EFFECT OF DRYING AND BLANCHING PARAMETERS ON DRYING RATE OF 'POUNDO' YAM

Shuaeeb Niyi Oyewole, Joshua Olanrewaju Olaoye,

Abstract- This study was carried out to determine the effects of drying and blanching parameters on drying rate of 'poundo' yam. The 'poundo' yam was produced from white yam (*Dioscorea rotundata*) using an electrically powered experimental dryer. The product was dried to an average moisture content of 12 % w.b. The moisture loss and the drying rate were determined. The drying rate was subjected to statistical analysis using 3 x 3 x 3 factorial design to study the effects of drying temperatures (55 ^{o}C, 60 ^{o}C and 65 ^{o}C), blanching temperatures (80 ^{o}C, 90 ^{o}C and 100 ^{o}C), and blanching durations (10 minutes, 20 minutes and 30 minutes) on drying rate. It was observed that the drying temperature, blanching temperature, blanching duration and interaction between the three factors had significant effect on the drying rate at 5 % level of confidence. It is therefore established that increase in drying temperature irrespective of pre-treatment methods leads to decrease in drying time.

Keywords: Pre-treatment, moisture content, blanching temperature, blanching duration, drying time

1. INTRODUCTION

Drying is a complex operation involving transient transfer of heat and mass along with several rate processes, such as physical or chemical transformation, which in turn may cause changes in product quality as well as the mechanisms of heat and mass transfer [1]. The physical changes that may occur include: shrinkage, puffing, crystallization and/or glass transition. In some cases, desirable or undesirable chemical or biochemical reactions may occur leading to changes in colour, texture, odour or other properties of the solid product.

During air drying, water is removed from the surface of product and it moves from the deeper layers to the surface. Drying takes place in two distinct phases. In the first phase, whilst the surface of the product is wet, the rate of drying depends on the condition of the air around the product. If the surrounding air conditions remain constant, the rate of drying will remain constant; this phase is called the 'constant rate period'. Once all the surface moisture has been carried away, the second phase of drying begins and this depends on the rate at which moisture can be brought to the surface of the product. As the concentration of moisture in the product falls, the rate of movement of moisture to the surface is reduced and the drying rate becomes slower; this phase is called the 'falling rate period'.

- *Oyewole, S. N. is currently an Agricultural Engineer at the Nigerian Stored Products Research Institute, P.M.B. 1489, Ilorin, Nigeria*
- Olaoye, J. O. is senior lecturer at the Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin, Nigeria.

Pounded yam and 'poundo' yam are important sources of carbohydrate for many people of Nigeria. Pounding of yam with pestle in a mortar is the traditional way of producing pounded yam, a special delicacy in most part of the country. Pounding of boiled yam in a mortar with intermittent addition of water makes the yam softer and finer and increases the surface area upon which digestive enzymes will act [2].

The significance of drying in 'poundo' yam production cannot be underestimated. Among the benefits of this processing technique are:

i. Processing of yam via drying into 'poundo' yam prolongs the shelf life of the processed yam.

ii. It helps in reduction of transportation cost as about 64 % of the weight of yam tubers is water [3] and is lost during drying.

iii. Processing (drying) of yam into 'poundo' yam leads to value addition which could open opportunity for foreign exchange earnings.

iv. It presents the product in a form that can easily and conveniently be packaged for market acceptability.

v. It ends up producing product that eliminates drudgery of pounding as 'poundo' yam can easily be prepared without mortar and pestle.

Attempt was made to commercialize production of dehydrated pounded yam by drum drying in Côte d'Ivoire in the mid-1960s, under the trade name "Foutoupret" [4].

An improved method was developed in West Africa but when the flour was reconstituted in water, the process failed to free enough starch from the yam cells to give the desired stickiness and consistency in the 'fufu' [5]. The production process of instant pounded yam consists of simple operations [6], which have been mechanized. The unit operations are; yam selection and weighing, washing, peeling and slicing, parboiling, drying, milling and packaging. The process of producing instant yam flour is quite simple [7]; it involves slicing, parboiling and milling of the product to yield flour and equipment required for production can be sourced locally.

