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Biological and toxicological studies of predatory mite *Phytoseiulus persimili* athias-henriot *s* (Host preference) on *Tetranychus urticae* koch and *Tetranychus cucurbitacearum* on soybean plants

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Abstract
Three compounds were evaluated for their toxicity to the adult stage of the two-spotted spider mite *T. urticae* and *T. Cucurbitacearum* in this study, which included laboratory and field tests. The predatory mite *Phytoseiulus persimilis* was studied during in the life span of the predatory mite *Phytoseiulus persimilis* four compounds, abamectin, biofly, and two extract oils (moringa oil and garlic oil) on mites using the leaf disc technique. Moreover, to evaluate all stages of development of *P. persimilis*, which feeds on *T. urticae* and *T. Cucurbitacearum*, following exposure to different concentrations of these compounds on soybean plants in the field to adult females of *T. urticae* and *T. Cucurbitacearum*, the most toxic compound was abamectin, whereas biofly had a moderate toxicity to adult females of *T. urticae* and *T. Cucurbitacearum*, moringa oil and garlic oil were the least toxic. Also, abamectin had the highest toxicity index to adult females of *T. urticae* and *T. Cucurbitacearum*, whereas biofly had a moderate toxicity to adult females of *T. urticae* and *T. Cucurbitacearum*. Moringa oil and garlic oil were the most toxic to adult females. according the toxicity index. *T. urticae* and *T. Cucurbitacearum* adult females are not toxic to garlic oil. The effects of various concentrations of four compounds on *T. urticae* and *T. Cucurbitacearum* in evaluating the stages of development of *P.persimilis*, which feeds on *T. urticae* and *T. Cucurbitacearum*. When we applied abamectin on *T. urticae* and *T. Cucurbitacearum*, the immature stages of *P.persimilis* were 5.34 and 4.40 days, respectively, compared to the control of 6.4 and 6.05 days, and the adult longevity was 4.80 and 4.20 days, respectively, compared to the control of 12.4 and 12.00 days. The proportion of hatching eggs in abamectin was 30.23 % and 31.21%, respectively, as compared to the control, which had a ratio of 98.48% when a predator ate *T. urticae* and *T. Cucurbitacearum*, and 95.61 % when a predator consumed *T. urticae* and *T. Cucurbitacearum* abamectin. In the second season in the field on soybean plants, the results were similar.

Keywords: *Phytoseiulus persimili, Tetranychus urticae, Tetranychus cucurbitacearum,* athias-henriot s

Introduction

Predators are thought to be one of the biological control strategies for pests including phytophagous mites, scale insects, and whiteflies. Phytoseiid mites are natural enemies of tetranychid mites that play a key role in biological control (Croft 1997). Because of their well-known ability to decrease pest mite populations, primarily tetranychids, phytoseiid mites are important biological control agents in a variety of cropping systems (Colfer *et al.*, 2004). Because of their high predaceous efficiency on biological control, members of the phytoseiidae family have shown to be the most effective. There are about 1700 species in the world, with a global range (Walter, 1992). Some are crucial in the control of phytophagous mites. The predator used in this study was *phytoseiulus presimilis* (Athias-Hennoit) (Acari; phytoseiidae), which has a high oviposition and predation rate and has one of the higher development rates (Sabelis, 1981). It has attracted the curiosity of biologists working on the development of 1PM systems. The biological control of two spotted spider mites [Tetranychus urticae Koch (Acari: Tetranychidae)] was investigated using Papatya Tiftikçi (2020) *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseidae) at release ratios of 1:10, 1:20, and 1:40 predator prey. *Tetranychus urticae* is a polyphagous insect that has been seen eating over 1100 plant species (dermauw *et al.*, 2012).Spider mites eat by penetrating plant tissue with their needle-like sucking mouthparts, and they prefer to feed on the lower leaf surface (Attia *et al*., 2013). They also inject phototoxic chemicals that cause chloroplast damage and necrotic areas on the leaf surface.Chemical pesticides are the most frequently utilised method of spider mite control. Due to the widespread use of acaricides against this pest, as well as its high reproductive ability, Resistance eventually developed due to the short life cycle and arrhenotokous mating mechanism (Van leeuwen *et al*., 2009). Based on the total number of pesticides to which it has developed resistance, it is considered the most resistant arthropod species. Because the widespread use of synthetic chemical pesticides, which has resulted in resistance and contamination, there is a developing demand for more selective pesticides with novel modes of action. less environmental risks, and greater compatibility with natural enemies and biocontrol agents (Steiner *et al*., 2011). The point of the study was to see how some chemicals affected *T. urticae* and *T. cucurbitacearum*, and determining the life span of *Phytoseiulus persimilis* after exposure to different compounds on soybean plants.

