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# Small-scale postharvest practices among plantain farmers and traders: A potential for reducing losses in rivers state, Nigeria

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ABSTRACT

High postharvest losses (PHLs) caused by poor postharvest management of perishable staple foods is a serious food security problem in Nigeria. Adoption of suitable postharvest management techniques is necessary to maintain produce quality and minimize avoidable losses by relevant stakeholders. The challenge is that most popular postharvest technologies are unsuitable for small scale farmers and traders who are a majority in the Nigerian food supply chains. This paper proposes the adoption of small-scale friendly postharvest techniques in the form of small-scale postharvest practices (SSPPs). To justify this proposal, the impact of SSPPs adoption on self-reported losses were investigated in Rivers State Nigeria. The factors influencing plantain farmers and traders intention to use SSPPs were also studied. Multistage and snowball sampling techniques were used to obtain data from farmers and traders, respectively. Data were obtained via face-to-face interviews using structured questionnaire. The data were analysed using descriptive statistics, correlation analysis, chi-square test of independence and multiple linear regression analyses. The results indicate that farmers adoption of SSPPs was negatively correlated with quantitative losses ($r = -0.142$) and qualitative losses ($r = -0.412$). Gender, education level, occupation, amount of produce harvested, and information access were significantly associated with farmers adoption of SSPPs. From the regression analysis, attitudes ($\beta = 0.523$, $p < 0.05$), awareness knowledge ($\beta = 0.100$, $p < 0.05$) and perceptions ($\beta = 0.293$, $p < 0.05$) of farmers significantly predicted their intention to use SSPPs. The regression model was significant ($R^2 = 0.552$, $F(3, 308 = 126.264$, $p < 0.05$)), with attitudes, awareness and perceptions explaining 55.2% of the variation in the dependent variable, intention. Based on the results, we recommend that plantain farmers and traders should integrate small scale postharvest practices in their operations because it will help them maintain produce shelf life and minimize avoidable losses. Policy makers, food security proponents and relevant institutions should take the necessary action by formulating tailored intervention programs that would facilitate adoption of SSPPs at farm and market levels. These recommendations will positively impact food security efforts in the country.

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## Introduction

In Nigeria, the agriculture sector employs about 70% of the labour force and contributes about 30% of the national GDP [37]. Small-holder farmers account for almost 90% of the total food production [36] by mostly relying on traditional methods for their operations. In terms of economic contribution, crop-production is a key sub-sector in the Nigerian agriculture and most staple food crops are produced in the southern part of the country due to availability of arable land. Fertile soils and favourable climatic conditions in the South signals a high potential for adequate food production to satisfy the country's growing population. Sadly, the country grapples with food insecurity partly due to bottlenecks such as high food losses along its food supply chains. The main reason for high losses is because most small-scale farmers and traders do not employ appropriate postharvest handling practices in their operations.

In Nigeria, losses due to poor postharvest practices can reach up to 50% for some fresh food produce [14,16]. This means that half of the food that is produced for humans never get consumed. A multi-country study estimated food loss in Nigeria to be over 100 kg/capita/year [7]. No doubt that continuous high losses for staple crops will have a significant negative impact on food security. For instance, plantain, a highly consumed staple with year round availability is notable for high perishability. Plantain postharvest losses in Nigeria can range from 5% [1,37] to as high as 40% as reported in previous study by Olorunda and Aworth [38]. These reports for plantain in Nigeria almost agrees with the common knowledge that about one third of the food produced globally for human consumption ends up as food losses [19,21].

Food loss (FL) is defined as "the reduction in the amount of food, that was originally meant for human consumption", along the food supply chain [19,40]. Although the specifics of what constitutes food loss vary, available literature suggests that food losses manifests in two distinct forms along a commodity supply chain. When food losses occur at the earlier stages (from production to market) of a commodity's supply chain, they are termed 'postharvest losses' (PHLs) whereas at the later stages (from retail to consumption) the term 'food waste' (FW) is used [21]. Interestingly, only one form of FL tends to dominate a country's food system at a time, although exceptions may exist. The pattern is that PHLs are prevalent in developing countries while FW prevail in developed countries [7,23]. Such a distinct manifestation indicates that the underlying causes of food losses are different enough to refute the expectations that popular postharvest technologies in developed countries should simply work in developing countries.

