Analysis of factors influencing the adoption of tomato post-harvest technologies among smallholder farmers in Katsina state, Nigeria

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ABSTRACT

The study analysed the factors influencing the adoption of tomato postharvest technologies among smallholder farmers in Katsina State, Nigeria. A multistage sampling procedure was used to select 162 smallholder tomato farmers for the study. The data was analysed using frequencies, percentages, means and logit regression. Tomato farmers were predominantly male (85.0%), had a mean age of 39 years, a mean household size of 10 persons and a mean farm size of 0.7 hectares. Limited availability (44%), low capacity (94%), high initial capital (75%) and labour intensive (50.6%) were identified as the major constraints militating against the adoption of the technologies in the study area. The results of the logit regression show that regression coefficients of household size and distance to the nearest market were positive and significant at 1% in influencing the adoption of harvesting at turning stage and Zero Energy Cooling Chamber (ZECC), while age, farming experience, farm size, year of formal education, membership of association, participation in training and extension contacts were positive and significant at 5% for Solar dryer, Harvesting at turning stage, Reusable Plastic Crate (RPC) and ZECC, respectively, where farm size was positive and significant at 10% in the adoption of RPC. Farmers' socio-economic characteristics had positive and significant influence on the adoption of tomato postharvest technologies in the study area. The study therefore recommended that tomato postharvest technologies such as RPCs and Solar dryer should be made available and accessible to smallholder farmers.

Keywords: Harvesting, Postharvest, Solar drier

INTRODUCTION

Postharvest losses (PHL) encompass the detrimental reduction in quantity or quality of food that transpires along the entire food supply chain, commencing at the point of harvest until the ultimate consumption by the end consumer. Losses are incurred along the entire chain of activities involved in the handling, storage, shipping, and processing of agricultural commodities, leading to a decrease in both quantity and quality, as well as a decline in their market value. Fresh fruits and vegetables (FFVs) particularly have high levels of postharvest losses mainly due to its perishability and high moisture content making it susceptible to rot and spoilage (Jaspreet & Anita, 2013). One of the effects of postharvest losses is that it reduces the food that is available for human consumption, which is worsened by rising demand for food (Natsa, 2015). According to Arah *et al*. (2015), one of the constraints that makes tomato production costly is post-harvest loss, with incorrect handling being one of the key culprits. High levels of tomato postharvest losses reduce farmer welfare, undermining the desired worldwide trend of reducing poverty and hunger (Natsa, 2015). Adepeju (2014) similarly concludes that the overall value of post-harvest losses has been found to have a detrimental impact on per capita income and thus the welfare of tomato growers.

The World Packaging Organisation (WPO), which advocates enhanced tomato postharvest processing, has stated that growing global demand for food in the near future does not necessarily necessitate higher output, but rather better postharvest handling to ensure less food is wasted (WPO, 2010). Many donor countries have committed significant money in agricultural innovations through international development agencies, but have not fully achieved their anticipated aims, such as a high rate of adoption (Feltermeier & Abdulai, 2009). Adoption of recommended technologies implies that technologies are relevant to the farmers' circumstances. If farmer become aware of technologies that are relevant to their circumstances and can improve their farm production and thus their welfare, they will most likely adopt these changes (World Bank, 2011).

In recognizing the challenges of tomato postharvest loss in Nigeria, efforts were made by governmental and non-governmental organisations in promoting good postharvest technologies. Among the promoters was TechnoServe that implemented Yieldwise Project which piloted and promoted the use of Reusable Plastic Crates (RPC), Zero Energy Cooling Chamber (ZECC), Solar Dryer and Harvesting at turning stage as tomato post-harvest technologies in Katsina State. Despite the advantages offered by these technologies in tomato post-harvest loss reduction and promotion of its use in the study area, tomato farmers are still making use of the old and loss provoking methods thereby incurring greater losses.

However, based on the review of related literature, it was revealed that there is plethora of studies conducted on tomato post-harvest loss and adoption of post-harvest technologies, but there has been no study taking into consideration to determine the factors that influence the adoption of the tomato postharvest technologies in the study area. There is, therefore, the need to have such research information and hence the necessitates this study.

Considering the above, this study was therefore carried out to:

i. describe the socio-economic characteristics of smallholder tomato farmers in the study area.
ii. determine the factors that influence the adoption of tomato post-harvest technologies,
iii. describe the constraints militating against the adoption of tomato post-harvest technologies.

