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Research Article
Post-Harvest Management of Fruits and Vegetables: Addressing Urban Nutrition and Food Security Challenges

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Abstract

Background and Objective: Postharvest losses have been a serious challenge around the world and Benin City, Nigeria, is not left out of the problem. Most households in the urban areas are being affected by losses of perishable farm produce such as fruits and vegetables. This study investigated post-harvest handling of fruits and vegetables: A key panacea for nutritional and food security challenges in urban areas in Benin City, Nigeria. **Materials and Methods:** A structured questionnaire titled "Post-Harvest Losses of Fruits and Vegetables in Urban Areas Questionnaire (PHLFVUAQ) was used to solicit information from the respondents. The questionnaire was validated by three experts, while Cronbach's Alpha was used to test the reliability of the instrument and the result was 0.74. The instruments were later administered to farmers, food vendors and consumers who were randomly selected and used for the study. Data gathered were analyzed using statistical mean, standard deviation and Analysis of Variance (ANOVA) at the 0.05 level of significance. **Results:** The findings showed some of the postharvest handling of fruits and vegetables in the study area, such as washing before eating, storing in clean containers, using of refrigerator for preservation and keeping away from direct sunlight. Major causes of postharvest losses were also discovered to include transporting fruits and vegetables on bad roads and wrong packaging materials and inadequate modern facilities for storage, among others. The influences of the losses on availability and affordability include bruises, which cause a reduction in market value and quantities, as well as scarcity. The findings also revealed some levels of awareness and adoption of modern postharvest technologies, such as the use of cold storage, the use of plastic crates to transport produce and cleanliness while handling fruits and vegetables. **Conclusion:** The governments at all levels, non-governmental organizations and spirited individuals should help in providing modern technological facilities for the storage of fruits and vegetables, such as evaporative coolers and solar dryers, among others, while the use of hazardous chemicals for storage should be discouraged.

Key words: Postharvest losses, food security, fruits, vegetables, urban areas, nutritional

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Fruits are the edible parts of flowering plants that develop from the ovary after flowering. They carry seeds and are sweet in taste, though some have a sour taste. Some fruits are consumed raw, while others are processed before they can be consumed. Herrera *et al.*[1] and Wang *et al.*[2] defined fruits as the mature ovary of a plant that carries the seed after fertilization. Thompson *et al.*[3] defined fruits as the edible part of plants that taste sweet and are consumed fresh without being cooked.

Vegetables, on the other hand, are edible parts of plants such as leaves, stems, roots and bulbs, which are consumed by humans either as food or as part of food ingredients. Vegetables are generally less sweet and often consumed cooked or raw. Rosell and Fadnes[4] defined vegetables as the edible parts of plants such as leaves, stems, roots, flowers and bulbs, excluding sweet fruits and seeds and are used in dishes while, De *et al.*[5] viewed vegetables as harvested plant products that are perishable and due to their perishability, need proper handling after harvest to keep them fresh, safe and in good quality before they are consumed.

Fruits and vegetables are rich sources of essential nutrients such as vitamins A and C, potassium, dietary fiber and phytochemicals. These phytochemicals help to prevent chronic diseases in humans. Fruits and vegetables have high water content as well as a high rate of respiration, which makes them spoil quickly. Post-harvest management practices, such as timely harvesting, sorting, grading, cooling, storage, packaging and transportation, are key in extending the shelf life and maintaining the nutritional quality of harvested products. They also help to fight against several diseases in the body when consumed appropriately as opined by Kaur and Kaur[6].

The demand for vegetables and fruits is increasing from time to time. This is due to the population explosion in the country. Post-harvest handling of the products is the technique used for saving or reducing losses, yield and nutrition after harvesting. The post-harvest handling of fruits and vegetables is an important aspect of the agricultural supply chain. It involves a series of steps that ensure fruits and vegetables maintain their quality, safety and nutritional value from harvest to consumption. Proper handling practices during these stages are essential to minimize losses, extend shelf life and deliver a high-quality product to consumers and as well as lead to food security.

