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Influence of pest infestation, type of packages and different storage periods on seeds and essential oil composition of Coriander, *Coriandrum sativum* L. Family: *Apiaceae*

Wedyan F. M. Hassan[a,*], Rasha A. Zinhoum[a], T. M. Abdel-Razik[b]

[a] *Plant Protection Research Institute (PPRI), Agricultural Research Centre (ARC), Giza, Egypt.*

[b] *National Research Centre, Pharmaceutical Industries and Drugs Institute, Department of Medicinal and Aromatic Plants Research, Giza, Egypt.*

Abstract

Coriander (*Coriandrum sativum* L.) is a very popular medicinal plant that belongs to Apiaceae, which is widely used as a spice and also in pharmacy and the industry of food. *Coriandrum sativum* is cultivated for the seeds (fruits) which contain essential oil, fatty acids, coumarins, polyphenols, and flavonoids. Nowadays, the fruits exhibit internally carminative, spasmolytic, and galactagogic effects in many disorders. The current article focuses on coriander oil as affected by plant injuries with pre & post-harvest insects, storage and packing. Experiments were conducted at Qalubiya and Menoufia governorates as well as the laboratories of the Plant Protection Research Institute, Dokki, Giza. The obtained results indicated that during April and May months, there was high infestation with aphid stages at the two governorates in semi-fresh coriander, November month recorded the highest infestation of the examined stored insects on coriander dry seed, while the lowest numbers were recorded in July, September & October months occupied intermediate status, moreover, Cigarette beetle recorded the highest numbers, while Almond moth recorded the least numbers. November month recorded the highest losses in coriander seed weights, while the lowest losses were recorded in July month, from storage periods quality and constituents of essential oil, germination of seeds and yield affected by insect infestation, packing at different types of packages.

Keywords: Coriander, Coriandrum sativum, Aphids, cigarette beetle, Stored insects, packing storage, essential oil.

1. Introduction

Coriander, *Coriandrum sativum* L. is an annual herb that belongs to family Apiaceae (Umbelliferae). The leaves and mature seeds of coriander plants, which are a famous green vegetable and seed spice crop with a pleasant aroma and flavor, have been used in popular medications in addition to cooking uses. Coriander is herbaceous and aromatic and is cultivated in several countries, Egypt, Turkey, and the eastern Mediterranean Sea, India, Italy, Netherlands, China, and Bangladesh. Coriander plant rich with essential oils, vitamins (C and K), minerals (calcium, phosphorous, potassium, thiamine, and niacin), and other micronutrients and extensively used in the preparation of food items. Coriander essential oil and extracts possess various potential pharmacological properties and has been found to possess carminative, diuretic, stomachic, aphrodisiac, anti-inflammatory, antibacterial, antifungal, and anticancer activities.

Coriander seeds have abundance of polyphenols, particularly phenolic acids, and flavonoids which considered a good source of biologically active metabolites. Essential oil gave promising antibacterial, antifungal, and anti-oxidative activities that play a great role in maintaining the shelf-life of foods. The potential of coriander in food (flavoring or preservative), in pharmaceuticals (natural drugs), and in industry product ingredients (fragrances and cosmetics) has increased researchers' interest in studying this plant. This this plant was benefit in traditional uses, medicinal, and industrial applications of coriander plants, extracts, and essential oils [1].

Coriander seed oil is included among the 20 major essential oils in the world market [2]. Oil is extensively used as a flavoring agent in all types of food products, tobacco, candy, pickles, and meat sauce. Coriander oil having antimicrobial properties against selected pathogenic and saprophytic microorganisms, indicating that it may be useful as a disinfectant Coriander is also used in aromatherapy [3].

*Corresponding author e-mail: wedyenfathy@gmail.com; (Wedyan F. M. Hassan)

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Coriander is well-known for its medicinal benefits, which include being anti-diabetic and being used to treat allergies, eye infections, anemia, and lowering bad cholesterol while promoting good cholesterol in the body. Seeds contains copper, zinc, iron, and other vital minerals help to raise RBC and enhance heart health. Coriander plants attacking by many pest species, which cause serious damage to vegetative parts, seed quality, and quantity. Piercing sucking pests are the most destructive insects on these plants [4] - [8]. The coriander aphid, *Hyadaphis coriandri*, is reported to be the main aphid species infesting coriander and causes about 19 percent of losses [9]. Aphids pests are responsible for several damages to crop plant species not only as a result of their sap taking but also as virus vectors. The understanding of the chemical ecology of aphids is a key factor to know how the insect can locate their host amongst the plant. If semi chemicals from plants are important to declared the aphid distribution, intraspecific info chemicals are importance in the aphid migration in the field. When disturbed, many aphids release volatile substances including alarm pheromone. Important variation was observed among aphid species in their sensitivity to the latter kind of pheromone, which can be related to the ecology of the species [10].

In aphids the olfactory receptor neurons are housed in placoid sensilla on the antennae, [11], [12]. Plant volatiles play a role in the discrimination between the odour blends of host and non-host plant species during orientation and landing. Response of plant volatiles have been recorded in a number of aphid species, i.e., the English grain aphid *Sitobion avenae* (F.) and the rose-grain aphid *Metopotophiurn dirhodum* (Walk.) [13], [14], the black bean aphid *Aphis fabae* (Scop.) [17], and the vetch aphid *Megoura viciae* (Buckton.) [16], [17]. Insect infestation in stored spices is a serious problem, with about 20 pests [18] include: cigarette beetle *Lasioderma serricorne* (F.), Almond moth, *Ephestia cautella*, confused flour beetle *Tribolium confusum* Jacquelin du (Val.), Khapra beetle *Trogoderma granarium* (Everts.) and drug store beetle *Stegobium paniceum* (L.). *Lasioderma serricorne* is the major pest of seed spice under storage over the worldwide causing major economic losses [19] by larval feeding, while adults do holes to penetrate or escape packed commodities. Besides the harm done by feeding, the presence of dead insects, casting skin residues from various stages of larval life, pupal cases and frass are pollutants [20], [21]. *Lasioderma serricorne* caused big damage in coriander seed during storage and consumed about 26 g of coriander within a period of 4 months and weight loss ranged to 54.62% after one year**.** [21], [22].