The direct impact of PHLs is on the livelihoods of farmers and other supply chain actors who depend solely on income from their produce for survival. The indirect impacts are on consumers because high losses contribute to escalating food prices. Reduction in food volume promotes insecurity. As Gustavsson et al. [19] rightly explained that food insecurity may not necessarily mean supply inadequacy but also a reduced ability to adequately access the needed food. Thus, high postharvest losses in staple foods can undermine food security efforts and any increase in a country's food production. Understanding the specific causes of food loss variants can be an effective approach for identifying solutions that are need-based and adaptable to a local context. However, the paucity of food loss data, unpublished research and methodological inconsistencies challenge comparisons of research outcomes in Africa [3]. Besides, divergent interests that drive postharvest research may lead to under-reporting or exaggerations of losses thereby impeding comparisons and evidence based interventions.

For PHLs, that is food losses during the harvesting, storage, processing and distribution stages [13], the causative factors are categorized into primary or secondary [5]. Primary causes are factors that directly impact the fresh produce to cause deterioration whereas the secondary causes are indirect factors that facilitate the primary causes to increase deterioration [5]. The secondary causes are mostly human decision related factors such as poor harvesting and inappropriate postharvest handling and management practices that facilitate biological deterioration. Kader [28] explained that the primary causes are biological while the secondary causes are non-biological in nature [28]. Since the secondary causes of PHLs can facilitate the primary causes, it means that the primary causes can be controlled by the same secondary causes. Therefore, addressing food insecurity from a postharvest point of view would mean that adequate effort to manage human related factors around management of postharvest quality must be factored into food security policies and interventions.

Solutions to secondary causes of PHLs are mostly in the form of postharvest technologies. Popular postharvest technologies such as cool chains are not within the reach of small-scale farmers and traders who operate in traditional supply chains (fragmented with no systematic cordination) like those in Nigeria. To this effect, Kitinoja [30] documented a variety of small scale postharvest innovations for improving value and returns of farmers depending on appropriateness. In Nigeria plantain postharvest losses mostly result from improper storage, transportation activities [1,26,37] and production. Small-scale practices such as shade-cooling, hydro-cooling, use of protective transport materials were identified and selected as appropriate for maintaining produce quality and to consequently reduce PHLs of plantain farmers and traders. In terms of adaptability, these small-scale postharvest practices can be modified to suit the local context of smallholder agricultural systems [6,31,32].

Maintenance of fresh produce quality through proper postharvest handling by small-scale agriculture systems can only happen if farmers, marketers and traders show a willingness to include postharvest innovations and solutions in their operations. Thus, it is necessary to gain an understanding of small-scale farmers and traders willingness and to ascertain the factors that are influential in their uptake of SSPPs. While there is no validated theory or framework to differentiate posthar-

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vest solutions that will be successfully adopted or not, studies show that postharvest handling solutions are adoptable if they appear simple and compatible with the operations of potential adopters [52]. Socio-economic characteristics were reported to also influence acceptance of postharvest technologies by farmers in India [4,9,33]. In addition, recent food waste studies have highlighted human behaviour as to be significantly influential in the occurrence of food losses [48,51,53].

The low adoption of small-scale postharvest practices in Nigeria despite high PHLs (up to 50%) warrants the need to understand small-scale farmers and traders behaviour towards postharvest solutions. Therefore, this study investigated the effectiveness of selected small-scale postharvest practices at reducing losses. The study also examined factors that influence intention to use selected SSPPs in Rivers State, Nigeria.

## Materials and methods

### *Study area and sampling*

The study was conducted in Rivers State in the South-south geopolitical zone of Nigeria. The state is made up of three senatorial districts: Rivers West, Rivers East and Rivers South. Characterised with a tropical wet climate, Rivers state has an average annual temperature of ~26.5 °C with the months of May to October being wetter, and temperature ranging between ~21 to ~32 °C. The dry season is between November and March where temperatures can peak to ~33.5 °C. Rivers State is part of the oil rich Niger Delta region on 4°45′N 6°50′E, with a population of 5 million people of multiple ethnic groups who depend on small-scale agriculture for their livelihoods. Rivers state is classified as one of the high producing states for plantain in the country [11], hence its suitability for the study.