Food security is defined as a situation in which every individual in a country or region has both physical and economic means to access an adequate supply of food that meets their dietary needs for a healthy life at all times. According to Peterson *et al.*[7], food security is categorized into four components: the availability of a consistent and high-quality food supply, having consistent access to enough food and financial resources to buy it, understanding how to use the food effectively and ensuring reliable access to food. Postharvest loss is the reduction in quantity and quality of food products from the time of harvest to consumption. This affects the availability of food as it causes a shortage to farmers, distributors and consumers. Postharvest losses of fruits and vegetables contribute to food insecurity as well as nutritional insecurity. Hence, the researchers investigated post-harvest handling of fruits and vegetables: A key panacea for nutritional and food security challenges in urban areas. Specifically, the study sought to: To investigate the current post-harvest handling practices of fruits and vegetables in urban areas among farmers, food vendors and consumers; to determine the major causes of post-harvest losses of fruits and vegetables in selected urban areas; to analyze the influence of post-harvest losses on the availability and affordability of fruits and vegetables in urban areas and to evaluate the level of awareness and adoption of modern post-harvest technologies among farmers, food vendors and consumers in urban areas.

MATERIALS AND METHODS

Study area: The design of the study was a descriptive research design. The study was carried out in Benin City, Edo State, Nigeria. The study was carried out between June and August, 2025.

Study design and methodology: A simple random sampling technique was used to obtain a sample size of 150 respondents, consisting of 50 farmers, 50 food vendors (vegetables and fruits) and 50 consumers in Benin City. The instrument for the collection of data was a structured questionnaire titled "Post-Harvest Losses of Fruits and Vegetables in Urban Areas Questionnaire (PHLFVUAQ)". The questionnaire had five sections, which are A, B, C, D and E, with four-point scales of Strongly Disagree (SD) as 1, Disagree (D) as 2, Agree (A) as 3 and Strongly Agree (SA) as 4. The instrument was validated by three experts. The reliability index of 0.74 was obtained using the Cronbach's Alpha method according to Peterson *et al.*[7] in determining the internal consistency of the questionnaire. One hundred and fifty copies of the instrument were printed and administered to the respondents by one of the researchers with the assistance of two research assistants. The questionnaires were retrieved immediately after the administration.

Statistical analysis: Data collected through the questionnaire were analyzed using weighted Mean and Standard Deviation to answer the research questions and One-way ANOVA to test the hypothesis at the 0.05 level of significance. In making a decision, items with a mean value of 2.50 or above were considered as Agreed, while any item whose mean value was below 2.50 was considered as Disagreed. Statistical Package for the Social Sciences (SPSS) version 23 was used by the researchers for the analysis.

Ethical consideration: This study strictly adhered to ethical research principles. The farmers, food vendors and consumers who participated in the study were duly informed about the purpose of the study. Their anonymity, confidentiality and voluntary participation were all adhered to.

RESULTS

The results of the descriptive analysis are presented in Table 1-5.

Research question 1: What are the current post-harvest handling practices of fruits and vegetables in urban areas among farmers, food vendors and consumers in Benin City?

Data in Table 1 showed the mean values of respondents on the current post-harvest handling practices of fruits and vegetables in urban areas among farmers, food vendors and consumers in Benin City. The respondents agreed that seven out of the ten items have mean values ranging between 2.59 to 3.51 are the current post-harvest handling practices of fruits and vegetables in urban areas among farmers, food vendors and consumers in Benin City. This is due to the fact that the means are above 2.50, which was set as the benchmark. It can be interpreted from the data and mean values that all the items in Table 1 reflect the current practices of post-harvest of fruits and vegetables among people in Benin City. This showed that good practices in handling fruits and vegetables post-harvest exist, though there is still room to improve on the handling practices as three of the items had mean values below 2.50, showing that some handling practices are yet to be adopted in the study area.

Research question 2: What are the major causes of post-harvest losses of fruits and vegetables in selected urban areas in Benin City?

Data presented in Table 2 revealed the mean values of respondents on the major causes of post-harvest losses of fruits and vegetables in selected urban areas in Benin City. The respondents agreed that eight out of the ten items with mean values ranging between 2.83 to 3.50 are the major causes of post-harvest losses of fruits and vegetables in selected urban areas in Benin City. This is so because all the means are above the 2.50 benchmark for the study. It can be deduced from the analyzed data and mean values that most of the items in Table 2 are the major causes of post-harvest losses of fruits and vegetables in selected urban areas in Benin City.

