Low-cost, post-harvest preservation of fresh Ginger - *Zingiber officinale* rhizome during winter in Lusaka, Zambia

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ABSTRACT

In Zambia, fresh ginger is the ultimate home remedy to many common ailments such as common cold, sore throat and indigestion. The supply and availability of Ginger are greatly curtailed to the common man by lack of post-harvest and storage facilities coupled with high cost. Thus, the aim of the study was to identify a low-cost post-harvest technology to preserve ginger during the winter season of Lusaka, Zambia. The current study found that the clay-covered ginger can be stored up to 6 months at room temperature during the winter months from May to October in Lusaka, Zambia. Thus, the keeping quality of fresh ginger was extended the availability of fresh ginger rhizome in off-seasons for all walks of people.

Keywords: low-cost, Post-harvest technology, Ginger, Clay-covered Ginger

Introduction

Ginger *Zingiber officinale* has been used from ancient Greeks to modern times, to treat a wide range of diseases as well as in the production of a wide range of confectionery and cosmetics for common man's need. Every culture in this universe has a history of ginger with its use in traditional medicine. It is an essential culinary, aromatic spice in almost all the countries across the globe. Health benefits of Ginger is attributed due to its rich chemical constituents such as phenolic compounds, terpenes, polysaccharides, lipids, organic acids, and raw fibres. The pungency and aroma of ginger are due to its phenolic compounds, such as gingerols and shogaols[1]. Day to day usage of the ginger rhizome is on the raising side due to accumulated research evidences which proved its antioxidant, anti-inflammatory, antimicrobial, anticancer, neuroprotective, cardiovascular protective, respiratory protective, anti-obesity, antidiabetic, anti-nausea, and antiemetic activities of ginger. In Zambia, ginger is widely used in the preparation of traditional herbal drinks with lemon to provide resistance against cold and flu. The highest price in winter hinders its usage and harvest the health benefits. Due to continuous power shut down, it is difficult to preserve in cold storage. Though several researchers have addressed the post-harvest storage of Ginger, low cost zero energy and affordable technology is the need of the hour for Zambian farmers as well as the vendors.Thus, this study aims to find a low-cost preservation technology using local material for small, medium and street vendors leading to the availability of ginger to common man during off season.

Materials and Methods

Cross-sectional survey

A cross-sectional survey was done to collect the data by interviewing a representative sample at a single point in time i.e. from March to April 2019 addressing the research problem, and objectives. Vendors in 10 miles, Kamwala, Kulima tower, Gandhi Market, Tuesday market, and stadium market and city market were interviewed randomly to understand the availability, storage facility, and pricing of Ginger during winter in Lusaka, Zambia. Supermarkets such as Shoprite, pick and pay, and Spar were also observed for price fluctuations of Ginger during the study period.

Climate of the study area during the study period

Maximum temperature, Minimum temperature, Rainfall days and Humidity were recorded using the Android Mobile Climate data.

Sample collection: Ginger rhizomes were collected from the City market Lusaka on April 30, 2019. The rhizomes were stored in the Biology laboratory where the experiment was conducted.

Control

The clay-covered ginger rhizomes served as a control for this experiment.

Treatments

Part of the rhizomes were cleaned according to the treatment need of this experiment. Washed Ginger rhizomes were dried with paper towels to remove moisture. The rhizomes with cuts and bruises were rejected.

T1-Ginger rhizome covered with clay kept in the refrigerator

T2-Washed ginger stored in the refrigerator

T3- Washed Ginger Rhizome stored at room temperature

T4-Washed Ginger Rhizome Kept in polythene pouch and stored in the refrigerator

T5-Washed Ginger Rhizome Kept in polythene pouches and stored at room temperature

Quality parameters checked

A - Appearance (External quality)

B – Firmness &Texture (External quality)

C – Colour of the cut rhizome (Internal quality)

D - Aroma of the cut rhizome (Internal quality)

The quality index was set based on the comments provided by both sellers and consumers on the quality of fresh ginger rhizomes.

