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Abstract

Postharvest management of agricultural produce presents a considerable difficulty in developing countries like Nigeria. Staple crops of economic importance, including rice, wheat, cowpea, maize, and wheat, are prone to losses, primarily owing to insect pests at storage. The current study assessed the use and determinants of adoption of Purdue Improve Crop Storage bag (PICS) Technology among grain merchants in Dawanau market, Kano state. Multi-stage sampling techniques were used for the study. A total of 80 merchants were sampled. Data collected were analyzed using descriptive statistics, logistic model and garrets ranking techniques. The result revealed that the merchants are above economically active age, with household size beyond the national average and quit years of experience. Also, the result shows that majority (95%) are aware of PICS bag. The determinants of PICS bag technology indicated that age, household size, membership and extension contact are statistically significant in the adoption with R-square value of 0.45. The result further indicates that 46% of the merchants had never utilized the PICS bag technology due to the high cost of the technology. Garret ranking indicates inadequate finance and high cost of the PICS bag as the major constrained to the adoption and used of PICS bag technology among the merchants. The study, therefore, recommends that the government at all levels should play an important role by subsidizing or offering financial incentives to lower the cost of PICS bags. Additionally, NSPRI should create a feedback system where merchants can share their experiences, challenges, and suggestions regarding PICS bags. Lastly, targeted awareness campaigns should be initiated to inform merchants about the advantages of using PICS bags, particularly their effectiveness in reducing post-harvest losses.

Keywords: *Assessment, Adoption, Determinants, Food Security, Grains merchants, Garret ranking, PICS Bag Technology, Postharvest Management*

Introduction

Postharvest management of agricultural output presents a substantial difficulty in generating agricultural commodities resistant to deterioration. Staple crops of economic importance, including rice, wheat, cowpea, maize, and wheat, are prone to losses, primarily owing to insect pests at storage. Several storage methods exist for legumes and cereal grains, including traditional/local methods, insecticides, and hermetic systems. The most significant attribute of storage systems is maintaining grain integrity for a specific amount of time while minimizing quantity and quality loss.

Hermetic storage technologies, as an alternative to chemical control and traditional approaches, have sparked substantial interest among various actors, including farmers, the commercial sector, governments, and other development agencies. Hermetic storage technologies are useful because of the airtight conditions that are established during storage. Biological processes like respiration and metabolism, fueled by insects and other organisms, deplete oxygen and release carbon dioxide within hermetic containers (Murdock et al., 2012). The Purdue Improved Crop Storage (PICS) bag is a hermetic storage solution originally designed for cowpeas in Western Africa, now expanded to maize, Bambara nuts, and rice (Sudini et al., 2015). The system features two inner high-density polyethylene layers for hermetic sealing and an outer woven plastic layer for protection (Williams, Murdock & Baributsa, 2017).

Despite the significant advancements in cowpea storage with the introduction of Purdue Improved Crop Storage (PICS) bags (Baributsa et al., 2020), further research is needed to assess their long-term efficacy, scalability, and the development of alternative hermetic storage solutions in West and Central Africa to address postharvest losses and promote sustainable food security. Postharvest losses significantly impact food security and agricultural productivity in developing countries. Unlike in developed economies where such losses are often attributed to consumer behavior, developing countries primarily face challenges related to financial constraints, inefficient management, and technological limitations (Conteh et al., 2015; FAO, 2011; Premanandh, 2011).

Improved storage technologies offer potential solutions to reduce post-harvest losses (World Bank et al., 2011) and enhance food security and household well-being (Fuglie, 1995; Parmer et al., 2017). However, farm households, being diverse in their characteristics, may face limitations in adopting advanced storage technologies due to financial constraints, lack of information, and limited access to technology (Foster & Rosen Zweig, 2010; Tesfaye & Tirivayi, 2018). The Food and Agriculture Organization (FAO) of the United Nations emphasizes that increased agricultural investment in developing countries can facilitate the adoption of new technologies and potentially contribute to poverty reduction.

PICS (Purdue Improved Crop Storage) bags were first introduced in Nigeria in 2007 as part of a Bill & Melinda Gates Foundation-funded study. This initiative sought to reduce post-harvest losses in cowpea (bean) storage by offering farmers a pesticide-free, hermetic storage solution (Moussa et al. 2014). The bags were later adopted in several states, including Kano, via awareness campaigns and agricultural extension programs.

Agricultural extension programs and different farmer-focused awareness efforts aided the broad adoption of PICS bags in Kano and other parts of Nigeria. By sealing the crops in the airtight PICS bags, farmers could effectively prevent pest damage for extended periods, thus contributing to food security and reducing economic losses (Baributsa et al. 2010).