The objective of this study was to determine the effects of drying and blanching parameters of 'poundo' yam production on its drying rate. In order to run a well productive system of producing poundo yam from white yam (*Dioscorea rotundata* Poir) and to give consumers of the product the best nutrition quality, the 'poundo' yam production parameters must be investigated (Olaoye and Oyewole, 2012). The output of this research work will reveal how these parameters interact and the consequences of their interaction (drying rate trend).

2. Materials and Methods

2.1 Experimental Materials

White yam (*Dioscorea rotundata* Poir) species was considered for this study because it is abundant in Nigeria, and moreover the most preferred species for pounded yam preparation. The tubers were procured from 'Ipata' yam market in Ilorin. The tubers were transported to the engineering laboratory of Nigerian Stored Products Research Institute NSPRI, Ilorin, for investigations and analyses. The moisture content of the yam was determined to be 57 % w.b.

The experimental dryer designed and constructed by [8] and also used by [2] was used for the drying exercise. The dryer consists of heating chamber having one electrical heating coil of 1.8 kW power rating, linked directly to a centrifugal fan of 0.5 Hp, and drying chamber. The heating coil is connected to the temperature regulator which controls the temperature of the dryer by switching the heater on or off. Other devices used for the experiment in conjunction with the dryer were; weighing balance, thermo-hygrometer, mercury-in-glass thermometers and measuring cylinder. In addition to these are; stainless steel knife, plantain slicer, plastic bowls, water heater and plastic sieves.

2.2 Experimental Method

The production process of 'poundo' yam consists of simple operations (Figure 1) and they are; yam selection, peeling, washing, cutting, flaking, blanching, drying, milling and packaging.

2.2.1 Blanching Procedure

One thousand five hundred (1500) cm^3 of water was measured with a measuring cylinder into a container, after which it was heated to 80 ^oC. The chipped yam was poured into the heated water and timed for 10, 20 and 30 minutes respectively. The exercise was subsequently repeated for 90 ^oC and 100 ^oC heated water respectively. The chips with water were then poured into a plastic sieve in order to drain the water away and allowed to stay in the sieve for 10 minutes. The chips were then spread on the trays after which the trays were loaded into the dryer.

2.2.2 Procedure for Drying Operation

The dryer was pre-heated to the desired temperature of 55 ^oC by the means of temperature regulator while the samples were being prepared to ensure stability of the condition of the drying chamber when the yam chips will be introduced. The samples were weighed at an interval of 1 hour with a top loading balance (Snowrex counting scale SRC 5001, product of Saint Engineering Ltd, Saint House, London) with an accuracy of 1g and measuring capacity of 5000 g, and the weights recorded. The temperature of exhaust air from the dryer was also measured and recorded. Samples were removed, weighed and placed back in the dryer. The operation continued until the desired moisture content (12 %) was reached. The procedure was repeated for the samples at 60 ^oC and 65 ^oC respectively in three replications.

2.2.3 Measurement of Drying Rate

Reduction in moisture was monitored during drying by measuring the weight of the samples at regular interval of 1 hour until the desired moisture content was reached. At interval of an hour, the samples were brought out of the dryer for weighing and replaced back after measurement. The drying rate was calculated using equation 1.

$$R = \left(\frac{dM}{dt}\right) = \frac{m_i - m_f}{t} \qquad (1)$$

where;

R is the drying rate in g/hr, dM is the change in mass (g), dt is the change in time (hr) and t is the total time (hr). m_i and m_f are the initial and final mass of yam chip samples respectively in gram.

2.2.4 Statistical Analysis

The data recorded (drying rate) during the test was statistically analyzed using 3 x 3 x 3 factorial design to study the effects of drying temperatures, blanching temperatures, and blanching durations on drying rate. Three replicates were considered under the following factors: drying temperature (3 levels), blanching temperature (3 levels), and blanching duration (3 levels). The analysis enables to investigate the significance effect of the factors as well as the interaction effect [9]. In addition, there is need to conduct comparison of means for the significantly different factors. Therefore, Duncan's New Multiple Range Test (DNMRT) was carried out in order to compare the mean drying rates of the 'poundo' yam samples at the drying temperatures, blanching temperatures and blanching durations considered. From the results of the analysis, the effects of the main factors and their interactions with the drying rate were also determined. The research plan is given in Table 1.

