The Level of Adoption of Vegetable Sun-Drying Technology in Teso South Sub County, Kenya

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Abstract

Sun-drying is one of the most efficient and cost-effective, renewable, and sustainable technologies to conserve agricultural products in sub-Saharan African (SSA) countries. The aim of this study was to determine the level of adoption of vegetable sun-drying technology in Teso South sub-County, Kenya. A mixed survey design was used to access the target population. The population was first grouped into strata before the actual size was determined. Simple random sampling technique was used to administer semi-structured questionnaire to 384 farmers. Data gathered was analyzed using descriptive statistics. The study found out that 73% of respondents were aware of vegetable sun drying technology. The main source of information about sun-drying technology were farmer to farmer extension (59%), field days and demos (15%), researchers (10%) and agricultural extension services (9%). The study also revealed that seasonality had great influence on utilization of sun-drying technology with majority of the respondents preferring to sun-dry their vegetables whenever they had surplus (62%) and during the dry seasons (30%). The main reason for sun-drying vegetables was to increase availability during off season (40%). Cowpeas (63%), black night shade (12%), spider plant and amaranth (7%) were the most preferred sun-dried vegetables. The main materials used to sun-dry vegetables were polythene paper (32%), gunny bags (27%) and trays (20%). The major constraints to the use of sun-drying technology were unfavourable weather conditions (54%) and disturbance from livestock (21%) as most farmers lacked fabrication skills for enclosed solar dryers. In conclusion, sun-drying technology had positive influence on living standard of the people and therefore more farmers should be encouraged to embrace it. The study recommends commercialization of enclosed solar dryers by TVET institutions to overcome challenges associated with traditional sun-drying methods.

Keywords: Sun-Drying Technology; Vegetable; Seasonality; Constraints; Solar Sun-Dryers

Introduction

Post-harvest losses of agricultural produce are a global concern as a significant amount of food is lost amid the climatic, economic, and food insecurity crisis. The UNEP food waste index report in 2021 indicates that over 931 million tons of food go to waste every year, with a significant portion of these losses occurring during the post-harvest and processing phases in developing nations (Tchonkouang et al., 2023). In sub-Saharan Africa, an estimated 30-40% of food is lost following harvest (FAO, 2014). A large number of these losses happen primarily in rural regions where farmers lack access to grid electricity, have limited food processing technologies, and do not possess adequate storage facilities (Tchonkouang et al., 2023).

A majority of the African population resides in rural areas, with their livelihoods largely relying on agriculture (Harrington, 2016; Gustafsson, J, et al, 2013). There is a concern about exponential population growth in Africa's rural areas, projected to increase by 60% in 2050 (UNEP, 2016). This population surge has led to a corresponding increase in food production, heightened energy requirements, and ultimately, a rise in the amount of food that is lost or wasted (Ondraczek, 2013; Wakeford, 2017). As food loss continues, food insecurity persists as a significant issue, particularly in Kenya and many sub-Saharan African nations, where some people experience hardships due to insufficient food.

According to United Nations Environmental Programme (UNEP, 2016), the food sector accounts for almost 30% of the world's total end-use energy consumption. This consumption is mainly based on fossil fuel sources, contributing to approximately 19-29% of greenhouse gas emissions (Vermeulen et al., 2012). Conventional post-harvesting activities such as refrigeration, drying, transportation and packaging contributed to the highest number of emissions since they are energy-intensive (UNEP, 2016). Additionally, improper food loss and waste management end up in landfills and account for approximately 2.8% of anthropogenic GHG emissions (Vermeulen et al., 2012).

United nations (UN) highlighted the sustainable development goal (SDG) number 12 aimed at ensuring "sustainable consumption and production patterns," as one of its targets in 2015. The UN indicates that effective food production and consumption practices will significantly contribute to achieving related objectives such as eliminating hunger, alleviating poverty, and addressing climate change (Mwaniki & Nyamu, 2022). To realize many of these objectives, a fundamental transformation of the food system is necessary, incorporating sustainable methods including energy utilization throughout the food value chain. As a result, some of the efforts made by countries are to employ more green, renewable energy sources, such as solar energy.

