



ANALYSIS OF VEGETABLE MARKETERS ATTITUDE TOWARDS ADOPTION OF SOLAR-POWERED COLD STORAGE TECHNOLOGY IN NORTHEAST, NIGERIA

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ABSTRACT

The study analyzed vegetable marketers' attitude towards adoption of solar powered cold storage technology in Northeast, Nigeria. A multi-stage sampling technique was used to select 455 vegetable marketers from six vegetable markets in Adamawa, Bauchi, Gombe and Yobe States. Primary data were collected using structured questionnaires and analyzed using descriptive and inferential statistics. The results show a mean age of 43 years and a mean household size of 10 persons. Also, a mean marketing experience of 23 years and a mean monthly income of ₦174,516.85. Furthermore, most (97%) of the respondents were males and (98%) of them were married. Also, majority (85%) of the respondents had secondary education and majority of them 93% belong to cooperative society. Most (95%) of the respondents had no access to extension services and (99.2%) of the marketers sourced their capital from cooperative society and (98.7%) of them sourced capital from their personal savings. All (100%) of the marketers stored tomato and green pepper in the cold storage. The perception of respondents on the benefits of solar cold storage technology was positive with a mean score ranges between 3.6 - 4.7. The attitude of the respondents towards solar cold storage technology was positive with a mean score ranges between 1.0 - 4.7. The study concluded that vegetable marketers in the study area have positive attitude towards adoption of solar-powered cold storage technology and perceived solar powered cold storage technology as beneficial in reducing post-harvest losses. The study recommends that, Vegetable marketers through their cooperatives should partner with Government and NGOs in conducting seminars, workshops and training sessions to its members in order to educate them about the advantages and benefits of the technology.

Keywords: Attitude, Marketers, Adoption, Solar, Storage

INTRODUCTION

Agriculture plays a vital role in Nigeria's society and economy. For example, in 2020, agriculture accounted for over 24% of the total gross domestic product (GDP) and two-thirds of the work force (FAO, 2020). Nigeria is also the world's fifth largest producer of vegetables and eighth largest producer of fruits, making it an agricultural giant of Africa (FAO, 2022). The production of these fresh produce is largely carried out by smallholder or marginal farmers who often grow them on farms under 4 hectares. Ricciardi, *et al.* (2018). These farmers, who primarily rely on traditional farming practices, account for almost 90% of the total food production. Gekonge (2021). Nigeria's agriculture sector loses an estimated NGN 110 trillion to post-harvest losses (PHL) due to lack of sufficient storage, agro-processing, and transportation infrastructure accessible to farmers, fishermen and retailers USAID (2022). There is a growing demand for both stationary and mobile cold storage systems, from farms to markets, as a result of the combination of high temperatures that increase the rate of decaying, long distances traveled, and the prolong timespan in transit due to bad road conditions Bolarin and Bosa (2015). These losses are specifically, severe in the long-haul transport of fruits and vegetables, of which half of the total post-harvest losses (PHL) of up to 60% occur during transportation (FAO, 2022). According to official estimates by the Food and Agriculture Organization of the United Nations (FAO), global post-harvest losses (PHL) can reach up to 20% for cereals, 30% for dairy and fish, and 40% for fruit and vegetables FAO (2020). This level of waste is devastating, particularly in Africa where approximately 250 million people (20% of the continent's population) are



undernourished. In Sub-Saharan Africa, for example, an estimated US\$4 billion worth of food, which could feed over 48 million people, is lost every year due to post-harvest losses FAO (2020).

In more recent times, solar-powered cold storage technologies have been recognized as a sustainable and inexpensive solution to help under-resourced farmers /marketers avoid post-harvest losses on fruits and vegetables (Kitinoja, 2013). Evidence shows that if given necessary policy and support, solar-powered cold storage technologies offer several socio-economic and environmental benefits to farmers and food suppliers, particularly those in off-grid locations. In Nigeria, the introduction of affordable solar-powered cold storage facilities for vegetable farmers and traders mitigated losses of more than 5000 tonnes of fresh vegetables and fruits that could occur during storage and transportation, significantly increasing farmers' and traders' monthly profits (Ikegwuonu & Odeyemi 2021).

