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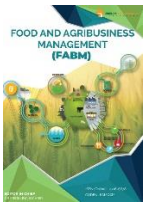

RESEARCH ARTICLE

ANALYSIS OF SPOILAGE AND STORAGE OF FRESH TOMATO IN PLATEAU STATE NIGERIA

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ABSTRACT

The purpose of this research was to determine spoilage resulting from adopted methods of storage among tomato sellers relative to quantity stored in major markets of Plateau State, Nigeria. Methods used to obtain data from 400 tomato sellers involve administration of structured questionnaires based on purposive and simple random sampling techniques. Descriptive statistics, F-test, t-test and Multiple Linear Regression (MLR) methods were used to analyse the data. Results from the use of F-test and t-test statistics showed that there is significant relationship among variables and that both storage methods and quantity stored of fresh tomato have significant effect on total quantity of tomato spoiled at 95% confidence bound. Consequently, a model of the association was presented. It was concluded that majority of tomato sellers used woven baskets to store tomatoes. Also, heat and pathogens were major factors causing tomato spoilage and more tomatoes spoiled during rain season than dry season.

KEYWORDS

Baskets, root cellar, refrigeration, lycopersicon, esculentum

1. INTRODUCTION

Tomato (Lycopersicon esculentum mill) is a fruit sometimes considered as vegetable commonly grown in Plateau State, Nigeria. It contains nutrients which are vital for adequate performance of human body metabolism. Multipurpose use of tomato (Joosten et al., 2015) makes it popular among residents of Plateau State. Its colour is one of the qualities that could encourage consumer preference and improve its demand by process industry (Arias et al., 2000). Tomato fruits' colour usually change through stages usually from green colour with more percentage of chlorophyll through other stages until it attains red colour ripening at harvest-time due to presence of β-carotene and lycopene (Jongen, 2002; Hobson et al., 1983). Epidemiological evidence has shown that β-carotene and other antioxidants can protect against certain types of cancer (Mascio et al., 1989). Other qualities of tomato include flavour, sourness and sweetness. While the sweetness depends on the level of glucose and sucrose, sourness depends on level of titratable acidity like citric acid (Borji and Jafarpour, 2012). However, despite its usefulness tomato fruits are vulnerable to abnormal handling both in the farm and during transportation from farms to sellers. The rate of spoilage could be colossal if environmental factors around storage structures are not favourable to harvested tomato fruits thereby leading to loss of investment to tomato sellers. There was emphasis on the need to maintain optimum environmental state for adequate reduction in fruits losses relative to adopted storage methods (Tolesa and Workneh, 2017). While focused on storage temperature and bruises of tomato as factors leading to spoilage of tomato fruits, adequate relative humidity for harvested stored tomato was reviewed by (Arah, 2015; Sablani et al., 2006).

While some researches discussed keeping tomato and other vegetables cool as one of the major approaches towards reduction in their spoilage, other studies discussed that more advanced treatment procedure coupled with storage conditions could be effective ways for extending the shelf-life of tomato and other vegetables (El-Ramadi et al., 2015; Qin et al., 2017; Seo et al., 2018). Considered post-harvest spoilage of tomato in Bayelsa State and some markets in Nigeria, did not include common methods of storage adopted in the areas of coverage in specific terms as the focus was on biotic and economic constraints leading to spoilage of tomato (Etebu et al., 2013). Their review on how to improve tomato storage for a long time discussed both cultural and advanced techniques of storage (Nassarawa and Sulaiman, 2019). Though specific names of cultural and economic practices were not discussed in detail, they however discussed advanced techniques such as modified ventilated structures, controlled atmospheric storage and modified atmospheric storage. A recent study concluded that major constraints along tomato value chain in Nigeria are constraints from production and storage among other constraints reviewed in their study (Abdul et al., 2020).

Investigated effect of agricultural services on livelihood of farmers in Plateau State, Nigeria was carried out and it was concluded that intervention of training centre project had positive impact on livelihood of farmers (Momoh et al., 2018). However, their focus was on production of tomato as a result of farmers' benefits from the agricultural services provided for them. They however did not consider storage methods and spoilage of tomato in their study area. Some researches have considered pathogenic activities on fresh tomato (Obafemi et al., 2021; Obafemi et al., 2019; Sale et al., 2018; John, 2016). Despite availability of myriads of reviews in literature, the need for this research stems from discovery that none of the researches in literature has determined most commonly used

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method of storage with reference to spoilage of tomato among sellers in major markets of Plateau State, Nigeria.