Solar energy has the potential to be used in the agricultural sector since it is more eco-friendly, clean and renewable. From a technical perspective, it is perceived that the amount of solar energy that reaches the Earth daily is sufficient to cover the world's primary energy needs (Ondraczek J, 2014). Traditionally, solar energy is used to dry food products. However, this method takes a lot of time, and the quality of food products is usually reduced or lost along the process (Adwek G. et. al., 2019). New solar energy technologies that are important in agricultural services have been developed as they can provide both the cooling and thermal energy required in all food chains (Chanda et al., 2023). This could be utilized for small and medium food processing and accessible to remote off-grid regions.

Post-harvest loss encompasses the unintentional decline in food quality and quantity harvested, making them unmarketable or unsafe for consumption. This study focused on the level of adoption of vegetable sun-drying technology, considering the opportunities and potentials available in the rural areas of Kenya. The specific objectives of the study were to determine the extent of awareness on vegetable sun drying technology, the major constraints to the use of vegetable sun-drying technology and strategies for scaling-up the use of vegetable solar sun-drying technology in Teso-South sub-County, Kenya. Vegetable sun-drying technology was one of the initiatives by Education and Training for Sustainable Agriculture and Nutrition in East Africa (EaTSANE) project. The main goal of the EaTSANE project was to implement sustainable farming practices and improved diets of households in Kenya and Uganda by diversifying the food systems with a participatory learning approach.

Methodology

Study Location

The study was conducted in Busia County which has seven sub-Counties (Nambale, Butula, Bunyala, Teso South, Teso North, Samia and Matayos). Agriculture is the main socio-economic activity within the County. About 75% of the population depends on Agriculture (MoALFC, 2023). The project was implemented in Teso South sub-County.

Research Design

The study employed mixed survey design where engagement with respondents through interviewer administered questionnaires and focus group discussion played a crucial role. This design was preferred because tacit knowledge, which is extracted through dialogue, can play a critical role in understanding farmer behaviour and hence inform more pragmatic policy for positive change.

Sample Size and Sampling Procedures

The survey targeted respondents from Teso south Sub-County which had a population of 168,116 (KNBS, 2019). Sampling involved identifying a subgroup within the population that represents a large group from whom they were identified from. In this regard the researchers selected a sample size of 384 respondents using the table for determining sample size as suggested by Darley and Robert (1970). The table is based on standardized figures of sample sizes for different population (or proportion of it) at 95% confidence level. By use of a standardized table, the researchers were 95% certain that the results obtained from the sample would be representative enough for the entire population.

Table 1: Sampling Frame for the Study

Category of respondents	Population	Sampling technique	Sample size
Farming household heads	168,116	Simple random sampling	384
Focus groups	4	Purposive sampling	4
Agricultural extension officers	4	Automatic inclusion	4
Total	168,124		392

Agricultural Extension Officers were automatically included in the study because they oversee farming activities in the area hence, they acted as key informants on issues concerning the potential of vegetable farming in the area, the challenges faced by vegetable farmers, and policy interventions for improvement. The focus group heads were purposively picked because being in constant touch with the farmers, they held crucial information about the reality on the ground which was of great interest to the researchers.

Data Collection Methods

Quantitative data was gathered using household questionnaires while qualitative data was gathered using qualitative tools or instruments such as participatory transect surveys (Transect Walk), Focus Group Discussions and Key Informant interviews as detailed below.

Questionnaires

For purposes of this study, a household was categorized as a family unit dependent on one head and a common livelihood. Questionnaires were formulated with questions aimed at getting answers to the three research questions. They were given to 384 households to get information, opinions and perceptions about the study objectives at the household level.

Key Informant Interviews

The study relied on Key Informant Interviews to give more and clear information especially on the technical knowledge about the study topic and area. Four Key Informants from the ministry of agriculture, livestock and fisheries were selected.

Focus Group Discussions

Four focus group discussions were selected randomly in the area of study. The semi-formal discussions were conducted at the chiefs" camps and nearby public schools with the assistance of a moderator.

Participatory Transect Survey

It`s an information gathering exercise where, the only knowledge needed is key informant advice on finding out the transect line routes and a few selected local analysts. This study made use of three transects walks. Each transect walk was done with local analysts taking about 2 to 3 hours. The walk started from one end of a define area and ended at the end of that administrative unit. The distribution of vegetable farmers including the status of post-harvest handling was mapped and documented.