Modern cooling technologies are becoming more widely acknowledged as a promising tool to address a number of issues that are arising in developing countries' increasingly complex food systems, such as environmental sustainability, poverty and economic growth, food loss and waste, food safety, and food and nutrition security. Solar powered cold storage have been increasingly recognized as a promising tool to address a multiple of challenges emerging in increasingly complex food systems in developing countries, including food loss and waste, food safety, food and nutrition security, poverty and economic growth and environmental sustainability (Takeshima *et al.*, 2021). Cold storages have become increasingly important technologies to reduce food loss and food waste globally, including developing countries, by reducing microbial growth that causes spoilage (Hassler and Baysal-Gurel 2019; IFPRI, 2020; Mayton, *et al.*, 2020 and Kashyap & Agarwal, 2020). Cold-storage is also expected to reduce the growth of most human pathogens, ensuring enhanced food safety (Ucar and Ozcelik, 2013). The viability of these technologies in developing countries like Nigeria is obvious. This is because they depend on the actual effective demand for increased freshness and various quality attributes including nutritional contents of perishable commodities, actual benefits that cold storage brings over traditional cooling methods and the extent of loss reduction among others (Takeshima, *et al.*, 2021).

Adoption of agricultural technology is a critical factor in enhancing food security, increasing agricultural production, and promoting sustainable farming practices. Rasyid, & Ningsih, (2024). Agricultural technologies include a varied range of innovations, from traditional practices to modern biotech and precision agriculture methods. These technologies not only improve crop yields and resource productivity but also help in the mitigation of environmental deprivation. Sulochna, *et al.* (2023). The high levels of postharvest food loss in Nigeria have raised concerns about food security and rising poverty, particularly for agriculture-dependent households. Ogwu *et al.* (2024). Post-harvest losses of food have resulted in drying up the incomes of poor and economically vulnerable farmers/traders whose earnings are inconsistent (Ridolfi, *et al.*, 2018). According to Mujuka, *et al.* (2020) more than 70 percent of agriculture-dependent households (farmers, transporters, vendors, processors, etc.) lose an average of 15% of their income due to postharvest food losses" This situation will elevate poverty, household food shortages and malnutrition as many poor marketers would not feed themselves and their families. (Sonka, *et al.*, 2023). Due to lack of cost-effective solution to minimize postharvest losses, farmers /marketers are forced to sell their produce at a lower price immediately after harvesting, earning low returns, thereby getting stuck in the cycle of poverty (Tefera, *et al.*, 2016). The study was carried out to:

- i. describe the socio-economic characteristics of the vegetable marketers in the study areas;
- ii. describe the perception of vegetable marketers on the benefits of solar powered cold storage technology; and
- iii. examine the attitude of vegetable marketers on the adoption of solar powered cold storage technology.

METHODOLOGY

The Study Area

The study was carried out in Northeast, Nigeria. Northeast consists of six (6) states of Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe. However, the study was conducted in four (4) states of Adamawa, Bauchi, Gombe and Yobe states, respectively. The study area is located between Latitude 9° 08' to 14°N and Longitude 8° 08' to 15°E. The area occupies a land mass of 280,419 km² (National Bureau of Statistics (NBS, 2017). According to National Population Census NPC, (2006) the region has a population of 29, 470, 062 people based on 2006 annual population growth rate of 3%. The main economic activities in the area include; farming (crop and livestock), fruits and vegetables production, hunting, fishing, food processing, transportation and craft with inputs largely sourced from government. The average population density is 89 persons per Km², while the mean annual rainfall ranges from less than 250 mm in the Northern Sahel to 1500 mm in the derived savannah. Northeast Nigeria is a suitable area to conduct this study because the demand for fresh horticulture commodities has been rising as a result of population growth and urbanization, and the region is one of the largest producers of major vegetable commodities within Nigeria (Nkonya, *et al.*, 2020). At the same time, the region's population continues to suffer from micronutrient deficiencies and lack of stable access to electricity.

