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CURRENT STATUS OF CONTROLLED ATMOSPHERE STORAGE IN THE PHILIPPINES

Glory C. SABIO
NAPHIRE CLSU Compound, Muñoz, Nueva Ecija, Philippines

ABSTRACT

Investigations conducted in the Philippines for the last seven years on Controlled Atmosphere (CA) as a storage option for pest and quality control of rice, maize, soybeans, and groundnuts, have been directed mainly towards technology validation. Studies have shown that indoor storage of bag-stacks of rice and maize (approximately 200 tonnes) and of soybeans (approximately 6 tonnes), within sealed plastic enclosures under high carbon dioxide (CO_2) atmospheres can control pest infestation effectively and prevent quality deterioration of grains when done correctly. A number of private processing plants, farmer cooperatives and the government through the National Food Authority (NFA) have recently shown a keen interest in adopting this technology. Effective control was observed in CA storage trials for groundnuts preserved in steel drums under an atmosphere of 15% CO_2. Hermetic storage experiments for rice and maize using Joseph bags have likewise proven successful. Highlights of the CA storage trials and the present direction of this technology in the Philippines are discussed. Temporary outdoor storage of bag-stacks of rice and maize (approximately 6-17 tonnes) in sealed plastic enclosures under CO_2 enriched atmospheres or hermetic storage are currently under investigation. The objectives and expected benefits of this technology are also discussed.

INTRODUCTION

In the Philippines, Controlled Atmosphere (CA) storage technology is still in its infancy. Research directed towards determining the technical, functional, and economic feasibility of this technology for storing bagged grains under local conditions commenced only in 1985. Initially, studies focused on the use of CA storage inside warehouses, but later on, investigations were extended to the application of this technology to the temporary storage of bagged grains outdoors. Presently, research on the indoor application of CA storage has been completed. The four studies conducted nationwide and completed to date, their significant sponsors, and

potential beneficiaries, are discussed below. Studies on CA application to outdoor storage are currently underway.

Two types of CA have been considered for investigation in the Philippines: high carbon dioxide (CO_2) or CO_2 enriched atmosphere, and hermetic storage. The tested commodities are paddy, milled rice, maize, soybeans, and groundnuts.

This paper will present the highlights of completed studies on the use of CA for indoor storage. In addition, the objectives and expected benefits of the use of CA for outdoor storage, and the present direction of CA technology in the Philippines, will be discussed.

LONG-TERM STORAGE OF GRAINS IN PLASTIC COVERS

This project was conducted by the National Post Harvest Institute for Research and Extension (NAPHIRE) in collaboration with the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Canberra, Australia. It was envisaged as a potential solution to the pest infestation and quality deterioration problems that almost always besiege the long-term storage of grains. The expected beneficiaries of this project are the government through the National Food Authority (NFA), private traders and processing plants, and farmer cooperatives.

The aim of this project was to determine the reliability and socio-economic feasibility of the combined use of sealed plastic enclosures and high CO_2 atmosphere in the control of pest infestations and quality deterioration of bag-stacks of paddy, milled rice, and maize during long-term storage.

A series of field storage trials were conducted in NFA warehouses using commercial-sized stacks (11m L x 7.3m W x 4.6m H) of bagged paddy, milled rice and white flint maize having a moisture content (m.c.) of approximately 14%. The stacks were disinfested with CO_2 at a dosage of 1-3.5 kg/tonne for paddy, and 1.5-2 kg/tonne for milled rice and maize, respectively, at the beginning of storage. The storage periods were extended progressively from approximately 4-13 months for paddy, 8-16.5 months for milled rice, and 4.5-13 months for maize. The sealed stacks were monitored regularly and inspected during storage to avert possible damage to the stored commodity.

Some of the parameters observed included baseline data on levels of insect infestation, percentage of damaged kernels, percentage of weight loss, and other quality data on the commodity prior to treatment, and corresponding data after treatment.

The field storage trials showed that the combined use of bag-stack storage within well-sealed plastic enclosures and initial disinfestation with adequate doses of CO_2 can be a reliable, functional, and cost-effective pest and quality control procedure for the long-term storage of milled rice and

maize. The quality of sealed maize stacks was just as good or better than that of maize stored in the conventional manner. Similarly, despite some isolated yellowing and increase in the amount of chalky kernels, the quality of sealed milled rice was comparable to that of conventionally-stored rice. Light infestation was recorded in several sealed paddy stacks. Infestation was caused by the rice weevil (*Sitophilus oryzae*) and the lesser grain borer (*Rhyzopertha dominica*) which were observed to bore through the covers into the stacks under conditions of very heavy infestation pressure. However, incidents of reinfestation by insects, and possibly by rodents, too, may be avoided if the operation utilizing the sealed stack storage technique is complemented by good storage practices, high levels of hygiene, and rodent control (Sabio *et al.*, 1992).

APPLICATION OF CA TECHNOLOGY

CA storage of soybean

This was a collaborative project of NAPHIRE and NESTLE Philippines. NESTLE, the major food processing industry in the country, had hoped that the CA technology would enable NESTLE to address its problem of maintaining required standard quality of soybean processed products. Quality deterioration of soybeans is attributed to pest infestation and the natural aging process. The objective of the project was to assess the reliability of sealed plastic enclosures and high CO_2 atmosphere in protecting bag-stacks of soybeans from insect infestation and in maintaining the quality of stored beans.

Storage trials lasting 6 months were conducted using 6-tonne capacity stacks of bagged soybeans having approximately 11% m.c. Food grade quality CO_2 was added at a rate if 1 kg/tonne. The parameters measured were insect infestation, percentage of insect-damaged kernels, percentage of weight loss, microbial infection, and browning of cotyledons. Organoleptic evaluation of beans was also performed.