Quality of the medicinal species of their therapeutic properties throughout storage, drying of plant material and the use of packaging. Drying process inhibits the development of microorganisms and enzymatic reactions, by reducing the deterioration of the active ingredients during storage, in addition to also helping to 'concentrate' the active compounds on a weight basis through water removal. Regarding to packaging, it involves and enhances products, from processing to consumption by the customer [23]. Packaging materials, storage condition and pre-treatment are important parameters which can significantly affect the quality of coriander during storage, [24]. Medicinal plants which stored for long periods before being used as raw material for the manufacture of various products, [25]. Storage may result in physical, chemical and microbiological changes [26], [27]. Despite the increased consumption and consequent expansion of the medicinal plant markets.

From the previous review this study was conducted to explain the effect of pest infestation, packing and storage on seeds and essential oil composition of Coriander plants.

2. Materials and methods

2.1 Insect collecting, rearing and infestation technique:

2.1.1. Collecting and preparing coriander infested with Aphid insects:

Collected different coriander plants which infested with alate viviparous and adults of aphids from Qalubiya and Menoufia Governorates in Egypt, using a camel’s hair brush, aspired off or by cutting ling the infested part of plants and putting them in a paper bag to transfer to the laboratory to push apterous adults and counted. Sampling (fresh - semi fresh) three replicates each replicate was 100 grams harvested and packed in paper bags. Samples were preserved in ice box contains ice freon and transfer to the laboratory to extract oil and identify the chemical constituents.

2.1.2. Rearing technique:

The initial culture of, Khapra beetle, *Trogoderma granarium*, Cigarette beetle, *Lasioderma serricorne*, and Almond moth, *Ephestia cautella* were reared and multiplied for two generations on artificial diet consisting of ground wheat and dried yeast (5:1 v/v) in glass jars (0.5 L) at the Stored Grain Insect Depart, Plant Protection Research Institute, Agriculture Research Center, under laboratory conditions of 28 ±2°C and 65 ±5 R.H.

2.1.3. Coriander samples:

Coriander seeds were frozen for two weeks to ensure sterilization and free from insect infestations.

2.1.4. Infestation technique:

Four jars were provided with 100 g of dry and clean coriander seeds for each, and infested with 20 newly unsexed adult of *T. granarium*, *L. serricorne*, and four pairs of *E. cautella* moths.

Four jars were provided only with 100 g of dry and clean coriander seeds for each and served as control.

The jars were covered with muslin cloth and fixed by rubber band to prevent cross infestation and possible pest escape and were left under laboratory conditions of 26 ± 5 °C and 65 ± 5% R.H. One month after infestation, the number of alive and dead insect was examined, counted and recorded monthly. The dead beetles were removed and discarded.

2.1.5. Weight loss ratio:

Along the experimental period (six months) every 45 days all insects were eliminated, and the remaining materials were weighed. Sample weight and weight loss ratio was calculated according to [28] formula**:**

$$WL\ \% = \frac{\text{Initial fresh weight} - \text{Final fresh weight}}{\text{Initial fresh weight}} \times 100$$

2.2. Effect of type of package and storage period:

2.2.1. Ability of insect attack package:

Tests were carried out on different packages. A sealed bag with 100 g of coriander seed was put in a glass jar (500 ml), and then 20 unsexed adults of L. serricorne were placed outside of the package. The glass jar was then covered with pieces of cloth, tied with rubber bands, and kept at room temperature for 60 days. Each treatment was replicated five times. Bags were inspected after 2, 4, and 8 weeks for each package type. The numbers of beetles (live and dead) were calculated.

2.2.2. Degree of pest infestation in different packages during six months of storage:

Under the laboratory conditions, 100 g of dry coriander seeds was stored in different packages, which were made of Kraft paper bags, Burlap bags or Polyethylene bags. Each packages were repeat four time, Samples were taken every 45 days of coriander seeds to investigation infestation appearance and its degree.

2.2.3. Insect population on different packages:

100 g of dry coriander seeds was stored in different packages, which were made of Kraft paper bags, Burlap bags or Polyethylene bags. The infestation by L. serricorne was carried out by using five pairs of adult stage (0-2 days). All packages (Kraft paper, Burlap and Polyethylene bags) were kept under laboratory conditions throughout the storage period extending for six months.

Four replicates of each package were done. Samples were taken every 45 days of coriander seeds to follow up the development of insect population in each container. Moreover, to determine the weight loss.

2.3 Effect of type of packing on chemical and physical quality of coriander seeds after storing for six months:

In these experiments the seed of coriander were taking after storing period end from every type of package and compare the differences between the treatments.

