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SuperGrainBag: A Hermetic Bag Liner for Insect Control of Stored Cocoa Beans in Ghana

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Abstract: This paper reports the development of hermetic storage in Ghana by highlighting the scientific research conducted using GrainPro SuperGrainBag™ in controlling insects of stored cocoa beans as an alternative to chemical treatment. Three stacks, all of which were composed of hermetically sealed bags of SuperGrainBag™ of 40kg dry cocoa beans each inserted into standard cocoa jute sacks were built in the same warehouse close to each other for sampling and observation at the Research Department, Quality Control Division of Ghana Cocoa Board facilities in Tema, Ghana. Two additional stacks of 64 kg per bag of dry cocoa beans were also built for sampling and observation; one stack for conventional storage (without fumigation) the other for standard storage (fumigated with phosphine). Oxygen concentration inside the SuperGrainBag™ of cocoa beans was monitored daily. Sampling was done after 30 days to observe changes in insect density. There was a steep decline in oxygen concentration in all SuperGrainBag™ during the storage with the lowest concentration of 0.0% being recorded from the fifteenth day of storage. This depleted oxygen concentration was maintained throughout the storage period. The depleted oxygen atmosphere was attributed to activity of all living organisms within the SuperGrainBag™, including the micro organism activity due to the cocoa beans moisture content which was 7%. Although this level of moisture content reflects the normal storage conditions in Ghana, it still permitted the generation of a depleted oxygen atmosphere. After 30 days of storage, 100% mortality of high populations of insects were observed in all cocoa beans stored in SuperGrainBag™ liners except one single bag in which a few individual insects were alive. The insect population consisted of adults of *Carpophilus hemipterus* and *Tribolium castaneum*. The conventional stack containing the control bags remained highly infested with insect counts reaching 88 live insects/64kg bag of cocoa beans. The standard stack recorded 100% mortality of insects in each 64kg bag of cocoa beans. These trials indicate that hermetic storage provides an environmentally safe solution for preventing development of insects in cocoa beans and thus avoid the use of chemical fumigations.

Key words: SuperGrainBag™, hermetic storage, cocoa beans, *raecerus fasciculatus*, *Lasioderma serricorne*, *Carpophilus hemipterus* and *Tribolium castaneum*, storage insect control, conventional storage, standard storage

Introduction

In recent times airtight storage or hermetic storage, also known as sealed storage technology, has generated a lot of interest as one of the methods of quality preservation for stored products. Substantial literature on sealed storage technology or airtight storage has been summarized^[1,2]. Its principle has been employed since ancient times in underground pits that are still used, particularly in semi-arid regions of the Mediterranean basin and Sahel^[3,4]. The inherent advantage of the hermetic storage of dry grain lies in the bio-generation of an oxygen-deficient and carbon dioxide-enriched inter-granular atmosphere of the storage ecosystem, a con-

dition produced by the aerobic metabolism of insects and microorganisms.

Stored product protection is enabled by the use of storage containers with hermetic seals^[5,6], one of which is the SuperGrainBag™, which provides an airtight environment. The basic principle of protection^[5,6] lies in the fact that from the time of sealing until the insects consume the volume of oxygen in the SuperGrainBag™, damage is negligible. If the insect population is low, the insects may survive causing minimal damage to the produce since it has been established that to obtain a complete kill, the oxygen tension must drop to two percent (2%) or below^[7].

At present, the conventional and standard

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storage technologies are employed to preserve cocoa beans. These conventional storage methods involve stacking of bagged beans on wooden pallets inside the warehouse. The cocoa beans are then protected from pest infestation with a combination of hygiene, sanitation and chemical control. However, this method is inadequate in preserving beans quality for long periods of time. Hence, the need for alternative storage technology that is technically feasible and cost effective. Therefore, this project explores the "hermetic, gastight or airtight" storage technology as an alternative using the SuperGrainBag™ as liners.

Materials and Method

Three stacks, all of which were composed of hermetically sealed bags of SuperGrainBag™ (SGB) of 40kg dry cocoa beans each inserted into standard cocoa jute sacks were built in the same warehouse close to each other for sampling and observation at the Research Department, Quality Control Division of Ghana Cocoa Board facilities in Tema, Ghana.

The dry cocoa beans which were already naturally infested with *Araecerus fasciculatus*, *Lasioderma serricornis*, *Carpophilus hemipterus* and *Tribolium castaneum* were re-bagged into jute sack by placing the SGB inside the jute sack as liners before the cocoa beans were poured in. The upper free plastic portion of the SGB were twisted and closed with cable ties with the aid of a cable gun. These bags of cocoa beans with SGB liners were stacked on pallets and stored for 30 days.

A butterfly needle was connected to the inlet side of the pump for measuring oxygen (O_2) concentration in the SGB. The needle was permanently inserted in the SGB and sealed with packaging adhesive tape and epoxy to eliminate any possible air/gas leakage. The hose end of the needle has a built-in plug for quick-connection to the pump. Temperature and oxygen concentration inside the SuperGrainBag™ of cocoa beans were monitored daily. Temperature was measured using data loggers inserted into each bag and for oxygen concentration in air, a GrainPro Oxygen Meter, a portable oxygen analyzer using electro-chemical sensor was used.

