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EFFECT OF PROCESS VARIABLES ON THE ACIDITY LEVEL AND SUGAR CONCENTRATION ON PINEAPPLE FRUIT MATURITY

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Abstract: **Urban lifestyles have contributed to consumers need for convenient and nutritious food products. This research was aimed at determining the optimum harvest time, storage temperature and the best variety of pineapple fruits (Anana Cosmosus) that could be used in juice and wine production. The maturity indices used were the acidity level and sugar concentration. Observations showed that as the fruit matures with time, the acidity level decreases while the sugar concentration increases. The empirical model developed at ($P \leq 0.0001$) showed that Optimum Harvest Time is 15weeks; Storage Temperature is 9.8℃ and Carbazoni or smooth Cayenne as the best variety. The results would provide relevant information /data which the pineapple grower and processor need to make intelligent harvest decisions.**

Keywords: **Pineapple fruits, Acidity level, Sugar Concentration.**

1. INTRODUCTION

Pineapple is the second most harvest fruits of importance after bananas, contributing to over 20 % of the world production of tropical fruits [1]. Nearly 70% of the pineapple is consumed as fresh fruit in producing countries. Its origin has been traced to Brazil and Paraguay in the Amazon basin where the fruit was domesticated [2]. Worldwide production started by 1500BC when pineapple was propagated in Europe and the tropical regions of the world. The most spread variety is Cayena lisa (Smooth Cayenne) which was first introduced in Europe from French Guyana [2]. It was until late XIX century that canned pineapple was produced commercially in Hawaii. Thailand, Philippines, Brazil and China are the main pineapple producers in the world supplying nearly 50 % of the total output [7]. Other important producers include India, Nigeria, Kenya, Indonesia, México and Costa Rica, and these countries provide most of the remaining 50% of the fruits. Maturity of fruits depends on the sugar concentration and acidity level [4]. As the sugar contents increases, the acidity of a matured fruit decreases [4]. This assessment which follows the fruit maturity development as it grows can be used to determine the time of harvest [5]. The timing of fruit harvest has a great impact on wine quality. A wine will express the same characteristics as those of the fruit at harvest and is therefore no greater in quality than the fruit it is made from [1]. Physiological changes in the fruit such as increase in sugar concentration, the maturation of tannins and development of aromas would occur, as ideal level of each coincides with a single harvest date. Howbeit, different fruit components such as those mentioned above, changes at different rates and remain largely independent of each other. Since it is hard for one to determine the ideal level of maturity, an approach using multiple criteria to determine fruit maturity is implemented and its definition will vary according to the fruit and the desired wine type [7]. However, in

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pineapple maturity, the colour change of the fruit exterior from green to yellow is the most common method of determining maturity. Fruits harvested during the warm season are picked when the basal eyes show a pale green colour. During the cool season, fruits mature slowly and they are not picked until the eyes at the base turns yellow [12]. If a pineapple contains too much acid, the fruit quality falls [9]. The acid-to-sugar ratio of the fruit helps determine whether a specific cultivar is produced for canning or for fresh use. Acid content varies with the climate and the season of the year. Flavor changes as harvested fruit ages, but sugar levels remain the same as when cut from the plant. The cool season fruits tend to be lower in sugar and higher in acid concentration than warm season fruits [11]. Thus this research is aimed at investigating the level of acid and sugar required in a pineapple for the production of high quality wine.

2. EXPERIMENTAL

Materials and Equipment

The test fruit (pineapple) sample was obtained from the horticulture unit of the National Root Crop Research Institute, University of Agriculture Umudike, Abia State Eastern province of Nigeria. Laboratory and other materials used in the bench work were obtained from the same Institute. Some of the Instruments used included: Sartores Digital balance, carbolated moisture attraction oven, GFL electric water bath, Jenway digital spectrophotometer, clipton with stirrer, general laboratory glassware materials and consumables. Reagents used included: distilled water, sodium hydroxide, anthrone powder, hydrochloric acid, glucose powder and phenolphthalein

Preparation of the samples

The pineapple sample was peeled to reveal the mesocarp. The sample was bisected symmetrically. The first part was used for determining the titratable acid while the other was used for the determination of the sugar concentration.

