Anandakumar S, Madhumathi G, Alagusundaram K, Abirami CVK, Alice SRPJ, Munendra S (2016) Effect of PVC coated fabric cover on quality of paddy (*Oryza sativa*) during cover and plinth (CAP) storage. Pp. 495–499. In: Navarro S, Jayas DS, Alagusundaram K, (Eds.) Proceedings of the 10th International Conference on Controlled Atmosphere and Fumigation in Stored Products (CAF2016), CAF Permanent Committee Secretariat, Winninpeg, Canada.

Effect of PVC coated fabric cover on quality of paddy (*Oryza sativa*) during cover and plinth (CAP) storage

S ANANDAKUMAR[1*], G MADHUMATHI[1], K ALAGUSUNDARAM[2], C V KAVITHA ABIRAMI[1], SUJEETHA R P J ALICE[1], MUNENDRA SINGH[3]

[1]*Indian Institute of Crop Processing Technology, Pudukottai Road, Thanjavur, Tamil Nadu 613005, India*

ABSTRACT

Cover and plinth (CAP) storage is an on farm outdoor storage practice followed by farmers for short life period. The general fumigation cover used in the storage godown is black poly ethylene (PE) cover. In this study, the effect of black PE cover and poly vinyl chloride (PVC) coated poly ester (PET) cover on quality of bulk storage of (20 tonnes) paddy (*oryza sativa* L.) was measured. The thickness, tensile strength and yield strength of the fumigation covers decreased with the increasing storage period. The difference in initial and final thickness of PVC coated polyester cover and black PE cover were recorded as 0.227 mm and 0.185 mm; 0.221 mm and 0.180 mm respectively. Similarly, the final yield points and tensile strength of the PVC coated polyestercover and black polyethylene were 37.5 kgf and 5.03 kgf respectively. The highest retention of PH_3 was found 734.38 ppm in PVC coated polyester compared to 636 ppm in black PE which was at the end of 6 months fumigation study. At the end of the study, the quality parameters of paddy stored in PVC coated polyester covered stack and black PE covered stack were measured. The quality such as hardness, cooking volume and final viscosity of paddy stored in PVC coated polyester were 5.40 kgf, 452 ml and 596 cp respectively. Similarly, for black PE covered paddy these were 5.41 kgf, 455 ml and 611 cp respectively.

Key words: CAP storage, Fumigation, Paddy, Phosphine, Peak viscosity, Rice quality

Paddy (*Oryza sativa* L.) is the most important and extensively grown food crop in the world. It is the staple food of more than 60% of the world population. India has the largest area under paddy in the world and ranks second in the production after China. According to World Bank Report (1999), the post-harvest losses in India amount to 12 – 16 million tonnes of food grains each year.

The primary factors influencing spoilage of stored grain are moisture and temperature. High moisture content in grain can occur due to improper moisture monitoring of grain during harvest, further moisture migration can be caused by in-storage air convection currents, moisture diffusion within bulk seed, or entry of water into the bulk storage (Khankari et al., 1995) Cover and Plinth (CAP) where the food grains bags are stored in dome shaped stacks of standard size and height on high plinth with masonry work and properly covered with low density polyethylene covers.

Storage in CAP is vulnerable to wind damage and the covers should be inspected frequently to detect damage. The system requires careful management if severe losses are to be avoided. The retention of phosphine gas during fumigation is mainly depended on gas barrier properties of fumigation cover, temperature and moisture content. The general fumigation cover used in the storage godown is black PE cover.