METHODOLOGY

The study was carried out in Katsina State, North-western Nigeria located between latitudes 11°081N and 13°221N and longitudes 6°521E and 9°201E (GPS, 2018). The State has 34 Local Government Areas, which are further divided into three ADP Zones: Ajiwa zone (Zone I), Funtua zone (Zone II), and Dutsinma zone (Zone III). It has a total land mass of 24,971 square kilometres with an estimated projected population of 7,831,300 people (NPC, 2018). The State shares common boundaries with Niger Republic to the North, Sokoto and Zamfara States to the West, Kaduna State to the South and Kano and Jigawa States to the East (Ibrahim, 2017). The duration of the rainfall is between May and October with the mean annual rainfall of 257mm, the minimum and maximum temperatures of 15^0c and 39^0c respectively (NIMET, 2018).

A multistage sampling procedure was used for this study. In the first stage, a purposive selection of three (3) Local Government Areas (LGAs) that participated in the Yieldwise Project implemented by TechnoServe between March 2018 and March 2021, one (1) LGA from each zone of Katsina State Agricultural and Rural Development Authority (KTARDA) based on the high concentration of the project beneficiaries. The selected LGAs were Batagarawa (Zone I), Danja (Zone II) and Ingawa (Zone III). The next stage involved a purposive selection of 50% of the project communities in each of the 3 selected LGAs based on the high concentration of the project beneficiaries. Finally, the third stage considered a random selection of 162 respondents using sample size determination. The mathematical formula is given below:

$$n = \frac{Z^2\ P\ q\ N}{e^2\ (N\ -\ 1)\ +\ Z^2\ P\ q} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$n = \frac{1.96^2\ (0.5 * 0.5 * 950)}{0.072^2(950-1) + 1.96^2 * 0.5 * 0.5} = \frac{912.38}{5.6105} = 162$$

Where:

n = Sample size
N = Population size
P = Population reliability (Frequency estimated for a sample size of n)
q = 0,5 considered for all developing countries population and P + q = (Where q = 1 – P = 0.5)
e = 0.07 error margin
$\frac{Z\alpha}{2}$ = normal reduced variable at 0.05 level of significance/confidence level and Z is 1.96

Table 1: Summary of the Sample Frame and Size

KTARDA Zones	Selected Yield wise Project LGAs	Yield wise Project Communities	Selected Communities (50%)	Sampling Frame	Sample Size
Zone I	Batagarawa	Ajiwa ‘A’, Ajiwa ‘B’,	Ajiwa ‘A’	100	17
		Gajerar Giwa, Tigrimis,	Kurtufa	100	17
		Yargamji and Kurtufa	Yargamji	100	17
Zone II	Danja	Dabai ‘A’, Dabai ‘A’,	Dabai ‘A’	100	17
		Danja ‘A’, Danja ‘A’,	Dabai ‘B’s	100	17
		Kokami, Kahutu,	Danja ‘A’	100	17
		Tsangamawa ‘A’ and TsanSgamawa	Kahutu	100	17
Zone III	Ingawa	Darmasho, Masibil,	Jobe	75	13
		Kwanar Maje, Maje,	Masibil	100	17
		Jobe, and Zucci	Zucci	75	13
Total:		**20**	**10**	**950**	**162**

Source: Field survey, 2023

Method of Data Collection

Primary data was employed in this study; it was sourced from project beneficiaries in the study area through a face-to-face interview using a structured interview schedule administered with the assistance of trained enumerators.

The data collected were analysed using descriptive statistics (mean, percentage, frequency, standard deviation) and logit regression. The logit model is implicitly stated as:

Prob $(y^*=1) = 1-F^* (\square x_i\beta_i) = \frac{e^{\square xi\beta i}}{1+e^{\square xi\beta i}}$ …………………………….................. (2)

Prob $(y^*=0) = F^* (\square x_i\beta_i) = \frac{e^{\square xi\beta i}}{1+e^{\square xi\beta i}}$ …………………………………….. (3)

Where:

Y = adoption of tomato post-harvest technologies
F = the cumulative distribution function for μi
e = exponential function

The probability of the farmers adopting tomato postharvest technologies was determined by the binary decision estimated in 0 and 1, which dichotomous dependent variable. Since the underlying adoption response variable is Y.

