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EFFECTS OF GAMMA RADIATION ON THE ELEMENTAL COMPOSITION OF THE FLOUR MOTH *EPHESTIA KUHNIELLA Z.*

BY

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دراسات على فراشة الدقيق بإستخدام الإشعاع

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تناول البحث دراسة العناصر الرئيسية والنادرة في الأطوار المختلفة لحشرة فراشة الدقيق وتأثير الجرعة المعقمة من أشعة جاما على هذه العناصر . وذلك بهدف تفهم دور هذه العناصر في العمليات الحياتية للحشرة ودورها ككاشفات حيوية لحساسية الحشرات للإشعاع . وقد تم التوصل إلى النتائج التالية :

أولا : العناصر الرئيسية والنادرة في حشرة فراشة الدقيق

(١) وجد أن حشرة فراشة الدقيق تحتوي في أطوارها المختلفة (اليرقة – العذراء – الطور اليافع) على العناصر الاتية : الماغنسيوم – الألومونيوم – السيلكون – الفوسفور – الكبريت – الكلوريد – البوتاسيوم – الكالسيوم – الحديد – النحاس – الزنك – الزرنيخ – البروم والاسترانشيوم .

(٢) ويمكن ترتيب هذه العناصر بناء على تركيزانها النسبية كالآتي :

العناصر الخفيفة : البوتاسيوم > الكلوريد > الكبريت > الكالسيوم > الفوسفور > السيلكون > الألومنيوم > الماغنسيوم .

العناصر الثقيلة : الزنك > النحاس > الحديد > الاسترانشيوم > البروم > الزرنيخ . لا يوجد فرق في ترتيب هذه التركيزات النسبية في الأطوار المختلفة كل على حده أو بين الذكور والأناث .

(٣) يحتفظ البوتاسيوم بأعلى تركيز نسبي في كل الأطوار بالمقارنة للعناصر الأخرى .

(٤) باستثناء عنصري البوتاسيوم والفوسفور ليس هناك دليل على تراكم العناصر الأخرى من الطور اليرقي إلى الطور اليافع .

(٥) انخفض التركيز النسبي لعنصري الكالسيوم والحديد في الطور اليافع .

ثانيا : العناصر الرئيسية والنادرة في حشرة فراشة الدقيق الناتجة من معاملة البيض بأشعة جاما

(١) تم التعرف على العناصر الخفيفة والثقيلة في الطور اليرقي (إناث – ذكور) وطور العذراء وكذلك في كل من إناث وذكور الحشرات الناتجة .

(٢) وجد أن هناك نقص عام في التركيز النسبي لكل العناصر في الحشرات المعاملة بالاشعاع مقارنة بالحشرات الطبيعية . باستثناء الكلور حيث زاد زيادة طفيفة .

(٣) البوتاسيوم كان هو أكثر العناصر تأثراً بالاشعاع حيث نقص تركيزه بنسبة ٥٠ ٪ ويليه كل من الماغنسيوم والكالسيوم .

Key Words: Gamma radiation effect, Element composition, Flour Moth.

ABSTRACT

The effect of gamma radiation on the elemental composition of larvae, pupae and adults stages of the flour moth *Ephestia kuhniella* after irradiation of eggs to the sterilizing dose was studied. The elemental composition as well as the concentration level of elements detected in the different stages are summarized in the following:

Larval stage:

low z elements K > Cl > S > Ca > P > Si > Al > Mg

female

high z elements Zn > Cu > Fe > Sr > Br > As

low z elements K > Cl > Ca > S > P > Si > Al > Mg

male

high z elements Zn > Cu > Sr > Fe > Br > As

Pupal stage:

low z elements K > Cl > S > Ca > P > Si > Al > Mg

high z elements Zn > Cu > Fe > Sr > Br > As

Adult stage:

low z elements Cl > K > Ca > S > P > Si > Al > Mg

female

high z elements Zn > Cu > Sr > Fe > Br > As

low z elements Cl > K > S > Ca > P > Si > Al > Mg

male

high z elements Zn > Cu > Fe > Sr > Br > As

The elements showed to behave differently due to radiation injury within each stage. However, a general decrease was observed in all elements except for chlorine in treated stages compared to normal ones.

