Effect Of Mechanised Shredding Of Cassava Roots On The Hydrogen Cyanide And Moisture Contents Of The Shreds: A Response Surface Analysis.

***Etoamaihe U. J. ,Dept. of Agricultural and Bioresources Engineering, Michael Okpara University of Agriculture Umudike, Iwe M.O. Dept. of Food Science and Technology, Michael Okpara University of Agriculture Umudike, *Corresponding Author.**

Abstract

Cassava roots in different states (fresh, steamed and dried) were shredded with a mechanized shredder. The hydrogen cyanide (HCN) and moisture contents of the shreds produced were evaluated. The results were subjected to regression analysis using response surface methodology. The moisture content of the shreds produced was influenced significantly ($P \leq 0.05$) by only the state of the cassava roots used. The highest moisture content obtained was 69.84% from fresh cassava roots at a shredder speed of 975rpm.The linear and quadratic effects of the state of cassava roots had significant effects ($P \leq 0.05$) on the HCN content of the shreds. The lowest HCN content was obtained from 3mm shredder aperture and from steamed cassava roots.

IJERT

Keywords: shredder, moisture content, hydrogen cyanide, response surface analysis

1.0 Introduction

Cassava is one of the most important crops in Africa. It derives its importance from the fact that its starchy roots are a low cost source of calories, especially in African countries where protein-calorie deficiency related malnutrition is widespread. The leaves and tender shoots of cassava are also consumed as vegetables that are rich in vitamins and proteins (Krochmal and Hahn, 1991).

Cassava varieties are often classified according to the levels of hydrocyanic acid (HCN) in their roots and leaves (IITA,1990). Hydrogen cyanide is a colorless extremely poisonous liquid that boils slightly above room temperature at 26^0C. Hydrogen cyanide is a linear molecule with a triple bond between carbon and nitrogen.

Cassava consists of 60 to 70% water (IITA, 1990). Processing it into dry form reduces the moisture content and converts it into a more durable and stable product with less volume which makes it more economically transportable and storable. Processing is also necessary to eliminate or reduce the level of cyanide in cassava and to improve the palatability of the food products (Agriga and Iwe, 2008).

The response surface methodology (RSM) are a collection involving experimental strategy, mathematical methods, and statistical inferences which when combined, enable the experimenter to make an efficient empirical exploration of the system in which he is interested, (Myers and Montgomery, 1995; Agriga and Iwe, 2008). RSM uses a sequential philosophy of experimentation the ultimate goal of which is to optimize a process. Response surface methodology uses the fewest possible number of experimental runs to achieve process optimization. It is therefore efficient for both experimentation and optimization (Lah *et al.*, 1980.,Iwe, 2008).

The objective of the present work was to apply statistical methods to optimize the HCN and moisture contents of cassava shreds produced from a locally developed cassava shredding machine.

