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Performance Evaluation of Fresh Ginger (*Zingiber officinale*) for Storage under Selected Methods

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ABSTRACT

This study was conducted to improve and maintain the quality of fresh ginger rhizome as planting material during storage for commercial use. Fresh ginger stored in clay houses under shade becomes over dried, rotten and over sprouted resulting unsuitable to use as planting materials. Seven treatments were used to store ginger rhizomes i.e. paddy husk, coir dust, with pesticide treatment (rhizomes dipped in pesticide), white polythene bag, coir with pesticide treatment, ginger stored in sand and control. Each treatment was tested with two levels of temperature; normal temperature (atmospheric) and low temperature (25 °C) in the laboratory. A field trial was conducted with selected treatments to store ginger in a zero energy cool chamber (ZECC). The weight loss of ginger, appearance and number of sprouts were recorded throughout the experiment for each test. Temperature levels were not significantly correlated with weight loss of rhizomes. However, the highest sprouting was recorded under low temperature. There was a treatment effect on ginger weight loss. The successful method to store ginger was in sand followed by white polythene bag. Treatments of paddy husk, white polythene and sand showed intermediate shrinking or drying. Only the ginger treated with sand showed no rot or decay. The cool and moisten condition at ZECC resulted in a least moisture removal and high sprouting in rhizomes than in a normal environmental conditions.

KEYWORDS: Ginger sprouting, Ginger storage, Rhizome weight loss, Zero energy cool chamber

INTRODUCTION

Ginger (*Zingiber officinale*), is a tropical herbaceous spice crop which belongs to family Zingiberaceae, and grown as an annual indigenous plant in tropical India, South East Asia, Australia and Japan (Purseglove, 1972). The highest extent of cultivation in Sri Lanka is recorded in the Kandy district, 379 ha, in year 2009 (DOA, 2009). Major ginger growing areas are Kurunagala, Kandy, Gampha, Colombo and Kegalle (Department of Census and Statistics, 2016). According to the Sri Lanka customs, 594 Mt of ginger valued Rs. 71 million has been imported to the country in 2009.

People's Organization for Development Import and Export (PODIE) is a limited liability company based in Negombo. Sri Lanka which is engaged in export of value added organic spice through fair trade channel based in European and Scandinavian countries, Australia, Hong Kong and New Zealand. Raw spices are purchased from the registered local farmer field those adopted organic farming system.

Recently, the company encountered a problem in supplying the seed ginger rhizomes for the farmers' cultivation requirement (Anon, 2016a). Fresh ginger of previous harvest were unable to store several months to be used in the cultivation season. Prevailing method of storing ginger is stacking over a clay floor under a shade house. Problems such as decaying, rotting, over drying, over sprouting, low viability and high pest attacks, making the seed ginger unsuitable to be used as good planting materials (Anon, 2016b).

Several conventional methods are widely used by the farmer to store rhizomes. Among them sand, saw dust, paddy husk, *in situ* storage are practiced at farm levels. Considering the availability of local materials an improved storage-structure was developed by ICAR Research Complex, Meghalaya (ICAR, 2015). The improved pit storage method provides cool conditions, ensuring freshness for prolonged storage. For better germination, the seed rhizomes are required to be stored properly in pits under shade (Sasikumar *et al.*, 2008). Fresh ginger should be stored in a cold and humid environment. Fresh ginger rhizome shelf life may be extended by storage at 10-12 °C and high humidity. In a study on Hawaiian ginger, quality was stable during 28 weeks when stored at 12.5 °C and 90% relative humidity. Irradiation at 0.05-0.06 kGy may be used to inhibit sprouting and extend shelf life of fresh ginger (FAO, 2002). Those are not affordable in a developing country. Therefore, low cost methods are demanded to store ginger rhizomes commercially in Sri Lanka.

However, cold storage may not always be available in the producing areas. A zero energy cool chamber (ZECC) was experimentally designed at the Indian Institute of spices

research to store fresh ginger maintaining the temperature 10 °C below the outside temperature at 90% relative humidity (FAO, 2002). Zero energy cool chambers are easy to build by locally available materials, such as brick, sand, bamboo, straw and gunny bags (IIRR, 1996).

Therefore, the objective of this study was to improve and maintain the quality of fresh ginger rhizomes under different storing methods using paddy husk, coir dust, sand, polythene, pesticide treatment and ZECC.

MATERIALS AND METHODS

Location

This research was conducted at the Department of Horticulture and Landscape Gardening, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila, in collaboration with People's Organization for Development Import and Export (PODIE), Negombo from January to May 2016. Field trials were conducted at the PODIE factory site located in Kadirana, Negombo.

Experimental Materials

All the materials required for the experiment including ginger rhizomes and other hard materials were provided by PODIE.

