EFFICACY OF A MODIFIED ATMOSPHERE ON CERTAIN STORED PRODUCT PESTS.*

Z.A. HALAWA

Plant Protection Research Institute, Agricultural Research Centre, Giza, Egypt.

(Manuscript received 5 February, 1997)

Abstract

Experiments were carried out to evaluate the efficacy of using a modified atmosphere of approximately 1% O_2 plus 99% N_2 against some stored product pests, namely, the grain and flour mite *Tyrophagus Putrescentiae* (schrank) and *Aleuroglyphus ovatus* Troupea, and the cow-pea beetle, *Callosobruchus maculatus,* (F.) in the laboratory at 26^oC as well as 6^oC.

Results showed that the time required to achieve certain kill for the various stages of the two mites species and insect species was considerably longer at the lower temperature than at the higher one.

Results showed also that, the adult stage of the two experimented mite species was the most susceptible to the modified atmosphere, whereas the eggs were the most tolerant.

Concerning, *C.maculatus* the adult as well as the larval stages were susceptible, while the eggs and the pupae were slightly more tolerant.

The LT 99-values regestired for the various stages of *T.putrescentiae* were 13, 15, 14 and 23 days at 26^oC and 29, 35, 32 and 60 days at 6^oC for the adults, nymphs, larvae, and eggs, respectively. while the LT99-values of *A.ovatus* were 23, 17, 21 and 32 days at 26^oC and 27, 34, 36 and 32 days at 6^oC for the various stages, respectively, but, were 5.4, 26, 29 and 31 days at 26^oC and 17, 34, 48 and 28 days at 6^oC for adults, larvae, pupae and eggs of *C.maculatus,* respectively.

The obtained results revealed that *T.Putrescentiae* was the more tolerant than *A.ovatus* within all stages, while *C.maculatus,* was the most susceptible to the effect of the gas.

INTRODUCTION

Modified atmospheres as means of disinfestation can help to avoid problems of residues with fumigants and chemical insecticides and the onset of resistance.

To avoid the problem of using methyl bromide and synthetic insecticides for controlling stored product pests, an alternative technique, i.e. the application of modified atmosphere (M.A.) is available. This technique involves changing the proportion of the normal atmosphere constituents of O_2, N_2 and CO2 in the store so as to create an atmosphere lethal to insects at an adequate length of time (Nvarro and jay 1987). The time required to achieve a certain mortality upon exposure to a given atmospheric gas composition is dependent on the environmental temperature (jay, 1984).

Oxygen concentration around 1% or less are usually recommended for insect control, but some species can be controlled using O_2-concentration as high as 4% (Reichmuth, 1986).

Bond (1989) mentioned that insects can survive without Oxygen or with deplected Oxygen for varying lengths of time, depending on insect species, stage of development, temperature, previous history of the population and some other factors.

The efficacy of a modified atmosphere containing about 1% O_2 plus 99% N_2 on some stored product insects; *S.oryzae* (L.), *R. dominica* (F.) and *T.castaneum* (Herbst) at two test temperatures were acheived by El-Lakwah et al. (under published).

Similarly, this study aims to evaluate the efficacy of using a modified atmosphere of approximately 1% O_2 plus 99% N_2 against three stored product pests, namely, the grain and flour mites *Tyrophagus Putrescentiae* (Schrank) and *Aleuroglyphus ovatus* Troupeau and the cowpea beetle, *Callosobruchus maculatus* (F.) at higher and lower temperatures.

MATERIALS AND METHODS

Pests used: Two mites species and the cowpea beetle were used in the present study. Mites were *Tyrophagus Putrescentiae* (Schrank) and *Aleuroglyphus ovatus* Troupeau. Mites were reared on wheat flour in (2.5 x 16 cm.) glass tubes were kept at 26±1^{o}C and 85±5% RH in desiccators using potassium hydroxide solution (Solomon, 1951).

