ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

Lactate dehydrogenase disturbance in the desert locust *Schistocerca gregaria* (Forskal) (Orthoptera: Acrididae) by extracts of *Punica granatum* Linn. and *Ammi visnaga* L.

M. Tanani

Department of Zoology and Entomology, Faculty of Science, Al-Azhar University, Cairo, Egypt

Manuscript Info

Manuscript History:

Received: 18 June 2015
Final Accepted: 22 July 2015
Published Online: August 2015

Key words:

adults, ethanol, fat bodies, haemolymph, nymphs, n-butanol, petroleum ether

***Corresponding Author**

M. Tanani

Abstract

The current work was planned and conducted to investigate the effects of *Punica granatum* Linn. (Lythraceae) peel extracts and *Ammi visnaga* L. (Apiaceae) fruit extracts on lactate dehydrogenase (LDH) activity in haemolymph and fat bodies of last instar nymphs and newly emerged adult females of *Schistocerca gregaria*. A prevalent enhancing effect was exhibited by *P. granatum* peel extracts on last instar nymphs of all ages to gain considerably increasing LDH activity in haemolymph, with an exceptional case of inhibited activity in the mid-aged nymphs by n-butanol extract. A similar promoting action was exerted by *A. visnaga* fruit extracts with an exceptional case of an inhibited activity in the late-aged nymphs by petroleum ether extract. LDH activity in haemolymph of the newly emerged adult females was drastically suppressed by all *P. granatum* peel extracts. The ethanol extract of *A. visnaga* fruits prohibited the enzyme activity but both petroleum ether extract and n-butanol extract induced it. All *P. granatum* peel extracts caused remarkable inhibition of LDH in fat bodies of early-aged nymphs. In fat bodies of the mid- and late-aged nymphs, petroleum ether extract prohibited the enzyme activity but both ethanol extract and n-butanol extract stimulated it. Treatment with *A. visnaga* fruit extracts resulted in dramatically declined enzyme level in both early- and late-aged nymphs but enhanced in mid-aged ones. With regard to adults, LDH activity was unexceptionally induced in fat bodies by all plant extracts.

Copy Right, IJAR, 2015,. All rights reserved

INTRODUCTION

As pointed out by some authors (Uvarov, 1977; Showler and Potter, 1991; Jahn, 1993; Showler, 1995; Ullman, 2006; Ceccato et al., 2007; Tawfik, 2012), the desert locust, *Schistocerca gregaria* is potentially the most dangerous among the locust pests because of its ability of swarms to fly rapidly across great distances affecting some 58 countries. It is a dangerous pest in a vast area of the old world stretching from Mauritania in the west to India in the east, and from Turkey to as far south as Tanzania. Plagues of the desert locust have threatened agricultural production in Africa, the Middle East, and Asia for centuries.

The widespread use of synthetic pesticides has considerable drawbacks, such as the development of insect resistance to insecticides, increased costs, handling hazards, concerns about insecticide residues, and great threats to both human and environmental health (Garriga and Caballero, 2011). Therefore, alternatives to conventional pesticides are required to be developed from the active ingredients of plant origin (Copping and Menn, 2001). The plant extracts and plant products are reported to be more effective, less expensive, rapidly biodegradable, have low toxicity to natural enemies and mammals, safe for mankind (Singh et al., 1996) and more selective in action than synthetic pesticides (Keita et al., 2001; Rahman and Siddiqui, 2004). Along the late decades, so many plant species in the world have been assessed for their insecticidal activities, antifeedant, growth retarding, morphogenic impairing or reproductive disturbing effects on various insect pests. *Azadirachta indica* and *Melia azedarach* are two species among the most well investigated plants and trees in this context affecting survival, feeding, growth,

fecundity, fertility and several anatomical and physiological processes of insects (Mordue et al., 1998; Breuer and De Loof, 2000; Sayah, 2002; Breuer et al., 2003; Huang et al., 2007; Senthil Nathan et al., 2008; Correia et al., 2009).

Among the methods used to fight against desert locust, chemical control remains the most accessible and most effective (Abou et al., 2005). Nevertheless, various researches on the effect of botanical biopesticides on desert locust had been carried out as alternatives to the currently used harmful pesticides (Krall and Wilps, 1994). Several plant species affect differentially the fertility, development, behaviour, and survival of this pest (Idrissi Hassani, 2000; Abbassi et al., 2004). As for examples, *Fagonia bruguieri* (Tanani et al., 2009; Hamadah et al., 2010; Basiouny et al., 2010; Aly et al., 2010), *Nigella sativa* (Hamadah et al., 2013), pomegranate (Ghoneim et al., 2014a,b,c; Mahmoud, **2014**) and toothpick weed (Ghoneim et al., 2014d,e,f; Mahmoud, 2014) had been assessed against this locust. These botanicals are still at the experimental stage and the large scale production is problematic and difficulties with the registration of variable products will limit adoption (Meinzingen and Kooyman, 1997). However, prior results on the effects of plant extracts on the desert locust have encouraging for implementing an alternative measure to synthetic pesticides (Idrissi Hassani, 2000; Abbassi et al., 2003).

Pomegranate (*Punica granatum* Linn., Lythraceae) is one of the oldest cultivated plants in the world (Lye, 2008). It is cultivated in Central Asia and the drier parts of Southern Asia (Holland et al., 2009), as well as in the Mediterranean, tropical and subtropical areas (Mars, 2000). It was introduced into Latin America, California and Arizona (Khan and Hanee, 2011). From the medical point of view, pomegranate is of a great interest to research in pharmaceutical and new drug development fields because of its distinctive bioactivities (Singh et al., 2002; Negi and Jayaprakasha, 2003; Vasconcelos et al., 2006; Reddy et al., 2007; Lansky and Newman, 2007; Jurenka, 2008; Tayel et al., 2009; Augusta et al., 2010; Abdollahzadeh et al., 2011; Das and Barman, 2012; Dkhil, 2013; Eldiasty et al., 2014). For the pest control, extract of *P. granatum* fruit rind was toxic against tape-worms, earthworms and round-worms (Hukkeri et al., 1993). Extracts of the bark exhibit molluscicidal activity (Tripathi et al., 2004). With regard to the insect pests, available literature reported insecticidal effects of *P. granatum* extracts and their disruptive effects on growth and development (Alanis et al., 2005; Melendez and Capriles, 2006, Liu et al., 2007; Sharma and Rajguru, 2009; Mansour et al., 2010; Ghandi et al., 2010; Mahmood, 2010; Ghandi and Pillai, 2011; Mansour et al., 2012; Mohammad, 2012; Eldiasty et al., 2014; Ghoneim et al., 2014a). Also, *P. granatum* peel extracts affected the adult performance and transaminase activity in *S. gregaria* (Ghoneim et al., 2014b, c). Toothpick weed (*Ammi visnaga* Lamarck, Apiaceae= Umbelliferaceae) is commonly known as khella or Al-khillah, especially in Egypt. It is native to Europe, Asia and North Africa but can be found throughout the world as an introduced species. The *A. visnaga* extracts have been used in the traditional medicine and their chemical components have been used in the modern medicine (Duarte et al., 1998; Khan et al., 2001; Cordero et al., 2004; Whitton et al., 2008; Kwon, et al., 2010; Lee et al., 2010; Vanachayangkul et al., 2011). However, the research work on using this plant, or some of its chemical constituents, in the pest control, is unfortunately scarce. The available literature reported its ovicidal activity against *Mayetiola destructor* (Lamiri et al., 2001), larvicidal activity against some mosquito species (Amer and Mehlhorn, 2006 a, b; Pavela, 2008) and its use as a grain protectant against weevils (Abdel-Latif, 2004; Ahmed and Al-Moajel, 2005). Also, fruit extracts disrupted the growth, development, general metabolism and phosphatase activity in *S. gregaria* (Ghoneim et al., 2014 d, e, f).