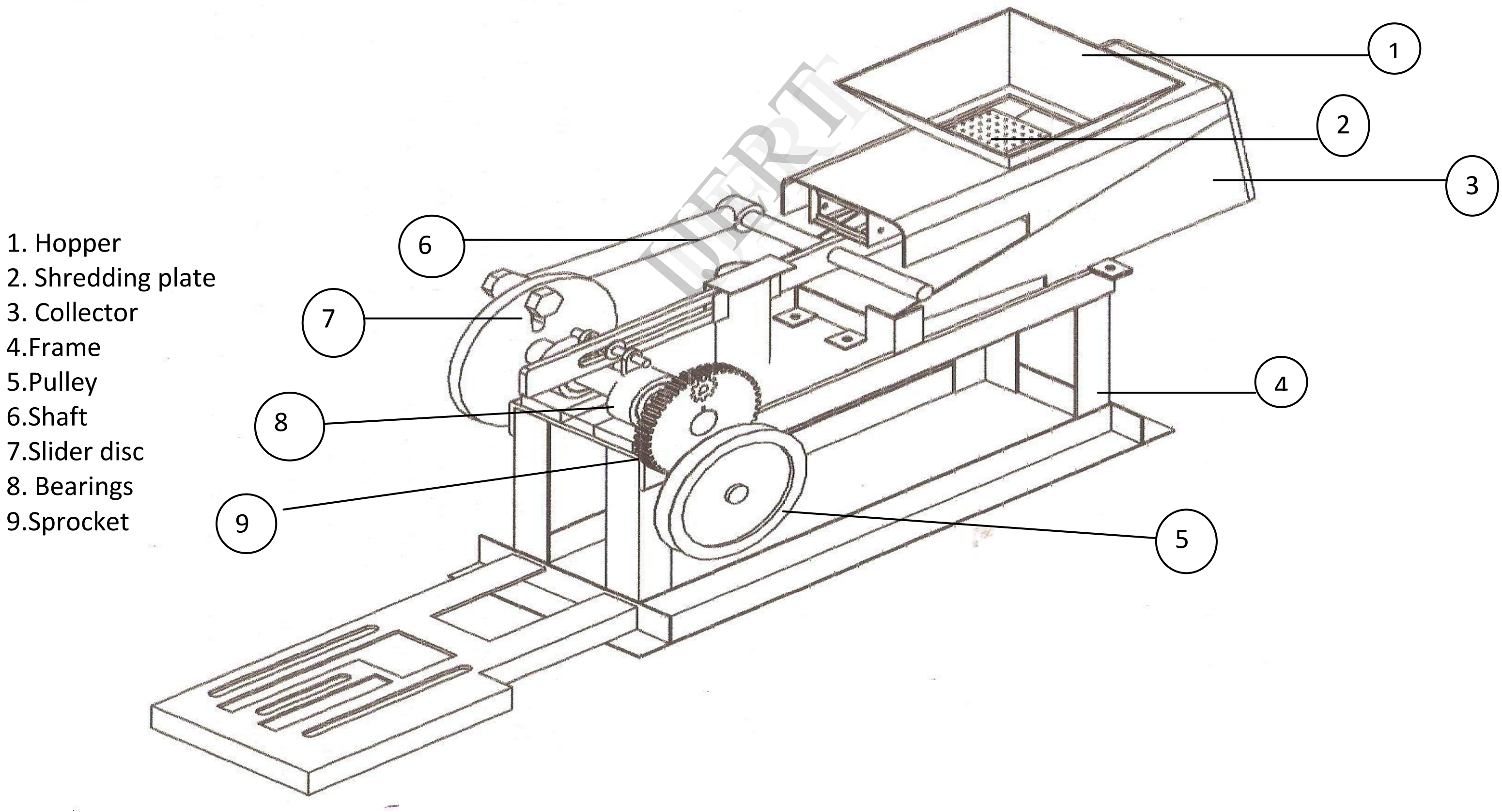

Fig.1 : Isometric View of The Cassava Shredding Machine

2.0 Materials and Methods

2.1 Determination of the HCN Content

A mechanized cassava shredder (Fig.1) was used for the tests. Three samples of the same cassava roots in different states, namely fresh, steamed and dried, were peeled, washed and separately shredded with the machine at three different speeds of operation, using three different shredding disc apertures of the machine. The same specie of cassava roots obtained from the University of Agriculture Umudike (TMS 30572), farm was used for all the tests. The experiments were planned using the Central Composite Design of Response Surface Methodology with fifteen runs. The steamed specimens for the tests were obtained by boiling fresh cassava root in water for about 20 minutes on a standard 80cm diameter gas ring and later cooled, while the dried specimens were obtained by drying fresh cassava roots in an oven at 100^0C for six hours.The method used for the determination of the HCN content of the cassava shreds produced by the machine was the one outlined by Onwuka (2005).In this method, 5gm of each cassava shred sample was ground into a paste and dissolved in 50ml of distilled water in a conical flask. This was allowed to stay overnight for solubilization of cyanide ions. The solution was later filtered. 2ml of the filtrate solution was transferred into a conical flask. 4ml of alkaline picrate solution was added to the mixture and then incubated in water bath for 5mins at a temperature of 60^oC for colour development (reddish brown) and absorbance was taken at 490nm with a Jenway spectrophotometer.

