INSECTICIDAL AND REPELLANT ACTIVITIES OF SELECTED BOTANICAL EXTRACTS AGAINST RICE WEEVIL (*SITOPHILUS ORYZAE* L.)

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DEDICATION

The thesis is first and foremost dedicated to Almighty Allah for seeing me through. Then to my parents for their unwavering support, advice, encouragement and prayers which guided me towards this achievement, I am very proud of them and may Almighty Allah reward them abundantly. The thesis is also dedicated to my brothers and sisters for their prayers and support.

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May Almighty Allah in his infinite mercy reward everyone abundantly.

ABSTRACT

Stored rice is infected primarily by adult rice weevil (*Sitophilus oryzae* L.). Botanical pesticides could be alternatives to synthetic insecticides due to their effectiveness and lower toxicity. This study investigated repellence activity, insecticidal activity and phytochemical composition of acetone and ethanol extracts of basil leaves (*Ocimum basilicum*), turmeric leaves (*Curcuma longa*) and *akar mempelas* stem (*Tetracera macrophylla*) against adult rice weevil (*Sitophilus oryzae* L.) on stored rice. Methodology involved preparing 0%, 10%, 20% and 30% concentrations of either ethanol or acetone extract of each plant to be examined for their repellence activity, contact toxicity and phytochemical composition using gas chromatography-mass spectroscopy (GC-MS). Results showed that acetone and ethanol extracts of the three plants exerted dose-dependent repellence and time-dependent contact toxicities. Ethanol extracts of the three plants showed superior repellence activity and contact toxicity were superior to those of their acetone extracts, while the repellence activity and contact toxicities of the ethanol and acetone extracts of basil were superior to those of turmeric and *Akar mempelas*. GC-MS indicated that basil acetone extract contained anethole, while the ethanol extract contained bis (2-Ethylhexyl) phthalate. Turmeric acetone extract contained Ar-turmerone, while the ethanol extract contained bis(2-Ethylhexyl) phthalate. *Akar mempelas* stem acetone extract contained 1-tetradecene, while the ethanol extract contained 1-octadecene and bis(2-Ethylhexyl) phthalate. In conclusion, acetone and ethanol extracts of basil leaves, turmeric leaves and *akar mempelas* stem exhibited effective dose-dependent repellant activities and time-dependent insecticidal activities against the adult rice weevil. However, the repellant and contact toxicity of ethanol extracts of the basil, turmeric and *akar mempelas* were superior to those of their acetone extracts, while the repellence and contact toxicities of the ethanol and acetone extracts of basil were superior to those of turmeric and *akar mempelas*.

ABSTRAK

Beras yang disimpan boleh dijangkiti terutamanya oleh kumbang padi dewasa (*Sitophilus oryzae* L.). Racun perosak botani mampu menjadi alternatif kepada racun serangga sintetik kerana keberkesanannya dan ketoksikan yang lebih rendah. Kajian ini menyiasat aktiviti penghalauan, aktiviti racun serangga dan komposisi fitokimia ekstrak aseton dan etanol daun selasih (*Ocimum basilicum*), daun kunyit (*Curcuma longa*) dan batang *akar mempelas* (*Tetracera macrophylla*) terhadap kumbang padi dewasa (*Sitophilus oryzae* L.) terhadap beras yang disimpan. Metodologi ini melibatkan penyediaan kepekatan 0%, 10%, 20% dan 30% sama ada ekstrak etanol atau aseton setiap tumbuhan yang akan diperiksa untuk aktiviti penghalauan, ketoksikan kontak dan komposisi fitokimia menggunakan kromatografi gas spektroskopi jisim (GC-MS). Hasil kajian menunjukkan bahawa ekstrak aseton dan etanol dari ketiga-tiga tumbuhan tersebut menunjukkan peningkatan bergantung kepada dos dan ketoksikan yang bergantung pada masa. Ekstrak etanol ketiga-tiga tumbuhan menunjukkan aktiviti unggul dan toksisiti sentuhan lebih tinggi daripada ekstrak asetonnya, manakala aktiviti penghalauan dan ketoksikan sentuhan ekstrak etanol dan aseton selasih lebih tinggi daripada ekstrak kunyit dan *akar mempelas*. GC-MS menunjukkan bahawa ekstrak aseton selasih mengandungi anethole dan ekstrak etanol mengandungi bis (2-Ethylhexyl) phthalate. Ekstrak aseton kunyit mengandungi Ar-turmerone, sementara ekstrak etanol mengandungi bis (2-Ethylhexyl) phthalate. Ekstrak aseton batang *akar mempelas* mengandungi 1-tetradecene dan ekstrak etanol mengandungi 1-octadecene dan bis (2-Ethylhexyl) phthalate. Kesimpulannya, ekstrak aseton dan etanol daun selasih, daun kunyit dan batang *akar mempelas* menunjukkan aktiviti penghalau yang berkesan dan aktiviti racun serangga yang dosnya bergantung kepada masa terhadap kumbang padi dewasa. Walaubagaimanapun, ketoksikan penghalau dan sentuhan ekstrak etanol daun selasih, kunyit dan *akar mempelas* lebih tinggi daripada ekstrak aseton mereka, sementara ketahanan dan ketoksikan sentuhan ekstrak etanol dan aseton daun selasih lebih tinggi daripada kunyit dan *akar mempelas*.

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LIST OF SYMBOLS AND ABBREVIATIONS

≤	-	equal to or less than
>	-	greater than
%	-	percentage
±	-	plus or minus
ANOVA	-	Analysis of variances
BCE	-	Before the Christian Era
C°	-	degrees Celsius
CAS	-	assigned number of registered compounds
GC	-	gas chromatography
GC-MS	-	gas chromatography-mass spectroscopy
cm	-	centimeter
CRD	-	Completely Randomized Design
FRIM	-	Forest Research Institute Malaysia
g/g	-	gram per gram
m	-	meter
Mc	-	control mortality
mg	-	milligram
ml	-	milliliter
ml/min	-	milliliter per minute
mm	-	millimeter
Mo	-	observed mortality
Nc	-	insect number on the untreated half of filter paper
Nt	-	insect number on the treated half of the filter paper.
PR	-	Percent repellency
RT	-	Retention Time
µl	-	microliter

µm	-	micrometer
v/v	-	volume per volume

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LIST OF PUBLICATIONS

Journals:

i. Albariman, N.H., Sabran, S.F., Othman, N.W., Ishak, N., Dheyab, A.S., Anjur, N. (2020) Insecticidal and Repellant Activities of Southeast Asia Plants towards Insect Pests: A Review Asian Journal of Chemistry, 32(5), 1026-1032.

Proceedings:

i. Participant in 4th International Symposium on Insects (ISoI 2020) on 1-2 December 2020 via a virtual online platform **http://entoma.net/isoi2020/**.

CHAPTER 1

INTRODUCTION

1.1 Background

Plants pests embrace wide organisms including insects, mites, nematodes, rodents (animal pests), viruses, bacteria, fungi, chromista (microbes) and weeds (Kang, 2019). However, insects are still the most devastating pests to agriculture production (Kortbeek *et al.*, 2019). In addition, plant pests infest either wild or cultivated plants (Agrios, 2005) causing damage to those plant through damaging foliage (Dukes *et al.*, 2009) or even direct feeding (Edwards & Singh, 2006). The damage of plants not only restricted to pre-harvest crops but also extends to involve stored crops (Bebber *et al.*, 2019). Stored grains are attacked by 600 species of beetle, 70 moths and 355 mites (Nenaah, 2013). which increases the need for developing effective strategies to minimize the infestation of stored grains (Nenaah, 2013) and produce adequate and safe food to feed the population worldwide (Kang, 2019).

Plants developed strategies to defend themselves against those invasive pests (Wilkinson *et al.*, 2019), which could be physical through accumulating minerals (e.g. calcium oxalate crystals, amorphous calcium carbonates and silica) which make the plant tougher, mechanically through capturing the pest or chemically through the production of secondary metabolites (e.g. iridoids) (Carper *et al.*, 2019; Villard *et al.*, 2019). However, such auto-defense of plants against invasive pests is lost in case stored grains. Therefore; human has developed several controlling strategies for preventing and/or killing plant pests, such as chemical pesticides (Abhilash & Singh, 2009). However, the use of synthetic pesticides is frequently associated with unsafe application because of the serious health risk to the environment, local workers and the people live near the treated areas (Abhilash & Singh, 2009).

Several chemical classes of insecticides include organochlorine (e.g. dichlorodiphenyltrichloroethane), organophosphates (e.g. glyphosate), carbamate (e.g. carbofuran), triazines (e.g., simazine), pyrethroids (e.g. permethrin) and neonicotinoid (e.g. imidacloprid) (Nicolopoulou-Stamati *et al.*, 2016). The health risks of insecticides that could affect human health could range from minor pain to severe paralysis and death because they can bind to different enzymes, receptors, and other proteins (Gupta *et al.*, 2019). For example, short term exposure to insecticides lead to harmful effects on several human organs including lung, blood, liver, kidney, endocrine glands, and even immune system, while chronic exposure results in several hazards to nervous system, lung, skin, eyes, gastrointestinal tract and development of cancer, particularly in children (Organization, 2019). Additionally, the cost of chemical pesticides is becoming increasingly inaccessible to farmers, particularly in developing countries (Jahromi *et al.*, 2012). Moreover, the flawed use of pesticides is also associated with a critical threat to non-target species, such as potential natural enemies of the pests. Therefore, finding effective, safe, and cost-effective alternatives pest control strategy is needed (Abhilash & Singh, 2009).