Dehydrogenases are very important tools for the investigation of insect metabolic activities during the course of development. The relative activities of the insect dehydrogenases may be related to the function and energy yielding demands of the tissues (Dickinson and Sullivan, 1975). Lactate dehydrogenase (LDH) (EC 1.1.1.28) is an important glycolytic enzyme present in virtually all animal tissues (Kaplan and Pesce, 1996). It is involved in carbohydrate metabolism and has been used as an indicative criterion of exposure to chemical stress and toxicology (Wu and Lam, 1997; Ribeiro et al., 1999; Diamantino et al., 2001; Senthil Nathan et al., 2006a). This enzyme may be a sensitive criterion in laboratory (Senthil Nathan et al., 2005). The aim of the present study was to assess the disturbing efficacy of *P. granatum* peel extracts and *A. visnaga* fruit extracts on the LDH activity in haemolymph and fat body of *S. gregaria.*

MATERIALS AND METHODS:

1) The insect.

The desert locust *Schistocerca gregaria* (Forskal)(Orthoptera: Acrididae) was used as an experimental insect in the present study. The present culture was originated by a sample of gregarious nymphs from Plant Protection Research Institute, Ministry of Agriculture, Giza. As designed by Hunter-Jones (1961) and improved by Ghoneim et al. (2009), insects were reared in wood formed cages (60 x 60 x 70 cm). The bottom was furnished with a sandy layer (20 cm depth) and provided with 10-15% humidity suitable for egg laying. An electric bulb (100 watt) was adjusted in each cage to maintain a continuous photoperiod (12 L: 12 D) as well as an ambient temperature (32±2°C). The insects were reared and handled under the crowded conditions. The feces, dead locusts and food remains were removed daily before introducing fresh food. Care was seriously taken to clean these cages at regular

intervals and the sand was sterilized in drying oven (at 140°C for 24 hours) to avoid contamination with any pathogenic microorganisms. Fresh clean leaves of clover *Trifolium alexandrinum* were provided as a food.

2) Plant extraction.

A weight of 1.5 Kg *P. granatum* peel was purchased from the Egyptian market and thoroughly cleaned with tap water for disposing of impurities. The peel was shade dried and then finely grinded by a micromill. The pulverized powder was macerated with ethanol in a stoppered container for a defined period with frequent agitation until soluble matter is dissolved as adopted from Ncube et al. (2008). The ethanol extract was divided into two parts, a part of the ethanol extract was evaporated for obtaining 37 gm dried extract. Another part was concentrated into 300 ml by rotary evaporator, and then diluted with 300 ml distilled water. Using a separating funnel, the dilute was fractionalized by petroleum ether (300 ml x 5) and n-butanol (300 ml x 5) giving 29 and 34 gm, respectively. From each of the crude ethanol extract and the fractionalized petroleum ether and n-butanol extracts, a series of concentrations were prepared: 80, 40, 20, 10, 5 and 2.5%. A weight of 1.5 Kg *A. visnaga* fruits was purchased from an Egyptian market and thoroughly cleaned with tap water for disposing of impurities. The fruits were shade dried and then finely ground by a micromill. Solvents of different polarities were used for the extraction, as follows. The pulverized powder was macerated with ethanol in a closed container for a defined period with frequent agitation until soluble matter was dissolved as adopted from Ncube et al. (2008) and treated as previously mentioned for *P. granatum*.

3) Nymphal treatments.

In a preliminary experiment, different concentration levels of ethanol, petroleum ether, and n-butanol extracts derived from *P. granatum* peel or *A. visnaga* fruits had been applied on the newly moulted penultimate (4th) instar nymphs of *S. gregaria* through the fresh food leaves of *Trifolium alexandrinum* dipped once in each extract for 3 minutes. LC_{50} values were calculated in 36.7, 22.2 and 40.7% of ethanol, petroleum ether and n-butanol extracts of *P. granatum* peel, respectively. LC_{50} values were calculated in 21.0, 12.0 and 22.5% of ethanol, petroleum ether, and n-butanol extracts of *A. visnaga* fruits, respectively. After treatment with these LC_{50}s, the successfully moulted last instar nymphs and newly emerged adult females were used to determine the influenced LDH activity in two tissues: haemolymph and fat body. Three ages of last instar nymphs were used: early- (1-day old), mid- (4-day old) and late-aged (7-day old) nymphs.

4) Tissue preparation and enzyme assay.

For the determination of LDH activity, samples of haemolymph had been collected from the last instar nymphs and newly emerged adult females. Haemolymph was obtained by amputation of one or two hind legs of the nymph or adult with fine scissors. Gentle pressure was done on the thorax until a drop appeared at the point of amputation. Haemolymph was drawn into Eppendorff Pipetman containing few milligrams of phenoloxidase inhibitor (phenylthiourea) to prevent tanning or darkening and then diluted 5x with saline solution 0.7%. For whole assays, the diluted haemolymph was frozen for 20s to rupture the haemocytes. The haemolymph samples were then centrifuged at 2000 r.p.m. for 5 min, and only the supernatant fractions were used directly or frozen until the use. Three replicates were used and the haemolymph of two individuals were never mixed. Also, samples of fat bodies (parietal and visceral) were collected from nymphs (of the same ages) and newly emerged adult females. The fat body was weighed and then homogenized in a saline solution (fat body of one insect/1 ml saline solution 0.7 %) using a fine electric homogenizer, tissue grinder for 2 min. Homogenates were centrifuged at 4000 r.p.m. for 15 min. The supernatant was used directly or frozen until the use. Three replicates were used and the fat bodies from two individuals were avoided to be mixed. LDH activity was determined according to the method of Tietz (1999) using a kit of Biolap reagents. The enzyme was measured at wave length 340 nm by spectrophotometer.

5) Statistical Analysis of Data.

Data obtained were analyzed by the Student's *t*-distribution, and refined by Bessel correction (Moroney, 1956) for the test significance of difference between means.

RESULTS:

1) Effects on LDH activity in haemolymph.

After treatment of the penultimate instar nymphs of *S. gregaria* with LC_{50} concentrations of *P. granatum* peel, data assorted in Table (1) obviously reveal a prevalent enhancing effect on last instar nymphs of all ages to gain considerably increasing LDH activity in haemolymph with an exceptional case of seriously inhibited activity in the mid-aged nymphs by n-butanol extract (46640.6±164.4 U/L compared to 48340.9±200.1 U/L of control nymphs).

The strongest enhancing effect was exhibited by n-butanol extract on the enzyme activity in haemolymph of the early-aged nymphs (30.0% increment).