The most striking reduction in concentration level was detected in K which reached 50% of its concentration level in normal insects, followed by Mg and Ca.

INTRODUCTION

Several authors studied the elemental composition of different insects, [1, 2, 3, 4 and 5]. Recently [6] investigated the major and trace elements in certain Egyptian cotton pasts using X-ray fluorescence technique.

A radiation program for the control of *Ephestia kuhniella* was initiated in different laboratories of the Atomic Energy Agency in Egypt. The results achieved were published by [7, 8 and 9].

The aim of this work is to study the elemental composition of the produced stages from irradiated and non-irradiated eggs of *E. kuhniella.*

MATERIALS AND METHODS

The Mediterranean flour moth, *Ephestia kuhniella* used in this study is a laboratory culture. The insects were reared in an incubator maintained at 28°C in complete darkness. The relative humidity was 75%. The diet used was wheat flour (Shmeto) which is available in the Egyptian markets to which 5% Brewer's yeast was added. Moths were put in 250 CC capacity jars and were covered with a nylon net and fitted with a rubber band. The jar was placed upside down in a petri dish to facilitate collection of eggs. The collected eggs were transferred to sterilized jars supplied with flour for feeding hatched larvae.

Samples Preparation

In this study a dose of 25 Gy was used for sterilizing 6 day old eggs, this dose was previously proved by [10] to be a sterilizing dose for resulting adults, (for both irradiated and non-irradiated).

The hatching larvae were supplied with food and maintained till adult emergence. Pools of 25 individuals of the following stages were used to determine the elemental composition:

1. Female and male larvae 30-35 days old.
2. Five days old pupae (unsexed).
3. Five days old female and male adults.

Two hundred milligrams of the samples were dried and grounded. Powder was then compressed into a pellet under 15 (tons) seq. inch with boric acid as a packing material.

The measurements have been performed in two different runs in order to have the optimum detection condition for each set of elements.

1. The low atomic number (Z) elements were analyzed using the following instrumental parameters:

Elements Analyzed: Mg, AL, Si, Ps, Ci, K and Ca
Anode: Molybdenum
Tube voltage: 10 KV
Tube Current: 25 μA
Present Live Time: 200 Sec.
Atmosphere: Vacuum.

2. The second set of elements - the heavier ones - were analyzed using the following conditions:

Elements Analyzed: Fe, Cu, Zn, As, Br and Sr
Anode: Molybdenum

Tube Voltage: 25 KV
Tube Current: 10 μA
Present live time: 200 Se
Atmosphere: air

The minimum detectable concentration of the used spectrometer was estimated to be one ppm. Thus, elements in the samples having concentrations less than this limit could not be detected.

RESULTS AND DISCUSSION

Insects have been found to concentrate major and trace elements in their tissues. In the present study, the analysis of the ash of the flour moth *Ephestia kuhniella* adult and immature stages has resulted in the identification of Mg, Al, Si, P, S, Cl, K, Ca, Fe, Cu, Zn, As, Br and Sr.

For the most part, these analyses have been qualitative indicating only the relative differences in the amount of elements present in the sample. Na could not be detected either because of a very low concentration level or due to the conditions of the technique used in this study.

Tables (1 and 2) show the concentration level of the fourteen elements detected in the different stages and could be arranged in the following order, for the low z elements (light elements): K > Cl > S > Ca > P > Si > Al > Mg and the high z elements (heavy elements): Zn > Cu > Fe > Sr > Br > As.

There were no variations in this pattern in the different stages studied or between sexes. The K level showed a high concentration level compared to other elements in all cases studied.