2.3.1. Germination:

Germination test was conducted in a complete randomized design with four replications. From each treatment, randomly 100 seeds are selected per replication were put for germination in the sterilized germination paper sheet in Between paper method and incubated at normal light at room temperature and was recorded separately for each treatment and replication on final count (21st day) [29].

$$\text{Germination percentage \%} = \frac{\text{Total number of germinated seeds}}{\text{Total number of planted seeds}} \times 100$$

2.3.2. Moisture:

Relative humidity testing were measured by grain moisture meter (Draminski sa Owocowa 17, 10-860 Olsztyn-Poland).

2.3.3. Essential oil (EO) isolation:

Fresh and dry fruits were collected from each treatment during both seasons and divided into three replicates each replicate was 100 grams. Each replicate of all treatments was subjected to hydro-distillation (HD) for 3 h using a Clevenger-type apparatus [30]. The EO content was calculated as a relative percentage (v/w) using the fresh and dry fruits weight. The EOs extracted from *Coriandrum sativum* L. was collected from each treatment and dried over anhydrous sodium sulfate to identify the chemical constituents of the oil.

2.3.4. Gas chromatography-mass spectrometry (GC-MS):

Analysis of coriander samples were conducted by using a gas chromatography (Agilent 8890 GC System), coupled to a mass spectrometer (Agilent 5977B GC/MSD) and equipped with a HP-5MS fused silica capillary column (30 m, 0.25 mm i.d., 0.25 mm film thickness). The oven temperature was maintained initially at 50 °C, then programmed from 50 to 200°C at a rate of 5°C/min and from 200°C to 280°C at a rate of 10°C/min, then held for 7 min at 280°C. Helium was used as the carrier gas, at flow rate of 1.0 mL/ min. The essential oil was dissolved in diethyl ether (20 µL essential oil / mL diethyl ether), and then 1 µL of this solution were injected in the GC with a split ratio 1:50. The temperature of injection was 230 °C. Mass spectra in the electron impact mode (EI) were obtained at 70 eV (volte machine) and scan m/z range from 39 to 500 amu. The isolated peaks were identified by matching them with data from the library of mass spectra (National Institute of Standard and Technology, NIST).

3. Results and discussion

The obtained results in Table 1 show the population density of aphid coriander species, *Hyadaphis coriandri*, green peach aphid, *Myzus persicae* attacking coriander fruits in open field conditions at Qalubiya and Menoufia governorates during 2021/2022 season.

Data recorded that no infestation with aphid coriander species in March at Menoufia governorate, and there were a few numbers at Qalubiya governorate with aphid coriander species, while along April and May months there were high infestation with aphid stages at the two governorates with significant differences.

Table 1. Population density of aphid coriander species, *Hyadaphis coriandri*, green peach aphid, *Myzus persicae* attacking coriander fruits in open field conditions at Qalubiya and Menoufia governorates during 2022 season.

Months	Average numbers of Aphid individuals per 100 g/fruits	
	2022	
	Qalubiya	Menoufia
March	10 e	0 f
April	405 d	416 c
May	1340 b	1420 a
Grand mean	585	612
LSD 5%	4.55	

The different letters mean significant difference at the 5% level

The obtained results in Table 2 show the population density of insect species attacking coriander seed crop under store conditions for 6 month from 1 June to 30 November of Menoufia and Qalubiya governorates.

Data in Table 2 revealed that November month recorded the highest infestation of the examined insects, while the lowest numbers were recorded at July month, and September & October months occupied intermediate status, moreover, Cigarette beetle recorded the highest numbers, while Almond moth recorded the least numbers. The statistical analysis of data recorded that there were significant differences among months of the experimental period as well as insect species. Results from Tables 1, 2 are confirmed with [31] who reported that studied the population of coriander pests from field to the store and declared the major pests attacking coriander fruits and seeds. Results also in harmony with [32] who recorded that Cigarette beetle causing high infestation to coriander seed during 45 day of storage.

Table 2. Population density of insect species attacking coriander seed under store conditions for 6 month from 1 June to 30 November from Menoufia and Qalubiya governorates.

Investigation periods (days)	Pests/ 100 grams					
	Cigarette beetle	Khapra beetle	Almond moth	Cigarette beetle	Khapra beetle	Almond moth
	2022					
	Qalubiya			Menoufia		
45	188 d	109 d	49 d	139 d	58 d	33 d
90	440 a	137 c	64 c	180 c	103 c	50 c
135	289 c	160 b	83 b	239 b	119 b	72 b
180	374 b	192 a	104 a	270 a	142 a	86 a
Grand mean	322.75	149.5	75	207	105.5	60.25

LSD 5% for drug store beetle = 38.54 for Khapra beetle = 18.25 for Almond moth =8.57
The different letters in each insect species mean significant difference at 5% level LSD 5% among insect species = 45.24

The obtained results in Table 3 and Fig 1 show the losses coriander in seed weights in store at different periods according to insect infestation in glass jars.

Data in Table 3 revealed that November month recorded the highest losses in coriander seed weights, while the lowest losses were recorded at July month, moreover, Cigarette beetle recorded the highest losses in coriander seed weights 55.29 %, while Almond moth and Khapra beetle recorded the least losses around 15.5,15.68 %. The statistical analysis of data recorded that there were significant differences among months of the experimental period as well as insect species. This finding similar to [33], [34] reported that Cigarette beetle as main insect of coriander and fennel plant during storage. Insect pests promote weight loss of the product stored, a very important factor, causing nutritional value loss, commercial loss, as well as quality degradation [35].

Table 3. Weight losses in coriander seed at different periods of store during 6 month according to insect infestation in glass jars.

