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Research Article

Influence of Boiling, Temperature and Thickness on Drying Time of Aerial Yam (*Dioscorea bulbifera* bulbis)

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Abstract: Effect of boiling, thickness (0.5 and 1cm) and temperature on drying time of *Dioscorea bulbifera* was investigated in a fabricated hot air drier at a temperature range of 50 -70°C. . The drying process was conducted in triplicates and average values recorded. The average moisture ratio was used to plot the drying characteristics curves for the temperature range studied with dimensionless moisture ratio against drying time. Drying took place mainly in the falling rate period whiles increased slab thickness influenced drying time for both the boiled and fresh yam slabs at all temperatures. Boiling was shown to have led to a decrease in the rate of moisture movement which led to increase in drying time of the yam slice at both thicknesses (0.5, 1cm). Drying time subsequently reduced with increase in hot air temperature. 70°C is therefore recommended for drying aerial yam. These results will provide food processors with information to determine the best processing conditions for the *dioscorea bulbifera* which will finally lead to elimination of waste.
Keywords: Drying rate, drying curve, pre-treatment, case hardening, and moisture ratio.

INTRODUCTION

Dioscorea bulbifera is among one of the most underutilized food crops in Ghana due to the preference for other yams. It has been shown to possess a myriad of compounds that have also been attributed to several health benefits. Studies have shown that the *D.bulbifera* possesses functional properties that make it suitable in the development of food products [1]. The low production cost of the *D. bulbifera* gives it an advantage over the more preferred yams as its production is on the decline due to the high cost of production and post-harvest losses. This specie of yam has certain advantages that go beyond its health benefits. It is very easy to grow under even harsh conditions and this presents an opportunity to have a reliable food source all year round.

As more studies seek to find alternative food sources and cash crops as well as develop novel and functional foods, it has become necessary to investigate the best means by which value can be added to the *D. bulbifera*. One way by which this can be done is by moisture removal to inhibit enzyme action and prolong the shelf life of the yam flour. The aerial yam has the tendency to discolour during drying; this has been attributed to the action of polyphenol oxidase [2]. There are a number of pre-treatments used to mitigate this action and includes sulphating, blanching and boiling [3]. These pre-treatments do have influence on the drying time and energy requirements of the product during drying.

According to Famurewa *et al.* [4], in commercial operation, it is essential to evaluate how fast a food will dry in a particular dryer in order to estimate the amount of production that can be achieved per hour, and also to optimize the conditions necessary for effective industrial applications. Though a number of agricultural produce have been dried there is little or no information of the influence of processing techniques and drying conditions on the drying characteristics of the aerial yam. The main aim of this work therefore, is to investigate the influence of boiling, temperature and thickness on drying time of the *D. bulbifera*.

MATERIALS AND METHODS

Plant Material

Samples of the cultivated (edible) *D.bulbifera* were obtained from farmers in the Northern Region of Ghana from which bulbis were randomly selected for analysis.

The Drying Process

Yams were washed with four litres of distilled water, manually peeled and cut into slabs having dimensions of 0.5cm×1cm×2cm, and 1cm×1cm×2cm using a sharp stainless steel knife. One part of the slabs was boiled at 100°C for 10min, quickly cooled with cold water and the surface moisture dried off with tissue paper. Two grams of the boiled and fresh samples of different thickness were arranged in stainless steel mesh trays of dimensions of 10cm ×7cm and transferred into the drier designed and fabricated at the Department of Agricultural Engineering, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. The drier was switched on and allowed to run for approximately one hour before the loading of samples to allow the heated air to stabilize at desired air temperatures of 50, 60 and 70°C. The loaded pre-weighed yam samples were removed and weighed with an electronic balance; Sartorius model CPA 6235 with 0.01g precision at 30mins intervals until three consecutive constant readings. Triplicates of samples were dried at each temperature and average mass values recorded. The mass values were converted to moisture content values using equation (1).

The average moisture ratio was used to plot the drying curves for the temperature range studied (50, 60 and 70°C) with dimensionless moisture ratio against drying time expressed in minutes.

$$MR = \frac{M_t - M_e}{M_o - M_e} \text{..........(1)}$$

Where, MR is the moisture ratio, M is the moisture content at any time, t, is the equilibrium moisture content, and M_o is the initial moisture content.

