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Efficiency of some Hermetic Monolayer Plastic Packing Materials for Protecting Wheat Grains against *Sitophilus oryzae*

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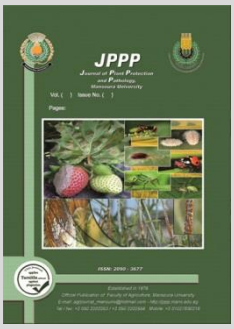

ABSTRACT

Packing is an important process in storage of wheat grain. Current study focused on using different packages and different colorless or colored included, red, blue, black and yellow colors as wheat grain protectants. Polypropylene (PP) was the best with 50 emerged adults of *Sitophilus oryzae*, 12.33% damage and 6.83% weight loss a compared with sack cloth which had 135 emerged adults, 25% damage and 13.50% weight loss. PP also had the best germination with 63.33%, 1.41% Ash and 10.48% protein of wheat grain after three months storage. Yellow color with all package types achieved the greatest promising findings it reduced the % damage and % weight loss compared to the other tested colors under study for example with PP package the damage of wheat grain with yellow color was 8.67% while with control the damage was 12.13% followed by blue color with 11%. The study also mentioned that the interaction between packages type and colors affected on *S. oryzae* development and also had a significant effect on chemical and physical components of wheat grain.

Keywords: Stored grain, Packing, Rice weevil, Polypropylene, germination

INTRODUCTION

Wheat represents the main food for most of Egypt's Population, alongside of rice and corn. Egypt's production of wheat grown in three million acres represent half the required consumption (FAO, 2015). During storage, the wheat crop suffers from the attack of some stored grain pests, the most important of which is the rice weevil, (*Sitophilus oryzae*) which reduces the weight of the crop. quality, and makes it unsuitable for consumption many methods were used to combat this insect such as heat, drying, fumigation, and mixing with chemical materials such as pesticides or natural materials such as plant products, oils and, powders and extract (Abouelatta *et al.*, 2020). The most important of these methods was" chemical pesticides, which caused many problems to environment and human health besides the development of insect resistance (Masoumzadeh *et al*., 2014).

Specialized Scientists have worked hard to find ways to protect grains as an alternative to pesticides. The use of different types of plastic packing materials with different layers, specifications, and colors, which have proven their efficiency in repelling insect attacks due to their inability to penetrate these containers, as well as the possibility of killing them due to the increase in Carbon dioxide and the decrease in the percentage of oxygen needed for the breathing process (Hou *et al*., 2004).

Some previous studies has proven the efficiency this method in protecting grain to a degree that may be equivalent to the use of some gases used in the process of the fumigations stored materials (Khalil et al., 2022).

Insect resistant packing is an alternative method to prevent damage of food from insects. Insect resistant packaging of food materials is the last line of defense for the producer against insect attack (Hou *et al*, 2004). Hermetic storage is one alternative to Synthetic pesticides recommended for storage of agricultural commodities (Navarro 2006, 2012). There are various hermetic options being used globaly at both commercial storage, namely Silo bags and Cocoons (Navarro and Navarro, 2014) and small scale storage, namely metal Silos, plastic silos, hermetic bags, Grain Safes, and plastic containers (Walker *et al*., 2018).

Plastic bags are acceptable to the customer and are lighter in weight than some other forms of packaging (Kindle 2001; Connolly 2011). Polyethelene (PE) and polypropylene (PP) are frequently used plastic packaging (Licciardello *et al*., 2013).

Various Coleoptera have color vision to locate the host. Color preferences by economically important insects have been demonstrated by (Abo-Arab and Salem 2018). *S. oryzae* prefers green and red colors, these colors are attractive to this insect and that proofed that *S. oryzae* has color vision (Azmy, 2022)

Based on the above, several laboratory experiments were conducted to evaluate these packages which are: Estimating the possibility of the rice weevil being able to penetrate from outside these containers to inside them. Development this insect inside the containers and estimating the reduction in weight, moisture content and quality standards for the wheat grain stored insides these packages. In addition to conducting a chemical analysis of some components of the grain used, also to evaluate colored and uncolored plastic packing materials with different physical and mechanical specifications to combat rice weevil and the effect of tested packages on stored seeds.

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The aim of this work to evaluate the effect of packing type and colors on *S. oryzae* and find a new method to protect stored products without chemical pesticides.