Several improved storage technologies have been introduced to farmers, merchants and agro-processors in Nigeria and Kano state in particular. However, research on the extent of PICS bag usage and the factors influencing their adoption in this zone remains scarce. More specifically, no research from

our literature search has been done to analyze the determinants for adoption of PICS bag in the study area. The dearth in information as to the extent to which PICS bag are adopted in Dawanau Market, Kano state, necessitated this study. Hence, this research seeks to bridge this gap by assessing the following objectives: to identify and describe the socio-economic characteristics of the merchants; to assess the extent of PICS bag technology usage by the merchants; to determine the factors influencing the adoption of PICS bag technology by the merchants; and lastly, to identify and describe the major constraints in the use of PICS bag technology. By analyzing the socio-economic characteristics of merchants and identifying challenges in PICS bag adoption, this study seeks to provide valuable insights for extension agents, policymakers, and future research focused on mitigating postharvest losses and enhancing food security.

Materials and Methods

The study area was carried out at Dawanau International Grains Market, situated in Kano State. The market that deals with both cash and food crops, and has served the grain needs of the state, nation, and neighboring nations, as well as operating as a storage hub for grains, to regulate the commodity's price when the need arises. A three-stage sampling technique was adopted for the study. In the first stage, a purposive sampling technique was used to select the Dawanau International Grains Market based on the preponderance of grain marketing activities in the state. The market has six sections, as follows: i). Section A for Cowpeas, Soya Beans, Maize, Hibiscus, Sesame, and Locust Bean; ii) Section B for Cassava Chips and Flower, Groundnut, Bambara nuts, and Local Wheat; iii) Section C for Yam Tubers, Sugarcane, and Local Chickens; iv) Section D for Retailing of All Kind of Food Items; v) Section E for Transport Companies and Agents, Mechanics, Spare Parts, Chile Pepper, and Slaughtered Animals; vii) Section F for Warehouses and Machinery (cleaning, loading, and offloading). The second stage, involved the purposive selection of section (A) out of six sections in Dawanau market based on the high concentration of grain marketers in the section. Due to unavailability of registered number of merchants in the section, the last stage involved the random selection of eighty (80) respondents which gives the total number of sample merchants. Meanwhile, primary data was used for this study which was collected through the use of a well-structured questionnaire administered with the aid of computer based assisted interview (mWater) Also, information from articles, gazette, journals, and unpublished works etc. has been used for the course of this research as secondary data.

Tools of Analysis

Data Analysis was carried out using SPSS version 20 and STATA version 13 software. Descriptive statistics such as mean, frequency and percentage, Binary Logistic regression model and Garrets Ranking Technique were used to achieve the objectives for the study.

Diffusion of Innovations Theory complimented by Technology Acceptance Model (TAM) are the theories used in this study. Diffusion of Innovations Theory, proposed by Everett Rogers in 1962, is one of the most influential frameworks for understanding how new technologies, products, or ideas spread across a population. Rogers (2003) defines diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social system." The theory describes the stages of adoption—knowledge, persuasion, decision, implementation, and confirmation—and classifies adopters as innovators, early adopters, early majority, late majority, and laggards.

Diffusion of Innovations Theory provided a strong theoretical foundation for the study. This theory explains how, why, and how quickly new ideas and technologies spread across civilizations. In terms of PICS bag adoption, it helped provide an understanding of how grain merchants at Dawanau Market were

adopting PIC bag technology, the factors influencing their decision, and the role of innovation characteristics such as relative advantage, compatibility, complexity, trialability, and observability.

An attempt is made to recognize the major constraints faced in the use of PICS bag technology by Dawanau grain merchants in Kano State. The estimated percentage position was converted into scores using Garrett's Table, as outlined by Garrett and Woodworth (1969) (Ao & Jamir, 2020). The identified constraints faced by the grain merchants in the Dawanau market are ranked using Garrett's Ranking Technique. The technique was utilized to rank respondents' preferences for various components and characteristics of the practice process. It is used to find the most significant factor that influenced the respondent in their practices. Founded on Garret's Ranking technique, the study had the respondents rank different problems and outcomes based on their impact thereby converting them into score values and ranking with the help of the following formula:

$$\text{Percent position} = \frac{100(Rij-0.5)}{\text{NJ}}$$

Where

Rij = Rank given for the i^{th} variable by j^{th} respondents

Nj = Number of variables ranked by j^{th} respondents

The Percent Positions and Garret Values

The Garret rankings were calculated using the applicable Garret Ranking methodology. The garret value was computed using the Garret ranks. The Garret tables and scores for each problem in the preceding table were multiplied by the recorded scores in the next table, and the overall Garret score was obtained by adding each row.

$$\text{Percent position} = \frac{100(Rij-0.5)}{\text{NJ}}$$

Results and Discussion

Socio-Economic Characteristics Merchant in the Study Area

The result of socioeconomic characteristics is presented in Table 1. It is evident that the grain merchants were dominated by the aged merchants (51.69 years). This means they are above economically active age brackets. Thus, they are usually not self-motivated and innovative. According to Mwangi and Kariuki's (2015) research, young farmers are more dynamic and willing to take on the risks associated with adopting new agricultural technologies than older farmers, who are frequently more conservative (traditional) and hesitant to adopt new technologies. Household size indicated that the majority had more than 10 family members with a mean of 12 persons. However, the mean household size of 12 persons is higher than the national average of 5, as recorded by the National Bureau of Statistics (2010). Responses on marketing experience show a mean of 21 years, indicating that merchants have been involved in the profession for quite some period.