Nowadays, the utilization of pesticides of plant origin; known as botanical pesticides, becomes one of the possible techniques (Javed *et al.*, 2007). Fortunately, pesticides of a botanical origin have been reported to be effective with the advantages of lower toxicity and a shorter degradation period compared to the synthetic ones (Gregoire *et al.*, 2009; Pavoni *et al.*, 2019). In recent times, the use of environment-friendly and biodegradable botanicals to control pests and other insect vectors of diseases are promising (Pavoni *et al.*, 2019). In addition, investigating the pesticidal activity of botanical extracts should be associated with a phytochemical investigation for secondary metabolites that are responsible for the insecticidal activity of the plant extract since such secondary metabolites are produced by plants to protect themselves from pests and diseases or attract pollinators (Stevenson, 2019). For example, pyrethrin is a commercial insecticide which is derived from flowers of *Tanacetum cinerariifolium* (Xu *et al.*, 2019). Therefore, if these substances are identified and extracted from plants, they can be recruited in the production of commercial insecticides.

One of the most global concerns is the world food security which encounters a threat of invasive plant pests that destroy pre- or post-harvest of crops (Bebber *et al.*, 2019). For example, 60% of the global caloric need comes from wheat, maize, rice (*Oryza sativa*) and soya (Almu *et al.*, 2019), and rice is one of the most important global nutritional crops constituting an essential cereal food for at least 3.5 billons people worldwide (Almu *et al.*, 2019). In Malaysia, at least 19 different pests attack, rest or live on rice plant in Malaysia alone (Ooi, 2015a). On the other hand, rice weevil (*Sitophilus oryzae* L.) is one of the primary insects that attack stored rice and this insect is resistant to most of the synthetic insecticides (Benzi *et al.*, 2009; Nenaah, 2013).

Essential oils from tea, cinnamon, cloves, lemongrass and thyme were reported to be dose-dependent repellant and insecticidal against adult (*Sitophilus oryzae* L.) (El-Salam, 2019). Similarly, essential oils of spearmint leaves (*Mentha spicata* L.) and clove showed insecticidal activity against rice weevil (*Sitophilus oryzae* L.) (Saad *et al.*, 2017). In addition, the seed extract of *Sesbania aegyptica* was effective insecticidal against weevil (*Sitophilus oryzae* L.) (Ahmed & Al-Moajel, 2019). Likewise, the leave extract of *Agave americana* leaf showed a repellant and insecticidal activity against the adult rice weevil (Maazoun *et al.*, 2019).

Basil (selasih; *Ocimum basilicum*.; Family: Lamiaceae), on the other hand, is an aromatic plant that contains essential oils consisting from methyl chavicol, methyl cinnamate, eugenol, methyl eugenol, linalool, geraniol, geranial, camphor and neral. In addition, basil is a plant that is famous in many countries worldwide including Malaysia for its therapeutic benefits (Ali & Setzerb, 2013). In addition, the repellant and insecticidal activities of basil against adult and larvae of mosquito (*Anopheles arabiensis*) as well as a repellant activity against diamondback moth (*Plutella xylostella*) were reported (Ali & Setzerb, 2013; Chokechaijaroenporn *et al.*, 1994; Elsiddig, 2019; Kianmatee & Ranamukhaarachchi, 2007; Kraikrathok *et al.*, 2013; Nour *et al.*, 2009).Similarly, turmeric (*Curcuma longa*; family: *Zingiberaceae*) is an aromatic spice plant, of which rhizome is well-known to contain curcumin and use in the traditional medicine for its therapeutic benefits (Chanda & Ramachandra, 2019; Govindarajan & Stahl, 1980). Interestingly, turmeric possesses insecticidal properties against insects and fungi. The isolated compounds of turmeric rhizome; ar-turmerone and curcumin, showed insecticidal activity against the larvae of *Culex pipiens* (Abdelgaleil *et al.*, 2019). Most studies in the literature focused on the repellant and insecticidal activity of rhizome extracts against several plant pests due to the presence of ar-turmerone rhizome, which was reported to be insecticidal (De Souza Tavares *et al.*, 2016). However, ar-turmerone was also isolated from the leaves of turmeric in a high concentration (De Souza Tavares *et al.*, 2016). In addition, essential oil and its principal bioactive (e.g. α-phellandrene) in the leave extract of turmeric exhibited insecticidal activity against the larvae of *Lucilia cuprina* (Diptera*:*Calliphoridae) (Chaaban *et al.*, 2019). In addition, one study reported that the essential oil extract of the leaves of turmeric exhibited contact and fumigant toxicity against adult rice weevil (*Sitophilus oryzae* L.) (Tripathi *et al.*, 2002), which needs to be further evaluated due to the scarcity of studies in the literature about the insecticidal or the repellant activities of the turmeric leaves against adult rice weevil.

The genus *Tetracera* embraces several species distributed in Asia, Malaysia, Australia and New Caledonia, and the species of the genus *Tetracera* are mostly aromatic (Hoogland, 1953). *Akar mempelas* (*Tetracera macrophylla*) Family: Dilleniaceae), is one species of such genus known with a local name; '*Akar mempelas*' and it is a wild plant distributed in Southeast Asia, Malaysia and Indonesia (Ong *et al.*, 2011). The decoction of the stem of *akar mempelas* is taken orally by local Malaysian for alleviating physical weakness (Ong *et al.*, 2011), while the collected sap of the stem of this plant is used orally by locals for relieving night fever (Sabran *et al.*, 2016). However, there is no data in the literature about the insecticidal or repellant activity of the stem extract of *akar mempelas* against adult rice weevil (*Sitophilus oryzae* L.) or even other insects. In addition, no data have been reported about the phytochemical composition of the stem of *akar mempelas*.

1.2 Problem statement

The use of synthetic pesticides in most of the developing countries, including Malaysia is, however, frequently associated with an unsafe application and incorrect training. This poses a serious health risk to the environment, local workers and the people living near the treated areas. The increasing public concern over pesticide safety and possible damage to the environment has resulted in increased attention being given to natural products for the control of pests. Therefore, the selected botanical pesticide of basil (*Ocimum basilicum*), turmeric (*Curcuma longa*) and *akar mempelas* (*Tetracera macrophylla*) to decrease the spreading of major pest that causing serious damage of stored rice are one of the solutions. Still, botanical pesticide control may become an alternative control for rice pests, as it is considered as an environmentally safe form of pest control. Further development of botanical pesticides against pests of stored rice is targeted the intended pests without adversely affecting the human health or the environment. The future development and use of safer pesticides in Malaysia will need to address safety concerns using botanical pesticide as basil leaves, turmeric leaves and *akar mempelas* stem extracts against rice weevil insect (*Sitophilus oryzae* L.) on stored rice. This will impact positively on health by controlling disease-causing vectors and food security as well.

1.3 Objectives

The goal of this work is to reduce the rice weevil (*Sitophilus oryzae* L.*)* on stored rice through achieving the following objectives:

(i) To determine the repellant activities of basil dry leaves (*Ocimum basilicum*), turmeric dry leaves (*Curcuma longa*) and *akar mempelas* dry stem (*Tetracera macrophylla)* against adult rice weevil insect (*Sitophilus oryzae* L.) on stored rice.

(ii) To evaluate the insecticidal activity of basil dry leaves (*Ocimum basilicum*), turmeric dry leaves (*Curcuma longa*) and *akar mempelas* dry stem (*Tetracera macrophylla*) against adult rice weevil insect (*Sitophilus oryzae* L.) on stored rice.

(iii) To profile phytochemical content of basil dry leaves (*Ocimum basilicum*), turmeric dry leaves (*Curcuma longa*) and *akar mempelas* dry stem (*Tetracera macrophylla)* by using gas chromatography-mass spectroscopy.

1.4 Scope of the study

Plants pests embrace wide organisms including insects, mites, nematodes, rodents (animal pests), viruses, bacteria, fungi, chromista (microbes) and weeds. However, insects are still the most devastating pests to agriculture production. One of the most global concerns is the world food security which encounters a threat of invasive plant pests that destroy pre- or post-harvest of crops. For example, 60% of the global caloric need comes from wheat, maize, rice (*Oryza sativa*) and soya, and rice is one of the most important global nutritional crops constituting an essential cereal food for at least 3.5 billons people worldwide. In Malaysia, at least 19 different pests attack, rest or live on rice plant in Malaysia alone. On the other hand, rice weevil (*Sitophilus oryzae* L.) is one of the primary insects that attack stored rice and this insect is resistant to most of the synthetic insecticides.

The human has developed several controlling strategies for preventing and/or killing plant pests, such as chemical pesticides. However, the use of synthetic pesticides is frequently associated with unsafe application because of the serious health risk to the environment, local workers and the people live near the treated areas. There are several chemical classes of insecticides including organochlorine (e.g. dichlorodiphenyltrichloroethane), organophosphates (e.g. glyphosate), carbamate (e.g. carbofuran), triazines (e.g., simazine), pyrethroids (e.g. permethrin) and neonicotinoid (e.g. imidacloprid). The health risks of insecticides that could affect human health could range from minor pain to severe paralysis and death because they can bind to different enzymes, receptors, and other proteins. Many herbal plants which known as botanical pesticides act as natural insecticides and could be provided with an alternative tool for control of stored rice pests also preventive of many pest's diseases in several developing countries. The current study aims to achieve effectiveness and potential of pesticides of plant origin for application in stored rice in Malaysia. The selected botanical pesticides are to decrease the spreading of rice weevil that causing serious damage to stored rice.