As clearly shown in Table (2), *A. visnaga* fruit extracts exerted a similar promoting actions on the nymphs to gain pronouncedly increasing enzyme activity with an exceptional case of a slightly inhibited activity in haemolymph of late-aged nymphs by petroleum ether extract (60188.2±157.1 U/L compared to 61346.7±102.2 U/L of control nymphs). The most potent inducing effect was exhibited by ethanol extract on the enzyme activity in haemolymph of early-aged nymphs (50.7% increment).

With regard to the newly emerged adult females, LDH activity in haemolymph was drastically suppressed by all *P. granatum* peel extracts (Table 1). Ethanol extract of *A. visnaga* suppressed the enzyme activity in haemolymph of adults (3.1% reduction). In contrast, petroleum ether extract and n-butanol extract significantly or slightly induced the enzyme activity (1.3 and 0.5% increments by petroleum ether extract and n-butanol extract, respectively, Table 2).

2) Effects on LDH activity in fat bodies.

According to data of Table (3), LDH activity in fat bodies of nymphs was remarkably disturbed by *P. granatum* peel extracts. The enzyme activity was significantly inhibited in fat bodies of early-aged nymphs, regardless the extract. The most potent inhibitory effect was exhibited by petroleum ether extract (38.1% reduction). The same extract caused continuously inhibited activity throughout the nymphal life (12.4 and 28.5% reductions in fat bodies of mid- and late-aged nymphs, respectively). On the contrary, ethanol extract caused largely stimulated LDH activity in mid- and late-aged nymphs (12.9 and 26.6% increments, respectively) and n-butanol extract enhanced the enzyme in the nymph congeners (47.9 and 12.7% increments, respectively).

In respect of the effects of *A. visnaga* fruit extracts on LDH activity in fat bodies of nymphs, data of Table (4) clearly show dramatically declined enzyme level in both early- and late-aged nymphs. The strongest inhibitory action was exerted by ethanol extract in fat bodies of late-aged nymphs (34.4% reduction). LDH activity was reversely affected in fat bodies of mid-aged nymphs since increasing activity was determined (23741.4±184.9, 21724.2±188.1 and 23442.6±92.9 U/L by ethanol extract, petroleum ether extract and n-butanol extract, respectively, vs. 15361.3±127.5 U/L of control nymphs).

In fat bodies of the newly emerged adults, unexceptionally increasing LDH activity was pronouncedly induced by both *P. granatum* and *A. visnaga* extracts (see tables 3 and 4). The most enhancing potency was exerted by ethanol extract of *P. granatum* peel (78.5% increment).

Table 1: Lactate dehydrogenase activity (U/L) in haemolymph of *S. gregaria* nymphs and adults as affected by LC_{50} of *P. granatum* extracts.

Solvent		Last instar nymphs			Newly emerged adults
		Early-aged	Mid-aged	Late-aged	
Ethanol	Mean±SD	62236.6 ± 159.5 d	58319.6 ± 119.0 d	75182.6 ± 119.0 d	63334.1 ± 165.8 c
	Change (%)	+21.4	+20.6	+22.6	-1.8
Petroleum ether	Mean±SD	58336.3 ± 176.6 d	52347.4 ± 190.5 d	66643.9 ± 156.8 d	63164.4 ± 124.5 c
	Change (%)	+13.8	+08.3	+08.6	-2.1
n-butanol	Mean±SD	66744.4 ± 146.3 d	46640.6 ± 164.4 d	62097.9 ± 98.0 c	63331.2 ± 164.3 c
	Change (%)	+30.2	-3.5	+01.2	-02.0
Control		51269.4 ± 179.3	48340.9 ± 200.1	61346.7 ± 102.2	64503.6 ± 169.4

Mean ± SD followed by letter (c): Highly significantly different ($P<0.01$), (d): Very highly significantly different ($P<0.001$).

Table 2: Lactate dehydrogenase activity (U/L) in haemolymph of *S. gregaria* nymphs and adults as affected by LC_{50} of *A. visnaga* extracts.

Solvent		Last instar nymphs			Newly emerged adults
		Early-aged	Mid-aged	Late-aged	
Ethanol	Mean±SD	77268.0 ± 184.0 d	51347.6.6 ± 169.3 d	66263.6 ± 171.8 d	62504.8 ± 213.6 d
	Change (%)	+50.7	+06.2	+08.0	-03.1
Petroleum ether	Mean±SD	61320.6 ± 180.2 d	50334.0 ± 173.8 d	60188.2 ± 157.1 a	65332.0 ± 176.5 c
	Change (%)	+19.6	+04.1	-01.9	+01.3
n-butanol	Mean±SD	65782.0 ± 149.3 d	61261.5 ± 158.0 d	69537.3 ± 176.0 d	64838.5 ± 169.1 a
	Change (%)	+28.3	+26.7	+13.4	+00.5
Control		51269.4 ± 179.3	48340.9 ± 200.1	61346.7 ± 102.2	64503.6 ± 169.4

Mean ± SD followed by letter (a): is not significantly different (P>0.05), c, d: See footnote of Table 1.

Table 3: Lactate dehydrogenase activity (U/L) in fat bodies of *S. gregaria* nymphs and adults as affected by LC_{50} of *P. granatum* extracts.

Solvent		Last instar nymphs			Newly emerged adults
		Early-aged	Mid-aged	Late-aged	
Ethanol	Mean±SD	19328.3 ± 180.9 d	17349.6 ± 171.3 d	25530.2 ± 168.5 d	20250.8 ± 159.5 d
	Change (%)	-32.8	+12.9	+26.6	+78.5

Petroleum ether	Mean±SD	17807.1 ± 175.4 d	13450.2 ± 187.2 d	14429.3 ± 177.1 d	16365.1 ± 159.7 d
	Change (%)	-38.1	-12.4	-28.5	+44.2
n-butanol	Mean±SD	20178.9 ± 119.7 d	22727.0 ± 167.2 d	22725.0 ± 171.7 c	19349.0 ± 184.6 d
	Change (%)	-29.8	+47.9	+12.7	+70.5
Control		28747.8 ± 139.8	15361.3 ± 127.5	20167.3 ± 116.6	11347.5 ± 152.9

c, d: See footnote of Table 1.

Table 4: Lactate dehydrogenase activity (U/L) in fat bodies of *S. gregaria* nymphs and adults as affected by LC_{50} of *A. visnaga* extracts.

Solvent		**Last instar nymphs**			**Newly emerged adults**
		Early-aged	**Mid-aged**	**Late-aged**	
Ethanol	Mean±SD	25330.0 ± 183.9 d	23741.4 ± 184.9 d	13229.4 ± 168.7 d	16334.2 ± 178.5 d
	Change (%)	-11.2	+54.6	-34.4	+43.9
Petroleum ether	Mean±SD	25728.4 ± 195.7 d	21724.2 ± 188.1 d	15721.5 ± 175.7 d	13730.0 ± 175.7 d
	Change (%)	-10.5	+41.4	-22.0	+21.0
n-butanol	Mean±SD	21748.5 ± 183.2 d	23442.6 ± 92.9 d	19425.6 ± 200.3 c	20235.0 ± 156.7 d
	Change (%)	-24.3	+52.6	-03.7	+78.3
Control		28747.8 ± 139.8	15361.3 ± 127.5	20167.3 ± 116.6	11347.5 ± 152.9

c, d: See footnote of Table 1.