Motivation to carry out this research is to determine the most commonly used method of storage for fresh tomato in major markets of Plateau State. It could also aid how positive interventions would be introduced for effective applicability of the most commonly adopted method of storage whenever agricultural extension services are provided. Another factor which motivated this research is to investigate spoilage of fresh tomato with reference to adopted methods of storage with possibility of reducing its spoilage towards increasing food supply and attainment of food sufficiency in Plateau State, Nigeria.

In this research, one of the objectives of the study is to carry out analysis of spoilage and storage of fresh tomato to determine most commonly used method of storage among tomato sellers in the Plateau State, Nigeria. Another objective is to determine association between spoilage of fresh tomato and methods of storage relative to quantity of tomato stored. The null hypothesis to be investigated states that methods of storage and quantity of tomato stored do not have significant effect on total quantity of fresh tomato spoiled while the alternate hypothesis states that methods of storage and quantity of tomato stored have significant effect on total quantity of fresh tomato spoiled in Plateau State, Nigeria. The remaining part of this paper is organised as follows: section 2 considers materials and methods; section 3 is based on results and discussion and conclusion comes up in section 4.

2. Materials and Methods

2.1 Study Area

This study covers three major markets of Plateau State Nigeria. The environmental conditions of the study areas have average monthly temperature range between 21°C and 25° C. Also, the geographical location of this study lies within the coordinate 9° 34' N and 9° 04' E in West Africa region of African continent. The three major markets are Farin Gada market, New market and Angwan Rukuba market. The Farin Gada market is located in Jos, the capital city of Plateau State. It is a market where many farmers from different parts of Plateau State converge to sell their tomatoes and other types of vegetables to sellers who would later sell to retailers and consumers. Trailers loaded with tomatoes in baskets are brought from neighbouring states to Farin Gada market where different types of vegetables such as cabbage, cucumber, carrot, lettuce and onions are offered for sale on daily basis. Some buyers of tomato from the market are in business of transporting large quantities of fresh tomatoes to other regions of the country. The second location considered for this study is New Market which is situated along Bauchi road and it is just a few kilometres from main campus of the University of Jos, Plateau State. Activities in the market are controlled by trade union which has elected chairman as the head of the trade union. The third location used for this study is Angwan Rukuba market located in Jos North Local Government Area of Plateau State. It is a market situated very close to Yan Trailer area along a road leading to British and American Junction in Plateau State, Nigeria.

2.2 Design Framework

The design indicated in Figure 1 for this study considers response of total spoilage of tomato to methods of storage and quantity of tomato stored.

Figure 1 shows design framework of this study which is designed to investigate the impact of methods of storage of fresh tomato and quantities stored on total spoilage of fresh tomato in Plateau State, Nigeria.

Figure 1: Schematic representation of design framework

2.3 Sampling Techniques and Data Collection

The sampling technique adopted in the choice of markets for this study is purposive sampling technique. Data for this research were collected from respondents using primary source of data which means that data were obtained directly from tomato sellers. The collection of data was through administration of questionnaires to sellers of tomato in the three major markets of Plateau State. Administration of questionnaires to sellers of tomato is based on simple random sampling technique.

2.4 Data Analysis

The data for this study were analysed using descriptive statistics, Pearson Product-Moment Correlation (PPMC), F-test statistics, t- test and multiple linear regression (MLR) with the aid of Statistical Package for Social Sciences (SPSS).

2.5 Model Specification

Let $i \in \mathbb{N}$ be an index such that $X_i\ (i = 1, 2)$ represent methods of storage and quantity stored of tomatoes in Plateau State and let C_i represent some unknown parameters associated with adopted methods of storage and quantity of tomato stored. Let F be total spoilage which is dependent on methods of storage and total quantity of tomato stored then multiple linear regression is defined by

$$F = p\ (X_i, C_i)\ +\ \epsilon \tag{1}$$

where $p\ (X_i, C_i)$ is a function representing methods of storage and quantity of tomato stored, the ϵ is the associated error of the defined function $p\ (X_i, C_i)$. For two independent variables, equation (1) gives multiple linear regression for $X_i\ (i = 1, 2)$ as

$$F = C_2X_2 + C_1X_1 + C_0 + \epsilon \tag{2}$$

where the function $p\ (X_i, C_i) = C_2X_2 + C_1X_1 + C_0$ so that X_2 represents methods of storage of tomato and X_1 is quantity of tomato stored. The C_1 and C_2 are associated coefficients of the methods of storage and quantity of tomato stored respectively. C_0 is a constant term of the multiple linear regression model equation.