Table 1

Quantitative variables: Age, Household size and years of experience

Variables	Minimum	Maximum	Mean	S.D
Age	18	75	51.69	12.181
Household size	1	31	12.49	7.855
Years of experience	3	52	21.13	9.80

Source; Field survey 2023.

In Kano State, access to agricultural extension services is facilitated by government agencies, non-governmental organizations, and private agricultural firms, especially on the first contact. The Agricultural Development Program (ADP) is the primary government institution responsible for providing extension services in the state. Extension officers under the ADP are tasked with disseminating information on improved farming practices, new technologies, and market opportunities to farmers and merchants (Abubakar et al. 2018). Subsequent contacts can be made directly with the extension of agents.

These findings corroborate those of Manda et al. (2016), who demonstrated that farmers with frequent interactions with extension agents were more likely to adopt sustainable intensification practices. Similarly, Udimal et al. (2020) found that access to extension services significantly influenced farmers' decisions to adopt improved storage technologies, such as hermetic bags.

Merchants at Dawanau Market, like many others in rural and peri-urban areas, may have difficulty accessing extension services since there is an insufficient number of extension agents to serve the large population of farmers and merchants, because the extension agent-to-farmer ratio in Nigeria is far lower than the desired level, implying that many farmers and merchants do not receive timely or adequate extension services (Adedoyin, 2020). Additionally, lack of education and language hurdles sometimes prevent or limit merchants from completely comprehending the information offered by extension agents, particularly if it is not delivered in their native language or adapted to their reading levels.

Table 2

Qualitative variables: Sex, marital status, membership, access to extension agent, awareness on PICS bag and participation on use of PICS bag.

Variables	Frequency	Percentage (%)
Sex:		
Male	80	100
Marital Status:		
Single	4	5
Married	75	93.8
Widowed	1	1.3
Membership:		
Member	68	85
Non-member	12	15
Extension Access:		
Access	56	70
Non-Access	24	30
Awareness on PICS bag		
Aware	76	95
Not Aware	4	5
Use of PICS bag		
Yes	32	40
No	48	60
Total	80	100

Source; Field survey 2023.

The result in the Table 2 revealed that 100% of the respondents were male. The unavailability of female is probably because the business requires frequent outing from home to the market, which is against the culture and religion of the people in the study area. This is similar to the findings of Yakubu, (2010) who reported that majority of the respondents of Purdue improved cowpea storage in Jigawa State

were male. Also, 93.8% of the marketers were married. Such a result is expected, as married people bear the responsibility for their family members, making them more committed and able to make rational decisions in business. Also, Table 2 revealed that 70% have access to extension agents and this was exceptionally higher in the area due mainly to the merchants selected for the study. Also, 85% of the surveyed merchants were members of an association. Membership of association offer certain benefits to members such as input procurement, information on output market and subsidy.

Table 3 shows the sources of information about PICS bag reported by respondents. Markets (53.2%) and PICS project (32.8%) were the main sources of information for most of the grains' merchants. This is expected as the technology is quite aware in the market. Other sources include radio 12.5% and friends (1.5%). Also, more than a quarter (41.1%) of the merchants purchased PICS bags from the market. On the basis of the reason for not using PICS bags, 86.8% of the merchants reported that the technology is too costly for them to afford. Hence, there is a need for government intervention to support the use of the technology for better food safety and security.

Table 3

The table below shows the source of information on PICS bag, source of PICS bag and reason for not participating

Variables	Frequency	Percentage (%)
Source of information on PICS bag:		
Radio	8	12.5
Markets	34	53.2
PICS project	21	32.8
Friends	1	1.5
Source of PICS bags(purchase):		
PICS project	8	14.3
ADPs	10	17.9
Markets	23	41.1
Others	15	26.8
Reason for not using PICS bag:		
Prices is too much Costly	46	86.8
No Interest	2	3.8
Old method is better	5	9.4

