Economic Analysis of Post Harvest Losses in Plantain (and Banana): A Case Study of South Western Nigeria

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Authors' contributions

This work was carried out as a part of contributions to knowledge in the areas of reduction of post harvest losses in agricultural crops in the tropics with a view to enhancing food security by the collaborating author ORA. The design, management, data collection, analysis and drafting of the manuscript were carried out by the main authors. Final editing was done by author ORA. The two authors read and approved the content of the final manuscript.

ABSTRACT

Aim: The economic analysis of post harvest losses incurable in value addition to banana/plantain 'due to space' in the two major production and consumption centres in Nigeria.
Study Design: Structured questionnaires were used to obtain the required information

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from the banana/plantain merchants.

Place and Duration: The study was carried out in Ondo (collection/production depot) and Lagos (sales depot) states of Nigeria. It covered the period from January to December 2013.

Methodology: Primary data were collected from merchants at the collection and sales depot. Budgeting, Gross margin and Multiple linear regressions were used to analyze the data.

Results: The highest losses were incurred during transportation and these constituted about 5.62% of the potential total revenue. On the average, loss in gross margin was about ₦6,000.00 per merchant. The impacts of these losses are reflected in the continuously reducing level of their income.

Conclusion: The merchants need adequate and sustainable transportation and storage facilities as a matter of utmost urgency. There is the need for government to encourage producers of the product (farmers) by giving them incentives to motivate them and ensure that the environment is made conducive also for dealers by providing adequate storage facilities and providing ready markets locally and possibly for export.

*Naira (₦) is the Nigeria Currency; ₦160 is equivalent to $1.00 as at the time of this study.

1. INTRODUCTION

Banana and Plantain are the common names of tropical plants that belong to the genus *Musa* and though grow as tall as trees, they are actually herbaceous plants. They are native to South East Asia and are thought to have originated from Papua New Guinea but are grown in most tropical countries of the world. They now form part of the staple food of millions of people in the developing world. Half of the world's banana crops are grown in Asia, and in 2009, India led the world in banana production, representing approximately 28% of the worldwide crop, mostly for domestic consumption [1]. Uganda was the top producer of plantain in 2005, followed by Colombia. As economically important as these plants are, they are highly perishable and are best harvested while green. According to Tchango Tchango et al. [2], due to the perishable nature of the fruits, the rate of plantain post-harvest losses varies from one country to another according to the organisation of market chains and modes of consumption. Regrettably in many producing countries, there are no data on the post-harvest losses. The assessment of these post-harvest losses is rather complex because as green mature plantains are consumed so also are the overripe fruits. The seasonal nature of plantain production makes the crop vulnerable to loss during the peak periods of harvest which occur from September to February. Losses are common because the fruit ripens rapidly and most plantain products can only be stored for a few days which limit utilization both at the commercial and non-commercial levels. Precise figures on levels of post harvest losses are unclear, however, plantain is highly perishable at the ambient temperature prevalent in the tropics and information from Cote d'ivoire and Nigeria suggests that losses can be as high as 35% [3].

It has been reported that one of the major problems limiting the expansion of plantain production in West and Central Africa is high post harvest losses. In Nigeria, up to 40% of the harvested crop can be lost during distribution [4]. Post harvest losses result not only in the loss of the actual crop but also losses in the environment, resources, labour needed to produce the crop and livelihood of individuals involved in the production process. When

30percent of a harvest is lost, it implies that 30% of all the factors that contributed to producing the crop are also wasted [5].

Food supply situation can be improved either by increase in production or reduction in loss. Since many researches show that great effort is being made in the area of food production especially in the developing countries, the decline in food availability therefore can be traced to food losses. Thus, reduction in post harvest losses increases food availability hence alleviation of food problems. The effect of post harvest losses reduces the effect of the efforts and enthusiasm put into production and lowers marketing efficiency [6,7].