Also, the pairwise use of PPMC gives

$$r = \frac{N\sum X_iF - (\sum X_i)(\sum F)}{\sqrt{[N\sum X_i^2 - (\sum X_i)^2][N\sum F^2 - (\sum F)^2]}} \tag{3}$$

where r is the correlation coefficient such that -1 ≤ r ≤+1.

3. Results and Discussion

Data obtained from 400 tomato sellers in three major markets of Plateau State Nigeria were analysed. Results from the use of descriptive statistics on different storage methods adopted by the tomato sellers are presented in Table 1.

Table 1: Distribution of methods storage by number of users and factors causing spoilage of tomato in Plateau State.

Methods of Storage	Number of Users	Number of Users (%)	Major Factors Causing Tomato Spoilage			
			Heat	Pathogens/Pests	Loss of Water	Other Factors
Basket	262	65.5	167	52	37	6
Canned container	52	13.0	18	23	11	0
Refrigeration	65	16.3	29	21	12	3
Sack	21	5.3	11	2	6	2
Total	400	100	225	98	66	11

From results shown in Table 1, it can be seen that 262 tomato sellers which amount to majority of the sellers used baskets to store tomatoes before selling them to consumers. This means that 65.5% of tomato sellers most frequently used baskets to store tomato. The second commonly used method for storing tomato in Plateau State is refrigeration method with only 16.3% which is far lower than that of baskets users. Less number of users of refrigeration method may likely be due to cost of setting up large refrigeration units coupled with inadequate power supply. Results from Table 1 also show that majority of tomato sellers chose heat as a major factor responsible for spoilage of tomato which is about 56.25% of the major factors causing tomato spoilage in Plateau State, Nigeria.

The second major cause of spoilage according to tomato sellers is pathogen which is about 24.5% of major causes of tomato spoilage. While 66 tomato sellers which amount to 16.5% chose loss of water from tomato as a major cause of its spoilage, it is only 11 tomato sellers which give only 2.7% that chose other factors such as injury to tomatoes possibly during the course of transportation, rough handling and types of tomato species as factors influencing spoilage of tomatoes in the study area.

The distribution of methods of storage for tomato in Plateau State by age is shown in Figure 2.

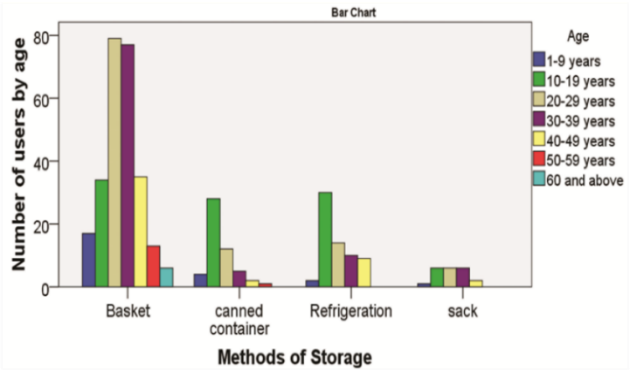

Figure 2: Distribution of methods of storage of tomato by age

It can be seen from Figure 2 that those within age range of 20-29 years consist of highest number of people who used baskets to store tomatoes when compared with those in other age ranges. This is followed by those within the age range of 30-39 years then followed by those within 40-49 years. After those within 40-49 years are those within 10-19 years. It can be observed that children within age 1-9 years were also involved in sales of tomato in Plateau State which suggests that child protection law was not enforced in the study population.

From results shown in Table 2, pairwise Pearson's Product Moment Correlation (PPMC) indicates that the total spoilage of tomato have positive correlation with methods of storage and quantity of tomato stored. This means that total spoilage of tomato have an association with methods of storage and total quantity of tomato stored.

Table 2: Pairwise PPMC of total spoilage with methods of storage and quantity of stored tomatoes.

	Methods of Storage	Quantity of Stored Tomatoes
Total Spoilage	0.112	0.305

Results presented in Table 3 indicated that only 10.5% changes occur in total spoilage of tomato when associated with both adopted method of storage and quantity of tomato stored. The value (0.105) in Table 3 shows that total spoilage of tomato do not have large proportionate response to methods of storage and quantity of tomato stored.

Table 3: Response of total spoilage to methods of storage and quantity of stored tomatoes.

Model[b]	R	R Square	Adjusted R Square	Std Error of the Estimate
1	0.324[a]	0.105	0.101	0.936

a. Predictor: (constant), methods of storage, quantity of tomato spoiled.

b. Dependent variable: Total spoilage of tomato.