Determination of acidity level

The alkaline titration method described by [14] was employed. A measured weight 5.0g of the sample was put in a warren blender and 100ml of distilled water free of CO_2 was added to it. It was carefully transferred into a conical flask after homogenization and three drop of Phenolphthalein indicator was added to it. The solution was titrated with 0.1moldm^{-3} sodium hydroxide. Titration was done to a pink colour end point which persisted for 15 seconds. The titratable acidity was calculated and expressed as a percentage of the weight of the sample analyzed in terms of the most predominant acid in the test fruit sample. It was calculated with the formula below:

$$\%T.A = \frac{100}{W} \times N \times \frac{\varepsilon.q.wt}{1000} \times V_T$$

Where, W= weight of the sample

N= Normality of the Titrant

$\varepsilon.q.wt$ = Equivalent weight of the predominant acid.

V_T = Titre value or volume of the titrant

T.A = Titratale acid

Determination of sugar concentration

The Anthrone calorimetry method of [14] was used in the determination of the sugar concentration. 5g portion of the sample prepared was measured and dispersed in 50ml of 80% ethanol in a conical flask. The mixture was kept in boiling water for 30 minutes before it was filtered. The residue was treated again with another 50ml portion of the 80% ethanol and extracted as before. The filtrates were mixed together to make up 100ml of the solution. 2ml aliquot of the extract was transferred to a test tube and placed in a water bath to evaporate to dryness. 4ml of the anthrone reagent was added to it and boiled for 10 minutes in a water bath with test tube covered, after which the test tube was removed and allowed to cool to room temperature and its absorbance was measured at 625nm in a spectrophotometer machine. A standard sugar solution was prepared and diluted to 0.05%. 2ml portion of the sugar solution was treated as described above for the

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sample and 2ml of ethanol also treated in the same way. The two served as a standard and reagent blank respectively. All the absorbances were read with the reagent blank at zero. The sugar concentration was calculated as follow:

$$\%Sugar = \frac{100}{W} \times C \times \frac{au}{as} \times \frac{vf/va}{va}$$

Where,

W = weight of the sample in grams

au = absorbance of the test sample

as = absorbance of standard glucose solution.

Vf = Total volume of extract analyzed

Va = volume of extract analyzed

C = concentration of the test sample in percentage

3. RESULTS AND DISCUSSION

Variation in sugar concentration with time

The concentration of sugar level in the test sample was analyzed using the standard method as described by Anthrone calometric method using spectrophotometer. From Figure 1 below it can be seen that the concentration of sugar in each variety of pineapple was very small at week 3 and 6 but increases significantly as the number of weeks increases. This clearly buttress that the concentration of sugar increases as the pineapple fruits mature as contained in the literature [12].