Findings showed that sealed enclosure storage under high CO_2 atmosphere can be a potential pest control option for storing soybeans. Insect infestation, percentage of insect-damaged kernels, and weight loss were nil in sealed soybeans, but were found to increase significantly in the control stacks. Microbial infection of beans with the three common storage fungi - *Aspergillus flavus, A. niger,* and *Penicillium* spp. - was also reduced significantly in sealed stacks. Brown spots on the cotyledons of soybeans became prominent in sealed stacks only after 5 months, as compared with 3 months for the control. In addition, the beany taste of sealed beans was retained for 5 months, but remained only 3 months in the control (Julian and Sabio, 1991).

CA storage of groundnuts

This project, implemented by NAPHIRE in collaboration with the Isabela State University, represented an attempt to solve the farmers' problem of an insufficient supply of groundnut seeds for planting material. This problem is attributed to the lack of a suitable storage technique for preserving groundnut seeds. The expected beneficiaries of this technology are the groundnut farmers and farmer cooperatives.

The storage of unshelled groundnut (BPI - PN9) seeds at 7.5% m.c. in various containers - steel drums, plastic drums, and ordinary fertilizer bags (i.e., polypropylene bag with polyethylene sheeting as inner lining) - under an atmosphere of 15% CO_2, was studied for six months under ambient conditions. The parameters examined were seed viability, seedling vigor, mold infection, discoloration of pods, and kernel shriveling.

Findings indicated that the quality of groundnut seeds could be preserved best in steel drums under an atmosphere of 15% CO_2. The viability of groundnut seeds kept in steel drums under an atmosphere of 15% CO_2 was reduced by only approximately 10%, while that of the seeds in fertilizer bags was reduced by more than 50%.

Seedling vigor was approximately 78.5% in samples maintained in steel drums under an atmosphere of 15% CO_2, but was only 22.25% in samples kept in fertilizer bags. Furthermore, the percentage of mold infection, discoloration of pods, and kernel shriveling was also lower in samples kept in steel drums under an atmosphere of 15% CO_2, as compared with those kept in fertilizer bags (Isabela State University and NAPHIRE, 1991).

JOSEPH SACKS - STORAGE SYSTEM FOR SUBSISTENCE FARMERS

Development of the Joseph Sack Storage System was a joint project of Siliman University, Philippines, and the Stored Grain Research Laboratory, CSIRO, Division of Entomology, Canberra, Australia (GASGA, 1988).

The Joseph sack is a sealable, plastic laminate bag having a capacity of approximately 40 kg. It was designed for grain storage at the subsistence farmer level using the principle of hermetic storage for insect control.

Joseph sack storage trials using paddy, maize, and milled rice were conducted for 12 months. Findings revealed the Joseph sack to be a good substitute for the polypropylene bags used commonly by subsistence farmers for the storage of small quantities of grain, whether for consumption or planting purposes. Joseph sacks consistently outperformed the polypropylene bags in the control of natural and artificially-induced infestations. They also maintained good germination rates, even under adverse conditions.

ON-GOING CA RESEARCH

Two CA studies are presently underway: one involving the outdoor storage of grains in the hot and humid tropics, and the other the application of modified atmospheres (MA) to the prevention of losses in grain storage. The former is being carried out in collaboration with the Stored Grain Research Laboratory, CSIRO, Division of Entomology, Canberra, Australia, and the latter with the Agricultural Research Organization, The Volcani Center, Bet Dagan, Israel.

Both studies attempt to determine the applicability of sealed plastic liners to the preservation of stacks of bagged grains in open spaces or outdoors. The need for temporary storage structures is often felt in times of glut or in disaster situations, when food must be transported to stricken areas or when there are bottlenecks in the food pipeline. Nevertheless, a simple, portable, reliable, and cost-effective storage technique has yet to be developed.

The development of such a storage system would be of great assistance to farmer cooperatives, small-scale traders, and emergency relief organizations.

FUTURE DIRECTION OF CA STORAGE TECHNOLOGY IN THE PHILIPPINES

Several private processing plants, farmer cooperatives, and the government through the NFA have expressed a keen interest in some of the technologies that have already passed validation procedures. However, none of these technologies have been adopted yet for the following reasons:

- High initial capital cost of CA technology.
- Scarce supply of food grade quality CO_2 in the Philippines.
- A present lack of local fabrication of tailored plastic enclosures.
- Insufficient awareness among potential users due to the so-far limited scope of the dissemination campaign.
- Requirement for managerial rethinking, e.g., changes in production strategy and value of stored stocks.
- Inadequate training of pest control officers/technicians.

Once some of the above constraints have been addressed, the present situation of non-adoption of CA technologies by private traders, processing plants, NFA, and farmer cooperatives is expected to change. In the meantime, much more could be done to improve the application of the CA storage technique in the Philippines. These include improvement of the enclosure sealing technique, development of methods of CO_2 generation, testing the applicability of industrial grade CO_2 or phosphine as alternate

gases to food grade quality CO_2, and addressing the problem of insect invasion of sealed stacks. While the above issues demand attention, the expansion of CA studies to include commodities, other than those already tested, must also be considered. The ultimate result of these efforts will be effective, pesticide-free alternative methods of pest control that are within our reach.

ACKNOWLEDGMENTS

I wish to thank Dr. Shlomo Navarro of the Agricultural Research Organization, The Volcani Center, Israel, and Messrs. Peter Annis and Jan van Graver of CSIRO, Canberra, Australia, for making my attendance at this conference possible.

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