The cyanide content was extrapolated applying a cyanide standard curve by using the equation;

$$HCN_{(mg/kg)} = \frac{V_f}{V_a} \times \frac{1}{10^6} \times \frac{100}{W} \times \frac{1000}{1} \qquad (1)$$

When Vf = Total volume of extract (ml)
Va = Volume of extract used (ml)
W = Weight of sample used (mg)

The cyanide standard curve was obtained by preparing concentrations of KCN solution containing 5 to 50µg cyanide in a 500ml conical flask. 25ml of 1N HCL was added to the mixture. Using different concentrations of this mixture a cyanide standard curve was prepared.

IJERT

Based on the experimental design used, cassava shreds that emerged from the three different shredding apertures of the machine at three different speeds of operation were tested for their HCN contents. Each test had 3 replications.

2.2 Determination of Moisture Content

The moisture contents of the cassava shreds were determined using the static gravimetric method (James 1996). In each case 5gm of the cassava shreds were put into a weighed sample can. The can and its sample contents were dried in the oven at 105^0C for 3 hours. The can and its sample contents were later removed from the oven and cooled and later reweighed. The drying, cooling and weighing were repeatedly done until a constant weight was obtained. The percentage moisture content on wet basis was determined using the equation.

$$MC_{(wb)} = \frac{W_3 - W_2}{W_0} \times \frac{100}{1} \qquad (2)$$

when, W_2 = Weight of can before drying.
W_3 = weight of can + sample after drying.
W_0 = weight of sample used.

IJERT

The three cassava shred, samples that emerged from the different apertures of the shredder at the three different speeds of operation of the machine had their moisture contents determined. In each case three replications of the moisture contents of each sample were determined, and the mean value was used.

2.3 Experimental Design, Statistical Analysis and Optimization

Response surface methodology (RSM) was used to investigate the effects of the state of cassava roots, speed and shred aperture of the cassava shredding machine on the hydrocyanic acid and the moisture content of the shreds produced. A central composite design including 15 experiments with a centre point of three factors at three levels was used (Table 1).

Experimental data were fitted to a second order polynomial model and regression coefficients obtained. The generalized second order polynomial model used in the response surface analysis was as follows:

$$Y = \beta_o + \sum_{i=1}^{3} \beta_i X_i + \sum_{i=1}^{3} \beta_{ii} X_i^2 + \sum \sum_{i<j=1}^{3} \beta_{ii} X_i X_j \qquad (3)$$

Where β_o, β_i and, β_{ii} are constant coefficients and X_i, X_j are coded independent variables linearly related to speed of machine, shred aperture and state of cassava roots.

Mathematical models were evaluated for each response by means of multiple regression analysis using Minitab software. The modeling included linear, quadratic and the interaction terms. Significant terms in the model for each response were found from the analysis of variance (ANOVA). The response curves were drawn with Matlab software.

IJERT

2.4 Results of the HCN and Moisture Contents of the Shreds Produced

Table 1: Experimental Results Data of Machine Parameters, Versus HCN/MC Contents in Coded Terms.

Runs	Speed of machine(rpm)	Shredding Aperture (mm)	State of cassava roots	HCN(mg/kg)	MC(%)
1	-1	-1	-1	32.68	65.41
2	-1	-1	1	42.75	73.62
3	-1	1	-1	36.38	62.32
4	-1	1	1	43.75	76.42
5	1	-1	-1	32.7	64.3
6	1	-1	1	40.6	73.2
7	1	1	-1	39.7	64.7
8	1	1	1	44.2	75.6
9	-1	0	0	21.2	70.32
10	1	0	0	14.7	72.11
11	0	-1	0	15.5	71.21
12	0	1	0	16.5	73.01
13	0	0	-1	28.7	64.66
14	0	0	1	43.2	76.22
15	0	0	0	17.32	71.46

IJERT

Coding

Speed: 1=975rpm, 0=650rpm,-1=325rpm
Shred Aperture: 1=10mm, 0=6mm,-1=3mm
State of Cassava Roots: 1=Fresh, 0=Steamed,-1=Dried

