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Transaminase perturbation in certain tissues of *Schistocerca gregaria* (Forskal) (Orthoptera: Acrididae) by *Punica granatum* Linn. (Lythraceae) extracts

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A B S T R A C T

The present study aimed to investigate the effects of peel extracts from pomegranate (*Punica granatum* Linn.) on the glutamic oxaloacetic transaminase (GOT) and glutamic pyruvic transaminase (GPT) activities in haemolymph and fat bodies of *Schistocerca gregaria*. LC_{50}s of ethanol, petroleum ether and n-butanol extracts (36.7, 22.2 and 40.7%, respectively) were applied for penultimate instar nymphs. The enzyme activity was determined in the last instar nymphs (of three ages) and newly emerged adult females. A predominant enhancing effect on the GOT activity in haemolymph of nymphs and adults was exhibited by all extracts, with few exceptions. Both ethanol extract and n-butanol extract exhibited a remarkable reducing effect on GOT activity in fat bodies of nymphs. In fat body of adults, ethanol extract promoted the enzyme activity but petroleum ether extract and n-butanol extract prohibited it. Petroleum ether extract exhibited a considerable inducing effect on the GPT activity in haemolymph of nymphs and adults. Ethanol extract promoted the enzyme activity in early- and mid-aged nymphs but prohibited it in late-aged nymphs and adults. The n-butanol extract significantly induced the enzyme activity in mid-aged nymphs and adults but slightly or seriously suppressed it in early- and late-aged nymphs. GPT activity was elaborately promoted in fat bodies of earl-aged nymphs, regardless the extract. On the contrary, the enzyme level was dramatically dropped in mid-aged nymphs. The GPT activity in fat body of adults was drastically suppressed, regardless the extract.

Introduction

As reported 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* (Forskal) (Orthoptera: Acrididae) is

potentially the most dangerous of the locust pests because of the ability of swarms to fly rapidly across great distances and has an invasion area of 29 million Km^2, 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. During plagues, the desert locust has the potential to damage the livelihood of a 10^{th} of the world's population. During the summer of 2004, large numbers of swarms from Northwest Africa invaded the Sahel in West Africa. As the year progressed, the swarms migrated over the continent causing devastation, and in November 2004 appeared in northern Egypt, Jordan and Israel for the first time in 50 years. Swarms also invaded Cape Verde, the Canary Islands, southern Portugal, and Crete. National teams in some 20 countries treated nearly 130,000 square kilometres by air and ground. The costs of fighting this upsurge have been estimated by the FAO to have exceeded US$400 million and harvest losses were valued at up to US$2.5 billion which had disastrous effects on the food security situation in West Africa. However, some countries lost significant portions of their crops to the locusts, particularly Mauritania, which lost as much as half of its harvest.

Because of the difficulty to predict locust outbreaks, the concerned countries usually apply pollutant chemical pesticides for control (Gruys, 1993). Current locust control operations are mainly based on organophosphorus pesticides (Lecoq, 2001). Rembold (1994) adverted to the rapidly increasing insect tolerance against any type of neurotoxic insecticide, and all insecticides given their wide spectrum of action undoubtedly had substantial side-effects on the non-target fauna (Müller, 1988). Various researches on the effect of botanical biopesticides on desert locust have been or are being carried out as alternatives to the currently used harmful pesticides (Krall and Wilps, 1994). Several plant species affect differentially the fertility, development, behaviour, and mortality of the desert locust (Idrissi Hassani, 2000; Abbassi et al., 2004). The use of botanicals may be aimed at protecting crops locally (Lecoq, 2001). These botanicals are still at the experimental stage as far as locust control is concerned and 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 were encouraging for implementing an alternative method to chemical control (Idrissi Hassani, 2000; Abbassi et al., 2003).

Pomegranate (*P. granatum*) is one of the oldest cultivated plants in the world (Lye, 2008) and was a symbol of immortality and love in oriental regions (Ageel et al., 1991). Also, 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). Botanically, *P. granatum* is included in the family Punicaceae but recently classified in the family Lythraceae (Boulos, 2000). Many chemical constituents had been isolated and identified from flowers and fruits of pomegranate (Mohammad and Kashani, 2012). The bark and stem contain a number of alkaloids (Hukkeri et al., 1993). In addition, some other compounds have been reported such as punicalagin,

ellagic acid, hydroquinone pyridinium and pelargonidin (Noda et al., 2002; Schmidt et al., 2005). Ethanolic, aqueous and chloroform extracts from seeds or peel contain triterpenoids, steroids, glycosides, saponins, alkaloids, flavonoids, tannins, carbohydrate and vitamin C (Bhandary et al., 2012). The peel is, also, a rich source of polyphenols and some anthocyanins as delphinidins and cyanidins (Li et al., 2006).