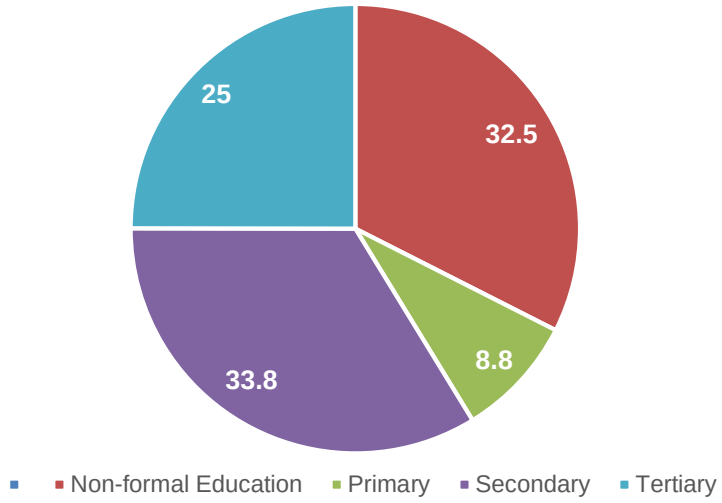
Source; Field survey 2023.

The results in Figure 1 show that 33.8% of the respondents had secondary education, followed by tertiary (25%), non-formal (32.5%), and primary (8.8%). This implies that formal education was the most prominent education level attended by most of the respondents. This finding is in line with that of Yusuf et al. (2009) who reported that 62% of grains merchant in the urban areas had formal education in Sokoto State.

The main occupation of the respondents, as presented in Figure 2, revealed that more than fifty percent (66.3%) of respondents considered trading/marketing grains as their predominant occupation and source of livelihood. 26.3% engage in farming, 6.3% work as civil servants, while others (1.3%) engage in other livelihood activities such as barbing, masonry, bricklaying, etc. It is common in developing countries like Nigeria for household members to engage in other occupation to complement their earnings.

Figure 1

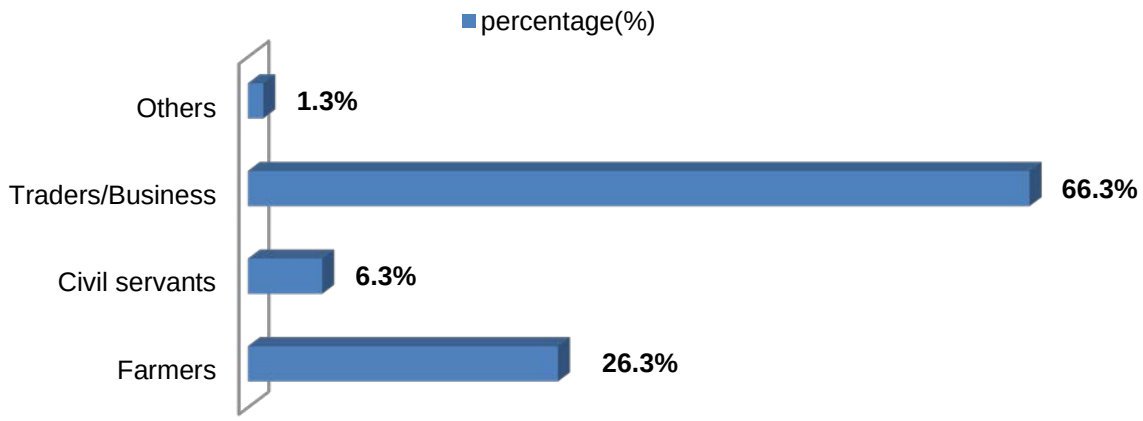
Distribution of the respondents based on educational level



Source: Field survey 2023.

Figure 2

Shows the Distribution of the occupation of the respondents.