Materials and Methods

Stock culture of *Tetranychus urticae* Koch and *T. cucurbitacearum.*

Females from an soybean plants on a farm in sakha Agric. Research station in Kafr El-Sheikh, Egypt have been used to start the stock culture. The two-spotted spider mites, *T.*

urticae and *T. cucurbitacearum*, infected soybean leaves were collected and placed in paper bags. The samples were sent to laboratory straight away. The mass culture was started by transferring female individuals into petri-dishes with such a 10 cm diameter and a camel's hair brush. which fed *T. urticae* and *T. cucurbitacearum* with untreated soybean plant leaves discs of 3 cm diameter put on a pad of cotton wool, thoroughly soaked with water as a source of moisture and to prevent mite escape Adult females were released overnight on fresh and clean mulberry leaf discs and all of the adult females were removed the next day to get newly deposited eggs. The newly larvae were deposited on fresh leaf discs in prepared petri-dishes after the eggs had hatched. After one day, the old leaf discs were removed and the mites were given fresh leaf discs. According to Dittrich, the colony was grown in an incubator at 27± 2ºC and 65± 5% R.H. (1962)

Rearing of the predatory mite; *Phytoseiulus persimilis*

P. persimilis, a predatory mite, was obtained from soybean fields in in sakha Agric. Research station in Kafr El-Sheikh, Egypt as a stock culture. Soybean plants leaf discs with a diameter of 3 cm were used as a substrate for rearing the predator and were deposited in Petri-dishes on cotton wool, with each disc coated with a dry cotton barrier. Every day, a few drops of water were added to keep the predator wet. When the leaf substrate began to decay, it was replaced with a new one and a sufficient number of *T. urticae* and *T. cucurbitacearum* were given as prey at various stages. The studies were done out in a controlled setting. According to Overmeer *et al* were raised at 272º C and 65.5% R.H. (1982).

2-Compounds tested

The doses were calculated using ppm of four chemicals: abamectin, biofly, moringa oil, and garlic oil.

1- Abamectin,

2- Biofly

A liquid microbial pesticide containing 3x107 conidia of the entomopathogenic fungus *Beauvaria bassiana* (Balasamo). El-Nasser for Fertilizers and Pesticides-Egypt provided it.

3- Plant oils and investigated in the present study.

Table 1

Family	Scientific name	Common name	Arabic name	Part used
Moringaceae	Moringa	Moringa oil	زيت المورينجا	Seeds
Allioideae	*Allium sativum*	Garlic oil	زيت الثوم	Seeds

Effect of food type on some biological aspects of predacious mite:

Feeding on different diets: The laboratory stock culture of the predacious mite, *P.persimilis*, used in this study was grown on various diets at 27 ± 2ºC and 65 ± 5% R.H.

Bioassay testes

Feeding *Phytoseiulus persimilis* on different kind food

The arenas used in this study were made from (3 × 3 cm.) mulberry leaf discs put on a water-soaked sponge pad with the upper surface down. Around the outside edge of the leaves, a strip of moistened absorbent cotton was placed. Individual venues with the food supply to be evaluated were fed with single freshly hatched larvae. Every day, the arenas were checked, and the development and survival of predators were recorded. Freshly collected pollen was made available to the predator by placing a small amount of test pollen in each arena, which was replaced each 48-72 hours. When used as a food source for mite rearing, the pollen must keep well and preferably have a low water content to minimize molding. Fresh prey tetranychid mites were replaced on a daily basis. Female newly emerged from the eggs, mated, and kept to individual test venues with food to be tested. The leaf was given by a single leaf (1 cm) placed on the large veins of each leaf (arena). The duration of immature stags' life, as well as their longevity and fertility, were all recorded. Every experiment was repeated twice and all were carried out in the laboratory at a temperature of 27 ± 3ºC and a humidity levels of 65 ± 5 %.