Research question 3: What is the influence of post-harvest losses on the availability and affordability of fruits and vegetables in urban areas in Benin City?

Data presented in Table 3 showed the mean values of respondents on the influence of post-harvest losses on the availability and affordability of fruits and vegetables in urban areas in Benin City. The respondents agreed that the six items with mean values ranging between 3.17 to 3.42 are the influence of post-harvest losses on the availability and affordability of fruits and vegetables in urban areas in Benin City. This is so because all the mean values are above the 2.50 benchmark for the study. It can be deduced from the analyzed data and mean values that all the items in Table 3 are influenced by post-harvest losses on the availability and affordability of fruits and vegetables in urban areas in Benin City.

Research question 4: What is the level of awareness and adoption of modern post-harvest technologies among farmers, food vendors and consumers in urban areas in Benin City?

Data in Table 4 revealed the mean values of respondents on the level of awareness and adoption of modern post-harvest technologies among farmers, food vendors and consumers in urban areas in Benin City. The respondents agreed that the eight items with mean values ranging from 3.00 to 5.94 are the level of awareness and adoption of modern post-harvest technologies among farmers, food vendors and consumers in urban areas in Benin City. This is so because all the means are above the 2.50 benchmark for the study. It can be inferred from the analyzed data and mean values that all the items in Table 4 are the level of awareness and adoption of modern post-harvest technologies among farmers, food vendors and consumers in urban areas in Benin City.

Data in Table 5 revealed that p-value>0.05 (0.07) significant level meaning that there is no significant difference in the mean values of the respondents. Therefore, the null hypothesis that there is no significant difference in the mean rating of farmers, food vendors and consumers on the influence of post-harvest losses on the availability and affordability of fruits and vegetables in urban areas in Benin City was retained.

Table 1: Mean ratings of respondents on the current post-harvest handling practices of fruits and vegetables in urban areas among farmers, food vendors and consumers in Benin City (n = 150)

Current postharvest handling practices items	X	SD	Decision
I wash fruits and vegetables before displaying or eating them	3.49	0.88	Agree
I store fruits and vegetables in clean containers	3.34	0.48	Agree
I store/sell fruits and vegetables under shade away from sun	3.51	0.86	Agree
I handle fruits and vegetables with care to avoid bruises and damage	3.43	0.85	Agree
I use modern preservation techniques such as refrigeration to preserve fruits and vegetables	3.51	0.64	Agree
I transport fruits and vegetables in bags and other containers without ventilation	2.42	1.32	Disagree
I separate bad fruits and vegetables from good ones before selling/eating them	3.42	1.12	Agree
I use chemicals to preserve fruits and vegetables to avoid spoilage	2.08	1.12	Disagree
I keep/shade fruits and vegetables under sun	2.49	0.87	Disagree
I use hand gloves when sorting fruits and vegetables to prevent bruises and contamination	2.59	0.86	Agree

X: Mean, SD: Standard deviation and n: Number of respondents

Table 2: Mean ratings of respondents on the major causes of post-harvest losses of fruits and vegetables in selected urban areas in Benin City (n = 150)

Major causes of postharvest losses items	X	SD	Decision
I transport fruits and vegetables on poor roads	2.09	0.28	Disagree
Fruits and vegetables are packaged with wrong materials and methods	2.49	0.87	Disagree
Fruits and vegetables are overloaded in containers and vehicles	2.83	0.99	Agree
High temperature in the markets makes fruits and vegetables to ripen on time	2.99	0.41	Agree
There are not enough modern facilities to store fruits and vegetables	2.83	0.81	Agree
Pests do have access to fruits and vegetables in storage and do cause damage	3.50	0.50	Agree
Poor harvesting methods cause bruises and damage to fruits and vegetables	3.25	0.60	Agree
Hoarding of fruits and vegetables causes losses after harvesting	3.25	0.44	Agree
Inconsistent power supply is a major cause of losses of fruits and vegetables	3.26	0.60	Agree
Mishandling of fruits and vegetables by transporters causes damage	2.99	0.58	Agree

