International Journal of Research in Engineering and Applied Sciences (IJREAS)
Available online at: http://euroasiapub.org
Vol. 7 Issue 10, October- 2017, pp. 44 ~ 55
ISSN(o): 2249-3905 ISSN(P): 2349-6525 | Impact Factor: 7.196|

DRYING CHARACTERISTICS OF THREE CMD RESISTANT CASSAVA VARIETIES IN GHANA AS AFFECTED BY PRE-TREATMENT AND HARVEST AGE

Eje Brendan Ekete

Department of Agricultural and Bio-resource Engineering,

Enugu State University of science and Technology, Enugu, Nigeria

ABSTRACT

The effects of different pre-treatment methods on drying characteristics of *Ampong, Broni* and *Otuhia* cassava varieties harvested at 10, 12 and 14 months were investigated. The harvested cassava tubers were Pre-treatment by chipping, chipping and steeping in citric acid, grating, steeping in citric acid, grating and toasting. The pre-treated samples were dried to equilibrium moisture content at 70 ºC in a mechanically ventilated hot air dryer. Results from the study showed that pre-treatment methods influenced the drying characteristics of the three cassava varieties with toasting and grating pre-treatments having the greatest influence as more than 50 % of the drying time was saved by using these pre-treatment methods.

KEY WORDS: Cassava, Drying, grating, moisture content, pre-treatment, toasting.

1. INTRODUCTION

Thin layer drying is a very vital dehydration technique commonly used in food industries. The dried products that result from this process usually record minimum loss in their physical, nutritional and chemical qualities whereas their shelf life and onset of their microbial spoilage are extended (Orikasa et al., 2010; Akpinar and Bicer, 2008). Factors like the condition and type of crop (morphology, pre-treatment, initial moisture content and dimension), drying temperature, thermal energy type (hot air, solar, infrared etc.) and type of dryer (tray, tunnel, fluidised bed etc.) have been established to affect the qualities and drying kinetics of the materials(Tunde-Akintunde and Ayala, 2010 ; Orikasa et al.,2010). Other researchers (Satimehinet al., 2010) also reported that the general effect of drying temperature, pre-treatment method, relative humidity, and product sizes on the drying kinetics of food crops are crop specific.

The onset of the deteriorative activities of microorganism on fresh cassava roots is a factor of its moisture content. Reduction of the crop moisture content to equilibrium level within a very short time minimizes the time available for microbial deterioration hence enhancing product quality. This work was therefore carried out to investigate the effect of some pre-treatment methods on the drying characteristics of some new cassava varieties harvested at different maturity ages.

2. MATERIALS AND METHODS

2.1. MATERIALS

The cassava tubers used for these studies were *Ampong, Broni and Otuhia*cassava varieties which were recently released by the Crop Research Institute of Ghana. These tubers were harvested at 10 months, 12months and 14 months.

2.2. PRE-TREATMENT METHODS

2.2.1 CHIPPING (T1)

The first pre-treatment (T1) process was chipping. The washed cassava tubers were chipped to size of 10 x 10 x 50mm using a slicing machine. The machine has a rotating blade and an adjustable guard rail which can be adjusted to cut the sample to the desired thickness (Fig 1). The dimensions of the chips were chosen in line with the recommendations by previous researchers (Floreze and Bruno, 2000; Cock, 1985) on the optimum chipping size of some tuber crops such as yam and cassava for effective drying.

2.2.2. GRATING AND TOASTING (T_2)

The cassava roots were harvested, peeled, washed and reduced in size to mash by grating with a cassava grater. The mashed product was put in a porous bag and then dewatered using a mechanical screw jack. The compression was carried out for 12 h leading to reduction of the moisture content to 40% (wet basis). The samples were toasted for 6 min in a toasting pan where it was continuously stirred to avoid clogging (Ejeet al., 2015). The average toasting temperature was maintained at 90 °C.