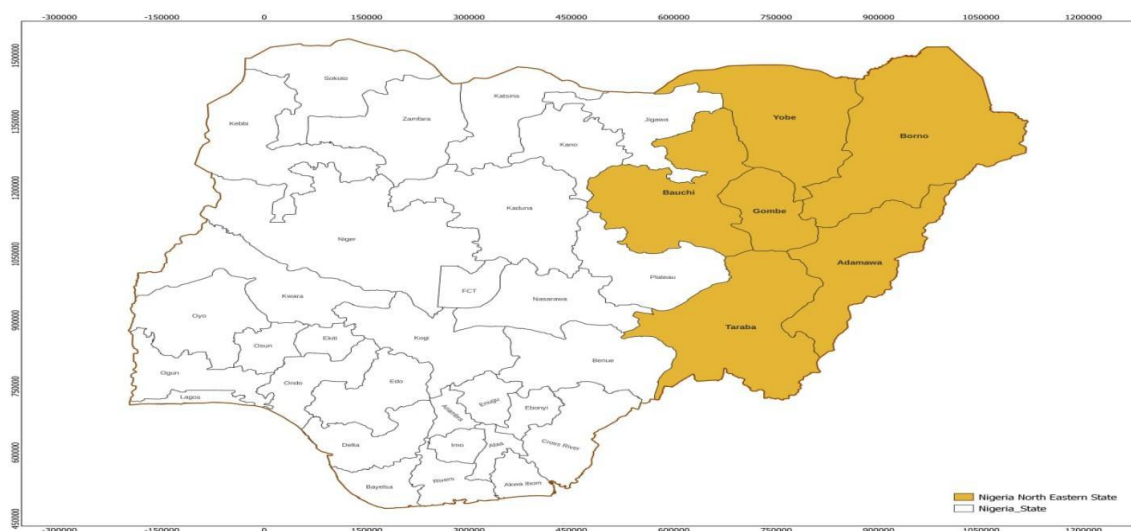


Figure 1: Map of Nigeria Showing the Location of the Study Area

Sampling Procedure and Sample Size

A multi-stage sampling technique was employed in selecting respondents for first stage, involved purposive selection of four (4) states based on their participation in horticulture production and marketing namely; Adamawa, Bauchi, Gombe and Yobe states. The second stage, involved selection of six (6) horticulture markets in the four states namely; Jimeta ultra-modern market, Yola by-pass market, Muda lawan market, Wunti market, Gombe main market, Potiskum main market due to the presence of solar powered cold storage technology (installed in the markets). The final stage, involved selection of 30% of the respondents in the selected markets making a total of 455 respondents as a sample size for the study drawn from the population.

The sample size for this study was arrived at using Taro's Yamane formula. The formula is given as:

$$n = N / 1 + (e)^2 \quad \dots (1)$$

where; n = sample size.

N = population size.

E = margin error (5%)



Table 1: Sample Size Selection

State	Horticulture market	Population	Sample Size (30%) Proportion
Adamawa	Jimeta ultra-modern market	246	74
	Yola by-pass market	285	86
Bauchi	Muda Lawan market	258	77
	Wunti market	192	58
Gombe	Gombe main market	221	66
Yobe	Potiskum Main market	316	94
TOTAL		1,518	455

Source: Field Survey, 2023

Method of Data Collection

The study used primary data collected from the respondents using structured questionnaire, the questionnaires were filled by the data enumerators who read, explained the questions and then filled the marketer's responses.

Methods of Data Analysis

Both descriptive and inferential statistics were used in analyzing the data for the study. Descriptive statistics used include; frequency distribution, percentages, means and ranking. While, inferential statistics logit regression model was used in analyzing the data for the study.

Descriptive statistics

Descriptive statistics such as frequency, mean, percentages and ranking were used to analyzed objectives i, ii and iii. A 5 Point Likert Scale was used to measure the perception of vegetable's marketers on the benefits of Solar Powered Cold Storage. The response option and values assigned were; Strongly agree = 5, Agree = 4, Undecided = 3., disagree = 2, Strongly disagree = 1 These values were added to get 15 and later divided by 5 to get a cut of point of 3 as a threshold. This means that variables with a mean score of 3 and above were regarded as positive perception towards adoption of Solar Powered Cold Storage Technology while, variables with a mean score below 3 were regarded as negative perception towards adoption of Solar Powered Cold Storage Technology. Similarly, 5 Point Likert Scale was used to measure attitude of vegetable's marketers towards adoption of Solar Powered Cold Storage Technology. The response option and values assigned were; Strongly agree = 5, Agree = 4, Undecided = 3, disagree = 2, Strongly disagree = 1 These values were added to get 15 and later divided by 5 to get a cut of point of 3 as a threshold. This means that variables with a mean score of 3 and above were regarded as positive attitude towards adoption of Solar Powered Cold Storage Technology while, variables with a mean score below 3 were regarded as negative attitude towards adoption of Solar Powered Cold Storage Technology.