X: Mean, SD: Standard deviation and n: Number of respondents

Table 3: Mean ratings of respondents on the influence of post-harvest losses on the availability and affordability of fruits and vegetables in urban areas in Benin City (n = 150)

Influences of postharvest losses items	X	SD	Decision
Bruises on fruits and vegetables reduce the quality of fruits and vegetables	3.17	0.69	Agree
Damage to fruits and vegetables reduces their quantity in the market	3.42	0.63	Agree
Inadequate preservation facilities cause shortage of fruits and vegetables during off-season	3.17	0.56	Agree
Poor storage systems cause scarcity of fruits and vegetables	3.17	0.69	Agree
Consumers don't have access to preferred fruits and vegetables due to losses	3.34	0.48	Agree
Post-harvest losses cause inflation in prices of fruits and vegetables	3.42	0.49	Agree

X: Mean, SD: Standard deviation and n: Number of respondents

Table 4: Mean ratings of respondents on the level of awareness and adoption of modern post-harvest technologies among farmers, food vendors and consumers in urban areas in Benin City (n=150)

Level of awareness and adoption items	X	SD	Decision
I am aware of cold rooms and evaporative coolers for storage of fruits and vegetables	3.09	0.76	Agree
I know about the use of modified atmosphere on packaging for fruits and vegetables	3.00	0.58	Agree
I have access to information about post-harvest technologies through TV, radio and social media	3.00	0.58	Agree
I use plastic crates to transport fruits and vegetables instead of baskets	2.92	0.64	Agree
I am aware that chemical treatment can extend the shelf life of fruits and vegetables	3.00	0.71	Agree
I know about the use of solar dryers to preserve fruits and vegetables	5.94	8.71	Agree
I use temperature control methods to preserve my fruits and vegetables after harvest	3.67	0.62	Agree
I maintain cleanliness while handling fruits and vegetables	3.58	0.50	Agree

X: Mean, SD: Standard deviation and n: Number of respondents

Table 5: Analysis of Variance (ANOVA) of the mean of farmers, food vendors and consumers on the influence of post-harvest losses on the availability and affordability of fruits and vegetables in urban areas in Benin City

	Sum of square	df	Mean square	F	Significance	Decision
Between groups	89.27	2	101.08			
Within groups	0.000	147	312.11	64.58	0.07	Rejected
Total	321.78	149				

DISCUSSION

The findings of this study in Table 1, showed that ten items on the table are the current post-harvest handling practices of fruits and vegetables in urban areas among farmers, food vendors and consumers in Benin City. They include washing fruits and vegetables before displaying or eating them, storing fruits and vegetables in clean containers, storing/selling fruits and vegetables under shade away from sun, handling fruits and vegetables with care to avoid bruises and damage, using modern preservation techniques such as refrigeration to preserve fruits and vegetables, transporting fruits and vegetables in bags and other containers without ventilation, separating bad fruits and vegetables from good ones before selling/eating them, the use chemicals to preserve fruits and vegetables to avoid spoilage, keeping/shading fruits and vegetables under sun and the use of hand gloves when sorting fruits and vegetables to prevent bruises and contamination according to Gibson[8]. The findings aligned with the reports of Kumar *et al.*[9], where it was reported that postharvest handling of fruits and vegetables includes permanent shade structure, sustainable packaging and smart packaging. The findings also showed other good handlings of fruits and vegetables after harvest to include the use of ventilated containers, such as wooden boxes and cardboard cartons for transporting fruits and vegetables and careful loading of containers.

The findings of the study in Table 2, revealed the major causes of post-harvest losses of fruits and vegetables in selected urban areas in Benin City. The causes are transporting fruits and vegetables on poor roads, fruits and vegetables are packaged with wrong materials and methods, fruits and vegetables are overloaded in containers and vehicles, high temperature in the markets makes fruits and vegetables to ripen on time, lack of enough modern facilities to store fruits and vegetables, pests do have access to fruits and vegetables in storage and do cause damage, poor harvesting methods cause bruises and damage fruits and vegetables, hoarding of fruits and vegetables causes losses after harvesting, inconsistent power supply and mishandling of fruits and vegetables by transporters. These findings agreed with the report of Yeshiwas and Tadele[10], where it was reported that poor handling of harvested produce, such as improper management of temperature and relative humidity, poor hygiene and mechanical damage due to poor transportation methods, are major causes of losses of fruits and vegetables. The findings also align with the study Yuan *et al.*[11] where improper handling of fruits and vegetables after harvest, which cause severe losses, were highlighted to include inadequate temperature control, mechanical injuries during packaging and transportation, among others.