The explicit logistic model is expressed as:

$Y = a + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \mu i$

Where:

Y = Adoption of tomato post-harvest technologies (1= Adoption, 0= No Adoption)

a = the intercept

$\beta_1 - \beta_n$ = the parameters

X= Factors that influence the adoption of tomato post-harvest technologies

X_1= Age (years)
X_2 = Household size (number of persons)
X_3 = Farming Experience (years)
X_4 = Farm size (Ha)
X_5 = Year of formal education
X_6 = Membership of association (member = 1, otherwise, 0)
X_7 = Participation in training (participated = 1, 0 otherwise)
X_8 = Extension contacts (contact = 1, otherwise, 0)
X_9 = Access to credit (Access = 1, 0 otherwise)
X_{10} = Distance to market (km)
μ = error term

RESULTS AND DISCUSSION

Socioeconomic characteristics

Results in Table 2 reveal that the tomato farmers had a mean age of 39 years. This indicated that most tomato farmers were young, within their active age group and believed to be flexible in decision making towards adopting tomato post-harvest technologies in the study area. This is in agreement with the findings of Bukar *et al.,* (2022) in their study on the effect of tomato post-harvest losses on households' food security where a similar average age of farmers was reported. The tomato farmers had a mean household size of 10 members, implying a large family size. Large family size is an indicator of the availability of labour since the main source of labour in most African communities is from immediate family. This is in line with the findings of Korie *et al.* (2022) in the study of the effects of selected drivers of information and communication on awareness and perception of tomato post-harvest loss-reduction technologies in Kaduna, Nigeria, who reported a similar household size. The mean farm size of tomato farmers was 0.71 hectares. This is in agreement with the findings of Murtala *et al.,* (2021) in their study on "assessment of post-harvest losses of tomato in Zobe irrigation project in Dutsinma local government area of Katsina state" which revealed that the majority of the tomato farmers had less than 1 hectare of farm size. This implies that the majority of the tomato farmers in the study area are small-scale farmers. This might be due to the land tenure system and as a result of inheritance and an increase in population which led to subdivision and fragmentation of farmlands. The tomato farmers had a mean of 15 years of experience in tomato production. This shows that tomato farmers in the study area have considerable years of experience in tomato production. Thus, farmers with such experience in tomato farming can perform better and make appropriate decisions in the adoption of post-harvest technologies and in improving their living conditions. This corroborates Elemasho *et al.* (2017), who stated that high experience could make farmers make comparisons on old and new technology practices and such judgement could facilitate the adoption of new post-harvest practices thereby enhancing their farm practices and by their earnings.

Table 2: Socio-Economic Characteristics of the Respondents

Variables	Minimum	Maximum	Mean	Std. Deviation
Age	21	69	39	10
Household Size	1	31	10	6
Farm Size (Ha)	0.1	2.5	0.71	0.53
Farming experience	3	47	15.46	8.33

Source: Field survey, 2023

Postharvest technologies in use among smallholder Farmers

The study described the different types of tomato post-harvest technologies adopted among small holder farmers in the study area as presented in Table 3. Findings of the study established that most (83.3%) of the respondents were found using harvesting at turning stage technology, 42.6% were found using RPCs, 8.0% and 14.8% were found using Solar Dryer and Zero Energy Cooling Chamber, respectively. Low adoption of RPC technology could be attributed to the high initial cost and unavailability of RPCs in the study area. The low adoption rate of Solar dryer is attributed to its high initial cost and low capacity, which is why most of the farmers prefer to use their conventional sun drying method despite the differences in quality of outputs between the two methods.

Table 3: Adoption of Tomato Postharvest Technologies

Technologies	Frequency	Percentage
Reusable Plastic Crate (RPC)	69	42.6
Solar Dryer	13	8.0
Harvesting at turning stage	135	83.3
Zero Energy Cooling Chamber (ZECC)	24	14.8