It is evident therefore that there is a great need to tackle the problem of post harvest losses if the goal of a food secure nation is to be realised. The specific objectives of the study therefore are:

   (a) To identify the socio economic characteristics of banana/plantain dealers and
   (b) To determine the perceived effects of the losses on the merchants, their income, environment and their welfare.

2. MATERIALS AND METHODS

Plantain production is found mainly in the southern states of Nigeria, especially in Cross River and Rivers States [8,9]. A large concentration of plantain production also exists in Benue and Plateau States, while isolated spots are found in the Bida area of Niger State [10]. The western parts of Ondo and Osun states also produce plantains in large quantities that are transported to nearby cities and other parts of the country such as Lagos and Ibadan (Oyo state) metropolis for marketing [11] see Fig. 1.
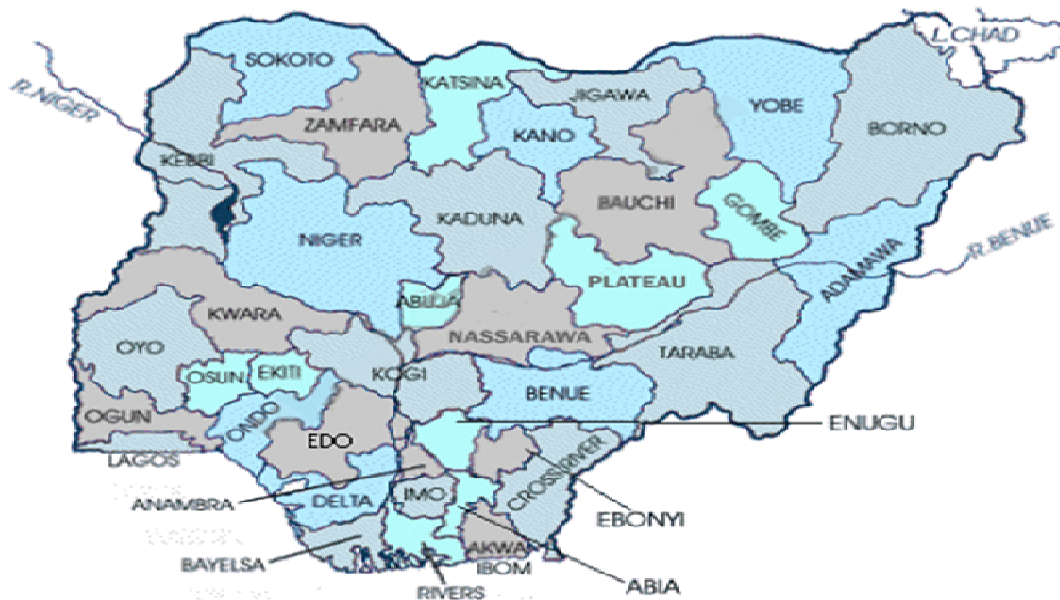

Fig. 1. Map of Nigeria showing the states of the federation
Source: ngex.com/Nigeria/places/default.htm. Accessed 16th July, 2014

The current study was carried out in Ondo and Lagos states of south western Nigeria. Purposive sampling technique was used to collect information from "Kolawole plantain depot" and its surroundings in Ondo East area of Ondo State as the base of purchase by marketers and Alamutu plantain market in Mushin area of Lagos state as the sale point. Kolawole plantain depot is located about 17 kilometres to Ore town along Ore- Benin road in Ondo State. It is a conglomerate depot where all the local producers and purchasers of banana and plantain converge to exchange their goods while Alamutu market is a depot for distribution and sale of banana and plantain to retailers and final consumers in Lagos State and its environs.