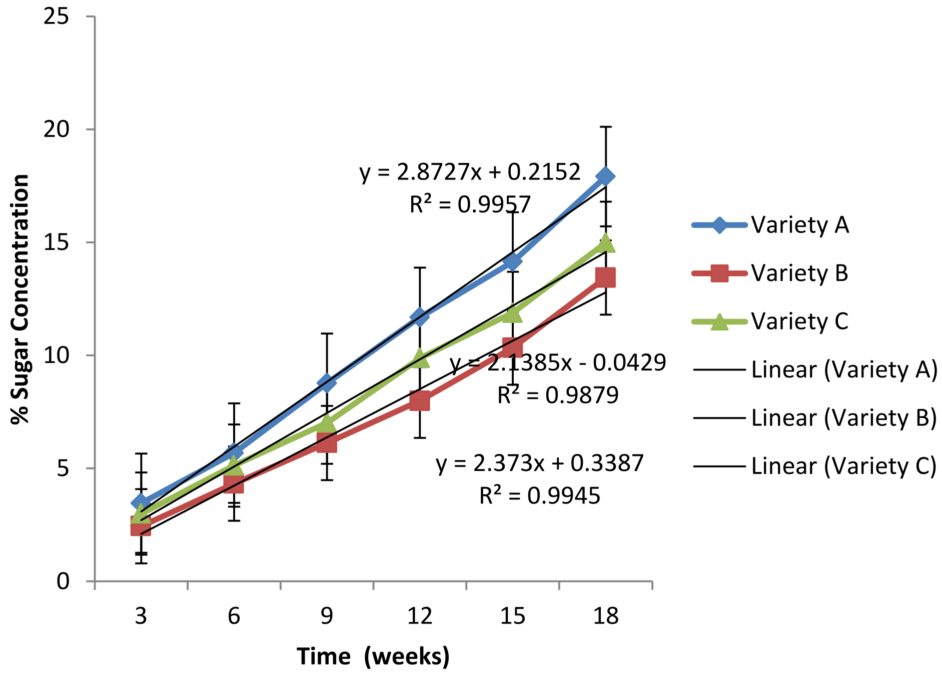

Figure 1: % Change in Sugar concentration with time (weeks)

Variations of acid concentrations with time

Pineapple fruits contain different variety of acids such as Citric acid, Ascorbic acid and Pantothenic acid. Ripe pineapple also contains some percentage of malic acid but the concentration of Citric acid predominates in pineapple fruits. The acid level in the fruit was determined by titrating the fruit juice (test samples) with a standard alkaline solution. From Figure 2

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it can be seen that the acidity level of each variety of pineapple decreases as the fruit attains maturity which shows that acidity level is higher in early stage of pineapple fruit development.

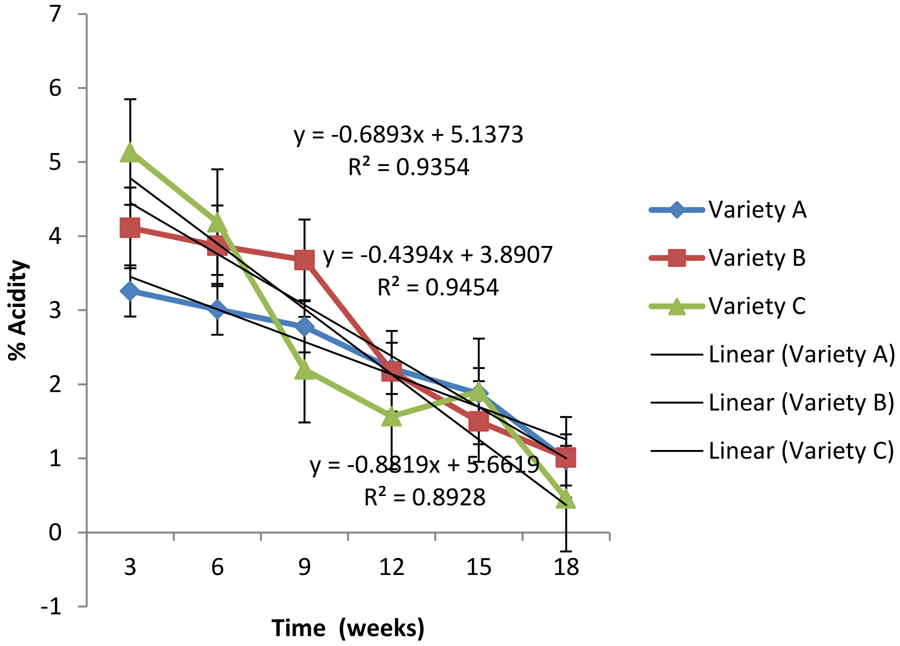

Figure 2: % Change in acidity level with time (weeks)

Effect of Storage temperature, variety of fruits and time on the sugar concentration

In order to study the effect of the three independent variables (Time, Variety of Fruits and Storage temperature) on sugar concentration, Box- Behnken design of experiment was employed.