2.2.3. CHIPPING AND STEEPING IN CITRIC ACID SOLUTION (T_3)

The third lot of the samples (T_3) were chipped to the same sizes of 10 x 10 x 50 mm as in section 2.2.1 and further soaked in citric acid solution, pre-mixed to a concentration of 20% m/v. The chips were allowed to remain in the solution for 24 h before they were transferred to the drying tray. This pre-treatment was done according to the recommendation by Owuamanam (2007).

2.2.4. GRATING AND DEWATERING (T_4)

The fourth lot of the samples (T4) was reduced to mash as described in section 2.2.2. The compression continued for about 12 h resulting to the reduction of the moisture content of the mash to about 40 % (wet basis) before the commencement of drying.

2.2.5 STEEPING IN CITRIC ACID, GRATING AND TOASTING (T_5)

The fifth set of samples (T_5) were peeled, washed and steeped in citric acid solution (20% m/v) for 24 h. The samples were then grated, dewatered and toasted as described in section 2.2.2 above.

3.2.6 DRYING

A mechanically ventilating hot air dryer was used in the drying experiment. The dryer consist of a blower, an inlet and outlet air vent, and a drying compartment with six large movable trays having a wire mesh base (Fig 2).

Each of the large trays measures 80 x 43 cm and can hold three smaller aluminium trays with dimensions of 25 x 38 cm. A temperature sensor was fitted inside the drying chamber with an external digital display unit which was used to pre-set the dryer temperature to the desired value (fig.3). The dryer was operated for 8 min to attain the desired stable drying temperature.

The initial moisture content of the samples was determined using the gravimetric method of moisture content determination (AOAC, 1990). The pre-treated samples were arranged on the aluminium trays which were in turn placed on the larger trays with a wire mesh base (Fig 2).

Each of the larger trays contained three smaller aluminium trays. The chipped cassava samples were arranged in a single layer on the aluminium trays (Fig 4a) whereas the grated samples and the toasted samples were evenly spread on the tray (Fig 4b) such that the sample thickness was not more than 1 cm.

The dryer was switched on and allowed to attain a pre-set temperature of 70 °C (Fig 3) before the samples were put into the drying chamber. The initial weight of each sample was 600g and as the drying progressed, the sample’s weight was monitored after every one hour. The drying continued until a constant weight was obtained after which the drying was terminated. The instantaneous moisture content at time t of the samples was determined from the samples’ weight using Equation 1:

$$MC_t = \frac{w_t - (w_i \times d_m)}{w_t} = \frac{w_t - w_d}{w_t} \qquad (1)$$

Where, MC_t = moisture content (% wb) at time t;

w_t = instantaneous weight (g) of the sample;

w_i = initial moisture content (% wb);

d_m = dry matter ratio;

w_d = weight of dry matter.

RESULTS AND DISCUSSION

3.1. EFFECT OF PRE-TREATMENT ON THE DRYING CHARACTERISTICS

The changes in the moisture content of pre-treated cassava samples with time for the samples from *Ampong, Broni* and *Otuhia* cassava varieties harvested at various ages of maturity are shown in Fig. 5 to 7. The plots in these figures are relatively similar to each other as they follow typical drying trends of moisture content decreasing exponentially with time. For each of the graphs, the five pre-treatment methods can be grouped into two categories.

In the first category, which comprises the grated cassava samples (T_4) and the toasted samples (T_2 and T_5), the moisture content of the samples decreased very rapidly during the first 1 h after which it decreased more slowly with further drying and attained equilibrium level within two to four hours. The second category which comprises of chipped samples ($T_1$and T_3) lost moisture very rapidly within the first one hour and then much more slowly for the next seven to nine hours before it attained equilibrium moisture content.

As can be observed from the graphs, there was no constant drying rate period in all the pre-treated cassava samples and all the drying processes were seen to have occurred within the falling rate period. In the falling rate period, the surface of the material is not saturated with water and drying is controlled by moisture diffusion from the interior of the material to the surface (Khazaeiand Daneshmandi, 2007; Diamanteand Munro, 1993). This observation was in agreement with the results reported by other researchers on root crops and other agricultural products (Addoet al., 2009; Khazaei and Daneshmandi, 2007; Doymaz,2006; Ayim,2011;Olawaleand Omole,2012;Koua, 2013).