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, such as hypolipidemic, antiviral, antifungal, antineoplastic, anticandidal, anti-inflammatory, antimutagenic antioxidant, antibacterial and antidiarrheal (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).

In the field of pest control, aqueous extract from *P. granatum* fruit rind was more toxic against tape-worms than earthworms and round-worms (Hukkeri et al., 1993). Also, extracts from pomegranate bark exhibit molluscicidal activity on the *Lymnaea acuminata* (Tripathi and Singh, 2000; Tripathi et al., 2004). Also, pomegranate fruit rind is effective on some parasitological parameters of *Schistosoma mansoni* (Osman et al., 2013). With regard to the biocontrol of insect pests, the available literature reported some insecticidal effects of *P. granatum* extracts (Alanis et al., 2005; Melendez and Capriles, 2006). The n-hexane extracts possessed contact toxicity against *Sitophilus zeamais* and *Tribolium castaneum* (Liu et al., 2007). The insecticidal efficacy of pulverized leaves had been recorded against *T. castaneum* (Ghandi et al., 2010) and *Rhyzopertha dominica* (Ghandi and Pillai, 2011). Ethanolic extract from leaves and peel was found toxic to *T. castaneum* (Mohammad, 2012). Also, extracts exhibited insecticidal activities against *Spodoptera litura* (Sharma and Rajguru, 2009), *Anopheles pharoensis* (Mansour et al., 2010), *Culex pipiens* (Eldiasty et al., 2014) and *Musca domestica* (Mahmood, 2010; Mansour et al., 2012).

Transamination has been demonstrated in a number of insect tissues, particularly that concerning glutamate, aspartate and alanine (Gilmour, 1961). The glutamic oxaloacetic transaminase (GOT) and glutamic pyruvic transaminase (GPT) are key enzymes in the formation of non-essential amino acids, in metabolism of nitrogen waste, gluconeogenesis and correlated with protein anabolism and catabolism (Mordue and Golworthy, 1973). Moreover, transaminases, especially GPT, acts as a catalytic agent in carbohydrates metabolism (Katumuma et al., 1968). The present work was conducted aiming to investigate the effects of different extracts from the pomegranate (*P. granatum*) peel on the activities of GOT and GPT in haemolymph and fat body of the economically dangerous locust *S. gregaria*.

Materials and methods

Experimental insect

The desert locust *Schistocerca gregaria* (Forskal)(Orthoptera: Acrididae) was used as an experimental insect in the present study. The 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 with10-15% humidity to be suitable for egg laying. An electric bulb (100 watt) was adjusted to maintain a continuous photoperiod (12 L: 12 D) in each cage as well as in order to maintain an ambient temperature (32±2^{o}C). The insects were reared and handled under the crowded conditions. Care was seriously taken to clean these cages at regular intervals and the sand was sterilized in drying oven (at 140^{o}C for 24 hours) to avoid contamination with any pathogenic microorganisms. Fresh clean leaves of clover *Trifolium alexandrinum* were provided, as a food for insects, every day.

Plant Extraction

A weight of 1.5 Kg *Punica granatum* peel, which purchased from the Egyptian market, was 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%.

Nymphal treatments

In a preliminary experiment, different concentration levels of ethanol, petroleum ether, and n-butanol extracts derived from *P. granatum* peel 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 the extract for 3 minutes. A day after treatment, all nymphs (treated and control) were provided, individually, with untreated fresh food leaves. Each individual nymph was isolated in a glass vial provided with a thin layer of sterilized sand as a floor.

All vials were located in a large cage having a suitable electric bulb. After treatment of newly moulted penultimate instar nymphs with the peel extracts, LC_{50} values were estimated in 36.7, 22.2 and 40.7% of ethanol, petroleum ether and n-butanol extracts, respectively. After treatment with these LC_{50}s, the successfully moulted last instar nymphs and newly emerged adult females were undergone to determine the influenced glutamate oxaloacetic transaminase (GOT) and glutamate pyruvic transaminase (GPT) activities in two tissues: haemolymph and fat body. Three ages of last instar nymphs were only used: early- (1-day old), mid- (4-day old) and late-aged (7-day old) nymphs.

