

NIGERIAN INSTITUTION OF AGRICULTURAL ENGINEERS

National Executive Committee 2013

S/N	Name	Position	E-mail address
1	Engr. (Prof.) B. A. Adewumi	National Chairman	adewumiba@unaab.edu.ng or babatundeaderani@yahoo.com
2	Engr. (Dr.) S. M. Musa	National Vice- Chairman	shbmusa@yahoo.com
3	Engr. (Prof.) S. Z. Abubakar	Immediate Pass Chairman	Szabubakar@yahoo.co.uk
4	Engr. (Dr.) M. A. Enaboifo	National Secretary	m_aireloena@yahoo.com
5	Engr. (Dr.) J. C. Adama	Assistant National Secretary	adamajoseph@yahoo.com
6	Engr. B. G. Jahun	National Financial Secretary	bgjahun@yahoo.com
7	Engr. (Mrs.) C. A. Adamade	National Treasurer	Adamadechristiana@yahoo.com
8	Engr. (Dr.) M. K. Othman	Publication Secretary	mkothman@yahoo.co.uk
9	Engr. S. Bello	National PRO	Sabiubello64@yahoo.com or bellosabiu10@gmail.com
10	Engr. (Dr.) S. A. Iya	North East Regional Chairman	Us5iya@yahoo.com
11	Engr. (Dr.) L. A. O. Ogunjimi	South West Regional Chairman	laogunjimi@yahoo.com
12	Engr. A. A. Akintola	North Central Regional Chairman	toye_akintola@yahoo.com
13	Engr. A. L. Ijasan	South South Regional Chairman	ijasanal@yahoo.com
14	Engr. C. C. Emekoma	South East Regional Chairman	mekuga24@yahoo.com or engrace2020@gmail.com
15	Engr. J. O. Daudu	North West Regional Chairman	jodaudu@hotmail.com
16	Engr. Y. K. Dalha	Ex. Officio	ydalha@yahoo.com
17	Engr. (Mrs.) N. I. Nwagugu	Ex. Officio	nnenwagugu@gmail.com
18	Engr. I. Azogu	Executive Director, National Centre for Agricultural Mechanization, (NCAM)	ikechukwuazogu@yahoo.com
19	Eng. M. Y. Kasali	Business Manager	yommekasali@yahoo.com
20	Engr. (Dr.) F. Alonge	Auditor 1	falonge6@yahoo.com
21	Engr. (Mrs.) R. S. Samaila	Auditor 2	roysformi@yahoo.com
22	Engr. (Prof.) A. P. Onwualu	Editor-in-Chief	ponwualu@yahoo.com

JOURNAL OF AGRICULTURAL ENGINEERING AND TECHNOLOGY (JAET)

EDITORIAL BOARD

Editor-In-Chief

Professor A. P. Onwualu, FAS

Raw Materials Research and Development Council (RMRDC)
17 Aguiyi Ironsi Street, Maitama District, PMB 232 Garki, Abuja, Nigeria.
aponwualu@niae.net; ponwualu@yahoo.com Phone: 08037432497

Prof. B. Umar - Editor, Power and Machinery

Rector, Adamawa State Polytechnic, Yola, Adamawa State, Nigeria.

E-mail: bobboiumar@yahoo.co.uk Phone: 08023825894

Prof. A. A. Olufayo - Editor, Soil and Water Engineering

Agricultural Engineering Department, Federal University of Technology, Akure, Ondo State, Nigeria.

E-mail: ayo_olufayo@yahoo.com Phone: 08034708846

Prof. A. Ajisegiri - Editor, Food Engineering

College of Engineering, University of Agriculture, Abeokuta, Ogun State, Nigeria.

E-mail: ajisegiri@yahoo.com Phone: 08072766472

Prof. K. Oje - Editor, Processing and Post Harvest Engineering

Agric. and Bio-resources Engineering Department, University of Ilorin, Kwara State, Nigeria.

E-mail: kayodeoje2@yahoo.com Phone: 08033853895

Dr. A. El-Okene - Editor, Structures and Environmental Control Engineering

Agricultural Engineering Department, Ahmadu Bello University, Zaria, Kaduna State, Nigeria.

E-mail: abdullahielokene@yahoo.com Phone: 08023633464

Prof. D. S. Zibokere - Editor, Environmental Engineering

Agric. and Environmental Engineering Dept., Niger Delta University, Wilberforce Island, Yenegoa.

E-mail: zibokere@yahoo.co.uk Phone: 08037079321

Prof. C. C. Mbajorgu - Editor, Emerging Technologies

Agricultural and Bioresources Engineering Department, University of Nigeria, Nsukka, Nigeria.

E-mail: const.c.mbajorgu@talk21.com Phone: 07038680071

Prof. (Mrs) Z. D. Osunde - Editor, Processing and Post Harvest Engineering

Agricultural Engineering Department, Federal University of Technology, Minna, Niger State, Nigeria.

E-mail: zinashdo@yahoo.com Phone: 08034537068

Mr. Y. Kasali - Business Manager

National Centre for Agricultural Mechanization, PMB 1525, Ilorin, Kwara State, Nigeria.

E-mail: ncam@skannet.com Phone: 08033964055

Dr. J. C. Adama - Editor, Agricultural Mechanization

Agricultural Engineering Department, University of Agriculture, Umudike, Abia State, Nigeria.