The beginning of the drying process was characterized by very fast drying which was enhanced by available free water and the initial high moisture content of the material. As the moisture content reduced, the drying rate progressively reduced until the moisture content attained equilibrium level.

The very short drying time (2 to 4 h) of the grated samples (T_4) and the toasted sample (T_2 and T_5) could have resulted from the very low initial moisture content of the sample which was accomplished by the initial moisture removal during the pre-treatment. The mechanical grating of the samples also reduced the materials into smaller particle sizes with large surface areas exposed to the drying air which enhanced faster moisture removal. This agrees with the observation of other researchers that the smaller and more porous the agricultural material, the shorter the time required to move the moisture to the surface of the particles where ultimate moisture evaporation into the hot air occurs (Tunde-Akintunde and Ayala, 2010; Falade and Solademi, 2010). The short total drying time of these samples gave them economic advantage over the chipped samples with long drying duration of 7 to 10 h total drying time. The pre-treatment method which involved grating and dewatering or grating dewatering and toasting could therefore reduce the total energy cost for drying by more than 50%.

4. CONCLUSION

The cassava samples were dried to a moisture content of 2-7% (wb) within three to four hours for the toasting and grating pre-treatment. For the chipping pretreatment the same moisture content level was attained after eight to ten hours. For all the pre-treatment methods, drying took place in the falling rate period and the moisture loss was more rapid during the first 1 h than the rest of the drying period. A plot of the changes in moisture content with time followed a typical drying trend of moisture content decreasing exponentially with time for all the samples.

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Fig. 1: Electrically operated chipping machine

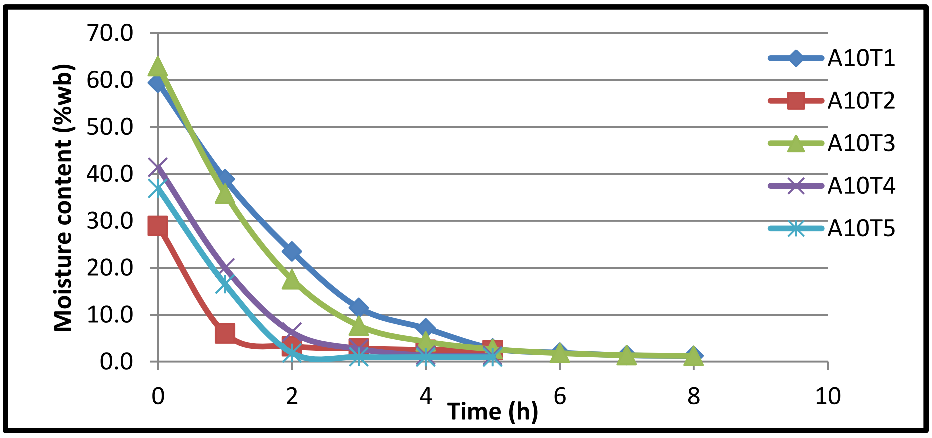
Figure 2: Mechanically ventilated hot air dryer with cassava samples for drying

Figure 3: Mechanically ventilated hot air dryer showing the temperature display unit

(a)

(b)

Figure 4: The pre-treated cassava samples (a) chipped samples (b) grated and toasted samples