MATERIALS AND METHODS

Insect

Rice weevil *Sitophilus oryzae* (L.). (Order: Coloeptera) (Fam. Curculionidae)

The adults of rice weevil, *S. oryzae* 1–2 weeks old, used in this study were obtained from laboratory colony, established and reared on wheat grain (*Triticum aestivum*) under laboratory constant conditions of 26 ± 1 °C and (65 ± 5 R.H.). New adults 2–3 weeks old were selected for toxicity evaluation test (Feng et al. 2009).

Plastic packing materials

The plastic packing materials shown in Table (1) were obtained from the Arabic Medical Packing Company (Flexpack), Cairo, Egypt except sackcloth that was obtained from the local market.

The properties, mechanical, physical and permeability of tested packages were shown in Table (1). Sackcloth packing material was as conventional bags used for comparison and their properties have not been measured.

Table 1. Mechanical, Physical and permeability properties of plastic packing materials used:

property	Plastic packing materials			
	HDPE	LDPE	MPP	PP
Mechanical impact strength N (cm^2)	3100	3000	11500	11900
Elongation	95%	90%	85%	84%
heat sealing temp (C^0)	130	140	130	130
printability	Poor(p)	High(h)	Medium(m)	Poor(p)
Physical thickness (um)	85	90	40	45
Clarity	Transparent	Transparent	opaque	Transparent
water vapor (9/ m^2.d)	10.3	11.6	1.1	1.2
permeability 0^2 (ccm^2. d)	460	480	950	951

First experiment:

Penetration ability of *Sitophilus oryzae*.

In this laboratory experiments, four types of plastic packing materials viz low density, high density of polyethelene, Polypropylene and milky Polypropylene were used. Sackcloth were used as reference bags. The all four types have only one layer of the plastic material. The colorless bags of these patterns were filled with 50 gm of wheat grain and tightly closed. Four bags of the all colorless types were introduced in plastic jars (1/2 liter) and 50 adults of *S. oryzae* were released external around the bags.

Jars were covered with muslin and incubated at the same conditions of the original culture. Three replicates of each type were done. The numbers of holes and adults penetrated into the bags were recorded after 10 days of treatment.

Second experiment:

Effect on progeny of *Sitophilus oryzae* and quality parameters of wheat grain:

To assessment the efficiency of plastic packing materials used in this experiment for disruption the life cycle development of *S. oryzae* adults, sacks of each type were filled with 50g of wheat grain, ten unsexed pairs of *S. oryzae* adult (7 days old) were transferred to each sack. Then sacks were sealed by sealing machine except sackcloth which tightly closed with plastic tape. Sacks which have not containe insects were used as untreated control treatment. Three replicates of each packing pattern were done. The plastic bags used in two ways, one was colorless and the other included color bags of four colors (red, blue, yellow and black) to study the effect of different colors on the behavior of *S. oryzae*. At the end of experiment (three months) the important parameters such as number of holes, number of adults, % damage, % weight loss and quality criteria, % germination, % Moisture content (M.C.), % ash, % ether content and/% protein content were measured and recorded.

Analysis of ether extract, Ash and protein of wheat grains

Proximate composition of moisture content, crude protein, crude ether extract, crude protein and total ash were carried out according to the AOAC (2013) procedures.

Statistical analysis

Statistical analysis was performed using one-way ANOVA. The means were compared using Duncan's Multiple Range Test (Duncan, 1955) at a 5% probability level. All analyses were conducted by "SPSS" computer software package version 23.

RESULTS AND DISCUSSION

Results

Effect on development of *Sitophilus aryzae*:

Data summarized in Table (2) showed that *S. orayzae* adults failed to penetrate the four rested plastic package whether from outside or inside the package. While *S. oryzae* adults enabled to inside the sackcloth bags through 10 days after releasing adults surround the bags. Furthermore the four tested bags reduced the % damage, % Loss and affected the development of *S. oryzae* compared to the sackcloth bags. Number of adult emergence ranged between 50 - 57.0 adults compared to 135 adult in sackcloth as convention package material. Also, % damage and % weight loss ranged between 12.33 - 17.67 and 6.83 - 8.67, respectively in comparison with 25.00 and 13.50 with sackcloth.

Table 2. Development of *Sitophilus aryzae*, holes, % damage, weight % loss and their relationship to package type after three months of wheat storage.

Type of package	No. of hole	No. of adults emerged	% damage	% Weight loss
LDPE	0	57.00_b	14.33_b	7.87_b
HDPE	0	75.00_a	17.67_a	8.67_a
MPP	0	55.00_b	12.33_c	7.03_c
PP	0	50.00_c	12.33_c	6.83_c
Sackcloth	0	135.00	25.00	13.50

All adults of *S. oryzae* entered inside the sackcloth bags.

