Physicochemical impact of dietary and antinutritive compounds on some pests

A Thesis
Submitted for the Degree of Ph.D.
in

Physical chemistry

BY
Takwa El-sayed Hamed Ellakwa
M.sc., chemistry, (2001)

Supervised By

Prof. Dr. Salah A. Abo-El-Enein
Professor of physical chemistry, chemistry department,
Faculty of science, Ain Shams University, Cairo

Dr. Tarek Raies Amin
Associate professor of pest physiology
Department of pest physiology
Plant protection Research Institute
Agriculture Research center, Giza

To

Chemistry Department
Faculty of Science

Ain-Shams University

2007

Physico-chemical impact of dietary and antinutritive compounds on some pests

By

Takwa El-Sayed Hamed Ellakwa

Supervised By | **Approved**

Prof. Dr.Salah A. Abo-El-Enein
Professor of physical chemistry, chemistry department, Faculty of science, Ain Shams University, Cairo

……………………………

Dr. Tarek Raies Amin
Associate professor of pest physiology
Department of pest physiology
Plant protection Research Institute
Agriculture Research center, Giza

………………………………

Head of Chemistry department

Prof. Dr. El-Said Ahmed Soliman

ACKNOWELDGEMENT

The author wishes to express her sincere thanks and gratitude to ***Prof. Dr. Salah Abo-El-Enein*** **,** professor of physical chemistry, faculty of science, Ain Shams University, Cairo for his kind interest in the subject and for his valuable support.

I would to express my deep appreciation and gratitude to ***Dr. Tarek Raies Amin*** Associate Professor of pest physiology Department of pest physiology, plant protection Research Institute, Agriculture Research center, Giza for his encouragement and preparing this thesis, valuable advice, continuous guidance, constructive criticism and useful discussions.

I’m also gratitude to all staff members and my colleagues at physical chemistry department, Plant protection Research Institute, for their encouragement during the fulfillment of this work.

I would like to express my deep appreciation to my family for their kind help, support and patience.

Finally, thanks are also expressed to the Plant protection Research Institute , for all the facilities provided to the work to be accomplished.

List of contents

	Contents	

List of tables

..

LIST OF FIGURES

Abstract

The pressent study was performed to demonstrate the phytochemical effects on the cotton leafworm, *Spodptera littoralis* (Boisd.) larvae .Total phenols of some cotton leafworm host plants leaves i.e castor bean, cabbage, grapevine and garden rocket, were extracted by using homogenizing method and aqueous (80%) methanol and acetone . Quantification of phenolics was carried out by Folin-Ciocalteu method . The results revealed that the amount of phenols significantly, differed among the tested host plants in the following order: castor bean < garden rocket < cabbage < grapevine . Although acetone was of a good extraction efficiency, methanol was more efficient in some cases . The yield of total phenols using this method of extraction was satisfactory and total analysis has been achieved, the situation which fullfil the progressing interest to screen these important compounds . When the larvae fed on those host plants from egg hatching to fifth larval instar (10 days), host plants significantly modify the titre of detoxification enzymes ;alkaline phosphatase, non-specific esterases and glutathione-S-transferase . This suggests that phenolic compounds could be implicated in the change of *S. littoralis* susceptibility to insecticides . When tannic and salicylic acids were incorporated into artificial diet at concentrations of 20 X 10^{-3} M through 160 X 10^{-3} M , and introduced to the 4 *th* larval instar for 5 days to demonstrate some aspects of their mode of action, they could , significantly , reduce growth , main metabolites and digestive enzymes of the larvae . *In vitro* experiments indicated that incubation of phenolic acids not only had the ability to affect protein (casein), but also affected carbohydrates (sucrose) and their specific enzymes ; protease and invertase , respectively , suggesting their ability to get food less digestible. The inhibitory effect that obtained after 10 min incubation was not significantly differed from that obtained after 20 min , indicating that the interaction of the enzymes or their substrates with phenolics was rapid. The results revealed that the phytochemical effects was not limited to the chemical composition of the food , but also to its physicochemical characters . The 4 *th* larval instar fed on artificial diets (for 4 days) differing their pH and buffering capacity . These diets caused significant changes in growth, nutritional indices and total carbohydrates of the larvae . The larvae probably to overcome unsuitable physicochemical conditions of the introduced diets, increased their demand on energy through consuming digested or assimilated food like carbohydrates, which finally influencing larval performance parameters . In general, the study emphasizes the importance of nutritional ecology in the field of insect control .

