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Full-Length Research Paper

Evaluations of some Selected Yam Flour Production Variables on Drying Time and Final Moisture Content of Sliced Dried Yam

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ABSTRACT: The time required for drying to save moisture content is important to yam flour millers in the production of yam flour. Understanding the effect of some processing variables on the final moisture content and drying time is an important theoretical and experimental cornerstone in optimizing the drying processes used in food industries to produce yam flour. As a result, the purpose of this research is to determine the effect of some selected processing variables and final moisture on sliced yam for the production of yam flour. A 4 by 5 factorial response surface methodology (RSM) of design expert version 6.0.8 was used to identify the relationship between the response functions and the process variable of the dried yam chips in order to study the effect of these selected production variables. Soaking time (5, 10, 25, 40, and 55 minutes), soaking temperature (40, 60, 80, 100, and 120 degrees Celsius), drying temperature (45, 60, 75, 90, and 105 degrees Celsius), and chip size in volume are the four factors considered with their levels (20, 50, 90, 160, and 230 cm^3). The functional relationships between the selected processing variables were established using an empirical model that was validated using the design expert software's coefficient of determinant (R^2). The drying time was observed to decrease from 1736 to 334 minutes as the drying temperature increased from (45 to 105ºC), while the effect of soaking time and yam variety on drying time was insignificant ($P<0.05$). It was also discovered that as the soaking temperature rises from 40 to 80 degrees Celsius, the final moisture content falls from 13 to 7%. The study concluded that the investigated processing factors must be taken into account in the modeling of drying operations and the design of equipment for the production of yam flour.

Keywords: Optimizing, miller, design, yam flour, modeling, drying, soaking

INTRODUCTION

Yam is a tuber crop which belongs to the family *Dioscorea spp*. It is a semi-perishable class of food due to its high moisture content (Adejumo et al., 2013; Falade et al., 2007; Falade and Onyeoziri, 2012). This staple crop (yam) is primarily grown in Sub-Saharan Africa (Celestina et al., 2019), particularly in Nigeria's Northern and Western regions, with fewer productions from the Eastern region.Yam production in sub-Saharan Africa contributed more than 95% of global yam production. It was reported as the world's fourth-leading root crop after cassava, potatoes, and sweet potatoes (Akinoso and Olatoye, 2013). FAO (1997) rated it the second most valuable tuber crop in Africa and a vital food security crop for approximately 700 million peop le in the world. The crop has been reported to have a medicinal value in curing diarrhea and diabetics (Xiaoyong et al., 2018) and as a good source of stable food for many people in the sub-Sahara region (Faal et al., 2018). Fresh yams are difficult to store and are subject to deterioration during storage (Afoakwa and

Dedeh, 2001; Martin and Soumaila, 2010). It has been observed that fresh yam tuber is highly perishable because of its high moisture content, so there is a need to process it into more stable products like yam flour. Yam flour production is a significant means of preserving the crop. The drying of the chips is a major intermediate unit operation between blanching and milling in the production of yam flour. The moisture content of food materials before milling is an important factor, since it determines the materials' physical properties and the powder properties, such as flow ability after milling (Hwabin et al., 2018). Currently, the drying of yam for yam flour is mostly done by hand with sun drying, which is unscientific, unsanitary, and discourages industrial production of the product. Thus, this study will serve as a baseline for modeling automation of yam drying for yam flour production.

MATERIALS AND METHODS

Two varieties of local yam were bought from the local market in Ibadan, south western Nigeria. The experiment was carried out using a drier with a digital thermocouple that regulates the cabinet temperature. The final moisture content and the drying time for each prepared sample was then determined.

Determination of final moisture content

The moisture content of the samples was determined using the oven-drying methods reported by Philippine Agricultural Engineering Standard (2004). The moisture content of each sample was determined by using Equation (1)

$$Mc_d = \frac{W1-W2}{W2} \times 100, \% \qquad (1)$$

Where, Mc_d is Moisture content dry basis, %;
W_1 is Initial mass of the sample, g
W_2 is Final mass of the sample after drying, g

Drying of the samples

Each of the samples after blenching was put in a drying tray and placed in the oven at a specified oven temperature. However, continuous weighing of drying samples was done until a constant weight was achieved at three consecutive recording. And this was used to calculate the final moisture content at that drying temperature. The time of drying to final moisture content is recorded as time of drying (Idowu, 2009).