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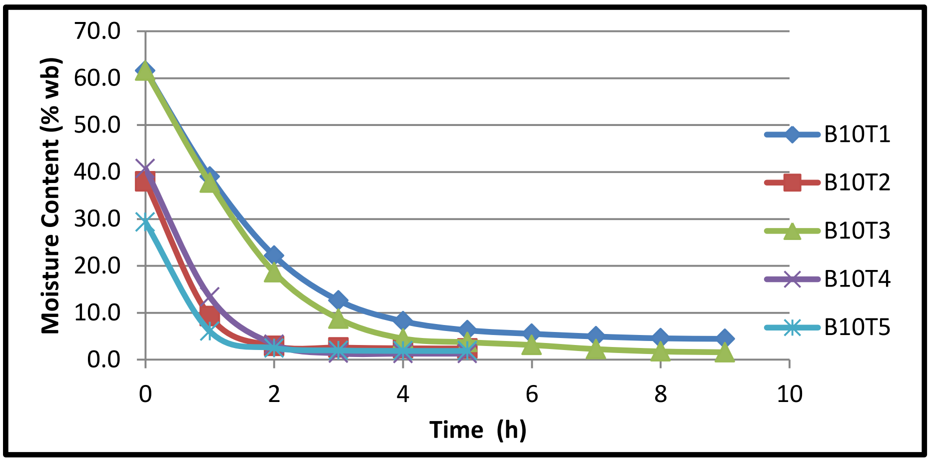

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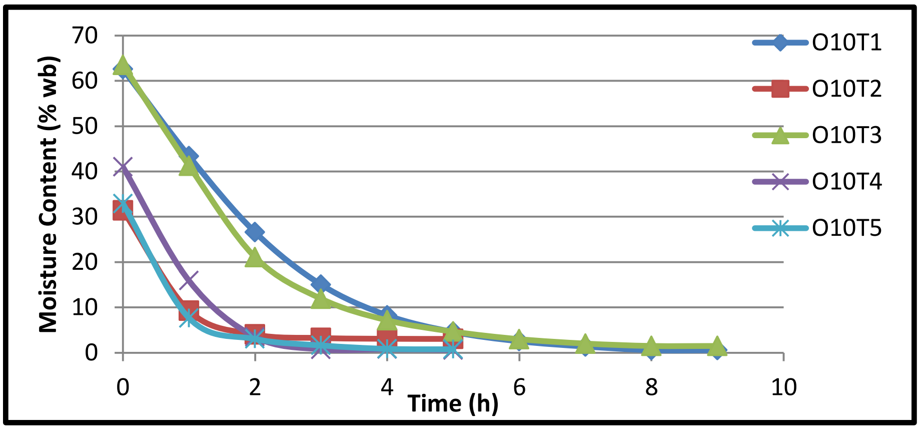
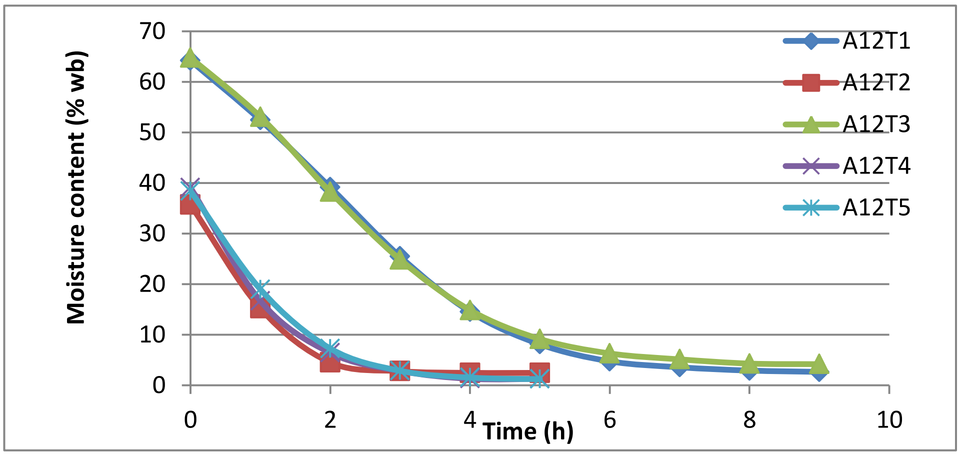


(c)