Data was obtained via face to face interviews from plantain farmers and traders. The data was obtained via face to face interviews using two structured questionnaires, one for each group. The sampling techniques used were multistage and snowball sampling for farmers and traders respectively. Multistage sampling was employed to systematically obtain a sample of farmers that is representative of the senatorial districts and local government areas in the State. A snowball sampling was more appropriate for traders because of the unstructured way plantain trading is conducted in the study area; plantain traders usually operate in multiple plantain markets in the state. The state's agriculture ministry had only records of registered farmers without specification on the type of crops farmed. Given that there was no definite sampling frame when this study was conducted, literature prescribed that the assumptions of the statistical techniques can guide the decision on appropriate minimum sample size [47] in such scenarios. Some of such important assumptions include statistical power and effect size. Acceptable power level for moderate effect sizes at alpha levels of 0.05 require sample sizes of at least $\geq$ 100 [20,35]. In addition, Israel [27] suggested that a sample size of at least 100 for each subgroup will suffice for cases of comparisons between subgroups. In this study, 350 questionnaires were administered to plantain farmers while 150 questionnaires were administered to traders. Due to cases of invalid responses 312 and 114 were the valid observations retained for data analysis for farmers and traders respectively.

### *Definition and measurement of variables*

The loss estimates in this study were based on self-reported incidences since this was a cheaper way of obtaining loss data. Respondents were asked to report the average number of plantain bunches that were lost in a typical market day. The estimates were then multiplied by the average number of market days in a month. Qualitative losses were estimated based on the percentage of produce that respondents indicated as deteriorated in quality but still sold or consumed whereas quantitative losses were estimated as the percentage of produce that were unfit for consumption and therefore discarded [18,22]. As suggested by Genova et al. [17], losses for farmers were quantified as a percentage based on their total harvested quantity whereas losses for traders were based on the quantity purchased. The definitions of quantitative and qualitative food losses were consistent with literature [22]. Quantitative losses is the percentage of produce discarded for each harvest/purchased batch while qualitative losses is the percentage of produce that pricing reduced because of deteriorating quality [23]. In most cases, respondents provided loss figures in counts such as number of bunches or number of fruits, which were then converted to percentage.

Small-scale postharvest practices were defined as techniques or practices that help to maintain produce quality, improve market appearance and prolong postharvest life of the produce [45,52]. Seven postharvest practices: pre-harvest bagging (applicable to only farmers), hydro-cooling, shade-cooling, storage in a cool environment, use of ventilated boxes, plastic crates and sealed packaging in relation to these loss hotspots were selected and used to investigate farmers and traders adoption behaviour. Usage or adoption of SSPPs were measured based on the number of postharvest practices each respondent indicated to have used and the frequency of usage for each postharvest practice were used to compute a score for SSPPs usage which was then analysed with the loss values provided.

The definition of variables were consistent with the adoption literature but with modifications to reflect the current study. Questionnaire scales were developed as recommended by previous authors [2,10,49,50]. For instance awareness level is defined as "what is knowledge" described by Rogers [43]. In this study, "what is knowledge" represents awareness about each specific SSPP. Attitudes towards SSPPs was defined based on the tri-component model which consists of affective, belief and action components [10,41]. Attitudes towards SSPPs were measured in terms of respondents beliefs, positive reactions and willingness to acquire more information about SSPPs. Perceptions refer to the perceived characteristics towards

an innovation [34]. Positive perception signifies receptiveness towards a new idea that satisfies a need; a concept known as perceptive vigilance [41]. On this premise, smallholder farmers are expected to demonstrate positive perceptions towards SSPPs that meet their needs. Intention, which is the dependent variable, is an immediate precursor of the target behaviour [12,15] – adoption of SSPPs. Intention was assessed based on the respondents' purposeful desire or acceptance to use SSPPs. This is a feasible way to measure acceptance towards a targeted behaviour in cross sectional studies [24]. Excluding awareness knowledge and demographics, all variables were measured using a five point Likert scale where "1″ represents "Strongly disagree", "2″ represents Disagree, "3″ represents "Neutral", "4″ represents "Agree" and "5″ represents "Strongly Agree" to the statements.