RESULT AND DISCUSSION

Socio-economic Characteristics of Vegetable Marketers

The result from Table 2 shows that the age of the vegetable marketers in the study areas ranged between 22 – 67 years. The mean age was 43 years which is considered active and productive age. Out of which majority 58.9% were within the age bracket of 34-55 years. While, 22%, 17.3%, and 0.92% of the respondents were within age of 22-33, 55-66, and above 67 years respectively. This assertion agrees with the findings of Takeshima, *et al.* (2023). in their study on “Solar-powered cold storage and agri-food market modernization in Northeast, Nigeria”. where they reported that the mean age of vegetable marketers was 42 years. Similarly, Korie, *et al.* (2023). in their study on “Assessment of factors influencing adoption of tomato post-harvest loss-reduction technologies in Kaduna state, Nigeria” reported that the mean age of the respondents in the study area was 42.5. The result further revealed the minimum household size of the marketers was 1 person and the maximum was 26 persons. The mean household size was 10 persons. Out of which 39% of the marketers had household size of 8-13 persons. while, 33.9%, 23.8%, 2.2% and 0.9% had 2-7, 14 -19, 20 -25, and 67 and above



persons respectively. Sebatta, *et al.* (2015), reported bigger household sizes supply the required labour for value addition activities, thus reducing the need for hired labour to undertake postharvest practices. This result agrees with the findings of Takeshima, *et al.* (2023). in their study on Solar-powered cold storage and agri-food market modernization in Nigeria reported that the mean household size of vegetable marketers in the study areas was 10 persons.

Table 2: Distribution of Respondents Based on Socio-economic Characteristics (n=445)

Variable	Frequency	Percentage	Mean
Age(years)			
22-33	102	22.9	43
34-44	132	29.7	
45-55	130	29.2	
Sex			
Male	431	96.9	
Female	14	3.1	
Marital Status			
Married	437	98.2	
Divorced	8	1.8	
Education Level			
No formal	25	5.6	
Primary	42	9.4	
Secondary	378	84.9	
Household size			
2-7	151	33.9	10
8-13	174	39.1	
14-19	106	23.8	
20-25	10	2.2	
Marketing Experience (Yrs)			
5-13	105	23.6	23
14-22	137	30.8	
23-31	111	24.9	
32-40	66	14.8	
41 and above	26	5.8	
Membership of Cooperatives			
Yes	416	93.5	
No	29	6.5	
Access to Extension			
Yes	24	5.4	
No	421	94.6	
Monthly Income (₦)			
40,000-122,000	116	26.1	₦174,516.85
123,000-205,000	212	47.6	
206,000-288,000	61	13.7	
289,000-371,000	29	6.5	
372,000 and above	27	6.1	

Source: Field Survey; 2023

The result further revealed that 30.8% of the marketers had marketing experience of 14-22 years. While, 24.9%, 23.6%, 14.8%, and 5.6% of the marketers had experience of 23-31, 5 – 13, 32 – 40, and 40 and above years of experience respectively with an average of 23 years. Mutayoba and Ngaruko, (2015). States that farmers experience increased quality and quantity of vegetables produced. Additionally, experience gives farmers bargaining power as well as improved their marketing networks. Again, a similar study conducted by Al Shadiadeh, *et al.* (2012). showed that farming experience had positive and statistically significant effect on influencing farmers' decision to adopt postharvest practices in vegetable production. This result agrees with the findings of Korie, *et al.*



(2023). in their study on “Assessment of factors influencing adoption of tomato post-harvest loss-reduction technologies in Kaduna state, Nigeria” reported the mean marketing experience was 23.5 years.

The result also revealed that majority 47.6% had an annual income of N123,000.00 – N205,000.00. while, 26.1%, 13.7%, 6.5% and 6.1% had an annual income of N40,000.00 – N122,000.00, N206,000.00 – N288,000.00, N289,000.00 – N371,000.00, N372,000 and above respectively. The average monthly income was N174,516.85. This agrees with the findings of Olayide *et al.* (2024) in their study on Assessing post-harvest loss of tomato and its implications for food systems transformation in Nigeria Reported a mean monthly income of N141,382.99. However, the findings disagree with the findings of Tijani, (2022). in her study on “Determinants of utilization of tomato value addition technology among beneficiaries in Oyo State, Nigeria”. reported that the mean income of the respondents in the study areas was N65,948.94.

