

Use of plastic films in grain stores¹

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SUMMARY. A laboratory study of wheat stored at two different levels of moisture content with and without presence of *Sitophilus zeamais* Motschulsky was performed. Flexible PVC and polythene films as seals were used in order to examine their effectiveness to maintain the wheat quality by comparing changes in moisture content, germination and weight loss. The PVC film showed a high water vapor permeability and it behaved as the permeable muslin control, keeping the grain quality in all tested conditions. The polythene film showed a low water vapor permeability and it allowed the insects development. It seems that plastic films may be useful in grain stores bearing in mind their properties, adequate sealing and protecting them from insect damage, besides they should be selected according to environmental conditions.

RESUMEN. Uso de películas plásticas en el almacenamiento de granos. Se realizó un estudio a nivel laboratorio con trigo almacenado a dos diferentes contenidos de humedad, con y sin *Sitophilus zeamais* Motschulsky. Se utilizó PVC flexible y polietileno como materiales sellantes con el objeto de probar su efectividad para mantener la calidad del grano, comparando los cambios que hay en su contenido de humedad, germinación y pérdida de peso. El PVC mostró tener alta permeabilidad al vapor de agua y se comportó como el testigo (muslin) que era permeable, manteniendo la calidad del grano en todas las pruebas llevadas a cabo. El polietileno tuvo baja permeabilidad al vapor de agua, lo que permitió el crecimiento de los insectos. Todo parece indicar que los plásticos pueden ser de gran utilidad en el almacenamiento de granos, teniendo especial cuidado en sus propiedades y las condiciones ambientales donde serán usados, así como del sellado y protección al ataque de insectos.

INTRODUCTION

The population of the world is still increasing due to a disproportionately large increase in developing countries (1). It is therefore necessary to increase the food availability just to keep the current food situation. A partial alternative to improve food availability consists of improving storage and conservation, leading to reducing post-harvest losses (2).

Several workers have described the potential use of plastics during the process of drying crops (3), storing (4,5,6,7), packaging and transportation of produce (8,9,10). Also, studies have been carried out on the behaviour of insects (11,12,13) and changes of wheat viability in airtight conditions (14,15,16).

The objective of the present study was to examine the effectiveness of two plastic films which are currently used in the construction and food industries. This was done by comparing changes in moisture content, germination, and weight loss of wheat.

MATERIAL AND METHODS

A 100 kilograms of hard red winter wheat, variety Norman, was cleaned up and divided into two equal portions. One of the portions was maintained at the original $14.5 \pm 0.10\%$ of moisture content (MC) and the remainder conditioned to $12.5 \pm 0.25\%$. To obtain this low moisture

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level the grain was spread out in thin layers on perforated trays and exposed to air at $37 \pm 2^\circ\text{C}$. Samples were tested until they reached an even distribution of moisture. Wheat at different moisture content levels was divided into portions of about 0.5 kg each and packed in 150 μm Sharpac, Punnet N° 15B rigid polyvinyl chloride (UPVC) containers. Before packing these containers were treated, just on the lip, with fluon (Brubaker, US Du Pont) to avoid sealed materials damage by insects. As sealed materials, 125 μm high pressure polythene (POLY) film (density=0.1 kg/m²) and 15 μm flexible polyvinylchloride (PVC) stretch film (density=0.02 kg/m²) were used. Ninety UPVC containers were infested each one with 20 unsexed adult insects (*S. zeamais*), which came from the laboratory stocks of the Tropical Development and Research Institute (TDRI), nowadays Natural Resources Institute (NRI). One third of the UPVC containers were covered with muslin as a permeable control. The rest of them were sealed with the PVC and POLY films. Another 90 UPVC containers were prepared as before but without insects. Experimentations were carried out in triplicate for each condition. All containers were stored in a cupboard at $30 \pm 2^\circ\text{C}$ temperature and $35 \pm 2\%$ relative humidity (RH).

