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Optimization of some Operating Parameters for Steam Peeling of Cassava Tubers

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Abstract: The optimization of some operating parameters for the steam peeling of cassava tubers was studied using second order full factorial optimization method and the model equation obtained is:
$Y= 1.22778 +0.05000\ X_1 +0.10000\ X_2 +0.18333\ X_1^2 -0.01667\ X_2^2 +0.02500\ X_1X_2$
Using the Minitab application, the equation reduces to: $Y= 1.22778 +0.10000\ X_2 +0.18333\ X_1^2$.
The experimental, modeled and graphical results show maximum yield of cassava at the highest values of time and temperature.
Key words: Cassava, steam peeling, optimization, factorial method.

Introduction

Cassava (manihot esculenta crantz) is an important economic crop which was introduced into the central Africa from South America in the sixteenth century. The plant is cultivated in many parts of the world most especially in the tropical region such as Brazil, India and several West African countries. It was thought to have made its entry into Nigeria in the late 17th century through the islands of Sao Tome and Fernando Po (wikipedia, 2010) and has since become widely distributed throughout the country. Nigeria is the world's largest producer of cassava producing over 34 million tonnes of fresh tubers annually followed by china; however, based on the statistics from the FAO of the United Nations, Thailand is the largest exporting country of dried cassava with a total of 77% of world export in 2005. The second largest exporting country is Vietnam, with 13.6%, followed by Indonesia with 5.8% and Costa Rica with 2.1% (FIIR, 2006).

Botanically, cassava is a perennial woody shrub making it preferable to other more seasonal cops such as grains, pears and beans. Cassava is rich in carbohydrate especially starch and consequently has a multiplicity of end use (Hullocks etal, 2002). Cassava must be peeled to remove the inedible outer parts of the roots consisting of the corky periderm and the cortex which contains toxic cyanogenic glucosides compared to the starchy flesh varying between 5-10:1 (Bencini, 1991; Ajibola, 2000). Prior to the time of mechanized cassava processing involving the use of simple machines, cassava peeling was done manually using knives. Manual peeling using knives causes a lot of the skin of the cassava where most of the cyanide resides to be removed, it is also slow and labour intensive but research results have shown that this method still yield the best result (Bruinsima,1983; Adetan etal, 2003). Another method of peeling of cassava is through the use of hot solution of sodium hydroxide (lye) to loosen the skin to facilitate later peeling such as removal by water spray or scrubbing with brushes. The desired effect can be obtained by a combination of lye concentration, temperature, time of immersion (Diop, 1998). 'Steam peeling' involves the use of water at high temperature to facilitate the removal of cassava skin. Optimization techniques refer to choosing the best element from some set of available alternatives (Wikipedia, 2010). This research work is aimed at optimizing some parameters such as tuber size, temperature and time for the steam peeling of cassava tubers using second order full factorial method.

Experimental Procedure

10kg of cassava was cut and weighed and the initial weight was recorded as W_1. A beaker 50ml half filled with water was placed in a thermostatic heater. Gauze was put over the beaker and the weighed cassava was placed on the gauze. Another beaker (50ml) was placed over the first beaker housing the cassava. The thermostatic heater was adjusted to a temperature of 70^o and the stop watch used to time the process for 15mins for the first run. After the first run of 15mins, the cassava was slightly washed to remove the cover and then allowed to dry at room temperature. After drying the cassava was weighed and the final weight was recorded as W_2. The difference between the initial weight and final weight was recorded as Y_1. This procedure was repeated for 10.5kg weight of cassava using the values for temperature and time and the difference between the initial and final weight was recorded as Y_2. The above procedure was repeated using temperatures of 80^o and 90^o with times of 10mins and 15mins. The respective Y_1 and Y_2 obtained and were recorded.

