Effect of Modified Atmospheric Conditions of Hermetically Sealed Large Capacity Cocoons for Storage of Maize Seeds (*Zea mays*)

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Abstract

Studies conducted in Sri Lanka have shown that significant amount of maize is lost during post-production operations due to improper post harvest techniques. Hermetically sealed modified atmospheric cocoon storage is one of the advanced grain storage methods for commercial level storage. This research is focused on the effect of modified atmospheric conditions of sealed cocoons for physical properties and quality conditions of maize seed under local climatic conditions. Initial values of thousand kernel weight, bulk density, hardness, colour, immature seed %, damaged seed % and impurities %, of maize seed were compared with those values obtain after 8 months storage in two methods i.e. large capacity (1100 kg) hermetic cocoon and conventional warehouse storage. Oxygen level inside the hermetically sealed cocoon took 2 weeks to reduce 20.5 to 0.4%. Temperature fluctuation inside the hermetic cocoon was very low in comparison with warehouse. Hermetically sealed cocoon maize seed sample reported similar values as its initial values in terms impurities %, and damaged seed % after 8 months storages, however they were changed significantly in warehouse sample. Change of thousand kernel weight/mass maize seed during storage period was significantly low in cocoon sample. Bulk density and paddy kernel hardness values were significantly reduced in both storage methods from its initial values. Finally, it can be concluded that hermetically sealed cocoon storage has more advantages to preserve seed quality characteristics in comparison to conventional warehouse storage for large capacity commercial storage. However, hermetically sealed condition must be maintained throughout storage period to gain these advantages.

Key words: Commercial maize seed storage, Hermetically sealed cocoon, Maize Quality, Weight loss

Introduction

Maize is the most widely cultivated cereal crop in the world after wheat and rice. It is also the second most important grain cultivated in Sri Lanka. The loss assessment studies conducted in Sri Lanka have shown that nearly 13 to 18% of maize was lost during postproduction operations from which a greater amount is lost during their storage practices due to climatic conditions in Sri Lanka (Fernando *et al.*, 1988). Sri Lanka is tropical island hence high environment temperature and humidity can be observed most of the months in year. These conditions are favorable for microbial growth such as fungus and secrete aflatoxin substances to maize the seed. Hermetically sealed storage (modified atmospheric storage) is one of the suitable storage methods for grain because it prevents maize seed from most of the storage problems. Maize seed need be dried up to 12% moisture content before hermetic storage (Donahaye *et al.*, 1991). Few studies conducted in Sri Lanka and many others studies in elsewhere have revealed that growth of fungus, insect and pests were inhibit under the hermetic storage conditions and also metabolic rate of grain was decreased due to lack of oxygen. Donahaye *et al.* (1991) and Chin and Kieu (2006). However, it is not reported research studies performed in Sri Lanka for evaluation of physical and quality changers of maize seed under large quantity (more than 1000 kg) hermetic storage in local climatic conditions. Therefore this research study has been focused to evaluate and comparison of conditions, change of thousand kernel mass/weight, bulk density, hardness, colour, immature seed %, damaged seed %

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and impurities %, for 8 months storage period of hermetically sealed large capacity cocoon storage and conventional warehouse storage of maize seed.

Materials and Methods

Freshly harvested locally grown maize seeds were used for experiment. And seeds were dried up to 12.5% moisture content. Commercial level grain storage cocoons are available in 1Mt to 500Mt capacity. The 1Mt capacity cocoon is used for this study. The 1100kg of maize seed bagged in 22 poly-sack bags and they were stored/placed inside 1Mt capacity cocoon length, width and height 1.2m, 1.1m and 1.6m and sealed. Cocoon was placed in inside length, width and height 30m, 15m and 5m size warehouse and same maize seed containing 22 poly-sack bags were stored/placed in same warehouse as a conventional storage method. Thousand kernel mass/weight, bulk density, hardness, colour, immature seed percentage, damaged seed percentage and impurities percentage, were measured before storage. Oxygen level inside the sealed cocoons was measured by oxygen level monitoring meter (GP02-0583564) daily until it becomes constant. When it becomes constant, it measured in once in two weeks of intervals. Inside temperature of hermetically sealed cocoon and warehouse were measured using thermo couples. Maize seed colour was measured by using Mini-scan XE plus Hunter Lab Colorimeter. L, a, b value were measured as colour value. Compression test (yield stress) was carried out to measure maize kernel hardness. Grain hardness tester had been adapted to perform a compression test. Force at rupture was considered as the hardness. Five seeds were subjected to compression test and the average was considered. For calculation of impurities percentage, immature seed percentage, and damaged seed percentage representative working sample of 100g of maize seed in each treatment were obtained by using sample divider. Impurities percentage, damaged seed percentage and immature seed percentage were calculated by flowing equations respectively.

$$\text{Impurities percentage} = \frac{\text{Weight of the impurities}}{\text{Weight of the sample}} \times 100$$

$$\text{Damaged seed percentage} = \frac{\text{Weight of the damaged seeds}}{\text{Weight of the sample}} \times 100$$

$$\text{Immature seed percentage} = \frac{\text{Weight of the immature seed}}{\text{Weight of the sample}} \times 100$$

Each treatment was replicated three times. Analysis of Variance (ANOVA) on Complete Randomized Design (CRD) by General Liner Model (GLM) procedure was performed and also treatment means were separated by the Duncan's Multiple Range Test (DMTR) at $\alpha = 0.05$ level of significance.