*Data analysis*

Normality of data was assessed using the graphical method, kurtosis and skewness criteria [29]. The skewness values were between the values of 0.714 for age and 1.558 for years of experience with standard errors of 0.138 while the kurtosis values were between the values of – 0.093 for age and 2.886 for years of experience with standard error of 0.275. Z-test values were computed from the skewness and kurtosis values. The z values for most descriptive values violated the assumptions of normality, therefore these variables were transformed to categorical variables used for the Chi-square analyses, and therefore excluded from the regression analyses. The data were analysed with IBM SPSS version 21 [25] using descriptive statistics, chi-square test of independence, correlation analysis and multiple linear regression analysis.

The regression equation to predict smallholder farmers intention to use SSPPs is given in Eq. (1).

$$Y_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon \mathrm{i} \quad (1)$$

Where:

$Y_i$ = Intention to use Small-scale postharvest technologies
$\alpha$ = Constant
$\beta_1$, $\beta_2$, and $\beta_3$ = Regression coefficients for $X_1$, $X_2$, and $X_3$ variables respectively
$X_1$ = Attitudes towards small-scale postharvest practices
$X_2$ = Awareness knowledge of small-scale postharvest practices
$X_3$ = Perceptions towards small-scale postharvest practices
$\varepsilon_i$ = Error term

## Results and discussion

*Socio-demographic profiles of respondents*

Tables 1 and 2 show the demographic characteristics of the plantain farmers and traders respectively. According to Table 1, the mean age and experience of the farmers were 42.2 years (SD = 13.75) and 11.89 years (SD = 9.5) respectively. A majority (75%) of the farmers engaged in plantain farming as a part time occupation. The mean age of plantain traders was 41.36 years and most of them had secondary education (Table 2). Unlike the farmers, a high majority of the plantain traders were women; indicating that plantain farming is male dominated whereas plantain trading is female dominated. This observation agrees with that of earlier studies by Ben-Chendo et al. [8]. Based on Tables 1 and 2, the average monthly income for farmers and traders are 40,718.59 Naira and 38,793.10 Naira with high standard deviations of 68,700.65 and 49,684.53 respectively. The reasons for such high standard deviations could be the huge disparity between the high earners and low earners coupled with sparse income data due to the unwillingness of respondents to disclose this information since participation was purely voluntary.

*Relationship between small-scale postharvest practices and postharvest losses*

Table 3 shows the results of the correlation analyses between usage of small-scale postharvest practices and self-reported plantain PHLs in the study area. The results revealed that usage of the selected SSPPs negatively correlated with loss incidence. The coefficients of correlation between usage of SSPPs and qualitative PHLs, for farmers and traders were $r = -0.392$ ($p < 0.05$) and $r = -0.479$ ($p < 0.05$) respectively. These correlations were significant at the 1% level of significance. Similarly, usage of SSPPs negatively correlated with quantitative PHLs at the farm and market levels; although, only the correlation coefficient for farmers quantitative losses were statistically significant at the 5% level of significance. These findings supports the belief that PHLs can be reduced by an increased use of SSPPs in small-scale operations. The non-significant relationship for traders quantitative PHLs could be as a result of traders not willing to quickly discard plantain fruits even when quality deteriorates. They would rather bargain for a reduction in price, since plantain fruits of poor quality can still be used for alternative purposes such as fermentation drinks and porridge dishes. Overall, the correlation results confirms the effect of human decisions or secondary causes on food losses in the study area. In this case, the decisions revolve around postharvest handling and management. Clearly, such decisions have significant impact on losses of fresh produce; even though the effect happens indirectly. For instance, if a stakeholder makes the decision to use SSPPs they slow down the biological or primary

