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RECENT DEVELOPMENTS IN THE STORAGE OF DRY COCOA BEANS IN GHANA

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ABSTRACT

In the past, methyl bromide was used in the fumigation of stored cocoa beans in Ghana but following the signing of the Montreal Protocol by 183 countries including Ghana, methyl bromide was phased out. Being an international treaty the Protocol was aimed at reducing or eliminating the use of chemicals that contribute to the depletion of the atmosphere's ozone layer and mitigate some of the harmful effects that could also have some negative effects for producers and consumers. As an alternative, phosphine fumigant which is more user and environmental friendly was adopted for the fumigation of dry cocoa beans in Ghana. However, much effort is being put in to minimise the use of agro-chemicals in Ghana. Hence, hermetic control has been adopted alongside phosphine fumigation in storage as a national policy as part of integrated pest management (IPM) with great success, resulting in a 50% reduction of agro-chemical application. There is a reduction in the frequency of fogging and spraying. Organic cocoa beans from Ghana are now fully treated using the principles of hermetic storage and as a result, the quality of the cocoa beans is maintained with 100% insect mortality.

Key words: cocoa beans, storage, phosphine, hermetic, fumigation, fogging, spraying, IPM, insect mortality

INTRODUCTION

In Ghana dry cocoa beans are first packed in jute bags and stacked into warehouses, depots and sheds. Dry cocoa beans are usually stored in warehouses at three Take -Over Centres namely; Tema port, Takoradi port and Kaase Inland Port in Kumasi. Storage of dry cocoa beans in Warehouses mainly at the ports is designed for longer storage of cocoa compared to that of depots and sheds being practiced up-country.

Cocoa, like other tropical crops, is often ravaged by insects, diseases and other pests that must be controlled effectively as well as safely. Their control involves intensive use of agro-chemicals which is now facing some international challenges in terms of rigid international standards on Maximum Residue Levels (MRLs).

Insect infestations in dry cocoa beans can be controlled effectively by the application of Integrated Pest Management (IPM), but insect pest populations could be reduced drastically through efficient cultural practices in combination with the IPM. The quality of cocoa beans can be sustained by ensuring general good sanitation, maintaining low Moisture Content (MC) to as low as 6.0 – 7.5% to curtail metabolic activity of any organism present. The recent approach in controlling insect infestation in dry cocoa in Ghana is the application of modified

atmospheres (MAs) in combination with other IPM strategies. By this approach, oxygen availability is reduced while carbon dioxide concentration increases. This approach was not used in the storage of cocoa beans but it was initiated when methyl bromide, an important fumigant was withdrawn under the international Montreal Protocol agreement due to its ozone depletion property and also when there were sporadic reports that the phosphine fumigant alternative did not offer 100% mortality of insect pests. Treatments involving MAs have been investigated and accepted as viable alternative treatments (Villers *et al.* 2001; Navarro *et al.,* 1996; Navarro *et al.,* 1994; 1989; Calderon and Navarro 1980; Navarro and Calderon, 1980) for further development in the immediate future including hermetic treatment.

Hermetic storage consists of a sealed storage system containing a modified atmosphere. This means that, as a result of respiration effects, there is generally depletion of oxygen (O_2) and production of high carbon dioxide (CO_2) atmosphere. Pioneering modern hermetic storage, Calderon and Navarro (1980), Navarro and Calderon (1980), Navarro *et al.* (1989; 1994) used safe, pesticide-free hermetic material made of flexible Polyvinyl Chloride (PVC) plastic liner (also known as GrainPro Cocoon^{TM}) for the storage of many commodities and seeds, particularly in hot and humid climates. PVC plastic liner is suitable for maintaining a constant moisture environment.

Ghana has successfully adopted the hermetic control alongside phosphine fumigation of dry cocoa beans in storage. Hermetic storage of cocoa beans in Ghana has led to 50% reduction in the use of agro-chemicals. Ghana has also maintained its premium grade cocoa with 100% insect mortality with hermetic storage facility (Jonfia-Essien *et al.* 2008a). Quality parameters of dry cocoa beans as well as mortality level of stored insect pests of cocoa beans under hermetic storage were closely monitored alongside those under the phosphine fumigation by the Research Department, Quality Control Company Limited (COCOBOD) (QCC).