During storage, quantitative as well as qualitative losses occur due to insects, rodents, and micro-organisms. The occurrence and numbers of stored grain insect pests are directly related to geographical and climatic conditions (La1 and Srivastava, 1985). *Tribolium* (Jacquelin du val) *confusum* and *T. castaneum* (Herbst) are two important beetles in storage godowns. Fumigation plays a vital role in insect pest

[2]ICAR, New Delhi, [3]SRF limited, Chennai.
[*]Corresponding author e-mail: *s_anandakumar@iicpt.edu.in*

elimination of stored food grains. Aluminium and magnesium phosphide react with atmospheric moisture to produce phosphine (hydrogen phosphide gas and metallic hydroxides). Aluminium phosphide slowly releases about one-third of its weight as phosphine over periods of between 24 and 72 hours, depending on the particular formulation. Hence considering the storage practices, climatic factors and effect of fumigation methods and covers on the quality of paddy during storage, a research attempt was made for CAP storage of bulk paddy with different fumigation covers such as black PE and PVC coated polyester.

MATERIALS AND METHODS

The CAP storage studies were carried out on paddy variety of 'Sona masuri'. Good quality paddy (20 tonnes), free from insects, were procured from M/s Selvam Modern Rice Mill, Kangayam district, Tamil Nadu. The initial physico-chemical properties and quality of paddy have been analyzed as per the standard procedure.

Cap bulk storage of paddy

The paddy variety was packed in 50 kg gunny bags. The size of the bag was 0.67 (l) × 0.56 (b) × 0.3 (h) m. About 4 bulk stacks of each 5 tonne capacity (i.e. 100 gunny bags per stack) for the floor area of 2.26 m × 2.20 m and nine bags height (2.46 m) was stacked. Up to eight bag height, about 12 bags were stacked in each layer in crisscross direction. The ninth layer was stacked only with four bags to form cone shaped structure for easy runoff of rain water, without any stagnation on the top of the paddy bulk stacks (Fig. 1). The total volume of each stack was 12.32 m^3. Among the four stacks, three paddy bulk stacks were covered with PVC fabric coated polyester cover and the fourth one was covered with black polythene cover (conventional) as the control.

Thickness

The thickness of fumigation covers has been measured using thickness calliper gauge. Ten sheets in each fumigation covers were taken and placed between the probes of thickness calliper. The thicknesses of 10 sheets were measured at different locations and the average value was recorded as the thickness of selected fumigation cover.

Fig.1. Effect of PVC coated polyester cover on paddy storage

Tensile strength

As per the ASTM D 882 procedure, the tensile strength and yield strength of fumigation covers such as PVC coated polyester and black polyethylene covers were noted using the Universal Testing Machine regularly at an interval of 30 days. The Universal Testing Machine (Pack Test 3000 kg, Gujarat) with load cell 20 kgf was used for estimation of tensile and yield strength.

Fumigation of bulk paddy stack

The bulk paddy stacks were fumigated two times during the entire storage period of 6 months. The paddy bulk stacks were fumigated with the recommended standard dosage of 3 aluminium phosphide tablets/ tonne for 7 days (Fumigation Manual, GoI, 1997). The number of tablets taken for each stack of 5 tonne capacity was 15.

Hardness

The hardness of paddy was measured using Kiya Hardness tester (Fujihara Seisakusho Ltd, Japan) during the storage periods. The peak force required for the breakage of the rice was measured at one month intervals (Kanlayakrit and Maweang, 2013).

Cooking volume

Cooking quality is the major determinant of the rice quality (Sowbhagya and Ali, 1991), based on which the variety fetches the best price in the market. To analyse the cooking volume of rice, 10 g milled rice was taken with 25 ml water (2.5 times) in graduated test tube. The rice was cooked by double pot method for 45 min and the final volume was noted. While cooking, the test tubes were covered with glass balls to prevent evaporation. When the cooked rice cools to room temperature, the cooked rice volume was measured and the result is expressed in ml/100 g of rice as per following equation

$$\text{Cooking volume (ml)} = \text{Level of volume increased} * 10$$

Pasting behaviour

Pasting characteristics were determined by the approved method AACC 61-02 (AACC, 2000) with a Rapid Visco Analyser (RVA). To conduct the analysis,

2.5 g samples were weighed into a dried empty container, then 25 ml distilled water was dispensed into the canister containing the sample. The solution was mixed and the canister was well fitted into the RVA, as recommended. The slurry was heated from 50°C with 2 min holding time. The rate of heating and cooling were at a constant rate of 11.25°C/min. Peak viscosity, trough, breakdown, final viscosity, setback, peak time and pasting temperature were read from the pasting profile with the aid of thermo cline for windows software connected to a compute (Kanlayakrit, 2012).