Test in Laboratory

Seven methods were tested for ginger storage (Table 1). The treatment effect was tested under two temperature levels (normal and low). Ginger rhizomes were covered with paddy husk, coir dust, polythene and rhizomes were dipped in Temaron (normal pesticide used to treat rhizomes by PODIE).

Table 1. Tested methods for storing ginger

Treatment	Store method
T_1	Paddy husk
T_2	Dried coir dust
T_3	Pesticide liquid treatment (Rhizomes dipped in Termaron "Metarhizium anisopliae) for few minutes and allowed to drain
T_4	White polythene bag (made holes in the polythene bag for aeration)
T_5	Coir treated with pesticide (Termaron "Metarhizium anisopliae)
T_6	Sand (Sand was sun dried and sieved)
T_7	Control (Rhizomes bare opened)

Test in Zero Energy Cool Chamber (ZECC)

The ZECC was constructed in Kadirana, Negombo. An open land (no buildings or trees in the 10 m vicinity), with direct sunlight, good blowing and without water logging that closer to a source of water was selected. A thatched roof shed was implemented using dried woven coconut leaves to shield the chamber from direct sun and rain. A layer of bricks was placed on ground as the basement. Two single bricked walls were erected with a 7.5 cm gap apart enclosing a 3½ ', 1×3×1 m (H×L×W) cubic area.

The gap was filled with moistened sand and walls of the chamber were soaked in water from dripper. The chamber walls were wetted with a dripper every day. The chamber was covered with a plastic poly sheet followed by a cover frame made by bamboo and coconut leaves. Three chambers were prepared in the same manner.

Experimental Design and Statistical Analysis

In the *in vitro* test 500 g of ginger rhizomes in plastic trays were used as a sample test unit. While in ZECC 15-20 kg of ginger in plastic crates were used as a sample test unit. The tested sample units were randomly treated with selected treatments in (Table 1). The experiment was arranged in Completely Randomized Design (CRD) with three replicates.

Data Collection

Treated ginger samples were weighted weekly and calculated water loss percentage in every week for each treatment. The number of sprouts were also recorded through-out the experiment. The average wet and dry temperatures in the storage environments were recorded by a wet and dry bulb thermometer.

Data Analysis

The data obtain from the study was statistically analyzed using the General Linear model (GLM) procedure of Statistical Analysis System (SAS) version 9.2.

RESULTS AND DISCUSSION

Test in laboratory

The results revealed that there was a significant treatment effect on fresh weight loss of the rhizomes ($P<0.000$). According to the analysis the temperature conditions had no significant effect over weight loss of fresh ginger (Table 2).

Considering the treatment effect in Table 3 ginger stored in white polythene bag (T_4) gave the lowest weight loss percentage (25.47%) that is significantly different from control (T_7). The second and third lowest weight loss was recorded respectively in methods of sand (T_6) and paddy husk (T_2). However, effects of T_1 and T_6 are not significant from control (T_7) (Table 3). Covering ginger with coir (T_2), either treated with pesticide (T_3) and coir (T_5) recorded

significantly higher weight loss than the control (T_7).

Table 2. Analysis of variance table for temperature and treatment

Source	DF	Mean Square	F value	Pr>F
Temp	1	1.13	0.03	0.8573
Trt	6	1477.07	42.88	<.0001

Significance at 0.05 level. Temp- temperature, Trt-Treatment, DF- Degrees of freedom

Table 3. Mean ginger weight loss percentage in different media

Storage method	Mean weight loss %
T_1	30.87^{dce}
T_2	45.62^{b}
T_3	34.60^{c}
T_4	25.47^{e}
T_5	70.24^{a}
T_6	26.57^{de}
T_7	32.53^{dc}

Note: Values with same superscript letters are not significantly different at 0.05 level. T_1- Paddy husk, T_2- Coir dust, T_3- Pesticide dip, T_4- White polythene, T_5- Pesticide+Coir, T_6- Sand, T_7- Control

Lowest weight loss in white polythene bag could be due to the moisture barrier created by the polythene surrounding the ginger rhizomes.

Sprouts Number and Appearance of Ginger

During the laboratory experiment the temperature levels and treatments had shown significant effect on sprouting of ginger (Table 4). Number of sprouts in each treated methods under both normal (NT) and low temperature (LT) are depicted in Figure 1.

Significantly higher number of sprouting was obtained in low temperature condition when compared to the normal temperature. Out of treated media the first best 68 sprouts were in coir dust (T_2) under LT while it was 39 in NT. Second best was sand (T_6) with 56 sprouts in LT conditionwhile in NT, it was 54 sprouts (Figure 1).

When compared to number of sprouts, viability is higher in low temperature. This fact was also proven by Sasikumar *et al.*, (2008) in their experiment in storing rhizomes for germination in cool pits. The sucker production increased with in sprout number per seed sett (Kandiannan *et al.*, 2008).