1.5 Significance of the study

This study differs from previous studies since it is searching for major pests on stored rice and applied an extract of basil leaves (*Ocimum basilicum*), turmeric leaves (*Curcuma longa*) and *akar mempelas* stem (T*etracera macrophylla*) to control the infestation of adult rice weevil insect (*Sitophilus oryzae* L.) on stored rice.

The three selected plants were studied for their repellant and contact toxicities against several plant pests, adult rice weevil and their phytochemical composition. Interestingly, these plants are available in Malaysia and their repellant and insecticidal activities as well as their phytochemical composition should be studied to compare those activities and phytochemical composition to those studied in the other countries.

The results of this study may provide insight for the discovery and development of promising botanical effective repellants and insecticides from the extracts of basil leaves, turmeric leaves and *akar mempelas* stem against rice weevil insect (*Sitophilus oryzae* L.) on stored rice. In addition, this study would contribute to the production of newly defined botanical formulation that could provide an environmentally friendly alternative for controlling rice weevil insect (*Sitophilus oryzae* L.) on stored rice.

CHAPTER 2

LITERATURE REVIEW

2.1 Plants with insecticidal and repellant activities

Globally, utilization of botanicals is becoming a trend of important means to protect crop harvest and environment from pollution by pesticides (Prakash *et al.*, 2008). The new agricultural trend is directed toward exploring and developing friendly insecticides (Matassini *et al.*, 2020). For such reason, the botanical pesticides could be probable alternatives (Javed *et al*., 2007) since several botanical pesticides provide effectiveness against several plant pests, lower toxicity, multiple mechanisms of insecticidal activity and shorter degradation period (Gregoire *et al*., 2009; Pavoni *et al*., 2019; Campos *et al.*, 2019). Interestingly, there are promising evidence indicated the effectiveness and efficacy of botanical pesticides from aromatic plants in controlling agriculture pests (Campos *et al.*, 2019). In general, botanical pesticides are characterized by several advantages over synthetic ones including availability, abundance, ease to be obtained, low toxicity to mammals, least pollution to the environment, minimal hazards to health, lower pest resistance to their pesticide effects, minimal adverse effects on the growth of plants, no effect on viability of seeds, no effect on the quality of grains cooking, and low cost (Prakash *et al*., 2008). For such reasons, the European Union took steps to enhance the environmental awareness about the hazards of using synthetic pesticides and recommended several strategies for sustainable use of pesticides among them using botanical pesticides as a safe option (Stoytcheva, 2011).

Up to know, the pesticide efficacy of several plants has been approved including sweet flag, bel, neem, mahua, senwar, karanj pyrethrum and tobacco, while efforts of exploring new bio pesticides from plants are ongoing (Prakash *et al.*, 2008).

In Europe, it was reported that seed extract of black pepper (*Piper nigrum* L.) against third instars of European chafer (*Rhizotrogus majalis* larvae) has been reported to be effective (Scott *et al.*, 2005), while the standardized twig extract of *Aglaia odorata Lour*. (Meliaceae) was effective in controlling infestation of the European corn borer (*Ostrinia nubilalis* Hübner) (Ewete *et al.*, 1996). In Southeast Asia countries (Malaysia, Indonesia, Myanmar, Thailand, Laos, Vietnam, Cambodia (Perry & Metzger, 1980), a shortlist was adopted to demonstrate some plant extracts that reported to exert an insecticidal and/or repellant activities against some common plant pests, which are organisms that attack and infest plants causing diseases and damages (Kang, 2019), (Table 2.1).

Table 2.1: List of some insecticidal and repellant plants against insects infested crops in some Southeast Asia countries

Plant species	**Activity**	**Insects**	**References**
Piper retrofractum (Indonesia)	Insecticidal	(*Crocidolomia pavonana* F.) and (*Plutella xylostella* L.)	(Dadang & Prijono, 2009)
Piper nigrum (Malaysia)	Larvicidal	Larvae of *Spodoptera litura*	(Fan *et al.*, 2011)
Piper nigrum (Malaysia)	Larvicidal	Larvae of rice weevil, (*Sitophilus oryzae* L.) and rice moth (*Corcyra cephalonica*)	(Khani *et al.*, 2012)
Piper longum (Malaysia)	Insecticidal	Housefly (*Musca domestica* L.)	(Prodhan *et al.*, 2012)
Piper retrofractum (Thailand)	Insecticidal	Diamondback moth (*Plutella xylostella*)	(Kraikrathok *et al.*, 2013)
Piper aduncum (Malaysia)	Adulticidal	Housefly (*Musca domestica*)	(Mee *et al.*, 2009).
Azadirachta excelsa (Indonesia, Malaysia and the Philippines)	Insecticidal	Larvae of *Crocidolomia binotalis*	(Teik Ng *et al.*, 2003)
Azadirachta indica (Indonesia)	Insecticidal	Second instar larvae of *Crocidolomia binotalis* Zellar	(Prijono, 1998)
Azadirachta indica (Malaysia)	Insecticidal	Silver leaf whitefly (*Bemisia tabaci*)	(Islam *et al.*, 2011)
Azadirachta indica A.Juss (Vietnam)	Repellant	Maize weevil bugs (*Sitophilus zeamais*)	(Thanh *et al.*, 2011).
Azadirachta indica L. (Malaysia)	Repellant	Gold dust beetle (*Hypomeces squamosus* L.)	(Singh *et al.*, 2013).
Azadiracta indica (Indonesia)	Insecticidal	*Nephotettix virescens D., Nilaparvata lugens S., S. incertulas*, and *Leptocorisa oratorius*	(Abdullah *et al.*, 2015).

REFERENCES

Ababutain, I. M. (2019). Antimicrobial Activity and Gas Chromatography-Mass Spectrometry (GC-MS) Analysis of Saudi Arabian *Ocimum basilicum* Leaves Extracts. *J Pure Appl Microbiol, 13*(2), 823-833.

Abdelgaleil, S., Zoghroban, A., El-Bakry, A., & Kassem, S. (2019). Insecticidal and Antifungal Activities of Crude Extracts and Pure Compounds from Rhizomes of *Curcuma longa* L.(Zingiberaceae). *Journal of Agricultural Science and Technology, 21*(4), 1049-1061.

Abdullah, T., Gassa, A., Ngatimin, S. N. A., Agus, N., & Fattah, A. (2015). Impact Of Different Time Planting In Soybeans And Neem Seed Extract Application To Insect Population On Rice Field. *International Journal of Scientific Research and Technology, 4*(10), 62-65.

Abegunde, S., & Ayodele-Oduola, R. (2015). Comparison of efficiency of different solvents used for the extraction of phytochemicals from the leaf, seed and stem bark of *Calotropis procera*. *International Journal of Science and Research, 4*(7), 835-838.

Abhilash, P., & Singh, N. (2009). Pesticide use and application: an Indian scenario. *Journal of hazardous materials, 165*(1-3), 1-12.

Abid, M. D. N., Chen, J., Xiang, M., Zhou, J., Chen, X., & Gong, F. (2013). Khat (*Catha edulis*) generates reactive oxygen species and promotes hepatic cell apoptosis via MAPK activation. *International Journal of Molecular Medicine, 32*(2), 389-395.

Adel, I., Seada, M. A., Arab, R. A., & Seif, A. I. (2015). Efficacy of three locale gyptian essential oils against the rice weevil, *Sitophilus oryzae* (Coleoptera: Curculionidae) and the cowpea weevil, *Callosobruchus maculatus* (Coleoptera: Bruchidae). *The Egyptian Journal Of Experimental Biology, 11*(1), 95-105.

Agrios, G. N. (2005). *Plant pathology* (5th ed. Vol. 1). Cambridge, Massachusetts, United states of America: Academic press.

Ahmad, S. Z. S., Halim, M., AR, N. A., & Yaakop, S. (2018). Diversity and abundance of storage pest in rice warehouses in Klang, Selangor, Malaysia. *Serangga, 23*(1), 89-98.

Ahmed, S., & Al-Moajel, N. (2019). Insecticidal activity and biochemical studies of Egyptian sesban, *Sesbania aegyptica*; Jynit. seed extracts against rice weevil, *Sitophilus oryzae* L. *Arab Universities Journal of Agricultural Sciences, 13*(2), 537 - 548.

Ajaiyeoba, E. O., Sama, W., Essien, E. E., Olayemi, J. O., Ekundayo, O., Walker, T. M., & Setzer, W. N. (2008). Larvicidal Activity of Turmerone-Rich Essential Oils of *Curcuma longa*. Leaf and Rhizome from Nigeria on *Anopheles gambiae*. *Pharmaceutical Biology, 46*(4), 279-282.

Ajanal, M., Gundkalle, M. B., & Nayak, S. U. (2012). Estimation of total alkaloid in Chitrakadivati by UV-Spectrophotometer. *Ancient science of life, 31*(4), 198.

Akhtar, Y., Yeoung, Y.-R., & Isman, M. (2008). Comparative bioactivity of selected extracts from Meliaceae and some commercial botanical insecticides against two noctuid caterpillars, *Trichoplusia ni* and *Pseudaletia unipuncta*. *Phytochemistry Reviews, 7*(1), 77-88.

Akhter, M., Sultana, S., Akter, T., & Begum, S. (2017). Oviposition preference and development of rice weevil, *Sitophilus oryzae* (Lin.)(Coleoptera: Curculionidae) in different stored grains. *Bangladesh Journal of Zoology, 45*(2), 131-138.

Ali, H., Nesa, M., Rekha, S. B., & Islam, N. (2019). Dose-mortality and repellent potentials of *Argemone mexicana* L. extracts against *Sitophilus oryzae* L. and *Callosobruchus chinensis* L. *Journal of Entomology and Zoology Studies, 7*(2), 288-339.