The findings of this study in Table 3, revealed the influence of post-harvest losses on the availability and affordability of fruits and vegetables in urban areas in Benin City. These influences include: Bruises on fruits and vegetables which reduce the quality, damage on fruits and vegetables which reduce their quantity in the market, inadequate preservation facilities cause shortage of fruits and vegetables during off-season, poor storage systems cause scarcity of fruits and vegetables, consumers don't have access to preferred fruits and vegetables due to losses and post-harvest losses cause inflation in prices of fruits and vegetables. The findings corroborated that of Ali *et al.*[12] some of the effects of post-harvest losses of food products include a reduction in the market value of the product and quantity as well, which are due to bruises and improper storage. The findings also align with the report of Ojeleye *et al.*[13], where it was reported that losses during harvesting, transportation and poor packaging cause a reduction in the quality and quantity of farm produce.

The findings of this study in Table 4, revealed the level of awareness and adoption of modern post-harvest technologies among farmers, food vendors and consumers in urban areas in Benin City. The level of awareness and adoption are the use of cold rooms and evaporative coolers for storage of fruits and vegetables, the use of modified atmosphere packaging for fruits and vegetables, access to information about post-harvest technologies through TV, radio and social media, the use of plastic crates to transport fruits and vegetables instead of baskets, the use of chemical treatment to extend the shelf life of fruits and vegetables, the use of solar dryers to preserve fruits and vegetables, the use temperature control methods to preserve fruits and vegetables after harvest and maintaining cleanliness while handling fruits and vegetables. The findings align with that of Balana *et al.*[14], where it was discovered that the high cost of technology affected the adoption negatively, but losses were reduced as the respondents practiced the use of proper packaging technique, use of crates for transporting fruits and vegetables and solar dryers. The findings of the study also align with that of Korie *et al.*[15], where a report showed an increase in the level of adoption of modern technologies of tomato during postharvest handling.

The findings in Table 5, revealed that there is no significant difference in the mean rating of farmers, food vendors and consumers on the influence of post-harvest losses on the availability and affordability of fruits and vegetables in urban areas in Benin City.

The study faced certain limitations. First, data on post-harvest losses of fruits and vegetables were scarce when collecting information from respondents. Second, the researchers encountered challenges in engaging key stakeholders, particularly transporters of fruits and vegetables, as part of the respondent group.

Based on the findings, several recommendations are proposed. Extension agents should actively engage farmers and other stakeholders through town hall meetings and seminars to emphasize the importance of proper handling practices for fruits and vegetables while introducing them to modern techniques. Regular training sessions for farmers and transporters should be organized to address the causes of post-harvest losses and to promote effective preventive measures. Furthermore, the adoption of modern storage techniques for fruits and vegetables should be encouraged among farmers, vendors and consumers to minimize losses and ensure better quality produce.

CONCLUSION

Considerable losses occur due to poor handling methods, insufficient storage methods and a lack of knowledge among farmers, food transporters and vendors. Hence, effective management after harvest is crucial for maintaining quality, prolonging shelf life and increasing the market value of these perishable foods. The results clearly show that proper education, awareness initiatives and the integration of modern handling and storage methods are vital for minimizing post-harvest losses. Actions such as hosting regular training workshops, enhancing extension services through community meetings and seminars and encouraging the use of advanced storage methods will ensure a consistent supply of high-quality fruits and vegetables, thereby leading to nutritional and food security.

SIGNIFICANCE STATEMENT

This study discovered the key postharvest handling practices and challenges affecting the preservation and quality of fruits and vegetables in Benin City, Nigeria, which can be beneficial for improving nutritional and food security in urban areas. The findings underscore the significance of modern technologies, including cold storage and enhanced transportation methods, in minimizing losses. This study will help researchers uncover the critical areas of postharvest management that many researchers have been unable to explore. Thus, a new theory on sustainable postharvest preservation may be arrived at.

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