RESULTS AND DISCUSSION

Thickness and tensile strength of fumigation covers

The thickness of the fumigation covers such as PVC coated polyestercover and black PE cover was measured during the CAP storage period of paddy. The initial thickness of PVC coated polyestercover and black PE cover was 0.227 mm (900 gauge) and 0.185 mm (750 gauge) respectively. Similarly, the thickness of the fumigation covers at the end of storage period was 0.221 mm (884 gauge) and 0.180 mm (736 gauge) respectively. The reduction in thickness of fumigation covers was due to the continuous lifting and closing of covers in day time for aeration of paddy stack and caused friction between the stack and fumigation covers (Rajendran et al., 2003).

The initial yield strength of PVC coated polyester cover and tensile strength of black PE cover was 50.81 and 6.95 kgf, with the deflections of 24.2 mm and 431.5 mm respectively (Fig. 2). Similarly, the tensile strength and deflections of the fumigation covers of PVC coated polyester and black PE at the end of storage period was found as 37.5 kgf and 8.5 mm and 5.03 kgf and 16.1 mm respectively. Among the covers, the tensile strength value was found high in PVC coated polyester cover compared to the black PE cover. Chen and Shingling (2013) reported that tensile property of PE films became lower (15.08%) during ultraviolet aging process of 120 h compared with thermal aging (6.07%).

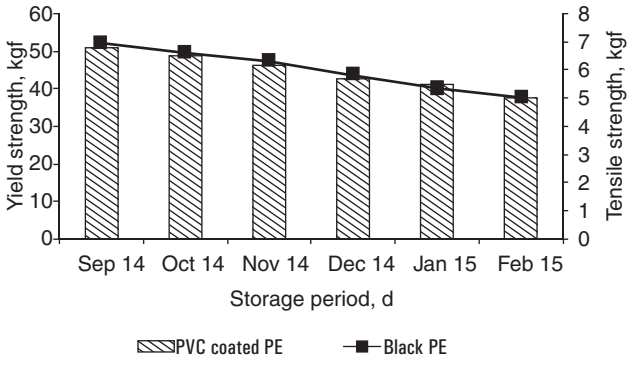

Fig. 2. Tensile strength of fumigation covers during storage periods

Phosphine fumigation

The bulk paddy stacks were fumigated twice during the entire storage period. The average phosphine concentration in both PVC coated polyester and black polyethylene paddy stacks showed a similar trend during fumigation at the beginning of the storage period (Fig. 3). The peak concentrations of paddy bulk stacks covered with PVC coated polyester and black polyethylene were 851.42 ppm and 848.33 ppm respectively. The final concentrations of PVC coated and black polyethylene were 36.17 ppm and 27.92 ppm respectively. During the fumigation period of 7 days, the phosphine concentration but increased in the initial 3 days but decreased later. During the second fumigation study with the same covers at the end of storage period, the maximum phosphine concentration obtained was less than the first fumigation. The peak concentrations during the second fumigation were 734.38 ppm and 636.43 ppm for PVC coated polyester and black polyethylene respectively. The peak concentration was found less, being 24.97%