3.0 Results and Discussion

3.1 HCN Content of the Cassava Shreds

The estimated regression coefficients associated with the HCN content of different cassava shreds produced with the machine are shown in Table 2. The linear and quadratic effects of state of the cassava were significant ($P \leq 0.05$). The other variables had no significant effects on the HCN content. From the analysis of variance Table 3, linear and quadratic effects of the state of the cassava accounted for 97.7% of the total variation in the response (HCN) content, with the highest overall values from fresh cassava roots. This shows that fresh cassava roots obviously have more HCN content than other samples. The result is in line with the works of (Kay *et al*, 1987,Okoli *et al.*,2012, and Enyenihi *et al.*, 2009.), which showed that a lot of the hydrocyanic acid in fruits and vegetables is lost during soaking and cooking, so that its content in the vegetable and fruits poses no danger of toxicity, after such processing. From Figure 2, the HCN content of the cassava shreds had the lowest value of 14.6mg/kg from a shred aperture of 3mm and a speed of 650rpm. In Figure 3, the lowest value of HCN content (16.32mg/kg) was obtained when the cassava was steamed and shredded at machine speed of 650rpm. This also confirms that processing operations such as steaming, washing etc, can reduce the HCN content of cassava (Morgan and Julius 2012, Cardozo *et al.*, 2005, Brainbridge *et al.*, 1998). Finally from Figure 4, the lowest value of HCN content was 5.47mg/kg and it was obtained when the cassava was steamed from a shred aperture of 3mm.

Table 2: Estimated Regression Coefficients For HCN Contents Versus Speed, Shredding Aperture and State of Cassava Roots.

IJERT

Predictor	Coef	StDev	T	P
Constant	15.956	1.568	10.18	0.000
Speed	-0.4860	0.9223	-0.53	0.621
Shred aper	1.6300	0.9223	1.77	0.137
State of root	4.935	1.077	4.58	0.006
Speed* speed	2.334	1.819	1.28	0.256
Shred aper*shred aper	0.384	1.819	0.21	0.841
St. of rt*st.of root	20.334	1.819	11.18	0.000
Speed*shred aper	0.737	1.031	0.72	0.506
Speed*st. of root	-0.003	1.244	-0.00	0.998
Shred aper*st of root	-1.254	1.390	-0.90	0.409

S = 2.916   R-Sq = 97.7%   R-Sq(adj) = 93.5%

Table 3: Analysis of Variance for HCN Contents

Source	DF	SS	MS	F	P
Regression	9	1786.76	198.53	23.34	0.001
Error	5	42.53	8.5		
Total	14	1829.29			

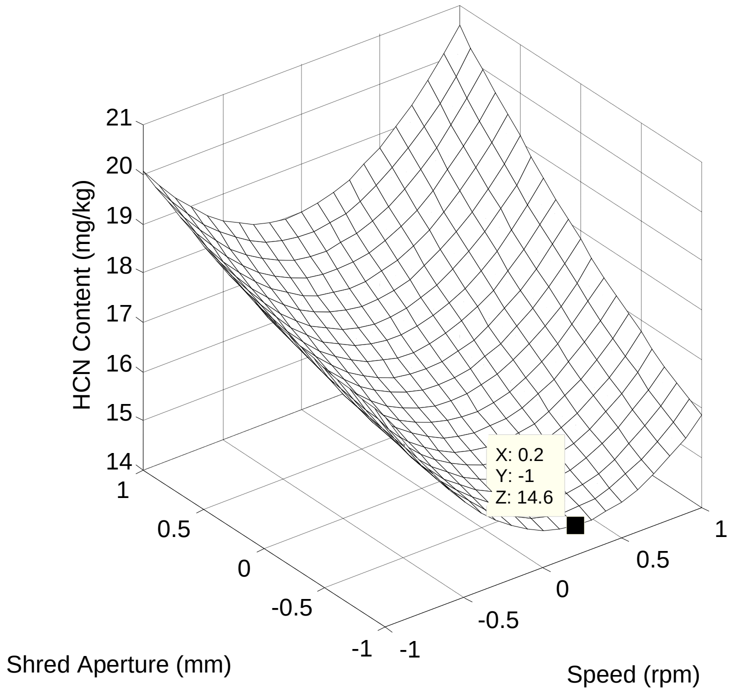

Fig. 2: Response Surface Curve of Effects of Speed and Shred Aperture on the HCN Content