Tissue preparation

For the determination of GPT and GOT activities in the haemolymph, it was collected from the last instar nymphs and newly emerged adult females. Haemolymph was drawn into Eppendorff Pipetman containing few milligrams of phenoloxidase inhibitor (phenylthiourea) to prevent tanning or darkening and then diluted 5× 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 for assay directly or frozen until use. Three replicates were used and the haemolymph of two individuals were never mixed. Also, samples of fat bodies were obtained from nymphs (of the same ages) and newly emerged adult females. The fat body was weighed and then homogenized in a saline solution (the 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 for the enzymatic determination. Three replicates were used and the fat bodies from two individuals were avoided to be mixed.

Transaminase Measurements

The GOT and GPT activities were determined according to the method of Harold **(**1975) using a kit of Bioadwic. The enzyme was measured at wave length 546 nm by spectrophotometer.

Statistical analysis

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 and Discussion

Effects of *P. granatum* peel extracts on the glutamic oxaloacetic transaminase (GOT) activity in *S. gregaria*

According to the data assorted in Table (1), a predominant enhancing effect was exhibited by all extracts on the GOT activity in haemolymph of nymphs and adults, with few exceptions. These exceptional cases were the remarkably reduced enzyme activity in the mid-aged nymphs (Change%: -4.7)($p<0.05$) and newly emerged adults (Change%: -5.2) ($p<0.05$) after treatment with only n-butanol extract. For some detail, the strongest inducing effect was exhibited by n-butanol extract on the enzyme activity in haemolymph of early-aged nymphs (209.4±1.9 U/L in comparison with 81.4±2.0 U/L in control nymphs). On the other hand, the least inducing effect was detected for petroleum ether extract in haemolymph of late-aged nymphs (90.6±2.4 U/L in comparison with 55.1±2.3 U/L in control nymphs) With regard to adult females, the most potent enhancing action on the enzyme activity was exerted in haemolymph by ethanol extract (205.4±2.3 U/L vs. 66.9±2.6 U/L in control adults).

In addition to the disturbed GOT activity in haemolymph of nymphs adults, it was disrupted in fat bodies of these stages as exiguously shown in Table (2). Concerning the last instar nymphs, ethanol extract exerted a rigorous reducing action on the enzyme activity throughout the nymphal life (6.7, 3.4 and 8.6% reductions in early-, mid- and late-aged nymphs, respectively). A similar powerful inhibitory effect was exhibited by n-butanol extract throughout the nymphal life (6.3, 3.3 and 5.1% reductions in early-, mid- and late-aged nymphs, respectively). The ethanol extract enhanced the enzyme activity in fat bodies of adults (261.7±1.8 U/L, $p<0.01$, vs. 244.2±2.5 U/L in control adults) while petroleum ether extract and n-butanol extract caused a pronounced declination in the enzyme level (217.4±1.7, $p<0.001$, and 210.5±1.9 U/L, $p<0.001$, by petroleum

ether extract and n-butanol extract, respectively, vs. 244.2±2.5 U/L in control adults).

Effects of *P. granatum* peel extracts on the glutamic pyruvic transaminase (GPT) activity in *S. gregaria*

Depending on the data arranged in Table (3), the GPT activity was considerably induced in haemolymph of nymphs, regardless the age, as well as of adults, by petroleum ether extract. The strongest inducing potency was detected in mid-aged nymphs (140.0% elevation). In respect to the other two extracts, contradictory results of GPT activity were recorded. After treatment with ethanol extract, the enzyme activity was activated in haemolymph of early- and mid-aged nymphs but reversely declined in late-aged congeners and newly emerged adults. In addition, treatment with n-butanol extract resulted in significantly increased GPT activity in mid-aged nymphs and adults (163.9 and 16.3% elevation in mid-aged nymphs and adults, respectively) but slightly or seriously suppressed enzyme activity in early- and late-aged nymphs (9.5 and 97.3% reduction in early- and late-aged nymphs, respectively).