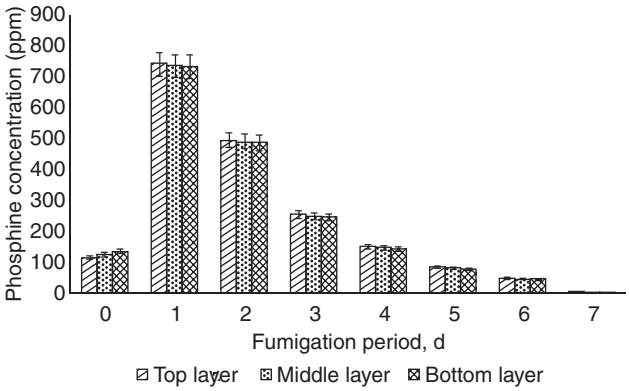

Fig. 3. Effect of PVC coated polyester cover on retention of phosphine during the fumigation of bulk paddy stack

in black polyethylene and 13.75% in PVC coated polyester cover compared to that of first fumigation. The phosphine retention of black polyethylene was 13.33 % less than PVC coated polyester covered stacks

Hardness

The hardness increased with the increase in storage periods for both covered paddy stacks (Fig. 4). The hardness for polyethylene (PE) covered paddy stacks and PVC fabric coated paddy stacks on day 180 of storage was 5.41 and 5.40 kgf respectively. The initial

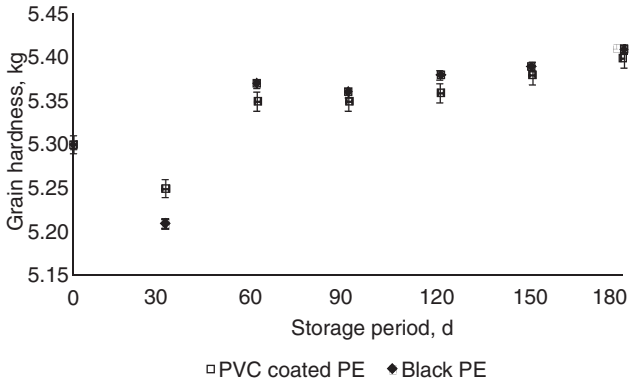

Fig. 4. Effect of fumigation covers on hardness of paddy during the storage periods

stacks. The peak viscosities for polyethylene (PE) covered paddy stacks and PVC fabric coated paddy stacks on day 180 of storage were 296.6 and 301.3 cp respectively.

The RVA analysis revealed that the samples showed significant decreases in peak viscosity and breakdown after being aged. The decrease in peak viscosity during aging of rice showed that the starch granules of aged rice were more resistant to swelling than that of fresh rice (Wattinee and Sanguansri, 2012). The initial peak viscosities of PVC coated PET and black PE were 368.6 cP and 367.6 cP. The final viscosities on day 180 of storage were 597.3 cP and 611.3 cP respectively. Statistical analysis showed that

Table 1 Cooking characteristics of paddy during storage

Days	Cooking volume (ml)		Peak viscosity(cP)		Final viscosity (cP)	
	PVC coated polyester	Black PE	PVC coated polyester	Black PE	PVC coated polyester	Black PE
0	441.3 ± 1.52	440.6 ± 3.05	368.6 ± 2.08	367.6 ± 2.51	497.0 ± 2.00	494.6 ± 2.51
30	447.6 ± 1.15	441.6 ± 2.08	361.6 ± 1.52	356.6 ± 2.08	512.3 ± 2.51	504.3 ± 1.52
60	449.6 ± 1.15	443.6 ± 1.15	355.3 ± 1.52	348.6 ± 4.16	529.0 ± 1.00	516.3 ± 1.52
90	450.3 ± 2.51	445.3 ± 1.52	343.0 ± 2.00	341.3 ± 1.52	544.3 ± 1.52	539.3 ± 2.08
120	451.6 ± 1.15	448.6 ± 3.21	329.3 ± 2.08	323.3 ± 3.51	562.3 ± 2.08	549.3 ± 1.15
150	453.3 ± 3.21	450.6 ± 1.15	317.3 ± 2.51	312.0 ± 2.00	583.6 ± 2.51	574.6 ± 1.52
180	455.0 ± 2.00	453.0 ± 1.00	301.3 ± 1.15	296.6 ± 2.08	611.3 ± 1.52	597.3 ± 2.08

hardness of rice was 5.30 kgf. The changes in the hardness were due to the moisture absorption and drying of paddy during the storage period, and were found to be less in PVC coated polyester cover than black PE covered paddy stacks. Similar results were observed for paddy variety 'NERICA 1' (Siebenmorgen et al., 1989; Meullenet, 2000).