MATERIALS AND METHODS

PRE-STORAGE QUALITY DETERMINATION

When cocoa beans graded, sealed and certified by QCC arrived from depots up-country, they were laid and samples of the cocoa beans were drawn from each bag for re-examination (i.e. 100% sampling). The samples were thoroughly bulked, quartered and the process repeated until final sample was obtained for thorough physical quality analysis. Quality parameters determined were moisture content, bean count, bean size uniformity and grade (i.e. mould, slate and all other defects including flat beans, germinated beans, as well as insect infested beans). Five bags of cocoa beans were randomly selected and sieved for insect infestation analysis at the Entomology laboratory before treatment.

Moisture content of cocoa beans was determined using AquaBoy moisture meter while mould, slate, purple and insect infestation were determined through cut test. Bean size uniformity was determined by counting number of whole cocoa beans in a weighed 100g beans. The unusual cocoa beans were counted and expressed as a percentage of total number of beans from the 100g weighed beans. A tolerance level of 10% was used as an index of bean size uniformity for any particular category of cocoa beans. Only cocoa beans that passed the quality parameters were accepted into stack and stored under either gas proof sheet with full dose of phosphine gas treatment or hermetic condition with half dose of phosphine gas at the take over centres (Port) warehouse.

PRE-SHIPMENT QUALITY DETERMINATION

Physical quality parameters of cocoa beans stored under both hermetic and gas proof sheet condition were determined in the same manner as that of pre-storage above.

Five bags each of cocoa beans were randomly selected from fumigated stacks (a bag each from the four sides and one from the top) under both the hermetic and gas proof sheet storage. With the aid of a sieving box selected bags of cocoa beans were sieved. Insect infestation analysis was performed at the Entomology laboratory and both live and dead forms of insects were identified.

RESULTS AND DISCUSSION

Physical assessment conducted on cocoa beans arriving from up-country to the Take Over Centre (TOC) during the period under review showed that the cocoa beans were of main crop size with all the MC within the threshold level of 7.5%. The average tolerance level (ATL) for all the cocoa beans was far below the 10% threshold level.

The importance of the ATL is to ensure good segregation of cocoa beans into various categories of sizes and the consignment is fairly uniform. High MC beyond 8% promote the growth of moulds but excessively low MC especially below 5.5% makes the cocoa beans too brittle and turn to break up during roasting for product processing and this account for the setting of national standard of MC between 6.0% and 7.5%.

Insect infestation of cocoa beans begins from the drying mat and it is essential to know the type of insects in the cocoa beans even before accepting the consignment into storage. Analyses of sieving samples revealed that cocoa beans received at all the TOCs (Tema, Takoradi and Kaase inland ports were found to be infested with *Cryptolestes ferrugineus, Ephestia cautella*, *Tribolium castaneum, Lasioderma serricorne, Araecerus fasciculatus, Rhyzopertha dominica and Carpophilus dimidiatus*. However the percentage infestation differed from the TOCs (Fig. 1).

With the exception of 2010/2011 crop year, Kaase inland port remained the TOC with the least insect infestation and Tema port being the TOC with the highest infestation level. This is an indication that distance of up-country depots to the TOC plays a pivotal role in infestation level of cocoa beans. The covering of cocoa beans in trucks during evacuation from the up-country depots to the TOC which is very critical to the sustainability of the cocoa beans also provides conducive environment for the multiplication of insect pests in the cocoa beans. It is therefore important to check the infestation level of cocoa beans and deal with it before accepting the consignment into storage.

Cocoa beans from different districts and up-country depots were brought together to construct a stack. However, physical assessment conducted on cocoa beans prior to shipment showed that the Bean Count (BC), ATL and the MC of the cocoa beans were still within the threshold levels. These physical parameters of the cocoa beans were not affected by the type of storage, whether the storage was under gas proof sheet of hermetic cocoon^{TM}. It can therefore be concluded that a thoroughly dry cocoa beans with MC between the 6.0 % and 7% will aid the sustainability of the quality of cocoa beans if good storage management practices are put in place.

Another factor that is critical to the sustainability of the quality of cocoa beans in storage is insect infestation. It was evidenced from the study that 100% mortality was recorded in most of the treatment of cocoa beans under gas proof sheet. However, a few percentages of the cocoa beans under the gas proof were found to be infested with insect pests, both adults and larvae (Fig. 2).