IJERT

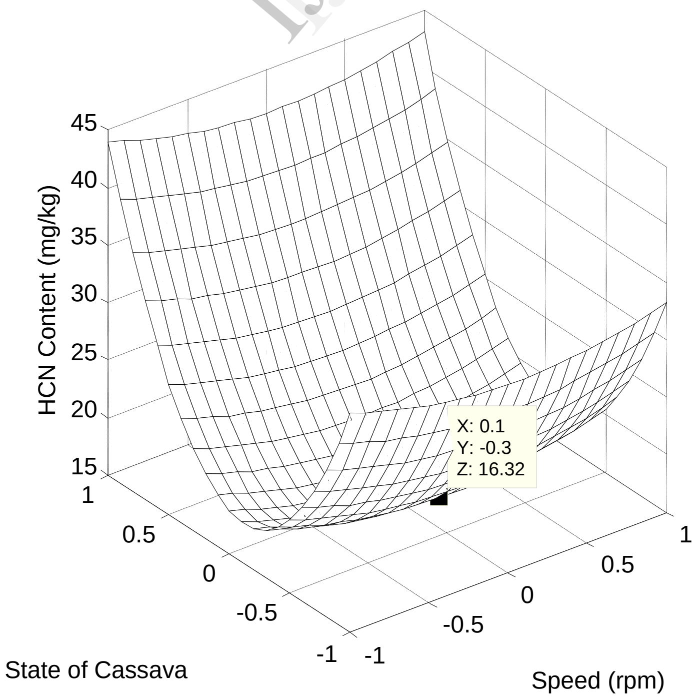

Fig 3: Response Surface Curve of the Effects of Speed and State Of Cassava on the HCN Content

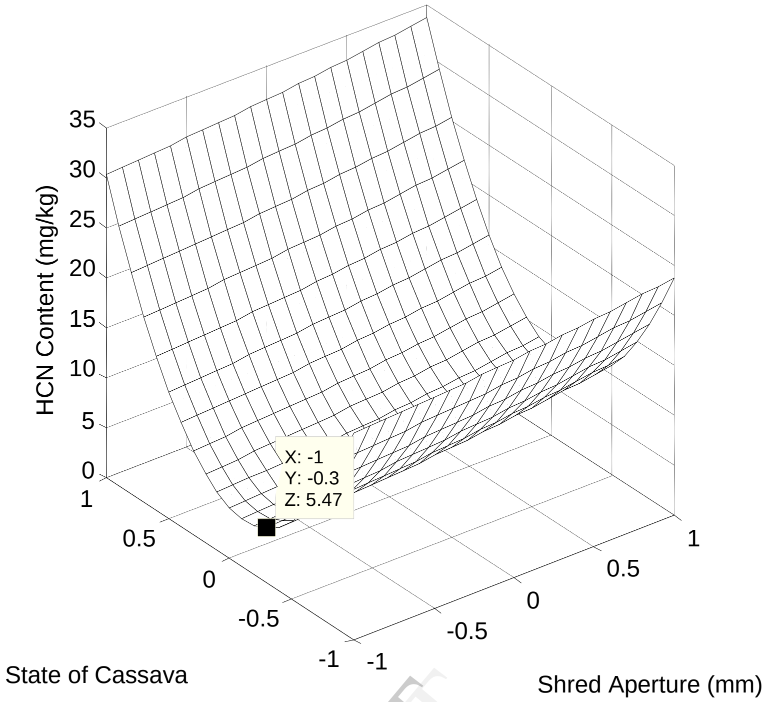

Fig. 4: Response Surface Curve of the Effects of Shred Aperture and State Of Cassava on the HCN Content

IJERT

3.2 Moisture Content of Cassava Shreds .

Table 4 shows the result of the regression on the data on moisture contents of the cassava shreds produced with the machine. The linear effects of state of the cassava was the only variable that was significant ($P \leq 0.05$) on the moisture content. The other studied variables had no significant effects. The state of the cassava accounted for 98.8% of the variation in the response. The analysis of variance, (Table 5) showed that the variable had significant effects ($P \leq 0.05$) on the moisture contents.