Data Analysis Methods

Questionnaire data from all the 384 households was analyzed quantitatively for all quantifiable data under research. This data was first coded and fed in Statistical Package for Social Sciences (SPSS) Version 22 and Excel spread sheets. The outcome was then analyzed through cross tabulations, rankings, percentages, frequency counts mean, and standard deviations. The analyzed data was then presented in form of tables, graphs and pie charts.

The rest of the data in this study was then analyzed qualitatively since it involved measurements that would not be quantified. All data collected using qualitative methods such as focus group discussions, key informant interviews and participatory transect survey was analyzed qualitatively and presented in form of ranks and scores of perceptions and descriptions. Cross-tabulations were also used to show trends, patterns and extent of influence of two variables on each other.

Ethical Considerations

Information from the respondents was treated with utmost confidentiality and the data given were used in a format in which the individual respondents were not identifiable. Their consent was obtained before the survey commenced hence assisted in taking photos, recording and made respondents to engage freely during the interview.

Findings and Discussion

Questionnaire Return Rate

Questionnaire return rate is the number of the questionnaires that are brought back after they have been answered by the respondents. The study targeted 384 respondents. There were 376 responses which represents 98% response rate that was satisfactory for analysis. This was possible because, the researchers, together with the research assistants went from one household to another soliciting response. This was necessary because some of the items in the questionnaire required the researcher to read loudly to the respondents, clarify ambiguities and make corrections on any misinterpretations. According to Mugenda and Mugenda (2003), any questionnaire return rate above 90% in considered representative enough for a study.

Respondent Characteristics

The survey paid a keen focus on analysing the demographic phenomena of the respondents to gather the information with reference to major life events (gender, age, marital status, level of education and main occupation). The results are presented in Table 2

Table 2: Respondent characteristics (N = 376)

Description	Variables	No. of Respondents (%)
Gender	Male	56
	Female	44
Education Level	No school	8
	Primary 1-4	17
	Primary 5-8	51
	Secondary	19
	College/University	5
Main Occupation	Farming	87
	Casual laborer	4
	Formal/Salaried employment	3
	Small/Petty trade	6

The findings shows that majority of the respondents were male, accounting for 56% of the total respondents (N = 384). The average age of the respondents was 52 years (SD=14) implying that the respondents were mainly adult farmers. The distribution of respondents by level of education showed that over 50% had basic education with about 8% not having both formal and non-formal education. Majority of the households (87%) relied on farming as the main source of income.

Extent Of Vegetable Sun-Drying Technology Awareness

The first objective of this survey was to determine the extent to which vegetable sun-drying technology was practiced in Teso South sub-County. The respondents were asked to indicate awareness about vegetable sun-drying technology as shown in Fig. 3.1.

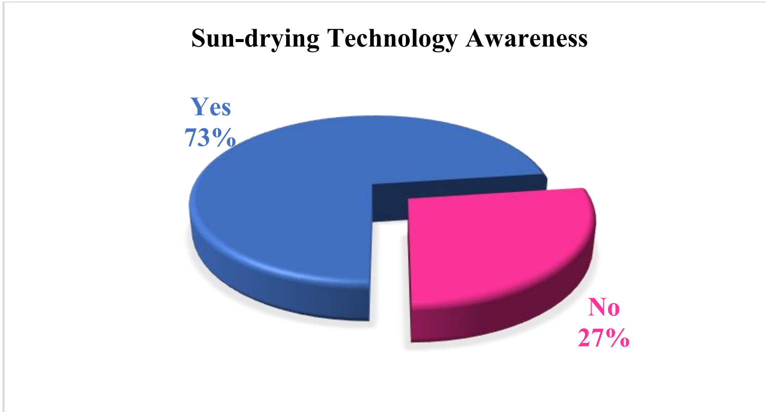

Figure 1: Household awareness of vegetable sun-drying technology

Majority of the respondents (73%) were aware of vegetable sun-drying technology in the study area. This indicates an improvement in adoption of vegetable solar sun-drying technology by 27% after Education and Training for Sustainable Agriculture and Nutrition in East Africa (EaTSANE) project intervention. Vegetable sun-drying technology was one the EatSANE project flagship areas, aimed at reducing food losses through improved handling and processing practices. Sun-drying is a crucial food preservation technique, especially in regions with limited access to refrigeration.