Primary data were collected in these depots using well-structured questionnaires containing open and close ended questions. Data collected included those on the farm gate prices of plantain/banana, quantity purchased at a trip, transportation cost, 'waiting period' between the times of purchase and sale to final consumers and the value of products at the city markets. Information on the perceived effects of the losses on merchants were obtained through responses from individual merchant which were collated and subjected to 'Likert Scale' ranking ranging from (1), No effect to (5), Very severe effect on merchants' income. Invariably, all of them experienced losses in one form or the other. The merchants buy and sell banana/plantain in "dozen" which contains 12 bunches of about the same size. A total number of 60 questionnaires were administered and 55 fully completed ones were returned. Gross margin analysis was used to capture the profitability. Gross margin (GM) is the difference between the Total Revenue (TR) and the Total Variable Cost (TVC) of production. For the purpose of this study the Total Revenue (potential and actual) was calculated from the values of all the banana/plantain harvested and the Variable Cost covers the costs incurred on labour (pre-harvest, harvest, and fruit collection cost) and transportation. Storage cost incurred by the banana/plantain dealers during the waiting period between the time of purchase and sale was also included in the variable cost calculation.

Mathematically, Gross Margin is expressed as follows:

GM = Gross Margin (TR–TVC) in Naira (₦)
TR = Total Revenue (Price×Quantity) in Naira (₦)
TVC = Total Variable Cost is the cost of all inputs (labour costs, transportation cost, storage cost) also expressed in Naira (₦).

Regression equation was employed in determining the effect of the following factors on post-harvest losses of banana/plantain:

1. The number of days the harvested banana/plantain spent on the farm and in the market.
2. The time spent in transportation and haulage from point of purchase to point of sale.
3. The number of collection working days and distance from base (market) of purchase.
4. The degree of relationship between the cost of loss and the revenue generated as well as the gross margin.

Multiple linear regression was carried out using the total loss incurred from harvesting to marketing stage as dependent variables and; harvest working days, distance of the farm from the market, number of days the banana/plantain spent on the farm, number of days that the banana/plantain spent in the market before it was sold off, transportation cost, collection working days, and storage cost as independent variables.

Simple regression was further carried out between the dependent variable specified as the value of total loss and revenue generated from banana/plantain production as independent variables.

The multiple linear regression model used is given as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots \beta_n X_n$$

Where Y – Dependent variable
β_0 – Constant
$\beta_1 \ldots \beta_n$ – Coefficient of linear regression
$X_1 \ldots X_n$ – Independent variables

3. RESULTS AND DISCUSSION

Table 1 shows that most of the merchants (54.54%) were in the middle age class of 30-50 years which signifies an agile workforce. About 21.81% of the merchants were male showing that majority of the merchants involved in banana/plantain marketing were female. There were about 73% of the merchants with 1-5 persons in the household. They claimed to be in dire need for steady income to cater for the needs of their families and so could not be comfortable financially to continue to incur losses. Majority of the respondents (63.63%) completed their secondary school education while a fairly large number of respondents (34.54%) also completed their primary school education. It is expected that with this their structure of literacy levels, they would have a fair knowledge of post-harvest technology which might have been gained through education and experience on the job. They should also be able to process and comprehend new information that can benefit them. Eighty percent of the respondents had more than 5 years of experience in banana/plantain marketing while those merchants with fewer years of experience had served as "apprentices" learning and serving under experienced marketers for a few years back and therefore were not likely to encounter much more losses than those with many years of experience. Based on experience on the job therefore, all the farmers were sufficiently capable in the trade for efficient management of the produce to minimise loss due to spoilage.

An inquiry into other subsidiary occupations by the plantain/banana merchants gave the result as presented in Table 2. As shown, 27.27% of the respondents were traders in plantain/banana retailing, and 58.18% of them had no other occupation apart from banana/plantain marketing. This means that as they put in all their human and material resources in the trade, they would least expect to experience post harvest losses.