In order to determine significance or otherwise of the association indicated in Table 2, F-test statistics was applied to investigate whether such relationship just occur by chance or not. The results are shown in Table 4.

Table 4: F-test statistics for the association of total spoilage with methods of storage and quantity of tomato stored, α = 5% level of significance.

Model[d]	Sum of Squares	df	Mean Square	F	p-value
Regression	40.655	2	20.328	23.213	0.000 [(c)++]
Residual	345.897	395	0.876		
Total	386.553	397			

a. Predictor: (constant), methods of storage, quantity of tomato spoiled (++ significant at α = 5% level of significance.).

b. Dependent variable: Total spoilage of tomato.

Results shown in Table 4 indicate that there is significant relationship among the variables representing total spoilage, methods of storage and quantity of stored tomato ($p < 0.05$) for results shown at 95% confidence bound. However, the F-test statistics do not possess the capacity to indicate which of the predictors is contributing to the response variable.

To determine whether one of predictors is inducing response variable significantly or whether the two predictors are together inducing responses in the dependent variable significantly, we use t-test whose results are shown in Table 5.

Table 5: Model parameters for total spoilage of tomato with methods of storage and quantity of tomato stored, α = 5% level of significance.

Model[e]	B	Std Error	Beta	t	p-value	LBound	UBound
(constant)	1.358	0.123		11.032	0.000[++]	1.116	1.600
Methods of Storage	0.114	0.050	0.109	2.288	0.023[++]	0.016	0.213
Quantity of Tomato Stored	0.197	0.031	0.304	6.394	0.000[++]	0.136	0.257

a. Dependent variable: Total spoilage of fresh tomato.

++ Significant at α = 5% level of significance

From statistical evidence presented in Table 5, all predictors of the total spoilage of tomato in the study area have effects that could not be ignored hence none of the two variables can be dropped from model equation. Thus, using equation (2) with Table 5 gives the following multiple linear regression equation

$$F = 0.197\,X_2 + 0.114\,X_1 + 1.358 \qquad (4)$$

where the X_1 and X_2 variables are as defined in equation (2). Equation (4) gives multiple linear regression model representing dependence of total spoilage of tomato on methods of storage and total quantity of tomato stored.

From Figure 3, adopted methods of storage by ethnic groups indicate that about 158 tomato sellers from Hausa, 37 people from Berom, 22 people from Yoruba, 8 people from Igbo, 15 from Fulani and 22 people from other ethnic groups adopted use of baskets for storing their tomato.

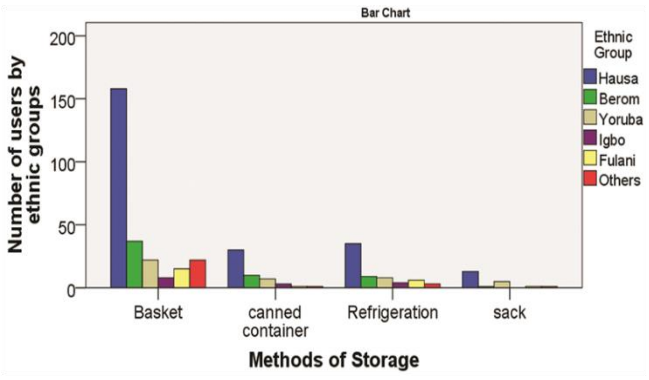

Figure 3: Methods of storage for tomato by ethnic groups in Plateau State.

Considering all methods of storage adopted in the study area, it can be seen from Figure 4 that about 118 tomato sellers stored between 1-5 baskets weekly followed by 115 tomato sellers who store between 6 and 10 baskets weekly. However, those who store more than 20 baskets of tomato weekly are in the third position.

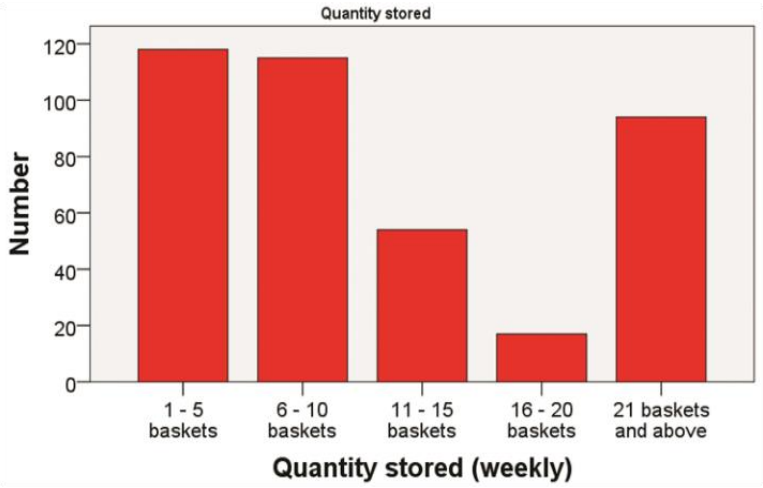

Figure 4: Quantities of tomatoes stored weekly by most commonly adopted method of storage (basket).