3. RESULTS AND DISCUSSION

3.1 The Average Drying Rate and Analysis of Variance for 'Poundo' Yam Production

The average drying rates calculated from the data obtained from the experiment were subjected to statistical analysis and Table 2 shows the Analysis of Variance (ANOVA) of the obtained average drying rates. The Analysis of Variance shows that the drying temperature, blanching temperature, blanching duration and interaction between the three factors have significant effect on the drying rate (F at 5 %) (Table 2). The effect of the interaction between the drying temperature and blanching temperature is not significant. This shows that the three factors do not have only individual effect but also combination effect on the drying rate of 'poundo' yam. Thus, any change in any of the factor will affect the drying rate and consequently the drying time significantly.

The results of the mean comparison are shown in Tables 3, 4 and 5. The mean drying rates at the three drying temperatures (55 ^{o}C, 60 ^{o}C and 65 ^{o}C) are significantly different. This confirmed the results obtained in the drying time as the samples dried at 55 ^{o}C, 60 ^{o}C and 65 ^{o}C attained the desired moisture content after 9 hrs, 8 hrs and 7 hrs respectively. Increase in drying temperature caused reduction in drying time. This is in conformity with the findings of [10], [11] and [12].

The mean drying rate for samples blanched at temperature of 80 ^{o}C and 90 ^{o}C are not significantly different (Table 4). Whereas the drying rate mean of samples blanched at 100 ^{o}C is significantly different from others. Comparison test was also conducted on mean drying rate of blanching durations. Table 5 shows the results of the comparison between the means. The results depict that there is no significant difference in the drying rate of samples blanched for the durations considered.

3.2 Effect of Drying Temperature on Drying Rate

Figure 2 shows the effect of drying temperature on drying rate at 100 ^{o}C blanching temperature and blanching duration of 30 minutes. The set of curves shown in the figure exhibits relatively the same trend. After 1 hour of drying, the drying temperature of 65 ^{o}C had the least drying rate. Due to the 30 minutes soak in water and drying temperature of 65 ^{o}C (being the highest considered), the moisture removal at the early part of the first hour was high and led to high humidity in the dryer which in turn reduced the drying rate after one hour. The curve of drying temperature of 60 ^{o}C followed the same trend, but its effect was not as pronounced as that of 65 ^{o}C because of the temperature difference. After 2 hours, the drying rate for both 65 ^{o}C and 60 ^{o}C drying temperatures increased to their maximum. Drying at 60 ^{o}C and 65 ^{o}C experienced constant rate drying within the first two hours of the exercise, while 55 ^{o}C drying temperature exhibited falling rate drying. After the fifth hour of drying, the rate of moisture removal was higher for 55 ^{o}C drying temperature compared with others (especially 65 ^{o}C). The percentage range of moisture removed after 4 hours of drying out of the total removed moisture for the drying temperature treatments are 75.46 %, 84.35 % and 92.17 % for drying temperatures 55 ^{o}C, 60 ^{o}C and 65 ^{o}C respectively. All the three drying temperatures had effect on their respective drying time. The 'poundo' flakes dried at temperatures of 55 ^{o}C, 60 ^{o}C and 65 ^{o}C attained the required moisture content of 12 % after 9, 8 and 7 hours of drying respectively. This confirmed the result of the statistical analysis, which says there is significant difference in the drying rate means of the drying temperature treatments. Consequently increase in temperature resulted in reduction in drying time. This is in conformity with previous studies carried out on drying of agricultural commodities [11 and 12].