**Table 1**
Socio-Demographic Profiles Of Plantain Farmers.

| Variables | Percentage (%) | Mean | Standard Deviation | Standard Error of Mean |
|---|---|---|---|---|
| **Gender** | | | | |
| Male | 61.2 | | | |
| Female | 38.8 | | | |
| **Operation of Plantain business** | | | | |
| Full-time | 25.0 | | | |
| Part-time | 75.0 | | | |
| **Education Level** | | | | |
| No formal education | 6.4 | | | |
| Primary | 19.2 | | | |
| Secondary | 54.2 | | | |
| Tertiary | 20.2 | | | |
| **Age (years)** | | | | |
| | | 42.20 | 13.75 | 0.992 |
| ≤ 30 | 24.0 | | | |
| 31 – 40 | 27.6 | | | |
| 41 – 50 | 25.3 | | | |
| 51 – 60 | 11.9 | | | |
| ≥ 61 | 11.2 | | | |
| **Monthly Income(Naira)** | | | | |
| | | 40,718.59 | 68,700.65 | 4870.06 |
| **Marital Status** | | | | |
| Single | 18.9 | | | |
| Married | 77.2 | | | |
| Separated/Divorced | 1.0 | | | |
| Widowed | 2.9 | | | |
| **Family size** | | | | |
| | | 5.85 | 2.81 | 0.218 |
| ≤ 3 persons | 19.9 | | | |
| 4 – 6 persons | 48.1 | | | |
| 7 – 9 persons | 22.4 | | | |
| ≥ 10 persons | 9.6 | | | |
| **Experience (Years)** | | | | |
| | | 11.89 | 9.50 | 0.702 |
| ≤ 5 | 30.1 | | | |
| 6 – 10 | 34.3 | | | |
| 11 – 15 | 10.9 | | | |
| 16 – 20 | 10.6 | | | |
| ≥ 21 | 14.1 | | | |

causes which then decrease deterioration as earlier hypothesized. The reverse case applies if the stakeholder decides not to use SSPPs. Therefore, it is recommended that farmers and marketers should integrate these small scale postharvest practices as effective alternatives for handling their fresh produce in localities where conventional large scale postharvest technologies are unsuitable.

*Associations between socio-demographic profiles and adoption of SSPPs*

Chi-square test of independence was performed to determine the association between the respondents socio-demographic profiles and their adoption of SSPPs. The categories for the dependent variable were adopters and non-adopters. Gender was significantly associated with farmers adoption of SSPPs at the 1% level of significance. Education level showed significant association with adoption at the 5% significance level (Table 4). Both results allowed for the rejection of the null hypotheses. Variables such as age, experience level and family size showed no significant associations with adoption in this study. On the contrary, a previous study in Eastern Nigeria reported household size as one of the factors that significantly influence adoption level of farm technologies by plantain farmers [39]. A possible explanation for the observed non-significant association with family size is that small-scale postharvest practices especially those considered in this study were very simple techniques, therefore, farmers with small family sizes and those with large family sizes had almost equal adoption capacity. Furthermore, farmers adoption showed a significant association with occupation (p-value $< 0.05$). The cross-tabulations suggested that full time plantain farmers were more likely to engage in the use of small scale postharvest practices than part-timers. The observation indicate that full-timers can afford to dedicate more time and attention to their plantain business operations than part-timers. The chi-square analysis between the amount of produce harvested and farmers' adoption indicated a significant association with a p-value $< 0.05$. Based on the cross-tabulation output, farmers with larger scale of operation are more likely to adopt postharvest practices than those with smaller scale of operation. This observation is similar to the study by Ali [4], who reported that diversified vegetable farmers were more likely to adopt new postharvest technologies in India. Likewise, association between adoption and access to information was found to be

**Table 2**
Demographic Profiles Of Plantain Traders.

| Variable | Percentage (%) | Mean | Standard Deviation | Standard Error of Mean |
|---|---|---|---|---|
| **Gender** | | | | |
| Male | 34.2 | | | |
| Female | 65.8 | | | |
| **Education level** | | | | |
| No formal education | 3.5 | | | |
| Primary | 21.9 | | | |
| Secondary | 59.6 | | | |
| Tertiary | 14.9 | | | |
| **Age (years)** | | | | |
| | | 41.36 | 8.72 | 1.14 |
| ≤ 30 | 17.5 | | | |
| 31 – 40 | 36.8 | | | |
| 41 – 50 | 29.8 | | | |
| 51 – 60 | 11.4 | | | |
| ≥ 61 | 4.4 | | | |
| **Monthly Income (Naira)** | | | | |
| | | 38,793.10 | 49,684.53 | 6523.89 |
| **Marital Status** | | | | |
| Single | 14.0 | | | |
| Married | 82.5 | | | |
| Separated/Divorced | 2.6 | | | |
| Widowed | 0.9 | | | |
| **Family size** | | | | |
| | | 6.02 | 2.32 | 0.305 |
| ≤ 3 persons | 16.7 | | | |
| 4 – 6 persons | 48.2 | | | |
| 7 – 9 persons | 27.2 | | | |
| ≥ 10 persons | 7.9 | | | |
| **Experience (Years)** | | | | |
| | | 10.57 | 7.07 | 0.928 |
| ≤ 5 | 30.7 | | | |
| 6 – 10 | 34.2 | | | |
| 11 – 15 | 12.3 | | | |
| 16 – 20 | 16.7 | | | |
| ≥ 21 | 6.1 | | | |
| **Plantain Trading Occupation** | | | | |
| Full-time | 37.7 | | | |
| Part-time | 62.3 | | | |