As regards the quality parameters studied and presented in Table (3), results had the same trend of data in Table (2) where PP bags achieved the best parameters followed by MPP, LDPE and HDPE. The highest % germination, % Ash, ether content and % protein content was found with PP followed by the three plastic bags afore mentioned, respectively. Additional that PP bags kept the moisture content (MC) of stored wheat grain at the least level compared to the other three bags. The highest % Ash was found with the PP bags among the tested bags.

Effect of each packing type on the studied parameters:

Results Summarized in Table (4) show the effect of each packing. According obtained data PP monolayer type demonstrated achieved the least values of both % damage, % weight loss,% moisture content while the same type performed the highest values of both% germination,% ash content,% of ether content (fats) and % protein content achieving the promising effect concerning the protection of the stored wheat grain for the period storage. MPP type had the second order followed by LDPE and HDPE types.

Table 3. effect of package type on quality parameters of wheat grain after three months of infected wheat storage.

Type of package	% germination	% M.C.	%Ash content	%ether content	% protein content
LDPE	58.33$_b$	13.33ab	1.10$_c$	16.69$_b$	10.33$_a$
HDPE	55.00$_c$	14.42a	1.08$_c$	16.23$_c$	10/59$_b$
MPP	62.00$_a$	12.52ab	1.13$_b$	17.61$_b$	10.40$_a$
PP	63.33$_a$	11.91b	1.41$_a$	17.90$_a$	10.48$_a$
Sackcloth	54.10c	14.33a			

Means of followed by the same letter (s) within each column are not significantly different (Duncan's multiple range test at P=0.05).

Table 4. Mean values of damage%, weight loss%, germination%, moisture content%, ash content%, ether content% and protein content% as affected by type of packages.

Packages type	Damage %	weight loss%	Germination %	moisture content%	Ash content%	ether content%	protein content%
LDPE	11.20^b	3.853^{ab}	65.00^b	11.27^b	1.512^c	16.69^b	10.87^b
HDPE	12.00^a	4.167^a	63.93^c	11.29^a	1.492^c	16.23^c	10.79^b
MPP	10.60^c	3.507^{bc}	66.47^{ab}	11.00^c	1.544^b	17.61^a	10.97^b
PP	10.40^c	3.327^c	67.20^a	10.77^d	1.644^a	17.90$_a$	11.07^a
L.S.D at 5%	0.51	0.353	1.65	0.13	0.023	0.38	0.04

Means of followed by the same letter (s) within each column are not significantly different (Duncan's multiple range test at P=0.05).

Effect of each color with the studied Parameters with PP package:

Results obtained in Table (5) elucidated the effect of each color with the PP plastic packing materials (it was the best package in previous experiments). Data obtained illustrated that yellow color gave the best effect for protecting the grain infested with *S. oryzae* adults through the storage period. This yellow color reduced % damage, % weight loss and kept the moisture content at the least level (9.96%). Chemical analysis of wheat grain after three months of storage exhibited that the highest values of % Ash content (1.788%), % ether content (23.51%) and% protein content (11.58%) compared to colorless type (control) which had 14.17% damage, 7.66% weight loss, 59.67% germination, 13.05 moisture content, 1.18% ash content, 17.11% ether content and 10.33% protein content.

Effect of each color with PP plastic type:

These results show that, any color of four tested colors with the all packing types had finalized protection to the stored grain exceed colorless bag (as conventional type) of plastic materials. Based on these results, it can be said that the tested colored plastic containers have a better therapeutic effect than their non- colored counterparts.

Table 5. Mean values of damage%, weight loss%, germination%, moisture content%, ash content%, ether content% and protein content% as affected by PP plastic package type colors.

Colors	Damage %	weight loss%	Germination %	moisture content%	ash content %	ether content%	protein content%
Red	11.59^b	2.867^c	65.83^c	10.99^c	1.598^c	20.65^c	10.85^c
Yellow	9.00^c	1.775^b	70.33^a	9.96^e	1.788^a	23.51^a	11.58^a
Blue	11.58^b	4.042^b	64.17^c	11.46^b	1.485^d	19.27^d	10.59^d
Black	9.92^c	2.283^d	68.25^b	10.32^d	1.690^b	21.58^b	11.28^b
Control	14.17^a	7.600^a	59.67^d	13.05^a	1.180^e	17.11^e	10.33^e
L.S.D at 5%	0.57	0.395	1.85	0.15	0.026	0.42	0.12

Means of followed by the same letter (s) within each column are not significantly different (Duncan's multiple range test at P=0.05).