Ali, N., & Setzerb, W. N. (2013). Pharmacological activities of basil oil a review. *Recent progress in medicinal plants, 37*, 286-307.

Almu, H., Rafii, M., Sulaiman, Z., Ismail, M. R., Harun, A. R., Ramli, A., . . . Halidu, J. (2019). Genetic Variability of Rice (*Oryza sativa* L.) Genotypes under Different Level of Nitrogen Fertilizer in Malaysia. *International Journal of Plant Breeding, 6*(1), 487-497.

Ambarningrum, T. B., Setyowati, E. A., & Susatyo, P. (2013). Aktivitas Anti Makan Ekstrak Daun Sirsak (*Annona Muricata* L.) Dan Pengaruhnya Terhadap Indeks Nutrisi Serta Terhadap Struktur Membran Peritrofik Larva Instar V *Spodoptera Litura* F. *Jurnal Hama dan Penyakit Tumbuhan Tropika, 12*(2), 169-176.

Amoabeng, B. W., Johnson, A. C., & Gurr, G. M. (2019). Natural enemy enhancement and botanical insecticide source: a review of dual use companion plants. *Applied Entomology and Zoology, 54*(1), 1-19.

Asawalam, E., Ebere, U., & Emeasor, K. (2012). Effect of some plant products on the control of rice weevil *Sitophilus oryzae* (L.) Coleoptera: Curculionidae. *Journal of Medicinal Plants Research, 6*(33), 4811-4814.

Aye, A., Jeon, Y.-D., Lee, J.-H., Bang, K.-S., & Jin, J.-S. (2019). Anti-inflammatory activity of ethanol extract of leaf and leaf callus of basil (*Ocimum basilicum* L.) on RAW 264.7 macrophage cells. *Oriental Pharmacy and Experimental Medicine, 19*(2), 217-226.

Baczek, K., Kosakowska, O., Gniewosz, M., Gientka, I., & Węglarz, Z. (2019). Sweet Basil (*Ocimum basilicum* L.) Productivity and Raw Material Quality from Organic Cultivation. *Agronomy, 9*(6), 279.

Bebber, D. P., Field, E., Gui, H., Mortimer, P., Holmes, T., & Gurr, S. J. (2019). Many unreported crop pests and pathogens are probably already present. *Global Change Biology, 25*(8), 2703-2713.

Bedini, S., Bougherra, H. H., Flamini, G., Cosci, F., Belhamel, K., Ascrizzi, R., & Conti, B. (2016). Repellency of anethole-and estragole-type fennel essential oils against stored grain pests: the different twins. *Bull Insectol, 69*(1), 149-157.

Benzi, V. S., Stefanazzi, N., & Ferrero, A. A. (2009). Biological activity of essential oils from leaves and fruits of pepper tree (*Schinus molle* L.) to control rice weevil (*Sitophilus oryzae* L.). *Chilean Journal Of Agricultural Research, 69*(2), 154-159.

Brusotti, G., Cesari, I., Dentamaro, A., Caccialanza, G., & Massolini, G. (2014). Isolation and characterization of bioactive compounds from plant resources: the role of analysis in the ethnopharmacological approach. *Journal of pharmaceutical and biomedical analysis, 87*, 218-228.

Campbell, J. (2002). Influence of seed size on exploitation by the rice weevil, *Sitophilus oryzae*. *Journal of Insect Behavior, 15*(3), 429-445.

Campos, E. V., Proença, P. L., Oliveira, J. L., Bakshi, M., Abhilash, P., & Fraceto, L. F. (2019). Use of botanical insecticides for sustainable agriculture: Future perspectives. *Ecological Indicators, 105*, 483-495.

Cantrell, C. L., Ali, A., Duke, S. O., & Khan, I. (2011). Identification of Mosquito Biting Deterrent Constituents From the Indian Folk Remedy Plant *Jatropha curcas*. *Journal of Medical Entomology, 48*(4), 836-845.

Carper, A. L., Enger, M., & Bowers, M. D. (2019). Host plant effects on immune response across development of a specialist caterpillar. *Frontiers in Ecology and Evolution, 7*(2019), 208.

Caunii, A., Pribac, G., Grozea, I., Gaitin, D., & Samfira, I. (2012). Design of optimal solvent for extraction of bio–active ingredients from six varieties of *Medicago sativa*. *Chemistry Central Journal, 6*(1), 123.

Chaaban, A., Richardi, V. S., Carrer, A. R., Brum, J. S., Cipriano, R. R., Martins, C. E. N., . . . Molento, M. B. (2019). Insecticide activity of *Curcuma longa* (leaves) essential oil and its major compound α-phellandrene against *Lucilia cuprina* larvae (Diptera: Calliphoridae): Histological and ultrastructural biomarkers assessment. *Pesticide Biochemistry and Physiology, 153*, 17-27.

Chanda, S., & Ramachandra, T. (2019). Phytochemical and Pharmacological Importance of Turmeric (*Curcuma longa*): A Review. *Research & Reviews: A Journal of Pharmacology, 9*(1), 16-23.

Chattopadhyay, I., Biswas, K., Bandyopadhyay, U., & Banerjee, R. K. (2004). Turmeric and curcumin: Biological actions and medicinal applications. *Current Science-Bangalore, 87*, 44-53.

Chayengia, B., Patgiri, P., Rahman, Z., & Sarma, S. (2010). Efficacy of different plant products against *Sitophilus oryzae* (Linn.)(Coleoptera: Curculionidae) infestation on stored rice. *Journal of Biopesticides, 3*(3), 604.

Chokechaijaroenporn, O., Bunyapraphatsara, N., & Kongchuensin, S. (1994). Mosquito repellent activities of *Ocimum* volatile oils. *Phytomedicine, 1*(2), 135-139.

Chomchalow, N. (2003). Protection of stored products with special reference to Thailand. *Assumption University Journal of Technology, 7*(1), 31-47.

Choudhury, S. D., & Chakraborty, K. (2014). Study on both the life cycle and morphometrics of *Sitophilus oryzae* on rice cultivar Sampa mashuri in laboratory condition. *Journal of Applied Science And Research, 2*(6), 22-28.

Collinge, D. B., Lund, O. S., & Thordal-Christensen, H. (2007). What are the prospects for genetically engineered, disease resistant plants? In M. L. Collinge D.B., Cooke B.M. (Ed.), *Sustainable disease management in a European context* (pp. 217-231). Dordrecht: Springer.

Dadang, E. D. F., & Prijono, D. (2009). Effectiveness of two botanical insecticide formulations to two major cabbage insect pests on field application. *J. ISSAAS, 15*(1), 42-51.

Damalas, C. A. (2011). Potential Uses of Turmeric ('*Curcuma longa*') Products as Alternative Means of Pest Management in Crop Production. *Plant omics, 4*(3), 136.

Dano, E. C., & Samonte, E. D. (2005). Public sector intervention in the rice industry in Malaysia *State intervention in the rice sector in selected countries: Implications for the Philippines and Rice Watch and Action Network (R1)* (pp. 187-216). Quezon City, Philippines,: Southeast Asia Regional Initiatives for Community Empowerment (SEARICE).

Das, S., Rayhan, M. Z., Kamal, M. M., Sarkar, R., Gharami, R. K., & Adhikary, S. K. (2015). Assessment of Toxic and Repellent Effect of Natural Bio Pesticides on Rice Weevil (*Sitophilus oryzae* L.). *J. Agr. Vet. Sci., 8*, 16-23.

De Souza Tavares, W., Akhtar, Y., Gonçalves, G. L. P., Zanuncio, J. C., & Isman, M. B. (2016). Turmeric powder and its derivatives from *Curcuma longa* rhizomes: Insecticidal effects on cabbage looper and the role of synergists. *Scientific reports, 6*, 34093.

de Souza Tavares, W., de Sousa Freitas, S., Grazziotti, G. H., Parente, L. M. L., Lião, L. M., & Zanuncio, J. C. (2013). Ar-turmerone from *Curcuma longa* (Zingiberaceae) rhizomes and effects on *Sitophilus zeamais* (Coleoptera: Curculionidae) and *Spodoptera frugiperda* (Lepidoptera: Noctuidae). *Industrial Crops and Products, 46*, 158-164.

Devi, S. R., Thomas, A., Rebijith, K., & Ramamurthy, V. (2017). Biology, morphology and molecular characterization of *Sitophilus oryzae* and *S. zeamais* (Coleoptera: Curculionidae). *Journal of Stored Products Research, 73*, 135-141.

Dukes, J. S., Pontius, J., Orwig, D., Garnas, J. R., Rodgers, V. L., Brazee, N., . . . Harrington, R. (2009). Responses of insect pests, pathogens, and invasive plant species to climate change in the forests of northeastern North America: what can we predict? *Canadian Journal Of Forest Research, 39*(2), 231-248.

Edwards, O., & Singh, K. B. (2006). Resistance to insect pests: what do legumes have to offer? *Euphytica, 147*(1-2), 273-285.

El-Salam, A. A. (2019). Fumigant toxicity of seven essential oils against the cowpea weevil, *Callosobruchus maculatus* (F.) and the rice weevil, *Sitophilus oryzae* (L.). *Toxicology & Pest Control, 2*(1), 1-6.

Elsiddig, F. (2019). Response of mosquito (*Anopheles arabiensis* patton) adult to leaves hexane extract of Rehan (*Ocimum basilicum* L.). *Egyptian Academic Journal of Biological Sciences, F. Toxicology & Pest Control, 7*(1), 49-54.