Experimental layout

The selected processing variables and their level were shown in (Table 1).

Statistical analysis

The data collected from the experiment were statistically analyzed using the design expert 6.0.8. The effect of size, drying temperature, soaking time and soaking temperature were then analyzed on final moisture content and time of drying.

RESULTS AND DISCSSION

The results of the experiment on the effect of some selected variables on the drying time and final moisture content are presented in (Table 2). The effect of five selected variables on the drying time and the final moisture content are discussed below.

Effect of varieties on drying time of sliced dried yam

The result of the experiment showed that the effect of varieties was not significant (p<0.05) on drying time. Figure 1A and 1B showed that as the drying temperature increases the drying time decreases but the effect of varieties were not significant.

Effects of the selected variables on drying time of dried yam pellets

It was observed from (Figure 1A and B) that as the drying temperature increases, the drying time decreases. The result shows that when the drying temperature increased from 75 to 105ºC, the drying time decreased from 1242 to 1128 minutes. In conventional mechanical drying, setting heat and mass transfer always results in the removal of moisture by thermal flow with the help of heated air. As the temperature of the air that flows across the surface of the sliced yam increased, the drying time decreased (Pokharkar et al. 1997). This report of decreased drying time with an increase in drying temperature was in agreement with the findings of Jindal and Siebenmorgen (1987) on rice, (Pokharkar et al. 1997) on sliced bananas, (Idah et al., 2010) on dried tomatoes, and (Idowu et al., 2010) on fermented cassava flour. The statistical analysis shows that the drying temperature had a significant

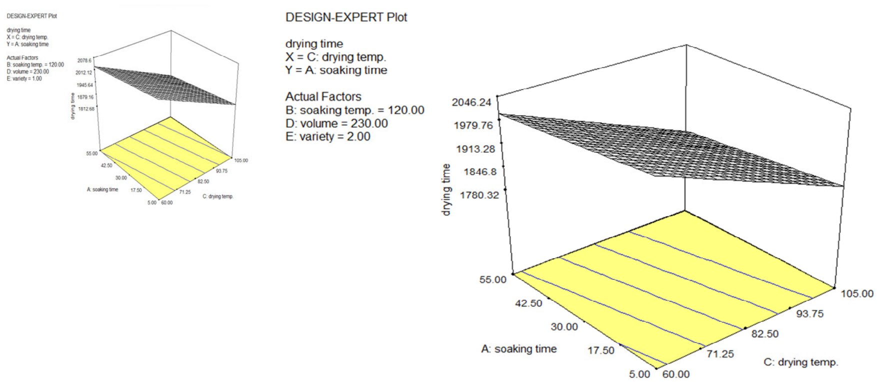
Table 1: Processing factors and their levels

Volume (cm^3)	Soaking time (mins)	Soaking temp (ºC)	Drying temp (ºC)
20	5	40	45
50	10	60	60
90	25	80	75
160	40	100	90
230	55	120	105

Table 2: Result of experiment of the effect of the selected variables on drying time.

