Request to support Research on a Solar-Powered Walk-in Cold Room, designed & built by Ecolife Foods Uganda

Table 1: Supporting Agribusiness through local cold storage technologies.

Product/Innovation Name:	Eco Cold Room
Status:	Pilot stage. We have built Four **Solar-Powered Walk-in Cold Room** to curb food losses in Luwero, Wakiso and Kasese.
Limitation	There is need to test the effectiveness of this innovation in extending the shelf life of different fresh fruits and vegetables in different climatic zones. Thus, the purpose of this study is to evaluate the performance of this Solar Powered Walk-in Cold room prototype in maintaining the quality of fresh fruits and vegetables.
Significance	This will directly contribute to Zero Food Loss and Waste, which is Uganda's vision to achieving Sustainable Development Goal [SDG 2] (Zero Hunger) and as well as SDG 1 (No poverty).

A student research proposal "**Performance Evaluation of a Solar-Powered Walk-in Cold Room, designed by Ecolife Foods Uganda"** has been submitted to Makerere university with the approval of the following supervisors; Professor Archileo Kaaya and Dr. Robert Mugabi (PhD)

Study will be carried out by:

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The Proposal was accepted by the School of Food Technology, Nutrition and Bio-Engineering in Partial Fulfilment of the Requirements for the Award of the Degree of Master of Science in Applied Human Nutrition of Makerere University.

Abstract

Uganda is the second largest producer of fruits and vegetables in Sub Saharan Africa, with an estimated annual output of 5.3tonnes (Dijkxhoorn et al., 2019). According to Wakholi et al., (2015), the fruit and vegetable sector is one of East Africa's fastest-growing industries, having significant market potential in local, regional, and international markets. However, a major setback in the sector is the high level of post-harvest loss. The high rate of deterioration in the quality of horticultural produce is because the commodity group has a high-water activity and respiration rate (Elansari et al., 2019). However, cold storage has been an integral part of the agricultural value chains of developed countries since the 1950s (Kitinoja, 2013), a big section of the developing world does not have access to affordable refrigeration for precooling, storage and transport of perishable produce (Kitinoja, 2014).

Ecolife Foods Uganda has designed and built a potential solution to cold storage for fruits and vegetables in the form of a low cost and ecofriendly Solar Powered Walk-in Cold Room. However, the effectiveness of this facility in extending the shelf life of fresh fruits and vegetables has not been established. The purpose of this study is to evaluate the performance of this Solar Powered Walk-in Cold room prototype in maintaining the quality of fresh fruits and vegetables. The study will determine if the facility can indeed be an efficient low-cost solution for extending shelf life of fruits and vegetables, which will consequently result in reduced post-harvest losses and improved availability of fruits and vegetables hence enhanced food and nutrition security.

Introduction

Ecolife Foods Uganda, a Social Enterprise located in Wattuba, Wakiso district, Uganda designed and built a Solar-Powered Walk-in Cold Room for storing fresh fruits and vegetables. The Company seeks to provide a low cost and environmentally friendly cold storage solution which can extend shelf life of fruits and vegetables to reduce post-harvest losses, improve incomes and nutrition. Today, Ecolife has piloted four working cold storage facilities in off-grid rural areas of Uganda. The facility comprises a three-chambered room 19.6m long, 16.3m wide and 11.2m tall, with a double wall made from Interlocking Stabilized Soil Blocks (ISSBs) and the cavity between the walls is filled with rice husks. Furthermore, it has solar panels with 10Kw capacity; a power room with a converter that converts DC to AC; air conditioning (AC) unit which is the source of the cool air in the cold room; a precool room for receiving produce before putting it in the cold room; phase change material to provide cooling efficiency and a mini weather station which records the daily weather (temperature, rainfall, wind).

Cold storage is necessary to create a sustainable food system which is able to equitably supply safe and nutritious food to the growing population (Hodges et al., 2022). Recent projections indicate that an average of 768 million people in the world faced hunger in 2020, representing an increase of about 118 million people from 2019 (FAO/UNICEF/WHO, 2021). Of the 768 million undernourished people, more than one-third (282 million) live in Africa. Despite these many hungry people, an estimated 30% of food produced globally is lost or wasted annually (FAO, 2011); i.e. it does not reach the intended destination (consumers). For fruits and vegetables, studies commissioned by FAO report loss or waste of 40-50% globally (FAO, 2015). In Sub Saharan Africa, post-harvest losses in fruits and vegetables are estimated to range from 30 to 80% depending on the commodity (James & Zikankuba, 2017). It is no surprise that the UN Assembly declared 2021 as the International Year of Fruits and Vegetables to raise awareness about the nutritional and health benefits of fruits and vegetables, as well as draw attention to the need to reduce losses and waste in the commodity group (FAO, 2021).