The results further shows that most (97%) of vegetables marketers were males, while (3%) were females. This indicates that vegetable marketing in the study areas was dominated by males and this is because the cultural traditions of the study areas do not allow females to be actively involved in vegetable marketing. This agrees with the findings of Rutta, (2022). in his study on understanding barriers impeding the deployment of solar-powered cold storage technologies for post-harvest tomato losses reduction in Tanzania. The result revealed that majority (85%) of the respondents were males. Similarly, Ajagbe, *et al.* (2014). in their study on “Assessment of post-harvest practices among Tomato Farmers and Processors in Abeokuta north Local Government of Ogun state, Nigeria”. Reported majority (70%) of the respondents were males, Also, Bello, *et al.* (2018). in their study on “Assessment of The Indigenous Knowledge of Farmers on Post-Harvest Storage of Tomato in Jigawa State, Nigeria” reported that majority (90%) of the respondents were males

The result also revealed that 98% of vegetables marketers were married and 2% were divorced. This agrees with the findings of Korie, *et al.* (2023). in their study on “Assessment of factors influencing adoption of tomato post-harvest loss-reduction technologies in Kaduna state, Nigeria who reported majority (95.9%) of the respondents were married. Similarly, Sennuga, *et al.* (2020). in their study on “Factors Influencing Adoption of Improved Agricultural Technology (IATs) among small holder farmers in Kaduna State, Nigeria reported (96.7%) of the respondents were married.

The result further shows that majority (85%) had acquired secondary education, while 9% and 6% had primary education and no formal education respectively. This finding is in tandem with that of Ajagbe, *et al.* (2014). in their work on “Assessment of post-harvest practices among Tomato Farmers and Processors in Abeokuta north Local Government of Ogun State, Nigeria”. They reported that majority of the respondents had secondary education followed by Tertiary education and primary education. Similarly, Sani *et al.* (2023). in their work on “Analysis of Socio-Economic Characteristics and Post-Harvest Loss Storage Facilities Used by Vegetable Crops Value Chain Actors in Adamawa State, Nigeria” reported that majority (88%) had secondary education.

The result also revealed that most (93%) of the vegetable marketers were members of cooperative society and only (7%) of them does not belong to a cooperative society. This agrees with the findings of Adepoju, *et al.* (2023). “On Tomato Farmers Willingness to Adopt the Hydroponics Farming System in Oyo State, Nigeria”. They reported majority of the respondents (58%) belong to membership of cooperatives Similarly, Bala, *et al.* (2022). in their study on “Analysis of Adoption of NERICA 1 Rice Technologies Among Farmers in Gombe State, Nigeria”. Reported that, majority (81.1%) of the respondents are members of cooperative.

The result further revealed that most (95%) of vegetable marketers had no access to extension services while, only (5%) of them had access to extension services. This agrees with the findings of Rutta, (2022). in his study on understanding barriers impeding the deployment of solar-powered cold storage technologies for post-harvest tomato losses reduction in Tanzania. Reported majority (90%) had no access to extension services



Perception of Vegetable Marketers on the benefits of Solar-Powered Cold Storage

The result from Table 3 shows the perception of respondents on the benefits of solar powered cold storage technology. The result revealed that all the items on perception had a mean greater than 3 which is above the set threshold which indicated that the marketers have positive perception on the benefits of solar powered cold storage technology. The findings indicated that the marketers perceived SPCST to reduce poverty 4.7, extend freshness 4.7, reduces food loss 4.6, improves quality 4.4, increases income 4.3, increases prices 3.6, prevent growth of pathogens 4.4, enhances food safety 4.3, improves food and nutrition security 3.8, increases profit 4.5, raises standard of living 4.5. This agrees with the findings of Elemasho, *et al.* (2017). on their study on “Farmers’ Perception on Adoption of Post-Harvest Technologies of Selected Food Crops in Rivers State, Nigeria” who reported the level of food crops perception on adoption of postharvest technologies packages was positive. Majority of the respondents agreed with the positive statements on adoption of post-harvest technologies, implying the possibility of the high level of adoption of post-harvest technologies. Similarly, Nyamah, (2020). reported that there is positive perception of pre and post-harvest technology’s ability to reduce post-harvest losses. Similarly, Korie, *et al.* (2023). reported farmers in Kaduna State perceive PHL reduction technologies as being able to reduce losses, easier to operate, save labor and gives overall satisfaction. The implication of this result is Marketers who perceive significant benefits from solar cold storage are more likely to adopt the technology.