RESULTS AND DISCUSSION

Effect of boiling, thickness and temperature on the drying characteristics of the *D. bulbifera* slabs

The influence of different thickness and boiling on drying time of *D. Bulbifera* at 70°C

Slabs of aerial yam were dried at 10°C intervals from 50°C to 70°C to investigate the effect of thickness, boiling and temperature on the drying time of *D. Bulbifera*. The effect of temperature, boiling and thicknesses of 0.5cm and 1.0cm on drying time is shown in Fig.1. Decreasing thickness resulted in increase in the rate of mass loss, and the total drying time reduced with decrease in thickness.

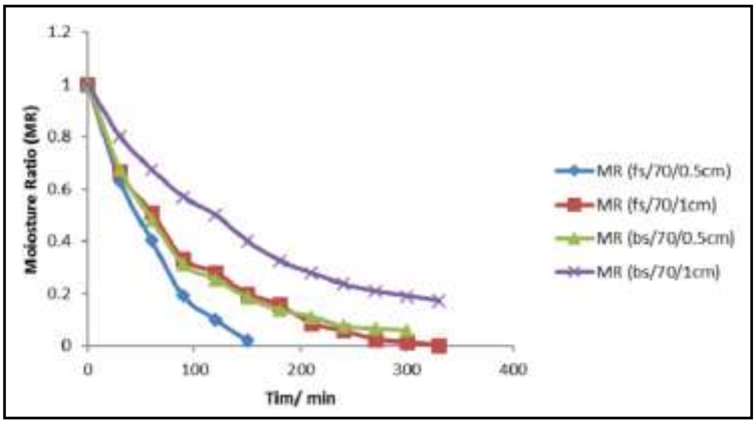

Fig-1: Drying curve of boiled and fresh samples of 0.5cm and 1cm dried at 70°C

The drying curve indicated that thickness had influence on the drying time. The moisture ratio versus pre-treatment (boiling) and drying time at various thicknesses of the fresh samples at 70°C are shown in Fig. 1. It is observed that increase in the sample thickness increased the time required to reach a certain level of moisture content.

Yam slab thickness of 0.5cm dried faster than yam slab of 1cm thickness. From the drying curve, the results indicated that, like the fresh yam slabs, the thickness of the pre-treated (boiled) yam influenced drying time. The boiled yam of 0.5cm thickness took a shorter time to dry as compared with the boiled yam of 1cm thickness. In both boiled and fresh samples dried at 70°C, thickness greatly influenced drying time.

At temperature of 70°C, boiling had great influence on drying time. The boiled yam of both thicknesses of 0.5cm and 1cm had longer drying times compared with the fresh yam at the same thicknesses. This is to be expected as pre-treatment decreases the resistance to moisture transport thereby increasing the drying time [4]. Boiling and blanching does cause gelatinization of yam starches which results in decreased rate of moisture transport from within the material to the surface during air drying [5]. This result agrees with Alzamora and Chirife [6] that blanching of potato did not increase the rate of drying due to starch gelatinisation which resulted in reduced porosity [7].

The influence of thickness and boiling on drying time of *D. bulbifera* dried at 60°C

Figure 2 shows the drying curves for fresh and boiled yam slabs dried at 60°C. Drying time increased with increase in thickness and decreased with decrease in thickness for the fresh yam. The same trend was observed in the boiled yam, increase in thickness influenced drying time which resulted in high moisture ratio for yam thickness of 1cm. This situation implies that increase in thickness will require more time to reduce moisture ratio to the required 10% for roots and tubers.