Source of Information on Vegetable Sun-Drying Technology

To establish the main sources of information about vegetables/fruits sun-drying technology in the study area, respondents who had embraced vegetable sun-drying technology (N = 275) were asked to outline their main source of awareness about the technology as presented in Fig. 3.2.

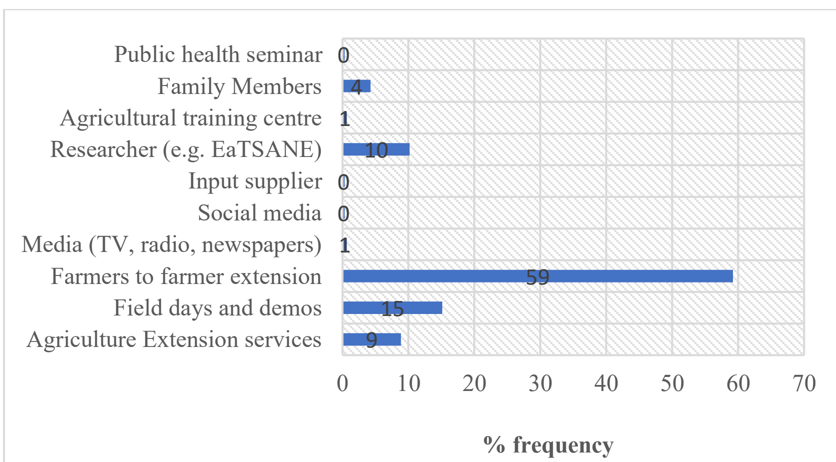

Figure 2: Source of information about sun-drying technology (N = 275)

From Fig. 2, farmer to farmer extension (59%) was the main source of information on vegetables sun-drying technology. This was followed at a distance by field days and demos (15%), researchers (10%) and agricultural extension services (9%). This highlights the importance of peer-to-peer knowledge sharing in agricultural practices. Field days and demos and agricultural extension services also plays a notable role, indicating the impact of practical demonstrations and formal extension programs. According to Jha &

Singh, (2021), farmer to farmer extension is the most effective way of promoting climate-smart agriculture practices because personal influence and social connections play a significant role in diffusion of innovations.

The respondents were also asked to state the main materials used to sun-dry vegetables as shown in Fig. 3

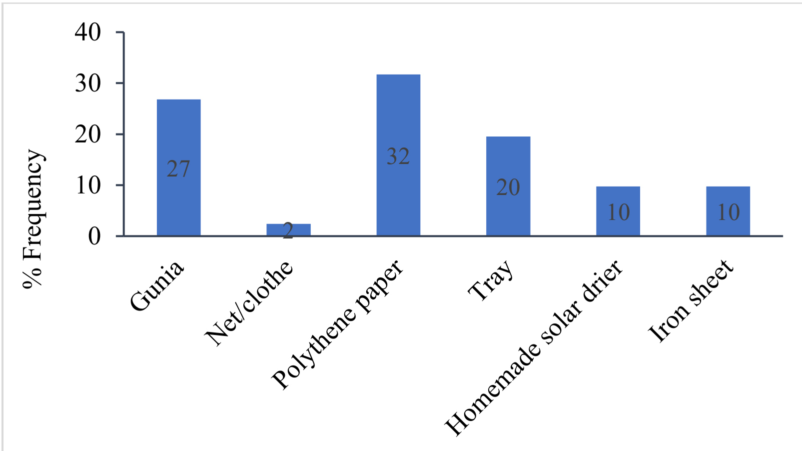

Figure 3: Materials used to sun-dry vegetables

From Fig. 3.3, most households opted for polythene paper (32%), gunia (27%) and trays (20%) as the main materials for sun-drying vegetables. Adoption of home-made solar drier was relatively low (10%) because most of the households lacked its fabrication skills (70%). Since there is already a suitable environment for solar product markets in Kenya, the government, through the Ministry of Agriculture and Energy, needs to encourage rural farmers to adopt enclosed solar dryers to prevent further food loss and waste (Mwaniki & Nyamu, 2022).

Influence of Seasonality on Vegetable Sun Drying Technology

To determine the influence of seasonality on vegetable sun drying technology adoption, the study went further to gauge respondents' opinion on the seasons they prefer to sun-dry vegetables as shown in Fig. 4.

