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Storage of Mungbean in Hermetic PVC Tank

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Abstract

This research was carried out to evaluate the effect of hermetic storage on quality of mungbean. About 260 kg of mungbean samples were stored in an especially design 350 L capacity hermetic PVC tanks (hermetic tank) and non-hermetic PVC tanks (control tank). Hermetic PVC tanks were closed air-tightly. All tanks were randomly placed in a warehouse. Each hermetic and control PVC tanks were artificially infested by 50 unsexed *Callosobruchus chinensis* kept in 4 glass jars containing 100 g of mungbean and jars were dipped in four different depths. The gas concentrations in the tanks were monitored up to 6 months intervals. Percentages of germination, moisture content, and grain damage were evaluated at the end of the storage. The oxygen content of hermetic samples was dropped to 11±1.2% and carbon dioxide content was increased up to 7±0.7% within 6 months of storage. Live insects of *C. chinensis* were not found in hermetic samples after 6 months but abundant population of *C. chinensis* was found in the control PVC tank just after one month. After 6 months, germination percentage of the mungbean samples stored in hermetic tanks had decreased from 95±3% to 82±4%, whereas it was decreased from 95±3% to 47±7% in control tanks due to grain damage. Percent grain damage of the hermetic sample was only 4.5±1% compared to the heavy insect damage of the control samples. Moisture content of hermetic samples remained unchanged compare to the control.

Keywords: Hermetic storgae, PVC tank, Mungbean, *Callosobruchus chinensis*

Introduction

Nearly 30-40% of cereals and grain legumes harvested in Sri Lanka are stored by farmers for consumption, seeds and future sale for a period of three to nine months (Adhikarinayake, 2006). Mungbean, cowpea, black gram, and soybean are major legume grain grown in Sri Lanka. These grains are mainly stored in polybags causing insignificant postharvest loss about 15% within 3-4 months (Sartaj and Ekanayake, 1991), but grain damage can be high as 68% after 4 months of stored in polysack bags (Prasantha et al., 2014a). Mungbean (*Vigna radiate* (L.) is cultivated around 9760 ha mainly by dry-zone farmers in Sri Lanka are yielding around 14000 MT per annum. Legumes are an inexpensive source of dietary protein supplement for more than 67% of Sri Lankans that consume them as an alternative to animal protein. However, local production is insufficient for local consumption and more or less 7000 MT is imported to Sri Lanka every year. Munbean and cowpea are highly susceptible to bruchids damage from pests such as *Callosobruchus chinensis* (L.) and *Callosobruchus maculates* (Fabricus) which are commonly known as southern cowpea weevil and cowpea weevil respectively. *C. chinensis* is the most common bruchid species that infests stored grain legumes in Sri Lanka. Mostly under poor storage conditions, *C. chinensis* attacks on stored grain legumes cause substantial losses to both quality and quantity. Although the infestation of grain legumes by bruchids begins in the field before seed maturation (Huignard et al., 1985), they reproduce rapidly in poor storage condition. New generation of weevil immerges in every 28 days (Prasantha et al., 2002) and may cause losses up to 12-15% in 2 months of storage. If infestation of weevil is not controlled, complete grain damage (100%) of mungbean could occur within 6 months where mungbean stored in common storage (in polybag) condition (Prasantha et al., 2014a). As a result, farmers try to sell their grains at low prices or apply hazardous insecticides to protect their stored grains soon after harvesting. Phosphine fumigation is not recommended at the farm level due to risk and safety issues in the application. Quality deterioration of mungbean is unavoidable under common storage in polybag. Hard-to-cook (HTC) defect is well-known quality deteriorating problem of mungbean which is related to the increase time of cooking due to poor storage (Prasantha et al., 2014a). The other problem is the loss of stored grain viability or percentage of seed germination due to insect infestation and development of HTC characteristics. Therefore, an effective storage method is necessary to prevent the insect infestation and avoid the development of HTC.

Hermetic storage is an airtight grain storage technique for controlling stored-product pests and avoid the development of HTC (Sanon, et al., 2011; Prasantha et al., 2014a). The respiration of insects, microorganisms and grains hinder the growth of insects as a result of creating high carbon dioxide (CO_2) and low oxygen (O_2) in the storage environment (Murdock, 2012). This indicates the importance of hermetic storage where early infestation can be avoided without substantial damage to the stored grains. According to previous studies hermetic storage of grain legumes in PET bottles containers and plastic bags can successfully control the damage of legume grains by bruchids (Murdock, 2012; Guenha et al., 2014; Prasantha et al., 2014b) more than 6 months. Although it is a relatively simple method of storage of mungbean, farmers are reluctant to adopt the method due to lack of appropriate plastic bags and handling problems of the bags. However, the farmers are preferring to use type of larger storage tanks where they can store larger quantities of grain with minimum space and low cost of larger numbers of bag handling.