Investigation periods (days)	Losses %					
	Cigarette beetle	Khapra beetle	Almond moth	Cigarette beetle	Khapra beetle	Almond moth
	2022					
	Qalubiya Governorate			Menoufia Governorate		
45	21.17 d	10.71b	7.14 c	13.83 d	6.43 d	6.29 c
90	54.24 c	19.62 a	15.1 bc	31.25 c	11.88 c	11.58 bc
135	66.22 b	25.48 a	21.42 ab	48.63 b	18.3 b	17. 85 b
180	79.53 a	30.78 a	26.88 a	62.94 a	25.44 a	27.02 a
Grand mean	55.29	21.64	17.63	39.16	15.5	15.68

LSD 5% for drug store beetle = 5.26 for Khapra beetle = 3.06 for Almond moth =2.81
The different letters in each insect species mean significant difference at 5% level
LSD 5% among insect species = 5.94

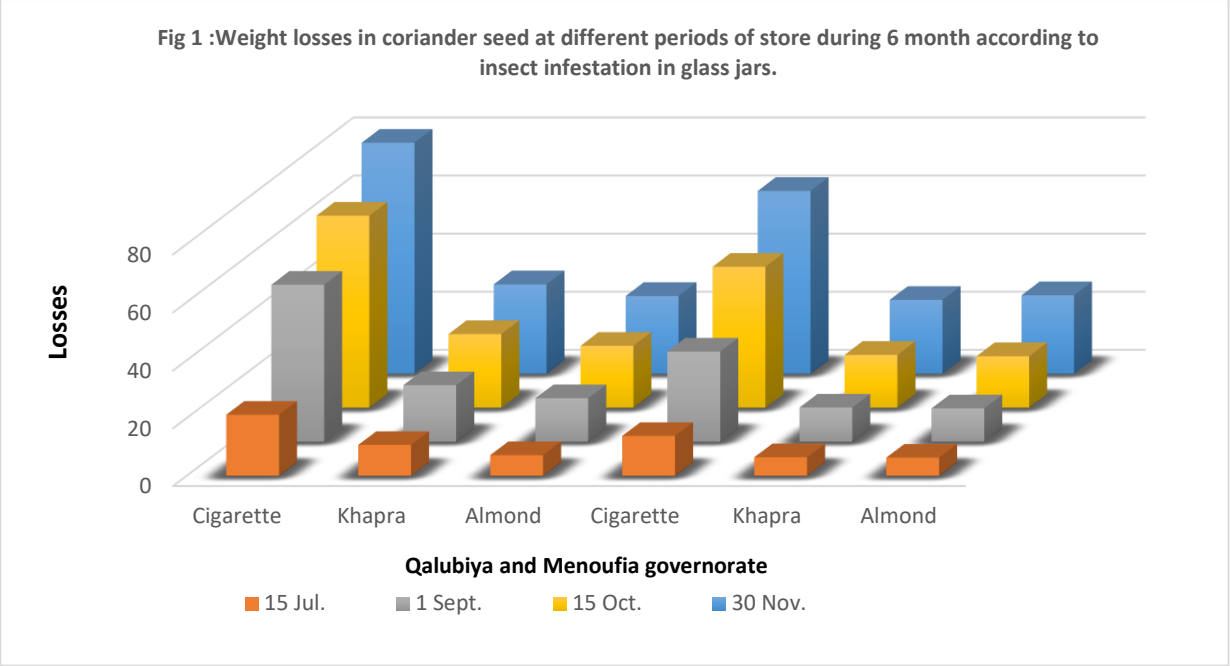


Fig 1 :Weight losses in coriander seed at different periods of store during 6 month according to insect infestation in glass jars.

The obtained results in Table 4 show the first appearance and degree of pest infestations in different package types during six month of storage indicated that Polyethylene package have high tolerance of insect infestation comparing with other types. This result is in harmony with [32] who recorded that plastic bags had the greatest resistance to package invasion by *Lasioderma serricorne*.

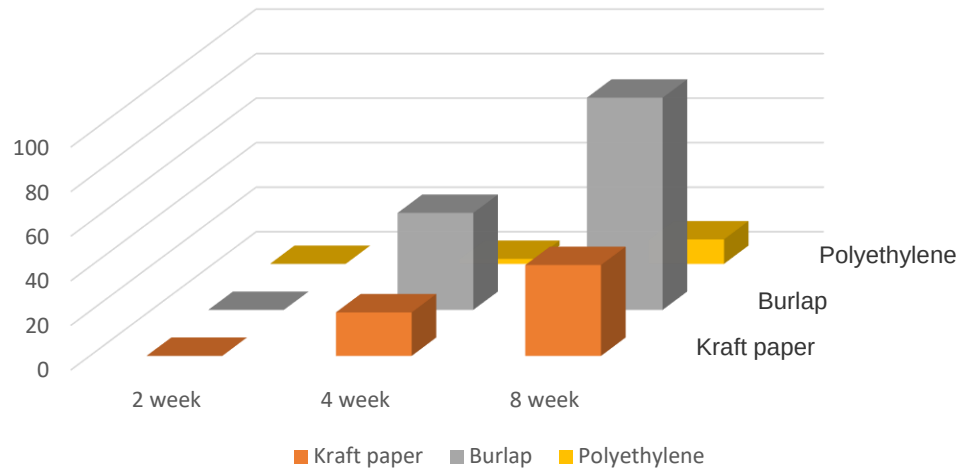
The obtained results in Fig 2 show the ability of Cigarette beetle, *L. serricorne* to attack different packages of coriander seed during storage. Data indicate that the number of insects increase with the increase of the time (2, 4 and 8 weeks) at the different types of packaging materials. The highest population density of Cigarette beetle infested stored coriander seeds was recorded at Burlap package 95.25, followed by Kraft paper package 40.75 and the lowest population was observed with Polyethylene package 11after 8 week. Our results showed that Polyethylene package was more effective than Burlap and there no infestation in Polyethylene packages during 2, 4 week of storage, this agree with [32] who reported that the infestation degree varied depending on the package materials and the highest infestation was observed in refined wheat flour packaged in woven cloth bags.