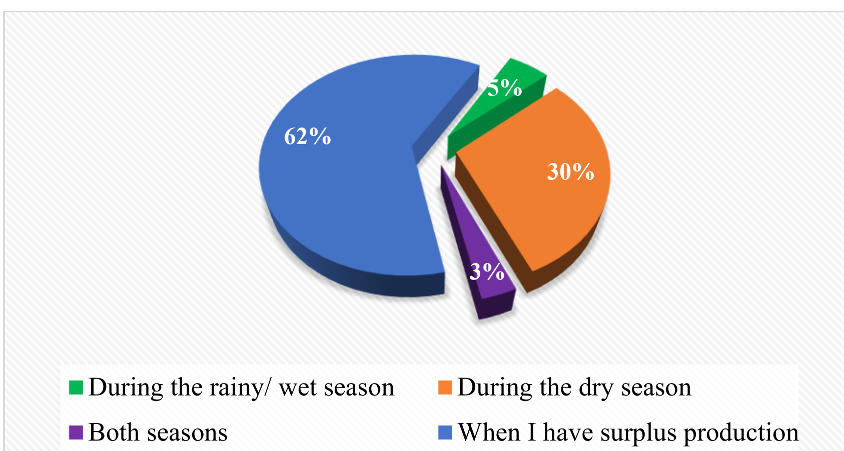

Figure 4: Influence of seasonality on sun-drying technology adoption

Majority of the respondents stated that surplus production (62%) and dry seasons (30%) are the main factors that positively influence the adoption of vegetables sun-drying technology. Remarkable food loss and waste have been prevented by solar drying systems. The great demand for dried products in Kenya and globally indicates the possibility of reducing food loss and waste in the future. Drying has enormous potential to preserve perishable crops, including fruits and vegetables, and reduce losses estimated at 11% and 7% for fruits and vegetables, respectively (Chanda et al., 2023).

The study also seeks to determine farmers preference on sun-dried vegetables. The results are presented in Fig. 5

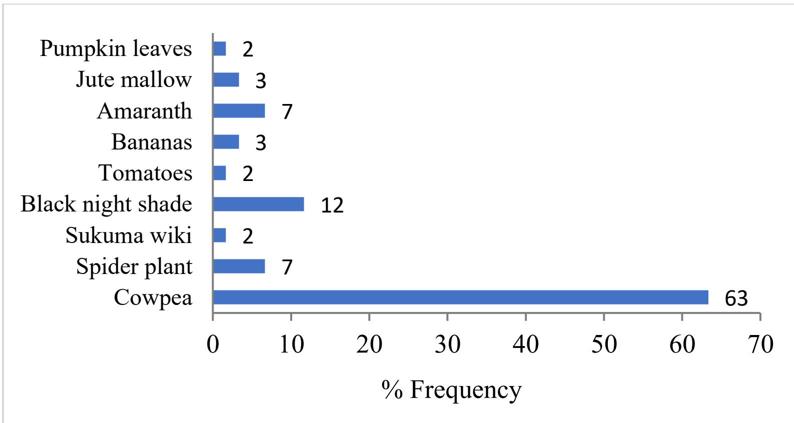

Figure 5: Farmers preference on sun-dried vegetables

The result showed that cowpeas was the most preferred crop (63%) for sun-drying. Almost all households grow cowpeas as the primary leafy vegetable crop due its first maturity, high biomass yield and versatility to a wide range of environmental conditions. Borrowing from India, their country's agricultural sector has increased the market value of food products and decreased conventional energy consumption by using solar dryers. Solar dryers decreased conventional energy consumption in India by 27-80%. Combining solar and other energy sources enables one to save up to 20-40% of energy (Udomkun et al., 2020).

Preparation and Consumption of Sun-Dried Vegetables Meals

The respondents were asked to explain how they use sun dried vegetables to prepare meal. The results are presented in Figure 6.