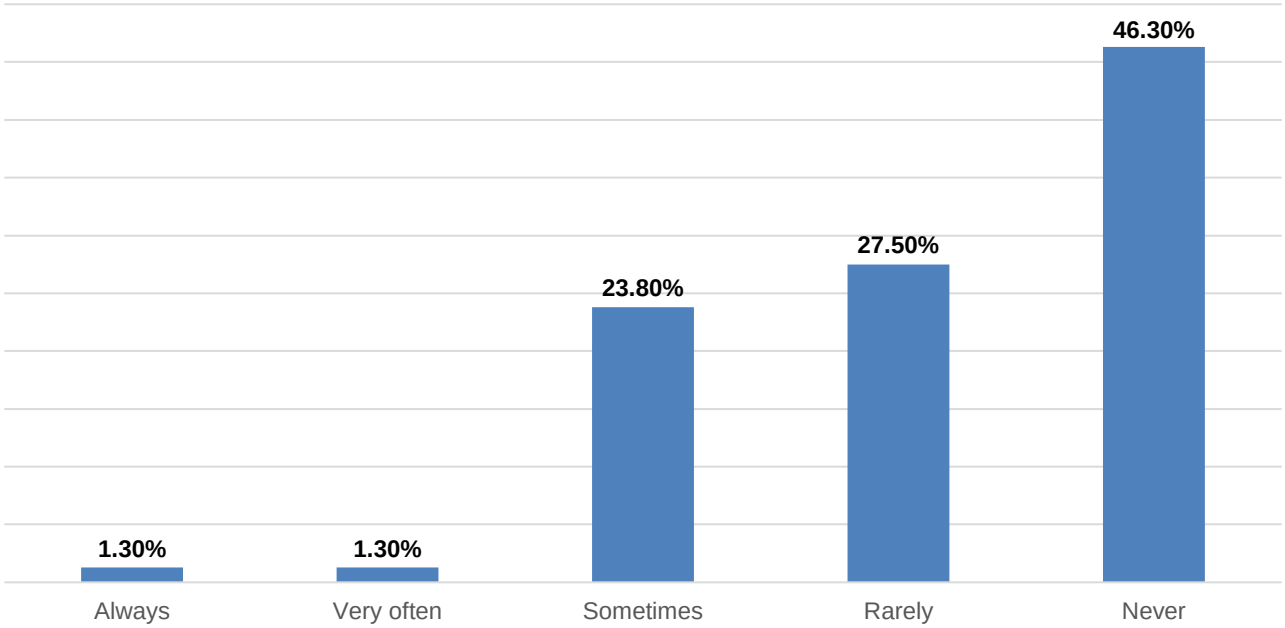
Source: Field survey 2023.

Extent in the use of PICS bag technology by the merchants

The results in Fig 3 revealed the extent of PICS (Purdue Improved Crop Storage) bag usage among merchants in the study area. The findings reveal that a significant majority of the merchants either rarely or never use PICS bags, with 46.3% reporting that they never use them and 27.5% using them rarely. A smaller proportion of merchants use the bags occasionally (23.8%), while only a tiny fraction (1.3%) report consistent use ("Always" or "Very Often"). It implies that the adoption of PICS bags among these merchants is generally low. The high percentage of those who rarely or never use the technology may indicate barriers such as limited awareness, accessibility issues and cost concerns. Identifying and addressing these challenges could be key to increasing the adoption and regular use of PICS bags in this population.

Figure 3

Shows the distribution of respondents on extent use of PICS bag



Source: Field survey, 2023

Socioeconomic Determinants of Merchants Adoption of PICS bag in the Study Area

The table 4 displays the findings of a binary logistic regression analysis, which explores the impact of different socioeconomic factors on the adoption of PICS bag technologies by merchants. The analysis was conducted using a forward stepwise method, where variables are added to the model incrementally based on their statistical significance. The R-square value of 0.450 suggests that about 45% of the variability in PICS bag adoption can be explained by the socioeconomic factors included in the model.

Age: The coefficient for age is positive (0.175) and highly significant at the 1% level (p = 0.000). This indicates that as merchants get older, their likelihood of adopting PICS bag technologies increases. Older merchants often believe their accumulated expertise and experience make them better equipped to evaluate technological information compared to younger farmers (Mignouna et al., 2011; Kariyasa & Dewi 2011).

Household size: The coefficient for household size is negative (-0.208) and also significant at the 1% level (p = 0.001). This suggests that larger households are less likely to adopt PICS bags. In larger households, there might be more diverse opinions and preferences, leading to differing attitudes towards adopting new products like PICS bags. Factors such as budget constraints, storage space availability and individual preferences can impact adoption. Smaller households might find it easier to reach a consensus on decisions, but the specific influence would depend on cultural, economic, and social factors.

Membership in Organizations: The coefficient for organizational membership is positive (1.836) and marginally significant at the 10% level (p = 0.058). This implies that merchants who are members of organizations are more likely to adopt PICS bag technologies, although the effect is weaker compared to age and household size. Membership tends to increase ones' access to information of PICS technology. This variable is expected to have a positive sign in the model.

Access to Extension: The coefficient for access to extension is positive (1.813) and significant at the 5% level (p = 0.012). This implies that merchants with access to agricultural extension services are more inclined to adopt PICS bag technologies. Extension representatives typically advise merchants on the presence, effective use, and benefits of PICS bag technology. Extension agents serve as a link between technology developers (researchers) and users. This helps to lower transaction costs associated with disseminating information about PICS bag technology to a diverse community of farmers (genius et al, 2010).

Table 4

Result of Binary Logit Regression (Forward Step-wise) for the Influences of Socioeconomic on the Adoption of PICS bag Technologies.

Explanatory variables	B	S.E	Wald	Df	Sig.
Age	0.175	0.45	14.958	1	0.000***
Household size	-0.208	0.64	10.566	1	0.001***
Membership	1.836	0.969	3.587	1	0.058*
Extension Contact	1.813	0.725	6.252	1	0.012**
Constant	-5.954	2.148	7.684	1	0.812
Observation(N) =80					
R-square = 0.450					
Dependent Variable: PICS bag Adoption					

Source: Survey, 2023 Note: ***, **, * = significant at 1%, 5%, and 10% probability levels respectively.