Figure 5: Effects of different pre-treatment methods on the drying characteristics of three cassava varieties at 10 months harvest age: (a) *Ampong*variety (b) *Broni*variety (c) *Otuhia* variety; Chipping (T1) , toasting pre-treatment (T2), chipping with citric acid pre-treatments (T3), grating pre-treatment (T4) and toasting with citric acid pre-treatment (T5)



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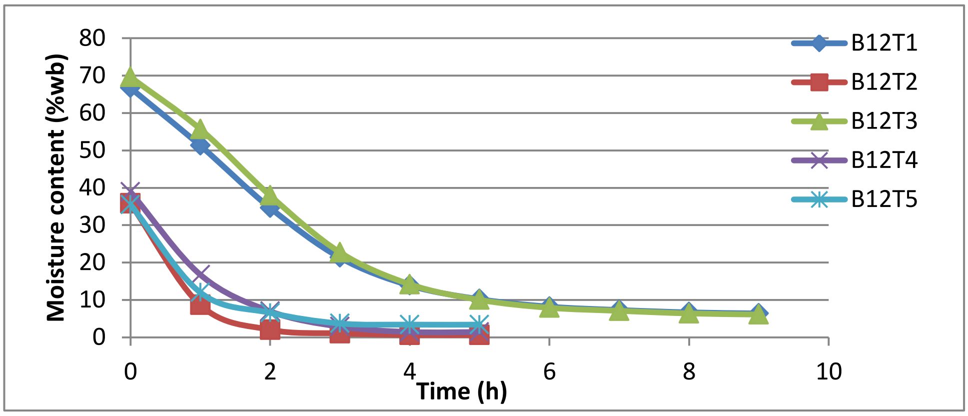

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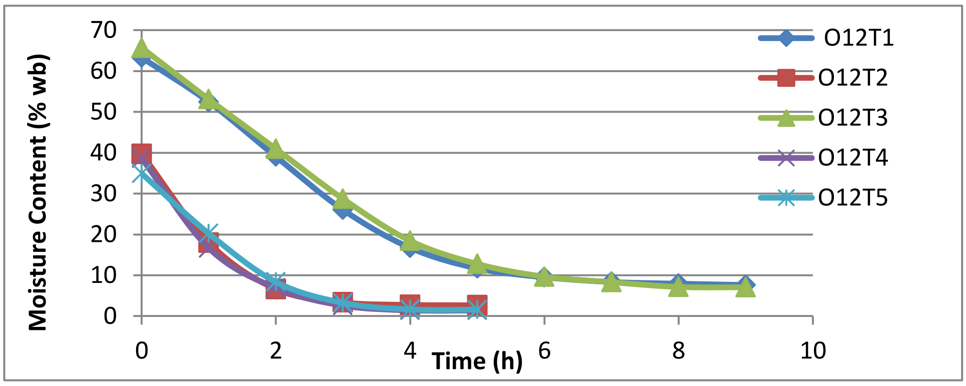
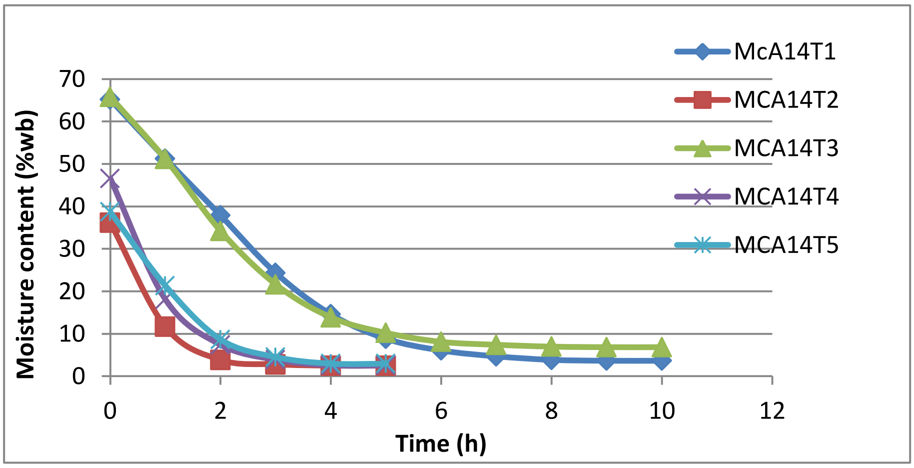