Variations in the amount of major and trace elements in adults and immature insects indicated that with the exception of K and P there is no specific accumulation pattern between life-cycle stages and no obvious difference in concentration level could be related to sex. Helmy and El-Domiaty [11] could detect a very slight difference between sexes in *Schistocerca gregaria* in the ionic composition of the blood (Na and K). [3] in their study on the elemental composition of 41 species of insects, arranged the element concentration as : K > Na > Mg > Fe > Cu; however, as with most biological systems, there were species as well as class-specific exceptions to this trend. They also found that the Na > Mg trend was apparently reversed in several species of adult and immature insects. These insects seemed to substitute relatively high concentrations of Mg for Na. It has been suggested that this substitution could serve to maintain normal ionic levels for nerve conduction and osmotic regulation in insects that had a low Na concentration [12].

The concentration level of Ca and Fe showed a decrease in the adult stage compared to the larval stage, while a high increase was observed in the pupal stage. This might be due to accumulation of these major constituents of the larval food in the pupal stage, while the decrease observed in the adult stage is attributed to the different dietary requirements of adults. Generally, the total body concentrations would indicate some degree of tissue accumulation from non biologically active or waste levels present in the gut before voiding or in the fat body and/or cuticle as a type of storage excretion.

Table 1
Concentration level of some major and trace elements "Low z elements" in normal male and female larvae of *Ephestia Kuhniella*

Stage	Counts per second ± S. E.							
	Elements							
	Mg	Al	Si	P	S	Cl	K	Ca
normal male larva	19.5 ± 0.04	42.0 ± 0.06	56.1 ± 0.09	195.4 ± 0.12	365.5 ± 0.18	536.5 ± 0.05	1267.5 ± 0.15	303.3 ± 0.22
normal female larva	19.2 ± 0.04	40.6 ± 0.11	52.2 ± 0.24	195.6 ± 1.15	357.5 ± 1.07	455.4 ± 0.66	1053.5 ± 3.05	301.6 ± 0.38
normal pupa	19.2 ± 0.87	41.9 ± 0.13	57.9 ± 0.14	230.7 ± 0.12	347.1 ± 0.20	417.4 ± 0.23	1862.3 ± 2.41	366.2 ± 0.23
normal male	20.3 ± 0.09	33.0 ± 0.17	54.9 ± 0.20	266.7 ± 1.81	358.7 ± 1.26	465.7 ± 0.23	1462.7 ± 2.67	296.1 ± 0.40
normal female	21.6 ± 0.08	37.5 ± 0.19	53.8 ± 0.29	240.8 ± 0.17	345.3 ± 0.16	454.3 ± 0.19	1430.6 ± 5.90	285.2 ± 0.31

Table 2
Concentration level of some major and trace elements "High z elements" in normal male and female larvae of *Ephestia kuhniella*

Stage	Counts per second ± S. E.					
	Elements					
	Fe	Cu	Zn	As	Br	Sr
normal male larva	47.3 ± 0.18	74.7 ± 0.23	77.4 ± 0.08	34.5 ± 0.10	35.5 ± 0.113	39.4 ± 0.09
normal female larva	68.3 ± 0.22	83.6 ± 0.36	76.0 ± 0.16	34.9 ± 0.08	35.6 ± 0.05	40.6 ± 0.06
normal pupa	55.3 ± 0.17	65.4 ± 0.10	77.1 ± 0.26	35.3 ± 0.13	35.5 ± 0.06	40.2 ± 0.06
normal male	46.3 ± 0.36	69.1 ± 0.14	79.1 ± 0.13	35.6 ± 0.04	36.0 ± 0.08	40.42 ± 0.07
normal female	43.8 ± 0.15	69.5 ± 0.08	81.4 ± 0.23	35.3 ± 0.06	36.2 ± 0.01	40.3 ± 0.04

Insects were known to accumulate levels of major and trace elements (minerals) in relation to their individual feeding preferences [13] and hence it was assumed that there would be a general relationship between the mineral content of the flour moth diet and the tissue accumulation of various metallic elements (cations). The analysis of the diet on which *Ephestia kuhniella* was raised proved to have K with a concentration level higher than the other cations detected (Fe, Ca, S), and this coincided with the high concentration level of K in the different stages of *Ephestia kuhniella.*

Deficiency test with mineral elements showed that some insects can survive for at least one generate, without many of the minerals usually considered to be necessary for life. Trace minerals commonly occur in the other dietary constituents, including distilled water, agar and chemicals, and also upon the surface of glassware and other objects used in peparing diets. Another probable important source of trace minerals is the insect egg, the material being included in the new born larvae.