The cowpea beetle *Callosobruchus maculatus* (F.) was reared on cowpea seed at 26±^{o}C and 60±5% RH. Insects were bred in small glass jars containing about 100 G. of the food material used.

Gas-tight apparatus : A circulatory multi-flask apparatus was established to provide exposure room suitable for the concentration applied. Gases were recirculated through a series of glass flasks of one litre with ground glass joints. The flasks were connected to a pressure cylinder containing around 1% oxygen + 99% nitrogen, which was connected with a pressure regulator. The valve of the cylinder was opened for two minutes in order to fill the flask with the nitrogen gas, after filling, the flask was closed tightly using two metal clips and rod glasses. Pests (mites and insect) in the gas-tight flasks exposed to the atmosphere of around 99% N_2 and 1% O_2, were kept at 26°C or 6°C for varying exposure periods.

Pre-exposure procedure : Adults and immature stages of the mite species used in the experiments were exposed to the atmosphere containing (1% O_2 + 99% nitrogen) in glass tubes (2x 4.5 cm) covered with muslin. Batches of about 200 individuals of mites were placed in each glass tube. At each exposure period three replicates of the mites were used.

Adults of C.maculatus (1-3 days old) were taken for the exposure experiments. Wire gause cages were filled with about 2 gm cowpea seeds.

Batches of 30 adult insects were inserted into each cage, and covered with rubber stoppers. For immature stages (eggs 24 hours old, larvae 10-11 days old, and pupae 2-4 days old), 5 gm portions of cowpea seeds were taken from the rearing culture and put in wire cages and then covered with rubber stopers. Three replicates were used in each treatment.

Post - exposure procedure : After exposure, mites were transferred and kept at 26 ± 1°C and 85 ± 5% RH for assessment of the mortality under the microscope.

The mortality of the mobile stages was assessed after 48h, the treated and untreated eggs were kept for at least 5 days to hatch and the hatchability was corrected using abbott's formula, 1925.

But, to *C.maculatus* after the desired exposure periods to the gas, the flasks were aeriated and insects transferred to plastic vessels covered with muslin and kept at 26 ± 1°C and 60 ± 5% RH for mortality assessement.

Adult morality was determined 2 days following exposure, the emergence of immature stages were recorded after 30, 45 and 60 days following the treatment. Mortalities of immature stages were determined according to the following equation

$$\% \text{ Mortality} = (AC-AT) * 100/AC$$

AC = No of adults emerged in control. AT = No. of adults emerged in treatment.

Statistical analysis : Lethal time values were determined by probit analysis (Finney 1971) using a computer program of (Finney 1951).

RESULTS AND DISCUSSION

The lethal times and parameters of probit regression line estimates for the various stages of *T.putrescentiae, A.ovatus* and C.maculatus to an atmosphere containing about 1% O_2 + 99% N_2 at 26 and 6^{o}C were tabulated in Tables 1-3.

Data obtained generally showed that the LT90 for the different stages of both mites species and for the cowpea beetle stages (*C.maculatus*) increased significantly with the decrease in temperature.

The suceptibility of different pests exposed to the effect of the gas varied obviously.

Talbe 1 showed that the LT90 values for *T.putrescentiae* at 26^{o}C were 5, 5, 5 and 9 days for the adults, nymphs, larvae and eggs, respectively, meanwhile the corresponding values at 6^{o}C were 11, 11, 9 and 14 days.

It was obvious from the results obtained within both temperatures used that the egg stage was the most tolerant to the effect of the gas.

Concerning LT50, LT95 and LT 99 values it is clear that they followed the same trend mentioned above.

LT90 values mentioned in Table 2 concerning the different stages of *A.ovatus* showed that these values at 26^{o}C were 11, 9, 10 and 14 days for the adults, nymphs, larvae and eggs, respectively, the corresponding values at 6^{o}C were 13, 16, 14 and 15 days.