INTRODUCTION

The extensive use of chemical insecticides has caused a number of ecological , economical and social problems to various ecological niches around the world including Egypt, in addition to resistance of several classes of insects to pesticides. Hence there is a growing necessity and interest in the search of new approaches in insect control

Phytophagous insects like the cotton leafworm, *Spodoptera littoralis,* (O:Lepidoptera) depend on plants as food which must fulfill their nutritional requirements for normal growth and development to occur . Alleochemicals, water and nitrogen content, and physical attributes of foliage are considered to be determinant factors greatly affecting the quality of plant as diet, which in turn suppress insect growth and survival (**Felton *et al* 1992; Appel, 1994**) .

Allelochemicals or allelochemics are non-nutrient compounds produced by one organism and affect another species (**Whittaker, 1970**). They occur in plant tissues as phenolic acids, polyphenols, flavonoids and tannins and appear to be involved in insect resistance of crop plants (**Todd *et al,* 1971**). Phenolics are considered as important components of both constitutive and induced defense against herbivores and pathogens, by acting as antinutritive compounds affecting the growth and development of a variety of insects (**Reese and Beck, 1976; Bernays, 1981; Reese *et al;* 1982; Duffy, 1986; Appel, 1993; Abdel-Baky *et al;* 2005**) .

Phenolic compounds have been quantified in several plant species (e.g. **Käkönen *et al;* 1999**) and identified (e.g. **Nakatani,**

1997; Abd El-Ghany, 2006) . In attempts to control insects using natural compounds, Effects of crude plant extracts contained phenolic compounds have been examined (e.g. **Hegazy** ***et al;*** **1992; Salem** ***et al;*** **1994; Heil** ***et al;*** **2002; Abdel-Baky** ***et al;*** **2005**) In spite of, cotton leafworm is a polyphagous pest and exposed to many allelochemicals, phenolic content of its most host plants is not known . **Antonious** ***et al*****. (1999)** measured total phenols of different commercial tomato leaflets cultivars in relation to mortality and feeding of fourth-instar larvae of *S.littoralis*. Also, the mode of action of phenolics on this pest is not well studied .

Since midgut pH has long been recognized as an important factor for the optimal activity of digestive enzymes, physicochemical characters of diet or plant such as pH, redox potential and buffering capacity and their affect on insect gut conditions have been reported **(Schultz and lechowiz, 1986; Appel and Maines, 1995; Johnson and Felton, 1996)** . But reports deal with effect of such characters on performance and fitness on phytophagous insects are few. **Karowe and Martin (1993)** found that the growth of fourth instar, *Manduca sexta* larvae on nutrient-rich artificial diets was significantly affected by the characteristics of the buffer system present in the diet . However, gut physico-chemistry which may strongly impact digestion and nutrient assimilation in herbivorous insects varies among lepidopteran larvae (**Johonson and Felton, 1996**) .

The aim of the present work was to demonstrate the effects of plant chemistry on the cotton leafworm , *S. littoralis* larvae and studies were carried out to :-

1- Extract and quantify total phenolic content of some cotton leafworm host plants i.e. grapevine, cabbage, castor bean leaves and garden rocket .

2- Find any correlation between phenolic content of those host plants and some detoxification enzymes such as glutathione S-transferase (GST), general esterases and alkaline phosphatase (alkpase) .

3- Evaluate the ability of some phenolic compounds which are known to occur in plant tissues, to inhibit dietary compounds and digestive enzymes of the larvae. Two benzoic acid derivatives were used; tannic acid and salicylic acid, and the inhibitory effect was estimated either *in vivo* or *in vitro.*

4- Examine the ability of change in some physicochemical conditions of the diet to affect the larvae. Hydrogen ion concentration (pH) and molarity (M) of an artificial diet were used to test their effect on nutritional indices and growth .