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STORAGE, EVALUATION AND UTILIZATION OF MARJORAM ESSENTIAL OIL (*Origanum majorana* L.) IN CUCUMBER PICKLING.

BY

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ABSTRACT

The essential oil of marjoram (*Origanum majorana* L.) grown in Egypt was extracted by steam distillation. Gas liquid chromatography (GC) analysis for its constituents was carried out. The essential oil was examined for its antimicrobial activities against four strains of fungi, two strains of yeasts and two strains of bacteria. In addition, the effect of storage conditions on physico-chemical properties of the essential oil was investigated. Moreover, the effect of adding different concentrations of the essential oil on improving sensory properties of pickled cucumber was also studied. The data showed that, the marjoram essential oil was rich in linalool (20.98 %), limonene (16.78 %), and β-pinene (12.49 %) *p*-cymene (10.88 %), α-pinene (9.69 %) and 1, 8- cineol (6.84 %). The identified compounds are representing 83.42 % of the total essential oil. Marjoram essential oil totally inhibited *Aspergillus niger, Aspergillus flavus, Fusarium moniliform* and *Penicillium expansum* at concentrations of 300-400 µl /100 ml medium, while it inhibited *Pichia anomala* and *Rhodotorula minuta* at concentrations of 100 and 120 µl / disc, respectively. The minimum inhibitory concentrations were 100 and 160 µl / disc against *Bacillus cereus* and *Escherichia coli*, respectively. The data also showed that, the oil samples stored at room temperature about 30°C had a remarkable effect on the properties of the oil as compared with those samples stored in refrigerator temperature. A sensory testing of pickled cucumber proved that, the addition of marjoram essential oil concentrations (100-160 µl / 100 ml brine solution) gave higher scores for taste, texture, appearance, flavor and color than that of lower concentrations (60 and 80 µl / 100 ml brine solution). On the contrary, the control sample had the lowest scores for most sensory properties.

Key words: Marjoram essential oil, Antimicrobial activities, Physical and chemical properties and pickled cucumber.

INTRODUCTION

The aromatic plant, *Origanum majorana* L., also known as sweet marjoram belongs to mint family (*Lamiaceae*). It grows abundantly in its natural areas, Egypt and North Africa (Furia & Bellanca 1971). The fresh or dried highly

aromatic leaves and flowering tops of marjoram are widely used to flavor many foods. Its essential oil and alcoholic extracts are applied in perfumes, cosmetics, pharmacology medical, clinical microbiology, phytopathology and food preservation (Reineccius, 1994; Circella *et al.*, 1995 and Price, 1995). The composition of the essential oil was found to vary with geographical origins, climatic conditions, stage of plant maturity and degree of the freshness of the plant material analyzed (Circella *et al.*, 1995). Marjoram essential oil possesses antimicrobial properties against food borne bacteria and mycotoxigenic fungi (Baratta *et al.*, 1998; Daferera *et al.*, 2000 and Ezzeddine *et al.*, 2001). However, it is only relatively recently that much attention has been given to its potential application as food preservative.

The aim of this study was to evaluate the chemical composition and antimicrobial activities of *Origanum majorana* L. The effect of storage conditions on physico-chemical properties of marjoram essential oil was investigated. The effect of adding different concentrations of the marjoram essential oil on improving sensory properties of pickled cucumber was also studied.

MATERIALS AND METHODS

Materials

Marjoram (*Origanum majorana* L.) was obtained from the middle region of Egypt (El-Menia), while the cucumber fruits (*Cucumis sativus*) were purchased from the local market in Cairo, Egypt. For the antimicrobial experiments, potato dextrose agar (PDA), yeast and malt extract agar (YM) and nutrient agar were used. Four strains of moulds, *Aspergillus niger* (DSMZ 737), *Aspergillus flavus* (NRRL 500), *Fusarium moniliform* (DSMZ 764) and *Penicillium expansum* (ATCC 2887), two strains of yeasts, *Pichia anomala* (NCY 20) and *Rhodotorula minuta* (DSMZ 70408), and one strain of Gram-negative bacteria, *Escherichia coli* (ATCC 25566) as well as one strain of Gram-positive bacteria, *Bacillus cereus* (DSMZ 345) were obtained from the Egyptian Microbial Culture Collection (EMCC) at the microbiological resources center (Cairo MIRCEN), Faculty of Agriculture, Ain Shams University, Egypt.