Ewete, F., Nicol, R., Hengsawad, V., Sukumalanand, P., Satasook, C., Wiriyachitra, P., . . . Philogene, B. (1996). Insecticidal activity of *Aglaia odorata* extract and the active principle, rocaglamide, to the European corn borer, *Ostrinia nubilalis* Hübn.(Lep., Pyralidae). *Journal of Applied Entomology, 120*(1-5), 483-488.

Fan, L. S., Muhamad, R., Omar, D., & Rahmani, M. (2011). Insecticidal properties of *Piper nigrum* fruit extracts and essential oils against *Spodoptera litura*. *International Journal of Agriculture and Biology, 13*(4), 517-522.

Fatimah, O., Qamar, U., Zaiton, M. S., Shah, S., Latip, J., Alhassan, M., & Akilah, M. S. N. (2020). Assessment of free radical scavenging and digestive enzyme inhibitory activities of extract, fractions and isolated compounds from *Tetracera macrophylla* leaves. *Journal of herbal medicine*, 100351.

Follett, P. A., Rivera-Leong, K., & Myers, R. (2014). Rice weevil response to basil oil fumigation. *Journal of Asia-Pacific Entomology, 17*(2), 119-121.

Follett, P. A., Snook, K., Janson, A., Antonio, B., Haruki, A., Okamura, M., & Bisel, J. (2013). Irradiation quarantine treatment for control of *Sitophilus oryzae* (Coleoptera: Curculionidae) in rice. *Journal of Stored Products Research, 52*, 63-67.

Freudenberg, F., Resnik, E., Kolleker, A., Celikel, T., Sprengel, R., & Seeburg, P. H. (2016). Hippocampal GluA1 expression in Gria1−/− mice only partially restores spatial memory performance deficits. *Neurobiology of Learning and Memory, 135*, 83-90.

Gakuru, S., & Foua-Bi, K. (1995). Compared effect of four plant essential oils against cowpea weevil *Callosobruchus maculatus* Fab. and rice weevil *Sitophilus oryzae* L. *Tropicultura (Belgium)*.

Gangwar, P., & Tiwari, S. (2017). Insecticidal activity of *Curcuma longa* essential oil and its fractions against *Sitophilus oryzae* L. and *Rhyzopertha dominica* F.(Coleoptera). *Int. J. Pure Appl. Biosci, 5*, 912-921.

Gatehouse, A. M., Hilder, V. A., & Gatehouse, J. A. (1992). Control of insect pests by plant genetic engineering. *Proceedings of the Royal Society of Edinburgh, Section B: Biological Sciences, 99*(3-4), 51-60.

Gayatree, S., & Sahoo, B. (2017). Repellency action of certain plant products against rice weevil, *Sitophilus oryzae* L.(Coleoptera; Curculionidae) in milled rice. *Environment and Ecology, 35*(4B), 3072-3075.

Ghasemi, A., & Zahediasl, S. (2012). Normality tests for statistical analysis: a guide for non-statisticians. *International journal of endocrinology and metabolism, 10*(2), 486-489.

Gillenwater, H. B., Jurd, L., & McDonald, L. L. (1980). Repellency of several phenolic compounds to adult *Tribolium confusum*. *Journal of the Georgia Entomological Society, 15*(2), 168-175.

Govindan, K., & Nelson, S. J. (2009). Insecticidal activity of twenty plant powders on mortality, adult emergence of *Sitophilus oryzae* L. and grain weight loss in paddy. *Journal of Biopesticides, 2*(2), 169-172.

Govindarajan, V. S., & Stahl, W. H. (1980). Turmeric — chemistry, technology, and quality. *C R C Critical Reviews in Food Science and Nutrition, 12*(3), 199-301.

Grayer, R. J., Kite, G. C., Goldstone, F. J., Bryan, S. E., Paton, A., & Putievsky, E. (1996). Infraspecific taxonomy and essential oil chemotypes in sweet basil, *Ocimum basilicum*. *Phytochemistry, 43*(5), 1033-1039.

Grayer, R. J., Kite, G. C., Veitch, N. C., Eckert, M. R., Marin, P. D., Senanayake, P., & Paton, A. J. (2002). Leaf flavonoid glycosides as chemosystematic characters in *Ocimum*. *Biochemical systematics and ecology, 30*(4), 327-342.

Gregoire, C., Elsaesser, D., Huguenot, D., Lange, J., Lebeau, T., Merli, A., . . . Schütz, T. (2009). Mitigation of agricultural nonpoint-source pesticide pollution in artificial wetland ecosystems–a review *Climate Change,* *Intercropping, Pest Control and Beneficial Microorganisms* (pp. 293-338): Springer.

Gupta, R. C., Miller Mukherjee, I. R., Malik, J. K., Doss, R. B., Dettbarn, W.-D., & Milatovic, D. (2019). Chapter 26 - Insecticides. In R. C. Gupta (Ed.), *Biomarkers in Toxicology (Second Edition)* (pp. 455-475): Academic Press.

Hameed, I. H., Ibraheam, I. A., & Kadhim, H. J. (2015). Gas chromatography mass spectrum and fourier-transform infrared spectroscopy analysis of methanolic extract of *Rosmarinus oficinalis* leaves. *Journal of Pharmacognosy and Phytotherapy, 7*(6), 90-106.

Hamzah, A., Ahmad, M. T., Shahar, A., Sahari, Y., & Ahmad, R. (2017). *Postharvest Management of Rice for Sustainable Food Security In Malaysia.* Paper presented at the https://www.semanticscholar.org/paper/Postharvest-Management-of-Rice-for-Sustainable-Food-Hamzah-Ahmad/5404a80f0145ffba3bb889254218b2118ed2586f.

Hanafiaha, M. M., Ghazalia, N. F., Haruna, S. N., Abdulaalib, H. S., AbdulHasana, M. J., & Kamarudinc, M. K. A. (2019). Assessing water scarcity in Malaysia: a case study of rice production. *Desalination And Water Treatment, 149*, 274-287.

Hanif, C. M. S., Ul-Hasan, M., Shagger, M., Saleem, S., Akthar, S., & Ijaz, M. (2016). Insecticidal and repellent activities of essential oils of three medicinal plants towards insect pests of stored wheat. *Bulgarian Journal of Agricultural Science, 22*(3), 470-476.

Hilder, V. A., & Boulter, D. (1999). Genetic engineering of crop plants for insect resistance–a critical review. *Crop protection, 18*(3), 177-191.

Ho, S., Ma, Y., & Huang, Y. (1997). Anethole, a potential insecticide from *Illicium verum* Hook F., against two stored product insects. *International Pest Control, 39*(2), 50-51.

Hoogland, R. D. (1953). The genus *Tetracera* (Dilleniaceae) in the Eastern old world. *Reinwardtia, 2*(2), 185-224.

Hossain, F., Lacroix, M., Salmieri, S., Vu, K., & Follett, P. A. (2014). Basil oil fumigation increases radiation sensitivity in adult *Sitophilus oryzae* (Coleoptera: Curculionidae). *Journal of Stored Products Research, 59*, 108-112.

Huang, Y., Ho, S.-H., Lee, H.-C., & Yap, Y.-L. (2002). Insecticidal properties of eugenol, isoeugenol and methyleugenol and their effects on nutrition of *Sitophilus zeamais* Motsch.(Coleoptera: Curculionidae) and *Tribolium castaneum* (Herbst)(Coleoptera: Tenebrionidae). *Journal of Stored Products Research, 38*(5), 403-412.

Hussain, A. I., Anwar, F., Sherazi, S. T. H., & Przybylski, R. (2008). Chemical composition, antioxidant and antimicrobial activities of basil (*Ocimum basilicum*) essential oils depends on seasonal variations. *Food chemistry, 108*(3), 986-995.

Hwang, Y.-S., Schultz, G. W., & Mulla, M. S. (1984). Structure-activity relationship of unsaturated fatty acids as mosquito ovipositional repellents. *Journal of chemical ecology, 10*(1), 145-151.

Ibrahim, Z. H. (2015). *Effect of Ocimum basilicum L. Leaves Powder and Extracts on the Faba Bean Beetle Bruchidius incarnatus Boh.* UOFK.

Islam, M. T., Omar, D., Latif, M., & Morshed, M. M. (2011). The integrated use of entomopathogenic fungus, *Beauveria bassiana* with botanical insecticide, neem against *Bemisia tabaci* on eggplant. *African Journal of Microbiology Research, 5*(21), 3409-3413.

Isman, M. (1997a). Neem and other botanical insecticides: barriers to commercialization. *Phytoparasitica, 25*(4), 339.

Isman, M. B. (1997b). Neem and other botanical insecticides: barriers to commercialization. *Phytoparasitica, 25*(4), 339.

Isman, M. B. (2008). Botanical insecticides: for richer, for poorer. *Pest Management Science: formerly Pesticide Science, 64*(1), 8-11.

Jahromi, M. G., Pourmirza, A. A., & Safaralizadeh, M. H. (2012). Repellent effect of sirinol (garlic emulsion) against *Lasioderma serricorne* (Coleoptera: Anobiidae) and *Tribolium castaneum* (Coleoptera: Tenebrionidae) by three laboratory methods. *African Journal of Biotechnology, 11*(2), 280-288.

Javed, N., Gowen, S., Inam-ul-Haq, M., Abdullah, K., & Shahina, F. (2007). Systemic and persistent effect of neem (*Azadirachta indica*) formulations against root-knot nematodes, *Meloidogyne javanica* and their storage life. *Crop Protection, 26*(7), 911-916.