DISCUSSION:

1) Enhancement of LDH activity in *S. gregaria* by plants extracts.

Dehydrogenases are very important tools for the investigation of insect metabolic activities during the course of development. The relative activities of the insect dehydrogenases may be related to the function and energy yielding demands of the tissues (Dickinson and Sullivan, 1975). Because LDH is an important glycolytic enzyme involved in carbohydrate metabolism in many tissues (Shekari et al., 2008), it has been used as an indicative criterion of exposure to chemical stress and toxicology (Wu and Lam, 1997; Diamantino et al., 2001). As reported in the available literature, LDH activity has been disturbed by plant extracts and insecticides (Nath, 2000; Ghoneim et al., 2014f; Mahmoud, 2014). LDH activity was promoted in haemolymph or fat bodies of *S. gregaria* nymphs and adults by the action of neem preparation Neemazal and *N. sativa* extracts (Hamadah, 2009). The *F. bruguieri* extracts enhanced the enzyme activity in haemolymph of nymphs and adults of the same locust (Hamadah et al., 2010). In addition, various insecticides promoted the LDH activity in several pests by, such as *Tribolium castaneum* (Pak. strain) by pyrethroid (Saleem and Shakoori, 1987), *Culex fatigans* (L.Y. strain) by malathion, cyfluthrin, and DDT (Azmi et al., 2002), *Spodoptera littoralis* by chlorantraniliprole and spinetoram (Rashwan, 2013), *Ephestia kuehniella* by pyriproxyfen (Sharifi et al., 2013) and the same lepidopteran by hexaflumuron (Delkash-Roudsari et al., 2014). In the present study on *S. gregaria*, *P. granatum* peel extracts and *A. visnaga* fruit extracts exhibited a prevalent enhancing effect on the last instar nymphs to gain considerably increasing LDH activity in haemolymph, with few exceptions. Both petroleum ether extract and n-butanol extract of *A. visnaga* induced the enzyme in haemolymph of newly emerged adult females. Both ethanol extract and n-butanol extract of *P. granatum* peel induced the enzyme in fat bodies of the mid- and late-aged nymphs. Also, *A. visnaga* fruit extracts enhanced the mid-aged nymphs to gain increasing LDH level. The enzyme activity was unexceptionally promoted in fat bodies of adults by all extracts of *P. granatum* peel and *A. visnaga* fruits. The enhancement of LDH activity in the present study can be understood because it may indicate an effective stimulation of the portion of Cori cycle responsible for the overall recycling lactate, since this would result in concomitant enhanced production of pyruvate and glucose *via* glucogenesis (Harper et al., 1984).

2) Inhibition of LDH activity in *S. gregaria* by plant extracts.

The pyruvate is the key intermediate of glycolysis, whereas lactate is the end product of glycolysis. The interconvertability of pyruvate and lactate has a great advantage in the operation of carbohydrate metabolism (Nath, 2000). In the present study on *S. gregaria*, LDH activity in haemolymph of the newly emerged adults was drastically suppressed by all *P. granatum* peel extracts. Only the ethanol extract of *A. visnaga* prohibited the enzyme activity in haemolymph of adults. All *P. granatum* peel extracts caused remarkable reduction of LDH in fat bodies of early-aged nymphs but only petroleum ether extract caused a considerable reduction in fat bodies of mid- and late-aged nymphs. Treatment with *A. visnaga* fruit extracts resulted in dramatically declined enzyme level in fat bodies of both early- and late-aged nymphs. These results are, to a great extent, in agreement with reported results of the inhibited LDH activity in several insect species by various botanicals, such as *Spodoptera litura* (Senthil-Nathan and Kalviani, 2005) and *S. littoralis* larvae (Abd El-Aziz, 2007) by azadirachtin (Azt), *Cnaphalocrocis medinalis* by some neem limonoids or *M. azedarach* (Senthil Nathan, 2006; Senthil-Nathan et al., 2006a), *C. medinalis* by Azt and *Vitex negundo* extracts (Senthil Nathan et al., 2006b), *S. gregaria* nymphal fat bodies by Neemazal, *Nigella sativa* and *F. bruguieri* extracts (Hamadah, 2009; Hamadah et al., 2010), *Callosobruchus chinensis* by *Cassia alata* fruit extracts (Upadhyay et al., 2011), *Sitophilus oryzae* by *Capparis deciduas* extracts (Upadhyay, 2013), *Glyphodes pyloalis* by Achook®(0.03% azadirachtin) (Khosravi and Sendi, 2013), *Xanthogaleruca luteola* by the same neem preparation (Valizadeh et al., 2013), etc. The inhibited LDH activity in haemolymph and fat bodies of some developmental stages of *S. gregaria* by *P. granatum* peel extracts or *A. visnaga* fruit extracts, in the present study, indicate the inhibition of lactate conversion to pyruvate, resulting in a shift from aerobic to anaerobic metabolism for meeting the required energy demands under toxic conditions.

In **conclusion**, the current results of disturbed LDH activity in haemolymph and fat bodies of nymphs and adults of *S. gregaria* by *P. granatum* peel extracts and *A. visnaga* fruit extracts indicate that the toxic compounds contained in these extracts (Martelli et al., 1984; Ortel et al., 1988; Li et al., 2006; Bencheraiet et al., 2011; Bhandary et al., 2012) might be affecting the synthesis or functional levels of LDH, directly or indirectly, by altering the cytomorphology of the cells (Nath, 2000). Also, the induction or inhibition, of the LDH activities, as recorded in the present study on *S. gregaria*, might be, on molecular levels, referred to depression or mutations of the regulating genes responsible for biosynthesis of polypeptide chains building this enzyme (Hassanein et al., 1996). However, further investigations should be carried out to identify the active ingredients in *P. granatum* peel extracts and *A.*

visnaga fruit extracts responsible for the gene promotion, rate of expression and eventually synthesis of nucleic acid and enzymatic peptides in the target tissues.

REFERENCES:

Abbassi, K., Atay-Kadiri, Z. and Ghaout, S. (2003): Biological effects of alkaloids extracted from three plants of Moroccan arid areas on the desert locust. J. Physiol. Entomol., 28: 232-236.

Abbassi, K., Atay-Kadiri, Z. and Ghaout, S. (2004): Activité biologique des feuilles de *Calotropis procera* sur le criquet pèlerin (*Schistocerca gregaria* Forsk. 1775). Zoologica Baetica, 15: 153-166.

Abd El-Aziz, H.S., Hanan, S., Mansy, M.S., Desuky, W.M. and Elyassaki, S.M. (2007): Toxicity evaluation and biochemical impacts of some *Bacillus thuringiensis* formulation on *Spodoptera littoralis* larvae. J. Egypt. Acad. Soc. Environ. Develop. 8(1): 1-10.

Abdel Latif, A.M. (2004): Tooth-pick seed *Ammi visnaga* L. extracts as grain protectants against the granary weevil *Sitophilus granarius* L.. Egypt. J.Agric. Res., 82(4): 1599-1608.

Abdollahzadeh, Sh., Mashouf, R.Y., Mortazavi, H., Moghaddam, M.H., Roozbahani, N. and Vahedi, M. (2011): Antibacterial and antifungal activities of *Punica granatum* peel extracts against oral pathogens. Journal of Dentistry, Tehran University of Medical Sciences, Tehran, Iran, 8(1): 6pp.