E-mail: josephadama@yahoo.com Phone: 08052806052

Dr. B. O. Ugwuishiwu - Editor, Farm Structures and Waste Management

Agricultural and Bioresource Engineering Department, University of Nigeria, Nsukka, Nigeria.

E-mail: ugwuishiwubo@yahoo.com Phone: 08043119327

Miss I. C. Olife - Technical Assistant to Editor-In-Chief

Raw Materials Research and Development Council, Abuja, Nigeria.

E-mail: ifeeolife@yahoo.com Phone: 08033916555

EMPIRICAL MODELS FOR PREDICTION OF NUTRITIONAL PARAMETERS OF STORED BANANAS

M. O. Sunmonu¹, C. Ogbonnaya², Z. D. Osunde² and A. B. Alabadan²

¹Department of Agricultural & Biosystems Engineering,
University of Ilorin, Ilorin, Kwara State, Nigeria.

²Department of Agricultural & Bioresources Engineering,
Federal University of Technology, Minna, Niger State, Nigeria.

E-mail: sholams2000@yahoo.co.uk

ABSTRACT

A study was conducted to develop empirical models to predict nutritional parameters of stored bananas. Three sets of four different types of passive evaporative cooling structures made of two different materials; clay and aluminium were designed and constructed as part of the study. One set consisted of four separate cooling chambers. Two cooling chambers were made with aluminium container (cylindrical and rectangular shapes) and the other two were made of clay container (cylindrical and rectangular). These four containers were separately inserted inside a bigger clay pot inter-spaced with clay soil of 5 cm (to form tin-in-pot, pot-in-pot, tin-in-wall and wall-in wall) with the outside structure wrapped with jute sack. The other two sets followed the same pattern with interspacing of 7 cm and 10 cm respectively. The set with 7 cm interspace served as the control in which the interspace soil and the jute sacks were constantly wetted at intervals of between 2 to 4 hours depending on the rate of evaporation with water at room temperature. The other two sets (5 cm and 10 cm interspaced soil) were constantly wetted with salt solution (Table salt (NaCl)) at the same interval to keep the soil in moist condition. Freshly harvested matured bananas were used for the experiment and the temperature, relative humidity and decay were monitored daily. The weight, vitamin A, vitamin C, vitamin E, lycopene, bacterial and fungal counts of these produce were determined at interval of two days for a period of 10 days. Mathematical models (using essential regression software package) were developed to predict the weight, vitamin A, vitamin C, and vitamin E and lycopene contents of the stored banana at various conditions considered in the study. The existence and sufficiency of the regression models given in the equations were also examined using the analysis of variance (ANOVA) of the multiple regression models. The models were found to be at 5% level of significant. The results of the pair-wise shows that there is no significance difference between the mean of observed and the predicted for all the models developed. The R_{adj2} value obtained were 89.00%, 54.34%, 58.22% and 56.40% for vitamin A, vitamin C, vitamin E and lycopene contents respectively for the stored bananas.

KEYWORDS: Prediction, models, empirical, banana, nutritional, storage.

1. INTRODUCTION

Banana (*Musa sapientium*) is the common name for herbaceous plants of the genus *Musa* and for the fruit they produce. They are native to tropical South and Southeast Asia. Today, they are cultivated throughout the tropics (FAO, 2005). Bananas are excellent sources of vitamin B₆ and contain moderate amounts of vitamin C, vitamin A manganese, calcium, iron, phosphorous and potassium (Southgate, 1969). Along with other fruits and vegetables, consumption of bananas may be associated with a reduced risk of colorectal cancer (Deneo-pellegrini *et al.*, 1996) and in women, breast cancer (Zhang, 2009) and renal cell carcinoma (Rashidkhani *et al.*, 2005). Banana fruits can also be used in the treatment of intestinal disorder, constipation, diarrhea, dysentery, arthritis, gout, allergies, kidney disorders, anemia, tuberculosis, urinary disorders, overweight, menstrual disorders, bums and wounds (PBGEA, 2010).

The optimum conditions for ripening bananas are at temperatures of 20 - 21°C and 90% relative humidity. As the fruit ripens, sugar content increases while starch content decreases. Green bananas can be stored for up to seven days at room temperature or up to 20 days under

refrigeration. Neither green nor ripe bananas should be stored at temperatures lower than 58 °F. Ethylene gas can be applied to bananas to start the ripening process and to assure evenness of ripening. Bananas also produce ethylene gas naturally. During the ripening process, pulp temperatures should range from 58 to 64 degrees F, relative humidity should be controlled, and there should be adequate air circulation to ensure high quality fruit (Chia, 1981; Huggins *et al.*, 1990).

Preventing microbial growth is one major practice of improving the storability of fresh agricultural produce. Microorganisms such as bacteria, yeasts, molds, and viruses are ubiquitous and are widely encountered in air, water, soil, living organisms, and unprocessed food items, and cause off-flavours and odours, slime production, changes in the texture and appearances, and the eventual spoilage of foods. They can be transferred to food products through the soil, handling, tools or through the atmosphere. It is therefore prudent to preserve foods by preventing microbial growth. It can be achieved through temperature and relative humidity control, elimination of excess water, harvest handling, preventing moisture loss and sanitation. Geeson, 1983; Salunkhe, 1974; Salunkhe and Kadam, 1998; Weichmann, 1987; ITC, 2002; Wilson *et al.*, 1995; Sharma and Singh, 2000; Kader, 2002; Wilson *et al.*, 1995).