3.3 Effect of Blanching Temperature on Drying Rate

The three curves in Figure 3 exhibit the same trend. The 80 ^{o}C blanching temperature had the least drying rate after the first hour of drying. As a result of high temperature of the two other treatments, there was free moisture in the samples compared to 80 ^{o}C blanched sample. After 2 hours, there was increase in the drying rate of the three treatments. After the third hour of drying, the three were at equilibrium. Throughout the later stage of drying, the 80 ^{o}C blanched drying rate maintained the lead, while the other were relatively at equilibrium. The curves in Figure 3 show that the products blanched for 10 minutes exhibited constant rate drying within the first two hours of drying irrespective of the blanching temperature.

3.4 Effect of Blanching Duration on Drying Rate

The effect of blanching duration on drying rate at 65 °C drying temperature and 100 °C blanching temperature is presented in Figure 4. The rate of moisture removal for the sample blanched for 30 minutes was initially low compared to others due to the soaking period. Both the 10 and 30 minutes treatments in the figure experienced both constant and falling rate drying. However, the 20 minutes blanched curves exhibit uniform trend in drying rate throughout the drying time and experienced only falling rate drying. This shows that blanching of 'poundo' yam for 20 minutes, irrespective of the blanching temperature considered, and drying at 65 °C temperature gives a better drying rate curve compared to others.

4. Conclusion

The results show that good quality pounded yam could be prepared without stress of pounding with mortar and pestle. It was also observed that the drying temperature, blanching temperature, blanching duration and interaction between the three factors had significant effect on the drying rate at 5% level of confidence. The three factors do not have only individual effect but also combination effect on the drying rate of 'poundo' yam.

Thus, any change in any of the factor will affect the drying rate and consequently the drying time significantly. It is therefore established that increase in the drying temperature irrespective of pre-treatment methods leads to decrease in drying time of the 'poundo' yam.

REFERENCES

[1] A. S. Mujumdar and S. Devahastin, Fundamental principles of dying. Mujumdar's practical guide to industrial drying. Exergex Corporation. Canada. Pp. 1 – 3. 2000

[2] J. O. Olaoye and S. N. Oyewole, Optimization of some 'poundo' yam production parameters. *Agric. Eng. Int: CIGR Journal.* 14 (2): 58-67. 2012

[3] T. Egbe, T. Agbor and S. Treche, Variability in the chemical composition of yams grown in Cameroon. In: Terry E.R, Doku E.V, Arene O.B, Mahungu N.M, editors. Tropical root crops: production and uses in Africa. 3rd ed. Ottawa: International Development Research Centre. Pp. 153-156. 1984

[4] Food-Info.net, Tropical roots and tubers: Yam. http://www.food-info.net/uk/products/rt/yam.htm. Downloaded on 6th May, 2011. 2009

[5] J. N. Anazonwu-Bello, Forms of quality of root crops in human nutrition. Proceedings of the 1st national seminar on root and tuber crops. National Root and Tuber Crops Research Institute. Umudike. Pp. 166 – 176. J. 1977

[6] FIIRO, Federal Institute of Industrial Research, Oshodi, Nigeria. Instant pounded yam flour production technology. http://fiiro-ng.org/Instant-pouded-yam.htm. Downloaded on 6th May, 2011. 2005

[7] A. E. Nnamdi, Instant pounded yam flour production in Nigeria. www.farriconsultingng.blogspot.com. Downloaded on 6th May, 2011. 2010

[8] M. A. Omodara, Effects of some drying parameters on drying rate and quality of African catfish. M. Eng. Thesis. Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin. 2011

[9] B. A. Oyejola, Design and analysis of experiments for biology and agriculture students. OLAD publishers, Ilorin. Pp. 29 – 172. 2003

[10] M. A. Omodara, A. M. Olaniyan and S. S. Afolayan, Effect of drying temperatures on the drying rate and quality of African catfish (*clarias garieppinus*). Proceedings of the 11th International Congress on Mechanization and Energy in Agriculture Congress. Istanbul, Turkey. Pp. 408 – 413. 2011

[11] S. Mujaffar and K. C. Sankat, The mathematical modelling of the osmotic dehydration of shark fillets at different brine temperatures. *Int. J. Food Sci. Tech*., 40: 1-12. 2005

[12] A. Kilic, Low Temperature and High Velocity (LTHV) application in drying: Characteristics and effects on fish quality. *Journal of Food Engineering*. 91(2009)173 -182. 2009

Table 1: Research Plan to Study the Effect of Controlled Variable Parameters.