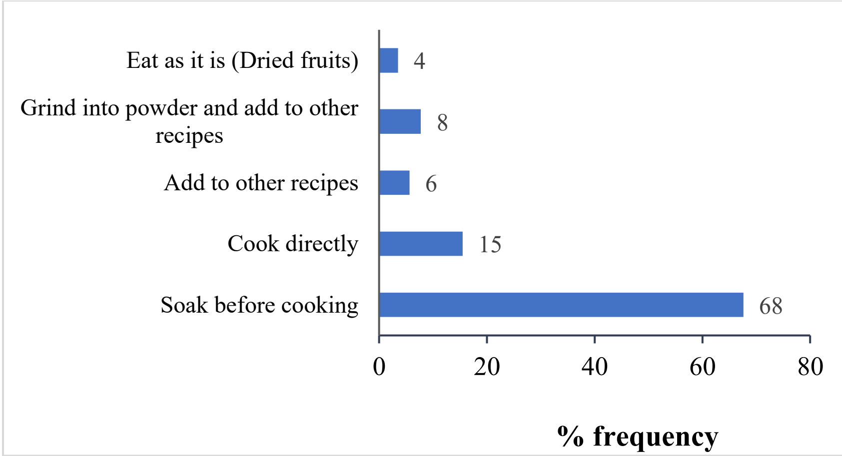

Figure 6: Methods of preparing sun-dried vegetable meals (N = 275)

Majority of the respondents attested that soaking sun-dried vegetables in water before cooking (68%) would retain the desirable characteristics. The high preference for soaking likely reflects established culinary practices and cultural norms in the region. Soaking might be perceived as a necessary step to rehydrate the vegetable, improve texture and reduce cooking time. Understanding the preparation methods used is essential for maximising the nutritional benefits and promoting the effective use of the technology (Muthoni et. al., 2020).

The study went further to establish whether the quality parameters would affect the willingness of respondents to consume meals prepared from sun-dried vegetables. In so doing, the respondents were asked to state their level of agreement or disagreement with some statements on a five-point scale of 1-Extremely not influenced, 2-Slightly not influenced, 3-Neutral, 4-Slightly influenced and 5-Extremely influenced. The analysis of the results is in Table 3

Table 3: Level of agreement with consumption of meals made from sun-dried vegetables

Statement	Response (% frequency)				
	Extremely not influenced	**Slightly not influenced**	**Neutral**	**Slightly influenced**	**Extremely influenced**
Colour of sun-dried vegetables	54.2	19.0	5.6	10.6	10.6
Taste of sun-dried vegetables	46.5	19.7	7.0	16.2	10.6
Texture of sun-dried vegetables	46.5	20.4	14.8	12.0	6.3
Nutritive value of sun-dried vegetables	44.4	17.6	14.8	16.2	7.0
Type of sun-dried vegetables	39.4	21.8	13.4	16.9	8.5
Method of preparation of sun-dried vegetables	43.0	15.5	10.6	15.5	7.8
Socio-cultural factors on sun-dried vegetables	54.2	8.5	14.1	14.8	8.5

From Table 3 majority of the respondents were not strongly influenced by the quality parameters and socio-cultural factors when consuming sun-dried vegetable meals. As a result, they were willing to recommend sun-drying of vegetable technologies to others (94%). This implies that sun-dried vegetables are integrated into their dietary practices and minor variations in quality parameters or socio-cultural factors do not significantly deter consumption. The high recommendation rate suggests that practical considerations like availability, affordability and preservation benefits may outweigh concerns about specific quality parameters (Kinyua & Mutua, 2022). While acceptance is high, there is still a segment of the population that is influenced by the listed factors. This highlights the potential for improvements in quality parameters to further enhance consumer satisfaction.

Challenges Facing Vegetables Sun-Drying Technology Adoption

The study sought to find out some of the constraints affecting adoption of sun-drying technology. On this regard, the respondents were asked to state challenges associated with sun-drying of vegetables. The analysis of the results is in Figure 3.7.