The three varieties of pineapple studied were classified using their weights.

Variety A = Carbazoni or Smooth cayenne - cylindrical shaped ranges from 2.3 - 4.5kg

Variety B = Pernambuca – cylindrical shaped ranges from 1.4 - 1.8kg

Variety C = Spanish Squarish - cylindrical shape ranges from 1.4 - 2.3kg

Parameters
Time (weeks) X_1 3 to 18
Variety (kg) X_2 1.4 to 4.5
Storage Temperature (^oC) X_3 7.2 to 12.8

Table 1: DOE represented in coded values

Parameter	Low Level	Null Level	High Level
Time (weeks) X_1	3 (-1.000)	10.5 (0.000)	18 (+1.000)
Variety (kg) X_2	1.4(-1.000)	2.95 (0.000)	4.5 (+1.000)
Storage Temperature (^oC) X_3	7.2 (-1.000)	10 (0.000)	12.8 (+1.000)

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Table 2: Analysis of variance for the effect of independent variables on sugar concentration of pineapple fruits

Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	Remark
Model	89.66	9	9.96	112.64	< 0.0001	Significant
X_1-Time	16.27	1	16.27	184.01	< 0.0001	
X_2-Weight	1.20	1	1.20	13.58	0.0078	
X_3-Temperature	9.113E-003	1	9.113E-003	0.10	0.7576	
$\mathbf{X_1X_2}$	2.46	1	2.46	27.87	0.0011	
$\mathbf{X_1X_3}$	0.051	1	0.051	0.57	0.4740	
$\mathbf{X_2X_3}$	5.06	1	5.06	57.24	0.0001	
$\mathbf{X_1^2}$	9.70	1	9.70	109.67	< 0.0001	
$\mathbf{X_2^2}$	26.01	1	26.01	294.07	< 0.0001	
$\mathbf{X_3^2}$	22.42	1	22.42	253.56	< 0.0001	
Residual	0.62	7	0.088			
Lack of Fit	0.61	3	0.20	149.29	0.0001	Significant
Pure Error	5.480E-003	4	1.370E-003			
Cor Total	90.27	16				

Std. Dev.	0.30	R-Squared	0.9931
Mean	89.02	Adj. R-Squared	0.9843
C.V. %	0.33	Pred. R-Squared	0.8912
PRESS	9.83	Adeq. Precision	27.498

$$Y = 11.99 + 1.43X_1 + 0.39X_2 + 0.78X_1X_2 + 1.13X_2X_3 - 1.52X_1^2 - 2.49X_2^2 - 2.31X_3^2$$

R-Squared of 0.9931 implied that the regression model accounted for 99.31% of the data in the experiment and thus signified that there is a very strong relationship between dependent and independent variables. The "Pred R-Squared" of 0.8912 is in reasonable agreement with the "Adj R-Squared" of 0.9843; i.e. the difference is less than 0.2. This is statistically significant. "Adeq Precision" measures the signal to noise ratio. A ratio greater than 4 is desirable. Statistically, a ratio of 27.498 indicates an adequate signal. This model can be used to navigate the design space.

Table 3: Numerical Optimization

Solution Number	Time*	Variety*	Temperature*	Desirability	Remark
1	15	3.4	9.8	1.000	Selected

From Table 3, 15weeks, 3.4kg Variety (Carbazoni or smooth cayenne) and storage temperature of 9.8℃ were selected as the best conditions for the study.

4. CONCLUSION

The model developed was statistically significant, which shows that it can be used by wine and fruit juice makers to predict the actual time to harvest the pineapple fruits, the right condition of storage (temperature) and the best variety of pineapple to use. Finally, as the pineapple fruits mature, the acidity level decreases while the sugar concentration increases.

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