3.1 Economic Analysis of Post Harvest Losses

Summary of results as related to the economic transactions on plantain/banana marketing in the study area is presented as follows:

The average quantity of banana/plantain in a full lorry load = 120 dozens
The average number of bunches in a dozen = 12 bunches
The average number of bunches in a full lorry load =120×12 = 1,440 bunches
Average price of a bunch = ₦5,500/12 = ₦458.3
Average transportation cost per merchant per trip/loading= ₦7,000
Average collection cost per merchant = ₦700

3.2 Analyses of Losses

The losses involved in banana/plantain marketing were in transportation and marketing. Table 3 shows the value of loss per merchant for each of the distribution groups. It also shows the averages of the losses during transportation, sales and marketing. These losses were incurred within one week, covering the period between initial purchase and eventual sale. As observed, the highest losses were incurred during transportation as indicated by 46.45%, followed by marketing (33.60%) and lastly, 19.95% during sales.

The analyses of Actual Total Revenue (ATR) and Potential Total Revenue (PTR) were carried out using the physical quantity of plantain acquired at the point of purchase as Potential output and the quantity available as at the time of sale as Actual output. The product of prices and physical quantity available at these two levels were the total revenues. As shown in Table 4, the actual revenue was lower than the potential revenue. Losses incurred in the revenue averaged about 5.69 percent of the potential total revenue. These were losses resulting from quantity and quality deterioration occasioned by the logistics involved in transportation and marketing.

Table 1. Socio economic characteristics of respondents

Variables	Frequency	Percentage (%)
Age of respondents (Years)		
Less than 30	7	12.72
30-40	20	36.36
41-50	10	18.18
51-60	11	20.00
61-70	7	12.72
Total	55	100.00
Gender of respondents		
Male	12	21.81
Female	43	78.19
Total	55	100.00
Family size		
1-5	40	72.72
6-10	12	21.81
11-15	3	5.47
Total	55	100.00
Level of education		
Primary	19	34.54
Secondary	35	63.63
Tertiary	-	-
None	1	1.83
Total	55	100.00
Years of experience on the job		
1-5	11	20.00
6-10	15	27.27
11-15	5	9.09
16-20	13	23.63
21-25	4	7.27
26-30	7	12.72
Total	55	100.00

Table 2. Subsidiary occupation of banana/plantain merchants

Occupation	Frequency	Percentage (%)
Trading in plantain/banana	15	27.27
Farming	5	9.09
Hair dressing	3	5.45
None	32	58.20
Total	55	100.00

The potential revenues could not be realised due to some factors causing deterioration and reduction in quality and quantity at post-harvest stages. These factors were pest and diseases infestation, poor handling during delays in transportation and marketing of produce.

Table 3. Estimation of total loss for the average merchant in the group (Naira)

Range of bunches marketed	Frequency	Number of bunches per merchant	Losses during transportation	Sales losses	Losses during marketing	Total losses
Less than or 20	5	10	2,350	1,200	1,500	5,050
21-40	21	31	2,500	1,250	1,900	5,650
41-60	19	51	2,750	1,350	2,250	6,350
61-80	6	71	3,500	1,400	2,500	7,400
81-100	2	91	4,000	1,650	3,000	8,650
101-120	2	111	5,500	2,000	3,750	11,250
Total	55	365	20,600	8,850	14,900	44,350
Average		60.83	3,433.33	1,475	2,483.33	391.67
percentage of total			46.45	19.95	33.60	100

Table 4. Potential total revenue (PTR) and the actual total revenue (ATR) plantain/banana marketing

Range of bunches	Frequency	Average number of bunches per merchant	PTR(₦)	ATR(₦)	Total loss (₦)	ATR as a % of PTR	Total loss as a % of PTR
≤ 20	5	10	55,000	49,950	5,050	90.82	9.18
21-40	21	31	105.000	99,350	5,650	94.62	5.38
41-60	19	51	120,000	113,650	6,350	94.71	5.29
61-80	6	71	140,000	132,600	7,400	94.71	5.29
81-100	2	91	160,000	151,350	8,650	94.59	5.41
101-120	2	111	200,000	188,750	11,250	94.38	5.62
Total	55	365	780,000	735,650	44,350		
Average		60.83	130,000	122,608.33	7,391.67	94.31	5.69

3.3 Gross Marginal Analysis

The results of gross margin analyses were considered at two levels. First, gross margins were evaluated without considering losses due to post harvest handling and second, with a consideration of the losses. These are shown in Tables 5 and 6 respectively.