Quality Index

0-Unacceptable, 0.5 as acceptable and 1 Good

Evaluation of quality was carried out by physical observation for external quality, destructive for internal, and smelled for aroma. The rhizomes were evaluated on the 7th day of every week starting from May 1, 2019. The experiment was replicated three times and the average values for each treatment were recorded. Temperature and Relative humidity prevailed during the study time was recorded using mobile weather data.

Results

The cross-sectional survey indicated that 90 percentage of the vendors are women who relied on the day today sale of perishable agricultural products (Figure 1&2). They procure the commodities in small quantities and sell in the markets and along the street.


Figure 1&2 Ginger sold in 10 miles market in Lusaka-Zambia

Majority of the buyers were Indians and a part by Zambians. The survey indicated that there is a lack of post-harvest facilities for vendors along the streets in Lusaka, Zambia. It also specified that none of them sell ginger rhizome as a sole commodity and always goes with seasonal fruits and vegetables of Zambia. In Zambia Ginger is grown in the Copper-belt, Mpika-Luapula and in Solwezi. Quality after harvest is influenced by relative humidity and temperature conditions. Quality loss results from the factors that are both internal (physiological processes) and external (microbiological, chemical, environmental, and mechanical) to the harvested produce.

The climate data collected through android phone. During the study period, the mean low temperature of Lusaka ranged from 10.7^{0}C to 16.2^{0}C mean high temperature ranged from 25.8^{0}C to 31.7^{0}C (Figure 3) were observed. As there is no precipitation recorded from May to September, (Figure 4) the mean humidity began to reduce from 69.3% 46.3% (Figure 5).

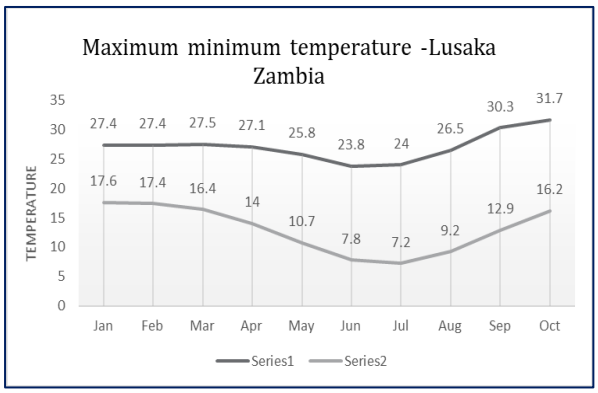

Figure 3 Maximum Minimum Temperature

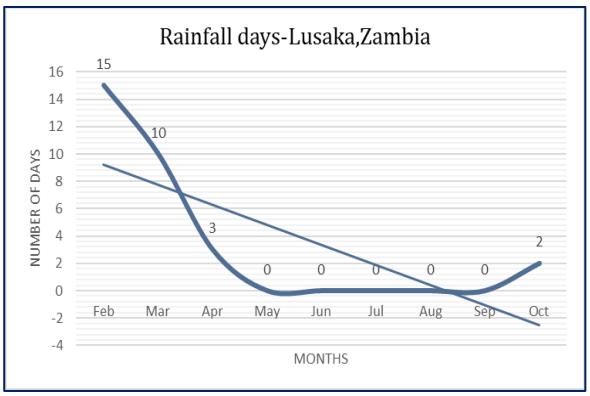

Figure 4 Rainfall days

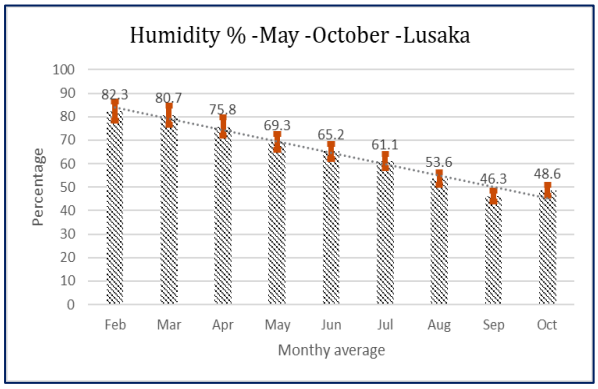

Figure 5 Humidity Percentage

Control

In the study it was observed that the clay-covered (Figure 6) rhizomes stored at the dry cold temperature, absence of rainfall and conducive humidity prevailed during the months of May to October maintained the external (Figure 7) and internal quality throughout the experiment period. 0.5 % of the rhizome begin to sprout (Figure 8) towards the end of October as the clay soil became dry and withered from the rhizome. The rhizomes were weighed every week and there was no significant weight loss noted during the study period.