Effect of prey density on egg laying, longevity and feeding behavior of *Phytoseiulus persimilis*

Stock laboratory cultures of the predatory mite *P.persimilis* were kept separate from the tetranychid mite *T. urticae* and *T. cucurbitacearum* soybean plant leaves (Basha *et al*., 2007). Mature virgin females and newly emerged males of the four species (within 24 - 48 hours of their last moult) were copulated and allowed enough time to mate on mulberry leaves with enough prey. The experiments were carried out on 4cm upside down mulberry leaf discs on water wet cotton wool pads in open Petri dishes with a wet strip of cotton wool border. *T. urticae* and *T. cucurbitacearum* adult females were used as prey, with densities of 5, 10, and 15 per leaf disc. The number of consumed preys and deposited eggs per two females were recorded daily when newly mated females of each species (as previously described) were transferred to each leaf disc through three experimental series with 15 - 20 replicates separately of each prey density leaf disc. All of the dead preys were removed and replaced with another one that was still alive. The experiments were carried out at a temperature of 27 ± 2ºC and a relative humidity of 65 ± 5% R.H. Statistical analyses were performed on the data using the F. test according to (Sendecor 1966) methods using the costat programme.

Life table parameters

For females reared at various temperature degrees, life table parameters were collected using a BASIC computer program (Abou-Setta *et al*., 1986). The mean generation time (T), net reproductive increase (R0), intrinsic rate of increase (rm), and expected rate of increase () were determined as population growth parameters. During the development period, result females' eggs were collected daily from each female, and the progeny's sex ratio was determined.

Field experiments

During the summer seasons of 2019 and 2020, two tests were performed at the farm sakha Agric. Research station in Kafr El-Sheikh, Egypt. The purpose of this study was to see if spider mite *Tetranychs urticae* and *T. Cucurbitacearum* preferred *P.persimilis* as a host after being fed with it. four chemicals, abamectin, biofly, and two oils (moringa oil and garlic oil) infesting soybean plants of the variety Giza 111 [each of 1/42 hectare] were considered as a plot laid out in a completely randomized blocks design, with four replicates for each treatment. Using a knapsack sprayer (20 L volume) with one nozzle, all tasted compounds were applied at half the recommended rate. Water was used to dilute the compounds at a rate of 200 liters per fadden. Before, two days, and one week after treatment, ten soybean leaves were randomly selected from each plot. The Henderson and Tilton equation was used to calculate the percentage reduction in infestation for each treatment (1955) [4]. Duncan's multiple range test was used to compare the statistically different means at the 5% level.

Statistical analysis

ANOVA, or one-way analysis of variance, was used to statistically analysis the data (Duncan 1955) [4].

Results and Discussion

Effect of different food types on developmental stages of female mites *P.persimilis* on two-spotted spider mite *T. urticae*.

The leaf disc technique was used to test the toxicity of three compounds, abamectin, biofly, and two extract oils (moringa oil and garlic oil), to the adult stage of a laboratory strain of two-spotted spider mite *T. urticae* and *T. Cucurbitacearum* (Siegler, 1947) [17]. The mortality was calculated using Abbott's formula (1925), plotted on a log-concentration probit paper, and the regression lines were statistically evaluated using Litchfield and Wilcoxon (1949). According the LC50 values in (Table 1), abamectin was the most toxic compound, with an LC50 value of 1.4 ppm. Biofly, on the other hand, exhibits a moderate toxicity to adult females of *T. urticae*, with an LC50 of 5.8 ppm. Moringa oil and garlic oil, with LC50 values of 97.50 and 146.44 ppm, respectively, were the least toxic to adult females of T. urticae. Biofly, on the other hand, has a moderate toxicity to adult female *T. urticae*, with a toxicity index of 24.13. However, moringa oil and garlic oil have low toxicity indices of 1.43 and 0.95, respectively, in mature female *T. urticae*. This experiment on adult female spider mites was carried out not only to obtain the most toxic compound, but also to record the continuous variations in the reaction of different chemicals towards the main pest belonging to phytophagous Tetranychide, which has been studied and will be studied in the future by many investigators. Without a doubt, these investigations reflect one of the essential stages in a successful IPM programme.