In the light of data distributed in Table (4), the GPT activity was elaborately promoted in fat bodies of early-aged nymphs, irrespective of the extract (Chang%s: +38.9, +42.6 and +3.2 by ethanol extract, petroleum ether extract and n-butanol extract, respectively). On the contrary, the enzyme activity dramatically dropped-off in mid-aged nymphs (Change%: -22.9, -17.3 and -38.5 by ethanol extract, petroleum ether extract and n-butanol extract, respectively). In the fat body of late-aged nymphs, the enzyme activity was enhanced by ethanol extract and n-butanol extract but prohibited by petroleum ether extract. With respect to the newly emerged adults, the GPT activity in fat body was drastically suppressed, regardless the extract (for detail, see table 4).

Disturbance of GOT activity in *S. gregaria*

Contradictory results of disturbed GOT activity in several insects by various botanicals had been reported in the available literature. Enhancement or prohibition of the enzyme activity usually depends not only on the insect species but also on its developmental stage, age, tissue, nature of the botanical and method of treatment (Saha et al., 1986; Tabassum, 1994; Tabassum et al., 1998; Bakr et al., 2002; Zohry, 2006; Abdel-Ghaffar and Ghoneim, 2007; Al-Dali, 2008; Ezz and Fahmy, 2009; Hamadah, 2009; Tanani et al., 2009).

In the present study, ethanol, petroleum ether and n-butanol extracts from peel of *P. granatum* exhibited a predominant enhancing effect on the GOT activity in haemolymph of last instar nymphs and newly emerged adult females of *S. gregaria*, with few exceptions. In fat bodies of nymphs, ethanol extract or n-butanol extract exhibited a remarkable reducing effect on the enzyme activity. A similar reducing effect had been recorded in fat bodies of adults after nymphal treatments with petroleum ether extract and n-butanol extract while ethanol extract promoted the enzyme activity. The current results of disturbed activity of GOT in haemolymph and fat bodies of *S. gregaria* agree, to some extent, with those reported results on the same locust by various botanicals, such as *Fagonia bruguieri* extracts (Tanani et al., 2009) and *Nigella sativa* extracts (Hamadah, 2009).

Table.1 Glutamic oxaloacetic transaminase activity (U/L) in haemolymph of desert locust *Schistocerca gregaria* after treatment of the newly moulted penultimate instar nymphs with of different extracts (LC_{50}) of pomegranate *Punica granatum*

Solvent		Last instar nymphs			Newly emerged adults
		Early-aged	Mid-aged	Late-aged	
Ethanol	**Mean±SD**	0161.4 ± 2.0 d	211.2 ± 2.1 d	127.6 ± 2.7 d	205.4 ± 2.3 d
	Change (%)	+098.2	+114.9	+131.6	+207.1
Petroleum ether	**Mean±SD**	0146.3 ± 2.4 d	177.2 ± 2.1 d	090.6 ± 2.4 c	164.2 ± 2.1 d
	Change (%)	+079.7	+080.3	+064.4	+145.4
n-butanol	**Mean±SD**	0209.4 ± 1.9 d	093.7 ± 2.1 b	107.4 ± 2.0 d	070.4 ± 2.1 b
	Change (%)	+157.2	-004.7	+094.9	-005.2
Control		0081.4 ± 2.0	098.3 ± 1.9	055.1 ± 2.3	066.9 ± 2.6

Early-aged: 1-day old nymphs, Mid-aged: 4-day old nymphs, Late-aged: 7-day old nymphs. Mean ± SD followed by letter (a): Not significantly different ($P>0.05$), (b): Significantly different ($P<0.05$), (c): Highly significantly different ($P<0.01$), (d): Very highly significantly different ($P<0.001$).

Table.2 Glutamic oxaloacetic transaminase activity (U/L) in fat bodies of desert locust *Schistocerca gregaria* after treatment of the newly moulted penultimate instar nymphs with of different extracts (LC_{50}) of pomegranate *Punica granatum*

Solvents		Last instar nymphs			Newly emerged adults
		Early-aged	Mid-aged	Late-aged	
Ethanol	**Mean±SD**	0351.2 ± 2.2 d	302.4 ± 2.2 d	181.5 ± 1.9 b	261.7 ± 1.8 c
	Change (%)	-006.7	-003.4	-008.6	+071.2
Petroleum ether	**Mean±SD**	1012.3 ± 1.9 d	567.3 ± 2.0 d	227.5 ± 2.4 c	217.4 ± 1.7 d
	Change (%)	+168.8	+082.0	+014.6	-011.0
n-butanol	**Mean±SD**	0352.7 ± 2.1 c	301.4 ± 2.1 b	188.4 ± 1.9 b	210.5 ± 1.9 d
	Change (%)	-006.3	-003.3	-005.1	-013.8
Control		0376.6 ± 1.7	311.7 ± 2.2	198.5 ± 2.5	244.2 ± 2.5

Early-aged, Mid-aged, Late-aged, b, c, d: See footnote of Table (1).