Controlled Variable Parameters	
Blanching Temperature (^oC)	$B_{t1} = 80$, $B_{t2} = 90$, $B_{t3} = 100$
Blanching Duration (min)	$B_{d1} = 10$, $B_{d2} = 20$, $B_{d3} = 30$
Drying Temperature (^oC)	$D_{t1} = 55$, $D_{t2} = 60$, $D_{t3} = 65$
Dependent Variables Parameters	
Drying Rate (%)	

Table 2: Analysis of Variance of the Drying Rate

Sources of Variation	d.f	S.S	M.S	F
Drying Temperature (D_t)	2	184.1859	92.0930	649.9150*
Blanching Temperature (B_t)	2	15.6963	7.8482	55.3857*
Blanching Duration (B_d)	2	2.6440	1.3220	9.3296*
$D_t \times B_t$	4	0.9904	0.2476	1.7474
$D_t \times B_t \times B_d$	8	4.3934	0.5492	3.8756*
Error	63	8.9282	0.1417	
Total	81	216.8382	2.6770	

*significantly different

$F_{(2, 63, 0.05)} = 3.144$

$F_{(4, 63, 0.05)} = 2.524$

$F_{(8, 63, 0.05)} = 2.094$

Table 3: Duncan's New Multiple Range Test for Drying Temperature

Drying Temperature (^oC)	Mean Drying Rate (g/hr)
55	11.68[a]
60	13.43[b]
65	15.38[c]

Values with different letters are significantly different

Table 4: Duncan's New Multiple Range Test for Blanching Temperature

Blanching Temperature (°C)	Mean Drying Rate (g/hr)
80	12.98[a]
90	13.45[a]
100	14.05[b]

Values with different letters are significantly different

Table 5: Duncan's New Multiple Range Test for Blanching Duration

Blanching Duration (°C)	Mean Drying Rate (g/hr)
10	13.59[a]
20	13.66[a]
30	13.25[a]