Predictive modelling is the process by which a model is created or chosen to try to best predict the probability of an outcome. A predictive model was made from a number of predictors, which were variable factors that were likely to influence future behaviour or results on banana storage. The development of this type of model is typically data driven (empirical/ inductive models) and requires minimal knowledge of the products or processes involved and it involves converting model inputs into outputs (Tijssens *et al.*, 2001).

Process modeling as described by NIST/SEMATECH(2009) is the concise description of the total variation in one quantity say, y , by partitioning it into a deterministic component of one or more other quantities such as $x_1, x_2, \dots, x_n$ and a random component that follows a particular distribution.

The general form of process model is given by;

$$y = f(x_1, x_2, \dots, x_n) + e \quad (2.1)$$

Where y is the response variable,

$f(x_1, x_2, \dots, x_n)$ is the mathematical model and,

e is the random or unexplained variation.

The response variable y is the quantity that varies in a way that we hope to be able to summarize and exploit via the modeling process. Generally it is known that the variation of the response variable is systematically related to the values of the one or more variable before the modeling process is begun, although testing the existence and nature of this dependence is part of the modeling process itself.

The objective of this study was to develop empirical models developed from various data generated from the evaporative cooling structures.

2. MATERIALS AND METHODS

2.1 Experimental Procedure

The experiment was carried out in Minna, Niger state, Nigeria and the samples of bananas were sourced from Garatu Market. The fresh bananas were stored inside the three sets of four different types of passive evaporative cooling structures for a period of 10 days. 30 samples of fresh bananas were stored in each structure. Two cooling chambers were made with aluminum container (cylindrical and square shapes) and the other two were made of clay container (cylindrical and square). These four containers were separately inserted inside a bigger clay pot inter-spaced with clay soil of 5 cm (to form tin-in-pot, pot-in-pot, tin-in-wall and wall-in wall) with the outside structure wrapped with jute sack. The other two sets followed the same pattern with interspacing of 7 cm and 10 cm respectively. The set with 7 cm interspace served as the

control in which the interspace soil and the jute sacks were constantly wetted at intervals of between 2 to 4 hours depending on the rate of evaporation with water at room temperature. The other two sets (5 cm and 10 cm interspaced soil) were constantly wetted with salt solution (Table salt (NaCl)) at the same interval to keep the soil in moist condition. Freshly harvested matured bananas were used for the experiment and the temperature, relative humidity and decay were monitored daily. The weight, vitamin A, vitamin C, vitamin E, lycopene, bacterial and fungal counts of these produce were determined at interval of two days for a period of 10 days. Mathematical models (using essential regression software package) were developed to predict the weight, vitamin A, vitamin C, and vitamin E and lycopene contents of the stored banana at various conditions considered in the study.

2.1 Determination of Temperature and Relative Humidity

The temperature and relative humidity of stored tomatoes in the two structures were taken daily using a digital thermometer and a relative humidity measuring instrument (Testo 625 Compact instrument). at 8.00am, 12 noon and 6.00pm and their average taken and compared with the average ambient temperature.

2.2 Microbial Analysis and Soil Bulk Density

The total fungal and bacterial plate counts were determined using the methods of Collins *et al.*, (2004). The bulk density was determined by core method in line with AOAC (1979).

2.3 Nutritional Parameters

Nutritional Analysis for vitamin A of the orange samples was carried out in the Central Laboratory of National Cereals Research Institute, Badeggi, Nigeria using AOAC (1995) methods of analysis. .

2.4 Preparation of Salt Solution

About 15000 parts/millions (ppm) solution of sodium chloride (NaCl) was prepared by dissolving 225g of NaCl in 15 litres of water at room temperature and 450g of NaCl in 30 litres of water at room temperature for keeping the four structures in moist condition in the 5 cm and 10 cm soil inter-space respectively. The four structures in the 7 cm soil inter space were kept in moist condition using 20 litres of water.

3. RESULTS AND DISCUSSION OF RESULTS

The data from the experiment is as presented in Table 1.

3.1 Model Equations for Stored Bananas

$$\text{VIT_A} = 8.60\text{E-}01 + 4.75\text{E-}03\text{TRF} - 7.87\text{E-}02\text{TF}^2 + 2.98\text{E-}01\gamma^2 - 2.81\text{E-}01\gamma\text{F}, R_{adj2} = 89.00\% \quad (\text{Equation 1})$$

$$\text{VIT_C} = 2.81\text{E+}01 - 8.07\text{E-}04\text{R}^2\text{B}, R_{adj2} = 54.34\% \quad (\text{Equation 2})$$

$$\text{VIT_E} = 2.07\text{E+}00 + 1.94\text{E-}02\text{SF}^2, R_{adj2} = 58.22\% \quad (\text{Equation 3})$$

$$\text{LP} = 2.07\text{E+}00 + 1.71\text{E-}02\gamma\text{F}\sigma - 3.41\text{E-}01\gamma\text{FB}, R_{adj2} = 56.40\% \quad (\text{Equation 4})$$

T=temperature, R=Relative Humidity, S=Soil Inter-space, γ =Storage Structure (1= Tin in pot or Pot in pot, 2= Tin in wall or wall in wall), γ =Material Component (1=Aluminium component, 2=Clay component), F=Fungal Count, σ =Bacterial Count, M=Soil Moisture Content, B=Bulk Density.