Abou M., Ahmed M. and Alzouma I. (2005): L'impact des pesticides utilisés en lutte contre le criquet pèlerin *Schistocerca gregaria* (Forskal, 1775) Orthopera, Acrididae sur deux espèces de *Pimelia* (Coleptera, Tenebrionidae) au Niger. Rev. Environ. Sci. Vertigo, 6(3): 19-28.

Ahmed, S.M.S. and Al-Moajel, N.H. (2005): Effect of toothpick (*Ammi visnaga* L.) seed extracts on the rice weevil *Sitophilus oryzae* (Coleoptera: Curculionidae). Arab Univ. J. Agric.Sci., Cairo, 13(2): 549-557.

Alanis, A.D., Calzade, J., Cervantes, A., Torres, J. and Ceballos, G.M. (2005): Antibacterial properties of some plants used in Mexican traditional medicine for the treatment of gastro-intestinal disorders. J. Ethnopharmacol., 100: 153-157

Aly, A.S. El-Ebiary, A.S. and Hamada Kh.Sh. (2010): Effects of the wild plant, *Fagonia bruguieri* on the adult performance and phase transition of *Schistocerca gregaria* (Orthoptera: Acrididae). Egypt. Acad. J. Biol. Sci., 3(2): 133-147.

Amer, A. and Mehlhorn, H. (2006a): Larvicidal effects of various essential oils against *Aedes*, *Anopheles*, and *Culex* larvae (Diptera, Culicidae). Parasitol. Res., 99: 466-472.

Amer, A. and Mehlhorn, H. (2006b): Persistency of larvicidal effects of plant oil extracts under different storage conditions. Parasitol. Res., 99: 473-477.

Augusta C., Bonzanini, F., Palla, G., Cirlini, M. and Bruni, R. (2010): Characterization of a potential nutraceutical ingredient: pomegranate (*Punica granatum* L.) seed oil unsaponifiable Fraction. Plant Foods Hum Nutr., 65: 277-283.

Azmi, M.A., Ahmad, I., Naqvi, S.N.H. and Akhtar, K. (2002): Level of lactate dehydrogenase (LDH) in resistant and susceptible strains of Culicine mosquitoes of the Karachi region after treatment with DDT, malathion and cyfluthrin. Turk. J. Zool., 26: 97-100.

Basiouny, A.L., Hamadah, Kh.Sh. and Tanani, M.A. (2010): Efficacy of the wild plant *Fagonia bruguieri* (Zygophyllaceae) on acid and alkaline phosphatase activities in the desert locust *Schistocerca gregaria* (Orthoptera: Acrididae). Egypt. Acad. J. Biol. Sci., 2(2): 1-10.

Bencheraiet, R., Kherrab, H., Kabouche, A., Kabouche, Z. and Jay, M. (2011): Flavonols and antioxidant activity of *Ammi visnaga* L. (Apiaceae). Rec. Nat. Prod., 5: 52-55.

Bhandary, S.K., Suchetha Kumari, N., Bhat, V.S., Sharmila, K.P. and Bekal, M.P. (2012): Preliminary phytochemical screening of various extracts of *Punica granatum* peel, whole fruit and seeds. Nitte Univer. J. Health Sci., 2(4): 34-38.

Breuer, M. and De Loof, A. (2000): Efficacy of an enriched *Melia azedarach* L. fruit extract for insect control. In: "Practice oriented results on use and production of neen ingredients and pheromones" (Kleeberg, H. and Zebitz, C.P.W., eds.). vol. VI, pp: 173-183.

Breuer, M., Hoste, B., De Loof, A. and Naqvi, S.N.H. (2003): Effect of *Melia azedarach* extract on the activity of NADPH-cytochrome *c* reductase and cholinesterase in insects. Pestic. Biochem. Physiol., 76: 99-103.

Ceccato, P., Cressman, K., Giannini, A. and Trzaska, S. (2007): The desert locust upsurge in West Africa (2003-2005): Information on the desert locust early warning system and the prospects for seasonal climate forecasting. Int. J. Pest Manage., 53(1): 7-13.

Copping, L.G. and Menn, J.J. (2001): Biopesticides: a review of their action, applications and efficacy. Pest Manage. Sci., 56(8): 651-676.

Cordero, C.P., Gomez-Gonzalez, S., León-Acosta, C.J., Morantes-Medina, S.J. and Aristizabal F.A. (2004): Cytotoxic activity of five compounds isolated from Colombian plants. Fitoterapia, 75: 225-227.

Correia, A.A., Wanderley-Teixeira, V., Teixeira, A.A.C., Oliveira, J.V. and Torres, J.B. (2009): Morfologia do canal alimentar de lagartas de *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae) alimentadas com folhas tratadas com nim. Neotrop. Ent., 38: 83-91.

Das, S. and Barman, S. (2012): Antidiabetic and antihyperlipidemic effects of ethanolic extract of leaves of *Punica granatum* in alloxan-induced non–insulin-dependent diabetes mellitus albino rats. Indian J. Pharmacol., 44(2): 219-224.

Delkash-Roudsari, S., Zibaee, A., Bigham, Z. and Fazeli-Dinan, M. (2014): Effect of hexaflumuron on intermediary metabolism of *Ephestia kuehniella* Zeller (Lepidoptera: Pyralidae). Plant Pests Res., 3(4): 22-52.

Diamantino, T.C., Almeida, E., Soares, A.M.V.M. and Guilhermino, L. (2001): Lactate dehydrogenase activity as an effect criterion in toxicity tests with *Daphnia magna* Straus. Chemosphere, 45: 553-560.

Dickinson, W.J. and Sullivan, D.T. (1975): Gene enzyme system in *Drosophila.* Springer-Verlag, Berlin and New York.

Dkhil, M.A. (2013): Anti-coccidial, anthelmintic and antioxidant activities of pomegranate (*Punica granatum*) peel extract. Parasitology Research, 112(7): 2639-2646.

Duarte, J., Lugnier, C., Torres, A.I., Perez-Vizcaino, F., Zarzuelo, A. and Tamargo, J. (1998): Effects of visnagin on cyclic nucleotide phosphodiesterases and their role in its inhibitory effects on vascular smooth muscle contraction. Gen. Pharmacol., 32: 71-74.

Eldiasty, J.G., Hassan, M.M. and Kamal, O.M.H.M. (2014): Evaluation of some agricultural waste extracts against mosquito larvae, and some types of microorganisms as insecticidal and antibiotic agents. Egypt.Acad.J. Biol. Sci., 6(1): 1-16.

Garriga, M. and Caballero, J. (2011): Insigths into the structure of urea-like compounds as inhibitors of the juvenile hormone epoxide hydrolase (JHEH) of the tobacco hornworm *Manduca sexta*: analysis of the binding modes and structure-activity relationships of the inhibitors by docking and CoMFA calculations. Chemosphere, 82: 1604-1613.

Ghandi, N. and Pillai, S. (2011): Control of *Rhyzopertha dominica* (Coleoptera: Bostrichidae) by pulverized leaves of *Punica granatum* (Lythraceae) and *Murraya koenigii* (Rutaceae). Int. J. Agric.Biol., 13: 535-540.