**Table 3**
Correlation Analyses Of Usage Of SSPPs And Self-reported Plantain PHLs.

| Supply Chain Player | Variable | Usage of SSPPs | Quantitative PHLs (%) | Qualitative PHLs (%) |
|---|---|---|---|---|
| **Farmers** | | | | |
| | Quantitative PHLs (%) | - 0.142[b] | 1 | |
| | Qualitative PHLs (%) | −0.412[a] | 0.279[a] | 1 |
| **Traders** | | | | |
| | Quantitative PHLs (%) | - 0.179 | 1 | |
| | Qualitative PHLs (%) | - 0.479[a] | 0.239 | 1 |

[a] Significant at the 1% level of significance,.
[b] Significant at the 5% level of significance.

significant with a p-value $< 0.05$. The cross-tabulation suggests a higher adoption rate for smallholder farmers with increased access to information. This finding is consistent with Rogers [44] postulation of communication accessibility as one characteristic that differentiates early adopters from others. Better access to communication increases exposure to new ideas and explains why innovators pick up new solutions than non-innovators. The study therefore recommends that government and relevant institutions should do more to improve farmers access to multiple communication channels where they can be exposed to new information.

The results of the chi-square tests of independence sheds lights on the necessary demographic factors to consider when promoting adoption of postharvest solutions among farmers. Government and non-governmental organizations seeking to integrate good postharvest handling practices can improve the effectiveness of programs by envisaging how these demographic factors possibly create behavioural differences and sub-categories among small scale farmers. A more in-depth

**Table 4**
Associations Between Farmers' Socio-Demographic Profiles And Adoption Of SSPPs.

| Variables | Chi-square Value | Degree of Freedom | P value |
|---|---|---|---|
| Gender | 7.992 | 1 | 0.005[a] |
| Age Group | 5.518 | 4 | 0.238 |
| Experience Level | 0.434 | 4 | 0.980 |
| Marital Status | 4.343 | 2 | 0.114 |
| Education Level | 10.965 | 3 | 0.012[b] |
| Occupation | 7.280 | 1 | 0.007[a] |
| Family Size | 0.429 | 3 | 0.934 |
| Produce Amount | 20.029 | 3 | 0.000[a] |
| Information Access | 22.372 | 1 | 0.000[a] |

[a] Significant at 1% level of significance,.
[b] Significant at 5% level of significance.

**Table 5**
Associations Between Traders' Socio-Demographic Profiles And Adoption Of SSPPs.

| Variables | Chi-square Value | Degree of Freedom | Significance Level |
|---|---|---|---|
| Gender | 0.25 | 1 | 0.875 |
| Age Group | 1.394 | 4 | 0.845 |
| Experience Level | 10.580 | 4 | 0.032[b] |
| Marital Status | 1.154 | 3 | 0.764 |
| Education Level | 1.540 | 3 | 0.673 |
| Occupation | 1.978 | 1 | 0.203 |
| Family Size | 2.798 | 3 | 0.469 |
| Produce Amount | 4.671 | 3 | 0.198 |
| Information Access | 7.642 | 1 | 0.006[a] |

[a] Significant at 1% level of significance
[b] Significant at 5% level of significance.

understanding of these differences could lead to the development of a more tailored approach that will further advance adoption rate.

Table 5 presents the results of the chi-square analyses of the associations between traders' demographic profiles and adoption of SSPPs. According to Table 5, traders experience level and information access were significantly associated with adoption of SSPPs at the 5% level of significance. The pattern observed in the cross-tabulation is that traders with higher experience level were more likely to be adopters than those with lower experience level. The cross-tabulations indicates a positive pattern between adoption and information accessibility. Thus, years of experience and information access play a role in promoting small scale traders adoption of SSPPs in their operations. Variables such as gender, age, marital status, education level, occupation, family size and produce amount showed no significant associations with adoption. This implies that experience level and information access are necessary demographic factors to consider when promoting traders adoption of SSPPs. Interestingly, the factors that are associated with adoption of SSPPs differed for farmers and traders. These differences urgently suggest a need for market tailored interventions if postharvest solutions are to be integrated in the existing supply chains for fresh produce in the study area.