Cooking characteristics

The cooking volume of paddy was increasing with the increasing storage periods for both polyethylene covered paddy stacks and PVC fabric coated paddy stacks (Table 1). The rate of change in cooking volume was higher in PVC fabric coated polyester covered paddy stacks compared to polyethylene (PE) covered stacks. The cooking rice volume of polyethylene (PE) covered stacks and PVC fabric coated paddy on day 180 of storage were 453 ml and 455 ml respectively. The initial cooking rice volume of paddy recorded were 440.6 and 441.3 ml.

It was also observed that the peak viscosity of rice was decreasing with increasing storage period for both polyethylene (PE) covered paddy stacks and PVC fabric coated paddy stacks (Table 1) and final viscosity of rice was increasing with increase in storage periods for both plastics covered paddy

for peak viscosity, F_{cric} (4.28) was greater than the F_{calc} (1.07) value. Hence there was no significant difference between the samples. Similarly, for final viscosity the F_{cric} (4.28) was greater than the F_{calc} (1.18) value.

CONCLUSION

It was concluded from cover and plinth storage sludies that the retention of phosphine gas during fumigation was higher in PVC coated polyester than black polyethylene during the storage period. Cooking volume of paddy covered in black polyethylene was 1% less than PVC coated polyester. Grain hardness for storage period showed no significance difference between PVC fabric coated and polyester (PE) covered stacks.

ACKNOWLEDGEMENT

The author would like to acknowledge SRF Ltd, Chennai, for financial support for this project.

REFERENCES

AACC (2000) Approved Methods of American Association of Cereal Chemists. The American Association of Cereal Chemists Inc., St. Paul, Minnesota, USA.

Basavaraja H, Mahajanashetti SB, Udagatti NC (2007) Economic analysis of post-harvest losses in food grains in

India: A case study of karnataka. Agricultural Economics Research Review **20**: 117–126.

Chen Li, Sheng Ling Xiao (2013) Effects on the properties of polyethylene film aging by different methods. Advanced Materials Research **830**: 49–52.

Kanlayakrit W, Maweang M (2013) Postharvest of paddy and milled rice affected physicochemical properties using different storage conditions. International Food Research Journal **20**(3): 1359–1366.

Khankari KK, Patankar SV, Morey RV (1995) A mathematical model for natural convection moisture migration in stored grain. Transactions ASAE **38**(6): 1777–1787.

Lal S, Srivastava BP (1985) Insect pests of stored wheat in Madhya Pradesh (India). Journal of Entomological Research **9**: 141–148.

Meullenet JF, Marks BP, Hankins JA, Griffin VK, Daniels MJ (2000) Sensory quality of cooked long-grain rice as affected by rough rice moisture content, storage temperature, and storage duration. Cereal Chemistry **77**(2): 259–263.

Rajendran S, Gunasekaran N, Muralidharan N (2003) Phosphine retention in new and aged fumigation sheets. Journal of Scientific and Industrial Research **62**: 184–187.

Siebenmorgen TS, Freer MW, Benz RC, Loxwer OJ (1989) Temperature and relative humidity data in bunker stored rice. American Society of Agricultural Engineers **5**(2): 259–264.

Sowbhagya CM, Ali SZ (1991) Effect of pre-soaking on cooking time and texture of raw and parboiled rice. Journal of Food Science and Technology **28**: 76–80.

Wattinee Katekhong and Sanguansri Charoenrein (2012) Effect of rice storage on pasting properties, swelling and granular morphology of rice flour. Asian Journal of Food and Agro-Industry **5**(4): 315–321.