Moisture content of samples was determined from two 5 g portions of coarsely ground wheat and dried separately in a forced draught oven at 130°C for 2 hrs. The percentage was recorded as the average of the two determinations and calculated on a wet weight basis.

Germination test was made in four replicas of 20 grains each, which were put into a petri dishes (88x15 mm) on wet filter paper Whatman N°3. Both, normal (radicle and plumule visibles) and abnormal (without presence of radicle or plumule) seedlings were taken as germinated in laboratory conditions ($27 \pm 2^\circ\text{C}$). The initial germination value was $95.0 \pm 2.1\%$.

Weight loss due to insect attack was carried out, in duplicate, on 25 g of wheat by the count and weigh method (2).

RESULTS

Germination

At 12.5% MC and using POLY films as a seal, there was reduction of germination with the presence of *S. zeamais* after 12 weeks of storage (Fig. 1). However, this reduction is in the predicted half-viability value at the same moisture content, as it is indicated in Table 1. Under these conditions, but without insects, the germination percentage was not affected.

With POLY films as a seal, 14.5% MC and *S. zeamais* presence, germination was drastically reduced after 8 weeks of storage (Fig. 2), and this reduction is less than the predicted half-viability value, at the same moisture content, as it is shown in Table 1. As before, the storage without insects did not modify the germination percentage.

Moisture content and weight loss

Using muslin and PVC films as a seal, at 12.5% MC and with *S. zeamais*, there was reduction of moisture content during the first 8 weeks of wheat storage and then it was nearly constant ($8.7 \pm 0.48\%$). Nevertheless, using POLY film the moisture content was almost maintained constant, and the weight loss increased slowly after 4 weeks of storage (Fig. 3). At the same conditions, except insect, moisture content acted as previously for muslin and plastic films, but there was not weight loss.

Wheat stored at 14.5% MC, POLY film as a seal and *S. zeamais* presence, had a strong increment in moisture content and weight loss after 8 and 4 weeks respectively, in fact, at the end of the experimental work there was insect damage on the containers base. But, using muslin and PVC films as a seal, there was moisture content reduction until it reached a constant value of $8.7 \pm 0.53\%$ and the weight loss was practically unaffected (Fig. 4). Under the same conditions, except insects, the moisture content behaved as before in terms of muslin and PVC film, and with POLY film, there was also reduction after 8 weeks until it reaches $11.8 \pm 0.48\%$ and the weight loss was virtually constant.

TABLE 1
PREDICTED AND ACTUAL PERIODS FOR
GERMINATION
TO FALL 50% IN WHEAT AT 30°C

Material	% MC ^a	Predicted ^b	Germination periods (weeks)	
			With Insects	Without Insects
Poly Film	12.5	24	>20	>20
Poly Film	14.5	14	10.5	>20

^a MC= moisture content.

^b By Roberts, relationship (18). $\log p = K_v - C_1 m - C_2 t$, where p=half-viability period (weeks), m=percentage moisture content, t=temperature ($^\circ\text{C}$), $K_v=4.222$, $C_1=0.108$ and $C_2=0.050$. (These values were estimated for wheat).

FIGURE 1
Changes in germination and moisture content with the presence of *Sitophilus zeamais* M. at the initial 12.5% MC.