Table.3 Glutamic pyruvic transaminase activity (U/L) in haemolymph of desert locust *Schistocerca gregaria* after treatment of the newly moulted penultimate instar nymphs with of different extracts (LC_{50}) of pomegranate *Punica granatum*

Solvents		Last instar nymphs			Newly emerged adults
		Early-aged	Mid-aged	Late-aged	
Ethanol	**Mean±SD**	077.4 ± 1.8 c	041.4 ± 1.9 c	016.1 ± 2.6 a	039.3 ± 1.8 a
	Change (%)	+136.6	+062.2	-07.3	-09.1
Petroleum ether	**Mean±SD**	051.3 ± 2.1 c	061.2 ± 2.0 d	024.4 ± 1.9 b	047.4 ± 2.4 b
	Change (%)	+057.0	+140.0	+51.7	+09.7
n-butanol	**Mean±SD**	029.6 ± 1.7 a	067.3 ± 1.9 d	034.3 ± 2.8 c	050.2 ± 1.9 b
	Change (%)	-009.5	+163.9	-97.3	+16.3
Control		032.7 ± 2.8	025.5 ± 2.1	017.4 ± 2.1	043.2 ± 2.1

Early-aged, Mid-aged, Late-aged, a, b, c, d: See footnote of Table (1).

Table.4 Glutamic pyruvic transaminase activity (U/L) in fat bodies of desert locust *Schistocerca gregaria* after treatment of the newly moulted penultimate instar nymphs with of different extracts (LC_{50}) of pomegranate *Punica granatum*

Solvents		Last instar nymphs			Newly emerged adults
		Early-aged	Mid-aged	Late-aged	
Ethanol	**Mean±SD**	176.7 ± 2.1 c	152.4 ± 2.2 c	191.2 ± 1.9 c	169.5 ± 1.4 d
	Change (%)	+038.9	-022.9	+14.9	-19.0
Petroleum ether	**Mean±SD**	181.4 ± 2.1 d	163.5 ± 1.9 c	141.4 ± 1.7 c	169.3 ± 1.8 c
	Change (%)	+042.6	-017.3	-15.0	-19.1
n-butanol	**Mean±SD**	131.3 ± 2.1 b	121.6 ± 1.7 d	183.3 ± 2.2 b	157.2 ± 1.9 c
	Change (%)	+003.2	-038.5	+10.1	-25.0
Control		127.2 ± 2.1	197.6 ± 2.2	166.4 ± 2.1	209.3 ± 2.2

Early-aged, Mid-aged, Late-aged, b, c, d: See footnote of Table (1).

Also, the current results are consistent with some of the reported results for various insect pests by different botanicals, such as *Euprepocnemis plorans* by some linonoids (Abdel-Ghaffar and Ghoneim, 2007), *Spodoptera littoralis* by Margosan-o (a neem preparation)(Mostafa, 1993) and *Melia azedarach* (Hassan, 2002), *Musca domestica* by Margosan-o and Jojoba oil (Ghoneim and Abdel-Ghaffar, 2007), *Tribolium castaneum* by RB-a (a neem fruit extract) (Tabassum, 1994; Tabassum et al., 1994), *Sitophilus oryzae* by RB-a (Azmi et al., 1998), *Rhynchophorus ferrugineus* by azadirachtin (Bream, 2003), *Anopheles stephensi* by RB-b (Rajput, 2003), *Ferrisia virgata* by mineral oils Alboleum and Super Misrona (Ezz and Fahmy, 2009), while *Capparis deciduas* extracts prohibited the GOT activity in *T. castaneum* (Upadhyay and Ahmad, 2011). Outside botanicals, the current results are concomitant with several reported results of disrupted GOT activity in certain tissues of various insect pests, as response to insect growth regulators (IGRs) or insecticides, such as *T. castaneum* by cypermethrin (Saleem and Shakoori, 1986), *M. domestica* by lufenuron and diofenolan (Al-Dali, 2008), *Bombyx mori* by estradiol-17B (Keshan and Ray, 1998), *Alphitobius diaperinus* by danitol (Tufail, 1991), *Gryllus campestris* by methoprene (Zera and Zhao, 2004), *S. littoralis* by flufenoxuron and chlorfluazuron (Bakr et al., 2007), *F. virgata* by pyriproxyfen (Ezz and Fahmy, 2009) and *S. gregaria* by pyridalyl (Teleb et al., 2012).