The other major problem is the lack of information on final quality of stored mungbean such as germination and cooking quality. Therefore, it is important to study the applicability and effectiveness of hermetic storage on preservation of mungbean. This research was carried out to evaluate the suitability of bin type PVC hermetic tank for storage of mungbean to minimize postharvest losses and thereby to improve the seed germination and minimizing the HTC characteristics of mungbean.

Materials and Methods

The research was carried out at the "Palvehre" seed farm, Department of Agriculture, Sri Lanka. Mungbean samples (*Vigna radiate* (L.) Wilczek) were obtained directly from the field 2-3 weeks after harvesting and sun dried to moisture content about 12±1% (w.b) before storage. Approximately 260 kg of mungbean sample stored in an especially design 350 L capacity hermetic PVC tank (hermetic tank) and non-hermetic PVC tanks (control tank). Hermetic tank was air-tightly closed using thread seal with airtight PVC lid and covered by high vacuum silicon grease. Control tank was closed without hermetic sealing by PVC lid (Fig. 1). The control tank was also allowed to infest naturally similar to the common aerated storage.

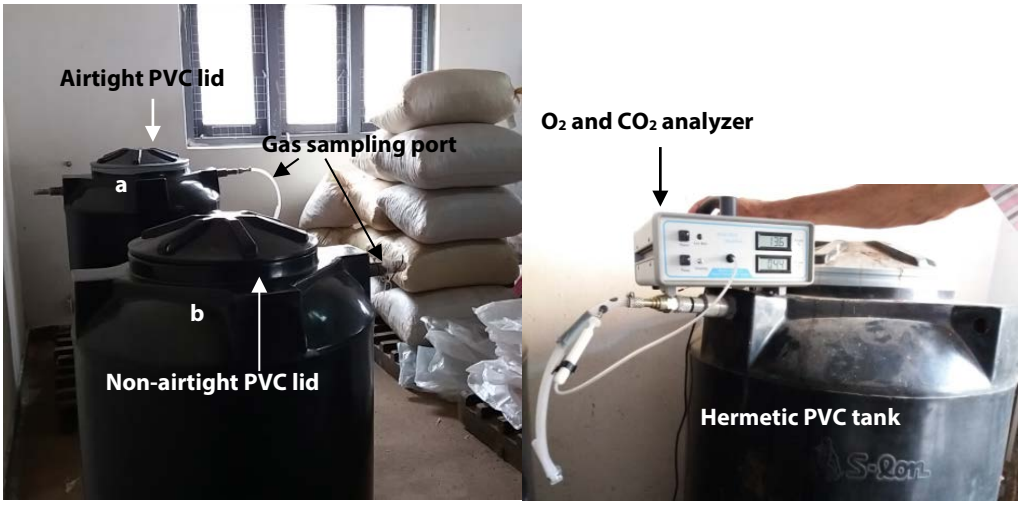

Fig 1. Storage of mungbean in PVC tanks (a) hermetic tank (b) control tank and (c) method of measuring of internal gas content

Biological tests

Prior to the experiment, 5 kg of mungbean sample was stored in a freezer (-18 °C) for about 2 weeks to destroy any hidden infestations of insects. Adults of *C. chinensis* were obtained from the same store and cultured on mungbean at the Department of Agricultural Biology, Faculty of Agriculture, University of Peradeniya, Sri Lanka, for 3 months. About 500 g of mungbean samples was obtained and stored in a 750 ml glass jar. The sample was artificially infested with 50 unsexed freshly emerged (1-3 days) adults of *C. chinensis* and the jar was covered with fine wire mesh. The samples were kept one week at ambient condition (26±1 °C and r.h. 78±3%) for egg laying and then weevils were removed from the samples through sieving. During grain loading, 3 artificially infested jars were buried inside each PVC tank at 3 different depths (i.e. bottom, middle and top) of each PVC tank. Number of adults emerged from the samples were determined by sifting three sample jars after 196 days of storage in hermetic and control tanks.

Hermetic storage

A rubber septum was glued onto the gas sampling rubber tube (10 mm internal diameter) as gas sampling port immerging from the centre of the PVC tank (Fig 1). Gas sampling port of the PVC tank pierced with a needle connected to the gas analyser (Quantek modle-902D, USA) to determine the percentage of O_2 and CO_2 contents. The initial O_2 and CO_2 content (atmospheric) were adjusted as 20.7% and 0.2% respectively. All experiments were conducted for 196 days in grain storage warehouse conditions. The temperature and relative humidity (r.h.) in these storages were 28±2 °C and 73±5%, respectively. Gas samples were measured almost at every 30-40 days intervals over the

period of 196 days. About 3-4 gas samples were withdrawn from each PVC tank in every test. This study was repeated 3 consecutive times during 2015-2017 at the same period (November-May) of each year. Altogether six PVC tanks were used in equal numbers for the control and hermetic study.