Gandhi, N., Pillai, S. and Patel, P. (2010): Efficacy of pulverized *Punica granatum* (Lythraceae) and *Murraya koenigii* (Rutaceae) leaves against stored grain pest *Tribolium castaneum* (Coleoptera: Tenebrionidae). Int. J. Agric.Biol., 12: 616-620.

Ghoneim, K.S., Tanani, M.A. and Basiouny, A.L. (2009): Influenced survival and development of the desert locust *Schistocerca gregaria* (Acrididae) by the wild plant *Fagonia bruguieri* (Zygophyllaceae). Egypt. Acad. J. Biol. Sci., 2(2): 147-164.

Ghoneim, K., Amer, M., Al-Daly, A., Mohammad, A., Khadrawy, F. and Mahmoud, M.A. (2014a): Disrupted survival, growth and development of desert locust *Schistocerca gregaria* (Forskal) (Orthoptera: Acrididae) by extracts from Toothpick weed *Ammi visnaga* Lamarck (Apiaceae). Int. J. Biosci., 5(1): 397-414.

Ghoneim, K., Amer, M., Al-Daly, A., Mohammad, A., Khadrawy, F. and Mahmoud, M.A. (2014b): Effectiveness of *Punica granatum* Linn. (Lythraceae) extracts on the adult performance of desert locust *Schistocerca gregaria* (Forskal) (Orthoptera: Acrididae). Entomol. Appl. Sci. Letters, 1(2): 9-19.

Ghoneim, K., Al-Daly, A., Amer, M., Mohammad, A., Khadrawy, F. and Mahmoud, M.A. (2014c): Disruptive effects of pomegranate *Punica granatum* Linn. (Lythraceae) extracts on the reproductive potential of desert locust *Schistocerca gregaria* (Forskal) (Orthoptera: Acrididae). Entomol. Appl. Sci. Letters, 1(1): 1-10.

Ghoneim, K., Amer, M., Al-Daly, A., Mohammad, A., Khadrawy, F. and Mahmoud, M.A. (2014d): Disturbed acid and alkaline phosphatase activities in desert locust *Schistocerca gregaria* (Forskal) (Orthoptera: Acrididae) by extracts from the khella plant *Ammi visnaga* L. (Apiaceae). Int. J. Adv. Res., 2(5): 584-596.

Ghoneim, K., Amer, M., Al-Daly, A., Mohammad, A., Khadrawy, F. and Mahmoud, M.A. (2014e): Transaminase perturbation in certain tissues of *Schistocerca gregaria* (Forskal) (Orthoptera: Acrididae) by *Punica granatum* Linn. (Lythraceae) extracts. Int.J. Current Res. Acad. Rev., 2(6): 18-34.

Ghoneim, K., Mohammad, A., Al-Daly, A., Amer, M., Khadrawy, F. and Mahmoud, M.A. (2014f): Metabolic responsiveness of desert locust *Schistocerca gregaria* (Forskal) (Orthoptera: Acrididae) to the khella plant *Ammi visnaga* L. (Apiaceae) extracts. Int. J. Adv. Life Sci., 7(2): 204-216.

Hamadah, Kh.Sh. (2009): Some developmental, haematological and enzymatic effects of certain plant extracts on the desert locust *Schistocerca gregaria* (Orthoptera: Acrididae). Ph.D. Thesis, Al-Azhar University, Egypt, 458 pp.

Hamadah, Kh.Sh., Basiouny, A.L. and Ghoneim, K.S. (2010): Alterations in the lactate dehydrogenase activity of the desert locust *Schistocerca gregaria* by the wild plant *Fagonia bruguieri* (Zygophyllaceae). Egypt. Acad. J. Biol. Sci., 3(2): 1-9.

Hamadah, Kh.Sh., Ghoneim, K.S., El-Hela, A.A., Amer, M.S. and Mohammad, A.A. (2013): Disturbed survival, growth and development of the desert locust *Schistocerca gregaria* by different extracts of *Azadirachta indica* (Meliaceae) and *Nigella sativa* (Ranunculaceae). Egypt.Acad.J.Biolog.Sci., 6(2): 1-21.

Harper, N., Osborne, A.J., Makov, U.E. and Bittles, A.H. (1984): The effects of oral ginseno administration on the activities and isozyme profiles of murine lactate dehydrogenases. Biochem. Pharmacol., 33(9): 1571-1573.

Hassanien, A.H.M., Baker, R. F.A., Saleh, N.A. and El-Bermawy, S.M. (1996): Biochemical aberrations induced by three insect growth regulators in the house fly *Musca domestica* L. (Diptera: Muscidae). Ain Shams Sci. Bull., 34: 319-350.

Holland, D., Hatip, K. and Bar-Yaakov, I. (2009): Pomegranate: Botany, Horticulture and Breeding. In: "Horticultural Reviews"(Janick J., ed.). John Wiley & Sons Inc, pp. 127-191.

Huang, Z., Shi, P., Chen, C. and Du, J. (2007): Effects of azadirachtin on hemolymph protein expression in *Ostrina furnacalis* (Lepidoptera: Crambidae). Ann. Entomol. Soc. Am., 100: 245-250.

Hukkeri, V.I., Kalyani, G.A., Hatapaki, B.C. and Manvi, F.V. (1993): *In vitro* anthelmintic activity of aqueous extracts of fruit rind of *Punica granatum*. Fitoterapia, 64: 69-70.

Hunter-Jones, P. (1961): Rearing and breeding locusts in the laboratory. Bull. Anti-locust Res. Center London, 12 pp.

Idrissi-Hassani, L.M. (2000): Analyse phytochimique de l'Harmel *Peganum harmala* L. (Zygophylaceae): Etude de ses effets sur le criquet pèlerin (*Schistocerca gregaria* Forskål 1775) (Orthoptera: Acrididae). Ph.D. Thesis, Ibn Zohr Univer., Agadir, Algeria.

Jahn, G.C. (1993): Supplementary environmental assessment of the Eritrean Locust Control Program. USAID, Washington DC.

Jurenka, J.S. (2008): Therapeutic applications of pomegranate (*Punica granatum* L.): a review. Altern. Med. Rev., 13(2): 128-144.

Kaplan, L.A. and Pesce A.J. (1996): Clinical Chemistry-theory Analysis and Correlation. Mosby-Year Book, MO, pp. 609-610.

Keita, S.M., Vincent, C., Schmit, J.P., Arnason, J.T. and Belanger, A. (2001): Efficiency of essential oil of *Oeteget meteteget* L. and *O. gracteeteget* L. applied as an insecticidal fumigant and powder to control *Callosobruchus maculates* (Fab.) (Coleoptera: Bruchidae). J. Stored Prod. Res., 37 (4): 339-349.

Khan, J.A. and Hanee, S. (2011): Antibacterial properties of *Punica granatum* peels. Int.J.Appl.Biol.Pharmac. Technol., 2(3): 23-27.

Khan, Z.A., Assiri, A.M., Al-Afghani, H.M.A. and Maghrabi, T.M.A. (2001): Inhibition of oxalate nephrolithiasis with *Ammi visnaga* (AI-Khillah). Int. Urol. Nephrol., 33(4): 605-608.

Khosravi, R. and Sendi, J.J. (2013): Effect of neem pesticide (Achook) on midgut enzymatic activities and selected biochemical compounds in the haemolymph of lesser mulberry pyralid, *Glyphodes pyloalis* Walker (Lepidoptera: Pyralidae). J.Plant Protec. Res., 53(3): 238-247.

