found not to be significantly different. Further, the results indicate that the grains dried in the solar tent dryer attained an equilibrium moisture content of 7% d.b from an initial one of 61.3–66.7% d.b after 4.5 hours of drying as opposed to 7 hours for the open sun. There was no significant difference in drying rates when the grains were dried in Layers 1 and 2 of the dryer. The Page model best described thin layer drying of the grains, attaining the highest R^2 (0.994–0.999) and η_p (80.0–88.2%), and the lowest RMSE (0.0003–0.0240) and χ^2 (0.0000–0.0154) values. Finally, the results showed that there was no significant difference on hardness, colour and crude protein content of the grains dried under different cover materials and the open sun. The results therefore demonstrate that natural convection solar tent dryers can be utilized to enhance drying of amaranth grains in layers without significantly affecting their physical, optical and nutritive properties.