Table 4. The first appearance and degree of pest infestations in different packages during six months of storage.

Investigation periods (days)	Control (unpackage)	Kraft paper	Burlap	Polyethylene
45	++	0	+	0
90	+++	0	++	0
135	++++	+	+++	0
180	++++++	++	++++	++

0= no infestation, += low infestation ++= moderate infestation +++=high infestation

Fig (2): Number of *L. serricorne* in different packaging materials after 2,6,8 weeks of storage at normal condition



The obtained results in Table 5 show the effect of package types on the population density of Cigarette beetle, *Lasioderma serricorne* infested stored coriander seeds along 6 month.

Data in Table 5 revealed that the highest population density of Cigarette beetle infested stored coriander seeds was recorded at Burlap package 162.67, followed by Kraft paper package 96.00 and the lowest population was observed with Polyethylene package 72.67, meanwhile November month recorded the highest population density of Cigarette beetle followed by October month, while September and July months recorded the least numbers.

Table 5. Effect of package types on the population density of Cigarette beetle, *Lasioderma serricorne* infested stored coriander seeds after 1.5, 3.0, 4.5, 6.0 months of storage.

Investigation periods (days)	Kraft paper	Burlap	Polyethylene
45	32.33 d	63.67 d	24.33 d
90	57.00 c	76.33 c	36.33 c
135	83.33 b	111.00 b	63.00 b
180	96.00 a	162.67 a	72.67 a
Grand mean	67.16 B	103.41 A	49.08 C
LSD 5%	3.76	7.66	3.76

The different letters in each insect species mean significant difference at 5% level

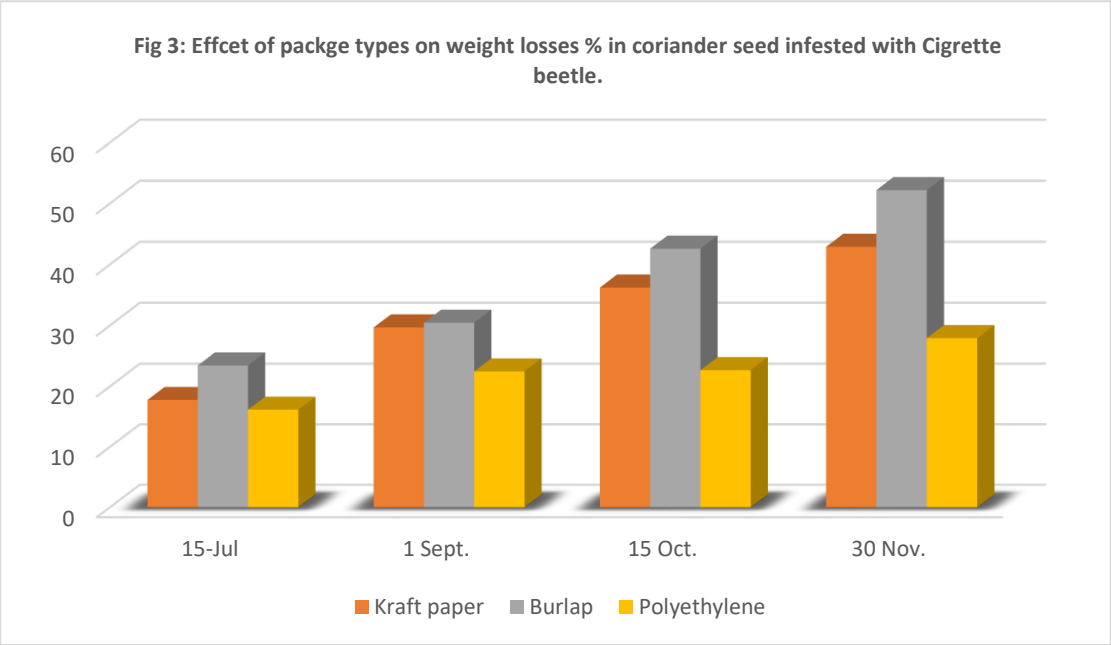
The obtained results in Table 6 and Fig 3 show the effect of package types on weight loss in coriander seed weight infested with Cigarette beetle, *Lasioderma serricorne*.

Data in Table 6 revealed that the highest weight loss in coriander seed weight was recorded at Burlap package 52.55 %, followed by Kraft paper package 42.92 % and the lowest population was observed with Polyethylene package 27.92 %, meanwhile November month recorded the highest population density of Cigarette beetle Cigarette beetle followed by October month, while September and July months recorded the least numbers. The statistical analysis of data recorded that there were significant differences among months of the experimental period as well as insect species. These results according to [21] who observed that after

four months of storage 32 gm of caraway and 26 gm of Coriander were consumed by Cigarette beetle followed by 24 gm of Red chili powder from 40 gm for every spice. Also, [33] reported a loss of 13.4 % in coriander by *Lasioderma serricorne*. [34] indicated a post-harvest storage loss and observed a maximum loss in fennel (58.02 %) followed by cumin (51.20%), coriander (49.58%) and ajwain (47.75%).

Table 6. Effect of package types on weight losses % in coriander seed infested with Cigarette beetle, *Lasioderma serricorne* after 1.5, 3.0, 4.5, 6.0 months of storage .