Krall, S. and Wilps, H. (1994): New trends in locust control. Deutsche Gesellschaftfür Technische Zusammenarbeit (GTZ) GmnH. Eschborn, Germany.

Kwon, M.S., Lee, J.K., Park, S.H., Sim, Y.B., Jung, J.S., Won, M.H., Kim, S.M. and Suh, H.W. (2010): Neuroprotective effect of visnagin on kainic acid-induced neuronal cell death in the mice *Hippocampus*. Korean J. Physiol. Pharmacol., 14(5): 257-263.

Lamiri, A., Lhaloui, S., Benjilali, B. and Berrada, M. (2001): Insecticidal effects of essential oils against Hessian fly, *Mayetiola desstructor* (Say). Field Crops Res., 71: 9-15.

Lansky, E.P. and Newman, R.A. (2007): *Punica granatum* (pomegranate) and its potential for prevention and treatment of inflammation and cancer. J Ethnopharmacol., 109(2):177-206.

Lee, J.K., Jung, J.S., Park, S.H., Park, S.H., Sim, Y.B., Kim, S.M., Ha, T.S. and Suh, H.W. (2010): Anti-inflammatory effect of visnagin in lipopolysaccharide-stimulated BV-2 microglial cells. Arch. Pharmacal Res., 33(11): 1843-1850.

Li, Y., Guo, C., Yang, J., Wei, J., Xu, J. and Cheng, S. (2006): Evaluation of antioxidant properties of pomegranate peel extract in comparison with pomegranate pulp extract. Food Chem., 96: 254-260.

Liu, Z.L., Goh, S.H. and Ho, S.H. (2007): Screening of Chinese medicinal herbs for bioactivity against *Sitophilus zeamais* Motschulsky and *Tribolium castaneum* (Herbst). J. Stored Prod. Res., 43: 290-296.

Lye, C. (2008): Pomegranate: preliminary assessment of the potential for an Australian industry. Rural Industries Research and Development Corporation of Australian Government. RIRDC Publication No 08/153, p. 17.

Mahmood, S.M. (2010): The effect of aqueous extract of pomegranate leaves on the histological structure of the midgut and ovaries of the housefly *Musca domestica* L. Tikrit J. Pure Sci. (Tikrit University, Iraq), 15(2): 174-180.

Mahmoud, M.A. (2014): Some physiological and biochemical studies on the desert locust *Schistocerca gregaria* (Orthoptera: Acrididae) by certain plant extracts. M.Sc. Thesis, Faculty of Science, Al-Azhar University, Cairo, Egypt, 290pp.

Mansour, S.A., Bakr, R.F., Hamouda, L.S. and Mohamed, R.I. (2010): Toxic and synergistic properties of several botanical extracts against larval and adult stages of the mosquito, *Anopheles pharoensis*. Biopestic. Int., 6(2): 129-45.

Mansour, S.A., Bakr, R.F.A., Hamouda, L.S. and Mohamed, R.I. (2012): Adulticidal activity of some botanical extracts, commercial insecticides and their binary mixtures against the housefly, *Musca domestica* L. Egypt. Acad. J. Biol.. Sci., 5(1): 151-167.

Mars, M. (2000): Pomegranate plant material: genetic resources and breeding, a review. In: "Production, processing and marketing of pomegranate in the Mediterranean region". (Melgarejo, P., Martínez-Nicolás, J.J., Martínez-Tomé, J., eds.). Adv. Res. Technol.. Zaragoza : CIHEAM,. pp. 55-62

Martelli, P., Bovalini, L., Ferri, S. and Franchi, G.G. (1984): Rapid separation and quantitative determination of khellin and visnagin in *Ammi visnaga* Lam. fruits by high-performance liquid chromatography. J.Chromatog., 301: 297-302.

Meinzingen, W. and Kooyman, C. (1997): Results and recommendations of the working group Control agents and methods. In: "New strategies in locust control"(Krall, S., Peveling R. and Ba Diallo, D., eds.). pp. 263-264. Birkhäuser, Basel, Switzerland.

Melendez, P.A. and Capriles, V.A. (2006): Antibacterial properties of tropical plants from Peurto Rico. Phytomedicine, 13: 272-276.

Mohammad, H.H. (2012): Insecticidal effect of different plant extracts against *Tribolium confusum* (Duval) (Coleoptera: Tenebrionidae). J. Agric.Sci. Technol., A 2: 1175-1181.

Mordue, A.J., Simmonds, M.S.J., Ley, S.V., Blaney, W.M., Mordue, W., Nasiruddin, M. and Nisbet, A.J. (1998): Actions of azadirachtin, a plant allelochemical. Pestic. Sci., 54: 277-284.

Moroney, M.J. (1956): Facts from Figures. 3rd ed., Pinguin Book Ltd. Harmondsworth, Middlesex, 228 pp.

Nath, B.S. (2000): Changes in carbohydrate metabolism in hemolymph and fat body of the silkworm, *Bombyx mori* L., exposed to organophosphorus insecticides. Pestic. Biochem. Physiol., 68(3): 127-137.

Ncube, N.S., Afolayan, A.J. and Okoh, A.I. (2008): Assessment techniques of antimicrobial properties of natural compounds of plant origin: current methods and future trends. Afr. J. Biotechnol., 7(12): 1797-1806.

Negi, P.S. and Jayaprakasha, G.K. (2003): Antioxidant and antibacterial activities of *Punica granatum* peel extracts. J. Food Sci., 68: 1473-1477.

Ortel, B., Tanew, A. and Honigsmann, H. (1988): Treatment of vitiligo with khellin and ultraviolet A. J. Am. Acad. Dermatol., 18(4 Pt 1): 693-701.

Pavela, R. (2008): Larvicidal effects of various Euro-Asiatic plants against *Culex quinquefasciatus* Say larvae (Diptera: Culicidae). Parasitol. Res., 102: 555-559.

Rahman M.F. and Siddiqui M.K.J. (2004): Biochemical effects of vepacide (from *Azadirachta indica*) on Wistar rats during sub-chronic exposure. Ecotoxicol. Environ. Saf., 59(3): 332-339.

Rashwan, M.H. (2013): Biochemical impacts of Rynaxypyr (Coragen) and Spinetoram (Radiant) on *Spodoptera littoralis* (Boisd.). Nature & Science, 11(8): 40-47. http://www.sciencepub.net. 7

Reddy, M., Gupta, S., Jacob, M., Khan, S. and Ferreir, D. (2007): Antioxidant, antimalarial and antimicrobial activities of tannin-rich fractions, ellagitannins and phenolic acids from *Punica granatum* L. Planta Medica, 73: 461-467.

Ribeiro, S., Guilhermino, L., Sousa, J.P. and Soares, A.M.V.M. (1999): Novel bioassay based on acetylcholinesterase and lactate dehydrogenase activities to evaluate the toxicity of chemicals to soil isopods. Ecotoxicol. Environ. Saf., 44: 287-293.

Saleem, M.A. and Shakoori, A.R. (1987): Resistance correlation to biochemical responses in larvae and adults of susceptible and two resistant strains of *Tribolium castaneum*. 7th Pakistan Cong, Zool. (Quetta) pp.: 33-34.