Table 2: Effect of different food types on developmental stages of female mites *P.persimilis*.

Compounds	Toxicity to *T. urticae*				
	Abamectin	**Biofly**	**Moringa oil**	**Garlic oil**	**Control**
LC_{50} (PPM)	1.4	5.8	97.50	146.44	-------------
Toxicity index	100	24.13	1.43	0.95	-------------
Development stages of *P.persimilis* feding on *T. cucurbitacearum*					
Inculpation period	2.06	5.80±0.11	4.20±0.45	5.40±0.31	3.80±0.32
Larva	1.36	2.80± 0.21	3.20±0.23	4.20±0.25	2.20±0.46
Protonymph	1.88	2.60± 0.21	2.80±0.31	3.20±0.71	2.00±0.51
Dutonyph	2.10	2.40± 0.32	3.80±0.29	4.00±0.42	2.20±0.51
Total immature stages	5.34	7.80± 0.31	9.8±0.41	11.40±0.42	6.4±0.81
Life cycle	7.40	13.60±0.32	14.00±0.81	16.80±0.31	10.2±0.31
Longevity	4.80	6.80± 0.61	8.40±0.32	9.4±0.21	12.4±0.27
Life span	12.2	20.4± 0.42	22.40±0.81	26.2±1.5	22.60±0.4
Average no. of lading egg-females	34.4	43.6± 0.51	55.20±0.91	63.41±0.62	66.00±0.9
% hatching of eggs	30.23	36.69	45.45	70.97	98.48
% Reduction of lading	47.87	33.93	16.36	3.92	0.00

The effects of different concentrations of four chemicals on *T. urticae* were studied in order to evaluate the developmental stages of *P.persimilis*, which feeds on *T. urticae*. The results showed that when we faded with *T. urticae*, the duration of immature stages was 5.34 days and adult longevity was 4.80 days, but when we used garlic oil, the duration of immature stages was 11.40 days and adult longevity was 9.4 days, but abamectin was 4.80 When compared to moringa oil and garlic oil, and I had the highest effect on the rate of hatching eggs to abamectin, with ratios of 30.23 % to 45.45 % and 70.97 %, respectively. Compared to the control, the control ratio was 98.48%. However, the predator's life span was influenced by the concentrations of four compounds, which led to a decrease life span in the control group, where the control diet was 98.48%. The life cycle was significant (13.60, 14.00 and 16.80 days, respectively) when the predator was feeding on *T. urticae*. Habashi (2018) investigated the ability and stability of the aqueous garlic extract (*Allium sativum linn*.) To combat the spider mite. *tetranyus urticae* in Egypt. The data showed that the maximum mortality of *T.urtecae* was 83.33 ± 7 days.

Effect of different food types on developmental stages of female mites *P.persimilis* on *T. cucurbitacearum*.

Based on the LC50 value, the results (Table 2) indicate that abamectin was the most toxic compound with an LC50 value of 2.3 ppm, while biofly has moderate toxicity in adult female *T. urticae* with an LC50 value of 7.5 ppm. Moringa oil and garlic oil were the least toxic to adult *T. urticae* females with LC50 values of 112.33 and 158.36 ppm, respectively. The data in Table (2) confirm that abamectin was the most toxic compound for adult *T. urticae* with a toxicity index of 100, and biofly moderate toxicity to adult *T. urticae* females with a toxicity index of 30.66. Moringa oil and garlic oil are weakly toxic to adult female *T. urticae*, with toxicity indexes of 2.04 and 1.45, respectively.

Table 3: Effect of different food types on developmental stages of female mites *P.persimilis*