Run	ST (min.)	STT (°C)	DTT (°C)	Vo cm^3	Va	DT (min.)	FMC (%)
1	25	80	75	230	y2	1722	16.5 0
2	40	60	90	160	y1	1345	18.70
3	40	100	60	160	y2	1478	17.60
4	25	80	75	90	y1	1215	11.0
5	25	80	105	90	y1	1128	8.60
6	10	60	90	20	y1	390	5.10
7	40	60	60	20	y2	505	1.60
8	40	100	90	160	y1	1385	11.30
9	25	120	75	90	y2	1246	8.60
10	25	80	75	90	y2	1250	6.80
11	25	120	75	90	y1	1308	13.30
12	25	80	75	90	y1	1252	15.00
13	25	40	75	90	y2	1236	13.00
14	25	80	105	90	y2	1078	17.25
15	25	80	75	90	y2	1242	12.16
16	10	60	60	20	y1	495	2.40
17	25	80	45	90	y1	1478	13.20
18	25	40	75	90	y1	1246	15.80
19	10	100	90	160	y1	1360	12.70
20	40	100	60	160	y1	1431	3.20
21	25	80	75	90	y2	1236	15.0
22	10	60	60	160	y2	1455	11.5
23	10	60	90	160	y1	1317	3.90
24	40	60	90	160	y2	1345	29.40
25	10	100	60	160	y1	1474	17.30
26	25	80	75	90	y1	1249	9.12
27	10	100	90	20	y2	334	2.53
28	40	100	90	160	y2	1367	23.60
29	10	100	60	20	y2	474	1.64
30	10	100	90	20	y1	380	2.50
31	25	80	75	50	y1	680	7.00
32	25	80	75	90	y2	1228	17.60
33	25	80	75	90	y1	1234	13.00
34	40	80	45	90	y2	1490	16.72
35	40	60	60	20	y1	505	2.90
36	10	60	90	20	y2	354	2.85
37	10	100	60	160	y2	354	13.88
38	10	60	90	20	y2	1470	1.70
39	10	100	60	20	y1	356	1,96
40	5	80	75	90	y1	470	15.0
41	40	100	60	20	y2	1248	1.60
42	40	100	90	20	y1	495	2.80
43	5	80	75	90	y2	383	15.00
44	10	100	90	160	y2	1244	24.58
45	40	100	60	20	y1	1460	1.62
46	25	80	75	230	y1	490	16.51
47	40	100	90	20	y2	1736	1,80
48	40	60	90	20	y1	354	1.49
49	40	60	60	160	y1	1428	18.50
50	55	80	75	90	y2	1218	15.77

Note; ST=soaking time, STT = soaking temperature, DTT = Drying temperature, Vv = Volume, VR = Variety, DT = Drying time. FMC =Final Moisture Content.



Aamula Yam Abuja Yam

Figure 1A: Effect of drying temperature on drying time and final moisture of yam pelet

Table 3: Analysis of variance on the effects of drying temperature on drying time.

Source	Sum of Squares	DF	Mean Square	F Value	Prob. > F	
Model	8.235E+006	5	1.647E+0006	49.97	< 0.0001	Significant
A	6893.24	1	6893.24	0.21	0.6497	
B	223.07	1	223.07	0.006.768	0.9348	
C	2.404E+006	1	2.404E+005	7.29	0.0098	
D	7.902E+006	1	7.902E+006	239.75	<0.0001	
E	12508.78	1	12508.78	0.38	0.5410	
Residual	1.450E+006	44	32959.29			
Lack of Fit	1.449E+006	37	39162.50	229.21	<0.0001	Significant
Pure Error	1196.00	7	170.86			
Cor Total	9.685E+006	49				

effect on drying time (Table 3).

Effect of soaking temperature on the drying time and final moisture content

It was observed that when the soaking temperature increased from 40 to 80ºC the drying time also decreased from 1246 to 1236 minutes. When the soaking time increased from 10 to 40 minutes, the drying time increased from 390 to 1345 minutes. Figure 2 shows the interaction effect of soaking time and soaking temperature on the drying time. It is observed from the figure that as the soaking time is increasing the drying time is decreasing while as the soaking temperature is increasing the drying time is also increasing. The relationship between drying time and the other variables are as presented in Equation 2 and the coefficient of determinant of the equation relating the processing factors to drying time is R^2 =.0.8503.

$$D_T = 886.16 - 0.93S_T - 0.11S_{TT} - 4.87D_{TT} + 6.67V_p - 32.35V_R \quad (R^2 = 0.8503) \qquad (2)$$