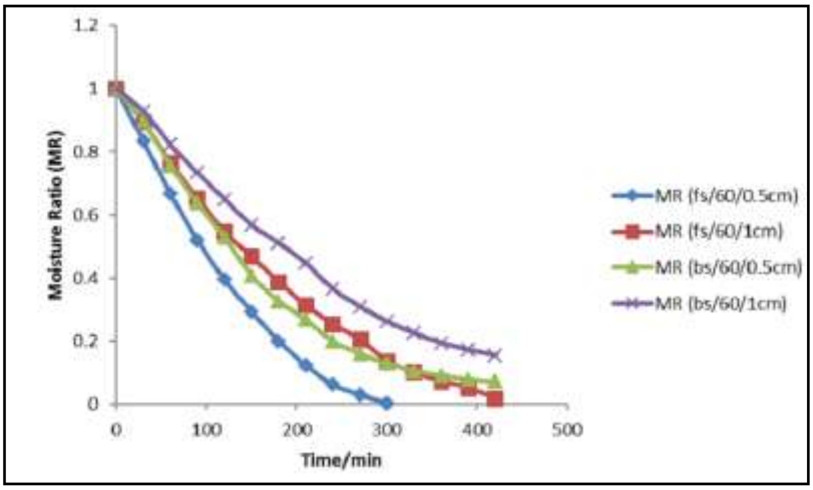

Fig-2: Drying curve of boiled and fresh samples of 0.5cm and 1cm dried at 60°C

This trend could be attributed to the fact that boiling increases the drying time due to gelatinisation of the yam starch. From Fig. 2, it is obvious that increase in thickness of yam slab size resulted in increase in moisture ratio for the boiled samples thereby drying time is increased.

From the drying curve, yam thickness, 0.5 and 1cm exhibited the same drying time of 420min and moisture ratio range between 7-18%. This result is contrary to that reported by Falade *et al* [5] for *D .rotundata* and *alata*. They reported a decrease in moisture ratio and drying rate as the thickness of the yam slices increased. They attributed it to the effect of the exposed surface area resulting in increased diffusion path of the yam slices. The variations observed in the present study could be attributed to difference in specie and thickness.

The influence of thickness and boiling on drying time of *D. bulbifera* dried at 50°C

The influence of thickness and boiling on drying rate of *D. bulbifera* are presented in Fig.3. It is observed from the drying curve that fresh yam of 0.5cm thickness had faster drying time than the fresh yam of 1cm thickness. Similar trend was observed in the boiled yam. The time required to dry yam slabs to specific moisture content is influenced by the thickness. The thinner the slab the shorter its drying time. Conversely, drying time increased with increased thickness of yam slabs. The results indicated that boiling decreased the rate of moisture movement which resulted in increased drying time.

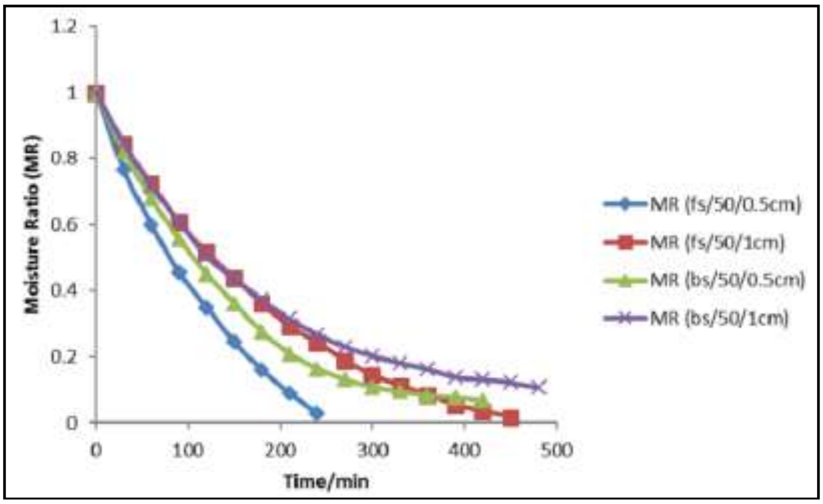

Fig-3: Drying curve of boiled and fresh samples of 0.5cm and 1cm dried at 50°C

The influence of temperature on drying time of *D. Bulbifera* at different thickness

The influence of various temperatures on drying time of *D. bulbifera* dried at 0.5cm thickness

The influence of different temperatures (50, 60 and 70°C) on drying time is shown in Figure 4.1 -4.2. Increasing temperature resulted in improvement of moisture loss and significant decrease in total drying time. The drying time of the fresh *D. bulbifera* slabs at 70°C was twice as fast as that at 60°C and five times as compared to slabs dried at 50°C. Decreasing drying time of approximately 150min with increasing 10°C was observed within this temperature range except for the slightly lower difference for the case of drying at 50°C. The drying time was lower for 50°C compared to 60°C. This phenomenon could be attributed to surface or case hardening due to quicker initial rate of evaporation of moisture from the sample surface. Case hardening slowed down drying rates of yam slabs at higher dry air temperature than at the lower temperature of 50°C.