Table 1: Experimental Data for Stored Bananas

S/No	Fruit	SI	SS	M	T	RH	FC	BC	SMC	BD	WT	VIT_A	VIT_C	VIT_E	LP	MC
1	3	1	1	1	26.60	76.90	1.40	24.00	68.40	0.88	243.02	8.76	25.52	1.90	2.16	12.00
2	3	1	1	1	26.10	74.20	2.60	26.00	72.60	0.96	221.06	10.24	23.76	1.80	2.42	15.40
3	3	1	1	1	26.70	77.70	1.90	23.00	87.40	1.04	228.34	10.78	24.42	1.80	2.54	16.16
4	3	1	1	1	26.20	75.90	2.40	24.00	88.40	0.89	211.15	12.42	22.84	2.60	2.42	16.32
5	3	1	1	1	26.60	77.70	2.10	26.00	79.80	1.14	182.43	12.40	22.54	2.30	1.74	17.55
6	3	1	1	2	26.60	77.00	1.40	21.00	68.40	0.88	232.06	10.32	23.40	2.30	2.32	18.20
7	3	1	1	2	26.00	74.10	1.20	22.00	72.60	0.96	212.73	9.48	24.04	2.10	2.16	16.78
8	3	1	1	2	26.70	77.70	2.40	24.00	87.40	1.04	224.62	11.42	22.06	1.90	2.72	19.24
9	3	1	1	2	26.40	75.90	1.60	23.00	88.40	0.89	213.39	12.12	24.54	2.50	2.62	18.54
10	3	1	1	2	26.70	77.80	1.60	24.00	79.80	1.14	196.65	11.14	23.36	2.20	2.42	17.24
11	3	1	2	1	26.90	76.10	1.60	23.00	68.40	0.88	242.07	11.18	22.54	2.20	2.23	15.33
12	3	1	2	1	26.40	74.20	1.90	24.00	72.60	0.96	223.65	10.52	23.88	1.90	2.31	16.12
13	3	1	2	1	26.80	75.20	1.40	22.00	87.40	1.04	233.73	9.96	23.52	2.60	1.75	19.04
14	3	1	2	1	26.60	73.60	2.00	23.00	88.40	0.89	221.76	11.21	32.66	2.80	1.76	15.36
15	3	1	2	1	26.80	75.20	1.90	24.00	79.80	1.14	202.83	12.06	23.14	2.20	2.22	16.74
16	3	1	2	2	26.80	76.20	1.40	23.00	68.40	0.88	225.41	10.62	24.12	1.60	2.22	17.06
17	3	1	2	2	26.30	74.20	1.80	24.00	72.60	0.96	203.62	12.42	24.02	2.40	2.32	16.50
18	3	1	2	2	26.90	75.10	2.60	26.00	87.40	1.04	214.31	10.36	22.42	2.80	2.66	21.01
19	3	1	2	2	26.60	73.80	2.20	23.00	88.40	0.89	202.76	11.26	21.54	1.90	2.32	16.16
20	3	1	2	2	26.90	75.10	1.30	23.00	79.80	1.14	185.75	10.74	22.78	1.80	2.19	17.82
21	3	2	1	1	26.50	76.60	1.20	23.00	74.60	0.92	255.16	8.82	24.60	2.00	2.18	19.00
22	3	2	1	1	25.70	74.30	2.40	25.00	88.72	0.89	227.66	9.78	24.12	2.00	2.39	16.24

23	3	2	1	1	26.60	77.40	2.80	26.00	84.56	0.98	244.37	11.24	23.34	2.40	2.66	18.44
24	3	2	1	1	26.20	75.50	1.80	23.00	89.20	1.08	232.17	13.54	22.96	2.40	2.33	17.41
25	3	2	1	1	26.70	76.20	2.30	23.00	82.20	0.89	209.47	11.98	22.62	2.40	1.98	16.28
26	3	2	1	2	26.50	76.70	1.80	23.00	74.60	0.92	214.09	9.86	23.36	2.10	2.24	17.40
27	3	2	1	2	25.60	74.30	1.60	21.00	88.72	0.89	2193.97	10.12	23.72	2.30	2.32	16.00
28	3	2	1	2	26.80	77.30	1.80	24.00	84.56	0.98	206.62	10.88	23.52	2.30	2.18	18.62
29	3	2	1	2	26.20	75.30	2.40	24.00	89.20	1.08	191.43	10.74	23.22	2.40	1.96	17.58
30	3	2	1	2	26.60	76.30	1.40	23.00	82.20	0.89	167.64	10.74	23.18	2.40	2.39	16.36
31	3	2	2	1	26.60	75.90	1.80	18.00	74.60	0.92	236.61	11.24	23.36	1.90	2.17	15.33
32	3	2	2	1	25.20	76.20	1.60	23.00	88.72	0.89	213.55	9.86	24.16	2.10	2.23	18.40
33	3	2	2	1	26.70	75.80	1.60	21.00	84.56	0.98	226.96	10.36	22.72	1.80	2.92	20.42
34	3	2	2	1	26.30	74.30	2.20	22.00	89.20	1.08	215.61	10.50	23.68	1.80	1.86	16.24
35	3	2	2	1	26.30	75.80	1.60	23.00	82.20	0.89	194.37	11.98	23.08	2.60	2.33	15.96
36	3	2	2	2	26.50	76.10	1.20	23.00	74.60	0.92	261.63	10.48	24.56	1.90	2.34	15.00
37	3	2	2	2	25.20	75.80	2.20	23.00	88.72	0.89	241.64	11.78	23.92	2.10	2.18	16.00
38	3	2	2	2	26.80	76.10	2.30	23.00	84.56	0.98	256.33	11.26	23.62	1.90	2.78	20.04
39	3	2	2	2	26.30	75.20	2.20	22.00	89.20	1.08	246.65	10.86	22.32	2.40	1.98	15.52
40	3	2	2	2	26.40	76.30	1.80	24.00	82.20	0.89	228.95	11.52	22.92	2.00	2.20	16.38
41	3	3	1	1	26.60	76.30	1.30	23.00	78.83	0.98	208.61	8.18	24.66	2.10	2.18	16.00
42	3	3	1	1	25.50	74.30	1.60	24.00	76.40	1.02	193.92	9.88	23.88	1.90	2.36	17.40
43	3	3	1	1	26.60	77.20	1.80	25.00	78.56	0.88	212.53	11.76	24.52	2.30	2.72	18.24
44	3	3	1	1	26.10	75.50	1.80	21.00	78.72	0.94	208.62	12.76	23.06	2.60	2.31	15.50
45	3	3	1	1	26.60	77.10	2.40	25.00	76.40	0.98	196.63	12.04	22.66	2.20	2.01	16.79
46	3	3	1	2	26.50	76.40	1.60	22.00	78.83	0.98	269.67	10.16	23.42	2.20	2.36	16.30