Investigation periods (days)	Kraft paper	Burlap	Polyethylene
45	17.59 b	23.46 b	16.19 b
90	29.69 a	30.46 a	22.48 a
135	36.24 a	42.6 a	22.69 a
180	42.92 a	52.55 a	27.94 a
Grand mean	31.61	32.26	22.32
LSD 5%	8.27	10.92	4.88



The obtained results in Table 7 show the effect of packing types on some factors on coriander seeds after 1.5, 3.0, 4.5, 6.0 month of storage.

As for germination % of the stored coriander seeds, data in Table 7 revealed that the highest germination % was recorded with seeds stored in Polyethylene package for 4 storage periods ranged between 80-90.66 %, followed by Kraft paper package ranged between 68.00-87 %, and the least percentages were recorded with Burlap package giving 40.66-79 %.

As for moisture % of stored coriander seeds data in Table 7 revealed that the highest moisture % was recorded with seeds stored in Burlap package for 4 storage periods ranged between 9.60 -11.83 %, followed by Kraft paper package ranged between 8.16-10.16 %, and the least percentages were recorded with Polyethylene package giving 7.63 - 8.56 %.

As for essential oil % of stored coriander seeds % data in Table 7 revealed that the highest essential oil % was recorded with seeds stored in Polyethylene package for 4 storage periods ranged between 0.36-0.57 %, followed by Kraft paper package ranged between 0.29 - 0.51 %, and the least percentages were recorded Burlap package with giving 0.16 - 0.45 %. [21] reported that physical parameters like temperature, humidity and also nutritional value are the main factors that effect on infestation ratio [36] observed that after six months of storage in coriander seed in different package the dimensions of the coriander seeds suffer different modifications that depend on the nature of the package used for each sample.

Moisture is one of the critical factors in safe storage of grains and seeds [37]. The increase of storage period resulted in decline in ability of seeds to germinate [38] reported by [40] This could have been due to the possibility that, the seeds stored for long time had higher metabolic activity which resulted to lowered germination ability.

Table 7. Effect of packing types on some factors on coriander seeds after six months of storage.

Package type	Samples	Storage period	Germination %	Moisture %	E.oil %
Kraft paper	Infected	1.5	85.66	8.83	0.42
		3.0	81.33	9.3	0.37
		4.5	73.00	9.93	0.33
		6.0	68	10.16	0.29
	Control	1.5	87	8.2	0.51
		3.0	83	8.16	0.45
		4.5	78.33	8.63	0.37
		6.0	72.00	8.26	0.39
Burlap	Infected	1.5	76	9.86	0.31
		3.0	65.33	10.66	0.28
		4.5	55.66	11.1	0.21
		6.0	40.66	11.83	0.16
	Control	1.5	79	9.13	0.45
		3.0	71	8.8	0.41
		4.5	61	8.93	0.31
		6.0	54.33	9.6	0.29
Polyethylene	Infected	1.5	88.33	8.1	0.46
		3.0	85.94	8.2	0.41
		4.5	81	8.53	0.40
		6.0	80	8.56	0.36
	Control	1.5	90.66	7.63	0.57
		3.0	88	7.66	0.52
		4.5	82.33	7.96	0.47
		6.0	81	7.86	0.44

The obtained results in Table 8 show the major constituents of essential oil for the three types of coriander yield.

Regarding to presence two constituents in three types of coriander yield, firstly Linalool, the highest values of Linalool % of essential oil was recorded at dry seeds type of coriander yield 53.44 %, followed by Semi fresh fruits 40.14 % and the least value was recorded at Fresh umble 38.82 %. Secondly α-pinene, recorded high values at dry seeds 3.1 %, followed by Fresh umble 3.0% and the least values recorded at Semi fresh fruits 2.90 %. However, all constituents distribute between two types of coriander yield mutually.

Regarding to the highest values of Decanal % of essential oil was recorded at Semi fresh fruits of coriander yield 13.27 %, Fresh umble recorded 13.8 %, and absence in dry seeds type.

Regarding to the highest values of Ethyl cinnamate % of essential oil was recorded at Semi fresh fruits of coriander yield 11.61 %, Fresh umble recorded 9.61 % and was presence in dry seeds type. trans-2-Decenal recorded highest values of essential oil % at Fresh umble 8.44 %, when the lowest values

recorded in Semi fresh fruits 4.29 %, and absence in dry seeds. γ-Terpinene recorded highest values of essential oil in dry seeds 7.2 % and lowest values 5.37 % in Fresh umble with completely absence in Semi fresh fruits. D-limonene was presence at dry seeds and Semi fresh fruits, recorded 1.9,1.11% respectively. Meanwhile Isophorone and Geranyl acetate recorded 5.21, 3.09 % respectively at dry seeds with completely absence in the other two types of coriander yield. These results are in harmony with [41] reported that the presence of limonene in this unattractive species agrees with our recent findings that limonene at high concentrations reduces damage by *T. apical* is in carrot crops. Meanwhile the interaction of plants and pests as well as fungi are scarcely known in case of medicinal plants. [42] reported that limonene, the second main component in caraway increased oviposition of *Trioza apicalis*. In higher Egypt, [43] studied and analyzed 120 different samples belonging to 24 different medicinal plant species, to investigate occurrence of mycotoxins. And showed that spice extracts revealed aflatoxins (8 - 35) µg/kg in 16 samples of anise, black pepper, caraway, black cumin, fennel, peppermint, coriander and marjoram. The new attraction for natural products like essential oils is important to develop a better understanding of their mode of biological action for new applications in human health, agriculture, and the environment. The essential oils could find many applications as an ingredient in different industries, like the cosmetic, the pharmaceutical, and the food industries.