Table 4. Analysis of variance table for sprouting

Source	DF	Chi - square	Pr>chisq
Temp	1	37.95	<.0001
Trt	6	82.44	<.0001
Temp * Trt	6	28.32	<.0001

Trt- Treatmentmt, Temp- Temperature, DF- Degrees of freedom

The results of Table 5 and Figure 1 suggest that when high shrinking of ginger seed, the number of sprouts per seed increased considerably. For an instance ginger treated with coir (T_2) had recoded high shrinking as well as highest sprouting. On other hand ginger treated with pesticide and coir (T_5) gave less sprouts both in LT and NT (Figure 1), but no any shrink appearances. That could be due to the rotting and decaying of the rhizomes (Table 5).

Table 5. Appearance rating for ginger over treatments

Treatment	Shrinking	Rot and decay
T_1	Intermediate	Less
T_2	High	No
T_3	No	No
T_4	Intermediate	Less
T_5	No	Yes
T_6	Intermediate	No
T_7	High	No

T_1- Paddy husk, T_2- Coir dust, T_3- Pesticide dip, T_4- White polythene, T_5- Pesticide+Coir, T_6- Sand, T_7- Control

According to the results in Table 5 the normal practices of PODIE treating ginger by pesticide (T_3) had no rotting or decaying however, when ginger was covered with coir treated with pesticide (T_5), rotting and decay had been recorded.

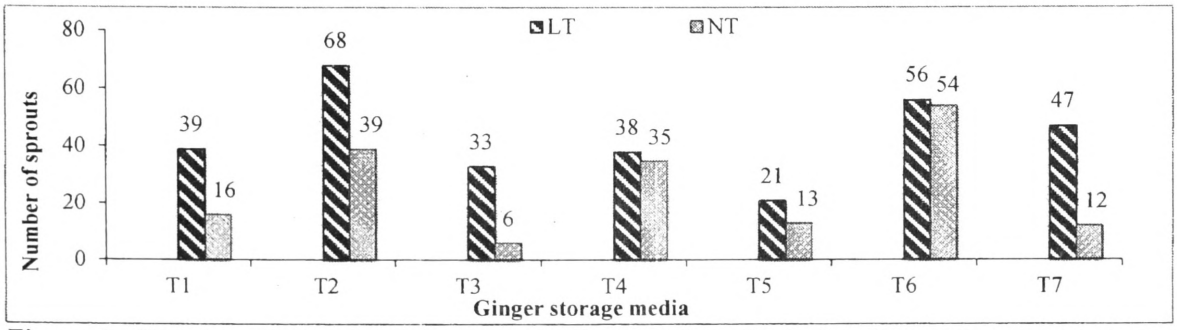

Figure 1. Number of ginger seed sprouts in the tested methods (*in vitro*). *LT- Low temperature, NT-Normal temperature, T_1- Paddy husk, T_2- Coir dust, T_3- Pesticide dip, T_4- White polythene, T_5- Pesticide+Coir, T_6- Sand, T_7- Control*

Treatments of Paddy husk (T_1), White polythene (T_4) and Sand (T_6) showed intermediate shrinking or drying but ginger treated by sand (T_6) did not show any rotting or decaying.

Test in ZECC

Weight loss percentage of fresh ginger was significant in main treatment factors T_6, T_4 and T_7 except T_2 and T_4 (Table 6). The lowest ginger seed weight loss (0.56%) was recorded in ginger in sand (T_6) while the control (T_7) recorded the highest significant weight loss (13.25%) (Table 6). Paddy husk (T_1) and white polythene (T_4) recorded second and third lowest respectively.

Comparing weight loss percentage in both laboratory and ZECC (Table 3 and Table 6) a significantly low weight loss percentage for all treatments were recorded in ZECC. The cool chamber maintained about 85-90% relative humidity (Susanta and Emeritus, 2007). During the experiment ZECC recorded 93% average relative humidity which was optimum for storage. Waelti (1991) reported in the research that humidity management is important in modern fruit storage along with temperature and storage atmosphere.

Table 6. Mean ginger weight loss percentage in selected media under ZECC

Storage method	Mean weight loss percentage
T_1	0.80 ^{c}
T_2	4.18 ^{b}
T_4	2.99 ^{b}
T_6	0.56 ^{c}
T_7	13.25 ^{a}

Values with same superscript letters are not significantly different at 0.05 level. T_1- Paddy husk, T_2- Coir dust, T_4- White polythene, T_6- Sand, T_7- Control

CONCLUSIONS

According to the results of the study, in normal temperature with low relative humidity ginger stored in white polythene bags have minimum moisture loss and high number of sprouts. Covering with sand and paddy husks are the next best alternatives after white polythene bags. In a cool high relatively humid environment (ZECC) ginger rhizomes stored in sand have lowest moisture loss and high number of sprouts.

Research should be extended to determine methods to control the storage pests such as shoot borer damage in commercial level.

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