Effect of interaction between types and colors of packages.

A laboratory experiment was carried out to evaluate the effectuation of interaction between types and colors of packages, where certain amounts of infested wheat grain were stored in colored plastic bag and their non- colored counterparts and parameters recorded in Table (6) were determined after the period of storage (three months). Based on results in Table (6), the yellow color with all package types and also the pp plastic type with the all colored tested achieved the greatest promising findings where these color (yellow) and type (PP) reduced the % damage and % weight loss compared to the other tested colors and type under study. Furthermore, they maintained the quality parameters (moisture content, % Ash, % ether content and % protein), where they demonstrated the highest% germination and the components of chemical analysis of wheat grain.

Table 6. Mean values of damage%, weight loss%, germination%, moisture content%, ash content%, ether content% and protein content% as affected by the interaction between types and colors of packages.

Type of packages	colors	Damage %	weight loss%	Germination %	moisture content%	ash content%	ether content%	protein content%
	Red	10.67^{dg}	2.967^{eg}	65.33	11.15^{gh}	1.570^{f}	20.41^{def}	10.82^{de}
	Yellow	9.33^{hi}	1.933^{hi}	70.00	10.06^{i}	1.760^{b}	22.48^{b}	11.41^{bc}
LDPE	Blue	11.67^{cd}	4.000^{de}	63.33	11.54^{ef}	1.460^{hi}	19.15^{d}	10.54^{fg}
	Black	10.00^{fgh}	2.500^{fgh}	68.00	10.26^{kl}	1.670^{d}	21.32^{cd}	10.26^{c}
	Control	14.33^{b}	7.876^{b}	58.33	13.33^{b}	1.100j	16.69^{i}	10.33^{b}
	Red	10.67^{dg}	3.233^{ef}	64.67	11.19^{g}	1.570^{f}	20.26^{ef}	10.76^{def}
	Yellow	9.33^{hi}	1.967^{hi}	69.33	10.15^{i}	1.740^{bc}	22.26^{b}	11.37^{c}
HDPE	Blue	12.33^{c}	4.467^{d}	63.33	11.64^{de}	1.410i	18.82^{g}	10.52^{fg}
	Black	10.00^{fgh}	2.500^{fgh}	67.33	10.54^{ik}	1.660^{de}	21.29^{cd}	11.23^{c}
	Control	17.67^{a}	8.667^{a}	55.00	14.42^{a}	1.080j	16.23^{i}	10.09j
	Red	10.67^{dg}	2.700^{fgh}	66.33	10.86^{hi}	1.610^{ef}	20.82^{de}	10.90^{d}
	Yellow	8.67^{i}	1.800^{hi}	70.33	9.95^{lm}	1.780^{b}	24.37^{a}	11.63^{b}
MPP	Blue	11.33^{cde}	3.900^{de}	65.00	11,41^{fgh}	1.510^{gh}	19.37^{d}	10.61^{eh}
	Black	10.00^{fgh}	2.100^{ghi}	68.67	10.25^{kl}	1.690^{cd}	21.82^{bc}	11.29^{c}
	Control	12.33^{c}	7.033^{c}	62.00	12.52^{c}	1.130j	17.61^{h}	10.40^{hi}
	Red	10.33^{fg}	2.567^{fgh}	67.00	10.77^{d}	1.640^{de}	21.09^{cde}	10.92^{d}
	Yellow	8.67^{i}	1.4400^{i}	71.67	9.69^{m}	1.870^{a}	24.92^{a}	11.92^{a}
PP	Blue	11.00^{def}	3.800^{de}	65.00	11.25^{fg}	1.560^{fg}	19.73^{fg}	10.69^{dg}
	Black	9.67^{ghi}	2.033^{hi}	69.00	10.21^{l}	1.740^{bc}	21.87^{bc}	11.32^{c}
	Control	12.13^{c}	6.833^{c}	63.33	10.91^{d}	1.410^{i}	17.90^{h}	10.48^{ghi}
L.S.D at 5%		1.14	0.789	N.S.	0.29	0.052	0.84	0.25

Discussion

Results explained that propylene bags were the best plastic materials regarding the protection of wheat grain through the period of storage (three months) followed by milky propylen, low density polyethelene and the least was high density polyethelene.