47	3	3	1	2	25.40	74.70	2.00	23.00	76.40	1.02	231.97	9.86	23.84	2.20	2.30	18.42
48	3	3	1	2	26.70	77.20	2.20	22.00	78.56	0.88	252.32	11.06	24.32	2.40	1.98	17.52
49	3	3	1	2	26.20	75.60	1.90	22.00	78.72	0.94	232.73	10.60	23.50	2.30	1.98	17.24
50	3	3	1	2	26.70	77.20	1.60	24.00	76.40	0.98	208.14	11.10	23.27	2.60	2.29	18.26
51	3	3	2	1	26.50	76.20	1.60	20.00	78.83	0.98	243.51	11.16	23.24	2.10	1.30	17.00
52	3	3	2	1	25.30	75.40	2.40	22.00	76.40	1.02	220.15	10.56	23.18	2.60	2.17	19.20
53	3	3	2	1	26.80	75.90	1.80	24.00	78.56	0.88	239.76	11.04	21.88	2.40	2.35	18.16
54	3	3	2	1	26.30	74.90	1.90	24.00	78.72	0.94	227.61	11.46	24.22	2.60	1.87	15.80
55	3	3	2	1	26.80	75.80	2.00	24.00	76.40	0.98	207.57	12.04	23.20	2.00	2.34	16.12
56	3	3	2	2	26.50	76.10	1.30	24.00	78.83	0.98	245.83	10.74	24.36	1.80	2.25	15.00
57	3	3	2	2	25.20	75.30	2.30	24.00	76.40	1.02	217.66	11.58	24.16	2.60	2.23	17.40
58	3	3	2	2	26.70	76.10	2.80	23.00	78.56	0.88	226.36	10.98	23.72	2.60	2.99	19.74
59	3	3	2	2	26.20	75.10	2.10	21.00	78.72	0.94	198.45	11.22	21.76	2.20	2.06	16.14
60	3	3	2	2	26.70	76.10	1.20	23.00	76.40	0.98	169.57	10.86	23.06	2.20	2.20	15.88

T=temperature, Rh=Relative Humidity, FC=Fungal Count, BC=Bacterial Count, SMC=Soil Moisture Content, BD=Bulk Density. SI=Soil Inter-space (1, 2 & 3 represent 5 cm, 7 cm and 10 cm respectively), SS= Storage Structures (1 represents tin-in-pot and pot-in-pot which are cylindrical in shape while 2 represents tin-in-wall & wall-in-wall which are rectangular in shape), M=Material Component for the Storage Structures (1represents tin component made of aluminium material while 2 represents pot /wall components made of clay material). 3= banana fruit

From the essential regression analysis, 256 model equations were generated under each fruit and vegetables out of which the best was selected for weight, vitamin A, vitamin C, vitamin E and lycopene contents of stored bananas based on their R_{adj2} as shown in equation 1 to 4. The existence and sufficiency of the regression models given in the equations above were also examined using the analysis of variance (ANOVA) of the multiple regression models shown in Tables 2. The analysis was carried out using essential regression computer software package. Regression models are sometime examined or tested with Analysis of Variance (ANOVA). This is because ANOVA tests the acceptability of the model from a statistical perspective. The four models developed for banana above (equation 1 to 4.) were selected as the best performing models based on their respective values of R_{adj2} . Also the analysis of variance table (Tables 2) which tests the acceptability of the model from a statistical perspective was seen to be significant at 5% for all the selected models.