Results

Tables showing the various results of the experiments carried out and the Minitab application of the results are presented in table 1 to table 5

Table 1 Experimental Results

S/NO	**X_0**	**Temp(^{o}C) X1**	**Time(min) X_2**	**Weight(g) Y_1**	**Weight(g) Y_2**	**Ave.Weight □=1/2(Y_1+Y_2)**
1	+	90	15	1.6	1.5	1.55
2	+	80	15	1.3	1.4	1.35
3	+	70	15	1.5	1.3	1.40
4	+	90	10	1.4	1.5	1.45
5	+	80	10	1.4	1.1	1.25
6	+	70	10	1.4	1.3	1.35
7	+	90	5	1.3	1.4	1.35
8	+	80	5	1.0	1.1	1.05
9	+	70	5	1.3	1.5	1.30

Table 2: Interval Level Code

S/NO	Temp (^{o}C) X_1	Time(min) X_2
+1	90	15
-1	70	5
ΔX	80	10

Modeled Results

The modeled results using the minitab software are presented in Table 3 to Table 5 The analysis was done using coded units.

Regression Coefficients

Table 3: Estimated Regression Coefficients for Weight

Term	Coef	SE Coef	T	P
Constant	1.22778	0.03993	30.746	0.000
Temperature	0.05000	0.02187	2.286	0.106
Time	0.10000	0.02187	4.572	0.020
Temperature*Temperature	0.18333	0.03788	4.839	0.017
Time*Time	-0.01667	0.03788	-0.440	0.690
Temperature*Time	0.02500	0.02679	0.933	0.420

S = 0.05358 R-Sq = 94.4% R-Sq (adj) = 85.1%

Table 4: Analysis of Variance for Weight at α=0.05

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	5	0.145278	0.145278	0.029056	10.12	0.043
Linear	2	0.075000	0.075000	0.037500	13.06	0.033
Square	2	0.067778	0.067778	0.033889	11.81	0.038
Interaction	1	0.002500	0.002500	0.002500	0.87	0.420
Residual Error	3	0.008611	0.008611	0.002870		
Total	8	0.153889				

Table 5: Estimated Regression Coefficients for Weight Using Data in Uncoded Units

Term	Coefficients
Constant	12.6944
Temperature	-0.293333
Time	-0.00666667
Temperature*Temperature	0.00183333
Time*Time	-6.66667E-04
Temperature*Time	0.000500000

Model Equation

The regression equations for the modeled results are obtained in equation 1 and equation 2

$$Y= 1.22778 +0.05000\ X_1 +0.10000\ X_2 +0.18333\ X_1^2 - 0.01667\ X_2^2+0.02500\ X_1X_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 1$$

The significant P-value or α-value is 0.05; any value greater than this is regarded as insignificant and can be discarded.

This implies that the reduced second order regression equation can be re-written thus;

$$Y= 1.22778 +0.10000\ X_2 +0.18333\ X_1^2 \ldots\ldots\ldots\ 2$$

Graphical Results

The graphical results for normal plot, contour plot, surface plot and pareto chart obtained using the Minitab application are presented in fig 1 to fig 4.