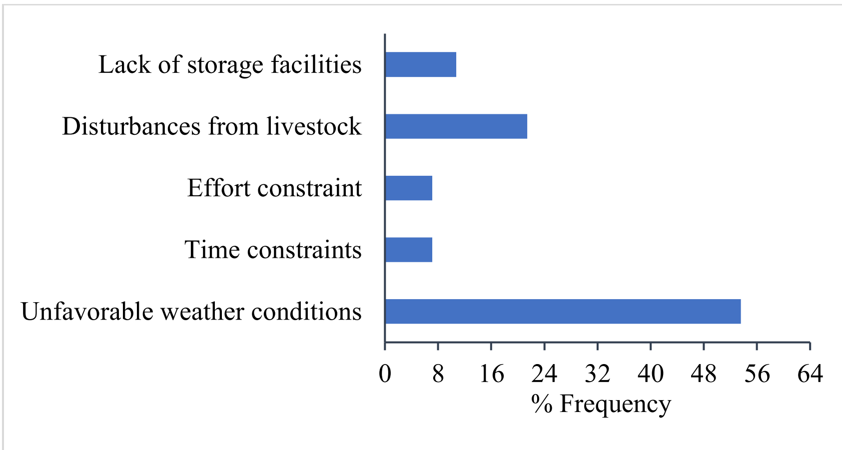

Figure 7: Challenges facing the adoption of vegetables sun-drying technology

According to the respondents, the major challenges facing the use of sun-drying technology were unfavourable weather conditions (54%) and disturbance from livestock (21%). The overwhelming impact of unfavourable weather underscores the vulnerability of sun-drying to climate variability. Disturbances from livestock and lack of storage facilities highlights the challenges related to post-harvest losses which can significantly reduce the quantity and quality of sun-dried vegetables (Ssepuuya & Birungi, 2023). Climate variability and disturbance from livestock may also be associated with inadequate fabrication skills for enclosed solar driers. Resource constraints (effort and time) suggests that resource limitations such as labour and time can also hinder the adoption of sun-drying technology.

Strategies for Vegetable Solar Sun-Drying Technology Commercialization

The third and last objective of this study was to identify strategies that could be put in place in order to promote vegetable sun-drying technology as a sustainable source of income and livelihood to the people of Teso South sub-County. Training on fabrication of enclosed solar driers was ranked as the most important strategy with the highest valid percent (55.6%). This indicates a strong need for practical skills and knowledge related to constructing and using solar dryers. Provision of ready market for sun-dried vegetables was ranked second, highlighting the importance of market linkages and demand for sun-dried vegetables. Public sensitization on vegetable solar sun-drying technology was ranked third, suggesting need for awareness campaigns and education to promote the benefit of solar drying. Subsidies on raw materials for solar sun-dryers was ranked last, indicating that financial support for materials is considered less critical than training and market access. The responses given are summarized in Table 3.3.

Table 4: Solar Sun-Drying Technology Adoption Strategies

Strategy	Valid Percent	Importance Rank
Public sensitization on vegetable solar sun-drying technology	13.7	3
Training in fabrication of enclosed solar driers	55.6	1
Subsidize raw materials for solar sun-driers	4.4	4
Provision of ready market for sun-dried vegetables	26.3	2
Total	100	

From Table 4, emphasis on training suggests that a lack of technical knowledge and skills is a major barrier to adopting solar drying technology. The highest ranking of market access indicates that farmers are more likely to adopt solar drying if they have a guaranteed market for their products. Public sensitization plays a vital role in creating awareness and promoting the benefits of solar drying, but it is considered less critical than training and market access (Njeru & Mwaura, 2021). The low ranking of subsidies suggests a preference for more sustainable and self-reliant approaches to technology adoption.

Conclusion And Recommendation

Conclusions

The results revealed that majority of the respondents were at least aware of vegetables solar sun-drying technology (73%) and farmer to farmer extension (59%) was the main source of information for the technology. The main reasons for sun-drying vegetables were due to surplus production (62%) and to increase availability during the dry seasons (30%). The result also showed that cowpeas (63%), black night shade (12%), spider plant and amaranth (7%) were the most preferred sun-dried vegetables.

The main challenges facing adoption of vegetable sun-drying technology were unfavourable weather conditions (54%) and disturbance from livestock (21%) as most of them lacked fabrication skills for enclosed solar driers.

Strategies suggested for commercialization of vegetable solar sun-drying technology were farmer training on enclosed solar dryers' fabrication skills (55.6%), provision of ready market for sun-dried vegetables (26.3%), public sensitization on vegetable solar sun-drying technology (13.7%) and subsidy on raw materials for solar sun-dyers (4.4%).

Recommendations

The findings indicated significant contribution of vegetable sun-drying technology on household income and nutrition though a number of challenges still impedes their effective adoption. Therefore, the study recommends the following:

- Capacity building on enclosed solar dryers' fabrication and commercialization by TVET institutions.

- Market-driven approach such as formation of farmer cooperative societies to guarantee market for sun-dried vegetables in the region.
- Information dissemination to create awareness and promote the benefits of vegetable sun-drying technology as a sustainable post-harvest handling technology.

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