Food Loss is often synonymous with Post-Harvest Loss (PHL) (Sheahan & Barrett, 2017) as both terms infer to the food which is produced for human consumption but ultimately not consumed (Flanagan et al., 2019). Elik et al., (2019) proposed that post-harvest loss can be reduced by adopting proper practices and tools during harvesting, storage, transportation, processing and packaging. During storage, Brasil & Siddiqui, (2018) pointed out that good temperature management is the most important method for delaying produce deterioration; the lower the storage temperature within optimum limits for the different commodities, the longer the storage. Furthermore, cold handling is recommended as an effective and cheaper alternative to improving food availability as opposed to continually increasing production to offset post-harvest loss (Kitinoja, 2013). FAO (2015) observed that solutions to reduce food loss usually require high consumption of energy especially during preservation. However, Kitinoja (2013) noted that small scale innovations like Zero Energy Cool Chamber (ZECC), Low Energy Cool Chamber, CoolBot™ equipped cold rooms and Walk-in Cold Rooms are efficient and can be appropriate for smallholder farmers and small and medium scale Enterprises (SMEs), hence the significance of the Ecolife Solar Powered Walk-in Cold Room.

Mode of operation of the Ecolife Solar Powered Walk-in Cold Room

The solar panels provide power to enable functioning of the AC unit installed in the third chamber of the cold room. Cool air from the AC maintains a low temperature in the ambience of the room, which enables extended storage of the fruits and vegetables. Each of the chambers have a different temperature to allow storage of different types of fruits and vegetables under their respective recommended storage temperatures. The cool air in the third chamber also cools the phase change material (PCM) in the *jerrycans* and maintain cooling at night or when the solar cannot generate sufficient power for running the AC. Insulation materials used for the wall and cavity wall cut off heat from the environment into the cold room.

Figure 1: Pineapples stored in Ecolife Solar powered cold store

Figure 2: State of Pineapples stored under tree shade after Five days.

Figure 3: State of pineapples sored in Ecolife Solar powered cold facility after three weeks.

Objectives of the study

Overall objective

The overall objective of the study is to assess the efficiency of the Solar Powered Walk-in Cold room as a storage facility that can extend the shelf life of fruits and vegetables.

Specific objectives

1 To determine the variation of temperature and relative humidity of each of the three chambers of the cold room during storage of fruits and vegetables.

2 To examine the progressive physical changes in the tomatoes, pineapples and chili during the storage period.

3 To examine progressive changes in physico-chemical attributes and Vitamin C content of tomatoes and chili during the period of storage.

4 To identify the spoilage microbes (moulds and bacteria) which develop on the tomatoes, pineapples and chili during the storage period.

Research Questions

1. What is the average temperature and relative humidity in each of the 3 chambers of the Solar Powered Walk-in Cold room during storage of tomatoes and chili?
2. What are the progressive changes in the physical parameters (colour, texture, firmness, weight) of the tomatoes and chili during storage in the Solar Powered Walk-in Cold room?
3. What are the changes in chemical composition of the tomatoes and chili in regard to PH, vitamin C content, moisture content, total soluble solids and titratable acidity during storage in the Solar Powered Walk-in Cold room?
4. Will spoilage muolds (*mucor*, *Rhizopus and others*) and bacteria (*erwinia carotovora*, *staphylococcus*, *E.Coli* and others) be detected in tomatoes and chili during the period of study?

Significance of the study

1. Increase household income through food loss reduction.

Rockefeller Foundation (2015) reported that smallholder famers and downstream value chain actors in Africa lose at least 15% of their income as a result of food loss. Furthermore, if food loss is not reduced, food production will need to increase by 70%, an investment which will require $83bn per year. Reducing food loss will reduce production investment, increase supply for the market and result in increased incomes.

2. Improve food and nutrition security and ending hidden hunger.

In the 21st Century, fruits and vegetables are recognized as a means to improving food and nutrition security (Yahia et al., 2019) and ending hidden hunger (James & Zikankuba, 2017). Yahia et al., (2019) highlighted that fruits and vegetables are a good source of carbohydrates, vitamins, minerals, bioactive compounds and maintain microbiome in the gut which significantly contributes to overall health. However, the high level of food loss of fruits and vegetables undermines efforts to end hunger because a significant quantity of the volume produced does not reach the consumer.

3. Reduce level of malnutrition due to micronutrient deficiency in Uganda

The level of malnutrition and specifically micronutrient deficiency in Uganda is still high as reported by the 2016 Uganda Demographic and Health survey (UBOS, 2016). The immediate causes of malnutrition are insufficient dietary intake and poor health. Insufficient dietary intake of micronutrients is attributed mainly to inadequate availability and access to micronutrient sources at household level (UNICEF, 2021).

Reducing post-harvest losses in fruits and vegetables can thus be a pathway for increased food availability, increased incomes and better nutrition without the need for additional production resources. Baysal & Ülkü, 2021 affirmed that efforts to minimize food loss of especially fruits and nuts should be scaled up because of their nutritional benefits and potential for processing/ value addition.

Conclusion

The Walk-in Cold Room designed and built by Ecolife Foods Uganda is an innovation designed to be a near farm facility with the potential to provide cold storage solution which will reduce post- harvest loss of perishable foods. The study is important because it will determine whether or not the facility is an efficient cold storage solution before it is fully utilized by farmers. If the facility is found to be efficient, it will scaled-out to smallholder farmers in East Africa where refrigeration is a challenge. This will directly contribute to Zero Food Loss and Waste, which is UN's vision to achieving Sustainable Development Goal [SDG 2] (Zero Hunger) and as well as SDG 1 (No poverty).

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