Table 2: Analysis of Variance of the Multiple Regressions on the Nutritional Parameters as Function of Stored Banana

<i>Variable</i>	<i>Source</i>	<i>Df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>F Signif.</i>
VIT_A	Regression	4	23.01	5.753	9.291	0.001*
	Residual	55	34.06	0.619		
	Total	59	57.07			
VIT_C	Regression	1	8.653	8.653	4.512	0.037*
	Residual	58	111.24	1.918		
	Total	59	119.89			
VIT_E	Regression	1	0.482	0.482	6.298	0.014*
	Residual	58	4.440	0.07655		
	Total	59	4.922			
LYP	Regression	2	0.808	0.404	5.516	0.0065*
	Residual	57	4.174	0.07323		
	Total	59	4.982			

*significant at 5% level

3.2 Model Validation

By substituting different values of predictor variables/ factors (materials, temperature, relative humidity, storage structures, fungal and bacterial counts etc) into the model equations, the expected values of weight, vitamin A, vitamin C, vitamin E and lycopene contents of stored bananas were predicted. The predicted and measured (observed) values were plotted as shown in figures 1 to 4 for stored bananas. The graphs suggest a very close relationship between the observed and the predicted an indication of a good fit. Further analysis was done using a paired sample t-test using SPSS 16.0 computer software package. The results are presented in table 3. The results of the pair-wise shows that there is no significance difference between the mean of observed and the predicted for all the models developed. This implies that all the models developed are adequate and can be used to predict optimum values of the nutritional parameters.