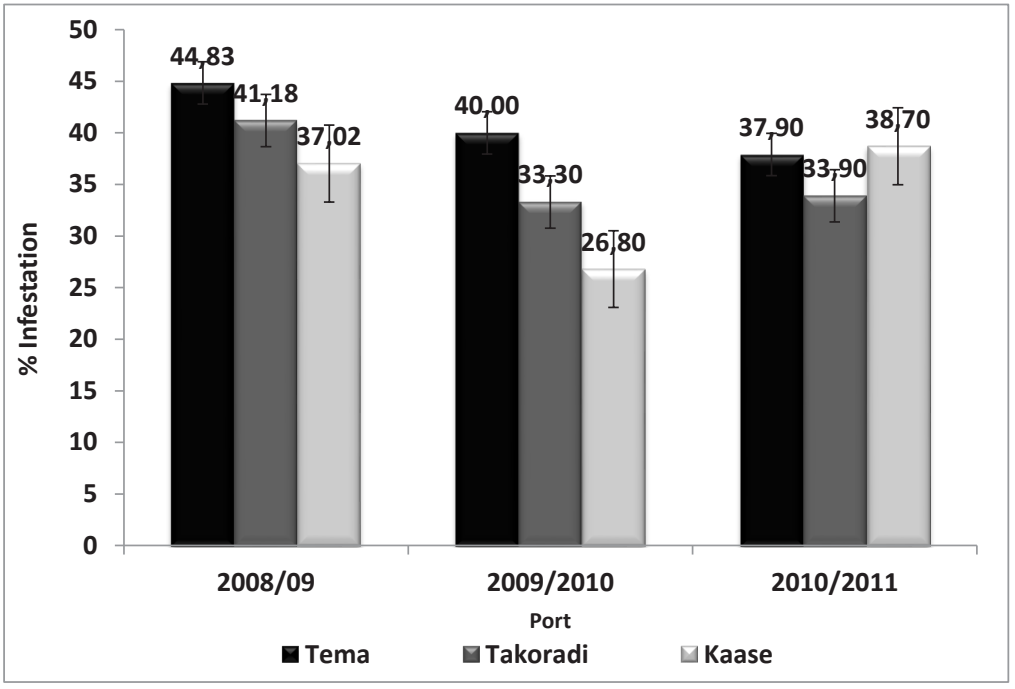

Fig. 1- Percentage of arrival cocoa beans infested with insect pests

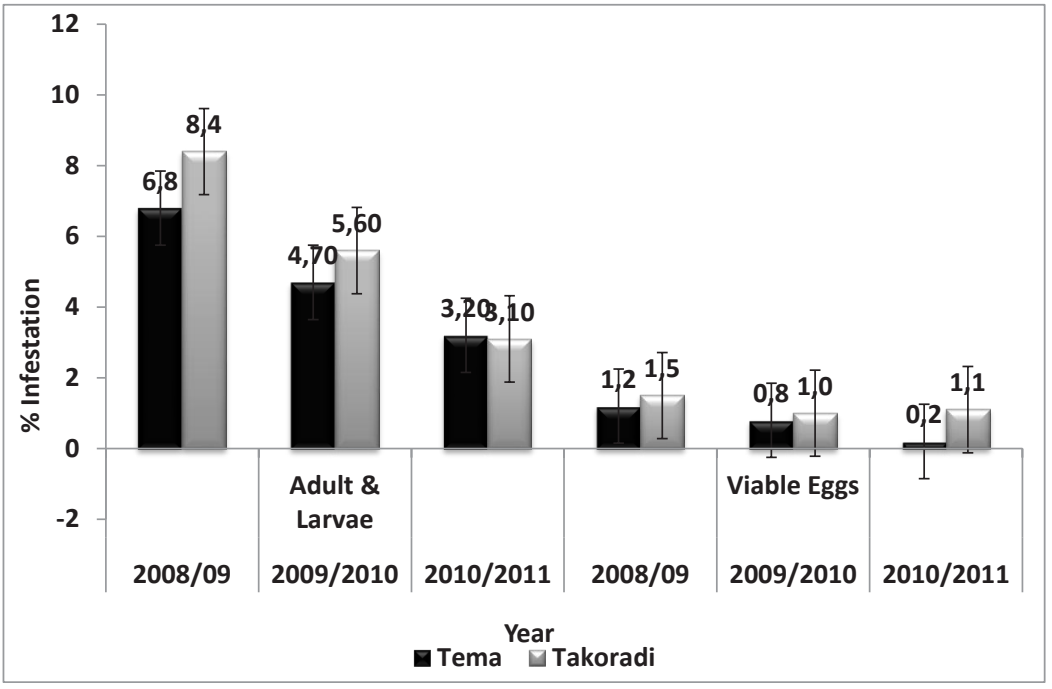

Fig. 2- Percentage of shipment cocoa beans with live insect pests after fumigation under gas proof sheet

Predominant among them were *Cryptolestes ferrugineus, Tribolium castaneum, Ephestia cautella,* and *Araecerus ferrugineus.* Takoradi port recorded the highest incidence of insect pest infestation contrary to the population of insects in the cocoa beans at the time of arrival. In very exceptional cases, isolated incidence of viable eggs was observed in post culture sieving analysis. Often than not the post culture sieving insect pests were identified to be *Cryptolestes ferrugineus* and *Ephestia cautella*.