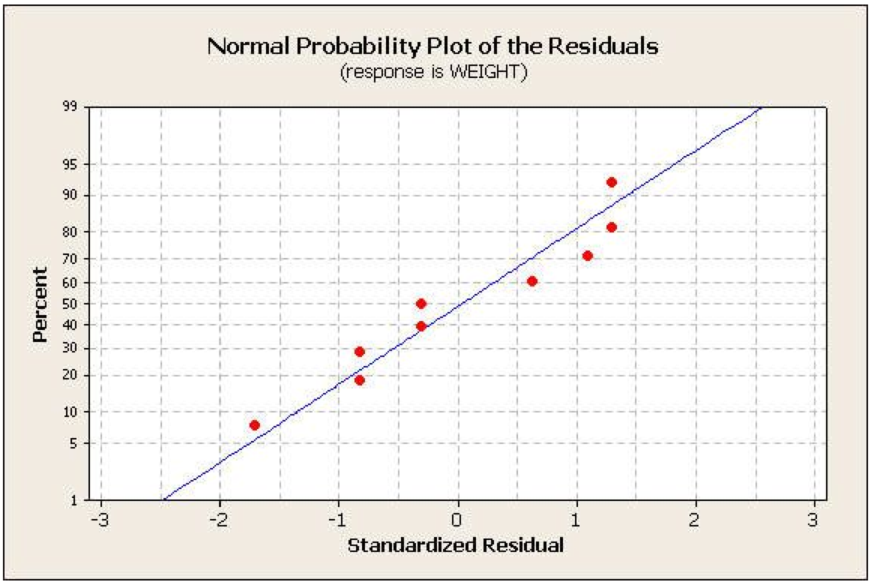

Fig 1 Normal Plot of Residuals for Weight

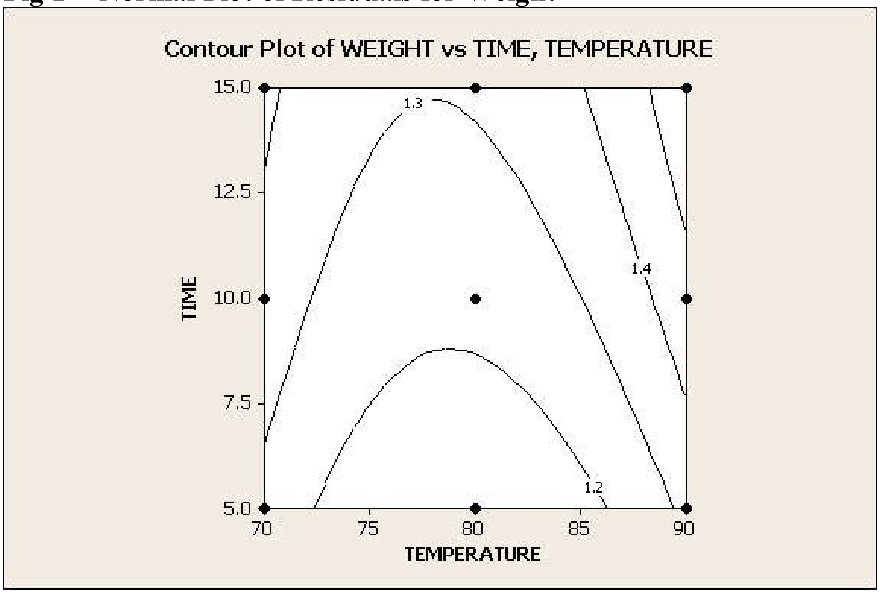

Fig 2 Contour Plot of Weight vs Time, Temperature

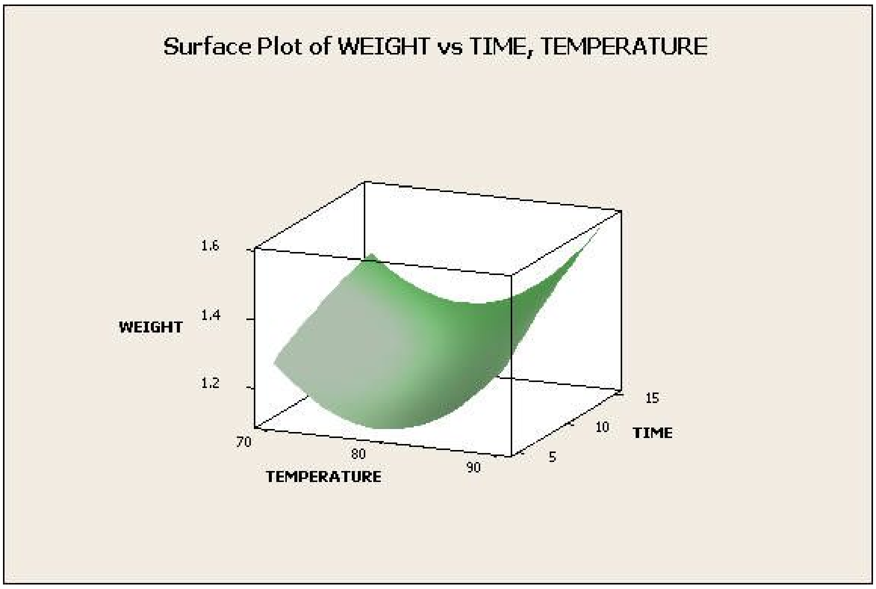

Fig 3 Surface Plot of Weight vs Time, Temperature

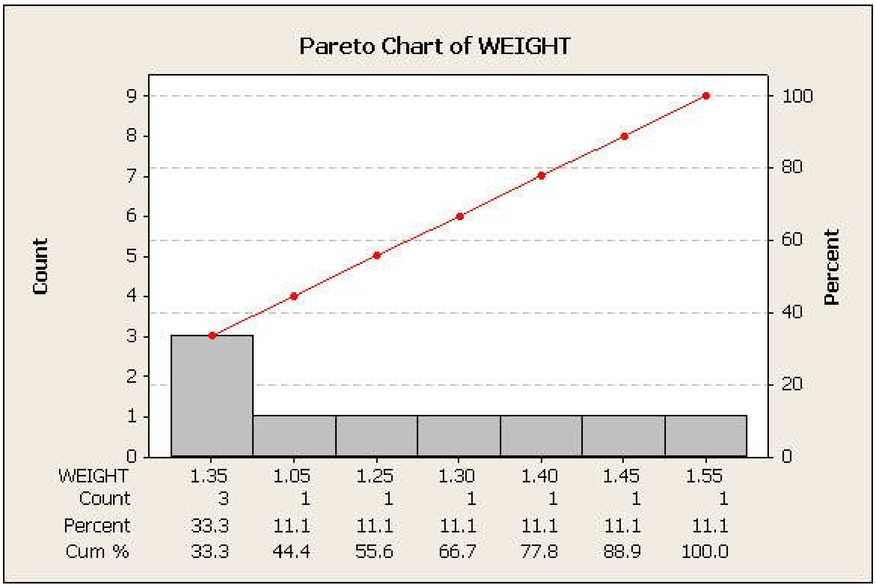

Fig 4 Pareto Chart for weight

Discussion of Results

From table 1, nine runs were carried out at various temperatures and time values. It can be seen that the average value for highest weight occurred on the first run at temperature of 90^{0}C and at time 15mins which indicates a better peeling rate while the lowest value for average weight occurred at the eighth run at temperature 80^{0}C and at time 5mins indicating a poor peeling rate. This implies that the higher the temperature and time, the better the rate of peeling and the lower the temperature and time the lower the peeling rate.

Interval level code for temperatures at 90^{0}C, 80^{0}C and 70^{0}C were taken as 90^{0}C to represent the highest temperature, 70^{0}C to represent the lowest temperature and ΔX which represent the average to be 80^{0}C. Also, time intervals of 15mins to represent the highest temperature, 5mins to represent the lowest temperature and ΔX which represent the average to be 10mins.

In table 3 the P-values represent predicted values. It forecasts the best parameter for the process. The table is used to get the regression equation for the model. The positive values of T (time) indicates that if there is an increase in time, it will still give a good value for weight after peeling. The negative values indicating a decrease in time will be favourable. S having a value of 0.05358 is the estimated standard deviation of the error which is less than the α-value of 0.05. R-sq is the coefficient of determination which indicates how much variation and response is explained by the model. It is used to explain the level of accuracy. The value of R-sq is beat from 90% and above and from the table the value of R-sq is 94.4% which accounts for the variance in weight. The higher the value of R-sq the better model fits the data. The R-sq (adj) accounts for the number of predictors in the table. R-sq is at a value of 85.1% which indicates the adjusted cause of the error.