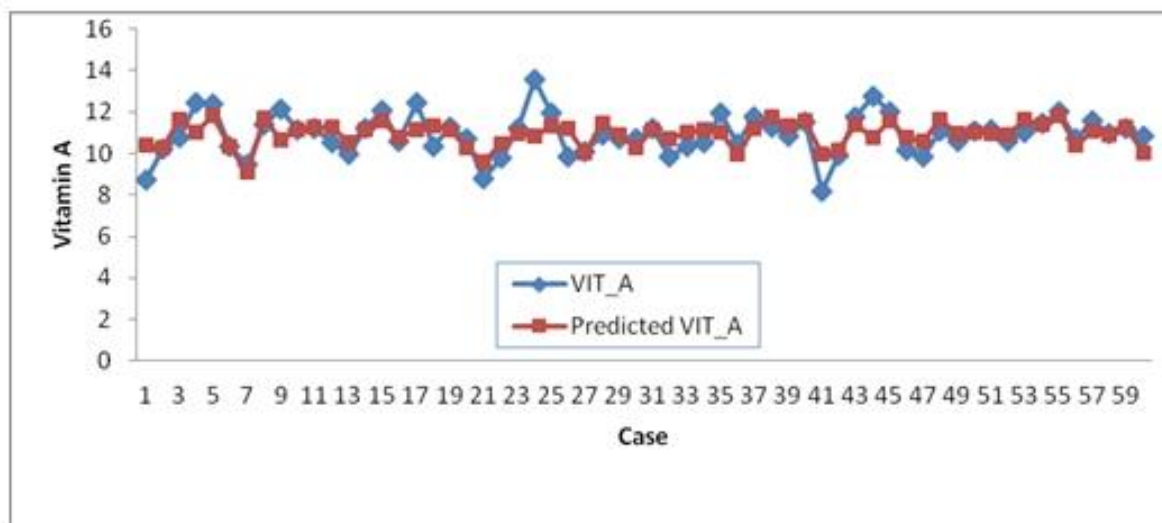


Figure 1: Predicted and observed values for vitamin A of stored banana

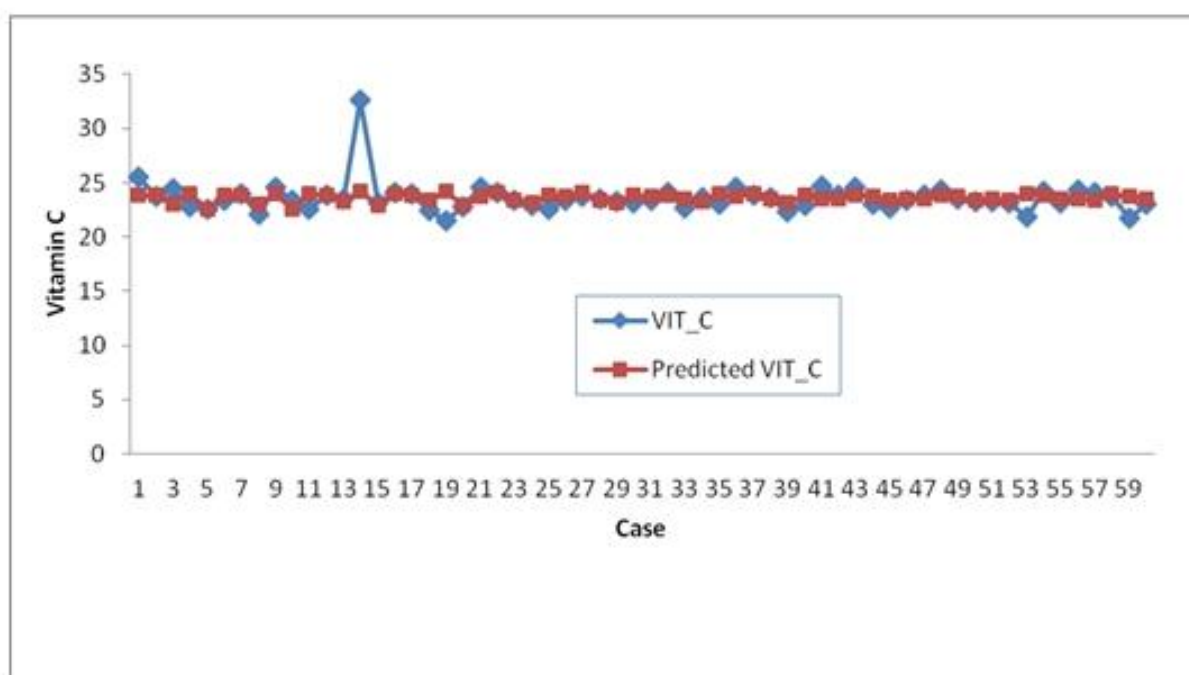


Figure 2: Predicted and Observed Values for Vitamin C of Stored Banana

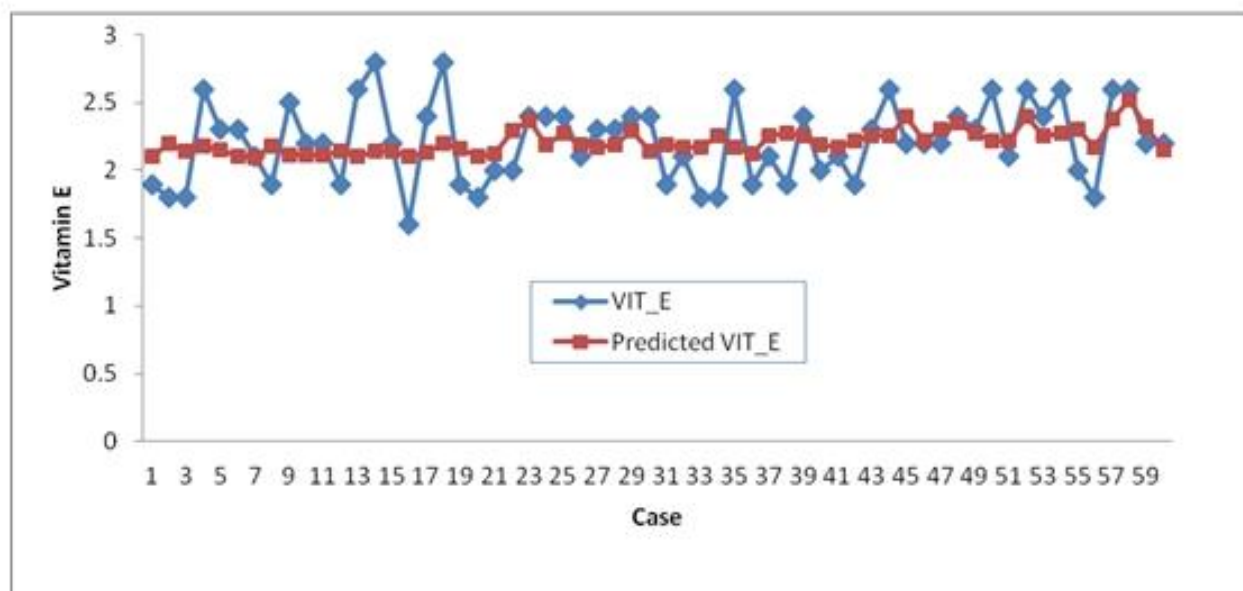


Figure 3: Predicted and Observed Values for Vitamin E of Stored Banana

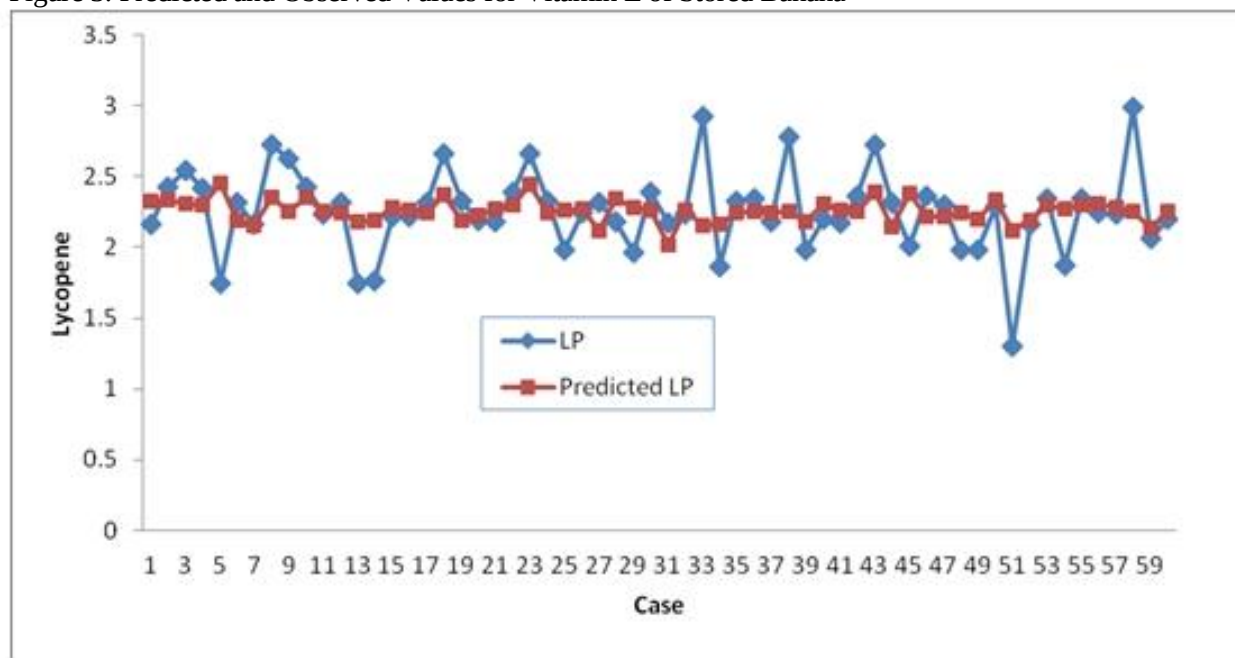


Figure 4: Predicted and observed values for lycopene of stored banana

Table 3: Pair-wise Test Comparing Observed and Predicted Values of Measured Parameters in Stored Bananas