Source: Field survey, 2023 *Multiple responses

Constraints to adoption of tomato postharvest technologies

Constraints are factors that can influence the innovation process negatively. Adoption of tomato post-harvest technologies is associated with certain constraints as reported by the tomato smallholder farmers in the study area. Table 4 presents the constraints faced by the farmers which affected the adoption of the technologies. Results in Table 4 reveal that buyers' preference was identified as the major constraint militating against the adoption of harvesting at the turning stage technology. This is attributed to the fact that some buyers that are not transporting the tomato to distant market prefer to buy the red ripe because most of their customers who are mostly the final consumers preferred the red ripe tomato, while low capacity was identified as the major constraint faced by the tomato farmers in the adoption of RPC and ZECC. This result agrees with the findings of Aghadi (2019) in Lagos State, Nigeria who reported inability of RPCs to contain as many tomatoes as woven basket as the major constraint hindering the adoption of the technology. High initial capital was identified as the 1st and 3rd constraints in the adoption of tomato solar dryer and RPC, respectively. This is in line with the findings of Izukanne and Chinweota (2018) in Taraba State, Nigeria where expensive nature and lack of funds have been identified as major barriers hindering the use of tomato post-harvest technologies. Limited availability was identified as the 2nd and 3rd constraints militating against the adoption of RPC and Solar dryer, respectively. This is in agreement with the findings of Akangbe *et al.* (2014) in Oyo State, Nigeria who described unavailability and insufficient knowledge as factors hindering the adoption of tomato post-harvest technologies.

Table 4: Constraints to Adoption of Tomato Postharvest Technologies

Constraints	Harvesting at Turning Stage		RPC		Solar Dryer		ZECC	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Inadequate training	2	1.2	2	1.2	3	1.9	9	5.5
Limited availability	-	-	44	27.2	38	23.5	-	-
High initial capital	-	-	75	46.3	74	45.7	6	3.7
Insecurity problem	11	6.8	17	10.5	27	16.7	7	4.3
Labour intensive	-	-	-	-	-	-	82	50.6
Buyer's preference	64	39.5	-	-	-	-	-	-
Low access o credits	-	-	15	9.3	36	22.2	5	3.1

Constraints	Harvesting at Turning Stage		RPC		Solar Dryer		ZECC	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Low capacity	-	-	94	58.0	54	33.3	51	31.5
Low extension contacts	13	8.0	8	4.9	14	8.6	17	10.5
Lack of market information	22	13.6	3	1.8	-	-	-	-

Source: Field survey, 2023

Factors that influenced tomato farmers' adoption of postharvest technologies

The results of logit regression in Table 5 indicate the influence of the socioeconomic factors in the adoption of tomato post-harvest technologies. The results indicated the relevance of the model for estimating the relationship between the dependent and independent variables. A positive coefficient indicates that a higher value of the independent variables tends to increase the likelihood of adoption of the technologies. Similarly, a negative value of coefficients implies that a higher value of the variables would decrease the adoption. The result presented in Table 3 shows that the regression coefficient of age of the respondents was positive and significant ($p<0.05$) in influencing the adoption of Solar drier. Indicating that an increase in farmer's age increases the likelihood of adoption of the solar dryer technology. Some studies reveal a positive relationship between age and technology adoption (Chuang, Wang & Liou, 2020). For example, Melesse (2018) refers to age as one main factor that determines the technology adoption behaviour of a farmer.

The regression coefficient of household size was also positive and significant ($p<0.01$) in influencing the adoption of ZECC. This indicates that the larger the household size the higher the adoption of the technology. Danso-Abbeam *et al.* (2017) opined that large households tend to have a free labour supply toward the adoption of the innovation than the smaller households. The result also indicates that farming experience was positive and significant ($p<0.05$) in influencing the adoption of solar driers. This means that when farmers experience increases the probability of using solar drier increases. The implication is that experience in farming can encourage a farmer to adopt new technologies and understand the benefits of the technology. The coefficient of farm size was positive and significant ($P<0.05$) and ($P<0.1$) in influencing the adoption of harvesting at the turning stage and RPC technologies, respectively. This shows that the adoption of the technologies increases with the increase in size of tomato farm cultivated. This finding is consistent with the finding of a research carried out in the Central Highlands of Ethiopia to determine the factors affecting the adoption of an improved maize variety, which revealed a positive relationship of farm size with the adoption behaviour (Dissanayake *et al.,* 2022).