Table 3: Perceptions of Marketers on the Benefits of Solar-Powered Cold Storage

Statements of Perception	Mean	Decision
Do you think adopting solar cold storage can help in reducing your poverty	4.7	Positive
Does solar cold storage enhance the freshness of your vegetables	4.7	Positive
Do you agree that solar cold storage help in reducing losses of your vegetables	4.6	Positive
Does solar cold storage help in improving the quality of your produce	4.4	Positive
Do you think that using solar cold storage can increase your income	4.3	Positive
Do you agree that using solar cold storage can earn you a better price of your vegetables	3.6	positive
Does solar cold storage prevent the growth of pathogens that causes spoilage/	4.4	Positive
Do you agree that using solar cold storage can enhance food safety	4.3	positive
Do you agree that solar cold storage improve health and nutrition security	3.8	positive
Do you think adopting solar cold storage will increase your profit	4.5	positive
Do you agree that solar cold storage improves your standard of living	4.5	positive

Source: Field survey, 2023

Mean ≥ 3.0 = Positive; Mean < 3.0 = Negative

Attitude of Vegetable Marketers towards Adoption of Solar-Powered Cold Storage

The result from Table 4 shows that vegetable marketers have positive attitude towards solar cold storage with most of the attitudinal statements had a mean score of 4 which is above set threshold of 3 and above. I believe my family influence my decision to adopt solar cold storage (4.6) If believe that my friends influence my decision to adopt solar cold storage (4.7) , I believe that peer influence within my community affects my decision to adopt solar cold storage (1.1), I believe that adopting solar cold storage is not essential in maintaining the quality and freshness of my vegetable (1.1), I believe that solar cold storage can increase the availability of fresh vegetable (4.5), My established habits can significantly influence my decision to adopt solar cold storage (4.4), I believe that adopting



solar cold storage will significantly improve my income (4.4), I believe that keeping my vegetables in cold storage prevent spoilage effectively (4.3), I believe that adopting cold storage is necessary for the quality of my vegetables (4.3), I do not see cold storage as profitable as profitable option for my business (1.0), I believe that traditional storage methods are just as effective as solar cold storage (1.2), I believe that solar cold storage improves the price of my vegetables (4.5), This agrees with the findings of Saadiah, *et al.* (2021). reported that fruit vegetable farmers in ECER have a high level of attitude towards postharvest technology at the handling and storage level. Similarly, Sukanya, *et al.* (2017). in Punjab reported that farmers had positive attitudes towards post-harvest management practices”. The implication of this result is that vegetable marketers have positive attitude toward solar cold storage technology which leads to higher adoption rate among vegetable marketers.

Table 4: Attitude of Vegetable Marketers towards Adoption of Solar-Powered Cold Storage

Statements of Attitude	Mean	Decision
I believe that the support and opinion of my family influence my decision to adopt solar cold storage.	4.6	Positive
I believe that friends opinions influence my decision to adopt solar cold storage.	4.7	Positive
I believe that peer influence within my community affects my decision to adopt solar cold storage	1.1	Negative
I believe that adopting SPCST is not essential in maintaining the quality and freshness of my vegetables.	1.0	Negative
I believe that solar cold storage can increase the availability of fresh vegetables	4.5	Positive
My established habits significantly influence my decision to adopt solar cold storage.	4.4	Positive
I believe that adopting solar cold storage will significantly improve my income.	4.4	Positive
I believe that keeping my vegetables in cold storage prevent spoilage effectively.	4.3	Positive
I believe that adopting cod storage is necessary for the quality of my vegetable.	4.3	Positive
I do not see cold storage as profitable option for my business.	1.0	Negative
I believe that traditional storage methods are just as effective as solar cold storage.	1.2	Negative
I believe that solar cold storage improves the price of my vegetable.	4.5	Positive

Source: Field survey, 2023

Mean ≥ 3.0 = Positive; Mean < 3.0 = Negative

CONCLUSION AND RECOMMENDATION

The study concluded that majority of vegetable marketers in the study area were young, males married and have acquired a basic education for them to understand and be willing to adopt the technology, Vegetable marketers in the study area have positive attitude towards adoption of solar-powered cold storage technology Vegetable marketers in the study area perceived solar powered cold storage technology as highly beneficial in reducing post-harvest losses, improving vegetable quality, and increasing their income, marital status, membership of association and annual income were.. The study therefore, recommends that, Vegetable marketers through their cooperatives should partner with Government and NGOs in conducting seminars, workshops and training sessions to its members in order to educate them about the advantages and benefits of the technology. Vegetable marketers through their cooperatives should partner with extension service providers. Government, cooperatives and NGOs for technical advice, training and updates on solar cold storage management, Government, NGOs and financial institutions should collaborate to provide financial assistance such as low-interest loans, grants, or subsidies to the marketers,



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