Major Constraints Face to the Use of PICS Bag Technology by Dawanau Grains Merchant in Kano State

The estimated percentage positions were converted into scores using Garrett's Table, as outlined by Garrett and Woodworth (1969). For each factor, individual scores were summed, and total and mean scores were calculated. The factor with the highest mean value is considered to be the most important. Below is the tabular representation of the major constraints faced in the use of PICS bag technology by Dawanau grains merchants in Kano State. The table provides a random categorization of the constraints found during personal interviews and with the help of questionnaires.

Table 5

The table shows the preference and ranking of major constraints faced to the use of PICS bag Technology by Dawanau Grains merchant in Kano State.

Major constraints facing by the grains merchant	Ranks giving by the respondents					
	1th	2th	3th	4th	5th	6th
Inadequate finance	29	10	7	6	6	22
Lack of Awareness	63	5	2	1	0	9
Location of Vendor’s unknown	1	2	11	13	22	31
Poor Quality of Cowpea	1	1	6	12	22	38
Inadequate of sufficient training on PICS bag	0	1	4	10	13	52
Un-availability of PICS bag	0	3	4	9	14	50

Source: Field survey 2023.

The result is provided in the following table below.

Calculation of Garret Value and Ranking

Table 6

The description of Garret value and ranking of problems faced by Grains merchants are shown below.

s/No	100(Rij-0.5)/NJ	Calculated value	Garrett Value
1	100(1-0.5)/6	8.33	77
2	100(2-0.5)/6	25	63
3	100(3-0.5)/6	41.66	54
4	100(4-0.5)/6	58.33	46
5	100(5-0.5)/6	75	37
6	100(6-0.5)/6	91.66	23

Source: Author's computation, 2023

Table 7

This table above shows the Garrett value of the respondents

Variables	Ranks given by the respondents						Total	Average	Rank
	1th	2th	3th	4th	5th	6th			
In-adequate finance	2233	4851	77	77	0	0	7238	90.47	1st
Lack of Awareness	630	315	126	63	63	189	1386	17.32	6th
Location of Vendor's unknown	378	208	594	324	216	216	1836	22.95	5th
Poor Quality of Cowpea	276	0	598	552	460	414	2300	28.75	4th
In-adequate of sufficient training on PICS bag	222	0	814	814	481	518	2849	35.61	3rd
Un-availability of PICS bag	506	207	713	874	1196	1150	4646	58.07	2nd

Source: Author's computation, 2023

Major constraints face to the use of PICS bag Technology

Based on Garret's Ranking Technique, it was revealed that 'inadequate finance' was the major problem, with the highest Garret score of 7238 and an average score of 90.47. This is not surprising because, earlier, the respondents indicated that 60% of the respondents are not utilizing the PICS bag, due to the high cost of the technology. This is in line with economic theories on technology adoption that suggest that initial investment costs can be prohibitive for smallholder farmers and small-scale merchants. This could be associated with the fact that their low-income levels or lack of access to credit. Also, Moussa et al. (2014) reported in agreement that the adoption of PICS bags was still constrained by financial issues, even though PICS bags were widely recognized for their efficacy in reducing post-harvest losses.

The least constraints with an average score of 28.75, 22.95 and 17.32 are poor quality of grains, local vendor's location and lack of awareness respectively. The low score attributed to the poor quality of grains indicates that grain quality is not a major factor influencing merchants' adoption of PICS bags. This could be due to the fact that PICS bags are primarily used for their ability to protect grains from pests and spoilage, rather than being directly associated with the quality of grains at the point of purchase. This finding is in line with studies like that of Moussa et al. (2014). Also, the relatively low score for the constraint "local vendor's location" suggests that, while some merchants may find it challenging to locate PICS bag vendors, this is not a predominant barrier to adoption. It is possible that merchants are aware of vendors or can locate them with relative ease. This is contrary to what Baributsa et al. (2010) found

out where they noted that in some regions, the distance to vendors and the availability of PICS bags in local markets posed a moderate barrier to adoption.

The lowest average score of 17.32 for "lack of awareness" implies that most retailers are properly aware of the PICS bag technology and also indicates that the merchants probably polled were well-informed about the existence and benefits of PICS bags. This supports the findings of Baributsa et al. (2014).