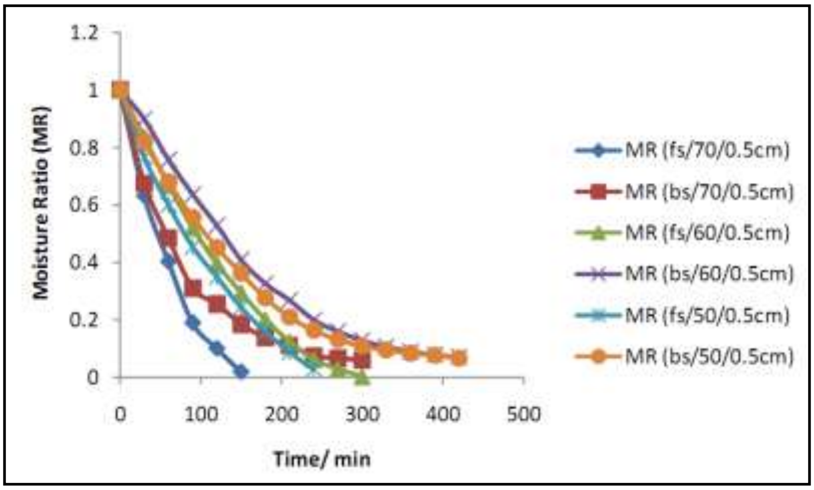

Fig-4.1: Drying curve of 0.5cm thickness of boiled and fresh *D. bulbifera* at various drying air temperatures.

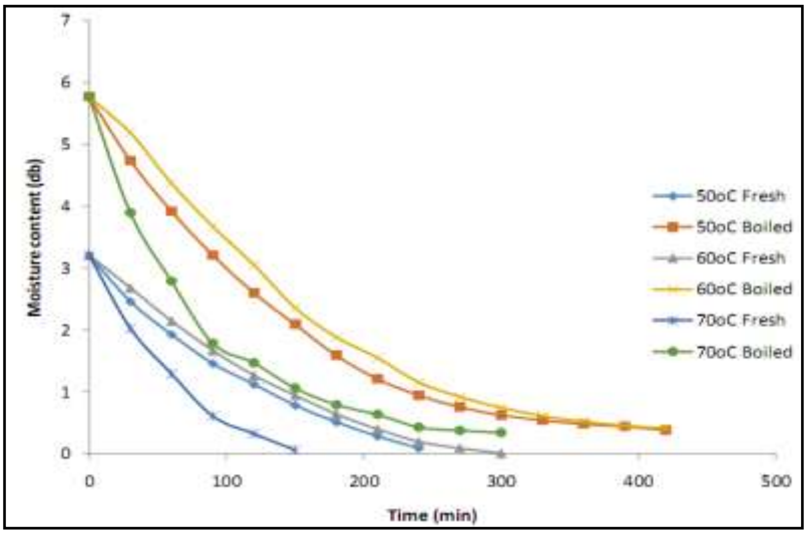

Fig-4.2: Drying curve of 0.5cm thickness of boiled and fresh *D. bulbifera* at various drying air temperatures.

It was observed from figure 4 for boiled yam slabs that, as the temperature increases, the drying time decreases. The drying time of the boiled yam slabs at 70°C was shorter by 120 min compared to yam slabs dried at 60°C and 50°C temperatures.

The same drying time recorded for both yam slabs dried at 50°C and 60°C may be attributed to the case hardening effect as observed for the fresh yam slabs. In the falling rate period, the concentration gradient in the food matrix controls the drying rate and is temperature dependent. This may account for the difference of drying time between the boiled and fresh yam slabs between 70°C and the two lower temperatures of 60 and 50°C. From the figure, it is obvious that differences of drying rate between 70°C and the two lower temperatures occurred in the early stage of drying within the first thirty minutes. The differences especially between 60°C and 50°C then gradually decreased to the point when the drying times were equal. Drying time to obtain equal moisture ratio for all the yam slabs decreased with increasing temperatures most evident with 70°C drying air temperature.