The enhanced GOT activity in haemolymph of nymphs and adults of *S. gregaria*, in the present study, after treatment with *P. granatum* peel extracts suggests the mobilization of amino acids during the stress exerted by certain toxic components in these extracts to meet the energy demands (Zeba and Khan, 1995). On the other hand, inhibitory effect of the *P. granatum* extracts on the enzyme activity may be due to difficulty in the formation of dissociable enzyme-inhibitor complexes which reduce the specific enzyme activity (Dragomirescu et al., 1979).

Disruption of GPT activity in *S. gregaria*

As clearly reported in the literature, the GPT activity was disrupted in *S. gregaria* by Neemazal (a neem preparation) and *N. sativa* extracts (Hamadah, 2009) as well by *F. bruguieri* extracts (Tanani et al., 2009). The enhancement or inhibition of the enzyme activity was reported to depend on the tissue, developmental stage and extract. Moreover, certain limonoids prohibited the enzyme activity in midgut of *E. plorans* nymphs (Abdel-Ghaffar and Ghoneim, 2007). Mineral oils promoted or suppressed the enzyme activity in *F. virgata* adults, depending on the age (Ezz and Fahmy, 2009). Treatment of *T. castaneum* with *C. deciduas* extracts resulted in reduced GPT activity in the body homogenate (Upadhyay and Ahmad, 2011). Outside botanicals, there are several reported results of reduced or induced GPT activity in some insects by a number of IGRs or insecticides (Ezz and Fahmy, 2009; Bakr et al., 2007; Teleb et al., 2012).

In the light of these contradictory reported results, the present study recorded a considerable inducing effect on GPT activity in haemolymph of nymphs and adults of *S. gregaria* after treatment with petroleum ether extract from *P. granatum* peel. Increasing or decreasing enzyme level depended on the nymphal age after treatment with ethanol extract or n-butanol extract. As determined in the present work, also, GPT activity was elaborately

promoted in fat bodies of early-aged nymphs, irrespective of the extract. On the contrary, the enzyme level was dramatically dropped in mid-aged nymphs. In late-aged nymphs, the enzyme activity was enhanced by ethanol and n-butanol extracts but prohibited by petroleum ether extract. The GPT activity in fat body of adults was drastically suppressed, regardless the extract. However, these opposing results of promoted or prohibited GPT activity in *S. gregaria* depended on the developmental stage, tissue and *P. granatum* extract. These contradictory results can be evidently supported by some reported results (Bakr et al., 2002; Bream, 2003; Ghoneim and Abdel-Ghaffar, 2007). The increasing or decreasing GPT level in haemolymph and fat bodies of *S. gregaria*, as responses to *P. granatum* peel extracts, in the present study, can be understood in the view of effect on synthesis or functional levels of this enzyme directly or indirectly by altering the cytomorphology of the cells (Nath, 2000), or the effect of certain effective components in these extracts on the neurosecretory hormonal pattern. In addition, the inhibited GPT activity was possibly because pyruvate is the precursors of Krebs cycle compounds, concerned with the mitochondrial oxidation phenomenon and ATP production (Azmi et al., 1998).

It is of interest to mention that GOT and GPT serve as a strategic link between the carbohydrate and protein metabolism and are known to be altered during various physiological and pathological conditions (Etebari et al., 2005). Accordingly, the disturbance in GOT and GPT levels will be closely related to metabolism of proteins and amino acids. Thus it will disrupt many physiological functions and ultimately lead to death, in other way control the pest (Ezz and Fahmy, 2009).

In conclusion, the pomegranate peel contains several chemical constituents, such as alkaloids, flavonoids, steroids, saponins, triterpenoids, tannins, polyphenols, anthocyanins, punicalagin and hydroquinone pyridinium (Li et al., 2006; Noda et al., 2002; Schmidt et al., 2005; Bhandary et al., 2012). Unfortunately, no isolated compounds, but crude peel extracts, were assessed in the present study on GOT and GPT activities. Thus, further investigation (s) should be carried out in future to identify the active ingredient (s) responsible for the disturbance of enzyme activity. Nevertheless, the current study may be the first report of transaminase perturbation in haemolymph and fat bodies of the desert locust by pomegranate peel extracts.

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