*Factors that influence intention to use small-scale postharvest practices*

A multiple regression analysis was conducted to examine how smallholder farmers awareness knowledge, attitudes and perceptions towards SSPPs influenced their intention to use small-scale postharvest practices in their operations. The results of the regression analysis which are summarized in Table 6. gives the unstandardized regression model for farmers intention to use SSPPs as follows:

$$\text{Farmers Intention to use SSPPs} = 0.318\ (\text{Attitudes}) + 0.065\ (\text{Awareness knowledge}) + 0.212\ (\text{Perceptions}) - -3.03.$$

The regression model is significant ($R^2 = 0.552$, $F(3, 308 = 126.264$, $p < 0.05)$). It was found that attitudes ($\beta = 0.523$, $p < 0.05$), awareness knowledge ($\beta = 0.100$, $p < 0.05$) and perceptions ($\beta = 0.293$, $p < 0.05$) significantly predicted farmers intention to use SSPPs. Based on the results, the independent variables explained 55.2% of the variation in farmers intention to use SSPPs. All variance inflation factor (VIF) values were less than 2 and the Durbin-Watson statistic of 1.781 shows that the data satisfied the assumptions of multicollinearity and autocorrelation. The positive regression coefficients of the model indicates that every unit increase in attitudes, awareness knowledge level and perceptions towards SSPPs will lead to an increase in farmers intention to use SSPPs by 0.523, 0.100 and 0.293 units respectively. These results indicate the important role of psychological factors such as attitudes and perceptions to the successful adoption of postharvest solutions. Attitudes and perceptions being significantly influential to farmers adoption behaviour are similar to the findings reported by Sharifzadeh et al. [46] and Rehman et al., [42], though on different farm technologies. The findings suggest the need for

**Table 6**
Multiple Linear Regression For Farmers Intention To Use SSPPs.

| Variables | Unstandardized Coefficients B | Standard Error | Standardized Coefficients Beta | t-Statistic | Significance Level |
|---|---|---|---|---|---|
| Constant | −3.030 | 0.817 | | - 3.711 | 0.000 |
| Attitudes | 0.318 | 0.027 | 0.523 | 11.840 | 0.000[a] |
| Awareness knowledge | 0.065 | 0.025 | 0.100 | 2.563 | 0.011[b] |
| Perceptions | 0.212 | 0.032 | 0.293 | 6.564 | 0.000[a] |
| R | 0.743 | | | | |
| R Square | 0.552 | | | | |
| Adjusted R Square | 0.547 | | | | |
| Std. Error | 1.6126 | | | | |
| $F = 126.264$ | | | | | |
| p-value = 0.000 | | | | | |

[a] Significant at 1% level of significance,.
[b] Significant at 5% level of significance.

**Table 7**
Multiple Linear Regression For Traders Intention To Use SSPPs.

| Variables | Unstandardized Coefficients B | Standard Error | Standardized Coefficients Beta | t-Statistic | Significance Level |
|---|---|---|---|---|---|
| Constant | 1.735 | 1.787 | | 0.971 | 0.334 |
| Attitudes | 0.281 | 0.046 | 0.502 | 6.058 | 0.000[a] |
| Awareness knowledge | 0.047 | 0.049 | 0.076 | 0.963 | 0.338 |
| Perceptions | 0.105 | 0.070 | 0.124 | 1.503 | 0.136 |
| R | 0.569 | | | | |
| R Square | 0.323 | | | | |
| Adjusted R Square | 0.305 | | | | |
| Std. Error | 1.730 | | | | |
| $F = 17.542$ | | | | | |
| p-value $< 0.05$ | | | | | |

[a] Significant at 1% level of significance.

campaigns focused on increased awareness and sensitization of stakeholders on the importance of small-scale postharvest practices. Campaigns and programs to change farmers perceptions and attitudes towards postharvest practices should be organized. These sensitization campaigns should communicate the long term benefits of SSPPs to the potential users. Most likely farmers adoption will improve if they perceive SSPPs to be beneficial.