The adoption challenges can only be met if the major constraints faced in the use of PICS bag technology by Dawanau grains merchant in Kano state are identified and prioritized for further improvement. Based on Garret's Ranking Technique, it was revealed that 'inadequate finance' was the major problem, with the highest Garret score of 7238 and an average score of 90.47. This is not surprising because, earlier, the respondents indicated that 60% of the respondents are not utilizing the PICS bag, due to high cost of the technology. The result is in line with the findings of Katanga et al. (2016) whose study revealed that, 44.7% of the traders were constrained by in-adequate finance. Accordingly, 'Unavailability of PICS bag' with Garret scores of 4646 and an average score of 58.07 is represented second. The calculation with an average score of 35.61 ranked 'Location of Vendor's unknown' third, while the least constraints with an average score of 28.75, 22.95 &17.32 are poor quality of grains, local vendor's location and lack of awareness respectively.

Conclusion

It can be concluded from the study that grains merchants in Dawanau international Grains market, Dawakin Tofa local Government Area of Kano state were all men and display a lower level in terms of using PICS bag Technology. The reason for the low level used of this technology is due to high cost of the technology between the old methods and the presence method of storage of grains. Also, grains merchants in the study area have very low adoption, which is an indication of their non-use of the PICS bag. Furthermore, access to extension agents/services was high. Hence, using one marketer to deliver a message can help since members tend to help build one another's capacity, leading to merchant-to-merchant diffusion of messages. Finally, inadequate finance and the high cost of PICS bags were the major constraints in the use of the technology, among others.

Recommendations

Based on the findings of this study, the following recommendations were made:

1. The government and policy makers need to play an important role by subsidizing or offering financial incentives to lower the cost of PICS bags, making them more affordable for merchants. This strategy could encourage greater trial and eventual adoption of the technology.
2. Research Institute such as Nigerian Stored Products Research Institute (NSPRI) should create a feedback system where merchants can share their experiences, challenges, and suggestions regarding PICS bags. This input can be used to improve the product and its distribution process.
3. There is a need to train more extension agents on postharvest and value addition technologies to enable more capable hands in addressing food security and safety.
4. Implement training programs to educate merchants on the correct use of PICS bags, ensuring they fully understand how to optimize the benefits.
5. Initiate targeted awareness campaigns to inform merchants about the advantages of using PICS bags, particularly their effectiveness in reducing post-harvest losses.

6. The study further calls for research into the area of post-harvest storage, food security and farmers' participation in the adoption of storage technologies.

Limitations of the Study

The study is limited to Dawanau international grains market which might not capture the broader usage or challenges of adopting PICS bag technology in other states.

References

Abubakar, S. Z., Kudi, T. M., & Kormawa, P. M. (2018). Agricultural extension services in Kano State, Nigeria: A case study of the Agricultural Development Program. *Journal of Agricultural Extension and Rural Development*, 10(5), 101-110.

Adedoyin, S. F. (2020). Agricultural extension services in Nigeria: Constraints and prospects for future development. Journal of Agricultural Economics and Rural Development, 8(3), 203-213.

Ao, W & Jamir, B.K. (2020). Application of garret ranking technique in studying the problems of bamboo cultivation: A case study of Mokokchung district, Nagaland. *Indian Journal of Hill Farming*, 33(2), 311-315.

Baributsa, D. and Njoroge, A.W.W. (2020). The use and profitability of hermetic technologies for grain storage among smallholder farmers in eastern Kenya. *Journal of Stored Products Research*, 87, 101618.

Baributsa, D., Lowenberg-DeBoer, J., Murdock, L., & Moussa, B. (2010). Profitable chemical-free cowpea storage technology for smallholder farmers in Africa: Opportunities and challenges. In *Proceedings of the 10th International Working Conference on Stored Product Protection*, Estoril, Portugal, 27 June–2 July 2010 (pp. 1046–1052). Carvalho, M. O., Fields, P. G., Adler, C. S., Arthur, F. H., Athanasius, C. G., Campbell, J. F., Fleurat-Lessard, F., Flinn, P. W., Hodges, R. J., Isikber, A. A., et al. (Eds.). Julius-Kühn-Archiv: Estoril, Portugal.

Baributsa, D., Williams, S. B., Murdock, L. L., & Baoua, I. B. (2014). PICS bags: Affordable technology for the African smallholder farmer. *African Journal of Agricultural Research*, 9(3), 338-350.

Conteh, A.M.H., Yan, X. & Moiwo, J.P. (2015). The determinants of grain storage technology adoption in Sierra Leone. *Cah. Agric*. 24 (1), 47–55. http://dx.doi.org/10.1684/agr. 2013.0663

Foster, A.D., Rosenzweig, M.R., 2010. Microeconomics of technology adoption. *Annu. Rev. Econ*. 2 (1), 395–424

Fuglie, K.O. (1995). Measuring welfare benefits from improvements in storage technology with an application to Tunisian potatoes. *Am. J. Agric. Econ.* 77 (1), 162–173.

Genius, M., Koundouri, P., Nauges, C., Tzouvelekas, V., 2014. Information transmission in irrigation technology adoption and diffusion: social learning, extension services, and spatial effects. *Am. J. Agric. Econ*. 96 (1), 328–344.