Figure 6 Clay covered Ginger

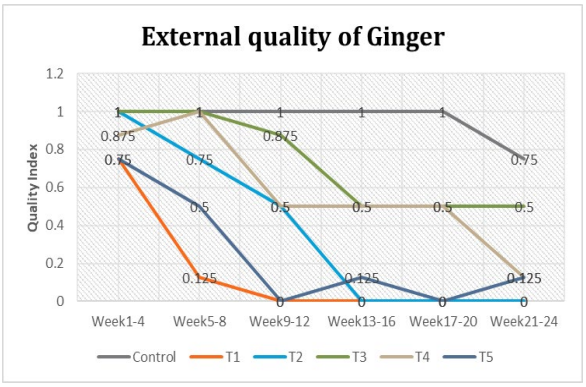

Figure 7 External Quality of Ginger

Figure 8 Sprouted Ginger

Figure 9 Bacterial Spoilage in Ginger

Figure 10 Fungal Spoilage in Ginger

T1. The clay-covered rhizome kept in the refrigerator was spoiled by bacteria (Figure 9) and fungus (Figure 10) in the second week of storage reducing the external as well as the internal quality.

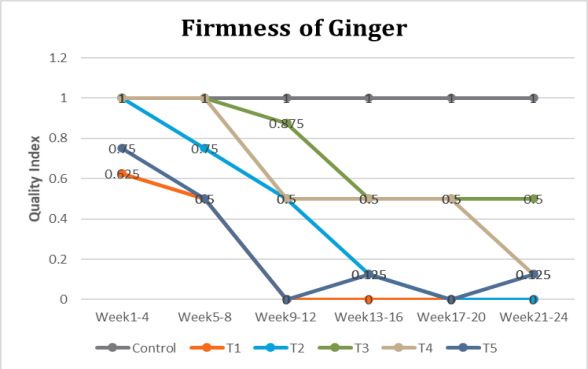

Figure 11 Firmness of Ginger

T2 Washed ginger stored in the refrigerator was fresh up to 6 weeks. 50% of the rhizomes begin to shrink and affected the firmness (Figure 11).

from 7th week onwards. There was a significant weight loss from the 6th week onwards. The aroma and internal quality begin to decline after 10 weeks and the water-soaked layer was observed under the skin which changed the aroma into unacceptable odour. (60% of the rhizomes).

T3 Washed ginger kept in room temperature were fresh up to 4 weeks and then the external quality started to degrade. The internal quality of 90% of the rhizome was observed to be good for up to 4 months. The ginger begins to lose moisture and turned into a hard structure. 10% of the rhizomes germinated and discarded.

T4 Washed dried ginger kept in plastic bags, and stored in the refrigerator were fresh up three 5 weeks. Both the external and internal quality of the rhizomes started to decline sharply from the 6th week onwards (Figure 12).