This result is expected as the steamed or oven dried cassava root have lower moisture content when compared to fresh roots as a result of the heat treatment causing drying, (Wilhemina *et al* 2009). This shows that drying is an efficient way to reduce moisture content of food materials (Igbeka,1987,). The response surface plot in Figure 5 shows that moisture content increased with shred aperture, having a maximum value of 65.43% at the speed of 975rpm from a shred aperture of 10mm.

Also in Figure 6, the moisture content increased with speed of the machine and had highest values for fresh cassava shreds. The moisture value of 69.84% was obtained at

975rpm and for fresh cassava shreds. In Figure 7, the moisture content also increased with shred aperture and had the highest overall value of 86.85% for fresh roots from 10mm shred aperture.

Table 4: Estimated Regression Coefficients for Moisture Content Versus Speed, Shredding Aperture and State of Cassava Roots.

Predictor	Coef	StDev	T	P
Constant	71.9573	0.5612	128.23	0.000
speed	0.1820	0.3302	0.55	0.605
shred aper.	0.4310	0.3302	1.31	0.249
St. of rt.	4.8691	0.3856	12.63	0.000
Speed*speed	-0.8667	0.6511	-1.33	0.241
Shred aper*shred aper	0.0283	0.6511	0.04	0.967
St. of rt *st.of rt	-1.6417	0.6511	-2.52	0.053
Speed*shred aper.	0.3863	0.3691	1.05	0.343
Speed*st. of rt.	-0.9361	0.4452	-2.10	0.089

S = 1.044 R-Sq = 98.3% R-Sq(adj) = 95.2%

IJERT

Table 5: Analysis of Variance for Moisture Content

Source	DF	SS	MS	F	P
Regression	9	314.129	34.903	32.02	0.001
Error	5	5.450	1.090		
Total	14	319.579			

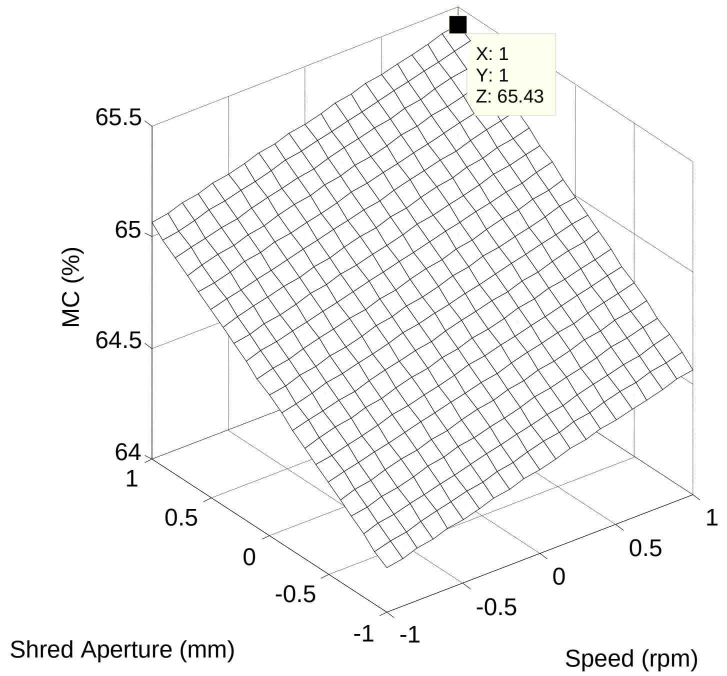

Fig. 5: Response Surface Curve of the Effects of Speed and Shred Aperture on the Moisture Content