The least moisture content and the highest % Ash may be the main factors that distinguished PP bags to be the best in protecting wheat grains compared to other bags. The results pronounced demonstrated that PP package type is the best suitable for grain storage for three months among four studied package types. The differences between the packages nearly due to the mechanical physical and permeability properties. These results are in accordance with yar *et al*., (2017) who found that protein and starch content played role in minimized the weight loss of wheat grain through the period of storage. Gomaa and Salem (2018) evaluated three types of packages (high density polyethylene (HDPE), polyamide/polyethylene (PA/PE) and polyester/aluminum/polyethylene (PET/AL/PE) as wheat grain protectants against *Tribolium castaneum* and *Rhizopirtha dominica* and found that (PET/AL/PE) was the best bags and advised to be used in wheat flour and wheat grain storage.

In agreement with current study, Yar *et al.*, (2017) evaluated plastic packages as stored flour protectants against *T. castaneum* and found that PP package was the best and achieved the least weight loss and the least population after 90 days of storage compared to PE and PCV.

Tripetch and Borompichaichartkul (2019) evaluated HDPE as stored bags for green coffee and found that it was efficient and protected coffee for 15 months of storage and protected stored coffee from color changes.

In the same line with current study Azmy (2022) studied the preference of colors of *Sitophilus oryzae* and found that the green and red colors were the most preferred colors while the white color was the least preferred color among six tested colors (red, white, green, black, yellow and blue). Green color is the most attractive color to *T. castaneum* with 17.3% while blue color was the less attractive color to *T. castaneum* with 3% and *Callosobrucus chinensis* blue color was the most attractive color with 16% attraction while the black color achieved the least attraction with 2% (Bugti *et al.*, 2021).

CONCLUSION

Based on these results the current study recommends the use of storage under controlled conditions in monolayer plastic bags, whether colored with the colors under study, and it is the best method compared to the same uncolored bags and also considering it one of the means of integrated control for pests of grains and stored products. Finally, the findings in the current study dramatically showed. that the hermitic storage in the all monolayer packing films (LDPE, HDPE, MPP and PP) whether colored with (red, yellow, blue and back) or uncolored resisted the attack of *S. oryzae* whether inside (infested wheat grain) or outside the all packing types where they controlled the development *S. oryzae* and reduced the damage and weigh loss of wheat grain. Also they maintained the quality parameters of wheat grains through storage period.

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كفاءة بعض مواد التغليف البلاستيكية أحادية الطبقة المحكمة الغلق في حماية حبوب القمح ضد حشرة سوسة الأرز *Sitophilus oryzae*

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قسم بحوث آفات الحبوب والمواد المخزونه – معهد بحوث وقاية النباتات – مركز البحوث الزراعية – الدقي – الجيزة – مصر

الملخص

التعبئة هي عملية مهمة في تخزين حبوب القمح. ركزت الدراسة الحالية على استخدام عبوات مختلفة عديمة اللون أو ملونة بأربعة ألوان هي الأحمر والأزرق والأسود والأصفر كحاميات لحبوب القمح. في اختبار التأثير على الخلفة كان البولي بروبيلين (PP) هو الأفضل ب 50 فردًا من الجيل الأول من *Sitophilus oryzae*، حيث بلغ الضرر الناتج في الحبوب الى 12.33% وفقدان الوزن بنسبة 6.83% مقارنة بالخيش الذي ظهر فيه 135 فردا بالغًا في الجيل الأول، وتلف 25% وفقدان الوزن بنسبة 13.50%. كان PP أيضًا أفضل إنبات بنسبة 63.33%، 1.41% رماد و10.48% بروتين لحبوب القمح بعد ثلاثة أشهر من التخزين. حقق اللون الأصفر بجميع أنواع العبوات أعظم النتائج الواعدة حيث قلل نسبة الضرر ونسبة فقدان الوزن مقارنة بالألوان الأخرى المختبرة تحت الدراسة على سبيل المثال مع عبوة PP بلغ تلف حبوب القمح ذات اللون الأصفر 8.67% بينما كان الضرر 12.13% يليه اللون الأزرق بنسبة 11%. كما أشارت الدراسة إلى أن التداخل بين نوع العبوات وألوانها أثر في تطور (سوسة الأرز) *S. oryzae* كما كان له تأثير معنوي على المكونات الكيميائية والفيزيائية لحبوب القمح.