Level of education was positive and significant ($P<0.05$) for tomato solar dryer technology. This indicated that the higher the farmers level of education, the higher the adoption of the technology. According to a study conducted by Mamudu, Emelia, and Samuel (2012), there exists a positive correlation between the highest level of education attained within a household and the likelihood of adopting modern agricultural technologies. This suggests that farming households with individuals who possess higher levels of education are more inclined to adopt these technologies compared to households lacking such educational attainment. The coefficient of membership of association was positive and significant ($P<0.05$) in influencing the adoption of harvesting at turning stage. This is in agreement with the findings of Tafida and Muntari (2017) in Katsina State, that suggested that the regression coefficient of membership of association was positive and significant for adoption of recommended planting date for cowpeas. The regression coefficient of participation in Yieldwise training was also positive and significant ($P<0.05$) in influencing the adoption of tomato solar dryer technology. This confirms the findings of Yuying *et al.* (2022) who reported that attending the technical training has a positive and statistically significant effect on farmers' adoption of biopesticides in China. The regression coefficient of extension contact was positive and significant ($p=0.05$) in influencing RPC technology adoption, which is consistent with the findings of Tafida and Muntari (2017) in Katsina State, Nigeria, who found that extension contact was positive and significant in the adoption of recommended cowpea planting distance (25cm x 75cm). Mwangi and Kariuki (2015) cited availability and access to extension services as important factors in technology adoption. Credit availability was discovered to have a positive link with RPC technology adoption. This was determined to be statistically significant at $p<0.01$. This suggests that credit is an essential component in the adoption of agricultural technology. This is consistent with the concept that farmer poverty and a lack of finance make it nearly impossible for them to acquire technologies (Ministry of Food and Agriculture, Ghana 2010). According to Udimal *et al*. (2017), when farmers have access to finance facilities, they are more likely to adopt new technologies. The regression coefficient of distance to the nearest market was significant ($p<0.01$) in influencing the adoption of harvesting at the turning stage and Zero energy cooling chamber, indicating that a unit increase in distance to the output market would lead to an increase in technology adoption. The positive association also suggests that the greater a household's distance from the market, the more forced they are to transport or store their products. This suggests that households located further away from the output markets are more likely to embrace the technologies than those located closer to the markets.

Table 5: Logistic Regression Results

Technologies	Harvesting at turning stage		RPC		Solar Dryer		ZECC	
Variables	**Coeff.**	**Signif.**	**Coeff.**	**Signif.**	**Coeff.**	**Signif.**	**Coeff.**	**Signif.**
Age	-0.038	0.957	0.801	0.161	2.093	0.036**	-0.155	0.881
Household size	-1.199	0.296	-1.176	0.158	1.542	0.182	3.623	0.007***
Farming experience	-1.158	0.398	0.527	0.473	1,950	0.028**	-0.765	0.590
Farm size	2.284	0.028**	1.298	0.052*	0.673	0.466	1.144	0.147
Year of formal educ.	0.672	0.610	-0.037	0.952	2.702	0.014**	-0.547	0.628
Membership of association	1.394	0.022**	0.261	0.538	-0.128	0.890	-0.507	0.516
Participation in training	0.204	0.913	1.028	0.284	0.357	0.781	2.431	0.0411**
Extension contacts	-0.567	0.461	1.201	0.022**	-0.898	0.326	-0.359	0.568
Access to credit	-0.705	0.585	1.884	0.009**	1.951	0.331	-1.771	0.259
Distance to market	2.992	0.000***	-0.337	0.469	0.246	0.794	2.003	0.009***
2Log likelihood ratio test	88.028		182.061		70.753		111.427	
Cox and Snell R^2	0.301		0.214		0.115		0.140	
Nagelkerke R^2	0.506		0.287		0.268		0.247	
Percentage prediction	86.4		74.1		92.6		87.0	

Source: Field survey, 2023 *** P<0.01, **P<0.05, *P<0.1

CONCLUSION AND RECOMMENDATIONS

Based on the findings of the study, it is concluded that, farmers' socio-economic characteristics such as age, household size, years of experience in tomato farming, year of formal education, farm size, participation in training, membership of association, extension contacts, access to credits and distance to market have positive and significant influence on the adoption of tomato postharvest technologies in the study area and the following recommendations were made:

1. Tomato postharvest technologies such as RPCs and Solar dryer should be made available and accessible to smallholder farmers.
2. Agricultural technology manufacturers should conduct needs assessment before producing any technology to avoid gap between technology production specifications and farmer's needs most especially in terms of capacity.
3. Tomato farmers using RPCs, Solar dryer and ZECC should be encouraged on saving of replacement cost to ensure sustainability.

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