		Std. Error				
Pair sample	Mean	Mean	T	Df	Sig. (2-tailed)	Correlation
observed- predicted ^a	0.00012	0.10271	0.000	59	0.999	0.588
observed- predicted ^b	0.00000	0.17722	0.001	59	1.000	0.270
observed- predicted ^c	-0.00003	0.03541	0.000	59	0.999	0.313
observed- predicted ^d	0.00003	0.03607	0.001	59	0.999	0.275

a=Vitamin A, b=Vitamin C, c=Vitamin E, d=Lycopene,

4. CONCLUSION

An empirical model based on the measured parameters on the field was developed to provide objective guidance on the nutritional values of stored bananas inside the passive evaporative cooling structures. The four models developed for banana above (equation 1 to 4.) were selected as the best performing models based on their respective values of adjusted coefficient of determination which were seen to be significantly higher. Also the analysis of variance which tests the acceptability of the model from a statistical perspective was seen to be significant at 1% for all the selected models. The verification of the models was done using pair wise t-test. The mathematical models developed are reasonably accurate to predict the storability of banana in passive evaporative cooling structures. Also, the model performance was found to be satisfactory and show good predictability.

REFERENCES

- AOAC 1979. Association of Official Analytical Chemistry. Approved Method of Analysis.
- AOAC 1995. Association of Official Analytical Chemist in Official Method of Analysis. 15th Edition. Washington DC, USA Pp 537-544.
- Chia, C. L. 1981. Bananas Commodity Fact Sheet BA-3(A) Fruit. Hawaii Cooperative Extension Service, CTAHR, University of Hawaii.
- Collins, C. H., Lyne, PM., Grange, JM and Falkinham, J. O. 2004. Collins and Lynes Microbiological Methods, 8th Edition. Arnold Publishers.
- Deneo-pellegrini, H, De Stefani, E and Ronco, A. 1996. Vegetables, Fruits and Risk of Colorectal Cancer: A Case-Control Study from Uruguay. Nutrition and Cancer journal, 25(3): 297-304.
- Food and Agriculture Organization 2005. Retrieved 12/09/2006 Geeson, JD (1983) Brassicas. In: C. Dennis (ed) Postharvest Pathology of Fruits and Vegetables, Acad. Press, NY, pp. 125-156.
- Huggins, C. A, Kevin M, Yokoyama, K W, Stuart T and Chia, C L 1990. Banana Economic Fact Sheet #11. Department of Agricultural and Resource Economics, CTAHR, University of Hawaii.
- International Trade Centre 2000. Export Packaging Bulletin. No 2.
- Kader, A. A. 2002. Quality Parameters of Fresh-cut Fruits and vegetables Products. In: Lamikanra O, editor. Fresh-cut Fruits and Vegetables. Boca Raton, Fla: CRC Press LLC. Pp 11-20.
- Pilipino Banana Growers and Exporters Association. 2010. News Bulletin.
- Rashidkhani, B, Linblad P. and Wolk, A 2005. Fruits, Vegetables and Risk of Renal Cell Carcinoma: A prospective Study of Swedish Women. International Journal of Cancer, 113 (3): 451-5.
- Salunkhe, D. K. 1974. Development in Technology of Storage and Handling of Fresh Fruits and Vegetables. Cri Rev. Food Technology. 15-54Pp.
- Salunkhe, D. K. and Kadam, S. S. 1998. Handbook of Vegetable Science and Technology: Production, Composition, Storage and Processing. New York: Marcel Dekker.
- Sharma, R. M. and Singh, R. R. 2000. Harvesting, Postharvest Handling and Physiology of Fruits and Vegetables. In: Verma, L.R., Joshi, V.K. Editors. Postharvest Technology of Fruits and Vegetables. Vol. 1. Handling, Processing, Fermentation and Waste management. Tagore Garden, New delhi: Indus publishing Co. pp 94-147.
- Southgate, DAT. 1969. Determination of Carbohydrates in Foods (ii). Unavailable Carbohydrates. Journal of Science of Food and Agriculture. 20, 331-5
- Tijsskens, L. M. M, Hertog, M. L. A. T. M, and Nicolai, B. M. 2001. *Food Process Modelling*. Published by Woodhead Publishing Limited, England. 510pp.
- Weichmann, J. 1987. Postharvest Physiology of Vegetables, Marcel Dekker, Inc., New York, NY
- Wilson, L. G, Boyette, M. D. and Estes, E. A. 1995. Postharvest Handling and Cooling of Fresh Fruits, Vegetables and Flowers for Small Farms. Leaflets 800-804. North Carolina Cooperative Extension Service. 17 p. Accessed on-line at: <http://www.foodsafety.org/nc/nc1055.htm>
- Zhang, C. X. 2009. Greater Vegetable and Fruit Intake is Associated with a Lower Risk of Breast Cancer among Chinese Women. International Journal of Cancer 125 (1): 181-8.