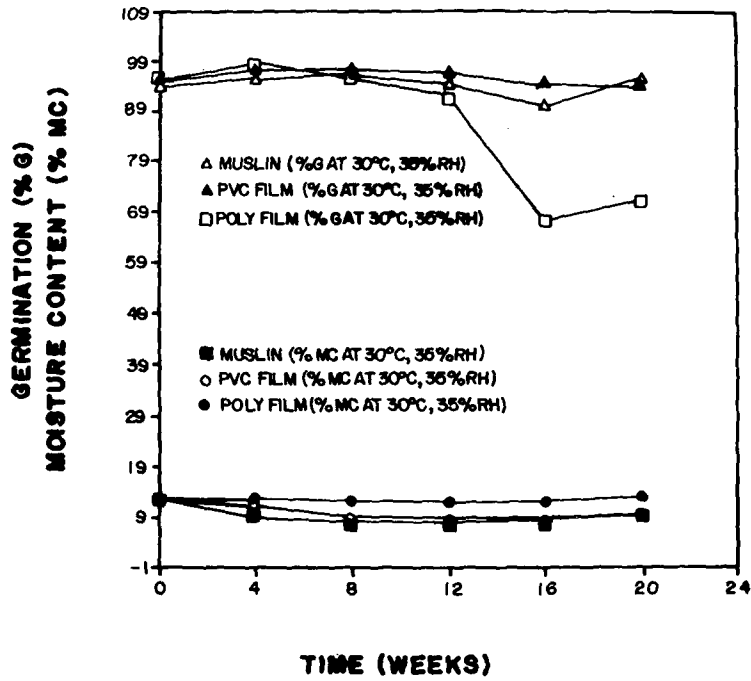


FIGURE 2
Changes in germination and moisture content with the presence of *Sitophilus zeamais* M. at the initial 14.5% MC.

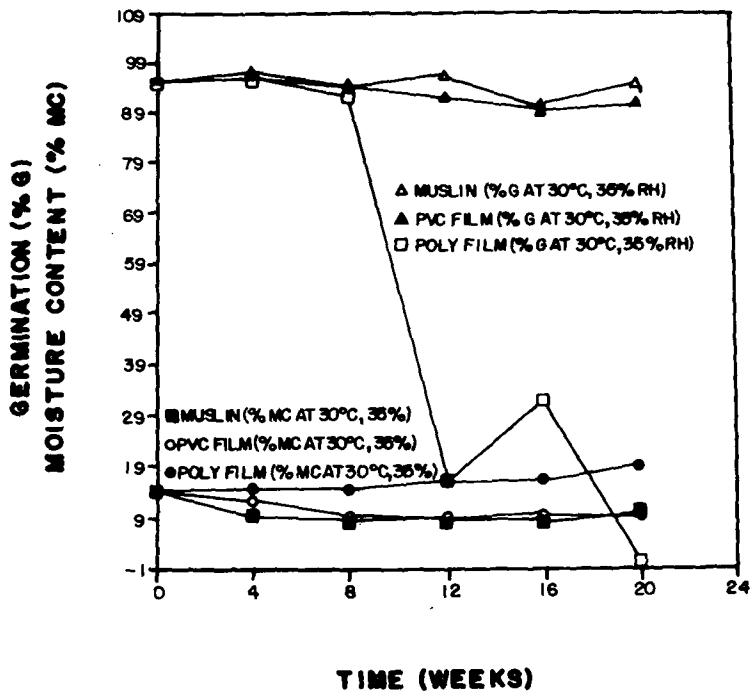


Figure 3
Changes in moisture content and weight loss with the presence of *Sitophilus zeamais* M. at the initial 12.5% MC.