Storage grain quality

The m.c, of the initial, control and hermetic samples was determined (% w.b) by forced-air oven drying at 105 °C for 24 h. Grain germination of the initial, control and hermetic mungbean samples was tested after 196 days (ISTA, 2006). Samples of 100 mungbeans from each storage method were germinated on wet paper towels. Percent germination was calculated as the number of grains showing plumule and radicle emergence after 24 h of incubation at room temperature of 28±2°C. The HTC characteristics was evaluated using minimum cooking time (Singh et al., 1991). Two grams of mungbean samples were taken into a boiling tube and cooked by adding 20 ml of distilled water in a boiling water bath. The cooking time was determined by removing few grains at different time intervals during the cooking. The gains were pressed in between two glass slides until uncooked core was disappeared. This experiment was repeated for 4 times.

Storage losses

Percent grain damage was estimated using 50 g samples (Boxall, 2002) at the end of storage method using the following equation. Altogether 30 replicates were used to estimate the storage loss of this study.

$$Grain\ damage\ \% = \frac{N_d}{N_d + N_u} \times 100$$

Where;
Nd = Number of damaged grains in the sample
Nu = Number of undamaged grains in the sample

Statistical analysis

Data were analyzed by one-way analysis of variance (ANOVA) using SAS (1990) statistical package using PROC GLM procedure. Duncan's multiple range tests was used to separate means when ANOVA showed significance at $P < 0.05$. Other descriptive statistics and graphical methods were used to present the data with time and storage when appropriate.

Results and Discussion

Biological tests

After one month of storage, the large number of insects emerged from the control tank were identified as *C. chinensis*. It is important to note that there was no other species of bruchids were found in the samples. Artificially infested mungbean samples stored in the control tank were found with high number of insect emergence holes and an abundant number of *C. chinensis* progeny. However, 0.5±0.25% grain damaged was observed in the initial samples obtained from the field (Table 1). This indicates that mungbean samples obtained directly from the field had already been infested by *C. chinensis*. Generally, mungbeans are highly susceptible to damage by bruchids. According to Mutungi et al. (2014) ineffective methods of storage cause a substantial loss in quality and quantity of grains.

Storage losses

Grain damage had increased up to 98.5±1.5% in the control samples after 196 days of storage. It was remained significantly low at 4.5±1% ($P<0.05$) in the hermetic samples, which was a 96% reduction of grain damage compared to that in the control samples. Mortality of *C. chinensis* was

recorded at 100% in mungbean sample stored in hermetic conditions for 196 days. The number of progeny emergence of weevils was significantly lower (11±3.0) in the artificially infested samples stored in a hermetic tank. Prasantha et al. (2014b) noted more or less similar results of hermetic storage of mungbean.

Storage grain quality

Initial moisture content of mungbean was 12.2±0.1% (w.b.). Control samples showed comparatively higher moisture content than hermetic samples but no significant difference (P>0.05) was noted in the moisture content between hermetic and control mungbean samples. Comparatively high moisture content detected in the control samples may be related to the accumulation of metabolic moisture (both weevils and grains) and the absorption of atmospheric moisture.

Germination of the initial mungbean sample was 95±3% and it was significantly reduced ($P < 0.05$) to 46.8±7% in the control samples compared to the 82±3.8% germination remained in the hermetic samples after 196 days (Table 1). However, there was a 14% reduction of germination observed in mungbean stored in the hermetic tank compared to initial samples. Adikarinayake et al. (2006) reported that paddy stored in a hermetically sealed bin has completely lost its germination percentage after six months. Similar to this study, Prasantha et al. (2014a) also showed that germination of mungbean stored in the hermetic condition decreased slightly compared to initial sample after 6-12 months. Hamel, (1989) reported that high CO_2 storage can reduce the seeds viabilities of wheat, rape seed, soybean, and onion. The possible reason for this reduction might be the lowering of physiological and biochemical activities in mungbean due to development of HTC characteristics with ageing.

Table 1. Number of adults emerged, moisture content, percent germination, percent grain damage and minimum cooking time of initial, control and hermetically stored mungbean samples in PVC tank under ambient conditions.