IJERT

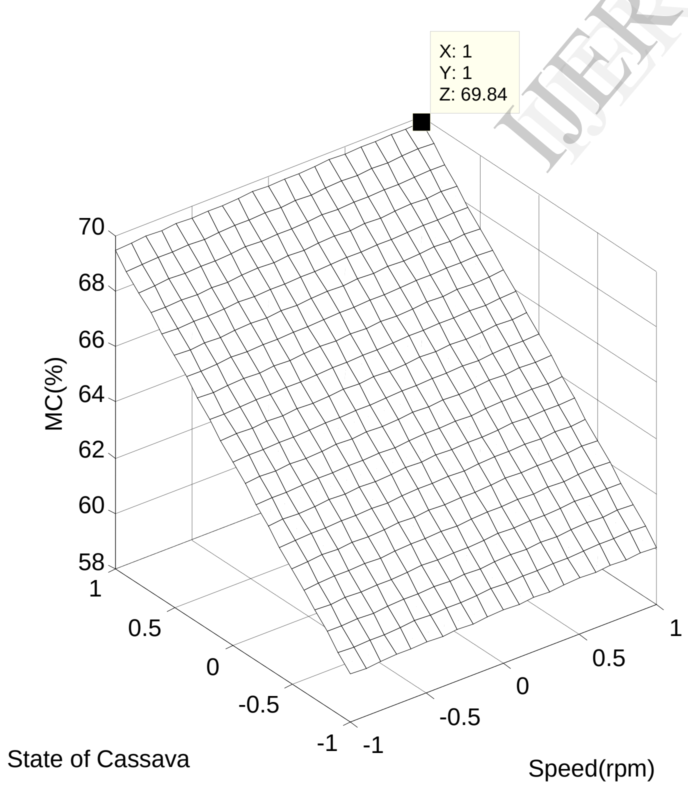

Fig. 6: Response Surface Curve of the Effects of Speed and State Of Cassava on the Moisture Content.

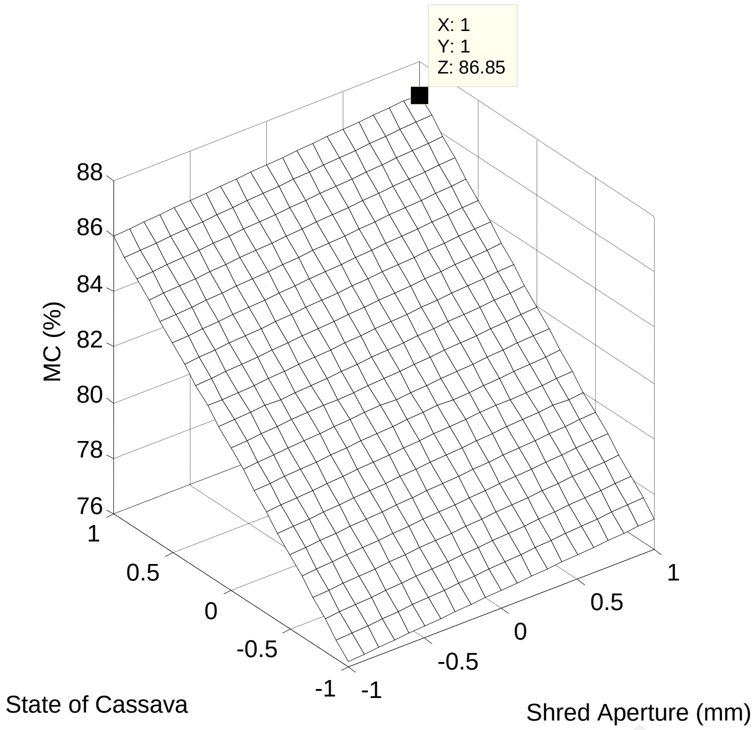

Fig. 7: Response Surface Curve of the Effects of Shred Aperture and State of Cassava on the Moisture Content

IJERT

4.0 Conclusions

The moisture content of the cassava shreds (*ighu)* produced was influenced significantly by the state of the cassava roots used and not by speed or shredding aperture of the machine. The highest moisture content of the shred was 69.84% and it was obtained from fresh cassava shreds at 975rpm machine speed. The linear and quadratic effects of the state of the cassava roots significantly affected the HCN content of the shreds produced by the machine. The lowest HCN was obtained from 3mm shred aperture of the machine for steamed cassava roots.