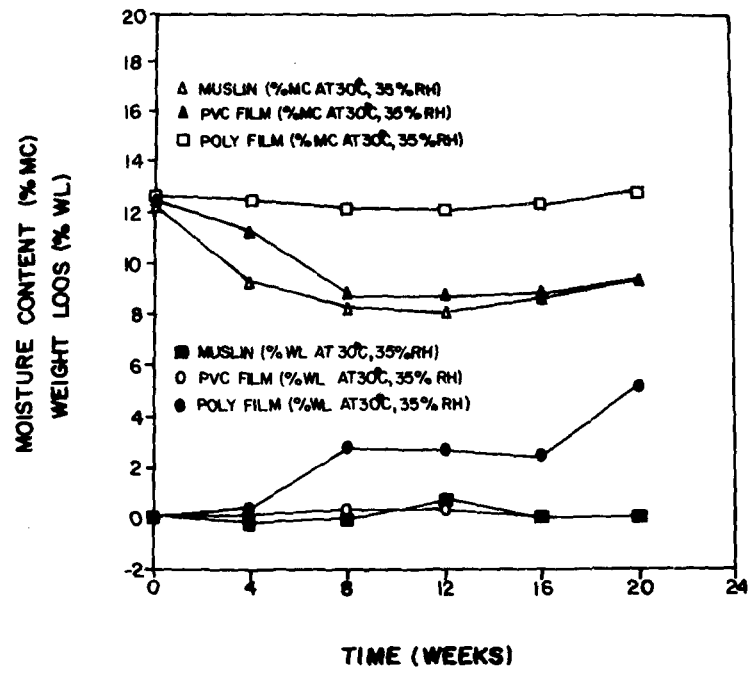
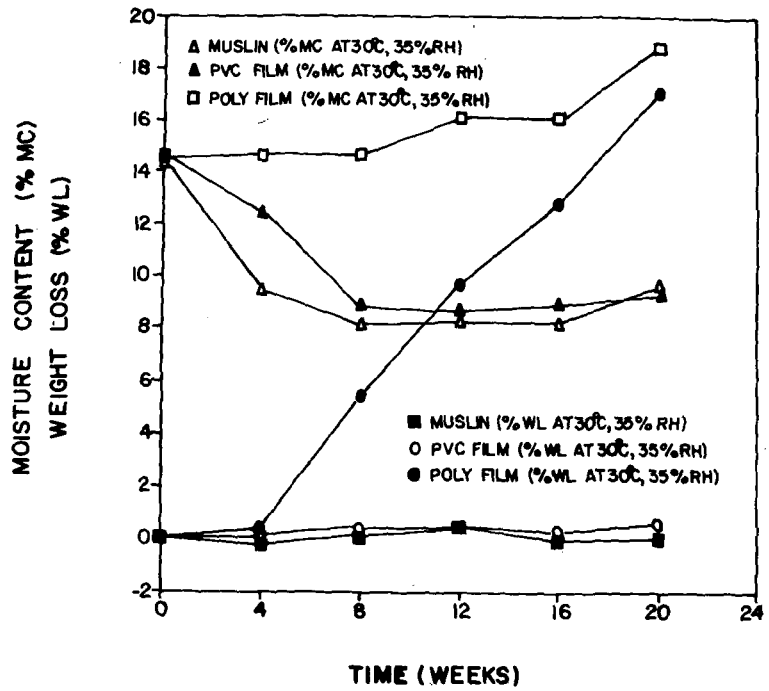


Figure 4
Changes in moisture content and weight loss with the presence of *Sitophilus zeamais* M. at the initial 14.5% MC.



DISCUSSION

During the trial period, at both 12.5% and 14.5% MC and without *S. zeamais*, the PVC film maintained the original quality of wheat stored with regard to germination and weight loss, as it happened using the permeable muslin control. This was due to the plastic film high water vapor permeability, which allowed that wheat reaches the moisture content equilibrium with its surroundings. Under such conditions and insects presence, they were unable to develop and even died by desiccation (17).

In contrast, the POLY film showed low water vapor permeability, therefore, *S. zeamais* had the opportunity to increase in number. When insects are present in any commodity there are metabolic processes with generation of moisture content and heat, then, the translocation of this moisture encourages the growth of fungi and the interaction of these micro-organisms and insects rises more and more heat and moisture (16). As a consequence of these activities, moisture content and weight loss increased and germination decreased, because the heat produced kill most of the wheat embryos. Obviously, these events are more marked at the highest moisture content. On other hand, when moisture content and temperature increase and food supply decreases, insects leave the infested grain and migrate (17). Hence, *S. zeamais* escaped from its environment boring the base of the wheat containers.

From the analysis carried out, the following recommendations may be suggested:

1) The PVC plastic film may be useful in grain stores in arid and semi arid conditions at any level of infestation and/or moisture content, but providing that a hermetic seal exists.

2) The POLY film may be useful in grain stores in tropical and arid conditions with a safe grain moisture content and previous treatment against insects before storing, but providing that a hermetic seal exists.

3) Plastic films used in grain stores must be protected from insect attacks.

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