As shown in Table 5, average gross margin increased with increase in number of bunches handled being least for the merchants' handling less than 20 bunches and highest for those handling up to 120 bunch. However, majority (72.73%) of the merchants handled produce ranging between 21 and 60 bunches. This according to the respondents was due to limitations posed by capital required for handling bigger volumes of produce as well as availability of the needed personnel.

On the average therefore, the potential average gross margin that could be earned in the study area was ₦106, 100 per period of about one to two weeks on-season.

Table 6 presents the result of the analysis of gross margin when losses incurred were taken into consideration. As expected, the trend observed was the increase in gross margin as the volume of business increased. Also, the higher the volume of business, the higher the reduction in gross margin realizable across the various groups tended to be hence, for the group handling less than 20 bunches, the reduction in gross margin when losses were taken into consideration was ₦5,050.00 while it was ₦11,250.00 for those handling up to 120 bunches. For the majority of the merchants handling between 21and 60 bunches on the average, loss in gross margin was ₦6,000.00 per merchant. The average gross margin when losses were taken into consideration was ₦98, 708.30.

The reduction in gross margin occasioned by post-harvest losses was therefore about ₦7, 391.67 in the study area.

3.4 Regression Analysis

The result of regression analysis to investigate the likely effects of some variables on the post-harvest losses incurred on plantain/banana marketing is shown in Table 7. The dependent variable(Y) is the value of loss incurred while the independent variables (X_i's) are defined as follows:

$X_1 =$ Age of respondents (AOR)
$X_2 =$ Harvest Working Days (HWD)
$X_3 =$ Distance of Farm to the market (DIS)
$X_4 =$ Number of days that banana/plantain spent on the farm before transporting (STF)
$X_5 =$ Number of days that banana/plantain spent in the market before sales (SDM)
$X_6 =$ Transportation Cost (TC)
$X_7 =$ Collection Working Days (CWD)
n= 55, k= 8, df (n-k) = 47

3.5 Régression Equation

$$Y = -16.9 - 0.008 X_1 + 0.773 X_2 + 0.582 X_3 - 0.725 X_4 + 0.366 X_5 + 0.210 X_6 + 0.536 X_7$$

Table 5. Gross margin realizable by merchants without considering the losses

Range of bunches	Frequency	Average number of bunches per merchant	Potential total revenue (₦)	Total variable cost (₦)	Average gross margin (₦)
≤20	5	10	55,000	14,200	40,800
21-40	21	31	105,000	16,000	89,000
41-60	19	51	120,000	17,400	102,600
61-80	6	71	140,000	19,400	120,600
81-100	2	91	160,000	22,800	137,200
101-120	2	111	200,000	53,600	146,400
Total	55	365	780,000	143,400	636,600
Average		60.83	130,000	23,900	106,100

Table 6. Gross margin realizable by merchants when losses are considered

Range of bunches	Frequency	Average number of bunches per merchant	Actual total revenue (₦)	Total variable cost (₦)	Average gross margin (₦)
≤20	5	10	49,950	14,200	35,750
21-40	21	31	99,350	16,000	83,350
41-60	19	51	113,650	17,400	96,250
61-80	6	71	132,600	19,400	113,200
81-100	2	91	151,350	22,800	128,550
101-120	2	111	188,750	53,600	135,150
Total	55	365	735,650	143,400	592,250
Average		60.83	122,608.33	23,900	98,708.33

The results show that HWD, STF, and the CWD were significant and as the coefficient of age of the respondents (X_1) increased by one unit, the value of the total loss (Y) incurred decreased by 0.008 units (0.8%). This proved that the age of the respondents played a major role in determining the level of care in the handling of the fruits.