Treatment under the hermetic Cocoon^{TM} was a great success. The 100% mortality of insects in both pre and post culture sieving analysis confirms the findings on hermetic storage of cocoa beans by Jonfia-Essien *et al.* (2008a) and in consequence there have been a 50% reduction in the use of agro-chemicals on stored cocoa beans in Ghana. No viable egg was observed in post culture sieving analysis throughout the period under review. These findings informed a policy shift by Ghana Cocoa Board to store and treat cocoa beans using the hermetic Cocoon^{TM}. At the moment the hermetic Cocoon^{TM} treatment is running concurrently with the treatment of cocoa beans under gas proof sheet. However the hermetic Cocoon^{TM} were installed only in two TOCs (Tema and Takoradi ports). In total, almost eight hundred and seventy three tons of organic cocoa beans (872.94 tons) treated under pure hermetic cocoon^{TM} has been exported between 2008/09 and 2010/11 crop years. The success of hermetic cocoon^{TM} contributed the decision by a buyer that every organic cocoa beans shipped to them should be treated under hermetic cocoon^{TM}.

The quality of cocoa beans prior to storage under gas proof sheet was maintained after storage, though there was a decline in some of the quality parameters especially the total mould and total slate (Table 1). Notwithstanding, the grade of the cocoa beans remained the same

Table 1. Quality of cocoa beans before and after treatment under gas proof sheet storage

Port	Crop year	Gas proof treated cocoa beans									
		Arrival analysis					Shipment analysis				
		TM	TS	AOD	Purity	Grade	TM	TS	AOD	Purity	Grade
Tema	1ST	1.0	2.0	1.0	96.0	I	1.0	2.7	1.3	95	I
	2ND	0.0	1.7	2.7	95.7	I	1.0	2.0	2.0	95	I
T'di	1ST	0.0	2	2.3	95.7	I	1.0	2.0	1.0	96	I
	2ND	0.0	1.3	2.7	96.0	I	1.0	2.3	1.7	95	I

MC- Moisture content TM- Total mould TS- Total slate AOD- All other defects

On the contrary, there was no decline in any of the quality parameters in the cocoa beans stored under the hermetic cocoon^{TM} and the quality was sustained (Table 2). The grade also remained the same.

Table 2. Quality of cocoa beans before and after treatment under hermetic cocoon^{TM} storage.

Port	Crop year	Hermetic cocoon^{TM} treated cocoa beans									
		Arrival analysis					Shipment analysis				
		TM	TS	AOD	Purity	Grade	TM	TS	AOD	Purity	Grade
Tema	1ST	0.0	2.7	2.3	95	I	0.0	2.7	2.3	95	I
	2ND	0.0	2.7	2.3	95	I	0.0	2.0	2.0	96	I
T'di	1ST	0.0	2.0	2.0	96	I	0.0	2.3	1.7	96	I
	2ND	0.3	2.7	2.0	95	I	0.3	2.0	1.7	96	I

MC- Moisture content TM- Total mould TS- Total slate AOD- All other defects

The observed differences between the use of the gas proof sheet and the hermetic cocoon™ in the treatment of cocoa beans could be attributed to type of material used in the manufacturing of the sheet and the cocoon™. The gas proof sheet allows the exchange of gas / air between the inner and outer environment whereas the hermetic cocoon™ does not allow for exchange of gas /air. This explains why carbon dioxide concentration in the hermetic cocoon™ increased while the oxygen concentration was being depleted.

CONCLUSIONS

As a leading producer of quality cocoa beans, implementing pragmatic measures such as IPM including hermetic control and good storage management to sustain the quality has been the hallmark of success in the storage of cocoa beans in Ghana. The 50% reduction in the use of agro-chemical will contribute to effective management of pesticide residues and therefore the effort is worth maintaining and possibly must be stepped up.

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