Compounds	Toxicity to *T. cucurbitacearum*				
	Abamectin	**Biofly**	**Moringa oil**	**Garlic oil**	**Control**
LC_{50} (PPM)	2.3	7.5	112.33	158.36	-------------
Toxicity index	100	30.66	2.04	1.45	-------------
Development stages of *P.persimilis* feding on *T. cucurbitacearum*					
Inculpation period	1.70	4.60±0.11	4.00±0.45	5.20±0.31	3.70±0.32
Larva	1.30	2.40± 0.21	2.80±0.23	4.00±0.25	2.00±0.46
Protonymph	1.70	2.5 0± 0.21	2.60±0.31	2.85±0.71	2.05±0.51
Dutonyph	1.40	2.35± 0.32	3.75±0.29	3.80±0.42	2.00±0.51
Total immature stages	4.40	7.45± 0.31	9.15±0.41	10.65±0.42	6.05±0.81
Life cycle	6.10	12.05±0.32	13.15±0.81	15.50±0.31	9.75±0.31
Longevity	4.20	6.20± 0.61	7.80±0.32	10.30±0.21	12.00±0.27
Life span	10.30	18.25± 0.42	20.95±0.81	19.30±1.5	21.75±0.34
Average no. of lading egg-females	37.80	40.20± 0.51	48.40±0.91	57.60±0.62	63.80±0.69
% hatching of eggs	31.21	35.32	47.93	71.87	95.61
% Reduction of lading	40.75	36.99	36.67	9.71	0.00

The duration of immature stages and longevity of adults decreased significantly depending on the type of foraging *P. persimilis*: 4.40 days and 4.20 days, it can be seen when we used different concentrations of this compounds on *T. cucurbitacearum* to development evaluation. Stages of *P.persimilis* on *T.cucurbitacearum*.The results showed that when we used moringa oil and garlic oil, the duration of the immature stages were 9.15 and 10.65 days the longevity were 7.80 and 10.30 days but abamectin was 4.20 days at that time the control was 12.00 days.The rate of hatching eggs to abamectin was 31.21%, while garlic oil was 71.87 % compared to the control, the control ratio was 95.61 %. Life span of a predator was affected by the concentrations of this compounds which led to a decrease in the life span in the control where the ration in the control was 21.75 %.Life cycle was significantly with (6.10, 13.15 and 15.50 days, respectively) for abamectin, moringa oil and garlic oil when a predator fed on *T. cucurbitacearum.* Hosam *et al*. (2019) determined the direct and residual effects of two natural plant extracts on *T.urticae*. The effect on the biological features of *T.urticae* was studied at two concentrations of 0.25 % and 0.5 %. The study found that these extracts used to have a beneficial effect on tick life aspects, changing and extending tick life cycles while also reducing the number of generations each year. Moreover, the extracts used had a high mortality rate, with 65.52 % and 51.72 %, respectively, before and after the infection when they were treated. Habashy (2018) [13] studied the effect of storage periods on the effectiveness of various six concentrations of aqueous garlic extract on *T.urticae*. The results showed that the acaricidal activity of the extract shortened the release time for all tested concentrations. After four weeks, he lost about 30% of his activity. Aqueous garlic extract significantly reduces the egg deposition and hatchability of *T.urticae*.

Pascoli *et al.* (2019) described the preparation and characterization of neem oil-loaded zein nanoparticles, together with evaluation of their toxicity towards nontarget organisms, using Allium cepa, soil nitrogen cycle microbiota, and Caenorhabditis elegans aiming to achieve the safer by design strategy. The spherical nanoparticles showed an average diameter of 278 ± 61.5 nm and a good stability during the experiments. In the toxicity assays with A. cepa, the neem oil-loaded zein nanoparticles mitigated the increase in the DNA relative damage index caused by the neem oil. Molecular genetic analysis of the soil nitrogen cycle microbiota revealed that neem oil-loaded zein nanoparticles did not change the number of genes which encode nitrogen-fixing enzymes and denitrifying enzymes. In C. elegans, the neem oil-loaded zein nanoparticles had no toxic effect, while neem oil interfered with pharyngeal pumping and GST-4 protein expression. Sibel and Irfan (2017). Determined the side effects of four acaricides (acequinocyl, etoxazole, bifenazate and milbemectin on the predator mites *phytoseiulus persimilis* and *Neoseiulus californicus.* The result indicated that effects o the different acaricides doses applied on predator mite adults increased according to the acaricides and counting daily. It was also found that the acaricides used in the study had significant side effects on predator mite adults. They were found that all of the acaricides used in the study showed high levels of toxic effect on *N. californicus* and *P. persimilis* adults.

Toxicity of tested compounds to adult females of predatory mite *p. presimilis*.