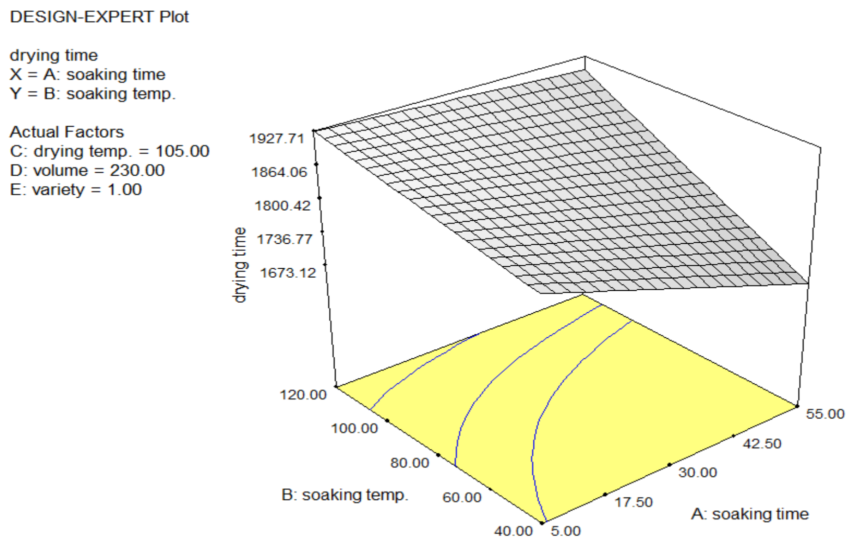


Figure 2: Effect of soaking time and soaking temperature on drying time.

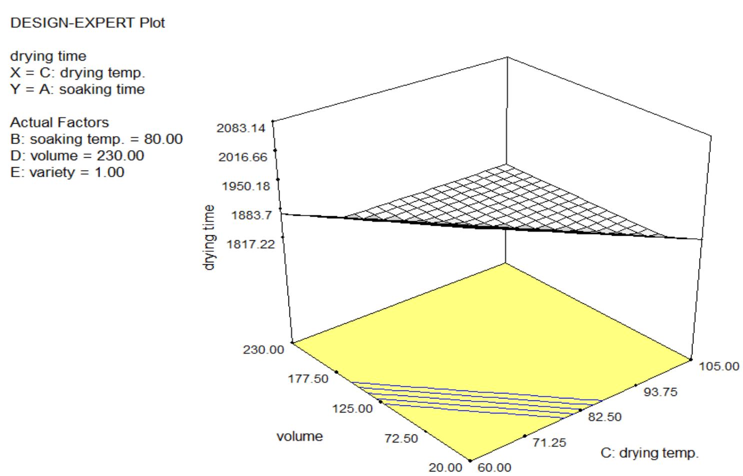


Figure 3: Effect of drying temperature and volume on drying time.

Where; D_T is Drying Time; S_T is Soaking time; S_{TT} is Soaking Temperature; D_{TT} is Drying Temperature: V_v is Volume and V_R is Variety

Effect of volume on drying time and final moisture content

The drying time increased from 495 to 1455 minutes as the volume increased from 20 to 160 cm^3. The longer the drying time, the longer the soaking time and tuber size. The increase in drying time with increasing soaking time may be due to more water absorption with increasing soaking time. The increase in drying time with increasing slice volume may be due to an increase in the distance covered by water movement from the inside of the chips to the product's surface via the liquid's diffusion mechanism. The greater the thickness, the greater the distance for water to diffuse to the surface resulting in a longer drying time. Figure 3 shows that interaction effect of volume and drying temperature on drying time is not significant.

Practical application

This study provide a basement line information on the effect of the selected processing variables on the drying time and final moisture content of dried sliced yam for yam flour production. The results from this research will be of great help in the design and modeling of yam drying for yam flour production.

Conclusion

Drying time is an important factor in the modeling of the automation of slice yam drying for yam flour production in the processing of yam flour from raw yam. The results of the experiment revealed that, with the exception of variety, all of the processing factors considered have a significant effect on drying time. The experiment also established the interaction effect of all of the chosen processing factors. According to the findings, increasing the drying temperature reduces drying time and final moisture content while increasing the thickness increases drying time and final moisture content.

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