Table 8. Major constituents of essential oil for three types of coriander yield.

Fresh umble		Semi fresh fruits		Dry seeds	
Compound	%	Compound	%	Compound	%
Linalool	38.82	Linalool	40.14	Linalool	53.44
Decanal	13.8	Decanal	13.27	γ-Terpinene	7.2
Ethyl cinnamate	9.61	Ethyl cinnamate	11.61	Isophorone	5.21
trans-2-Decenal	8.44	trans-2-Decenal	4.29	Geranyl acetate	3.09
γ-Terpinene	5.37	α-pinene	2.90	α-pinene	3.1
α-pinene	3.05	D-limonene	1.11	D-limonene	1.9

The obtained results in Table 9 show the components of the oil extracted from fresh coriander fruits infested with aphid insects in Qalubiya Governorate.

Regard to Linalool as a major component of fresh and semi fresh coriander fruits, data in Table 9 recorded 30.82 % compared to 38.82 % at control treatment at fresh coriander fruits, while semi fresh recorded 31.63 % compared to control treatment 40.14 %. meanwhile Decanal component recorded 10.04 % compared to 13.8 % at fresh coriander fruits at control treatment while semi fresh treatment was recorded 12.19 % compared to 13.27 %., γ-Terpinene recoded 5.91 % compared to 8.37 % at fresh coriander fruits, while at semi fresh fruits recorded 4.63 % compared to 5.69 %.

Table 9. Components of the oil extracted from fresh and semi fresh coriander fruits in Qalubiya Governorate.

Peak number	Compound	RT	Aphids		Control	
			Fresh %	Semi fresh %	Fresh %	Semi fresh %
1	α-Pinene	6.35	3.18	5.04	3.05	2.95
2	Octanal	8.029	0	0.72	0.66	0
3	p-Cymene	8.634	1.05	0.77	0.7	0.79
4	D-Limonene	8.743	1.47	1.04	0	1.11
5	γ-Terpinene	9.561	5.91	4.63	8.37	5.69
6	Octyl formiate	9.866	1.61	2.14	1.51	1.11
7	Linalool	10.769	30.82	31.63	38.82	40.14
8	Nonanal	10.822	0.5	0	0	0
9	(+)-2-Bornanone	12.008	5.37	4.17	3.47	5.12
10	Camphol	12.597	1.05	0	0	0
11	Decanal	13.645	10.04	12.19	13.8	13.27
12	Pulegone	14.634	1.9	2.05	1.39	1.52
13	Geraniol	14.981	1.02	0.61	0	0
14	Piperitone	15.043	4.04	3.65	3.84	4.31
15	trans-2-Decenal	15.181	6.04	10.33	8.44	3.29
16	trans-2-Decenol	15.365	0	0.64	0	0
17	1-Decanol	15.436	0.69	1.16	0	0
18	Thymol	16.041	1.16	0	0	1.6
19	Carvacrol	16.308	1.62	0	0	1.58
20	Undecanal	16.38	0	1.05	1.01	1.07
21	2-(4-Ethylphenoxy) ethanol	16.672	1.29	0	0	0
22	1-Ethyl-5,5-dimethyl-1,3-cyclopentadiene	16.822	0	0	0	0.89
23	2-Undecenal	17.887	2.24	1.35	1.59	1.07
24	Ethyl cinnamate, trans	18.263	0.8	0.9	1.32	1.22
25	Geranyl acetate	18.395	1.61	1.01	0	0
26	Dodecanal	19.035	0.58	0	0	0
27	Ethyl cinnamate	20.513	8.32	7.81	9.61	11.61
28	Spathulenol	23.306	1.04	1.03	1.18	1.68
29	trans-2-Tetradecenal	25.29	6.64	6.06	1.25	0
Sum			99.99	99.98	100	100

The obtained results in Table 10 show the components of the coriander fruits seed oil during storage in two Governorates that the major component was linalool which recorded high values in oil components at three studied stored insects.

Regard to linalool was recorded the highest values at Qalubiya Governorate compared to Menoufia Governorate. Almond moth insect recorded 67.06 % compared to 60.58%, Khapra beetle recorded 60.92 % compared to 53.44 % and Cigarette beetle recorded 45.79 % compared 27.5 %.

Table 10. Components of the coriander fruits seed oil during storage in two Governorates.