Linear sequence and interaction between the factors are used to explain the table for analysis of variance of weights. This is used to determine the least factor that will give the best result. The significant P-value or α-value is 0.05, any value greater than this is regarded as insignificant. The P-value for regression, linear and square are less than 0.05 which indicates that they fit the regression model while interaction is larger than 0.05 therefore it is discarded because it is insignificant. Adj SS and Adj MS values are used to calculate P.

A good standard by which to evaluate the model is to look for the P-values. In the estimated regression table for weights using uncoded units, it gave rise to large values indicating it is not appropriate for the regression model.

The line is the ideal (regression equation) plot for residual. Points are to be close and not very far off from the line. From the normal plot of residuals for weights, the response is weight and it can be seen that the points are close to the line indicating it conforms to the regression factorial design

On the contour plot of weight vs time, temperature, the relationship between the time and temperature is examined where the two variables are represented on the X and Y axis. The graph is a dimensional representation of the quadratic box in fig 3 looking at it from the top. Weight represents the curve. From the graph at the mid temperature of 80^0C at time 7.5mins, the weight yield is minimal. As temperature increases with time the weight yield curve reaches its maximum.

Surface plot shows how a response variable (weight) relates to two factors in this case time and temperature. From the plot, it can be seen as a three dimensional representation. The response variable of any surface plot is always on the left hand side. The plot is curved because the regression model equation is of a quadratic type. This plot indicates highest and lowest values. From the plot the highest value for time is at 15mins and that of temperature 80^0C while the lowest values are at 5mins and 70^0C indicating at higher temperature and temperature the weight is at maximum.

A pareto chart is a bar chart that orders the bars from largest to smallest along with a line that shows the cumulative percentage and count of the bars. The chart in fig 4 helps to focus improvement effort on errors where the largest gains can be made. From the chart ir shows that the most frequent count of runs for average weight is 1.35 while the other runs for average weight have one count each. Indicating that the largest gains are made at 1.35 there by increasing the weight yield

Conclusion

There is a strong positive interaction between temperature and time, which is resulting in higher yields of cassava weight. A positive increase in time will give good values for weight. The analysis of variance for weight determines the least factor that will give the best weight. Therefore it can be said that by increasing the time and temperature values from the interval level codes of 15mins and 90^0C, it will still give a favourable peeling effect without causing any loss in the mass of the cassava tubers.

References

1.Adetan, D.A; Adekoya, L.O. and Aluko, B.O. (2006) Theory of mechanical method of Peeling cassava tubers with knives, International Institute of Agrophysics, Polish Academy of science, Poland

2..Ajibola, O.O (2000), Adding value to the farmer's harvest: Obafemi Awolowo University inaugural lecture series, No.145. Obafemi Awolowo, university press Ltd. Ile-ife, Nigeria.

3.Bencini, M.C (1991), Post harvest and processing technologies of African stable foods, A technical compendium, Agriculture services bulletin No. 89 FAO, Rome.

4.Bruinsima, D.H., Witsenburg, W.W. and Wurden, W. (1983); Selection of technology For food processing in developing countries. Publication of the international Course in food science and nutrition, centre for agricultural publishing and Documentation Wageningen, the Netherland.

5.Diop, A. (1998), Storage and Processing of Roots and Tubers in the Tropics, Agro-Industries and Post – harvest management: Agricultural support systems Division, F.A.O, Rome, Italy.

6.Federal Institute of industrial Research (FIIR), Oshodi (2006); Cassava Production, Processing and utilization in Nigeria.

7.Hulocks,R.J, Thresh, J.M and Bellotti, A (2002) Cassava: Biology, Production and Utilization.

8.Wikipedia (2010), CASSAVA, http://www.wikipedia.com

9.Wikipedia (2010), OPTIMIZATION: MATHEMATICS, http://www.wikipedia.com

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