The significance of *phytoseiulus presimilis* soybean phytoseiids mite on *T. urticae* and *T. Cucurbitacearum*

Table 4: Toxicity of different compounds to adult females of predatory mite *p. presimilis*:

Compound	*p. presimilis*	
	LC_{50} (PPM)	**Toxicity index**
Abamectin	0. 55	100
Biofly	9.66	5.69
Moringa oil	112.67	0.48
Garlic oil	122.44	0.44

Abamectin was the most toxic chemical, having an LC50 value of 0. 55 ppm, according to the data in (Table 3). Biofly, on the other hand, has a moderate toxicity to adult females of *T. urticae*, with LC50 of 9.66 ppm but garlic oil with LC50 value of 122.44 ppm was the least toxic to adult females of *T. urticae*. The results from Table (3) revealed that abamectin was the most toxic compound to adult females of *P. presimilis*, with a toxicity index of 100.00%, followed by biofly with toxicity indexes of 5.69 respectively.Garlic oil had a low toxic effect on adult females of the *p. presimilis* with toxicity indexes of 0.44 %, respectively. (Sun, 1950) [18] of any toxic compound was suggested mainly to pool different information about this compound against different mite species and mite stages by comparing their LC_{50} values. The final values concluded from their calculation is the efficiency of the compound tested in integrated pest management. Duygu Cevizci *et al*. (2020).

Phytoseiulus persimilis and *Neoseiulus californicus* (Acari: Phytoseiidae). Experiments were conducted at 25 ± 1 °C, 70 ± 5% relative humidity, and 16:8h light:dark conditions. Our data showed that the bioactive acaricidal compound is most effective (86.5 to 89% mortality) when the entire integument of *T. urticae* comes in contact with it compared to contact of the ventral side only (26.5–34%). Against *P. persimilis*

Sibel and Irfan (2017). Found that all of the acaricides used in the study showed high levels of toxic effect on *N. californicus* and *P. persimilis* adults. Papatya Tiftikçi *et al*. (2020). *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseidae) at release ratios of 1:10, 1:20 and 1:40 predator:prey were evaluated to reveal its potential for biological control of two spotted spider mites [*Tetranychus urticae* Koch (Acari: Tetranychidae)].

Field studies

Effect of tested compounds on motile stages of *p. presimilis* on soybean plant in the field.

Tables 4 and 5 show that abamectin was the most effective compound in reducing the population density of motile stages of the mite, *T. urticae*, with (72.16 % and 75.76%) in the first and second seasons followed by biofly (61.82% and 69.83%) in two seasons but garlic oil was the least effective compound in reducing the population density of motile stages of *p. presimilis* with (34.64 % and 35.31 %) in the first and second seasons

Table 5: Effect of tested compounds on motile stages of *p. presimilis* on soybean plant in the field.

Compounds	No. of *p. presimilis* before treatment	No.of *p. presimilis* after treatment (weeks) of			
		1st week	2nd weeck	3rd weeck	4th weeck
Season 2020					
Abamectin	165.60	22.68	30.43	38.75	52.57
Biofly	153.65	29.33	37.46	48.35	68.88
Moringa oil	172.44	48.15	62.49	73.64	98.32
Garlic oil	168.35	74.86	86.74	102.43	117.55
Control	240.5	222.25	198.75	186.33	172.53
Season 2021					
Abamectin	168.77	16.63	24.15	31.55	56.23
Biofly	165.54	23.56	34.64	46.33	68.63
Moringa oil	167.34	41.56	56.58	68.56	96.22
Garlic oil	172.00	61.37	72.55	98.58	122.64
Control	248.22	236.00	207.13	192.77	180.43

Table 6: reduction of tested compounds on motile stages of *p. presimilis* on soybean plant in the field.

Compounds	% reduction				General mean
	1st week	2st weeck	3st weeck	4st weeck	
Season 2020 *T. urticae*					
Abamectin	85.20	77.76	69.81	55,87	72.16
Biofly	79.38	70.50	59.72	37.68	61.82
Moringa oil	69.84	56.15	45.33	20.77	48.01
Garlic oil	51.19	62.34	22.12	2.94	34.64
Season 2021 *T. urticae*					
Abamectin	89.65	82.97	76.07	54.35	75.76
Biofly	85.05	79.07	72.01	43.20	69.83
Moringa oil	73.92	59.76	47.55	21.22	50.61
Garlic oil	62.53	49.80	26.63	2.31	35.31

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