Jayasinghe, C., Gotoh, N., Aoki, T., & Wada, S. (2003). Phenolics composition and antioxidant activity of sweet basil (*Ocimum basilicum* L.). *Journal of Agricultural and Food chemistry, 51*(15), 4442-4449.

Juraimi, A. S., Uddin, M. K., Anwar, M. P., Mohamed, M. T. M., Ismail, M. R., & Man, A. (2013). Sustainable weed management in direct seeded rice culture: A review. *Australian Journal of Crop Science, 7*(7), 989.

Kang, L. (2019). Overview: biotic signalling for smart pest management. *Philosophical Transactions B, 374*, 1-5.

Khani, M., Muhamad Awang, R., & Omar, D. (2012). Insecticidal effects of peppermint and black pepper essential oils against rice weevil, *Sitophilus oryzae* L. and rice moth, *Corcyra cephalonica* (St.). *Journal of Medicinal Plants Research, 3*(43), 97-110.

Kianmatee, S., & Ranamukhaarachchi, S. (2007). Combining pest repellent plants and biopesticides for sustainable pest management in Chinese kale. *Journal of Asia-Pacific Entomology, 10*(1), 69-74.

Kim, D.-H., Kim, S.-I., Chang, K.-S., & Ahn, Y.-J. (2002). Repellent Activity of Constituents Identified in *Foeniculum vulgare* Fruit against *Aedes aegypti* (Diptera: Culicidae). *Journal of Agricultural and Food chemistry, 50*(24), 6993-6996.

Koba, K., Poutouli, P., Raynaud, C., Chaumont, J.-P., & Sanda, K. (2009). Chemical composition and antimicrobial properties of different basil essential oils chemotypes from Togo. ||| *Bangladesh Journal of Pharmacology, 4*(1), 1-8.

Koo, I., Kim, S., & Zhang, X. (2013). Comparative analysis of mass spectral matching-based compound identification in gas chromatography-mass spectrometry. *Journal of chromatography. A, 1298*, 132-138.

Kortbeek, R. W., van der Gragt, M., & Bleeker, P. M. (2019). Endogenous plant metabolites against insects. *European Journal of Plant Pathology, 154*(1), 67-90.

Kpoviessi, A., Agbahoungba, S., Agoyi, E. E., Chougourou, D., & Assogbadjo, A. (2019). Resistance of cowpea to Cowpea bruchid (*Callosobruchus maculatus* Fab.): Knowledge level on the genetic advances.

Kraikrathok, C., Ngamsaengi, S., Bullangpoti, V., Pluempanupat, W., & Koul, O. (2013). Bio efficacy of some piperaceae plant extracts against *Plutella* *xylostella* L.(Lepidoptera: Plutellidae). *Communication in Agricultural and Applied Biological Science, 78*, 305-309.

Kranthi, S., Kranthi, K. R., Rodge, C., Chawla, S., & Nehare, S. (2019). Insect Resistance to Insecticides and Bt Cotton in India *Natural Resource Management: Ecological Perspectives* (pp. 185-199): Springer.

Kumar, R., & Tiwari, S. (2017). Fumigant Toxicity of Essential Oils and their Combination Against *Sitophilus oryzae* (Coleoptera: Curculionidae) at Different Days Interval in Stored Wheat. *Journal of Postharvest Technology, 4*(2), S06-S10.

Lal, J. (2012). Turmeric, curcumin and our life: a review. *Bull Environ Pharmacol Life Sci, 1*(7), 11-17.

Lee, H.-S., Shin, W.-K., Song, C., Cho, K.-Y., & Ahn, Y.-J. (2001). Insecticidal Activities of ar-Turmerone Identified in *Curcuma longa* Rhizome against *Nilaparvata lugens* (Homoptera: Delphacidae) and *Plutella xylostella* (Lepidoptera: Yponomeutidae). *Journal of Asia-Pacific Entomology, 4*(2), 181-185.

Lee, S.-J., Umano, K., Shibamoto, T., & Lee, K.-G. (2005). Identification of volatile components in basil (*Ocimum basilicum* L.) and thyme leaves (*Thymus vulgaris* L.) and their antioxidant properties. *Food chemistry, 91*(1), 131-137.

Ling Chang, C., Kyu Cho, I., & Li, Q. X. (2009). Insecticidal activity of basil oil, trans-anethole, estragole, and linalool to adult fruit flies of *Ceratitis capitata*, *Bactrocera dorsalis*, and *Bactrocera cucurbitae*. *Journal of economic entomology, 102*(1), 203-209.

Loh, F. S., Awang, R. M., Omar, D., & Rahmani, M. (2011). Insecticidal properties of *Citrus hystrix* DC leaves essential oil against *Spodoptera litura* fabricius. *Journal of Medicinal Plants Research, 5*(16), 3739-3744.

Lopez, M. D., Jordan, M. J., & Pascual-Villalobos, M. J. (2008). Toxic compounds in essential oils of coriander, caraway and basil active against stored rice pests. *Journal of Stored Products Research, 44*(3), 273-278.

López, M. D., Jordán, M. J., & Pascual-Villalobos, M. J. (2008). Toxic compounds in essential oils of coriander, caraway and basil active against stored rice pests. *Journal of Stored Products Research, 44*(3), 273-278.

Lucas, E., & Riudavets, J. (2002). Biological and mechanical control of *Sitophilus oryzae* (Coleoptera: Curculionidae) in rice. *Journal of Stored Products Research, 38*(3), 293-304.

Luthra, P. M., Singh, R., & Chandra, R. (2001). Therapeutic uses of *Curcuma longa* (turmeric). *Indian Journal of Clinical Biochemistry, 16*(2), 153-160.

Maazoun, A. M., Hamdi, S. H., Belhadj, F., Jemâa, J. M. B., Messaoud, C., & Marzouki, M. N. (2019). Phytochemical profile and insecticidal activity of *Agave americana* leaf extract towards *Sitophilus oryzae* (L.)(Coleoptera: Curculionidae). *Environmental Science and Pollution Research, 26*(19), 19468-19480.

Mackeen, M. M., Ali, A. M., Abdullah, M. A., Nasir, R. M., Mat, N. B., Razak, A. R., & Kawazu, K. (1997). Antinematodal activity of some Malaysian plant extracts against the pine wood nematode, *Bursaphelenchus xylophilus*. *Pesticide Science, 51*(2), 165-170.

Mahmoud, A. K., Satti, A. A., Bedawi, S. M., & Mokhtar, M. M. (2014). Combined insecticidal effects of some botanical extracts against the khapra beetle (*Trogoderma granarium* Everts). *Research Journal in Engineering and Applied Sciences, 3*(6), 388-393.

Mahomed, A. A., Aajel, M. S., & Mesbahm, H. A. (2018). Eco-friendly tools for controlling of the rice weevil *Sitophilus oryzae* (Coleoptera: Curculionidae). *ALEXANDRIA SCIENCE EXCHANGE JOURNAL, 39*(3).

Maia, M. F., & Moore, S. J. (2011). Plant-based insect repellents: a review of their efficacy, development and testing. *Malaria journal, 10 Suppl 1*(Suppl 1), S11-S11.

Matassini, C., Parmeggiani, C., & Cardona, F. (2020). New Frontiers on Human Safe Insecticides and Fungicides: An Opinion on Trehalase Inhibitors. *Molecules, 25*(13), 3013.

Matter, M., Salem, S., Abou-Ela, R., & El-Kholy, M. (2008). Toxicity and repelency of *Trigonella foenum* L. and *Curcuma longa* L. extracts to *Sitophilus oryzae* (L.) and *Rhizopertha dominica* (Fab.)(Coleoptera). *Egyptian Journal of Biological Pest Control, 18*(1), 149-154.

Maurya, P. K., Malik, D., & Sharma, A. (2019). Impacts of pesticide application on aquatic environments and fish diversity. *Contaminants in Agriculture and Environment: Health Risks and Remediation, 1*, 111.

McNeil, M. J., Porter, R. B., & Williams, L. A. (2012). Chemical composition and biological activity of the essential oil from Jamaican *Cleome serrata*. *Natural product communications, 7*(9), 1231 - 1232.

Mee, K. C., Sulaiman, S., & Othman, H. (2009). Efficacy of *Piper aduncum* extract against the adult housefly (*Musca domestica*). *J. Trop. Med. Parasitol, 32*(2), 52-57.

Miresmailli, S., & Isman, M. B. (2014). Botanical insecticides inspired by plant–herbivore chemical interactions. *Trends in Plant Science, 19*(1), 29-35.

Mishra, B. B., Tripathi, S., & Tripathi, C. (2012). Repellent effect of leaves essential oils from *Eucalyptus globulus* (Mirtaceae) and *Ocimum basilicum* (Lamiaceae) against two major stored grain insect pests of Coleopterons. *Nature and Science, 10*(2), 50-54.

Mohammedi, Z., & Atik, F. (2011). Impact of solvent extraction type on total polyphenols content and biological activity from *Tamarix aphylla* (L.) Karst. *International Journal of Pharma and Bio Sciences 2*(1), 609-615.

Moundi, I. (2019). International commodity and consumption information as compiled by the United States Department of Agricultur.

Mulungu, L., Jilala, M., Mwatawala, M., & Mwalilino, J. (2011). Assessment of damage due to larger grain borer (Prostephanus truncatus Horn) on stored paddy rice (*Oryza sativa* L. Poaceae). *Journal of Entomology, 8*(3), 295-300.

Murali, S. (2013). Management of stored-product insect pests through biorational approaches: a review. *Biosciences, 6*, 133-137.