Generally, types weather conditions commonly experienced in Plateau State are the rain season and the dry season. This study investigates which season of the year has more spoilage of tomato in Plateau State than the other. The results are shown in Tables 6 and 7.

Table 6: Methods of storage by quantity spoiled weekly (rain season)

Methods of Storage	1-3 Buckets	4-6 Buckets	7-9 Buckets	10-12 Buckets	13-15 Buckets	16 Above Buckets
Basket	133	59	52	11	5	2
Canned Container	14	17	14	3	1	3
Refrigeration	17	14	19	6	3	6
Sack	10	3	4	1	0	3
Total	174	93	89	21	9	14

Table 7: Methods of storage by quantity spoiled weekly (dry season)

Methods of Storage	1-3 Buckets	4-6 Buckets	7-9 Buckets	10-12 Buckets	13-15 Buckets	16 Above Buckets
Basket	67	52	44	49	49	1
Canned Container	15	19	10	2	6	0
Refrigeration	15	18	19	6	7	0
Sack	6	4	3	4	3	1
Total	103	93	76	61	65	2

It can be seen from Table 6 that 133 people used baskets to store tomato and that average of between 1 and 3 rubber paint buckets of tomatoes spoil weekly during rain season. This is followed by 59 people indicating that average of between 4 and 6 rubber paint buckets of spoiled tomatoes are obtained weekly when stored in baskets during rain season. Obviously when all methods of storage are considered, a total of 174 people indicated that average of between 1 and 3 rubber paint buckets of spoiled tomato are usually obtained weekly during rain season followed by a total of 93 people who stated that between 4 and 6 rubber paint buckets usually become bad dunning rain season. On the other hand, during dry season 67 people indicated that between 1 and 3 baskets of tomato spoil weekly which are less than 133 people who chose the same range of tomato spoilage. Also 52 people estimated that between 4 and 6 rubber paint buckets of tomato become spoiled weekly during dry season, this is also less than 59 tomato sellers who estimated that the same range of tomato becomes spoiled during rain season. Clearly, a total of 103 people estimated that between 1 and 3 rubber paint buckets of tomato usually become spoiled during dry season which is far less than 174 people who chose the same range during rain season. From Table 6 and 7, it can be seen that estimated range of spoiled tomato is higher during rain season than during dry season. This means that more quantity of fresh tomato become spoiled during rain season than during dry season in Plateau State. This may be due to lower temperature range during certain periods of dry season in Plateau State usually between November and February of every year.

4. Conclusion

In this study, analysis of spoilage and storage of fresh tomato was carried out. The focus of the study was centred on sellers of fresh tomatoes in three major markets of Plateau State, Nigeria. Results from descriptive statistics showed that majority of tomato sellers (65.5%) used baskets made from palm trees to store their fresh tomato followed by few number of tomato sellers who used refrigeration method (16.3%). Also, heat was identified as first major factor responsible for tomato spoilage. The second major factor responsible for tomato spoilage was identified as pathogen.

Analysis of strength of relationship between total spoilage of tomato and methods of storage indicated an association between variables. Further analysis of the relationship using F-test statistics showed that there is significant relationship among variables representing total spoilage from tomato, methods of storage and quantity of tomato stored at 95% confidence bound. Determination of whether either independent variables or just one independent variable induced response variable was carried out. Results using t-test showed that both methods of storage and quantity of fresh tomato stored have significant effect on total spoilage of fresh tomato. Further analysis of results showed that more tomatoes become spoiled during rain season than during dry season. Therefore, policy makers can establish agricultural extension units in Plateau State to assist tomato sellers toward preservation of tomato during rain season since majority of fresh tomato sellers indicated that more tomatoes become spoiled during rain season than during dry season. The constraint encountered in this study is the inability to assess level of damage to fresh tomato while being harvested on farms and level of damage caused in the course of its transportation to markets. Consequently, the direction of future research should be focused on determining the level of damage to fresh tomato on farms relative to harvesting techniques and level of damage during the course of transportation relative to mode of transportation in the study areas.

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