(c)

Figure 6: Effect of pre-treatment methods on drying characteristics of three cassava varieties at 12 months harvest age: (a) *Ampong* variety (b) *Broni* variety (c) *Otuhia* variety; Chipping (T1) , toasting pre-treatment (T2), chipping with citric acid pre-treatments (T3), grating pre-treatment (T4) and toasting with citric acid pre-treatment (T5)



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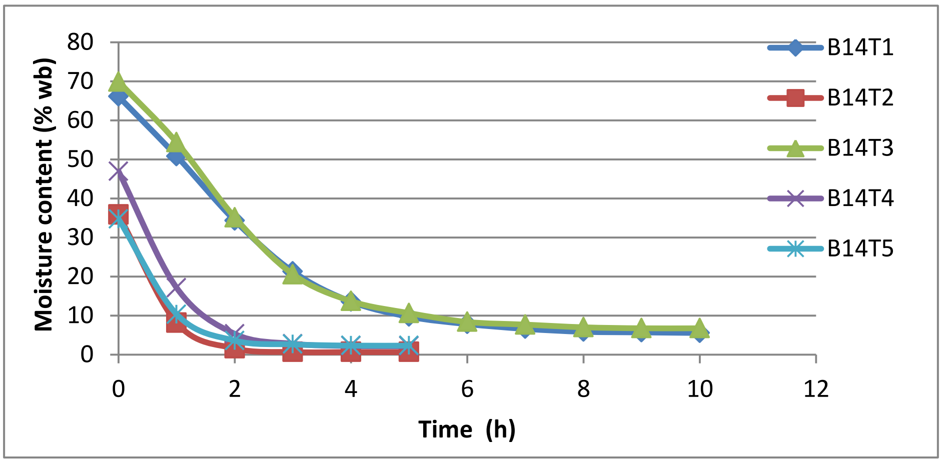

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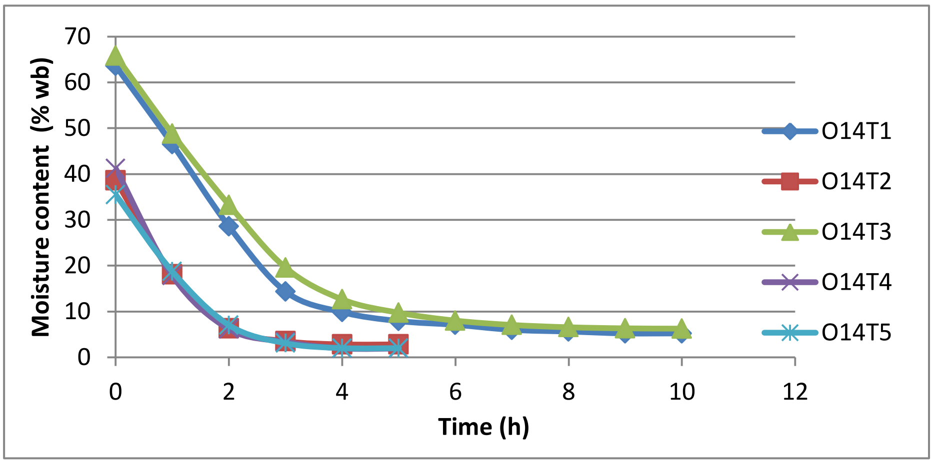

(c)

Figure 7: Effect of pretreatment methods on drying characteristics of three cassava varieties at 14 months harvest age:(a) Ampong variety (b) Broni variety (c) Otuhia variety; Chipping (T1), toasting pre-treatment (T2), chipping with citric acid pre-treatments (T3), grating pre- treatment (T4) and toasting with citric acid pre-treatment (T5)