Kariyasa, A. P., & Dewi, A. S. (2011). Factors influencing the adoption of agricultural technologies among smallholder farmers in Indonesia. *Journal of Agricultural Science and Technology*,3(1), 1-10

Manda, J., Alene, A. D., Gardebroek, C., Kassie, M., & Tembo, G. (2016). Adoption and impacts of sustainable agricultural practices on maize yields and incomes: Evidence from rural Zambia. *Journal of Agricultural Economics*, 67(1), 130-153.

Mignouna, H. D., et al. (2011). Factors influencing the adoption of agricultural technologies among smallholder farmers in West Africa. *African Journal of Agricultural Research*, 6(1), 1-10.

Miller, J., Baributsa, D. & Njoroge, E. (2017). The impact of PICS bags on food security and livelihoods in East Africa. Journal of Agricultural Science and Technology, 7(2), 57-72.

Moussa, B., Abdoulaye, T., Coulibaly, O., Baributsa, D., & Lowenberg-DeBoer, J. (2014). Adoption of on-farm hermetic storage for cowpea in West and Central Africa in 2012. Journal of Stored Products Research, 58, 77-86.

Murdock, L. L., Margam, V., Baoua, I., Balfe, S. & Shade, R. E. (2012). Death by desiccation: effects of hermetic storage on cowpea bruchids. *Journal of Stored Products Research* 49, 166–170.doi: 10.1016/j.jspr.2012.01.002

Murdock, L.L. & Baributsa, D. (2014). Hermetic storage for those who need it most-subsistence farmers. I*n Proceedings of the 11th International Working Conference on Stored Product Protection*, *Chang Mai*, Thailand, pp. 310–323.

Murdock, L.L., Margam, V., Baoua, I., Balfe, S. & Shade, R.E. (2012). Death by desiccation: Effects of hermetic storage on cowpea bruchids. J. Stored Prod. Res. 49, 166–170.

Mwangi, M. & Kariuki, S. (2015). Factors determining adoption of new agricultural technology by s mallholder farmers in developing countries. *Journal of Economics and Sustainable Development*, 6(5): 208-216.

National Bureau of Statistics (NBS) (2010). National Manpower Stock and Employment Generation Survey, Household and Micro Enterprises (Informal sector), www.nbs.org.ng,visited on 15th July, 2013, p51.

National Population Commission (NPC) (2006). Briefing on World Population Day in Abuja as Reported by the Guardian News Paper, No. 28, Vol.11885, July 12, 2006

Parmar, A., Hensel, O. & Sturm, B. (2017). Post-harvest handling practices and associated food losses and limitations in the sweetpotato value chain of southern Ethiopia. NJAS – Wageningen J. Life Sci. 80, 65–74. http://dx.doi.org/10.1016/j.njas.2016.12.002

Premanandh, J., 2011. Factors affecting food security and contribution of modern technologies in food sustainability. *J. Sci. Food Agric*. 91 (15), 2707–2714.

Rogers, E. M. (2003). Diffusion of innovations (5th ed.). Free Press.

Sudini, H., Ranga Rao, G.V., Gowda, C.L.L., Chandrika, R., Margam, V., Rathore, A., & Murdock L.L. (2015). Purdue Improved Crop Storage (PICS) bags for safe storage of groundnuts. *Journal of Stored Products Research*, 64(B),133-138. https://doi.org/10.1016/j.jspr.2014.09.002

Tesfaye, W., & Tirivayi, N. (2018). The impacts of postharvest storage innovations on food security and welfare in Ethiopia. *Food Policy, 75*, 52–67. https://doi.org/10.1016/j.foodpol.2018.01.004

Udimal, T. B., Jincai, Z., Mensah, O. & Etwire, P. M. (2020). Factors influencing the adoption of post-harvest storage technologies among grain farmers in northern Ghana. Sustainability, 12(5), 1913.

Williams, S. B., Murdock, L. L. & Baributsa, D. (2017). Storage of maize in Purdue improved crop storage (PICS) bags*. PLoS One*, 12(1), e0168624.

World Bank, Natural Resources Institute, & FAO, (2011). Missing Food: The Case of postharvest Grain Losses in Sub-Saharan African (Vol. 60371–AFR).

Yakubu, S. (2010). Economic Analysis of Purdue Improved Cowpea Storage (PICS) Technology in Kano, Jigawa and Katsina States. Unpublished M.Sc. Thesis, Department of Agricultural Economics and Extension, Bayero University Kano.

Yusuf, B. I., Baba, K. M., Mohammed, I., & Bello, H. M. (2009). Impact of inflation on farm families in Sokoto. *Proceedings of the 23rd Annual Conference of the Farm Management Association of Nigeria*, Sokoto, 98-103.