Naz, S., Ilyas, S., Parveen, Z., & Javad, S. (2010). Chemical Analysis of Essential Oils from Turmeric (*Curcuma longa*) Rhizome Through GC-MS. *Asian Journal of Chemistry, 22*, 3153-3158.

Nenaah, G. E. (2013). Potential of using flavonoids, latex and extracts from *Calotropis procera* (Ait.) as grain protectants against two coleopteran pests of stored rice. *Industrial Crops and Products, 45*, 327-334.

Nerio, L. S., Olivero-Verbel, J., & Stashenko, E. (2010). Repellent activity of essential oils: a review. *Bioresource technology, 101*(1), 372-378.

Nicolopoulou-Stamati, P., Maipas, S., Kotampasi, C., Stamatis, P., & Hens, L. (2016). Chemical Pesticides and Human Health: The Urgent Need for a New Concept in Agriculture. *Frontiers in public health, 4*, 148-148.

Nisar, T., Iqbal, M., Raza, A., Safdar, M., Iftikhar, F., & Waheed, M. (2015). Turmeric: A promising spice for phytochemical and antimicrobial activities. *American-Eurasian Journal of Agricultural & Environmental Sciences, 15*, 1278-1288.

Noralglil, W. A. H. (2015). The Effect of Bee Glue Powder and Ethanolic Extracts of Neem and Basil Mortality of the Asian Fruit Fly (*Bactrocera invadens,* Drew, Tsuruta and White)(Diptera: Tephritidae. Sudan University of Science and Technology.

Norris, D. M., & Liu, S. H. (1991). United States of America Patent No. 5,030,660. P. a. T. Office.

Nour, A. H., Elhussein, S. A., Osman, N. A., & Yusoff, M. (2009). A study of the essential oils of four Sudanese accessions of basil (*Ocimum basilicum* L.) against *Anopheles* mosquito larvae. *American Journal of Applied Sciences, 6*(7), 1359-1363.

Obata, H., Manabe, A., Nakamura, N., Onishi, T., & Senba, Y. (2011). A new light on the evolution and propagation of prehistoric grain pests: the world's oldest maize weevils found in Jomon Potteries, Japan. *PloS one, 6*(3), e14785.

Oladimeji, A., & Kannike, M. A. (2010). Comparative studies on the efficacy of neem, basil leaf. *African Journal of Microbiology Research, 4*(1), 033-037.

Omar, S., Shaharudin, A., & Tumin, S. (2019). The Status of the Paddy and Rice Industry in Malaysia: Kuala Lumpur: Khazanah Research Institute.

Ong, H. C., Ahmad, N., & Milow, P. (2011). Traditional medicinal plants used by the temuan villagers in Kampung Tering, Negeri Sembilan, Malaysia. *Studies on Ethno-Medicine, 5*(3), 169-173.

Ooi, A. C. (2015a). Common insect pests of rice and their natural biological control. *Utar Agriculture Science Journal, 1*(1), 49-59.

Ooi, A. C. (2015b). Common insect pests of rice and their natural biological control.

Organization, W. H. (2019). *Preventing disease through healthy environments: exposure to highly hazardous pesticides: a major public health concern*. Retrieved from

Pandey, A. K., Singh, P., & Tripathi, N. N. (2013). Chemistry and bioactivities of essential oils of some *Ocimum* species: an overview. *Journal of Coastal Life Medicine, 1*(3), 192-205.

Park, K., & Kwak, I.-S. (2008). Characterization of heat shock protein 40 and 90 in *Chironomus riparius* larvae: Effects of di(2-ethylhexyl) phthalate exposure on gene expressions and mouthpart deformities. *Chemosphere, 74*(1), 89-95.

Pathak, M. D., & Khan, Z. R. (1994). *Insect pests of rice*: Int. Rice Res. Inst.

Pavoni, L., Benelli, G., Maggi, F., & Bonacucina, G. (2019). Green nanoemulsion interventions for biopesticide formulations *Nano-Biopesticides Today and Future Perspectives* (pp. 133-160): Elsevier.

Perry, L. M., & Metzger, J. (1980). *Medicinal plants of East and Southeast Asia: attributed properties and uses*: MIT press.

Phasomkusolsil, S., & Soonwera, M. (2011). Comparative mosquito repellency of essential oils against *Aedes aegypti* (Linn.), *Anopheles dirus* (Peyton and Harrison) and *Culex quinquefasciatus* (Say). *Asian Pacific Journal of Tropical Biomedicine, 1*(1), S113-S118.

Phasomkusolsil, S., & Soonwera, M. (2012). The effects of herbal essential oils on the oviposition deterrent and ovicidal activities of *Aedes aegypti* (Linn.), *Anopheles dirus* (Peyton and Harrison) and *Culex quinquefasciatus* (Say). *Tropical Biomedicine, 29*(1), 138-150.

Poonsri, W., Pluempanupat, W., Chitchirachan, P., Bullangpoti, V., & Koul, O. (2015). Insecticidal alkanes from *Bauhinia scandens* var. horsfieldii against *Plutella xylostella* L. (Lepidoptera: Plutellidae). *Industrial Crops and Products, 65*, 170-174. doi:https://doi.org/10.1016/j.indcrop.2014.11.040

Popovic, Z., Kostic, M., Popovic, S., & Skoric, S. (2006). Bioactivities of essential oils from basil and sage to *Sitophilus oryzae* L. *Biotechnology & Biotechnological Equipment, 20*(1), 36-40.

Popp, J., Pető, K., & Nagy, J. (2013). Pesticide productivity and food security. A review. *Agronomy for sustainable development, 33*(1), 243-255.

Prakash, A., Rao, J., Gupta, S., & Behra, J. (1993). Evaluation of botanical pesticides as grain protectants against rice weevil, *Sitophilus oryzae* Linn. *Botanical pesticides in integrated pest management.*, 360-365.

Prakash, A., Rao, J., & Nandagopal, V. (2008). Future of botanical pesticides in rice, wheat, pulses and vegetables pest management. *Journal of Biopesticides, 1*(2), 154-169.

Preeti, D., & Nath, D. D. (2019). *Medicinal Plants Of India*. United States of America: World Scientific.

Prijono, D. (1998). Insecticidal activity of meliaceous seed extracts against *Crocidolomia binotalis* Zeller (Lepidoptera: Pyralidae). *Bul. HPT, 10*(1), 7.

Prodhan, Z. H., Biswas, M., Rahman, M., Islam, N., & Golam, F. (2012). Effects of plant extracts on salivary gland chromosomes of house fly (*Musca domestica* L.). *Life Sci. J, 9*(4), 1930-1935.

Pugazhvendan, S., Elumalai, K., Ross, P. R., & Soundarajan, M. (2009). Repellent activity of chosen plant species against *Tribolium castaneum*. *World Journal of Zoology, 4*(3), 188-190.

Purushothaman, B., Prasanna Srinivasan, R., Suganthi, P., Ranganathan, B., Gimbun, J., & Shanmugam, K. (2018). A comprehensive review on *Ocimum basilicum*. *Journal of Natural Remedies, 18*(3), 71-85.

Rafat, A., Philip, K., & Muniandy, S. (2010). Antioxidant potential and phenolic content of ethanolic extract of selected Malaysian plants. *Research Journal of Biotechnology Vol, 5*, 1.

Raghav, D. K., Rajvanshi, S., & Sharma, K. (2012). Management of stored pest, *Sitophilus oryzae* by botanicals. *Annals of Plant Protection Sciences, 20*(1), 145-147.

Rajendran, S., & Sriranjini, V. (2008). Plant products as fumigants for stored-product insect control. *Journal of Stored Products Research, 44*(2), 126-135.

Ravindran, P., Babu, K. N., & Sivaraman, K. (2007). *Turmeric: the genus Curcuma*: CRC press.

Razali, N. M., & Wah, Y. B. (2011). Power comparisons of shapiro-wilk, kolmogorov-smirnov, lilliefors and anderson-darling tests. *Journal of statistical modeling and analytics, 2*(1), 21-33.

Rita Devi, S., Thomas, A., Rebijith, K. B., & Ramamurthy, V. V. (2017). Biology, morphology and molecular characterization of *Sitophilus oryzae* and *S. zeamais* (Coleoptera: Curculionidae). *Journal of Stored Products Research*, *73*, 135-141.

Romo-Asunción, D., Ávila-Calderón, M. A., Ramos-López, M. A., Barranco-Florido, J. E., Rodríguez-Navarro, S., Romero-Gomez, S., . . . Rico-Rodríguez, M. A. (2016). Juvenomimetic and insecticidal activities of *Senecio salignus* (Asteraceae) and *Salvia microphylla* (Lamiaceae) on *Spodoptera frugiperda* (Lepidoptera: Noctuidae). *Florida Entomologist*, 345-351.

Roth, G. N., Chandra, A., & Nair, M. G. (1998). Novel bioactivities of *Curcuma longa* constituents. *Journal of Natural Products, 61*(4), 542-545.

Saad, A., Metraw, H. L., & Tayeb, E. H. (2017). Botanical oils as eco-friendly alternatives for controlling the rice weevil *Sitophilus oryzae*. *Alexandria Science Exchange Journal, 38*(4), 921-932.

Sabran, S. F. (2016). *Documentation, antimycobacterial activity, and phytochemical profiling of selected medicinal plants used by the Jakun community in Johor*. Universiti Tun Hussein Onn Malaysia.

Sabran, S. F., Mohamed, M., Bakar, A., & Fadzelly, M. (2016). Ethnomedical knowledge of plants used for the treatment of tuberculosis in Johor, Malaysia. *Evidence-Based Complementary and Alternative Medicine, 2016*.