		PVC tanks	
Test parameters	**Initial**	**Control**	**Hermetic**
Number of progeny	0	TNC[†]	11±3.0
Moisture (w.b %)	12.2±1.0[a*]	13.4±1.2[a]	12.7±0.7[a]
Germination (%)	95±3.0[c]	46.8±7.0[a]	82±3.8[b]
Grain damage (%)	0.5±0.25	98.5±1.5[b]	4.5±1.0[a]
Cooking time (min.)	25±1.2[a]	33±2.0[b]	26±1.0[a]

All data represent the mean ± SD of three-five replicates

*Values followed by the different small letters in each raw significantly different at $P < 0.05$

[†]TNC = Too numerous to count

Cooking time of hermetically stored mungbean samples did not show any significant change ($P > 0.05$) compared to the initial samples (Table 1). Cooking time of control samples significantly increased ($P < 0.05$) from 25±1.2 min to 33±2.0 min which was about 35% increase compared to the initial cooking time. Gradual development of high cooking time with storage is indication of grain hardness development and it is commonly known as HTC characteristics. Kon and Sanslulck (1981) reported that cooking time of common beans increased by about 5-fold when bean sample was stored at high r.h. and high temperature conditions. In contrast to finding of this study, Nasar-Abbas et al. (2008) reported HTC characteristics of faba bean increased significantly when beans stored in airtight bags. However, this study has revealed that hermetic storage can successfully delay the development of HTC in mungbean at least by 6 months.

Hermetic storage

A significant reduction of ($P < 0.05$) of O_2 and increase of CO_2 was observed in the hermetically stored mungbean samples in PVC tanks (Fig 2). Initially, the O_2 and CO_2 contents approximately dropped below 11% and increased more than 6% respectively, within the first 38 days after storage in

hermetic tank. Throughout the storage period, the O_2 content dropped to an average of 11.2±1.2% % and CO_2 increased to 6.8±0.7% in the hermetic PVC tank. There were no weevils found in the hermetic samples at the end of the storage period. The drop of atmospheric O_2 content in the hermetic PVC tank was approximately 48% compared to control tank sample, and there was no change in the gas composition detected in the control PVC tank. Similar results were observed by Murdock et al. (2012) and our previous studies of hermetic storage (Prasantha et al. 2014a and 2014b). Although the respiration of mungbean is low, but high metabolic activity of weevils and their developing immature stage (larval/ pupal) inside the mungbean were the reasons for lowering the O_2 and raising the CO_2 contents of inter-granular atmosphere of hermetic stored grains (Murdock et al., 2012; Navarro, 2012). The death of weevils may have occurred due to the low O_2 content and reduction of O_2 partial pressure within the inter-granular space during the storage period (Mbata et al., 2005). According to the data, successful developments of hermetic condition in the PVC tank without changing the gas composition during 196 days indicate that the suitability and sustainability of the hermetic PVC tank as a storage method for direct field application.

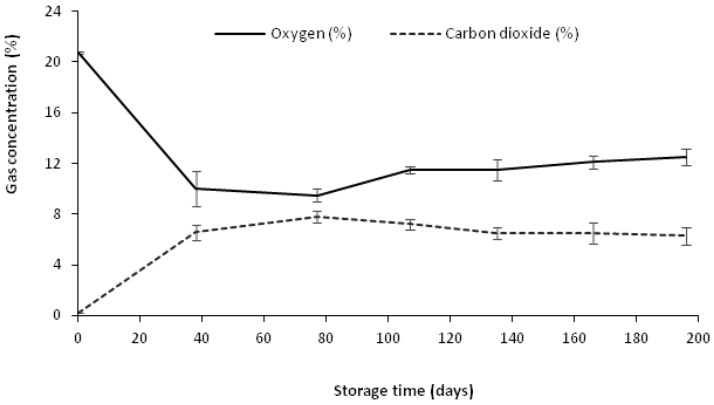

Fig 2: Changes in gas concentration (%) of hermetically stored mungbean samples in PVC tank. Data used are means ± SD of three tanks.

Conclusions

Storage damage of mungbean was mainly caused by *C. chinensis*. Hermetically storage of mungbean in PVC tack was successfully reduced the weevil development and grain damage. Although a slight change in percentage of germination was observed in the hermetically stored samples, moisture content and cooking time of beans did not change with the storage in hermetic tank. The increase of CO_2 and drop of O_2 contents in hermetic samples indicated the successful development of the hermetic condition within the stored mungbean in hermetic PVC tank. We conclude that hermetic storage can prevent the development of HTC characteristics and postharvest loss of mungbean.

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Combination of Mating Disruption and parasitoid Habrobracon hebetor against Plodia interpunctella in a chocolate factory

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Abstract

A field experiment of 4 years' duration was carried out to evaluate the efficacy of combining the mating disruption (MD) formulation Dismate ZETA (9Z,12E-tetradecadienyl acetate), with the parasitoid *Habrobracon hebetor* against the Indianmeal moth *Plodia interpunctella* in a chocolate factory. The experimental period began early in 2011 and ended in late 2014. Began Dismate dispensers were placed in the facility from 2011 to 2014 and *H. hebetor* was released in 2014. Pheromone-baited traps were used to monitor the flight activity of the male