Sayah F. (2002): Ultrastructural changes in the corpus allatum after azadirachtin and 20-hydroxyecdisone treatment in adult females of *Labidura riparia* (Dermaptera). Tissue Cell, 34: 53-62.

Senthil Nathan, S. (2006): Effects of *Melia azedarach* on nutritional physiology and enzyme activities of the rice leaffolder *Cnaphalocrocis medinalis* (Guenée) (Lepidoptera: Pyralidae). Pestic. Biochem. Physiol., 84: 98-108.

Senthil-Nathan S. and Kalaivani K. (2005): Efficiency of nucleopolyhedrovirus (NPV) and azadirachtin on *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae). Biol. Control, 34(1): 93-98.

Senthil Nathan, S., Kalaivani, K., Murugan, K. and Chung, P.G. (2005): Efficacy of neem limonoids on *Cnaphalocrocis medinalis* (Guenee) (Lepidoptera: Pyralidae) the rice leaf-folder. Crop Prot., 24(12): 760-763.

Senthil-Nathan S., Kalaivani K., Chung K., Murugan K. (2006a): Effect of neem limonoids on lactate dehydrogenase (LDH) of the rice leaffolder, *Cnaphalocoris medinalis* (Guenee) (Insecta: Lepidoptera: Pyralidae). Chemosphere, 62 (8): 1388-1393.

Senthil Nathan, S., Kalaivani, K. and Murugan, K. (2006b): Effect of biopesticides on the lactate dehydrogenase (LDH) of the rice leaffolder, *Cnaphalocrocis medinalis* (Guenee)(Insecta: Lepidoptera: Pyralidae). Ecotoxicol. Environ. Saf., 65: 102-107.

Senthil Nathan, S., Choi, M.Y., Seo, H.Y., Paik, C.H., Kalaivani, K. and Kim, J.D. (2008): Effect of azadirachtin on acetylcholinesterase (AchE) activity and histology of the brown planthopper *Nilaparvata lugens* (Stal). Ecotoxicol. Environ. Saf., 70: 244-250.

Sharifi, M., Kosari, A.A., Zibaee, A. and Sendi, J.J. (2013): Effects of Pyriproxyfen on detoxifying and intermediary enzymes of *Ephestia kuehniella* Zeller (Lepidoptera: Pyralidae). Plant Pests Res., 3(1): 35-44.

Sharma, A.N. and Rajguru, M. (2009): Efficacy of a herbal formulation against *Spodoptera litura* Fab. Soybean Res., 7:102-105.

Shekari, M., Sendi, J.J., Etebari, K., Zibaee, A. and Shadparvar, A. (2008): Effects of *Artemisia annua* L. (Asteracea) on nutritional physiology and enzyme activities of elm leaf beetle, *Xanthogaleruca luteola* Mull. (Coleoptera: Chrysomellidae). Pestic. Biochem. Physiol., 91: 66-74.

Showler, A.T. (1995): Desert locust control, public health, and environmental sustainability in North Africa. In: "The North African environment at risk" (Swearingen, W.D. and Bencherifa, A. eds.). West view Press, Boulder, CO., USA., pp.: 217-239.

Showler, A.T. and Potter, C.S. (1991): Synopsis of the 1986-1989 desert locust (Othoptera: Acrididae) plague and the concept of strategic control. Am. Entomol., 37: 106-110.

Singh, H., Mrig, K.K. and Mahla, J.C. (1996): Effect of different plant products on the fecundity and emergence of lesser grain borer *Rhizopertha dominica* in wheat grains. Ann. Appl. Biol., 12(1): 96-98.

Singh, R.P., Chidambara Murthy, K.N. and Jayaprakasha, G.K. (2002): Studies on the antioxidant activity of pomegranate (*Punica granatum*) peel and seed extracts using *in vitro* models. J. Agric. Food Chem., 50: 81-86.

Tanani, M.A., Ghoneim, K.S. and Basiouny, A.L. (2009): Impact of the wild plant, *Fagonia bruguieri*, extracts on the transaminase activities in some tissues of *Schistocerca gregaria* (Orthoptera: Acrididae). Egypt. Acad. J. Biol. Sci., 1(1): 45-55.

Tawfik, A.I. (2012): Hormonal control of the phase polyphenism of the desert locust: a review of current understanding. The Open Entomol. J., 6: 22-41.

Tayel, A.A., El-Baz, A.F., Salem, M.F. and El-Hadary, M.H. (2009): Potential applications of pomegranate peel extract for the control of citrus green mould. J.Plant Dis. Protec., 116(6): 252-256.

Tietz, N.W. (1999): Text Book of Clinical Chemistry. The 3rd (Burtis, C.A. and Ashwood, E.R., eds.). Philadelphia, PA, W.B. Saunders Co., pp.: 668-672.

Tripathi, S.M., Singh, V.K., Singh, S. and Singh, D.K. (2004): Enzyme inhibition by the molluscicidal agent *Punica granatum* Linn. bark and *Canna indica* Linn. root. Phytotherapy Res., 18(7): 501-506.

Ullman, M. (2006): African Desert Locusts in Morocco in November 2004. Brit. Birds, 99: 489-491.

Upadhyay, R.K. (2013): *Capparis decidua* Solvent and Aqueous Extracts Affect Biochemical and Enzymatic Parameters in *Sitophilus oryzae* Linn. (Coleoptera: Curculionidae). World J. Zool., 8(3): 245-255.

Upadhyay, R.K., Yadav, N. and Ahmad, Sh. (2011): Toxic effects of solvent and aqueous extracts of *Cassia alata* against bio-molecules and enzymatic parameters of *Callosobruchus chinensis* L. (Coleoptera: Bruchidae). Adv. Appl. Sci. Res., 2(2): 367-381.

Uvarov, B.P. (1977): Grasshoppers and locusts. Vol. 2, IX +613 pp. University Press (Cambridge).

Valizadeh, B., Sendi, J.J., Zibaee, A. and Oftadeh, M. (2013): Effect of Neem based insecticide Achook® on mortality, biological and biochemical parameters of elm leaf beetle *Xanthogaleruca luteola* (Col.: Chrysomelidae). J. Crop Protec., 2(3): 319-330.

Vanachayangkul, P., Chow, N., Khan, S.R. and Butterweck, V. (2011): Prevention of renal crystal deposition by an extract of *Ammi visnaga* L. and its constituents khellin and visnagin in hyperoxaluric rats. Urol. Res., 39(3):189-195.

Vasconcelos, L.C., Sampaio, F.C., Sampaio, M.C., Pereira Mdo, S., Higino, J.S. and Peixoto, M.H. (2006): Minimum inhibitory concentration of adherence of *Punica granatum* Linn (pomegranate) gel against *S. mutans, S. mitis* and *C. albicans*. Braz. Dent. J., 17(3): 223-227.

Whitton, M.E.; Ashcroft, D.M.; Gonzalez, U. (2008): Therapeutic interventions for vitiligo. J. Am. Acad. Dermatol., 59: 713-717.

Wu, R.S.S. and Lam, P.K.S. (1997): Glucose-6-phosphate dehydrogenase and lactate dehydrogenase in the green-lipped mussel (*Perna viridis*). Possible biomarker for hypoxia in the marine environment. Water Res., 31: 2797-2801.