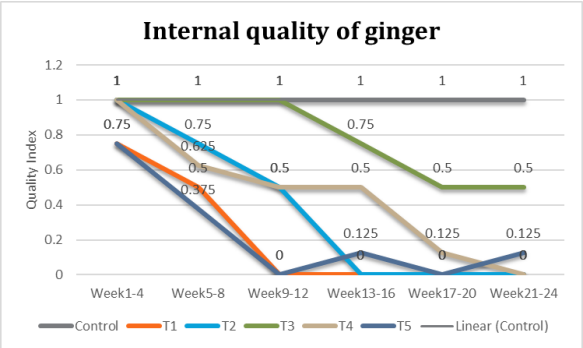

Figure 12 Internal quality of Ginger

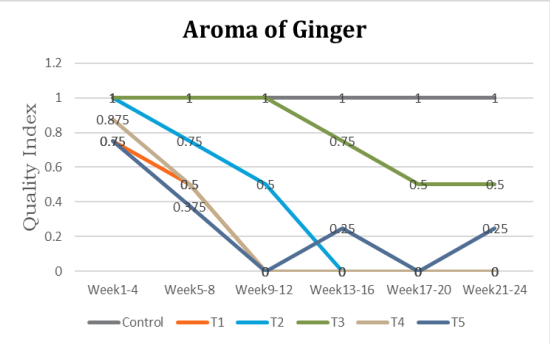

Figure 13 Aroma of Ginger

T5 Washed ginger kept in polythene pouches and stored in room temperature were fresh up to 2 weeks. Fungus growth was observed and the rhizomes begin to deteriorate both external and internal qualities. In most cases, the fungus growth was observed in minute cuts and bruises in the rhizomes which reduced the aroma of the ginger (Figure 13).

Compared to the control, the washed ginger rhizomes which were stored in the room temperature kept the internal and the external qualities up to a maximum of four weeks compared to the other treatment which failed to keep the same.

Discussions

Ginger, the rhizome of the *Zingiber officinale*, has shown a therapeutic role in health management since ancient times and considered as a potential chemo preventive agent. Numerous studies based on clinical trials and animal model has shown that ginger and its constituents show a significant role in the prevention of diseases. Research analysis has shown that ginger rhizome possesses antimicrobial activity [2], [3, 4], antidiabetic activity [5], anti-tumour activity [6], [7], [8], [9], Neuroprotective activity [10] osteoarthritis [11] gastroprotective effect [12],[13], anti-emetic activity [14], [15] [16] hepatoprotective effect [17]. Therefore, ginger is a spice of commercial and medicinal importance with high demand on the raising side. Maintaining quality after harvest necessitates proper handling to avoid mechanical and physical injury and the avoidance of chemical and microbiological contamination. Produce must also be stored under optimal conditions of temperature and relative humidity (FAO 2013). Since fresh ginger is preferred for culinary and medicinal use, the current research focus was on the storage of fresh finger rhizome. Nath et al (2013) found that the fresh ginger suffers from weight loss, shrinkage, sprouting, and rotting during storage after 3 to 4 weeks of harvesting and these spoilages can be overcome by processing fresh produce to some value-added products. Similar results were obtained for the washed rhizomes in the T4 of the current study. This study also found that the fresh Ginger rhizomes covered with clay stored well up to 6 months and beyond.

Storage of seed ginger greatly differs with the storage of fresh ginger as the former necessitates the use of fungicides and pesticides. The current study found that the fresh clay covered ginger stored at room temperature prevailed during May to October 2019 in Lusaka showed similar results with that of the seed ginger stored in pits with its wall coated with cow dung at a temperature of 12 to 14° C and relative humidity of 65 to 75 percent (FAO,2013). The above-mentioned conditions suited the storage of both seed and fresh ginger rhizome for 5-6 months without damage and deterioration in quality.

Paul and Chen (2017) found that mature ginger rhizomes can be stored at 12 to 14 °C (54 to 57 °F) with 85 to 90% RH for 60 to 90 days. After 90 days the rhizomes showed extensive dehydration and wilted appearance. Current study found that under similar temperature prevailed in Lusaka, the clay covered ginger rhizomes stored well at 69.3% RH.

The survey found that the fresh ginger rhizomes are preferred over the ginger paste, ginger powder, dried ginger, or ginger garlic paste. Mishra et.al (2004) found that a dosage 5-kGy Gamma irradiation extends the shelf life of farm-fresh peeled ginger at 10 °C storage temperature until 70 days whereas the non-irradiated (control) peeled ginger spoiled within 40 d under similar storage conditions [18]. This treatment might suit supermarkets or cold storage markets and not affordable for small vendors in Lusaka, Zambia.

Research limitations: As the ginger rhizomes were covered with clayey soil and it was difficult to select the rhizomes without cuts and bruises. Power breakdown for long hours continuously, sometimes for two to three days during heavy rains also interrupted the experiments.

Conclusion

The low-cost method to preserve fresh ginger rhizome will be a suitable method for the vendors of Lusaka, Zambia as well as the rest of Zambia and Africa where similar climatic conditions prevail. Further investigation on the stability of chemical constituents of the clay covered fresh ginger rhizome will be evident.

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