MODELLING THE RETENTION OF ASCORBIC ACID IN ORANGE JUICE

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INTRODUCTION

In the course of storage and distribution of orange juice there is an inevitable decline in quality value. The loss occurs because of the sensitivity of the ascorbic acid content of juice[1]. Ascorbic acid level is usually the criterion for judging fruit juice quality. It is the responsibility of orange juice manufacturers to ensure that quality losses in juices be minimal. The juice manufacturer must seek to control the changes, which reduce the quality value of their products. Thus, it is necessary to establish an analytical approach to the chemistry of fruit juice preservation so as to be able to specify the quality value of juices at different storage and distribution conditions.

The real problem of domestic orange juice industry is inadequate study on quality deterioration of juices and dearth of data on nutrient destruction from a quantitative, integrated standpoint. To predict the extent of deterioration of nutrient value, a knowledge of the loss of important nutritive quality as a function of the critical deterioration factors are needed[2]. Through integral modeling of the various deteriorative factors, a juice manufacturer will be able to specify the quality value of his product at the time of sale which is essential if nutrient claims are to be made on the label or advertising associated with the products.

For the domestic fruit juice industry, five main factors have been identified, as critical to the retention of ascorbic acid in fruit juices during storage and distribution. These are: (a) the level of dissolved oxygen, (b) the storage temperature, (c) the total soluble solids (brix value), (d) the pH and (e) the duration of storage[3,4]. Monitoring these factors will bring about satisfactory control of ascorbic acid degradation. In this paper, the effects of these critical factors on the ascorbic acid level under non-refrigeration storage and distribution of orange juice was investigated, shelf life and quality value of the juice were estimated, and a model based on these deterioration factors was developed.

EXPERIMENTAL TECHNIQUES

Experimental Materials

Orange fruit samples were obtained from experimental plots of National Horticultural Research Institute (NIHORT), Ibadan.

Experimental Design Methods

A five variable two-level factorial design provide the framework for the juice variable experiment. The design matrix for the 2^5 full factorial, which indicated the run-by-

run experimental design is shown in Table 1. With five variables, two levels, a complete or orthogonalized design leads to a total of 32 runs[5].
In the 2^5 full factorial experiment, the low and high levels of the factors are coded as "-" and "+", respectively. The levels of the five factors are listed in standard order in the columns $x_1, x_2, \ldots, x_5$ in the design table. The sequence of + and – signs in the columns tells us how to combine the observations to get the main effects and their interactions. Columns x_0, having only plus signs, represents the average of the entire experiment. Column $x_1, x_2, \ldots, x_5$ are the main effects while columns x_{12} through x_{12345} are the interactions.

Experiments and Presentation of Data
Data were drawn from 2^5 full factorial experiments conducted in a randomised order in three replicates according to the design matrix. The values of the varying factors and their coded levels are presented in Table 2.

Table 1: FACTORS AND THEIR CODED LEVELS

Level of Factors	Code	Independent Variables				
		X_1	X_2	X_3	X_4	X_5
Base Level	0	30 °C	10° Brix	3.2	0.08 g/litre	12 days
Interval of variation	Δx_i	10 °C	3° Brix	1.0	0.025 g/l	4 days
High Level	+1	40 °C	13° Brix	4.2	0.1 g/l	16 days
Low Level	-1	20 °C	7° Brix	2.2	0.05 g/l	8 days

Multivariate regression analysis was used for relating the variables. The functional relationship between the ascorbic acid level, y_u and the five deteriorative factors x_i (i = 1, 2, …., 5) is formulated as a linear model:

$$y_u = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_{12}x_{12} + b_{13}x_{13} + b_{14}x_{14} + b_{15}x_{15} + b_{23}x_{23} + b_{24}x_{24} + b_{25}x_{25} + b_{34}x_{34} + b_{35}x_{35} + b_{45}x_{45} + b_{123}x_{123} + b_{124}x_{124} + b_{125}x_{125} + b_{134}x_{134} + b_{135}x_{135} + b_{145}x_{145} + b_{234}x_{234} + b_{235}x_{235} + b_{245}x_{245} + b_{345}x_{345} + b_{1234}x_{1234} + b_{1235}x_{1235} + b_{1245}x_{1245} + b_{1345}x_{1345} + b_{2345}x_{2345} + b_{12345}x_{12345} + \varepsilon_i$$

Where the b's are the regression coefficients of the model, the x's are the coded variables and ε_i measures the discrepancy in the functional relationship and is a random error with zero mean and constant variance.

RESULTS AND DISCUSSION

The 2^5 full factorial experimental design technique led to the following optimal non-refrigeration storage/distribution conditions and models for predicting the ascorbic acid content:

20C storage temperature, 13° brix value, a pH of 4.2, 0.05 g/litre of antioxidant and a maximum storage duration of 16 days. At this condition, the ascorbic acid level was maintained at 22.93 mg/100ml

$$y_u = 11.76 - 2.97x_1 + 1.14x_2 - 2.05x_3 - 0.61x_4 - 2.76x_5 - 1.87x_{12} + 0.40x_{13} - 0.34x_{14} - 1.83x_{15} + 2.04x_{23} + 0.49x_{24} + 2.65x_{25} - 1.86x_{35} + 0.73x_{45} + 0.28x_{123} - 0.72x_{124} - 0.67x_{125} + 0.70x_{134} - 0.28x_{135} - 0.78x_{234} - 0.55x_{235} - 0.16x_{245} - 0.46x_{345} - 1.06x_{1234} - 1.14x_{1235} - 0.48x_{1245} - 0.61x_{1345} - 0.45x_{2345} + 1.65x_{12345}$$

where,

x_1	=	Storage temperature, °C
x_2	=	Total soluble solid, °brix
x_3	=	pH
x_4	=	Quantity of antioxidant, g/litre
x_5	=	Duration of storage, days
y	=	Ascorbic acid level, mg/100ml

CONCLUSIONS

The results of the orange juice experiments and the developed model confirms that storage temperature, brix value, pH, quantity of antioxidant and duration of storage govern the shelf life and are important for characterising the quality of fruit juices. These quality variables enable the prediction of shelf life of the juices under non-refrigeration storage and distribution. The developed model is valid only for values of x_i that fall within the intervals of values used in producing it. It is purely for non-refrigeration storage and distribution of orange juice.

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