Values with same letters are not significantly different

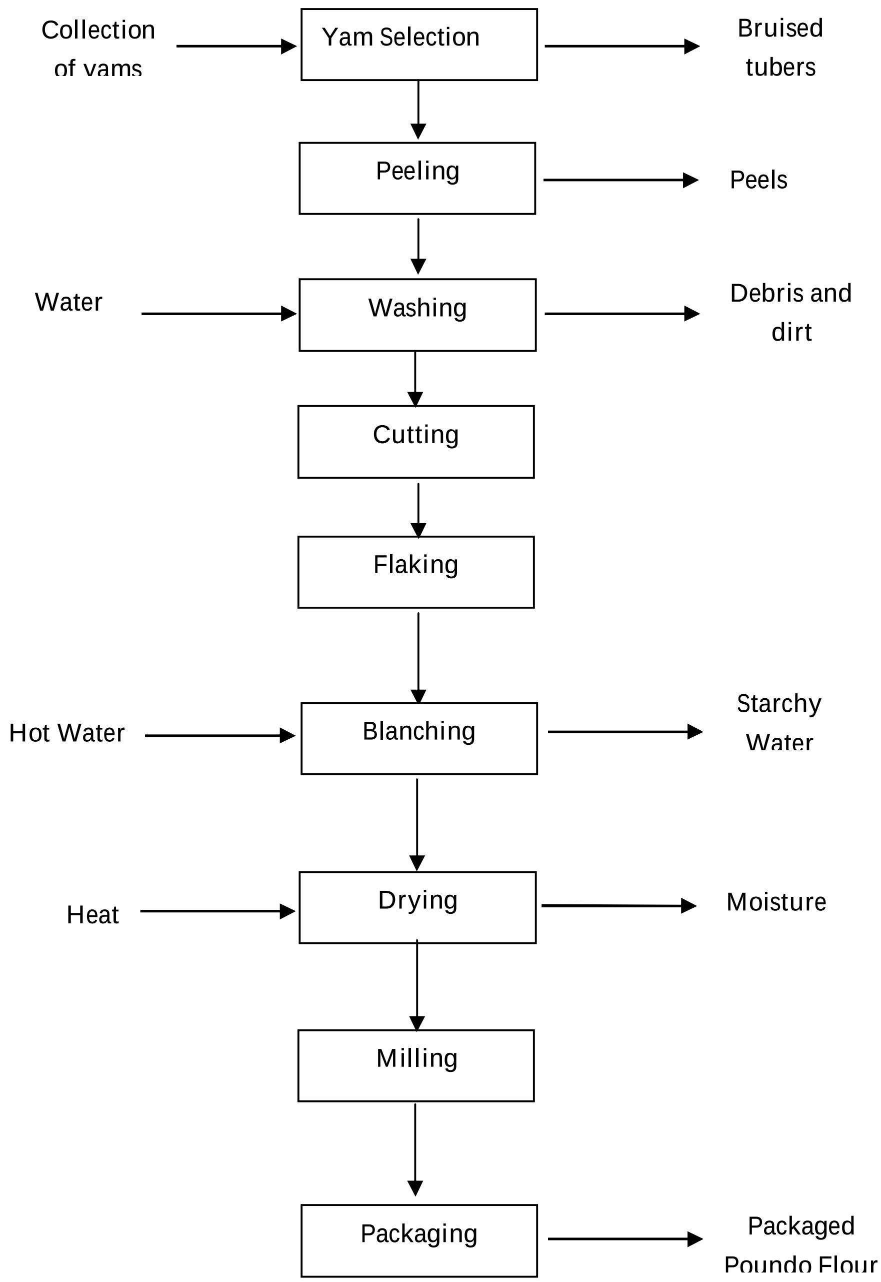

Figure 1: Flow Diagram for Poundo Yam Flour Production

(Source: [2])

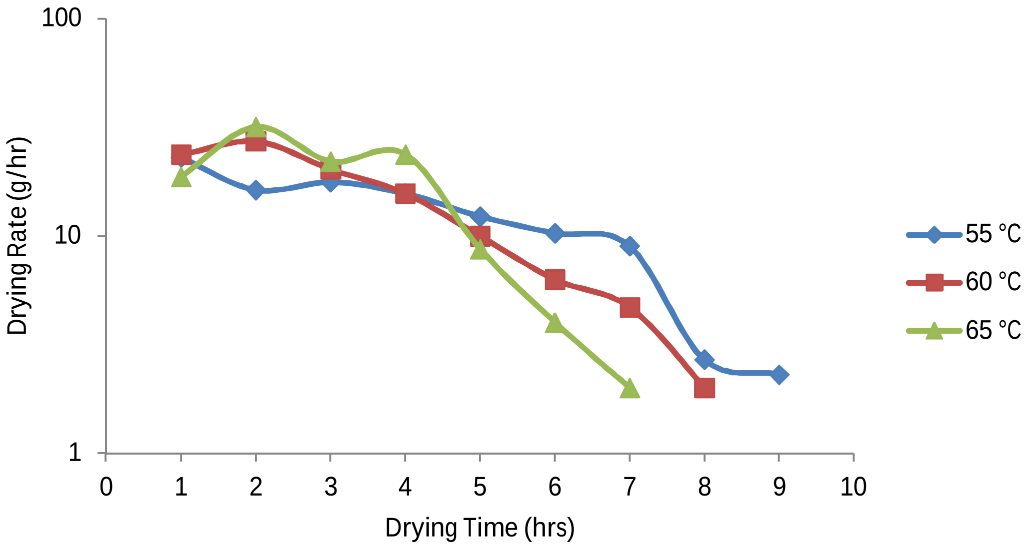

Figure 2: Effect of Drying Temperature on Drying Rate at Blanching Temperature of 100 °C and Blanching Time of 30 Minutes