Peak no.	Compound	RT	Qalubiya				Menoufia			
			Control %	Almond moth %	Khapra beetle %	Cigarette beetle %	Control %	Almond moth %	Khapra beetle %	Cigarette beetle %
1	α-Pinene	6.35	0.62	2.85	1.29	2.52	0.98	2.15	3.1	2.74
2	Camphene	6.71	0.98	0.38	0	0.39	0	0	0	0
3	Sabinene	7.31	0	0.28	0	0	0	0	0	0
4	β-Pinene	7.41	0	0.31	0	0	0	0	0	0
5	β-Myrcene	7.72	0.48	0.52	0.3	0.47	0	0	0.5	0
6	Mesitylene	7.82	0	0	0	0.81	0	0	0	3.11
7	p-Cymene	8.63	3.47	3.4	2.46	2.92	2.07	3.54	2.47	1.99
8	D-Limonene	8.74	2.02	1.91	1.52	1.5	0.89	2.15	1.9	1.06
9	γ-Terpinene	9.56	6.67	7.54	4.3	4.68	4.81	6.53	7.2	3.99
10	Artemisia ketone	9.62	0	0	0	0.64	0	0	0	1.1
11	Terpinolene	10.39	0	0.51	0.33	0	0	0	0	0
12	Linalool	10.77	72.63	67.06	60.92	45.79	77.65	60.58	53.44	27.5
13	Isophorone	11.33	0	0	0	0	0	0	5.21	0.63
14	(+)-2-Bornanone	12.01	4.57	6.95	5.87	6.7	2.75	1.56	0.61	6.08
15	Camphol	12.60	0	0.79	0.47	1.13	0	0	0	1.57
16	Terpinen-4-ol	12.91	0	0.44	0.44	0	0	0	0	0
17	α-Terpineol	13.28	0	0.63	0.62	0.44	0	0	0	0
18	Geraniol	14.98	1.36	2.71	2.83	1.54	0.84	0.75	1.09	0
19	Piperitone	15.04	0	0	1.62	6.34	0.97	0	3.45	11.33
20	Anethole	15.87	0	0	0	0.77	1.84	0	0	1.28
21	Thymol	16.04	0.84		2.05	2.11	0.82	4.29	2.23	3.53
22	Carvacrol	16.31	3.57	0.55	5.64	3.01	2.53	15.09	5.46	4.58
23	2-(4-Ethylphenoxy) ethanol	16.67	0	0	0	0	0	0	0	0.83
24	1-Ethyl-5,5-dimethyl-	16.82	0	0	0	0	0	0	0	1.55

	1,3-cyclopentadiene									
25	Ethyl cinnamate, trans	18.26	0	0	0.55	2.3	0	0	0.81	3.27
26	Geranyl acetate	18.40	2.76	3.17	3.42	1.88	2.32	1.83	3.09	1.1
27	trans-Methyl cinnamate	18.45	0	0	0.93	1.13	0	1.53	1.01	1.77
28	Ethyl cinnamate	20.51	0	0	3.66	10.45	1.54	0	6.65	17.22
29	Spathulenol	23.31	0	0	0.79	2.48	0	0	1.78	3.79
Sum			99.9	100	100	100	99.83	100	100	100

The obtained results in Table 11 show components of coriander fruits seed oil during storage in different package types the major components linalool that recorded 77.60 % at storage in Polyethylene package and decrease 48.24 % at storage in Burlap package.

Anethole and γ-Terpinene was the second and third main component ranged 5.24% and 4.25%, respectively in the essential oil of fruits were storage in Polyethylene package. Meanwhile (+)-2-Bornanone 6.9 %, γ-Terpinene 6.55%, and Geraniol 3.53% recorded the highest value in the essential oil of fruits were storage in Kraft paper package. Ethyl cinnamate and Piperitone was the second and third main component ranged 14.29 % and 7.52%, respectively in the essential oil of fruits were storage in Burlap package.

Coriander seed has essential oil, lipid and protein, which may influence by bad storage condition causes physical and physiological damage and ultimately decreases its quality and deterioration.

Comparison between the chemical constituents of coriander fruits essential oil stored under different package types the obtained data showed that the essential oil composition of the coriander plant varied in their responses; some increased, while the others decreased during the different storage package types [44].

Table 11. Components of coriander fruits seed oil during storage in different package types.

Peak number	Compound	RT	Package type		
			Kraft paper %	Polyethylene %	Burlap %
1	α-Pinene	6.35	2.04	1.67	0.7
2	Camphene	6.713	0.28	0	0
3	Sabinene	7.311	0.22	0	0
4	β-Pinene	7.407	0.23	0	0
5	β-Myrcene	7.72	0.41	0	0
6	Mesitylene	7.824	0	0	0.53
7	p-Cymene	8.634	3.23	1.65	1.16
8	D-Limonene	8.743	1.65	0.82	0
9	γ-Terpinene	9.561	6.55	4.25	3.51
10	Terpinolene	10.388	0.52	0	0
11	Linalool	10.769	67.95	77.6	48.24
12	(+)-2-Bornanone	12.008	6.9	2.44	5.12
13	Camphol	12.597	0.79	0.74	1.13
14	Terpinen-4-ol	12.91	0.47	0	0
15	α-Terpineol	13.281	0.79	0	0
16	Citronellal	14.254	0.97	1.04	0
17	Geraniol	14.981	3.53	2	1
18	Piperitone	15.043	0	0	7.52
19	Anethole	15.87	0	5.24	0.82
20	Thymol	16.041	0	0	2.44
21	Carvacrol	16.308	0.38	0	3.04
22	Ethyl cinnamate, trans	18.263	0	0	2.5
23	Geranyl acetate	18.395	2.61	1.83	2.96
24	trans-Methyl cinnamate	18.446	0	0	0.98
25	Ethyl cinnamate	20.513	0	0	14.29
26	Spathulenol	23.306	0	0	4.07
27	γ-Eudesmol	24.296	0.48	0.72	0
Sum			100	100	100

4. Conclusion

The storage of coriander seed at different packages type is accompanied with chemical and physical quality changes of coriander seeds. In addition, the infestation with different pest in pre and post-harvest make changes in component of coriander fruits seed oil. The study concluded that highest changes in quality parameters were observed in seed stored in Burlap packages. The seed stored in Kraft paper and Polyethylene showed a lower degree of infestation than Burlap bags. In addition, the content of coriander volatile oil decreases with increasing the period of storage. The present study suggests that coriander seed should be stored in Kraft paper or Polyethylene packages under ambient condition.

Conflict of interests

The author(s) declare(s) that there is no conflict of interests regarding the publication of this article.

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