As the number of days the fruits spent on the farm (X_4) increased by one unit, the value of the total loss (Y) decreased by 0.725 units. This tended to suggest that harvesting of plantain/banana should be timed appropriately for easy transportation. The practice of harvesting and delaying transportation for days in the collection depot for eventual transportation to sites for marketing aggravates losses. It was also observed that as the number of days the fruits spent in the market (X_5) increased by one unit, the value of the total loss (Y) increased by 0.366 units. This means that the fruits deteriorated in quality and quantity the longer they stayed in the open market unprocessed after harvesting. This could be due to exposure to harsh environmental conditions such as excessive heat and rain.

The coefficient of determination (R^2) was 79.2%. This implies that almost 80 % of the variation was explained by the analysed variables. Thus, we can safely assume that there existed other minor determinants of post-harvest losses that were not yet isolated and measured in the course of this study. This calls for further in-depth exploratory research.

Table 7. Results of regression analysis

Independent variables	Coefficients	Standard error	t-value
Constant	-16. 912	9.928	-1.70
AOR (X_1)	-0.0076	0.0031	-2.43*
HWD (X_2)	0.7728	0.3133	2.47*
DIS (X_3)	0.5821	0.3800	1.53
STF (X_4)	-0.7250	0.3414	-2.12*
SDM (X_5)	0.3660	0.1563	2.34*
TC (X_6)	0.2095	0.1459	1.44
CWD (X_7)	0.5363	0.1332	4.02**

** Significant at 1%; * Significant at 5%; F- Value is significant at 1%

4. CONCLUSION

Banana and plantain are noted to be among the staple foods consumed by a vast majority of the population in Nigeria and West Africa. Moves to boost production and availability of these crops will not only enhance the food security status and sustainability of the nation, it will also boost the economy through exports. The available data on current production of these crops suggest that there should not be any reason for Nigeria not being a leading exporter of these crops [1,8,11]. The farmers who supply the produce need to be encouraged, and the marketers also need motivation. It is however clear that, losses do not occur because the merchants are illiterate as findings revealed that about 98.17% of them had formal education, which implied that they were able to at least comprehend and apply post-harvest technology available and accessible to them.

Arising from the observations, it could be derived that the merchants need adequate and sustainable transportation and storage facilities as a matter of urgency. They are observed to be well focused enough in their business and most of them rely solely on banana/plantain marketing business to meet their family sustenance needs. Concerted efforts are needed to arrest the situation leading to post-harvest losses in banana/plantain production. The current

trend is that most merchants earn relatively reduced gross margins compared with the volume of their business and capital investments. The impacts of these losses are reflected in the continuously reducing level of their income and notable stagnancy in their standard of living.

5. POLICY RECOMMENDATIONS

Based on the findings from the research, the following policy recommendations could be made for implementation to reduce post harvest losses across all stages in the production process of plantain/banana:

1. The development of an effective and affordable transportation system such that there will be reduced need for 'stops' on the way. The development of the railway service in the country could help in combating this problem. This recommendation is based on suggestions preferred by almost all (97.5%) the merchants for success in the business.
2. The establishment of well structured farmers' market and effective co-operative marketing by the merchants could also help to minimize post-harvest losses.
3. Regular training should be organised to sensitize the farmers and merchants on proper handling of farm produce from the point of harvest till they are eventually disposed of to the ultimate consumers. This could help to reduce mechanical damage of the products and improve their shelf life.

There is need for government to encourage producers of the product (farmers) by giving them financial supports and other incentives to motivate them. The environment should also be made conducive for dealers by providing adequate storage facilities and ready markets locally and possibly for export.

COMPETING INTERESTS

Authors declare that there are no competing interests.

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