Table 7 shows that results of the regression analysis for traders intention to use SSPPs. The regression model for traders intention to use SSPPs is as follows:

Traders Intention to use SSPPs = 0.281 (Attitudes) + 0.047 (Awareness knowledge) + 0.105 (Perceptions) + 1.735. The results showed that the regression model is significant with $R^2 = 0.323$, $F(3, 110) = 17.524$, $p < 0.05$. It was found that attitudes ($\beta = 0.502$, $p < 0.05$) significantly predicted traders intention. Nevertheless, awareness knowledge ($\beta = 0.076$, $p > 0.05$) and perceptions ($\beta = 0.124$, $p > 0.05$) were not significant predictors of traders intention to use SSPPs. The independent variables in the regression model explained 32.3% of the variation in traders intention to use SSPPs. The results output produced VIF values that were less than 2 and a Durbin-Watson statistic of 1.732, which means that the data satisfied the assumptions of multicollinearity autocorrelation. Based on the positive regression coefficients obtained in the regression model, it can be explained that a unit increase in traders attitudes, awareness knowledge and perceptions will lead to a corresponding increase in smallholder farmers intention to use SSPPs by 0.502, 0.076 and 0.124 units respectively.

The multiple linear regression revealed that only attitudes was a significant predictor of plantain traders intention to use SSPPs. The results suggest that considerable effort should be put into increasing the level of awareness knowledge, perceptions and more especially attitudes towards small scale postharvest solutions. It is important to note that although all three independent variables - attitudes, awareness knowledge and perceptions - were significant predictors of smallholder farmers intention, only attitude was a significant predictor for traders. Again, this further buttress the exigency for tailor made interventions that are specific to the needs of the target group as opposed to a one size fits all approach in intervention programs.

## Conclusion

Small scale agriculture is a major economic activity in Rivers State, Nigeria; however, plantain production efforts are challenged with high postharvest losses. Human decision also known as secondary causes of losses significantly influence the occurrence of postharvest losses. The secondary causes revolve around effective postharvest handling and management of fresh produce by small-scale farmers and traders. The results of this study has confirmed the suitability of SSPPs adoption in reducing plantain food losses in small-scale operations where conventional postharvest technologies seem almost impos-

sible. Adoption of new technologies may seem risky because new decisions come with some form of risk. When it comes to adoption of SSPPs in the plantain postharvest chain, non-adoption is even riskier because these perishable produce are prone to high losses which would reduce small-scale farmers and traders profits. Thus, effective SSPPs that extend shelf life of plantain and other fresh produce, at very minimal effort should be considered an advantage rather than a risk for farmers and traders. As a recommendation, plantain farmers, traders and other supply chain players that deal with perishable food produce in Rivers state Nigeria should embrace these small-scale postharvest solutions to reduce their losses and alleviate food insecurity.

Socio-demographic factors are significantly associated with adoption of SSPPs. Awareness level, perceptions and attitudes are significantly influential in the decision process of SSPPs adoption. To holistically tackle food insecurity, Government and related organizations should formulate policies that encourage adoption of small-scale postharvest solutions in the food supply chains. To increase adoption of small scale postharvest solutions, food security proponents should make evidence based decisions by taking into account the demographic and psychological factors that significantly influence uptake of postharvest solutions. These factors differ at farm and market levels even within same locality. Thus, tailored interventions that focus on improving small-scale farmers and traders attitudes and perceptions towards SSPPs should be developed separately.

Finally, it is important to highlight that this study sheds light on an important but rarely researched aspect of postharvest studies. The authors do not claim absolute solution to postharvest losses but advocate for the need to diversify research strategies on food losses challenges. This is because the occurrence of continuous high PHLs signals inappropriateness of technologies or interventions. High PHLs despite existence of effective small scale postharvest solutions also signal a problem of adoption behaviour and not necessarily the lack of infrastructure as mostly reported in postharvest studies.

## Declaration of interest

None

## CRediT authorship contribution statement

**Kwami Justina Morris:** Investigation. **Nitty Hirawaty Kamarulzaman:** Supervision. **Kenobi Isima Morris:** Data curation, Writing - original draft.

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## Conflict of Interest

None

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