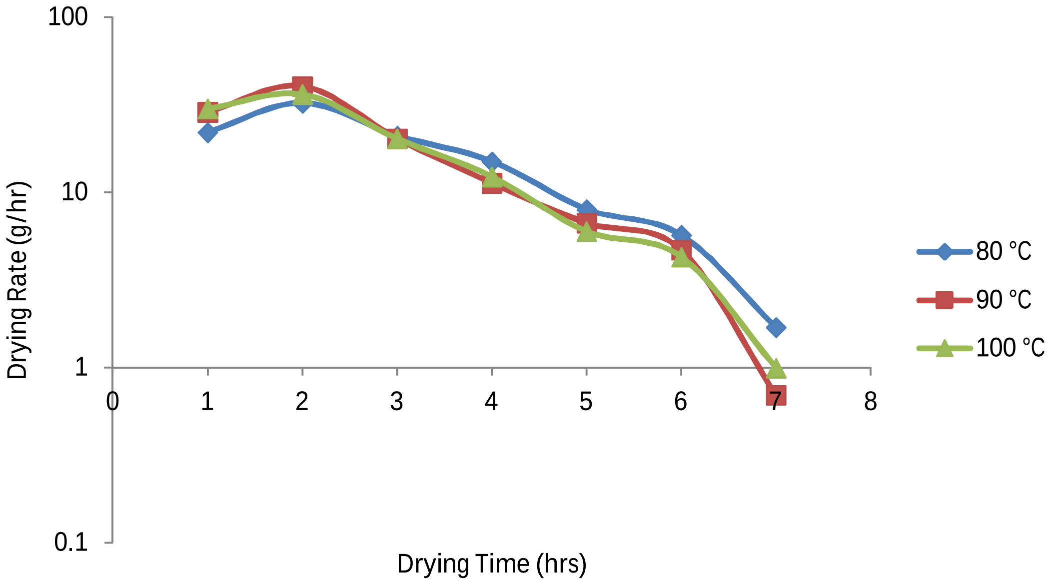

Figure 3: Effect of Blanching Temperature on Drying Rate at 65 °C Drying Temperature and Blanching Time of 10 Minutes

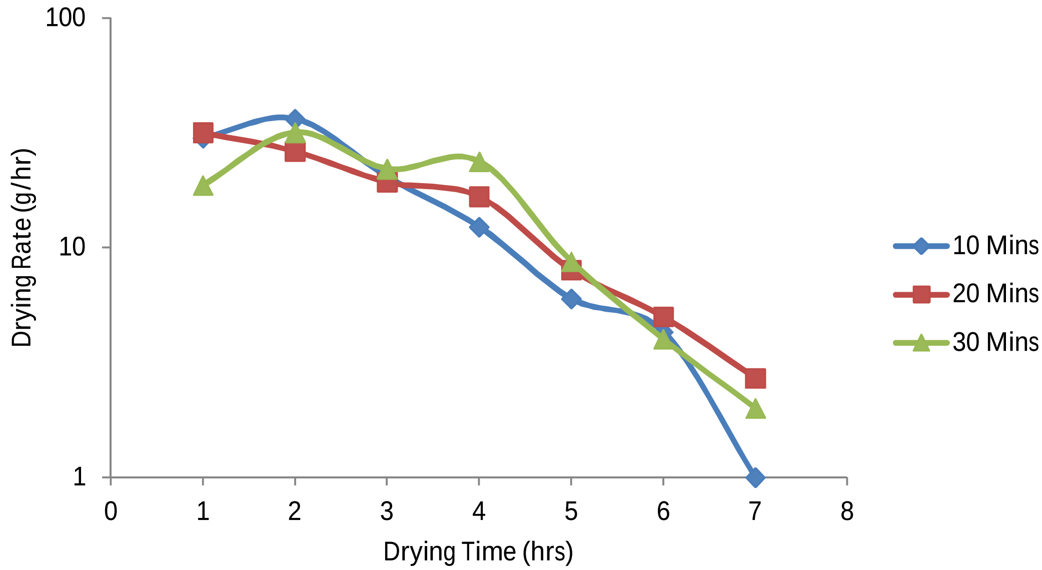

Figure 4: Effect of Blanching Duration on Drying Rate at 65 °C Drying Temperature and Blanching Temperature of 100 °C