Results and Discussion

Change of oxygen level and temperature inside the hermetically sealed cocoon

Oxygen level inside the cocoon reduced substantially to 0.4% from the environment O_2 level of 20.5% within 2 weeks of period. It was reported minimum constant oxygen level 0.4% after that it was fluctuated 0.4% to 0.5% until 8 months experimental period. Figure 1 shows the temperature change inside the hermetically sealed cocoon and warehouse. It was clear from the results that the temperature fluctuation was low inside the cocoon in comparison to warehouse temperature fluctuation.

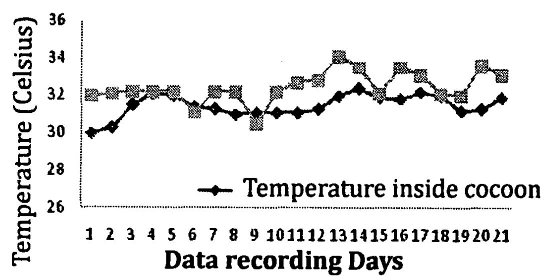

Figure1. Change of temperature inside cocoon and outside environment (warehouse)

Comparison of initial quality parameters and physical properties values of maize seed with hermetic cocoon and warehouse storage after 8 months.

Maize kernel moisture content was not observed significant difference between initial hermetically sealed and warehouse samples. Average moisture content was 12.50, 12.52 and 12.81% in initial samples, hermetically sealed and warehouse samples respectively. Comparison of initial maize seed quality values such as impurities percentage, immature seed percentage and damaged seed percentage with warehouse sample and cocoon sample after 8 months trial period has been shown, warehouse samples after 8 months storage were significantly differ from initial values in terms of impurities percentage and damaged seed percentage. However, these values were not changed significantly from its initial quality values in hermetically sealed storage samples after 8 months storage. Immature seed percentage not significantly changed from its initial value in both treatment and control. Insect pest and fungal attack were major caused to alter quality values of warehouse paddy seed sample. However, insect pest and fungal attacks were not observed in hermetically sealed cocoon sample. Growth of fungus, insect and pests were inhibiting under the hermetically sealed storage conditions and also metabolic rate of grain was decreased due to lack of oxygen Donahaye *et al.* (1991), Chin and Kieu, (2006) and Villers *et al* (2009). In contrast, the impurity percentage may be increased in warehouse sample due to deterioration of seed by high metabolic rate of seed, secretions of insect and totally damaged seed by insect. Table 1 shows the results of the mean comparison by Duncan Multiple Range Test. It was clear from the results that kernel weight/mass was reducing with storage duration. However it was reducing slowly in hermetically sealed cocoon than conventional warehouse storage. Hence, significantly different thousand kernel weight/mass can be observed in conventional warehouse, sample after 8 months storage in comparison to hermetically sealed storage. Hermetically sealed storage sample reported similar value of thousand kernel weight/mass to its initial value. Insect past damage was one of the major reasons for weight losses of stored grain. However, insect pest damage was not occurred under hermetically sealed condition Donahaye *et al.* (1991,) Respiration/ metabolic rate of maize seed also become very low due to low oxygen level Villers *et al.* (2009). Stored starch used very slowly by grain hence, weight loss due to respiration or metabolic function of grain was also very low. Initial value of bulk density and hardness of the maize seed were significantly reduced in both storage methods from its initial value. Maize kernel colour was reducing with storage duration in both, treatment and control time against its initial value but it was not significant. However, conventional warehouse sample showed high colour reduction in comparison to cocoon storage in terms of L value (lightness value).

Table 1. Different grain parameters stored under different storage conditions

Storage method	MC	IM%	DS%	IS%	TKW	BD	Hd	KC		
								L	*a*	*b*
Initial Mean values	12.50^{a}	0.289^{a}	4.03^{a}	3.39^{a}	292.2^{a}	816.3^{a}	16.74^{a}	61.94^{a}	6.37^{a}	28.17^{a}
Cocoon Mean values	12.52^{a}	0.302^{a}	4.59^{a}	3.78^{a}	279.9^{a}	730.5^{b}	14.32^{b}	55.80^{b}	8.01^{a}	18.59^{b}
Warehouse Mean values	12.81^{a}	3.988^{b}	14.81^{b}	4.08^{a}	220.2^{b}	724.2^{b}	12.83^{c}	52.19^{b}	5.36^{a}	18.02^{b}

* Columns having same letter are not significantly difference at P> 0.05 by DMRT

Oxygen level reduced from 20.5 % to 0.4 % constant level in maize seed stored cocoon by 2 weeks duration. The inside temperature of the hermetic cocoon showed less fluctuation in comparison to outside environment temperature fluctuation. Hermetically sealed cocoon maize seed samples reported similar values as its initial values in terms of quality parameters such as impurities percentage, immature seed percentage and damaged seed percentage after 8 months storages. Results also revealed that weight/mass losses were also minimum in sealed cocoon in comparison to conventional warehouse storage. Hermetically sealed storage preserves kennel mass. Hardness (textural of maize seeds) bulk density and seed colour were reduced even in hermetically sealed/modified atmospheric storage. Finally it can be concluded that commercial hermetically sealed cocoon storage method has more advantages in comparison to conventional warehouse storage. However, hermetically sealed condition must be maintained throughout storage period to gain these advantages.

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