Two additional stacks that served as controls and contained 48 bags each, with 64 kg per bag of dry cocoa beans were also built for sampling and observation; one for conventional storage (without fumigation), the other for standard storage (fumigated with phosphine).

Insect sampling was done when the bags were filled, and again after 30 days to observe changes in insect density and mortality.

Results and Discussion

There was a steep decline in O_2 concentration in all SGB during the storage with the lowest concentration of 0.0% being recorded from the fifteenth day of storage (Fig. 1). This depleted O_2 concentration was maintained throughout the storage period. The depleted O_2 atmosphere was attributed to activity of all living organisms within the SGB, including the micro organism activity due to the 7% cocoa beans moisture content. Although this level of moisture content reflects the normal storage conditions in Ghana, it supports an equilibrium relative humidity (ERH) of about 67% at 27-29°C^[8]. This ERH permits a moderate level of microflora activity^[9] that eventually leads to CO_2 generation and a depleted oxygen atmosphere.

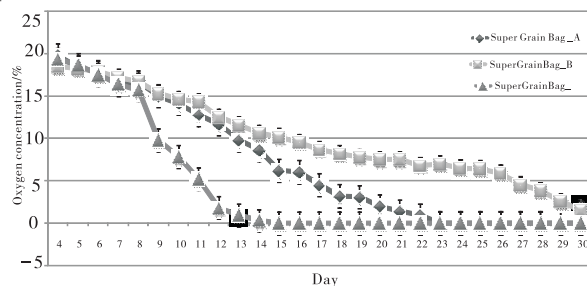


Fig. 1 Daily percent oxygen concentrations measured inside three hermetic Super Grain Bag™ over 30 days pf storage period.

Temperature of the cocoa beans inside the bags fluctuated throughout the storage period of 30 days within the range of 27°C and 32°C. The temperature of the warehouse where the bags were stored was also within the same range.

After 30 days of storage, 100% mortality of high populations of insects were observed in all cocoa beans stored in SGB liners, except one bag in which a few individual insects were alive. The insect population consisted of adults of *Carpophilus hemipterus* and *Tribolium castaneum* (Table 1). The depleted oxygen concentration achieved in these trials was apparently due to microflora activity and not due to insect activity as investigated for dry grains^[7]. In dry grains at ERH below 65% the microflora activity is negligible and the ERH values are below the critical levels for respiration and creating a depleted oxygen atmosphere in sealed stora-

ges^[5]. In dry commodities like cocoa beans, depleted oxygen atmospheres can be generated in a short time as in Fig. 1, when the insect populations are sufficiently large, the temperature is adequate for insect development, and the gastightness permits hermetic storage^[10,11]^[12,5]. The reason for the insect survival in the sealed bag marked A might be due to the delayed reduction in oxygen concentration when it reached the level of less than 1% after 23 days. However, such low level of infestation and under the hermetic conditions achieved insect damage was estimated as below the economic threshold limit for practical uses. It is quite likely that extended exposure to such low oxygen levels would have caused complete mortality of these two species.

Table 1. Population of live adult *C. hemipterus* and *T. castaneum* in one SuperGrainBag™ – A

SGB-A	<i>C. hemipterus</i>			<i>T. castaneum</i>		
	Larvae	Pupae	Adult	Larvae	Pupae	Adult
1	0.0	0.0	2.0	0.0	0.0	1.0

The conventional stack containing the control untreated bags remained highly infested with insect counts, reaching 88 live insects/64kg bag of cocoa beans (Fig. 2). The standard stack was fumigated using phosphine at a dosage of 2 – 4 g/m³ in which 100% mortality of insects was recorded in each 64kg bag of cocoa beans.

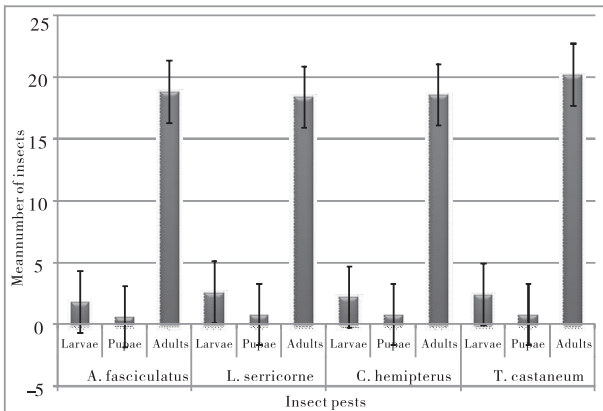


Fig. 2 Mean population density of live insect pests in a 64kg bag of the conventional stack.

At the end of the storage period, the cocoa bean samples taken from the hermetic and control bags were examined for quality control, and they were found within the standards set for commercial purposes by the Cocoa Board of Ghana. These trials indicate that hermetic storage provides an environmentally safe solution

for preventing development of insects in cocoa beans^[6] and thus avoid the use of chemical fumigations.

Conclusion

In view of the above findings, it is conclusive that SuperGrainBag™ is a good alternative to other pests control measures, especially during long term storage when it is used as a liner. The use of SuperGrainBag™ as liners thus avoids the use of chemical fumigations in storage.

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