REFERENCES

Agriga, A. N. and Iwe M. O. (2008). Physical Properties of Cookies Produced from Cassava Groundnut-Corn Starch Blend. A Response Surface Analysis. Nigerian Food Journal 26 (2) 83 – 96.

Brainbridge,Z., Harding,S., French,L., Kapinga,R., Westby,A., (1998).A Study of the Role of Tissue Disruption in The Removal of Cyanogens During Cassava Root Processing. Journal of Food Chemistry 62 (3):291-297

Cardozo A.P.,Mirione,E., Ernesto M., Massaza F., Cliffc,J., Haque,R.M., Bradbury H., (2005). Processing of Cassava Roots to Remove Cyanogens.Journal of Food Composition and Analysis 18(2005) 451-460

Cooke, R. D. and Maduagwu, E.N. (1978). The Effects of Simple Processing on the Cyanide Content of Cassava Chips J. Food Technol 13:299-306

Enyenihi G.E., Udedibie A.B.I., Akpan M.J., Obasi O.L and Solomon I.P (2009). Effects of 5Hr Wetting of Sundried Cassava Tuber Meal on the Hydrocyanide Content of Three Processed Cassava Products Used for Feeding Poultry in Nigeria. Asian Journal of Animal and Veterinary Advances 7:334-340

Grace, M. (1971) Processing of Cassava. Food and Agriculture Organization of the United Nations Agricultural Services Bulletin, No.8.Rome Italy: FAO, pp124.

Igbeka J.C (1987).Simulation of Moisture Profile in Stored Gari. Journal of Food and Agriculture 1:5-9

International Institute for Tropical Agriculture (1990) Cassava In Tropical Agriculture. A Reference Manual. Balding and Mansell International Wisbech. pp 86-97.

Iwe, M. O. (2008). Food Processing as a Hub of National Food Security. An R & D Track in Extrusion Cooking and other Techniques for Handling Tropical Crops for Food use. Seventh Inaugural Lecture, Michael Okpara University of Agriculture, Umudike,pp 60-61.

James C.S (1996) Chemical Analysis of Foods 7th edn. Churchill Livingstone,Edinburgh,pp 88-92.

Kay, D. E. (Revised by Gooding E.G.B.) (1987). Crop and Product Digest No2; Root Crops. Second Edition London: Tropical Development and Research Institute College London W8,5SJ England.

Krochmal, A. and Hahn, S. K. (1991) Tropical Root Crops in A Developing Economy: Proceeding of the Ninth Symposium of the International Society for Tropical Root Crops Accra, Ghana,pp 57-62.

Lah,C.L., Cheryan, M and Devor R.E (1980).A Response Surface Methodology Approach to the Optimization of Whipping Properties of an Ultrafiltered Soy Product .J.Food Sci. 45,1720

IJERT

Mahungu, N.M ,Yamaguchi,Y ,Almazan A.M ,Hahn S.K.(1987) Reduction of Cyanide during Processing of Cassava into Some Traditional African Foods. Journal of Food and Agriculture 1:11-15.

Morgan A. and Julius B.L. (2012).Potential of Fermentation in Detoxifying Toxic Cassava Root Tubers.Journal of Agricultural Science and Technology A2 (2012) 1182-1188

Myers, R. H. and Montgomery, D. C. (1995). Response Methodology: Process and Product Optimization using Designed Experiments. John Wiley New York,pp 101-103.

Okoli I. C., Okparaocha C.O., Chinweze C.E. and Udedibie A.B.I. (2012). Physicochemical and Hydrogen Cyanide of Three Processed Cassava Products Used for Feeding Poultry in Nigeria.Asian Journal of Animal and Veterinary Advances 7:334-340.

Onwuka, G.I. (2005). Food Analysis and Instrumentation: Theory and Practice. Naphthali Prints Lagos,pp 143-144.

Wilhemina Q.,Gayin J., Yawson I. and Pinhar W.A. (2009).Characteristics of Various Cassava Processing Methods and the Adoption Requirements in Ghana.Journal of Root Crops.Vol.35 No 1 pp 59-68.

www.wikipedia.org/wiki/Hydrogen Cyanide (2010) Accessed on 12th July 2010

IJERT