LT50, LT95 and LT 99 followed the same trend indicating that these values increased with the decrease in temperature.

Concerning the mites tested (*T.putrescentiae and A.ovatus*) the adult stage was the most sensetive followed by the larvae stages, meanwhile the egg stage was the most tolerant.

Table 3 indicate the LT90 values for the different stages of *C.maculatus* at 26 and 6^{o}C, these values were always higher at 6^{o}C than those at 26^{o}C.

From the data obtained, it is clear that within the two tested temperatures the adult stage was the most susceptible. LT50, LT95 and LT99 showed the same trend.

Table 1. Lethal times and parameters of probit regression line estimates for the various stages of *Tyrophagus putrescentiae*, exposed to a modified atmosphere containing around 1% O_2 + 99% N_2 at 26 and 6^oC and 85±5% R.H.

Stages	Lethal times and their 95 % confindence (days)				Parameters of regression line		
	LT50	LT90	LT95	LT99	Slope ± SE	F	a ± SE
	at 26^oC						
Adults	2(1.5-2.2)	5(4-9)	7(5-13)	13(8-29)	2.73±0.30	5	0.49±0.52
Nymphs	1.5 (1-2)	5(4-13)	8(55-23)	15(8-74)	2.33±0.28	5	1.35±0.64
Larvae	1.3(0.9-2)	5(3.4-10)	7(5-17)	14(8-52)	2.26±0.33	5	1.60±0.54
Eggs	2.4(2-3)	9(7-11)	12(10-17)	23(17-36)	2.36±0.18	5	0.84±0.32
	at 6^oC						
Adults	3(2.5-5)	11(7-26)	15(10-46)	29(15-132)	2.54±0.42	5	0.13±0.82
Nymphs	3(2-4)	11(7-60)	17(9-150)	35(14-845)	2.11±0.47	5	1.16±0.91
Larvae	2(1-3)	9(5-48)	14(7-141)	32(13-1114)	1.88±0.44)	5	1.90±0.84
Eggs	3(1-4)	14(7-379)	24(10-1826)	60(18-3560)	1.68±0.45	5	2.00±0.87

SE = standerd error of regession line, a = Axis intercept of regression line,
F = Degrees of freedom

Table 2. Lethal times and parameters of probit regression line estimates for the various stages of *Aleuroglyphus ovatus* exposed to a modified atmosphere containing around 1% O_2+99% N_2 at 26 and 6^oC and 85±5% R.H.

Stages	Lethal times and their 95 % confindence limits (days)				Parameters of regression line		
	LT50	LT90	LT95	LT99	Slope ± SE	F	a ± SE
	at 26^oC						
Adults	4 (3-5)	11 (8-22)	14 (9-35)	23 (14-87)	3.13 ± 0.54	5	3.04 ± 0.39
Nymphs	4 (3-5)	9 (7-15)	11 (9-21)	17 (11-42)	3.69 ± 0.57	5	2.78 ± 0.39
Larvae	4 (3-5)	10 (7-15)	13 (9-23)	21 (14-50)	3.18 ± 0.44	5	3.12 ± 0.31
Eggs	6 (4-7)	14 (10-34)	19 (12-54)	32 (18-135)	3.06 ± 0.53	5	2.73 ± 0.40
	at 6^oC						
Adults	5 (4-7)	13 (10-24)	17 (12-37)	27 (17-87)	3.34 ± 0.55	4	2.56 ± 0.47
Nymphs	6 (4-9)	16 (11-85)	21 (13-183)	34 (18-782)	3.15 ± 0.75	4	2.48 ± 0.67
Larvae	4 (2-6)	14 (10-47)	19 (12-106)	36 (18-488)	2.54 ± 0.55	4	3.36 ± 0.47
Eggs	7 (5-8)	15 (12-25)	20 (15-37)	32 (21-75)	3.42 ± 0.49	5	2.18 ± 0.46

SE = standerd error of regession line, a = Axis intercept of regression line,

F = Degrees of freedom

Table 3. Lethal times and parameters of probit regression line estimates for the various stages of *Callosobruchus maculatus*, exposed to a modified atmosphere containing around 1% O_2+99% N_2 at 26 and 6°C and 60±5% R.H.