From figure 4.1-4.2 the influence of drying temperature on drying time can be clearly observed. The fresh yam slabs dried at 70°C took 210mins to reach a moisture ratio of 8.7% on dry basis. Whiles it took the yam slabs dried at 60°C 330min to reach a moisture ratio of 10% (d.b) and 360mins for slabs dried at 50°C to reach a moisture ratio of 10% (d.b).

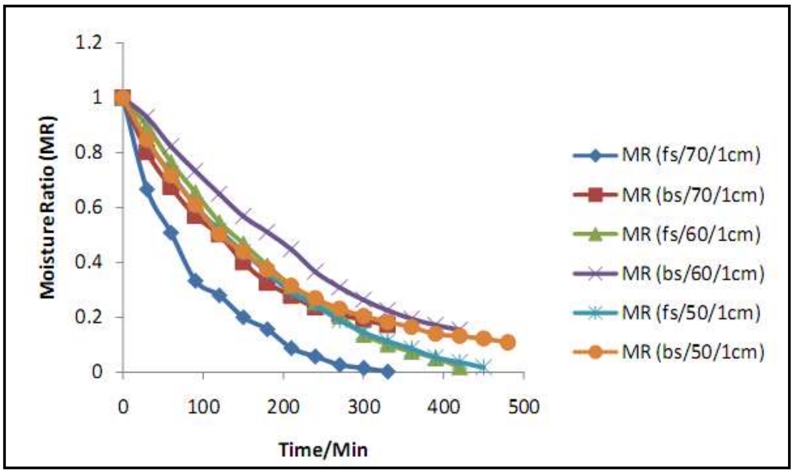

Fig- 5.1: Drying curve of 1 cm thickness of boiled and fresh *bulbifera* at various drying air temperatures.

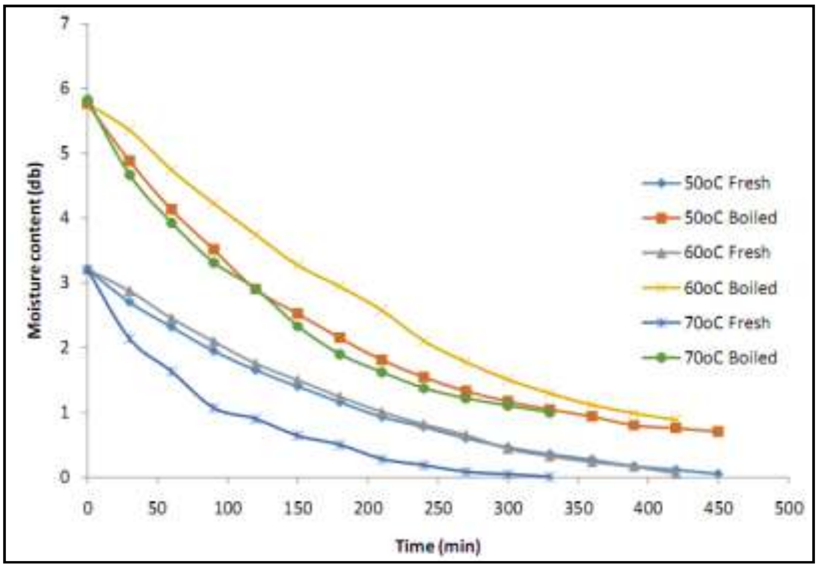

Fig-5.2: Drying curve of 1 cm thickness of boiled and fresh *bulbifera* at various drying air temperatures.

The same trend was observed (fig.5.1-5.2) in the boiled yam slabs where higher temperatures resulted in shorter drying times though the moisture ratio for 70 and 60°C were higher than 10% required moisture content for roots and tubers. This may be attributed to gelatinisation of the starch molecules thereby inhibiting the free movement of moisture from the sample. However, the yam slabs dried at 50°C had moisture ratio of 10% (d.b) when it was dried for 480min. This could imply that if the boiled slabs dried at 70 and 60°C had been dried further, it may have resulted in 10% moisture ratio.

CONCLUSION

Boiling was found to increase the drying time of the yam slice at both size thicknesses (0.5, 1cm) whiles drying time reduced with increase in hot air temperature. Drying at 70°C is therefore recommended for drying aerial yam. These results will provide food processors with information to determine the best processing conditions for the *Dioscorea bulbifera* and finally eliminate wastage.

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