Satasook, C., Isman, M., Ishibashi, F., Medbury, S., Wiriyachitra, P., & Towers, G. (1994). Insecticidal bioactivity of crude extracts of *Aglaia* species (Meliaceae). *Biochemical systematics and ecology, 22*(2), 121-127.

Scott, I., Gagnon, N., Lesage, L., Philogene, B., & Arnason, J. (2005). Efficacy of botanical insecticides from *Piper* species (Piperaceae) extracts for control of European chafer (Coleoptera: Scarabaeidae). *Journal of economic entomology, 98*(3), 845-855.

Seada, M. A., Arab, R. A., Adel, I., & Seif, A. I. (2016). Bioactivity of essential oils of basil, fennel, and geranium against *Sitophilus oryzae* and *Callosobruchus maculatus*: Evaluation of repellency, progeny production and residual activity. *Egypt. J. Exp. Biol.(Zool.), 12*, 1-12.

Sekulovic, D., Ristic, M., Sekesan, V., Kostic, M., Zabel, A., Sestovic, M., & Jovanovic, Z. (1996). The study of insecticidal effect of *Ocimum basilicum* L.(Lamiaceae) essential oil on *Sitophilus oryzae* L.(Coleoptera: Curculionidae). *Zbornik radova*.

Sharp, J. L., & Hallman, G. J. (2019). *Quarantine treatments for pests of food plants*: CRC Press.

Singh, A. K., Kumar, K., & Kumar, S. (2018). Taxonomic redescription of the rice weevil (*Sitophilus oryzae*). *Journal of Pharmacognosy and Phytochemistry*(SPI), 36-39.

Singh, G., Singh, O. P., & Maurya, S. (2002). Chemical and biocidal investigations on essential oils of some Indian *Curcuma* species. *Progress in Crystal Growth and Characterization of Materials, 45*(1), 75-81.

Singh, H., Al-Samararrai, G. F., Jaffar, M. H., Chemat, M. H., & Islam, A. (2013). Performance of Five Plant Extract On-Leaf-Cuttingbeetle *Hypomeces squamosus* on Harumanis Variety of Mango in Perlis, Malaysia. *International Journal of Agricultural Science and Research (IJASR), 3*(1), 89-98.

Soonwera, M., & Sinthusiri, J. (2014). Thai Essential oils as botanical insecticide against house fly (*Musca domestica* L.). Paper presented at the International Conference on Agricultural, Ecological and Medical Sciences, Bali, Indonesia.

Stevenson, P. C. (2019). For antagonists and mutualists: the paradox of insect toxic secondary metabolites in nectar and pollen. *Phytochemistry Reviews, 1*(2019), 1-12.

Stoytcheva, M. (2011). *Pesticides in the Modern World: Pesticides Use and Management*: BoD–Books on Demand.

Studyandscore. (2017). Pest of rice (*Sitophilus oryzae*): Distribution, Life cycle, Nature of damage and Control measures. https://www.studyandscore.com/studymaterial-detail/pest-of-rice-sitophilus-oryzae-distribution-life-cycle-nature-of-damage-and-control-measures.

Su, H. C., Horvat, R., & Jilani, G. (1982). Isolation, purification, and characterization of insect repellents from *Curcuma longa* L. *Journal of Agricultural and Food chemistry, 30*(2), 290-292.

Suzuki, T., Suzuki, T., Manh Huynh, Y., & Muto, T. (1975). Hydrocarbon repellents isolated from *Tribolium castaneum* and *T. confusum* (Coleoptera: Tenebrionidae). *Agricultural and Biological Chemistry, 39*(11), 2207-2211.

Teik Ng, L., Mun Yuen, P., Hong Loke, W., & Abdul Kadir, A. (2003). Effects of *Azadirachta excelsa* on feeding behaviour, body weight and mortality of *Crocidolomia binotalis* Zeller (Lepidoptera: Pyralidae). *Journal of the Science of Food and Agriculture, 83*(13), 1327-1330.

Thanh, N. T., Luong, D. T., Thuy, N. T. T., & Thang, B. X. (2011). Research on formulation of botanical pesticides from Neem trees to control maize weevil (*Sitophilus zeamais* Motschulsk) in stored grain in Viet Nam. *Science and Technology Journal of Agriculture and Rural Development*.

Thiagaletchumi, M., Zuharah, W. F., Rami, R. A., Fadzly, N., Dieng, H., Ahmad, A. H., & AbuBakar, S. (2014). Assessment of residual bio-efficacy and persistence of *Ipomoea cairica* plant extract against *Culex quinquefasciatus* Say mosquito. *Tropical biomedicine, 31*(3), 466-476.

Togola, A., Seck, P., Glitho, I., Diagne, A., Adda, C., Toure, A., & Nwilene, F. (2013). Economic losses from insect pest infestation on rice stored on-farm in Benin. *Journal of Applied Science, 13*(2), 278-285.

Tripathi, A., Prajapati, V., Verma, N., Bahl, J., Bansal, R., Khanuja, S., & Kumar, S. (2002). Bioactivities of the leaf essential oil of *Curcuma longa* (var. ch-66) on three species of stored-product beetles (Coleoptera). *Journal of Economic Entomology, 95*(1), 183-189.

Truong, D.-H., Nguyen, D. H., Ta, N. T. A., Bui, A. V., Do, T. H., & Nguyen, H. C. (2019). Evaluation of the use of different solvents for phytochemical constituents, antioxidants, and in vitro anti-inflammatory activities of *Severinia buxifolia*. *Journal of food quality, 2019*.

Van Emden, H. F., & Peakall, D. B. (1996). *Beyond silent spring: integrated pest management and chemical safety*: Chapman & Hall Ltd.

Vani, S. R., Cheng, S., & Chuah, C. (2009). Comparative study of volatile compounds from genus *Ocimum*. *American Journal of Applied Sciences, 6*(3), 523.

Velayudhan, K., Dikshit, N., & Nizar, M. A. (2012). Ethnobotany of turmeric (*Curcuma longa* L.). *Indian Journal of Ethnobotany Knowledge, 11*(4), 607-614.

Villard, C., Larbat, R., Munakata, R., & Hehn, A. (2019). Defence mechanisms of *Ficus*: pyramiding strategies to cope with pests and pathogens. *Planta, 249*(3), 617-633.

Wallner, W. (1996). Invasive pests (‘biological pollutants’) and US forests: whose problem, who pays? *Eppo Bulletin, 26*(1), 167-180.

Wang, C. F., Yang, K., Zhang, H. M., Cao, J., Fang, R., Liu, Z. L., . . . Zhou, L. (2011). Components and insecticidal activity against the maize weevils of *Zanthoxylum schinifolium* fruits and leaves. *Molecules, 16*(4), 3077-3088.

Wei, J., Ding, W., Zhao, Y.-G., & Vanichpakorn, P. (2011). Acaricidal activity of *Aloe vera* L. leaf extracts against *Tetranychus cinnabarinus* (Boisduval) (Acarina: Tetranychidae). *Journal of Asia-Pacific Entomology, 14*(3), 353-356. doi:https://doi.org/10.1016/j.aspen.2011.04.006

Widiyaningrum, P., Candrawati, D., Indriyanti, D. R., & Priyono, B. (2019). Repellent Activity of Waste Extract from Two Local Medicinal Plant Against Rice Weevil (*Sitophilus oryzae*). *Biosaintifika: Journal of Biology & Biology Education, 11*(1), 62-67.

Wilkinson, S. W., Magerøy, M. H., López Sánchez, A., Smith, L. M., Furci, L., Cotton, T. A., . . . Ton, J. (2019). Surviving in a Hostile World: Plant Strategies to Resist Pests and Diseases. *Annual review of phytopathology, 57*, 505-529.

Wiratno. (2008). Effectiveness and Safety of Botanical Pesticides Applied in Black Pepper (*Piper Nigrum*) Plantations.

Xu, H.-X., Zheng, X.-S., Yang, Y.-J., Tian, J.-C., Lu, Y.-H., Tan, K.-H., . . . Lu, Z.-X. (2015). Methyl eugenol bioactivities as a new potential botanical insecticide against major insect pests and their natural enemies on rice (*Oriza sativa*). *Crop Protection, 72*, 144-149.

Xu, H., Li, W., Schilmiller, A. L., van Eekelen, H., de Vos, R. C., Jongsma, M. A., & Pichersky, E. (2019). Pyrethric acid of natural pyrethrin insecticide: complete pathway elucidation and reconstitution in Nicotiana benthamiana. *New Phytologist, 223*(2), 751-765.

Yuan, H.-B., Shang, L.-N., Wei, C.-Y., & Ren, B.-Z. (2010). Comparison of constituents and insecticidal activities of essential oil from *Artemisia lavandulaefolia* by steam distillation and supercritical-CO2 fluid extraction. *Chem. Res. Chin. Univ, 26*, 888-892.

Zakaria, Z., Aziz, R., Lachimanan, Y. L., Sreenivasan, S., & Rathinam, X. (2008). Antioxidant activity of *Coleus blumei*, *Orthosiphon stamineus*, *Ocimum basilicum* and *Mentha arvensis* from Lamiaceae family. *Int J Nat Eng Sci, 2*(1), 93-95.

Złotek, U., Mikulska, S., Nagajek, M., & Świeca, M. (2016). The effect of different solvents and number of extraction steps on the polyphenol content and antioxidant capacity of basil leaves (*Ocimum basilicum* L.) extracts. *Saudi journal of biological sciences, 23*(5), 628-633.