Stages	Lethal times and their 95 % confindence limits (days)				Parameters of regression line		
	LT50	LT90	LT95	LT99	Slope ± SE	F	a ± SE
	at 26°C						
Adults	0.9 (07-1.1)	2.4 (1.8-4.3)	14 (9-35)	5.4 (3.3-15.2)	2.9 ± 0.40	4	1.10 ± 0.56
Nymphs	2.8 (1.3-4.6)	9.5 (5.5-78.5)	11 (9-21)	26 (10.7-1316)	2.40 ± 0.57	4	0.58 ± 1.10
Larvae	4.3 (1.3-4.6)	12.3 (8-39)	13 (9-23)	21 (14-50)	2.80 ± 0.57	5	-0.68 ± 1.80
Eggs	3 (1.1-4.4)	10 (6-66)	19 (12-54)	32 (18-135)	2.20 ± 0.53	5	1.00 ± 1.06
	at 6°C						
Adults	2 (1-3)	7 (5-17)	9 (6-32)	17 (9-107)	2.72 ± 0.56	5	4.0 ± 0.35
Larvae	7 (5-10)	17 (12-51)	21 (14-86)	34 (19-230)	3.53 ± 0.83	7	1.93 ± 0.75
Pupae	6 (1-29)	20 (9-1666)	7 (27-12)	48 (17-1665)	2.65 ± 0.78	3	2.86 ± 0.69
Eggs	4 (2-6)	12 (8-27)	16 (10-51)	28 (16-172)	2.68 ± 0.52	4	3.43 ± 0.44

SE = standerd error of regession line,
F = Degrees of freedom
a = Axis intercept of regression line,

However, the lethal times required for 99% mortality are very long, especially for the immature stages of the three pests, results indicated that, O_2 deficient atmosphere of around 1% + 99% N_2 is effective in killing the various stages of *T.putrescentiae*, *A.ovatus* and *C.maculatus*.

This result is in harmony with the findings of other investigators (Reichmuth, 1986; Hashem et al., 1993; Navarro and Jay, 1987; El-lakwah et al 1997 in press).

REFERENCES

1 . Abbott, W.W. 1925. A method of computing the effectiveness of an insecticide. j. Econ. Ent. 18 : 265-267.

2 . Bond, E.J. 1989. Current scope and usage of fumigation and controlled atmospheres for pest control in stored products. Proceedings of the Int. Conf of fumigation and controlled atmosphere, held at singapore. ACLAR-Proc. No 25 : 29-37.

3 . El-Lakwah, F.A., A.A. Darwish and R.A. Mohamed. 1997. Efficacy of a modified atomsphere of around 1% oxygen plus 99% nitrogen on some stored product insects. (in press) .

4 . Finney, D. J. 1952. Probit analysis. 2nd Ed. 318 pp, cambridge University press.

5 . Finney, D.J. 1971. Probit analysis. 3rd Ed. cambridge University press.

6 . Hashem, M.Y. E.M. Risha and A.A. Sharaf El-Din. 1993. A method for controlling stored product insects by changing the surrounding atmosphere. J. Egypt. Ger. Soc. 2001. 12 (D) : 32333 .

7. Jay, E.G. 1984. Control of *Rhizopertha dominica* with modified atmospheres at low temperatures. Agric. Entomol 7: 155-160.

8. Navarro, and E.G. Jay. 1987. Application of modified atmosheres for controlling stored grain insects Monogroph-British-Crop protection-council. 37, 229-236.

9. Reichmuth, CH. 1986. Low oxygen content to control stored product insects. working cong on stored product protection: 194-207.