The elemental composition as well as the concentration level of elements detected, were monitored in the surviving stages of larvae, pupae and adults. (Tables 3 and 4) after irradiating *Ephestia kuhniella* in the egg stage.

The elements showed to behave differently due to radiation injury. However, a general decrease was observed in all elements in the treated stages.

Table 3
Concentration level of some major and trace elements "Low z elements" in treated male and female larvae of *Ephestia Kuhniella*

Stage	Counts per second ± S. E.							
	Elements							
	Mg	Al	Si	P	S	Cl	K	Ca
Treated male larva	16.2 ± 0.06	36.9 ± 0.19	42.7 ± 0.14	197.1 ± 0.23	267.73 ± 0.22	588.0 ± 0.12	637.9 ± 0.75	277.2 ± 0.17
Treated female larva	15.0 ± 0.05	38.9 ± 0.07	40.9 ± 0.09	158.3 ± 0.20	294.5 ± 0.19	566.8 ± 0.16	695.6 ± 0.26	252.0 ± 0.27
Treated pupa	17.0 ± 0.06	36.0 ± 0.11	44.2 ± 0.16	202.4 ± 0.24	285.7 ± 0.33	336.2 ± 0.17	603.8 ± 1.62	262.9 ± 1.92
Treated male adult	16.1 ± 0.15	37.3 ± 0.29	50.2 ± 0.58	176.2 ± 0.53	263.9 ± 1.34	482.3 ± 3.08	454.6 ± 9.41	246.9 ± 3.06
Treated female adult	15.6 ± 0.08	33.5 ± 0.15	45.9 ± 0.18	190.5 ± 1.13	283.5 ± 1.05	549.5 ± 3.03	519.2 ± 3.18	213.5 ± 0.563

The most striking reduction in concentration level was detected in K which reached 50% its concentration level in the normal insects, followed by Mg and Ca. No increase in concentration level was observed except for chlorine.

Comparatively high ratio concentration level for Zn, Sr, Br and As are detected as trace elements in *Ephestia kuhniella.* Their concentration levels compared to those of potassium take the following sequence:

Zn > Sr > Br > As

Sr is considered to be a toxic element, and although detected in *Ephestia,* it is not an essential element. [14] stated that zinc, iron, iodine, cobalt, manganese and nickel are known essential trace elements. Zinc and manganese are found in blood of insects [12]. Bromine seems to be not required by insects, as the accumulation in the tissues of an organism is not alone sufficient evidence that an element is required. It is not required by most invertebrates and in vertebrates it can partially replace or spare the use of another element, [15].

No detectable changes occurred in the concentration level of Zn, Sr, Br and as an effect of irradiation.

Table 4

Concentration level of some major and trace elements "High z elements" in Treated male and female larvae of *Ephestia kuhniella*

Stage	Counts per second ± S. E.					
	Elements					
	Fe	Cu	Zn	As	Br	Sr
Treated male larva	43.0 ± 0.33	67.1 ± 0.18	73.4 ± 0.54	31.9 ± 0.03	36.9 ± 0.11	40.5 ± 0.06
Treated female larva	42.7 ± 0.22	66.7 ± 0.45	78.8 ± 0.14	31.8 ± 0.05	36.9 ± 0.03	40.1 ± 0.08
Treated pupa	43.5 ± 0.24	66.8 ± 0.15	85.9 ± 0.28	31.8 ± 0.40	36.6 ± 0.07	40.2 ± 0.063
Treated male adult	54.4 ± 0.11	66.9 ± 0.09	81.8 ± 0.56	31.6 ± 0.04	36.3 ± 0.06	40.2 ± 0.09
Treated female adult	43.4 ± 0.52	66.7 ± 0.06	81.7 ± 0.36	31.9 ± 0.13	36.8 ± 0.08	40.6 ± 0.05

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