10. Solomon, M.E. 1951. Control of humidity with potassium hydroxide sulphuric acid, or other solutions Bull. Ent. Res. 42: 543-559.

تأثير جو معدل من الهواء الجوى على بعض آفات المواد المخزونه

زغلول عبد الفتاح حلاوة

معهد بحوث وقاية النباتات - مركز البحوث الزراعية - الدقى .

أجريت تجارب هذا البحث معملياً عند درجة حرارة ٢٦م° و ٦ م° بغرض تقييم تأثير جو معدل يحتوى على حوالى ١٪ أكسجين ، ٩٩٪ نتروجين على نوعين من اكاروسات المواد المخزونة وهى *Aleuroglyphus ovatus* Troupeau, *Tyrophagus putrescentiae* (schrank)) وكذلك على حشرة خنفساء اللوبيا *Callosobruchus maculatus* (F.)

وقد أظهرت النتائج ان الزمن اللازم للحصول على نسبة موت معينة للأطوار المختلفة للأكاروسات والحشرة تحت الدراسة، كان أطول عند درجة الحرارة المنخفضة عنه عند درجة الحرارة المرتفعة وكانت هناك فروق واضحة فى حساسية الأطوار المختلفة للأفات المعاملة حيث كانت الحشرة الكاملة أكثر الأطوار حساسية لخنفساء اللوبيا، ولكن تباينت تلك الحساسية فيما بين الطور الكامل واليرقة لكل من نوعى الاكاروس تحت الإختبار بينما طور البيض لكل من A.ovatus , T.putrescentiae وهى أكثر الأطور تحملاً للنتروجين من الأطوار الأخرى ولكن طور البيضة والعذراء لحشرة خنفساء اللوبيا، هما الطورين الأكثر تحملاً لغاز النتروجين.

وقد تبين أن الوقت الذى يعطى ٩٩٪ موت (LT -99) المسجلة للأطوار المختلفة لنوع T.putrescentiae هى : ١٣ ، ١٥ ، ١٤ ، ٢٣ يوم عند درجة الحرارة ٢٦م° - وكانت ٢٩ ، ٣٥ ، ٣٢ ، ٦٠ يوم عند درجة حرارة ٦م° للطور الكامل، الحورية ، اليرقة ثم البيض على التوالى.

بينما كانت هذه القيم مع النوع A.ovatus هى ٢٣، ١٧، ٢١ ، ٣٢ يوم عند درجة حرارة ٢٦م° و ٢٧ ، ٣٤ ، ٣٦ ، ٣٢ يوم عند درجة حرارة ٦م° للطور الكامل، الحورية ، اليرقة ثم البيض على التوالى.

ولكن فى حالة حشرة خنفساء اللوبيا C.maculatus فكانت القيم المسجلة هى ٤ ، ٥ ، ٢٦ ، ٢٦ ، ٣١ يوم عند درجة حرارة ٢٦ه م و ١٧ ، ٣٤ ، ٤٨ ، ٢٨ يوم على درجة حرارة ٦م° وذلك للحشرة الكاملة اليرقة العذراء ثم البيض على التوالى.

ومن النتائج المتحصل عليها تبين أن النوع T.putrescentiae هى أكثر الأنواع المختبره تحملاً للغاز يليه النوع A. ovatus ، بينما خنفساء اللوبيا أقل تلك الأنواع تحملاً عند استخدام جو محكم يحتوى على ٩٩٪ من غاز النتروجين + ١٪ أوكسجين لمكافحة تلك الأفات المختلفة تحت الدراسة. وعليه فقد تبين أنه رغم طول المدة اللازمة للقضاء على الأطوار المختلفة غير الكاملة لهذه الآفات فيمكن إستخدام هذا الغاز (النتروجين ٩٩ ٪ + ١٪ أوكسجين) كجو محكم لمكافحة تلك الأطوار.