Methods

Extraction of marjoram essential oil

Steam distillation for 3 h was used for the isolation of the essential oil from the whole plant of marjoram. The isolated oil was dried with anhydrous sodium sulphate and preserved in a sealed flask at – 20±2°C until the moment of the analysis.

GLC analysis

The chemical composition of the oil was determined using Hewlett-Packard gas chromatography model 6200. The identification of compounds was based on a comparison of their retention times with those authentic samples.

Antimicrobial tests

Antifungal test

The inhibition of mycelial growth of fungi was determined by the disc agar method (Bauer *et al.*, 1996) in the appropriate culture medium (PDA) containing different concentrations of marjoram essential oil (100-500 µl / 100 ml). After incubation for 7 days at 28±1°C for germination, percentage of mycelial growth inhibition was calculated according to the formula of Pandey *et al.* (1982) as follows:

$$\text{Growth inhibition \%} = \frac{dc - dt}{dc} \times 100$$

Where dc: average diameter of fungal colony with control after seven days, dt: average diameter of fungal colony with treatment after seven days, (Five replicates were considered for each treatment).

Antibacterial and antiyeast tests

The effect of marjoram essential oil on the growth of both bacteria and yeast strains was tested by the disc diffusion method (Deans & Ritchie, 1987), marjoram essential oil was applied at different ranges of concentration (20-160 µl / disc). After incubation at 37°C or 30°C for 24 and 48 h for bacterial and yeast strains, respectively, the inhibition zone diameter (mm) of the microbial growth was measured.

Storage conditions of marjoram essential oil

To examine the effect of the storage temperature on the physical and chemical properties of marjoram essential oil, three types of bottles were used: brown glass bottles, colorless glass bottles and aluminum bottles. These containers were completely filled with oil. The samples were divided into two groups, one group was stored at room temperature (30±2°C) and the other group was stored in refrigerator (5±2°C) for 8 months. Specific gravity, refractive index, optical rotation, ester number and acid number were determined according to the method described by Guenther (1961).

Preparation of pickled cucumber

Pickled cucumber was prepared according to the method described by Moussa (1997), where fermentation was carried out at room temperature (30±2°C) for 2 weeks. After fermentation period, cucumber fruits were repacked in packaging brine solution which consists of 7% sodium chloride, 0.3% calcium chloride, 3% acetic acid and marjoram essential oil was added at different ranges of concentration (60-160 µl / 100 ml packaging brine). A control treatment was placed into brine without the addition of marjoram essential oil. Pickled cucumber was stored for 3 months at 30±2°C.

Sensory evaluation

Color, flavor, appearance, texture and taste of pickled cucumber were sensory evaluated by 10 panelists. The score of the sensory criterion of the sample was 10

Statistical analysis

All data obtained of both antimicrobial and pickled cucumber were exposed to the proper analysis of variance of completely randomized design and differentiation between means was assessed by Duncan's test at $P > 0.01$ using the SAS statistical program (SAS, 1996).

RESULTS AND DISCUSSION

Major oil composition

Data in Table (1) showed that marjoram essential oil has 15 compounds, 10 of them were identified and representing (83.49%) of the total essential oil. Marjoram essential oil was rich in linalool (20.98%), limonene (16.78%), β-pinene (12.49%), *p*-cymene (10.88%), α-pinene (9.69%) and 1, 8-cineol (6.84%). The essential oil also contained smaller quantities of terpinene-4-ol (1.92%), linalyl acetate (1.82%), α- terpinene (1.03%) and eugenol (0.99%). These results are in agreement with those of Omer *et al.* (1997) who reported that the major compounds of the essential oil of sweet marjoram (*Majorana hortensis*), grown in Egypt, were d- limonene (14.40%), β- pinene (11.58%), *p*-cymene (5.69%). On the other hand, Vera and Chane-Ming (1999) reported that the essential oil of marjoram was found to be rich in terpinene-4-ol (38.4%), cis-sabinene hydrate (15.0%). *p*-cymene (7.0%) and γ-terpinene (6.9%).

Table (1): Percentage composition of marjoram essential oil compounds.

No. peaks	Compounds	RT	%	Type
1	Unknown	2.99	2.70	-
2	α-pinene	4.02	9.69	M
3	Unknown	4.53	0.42	-
4	β-pinene	5.29	12.49	M
5	Unknown	5.80	8.54	-
6	Limonene	6.92	16.78	M
7	1,8-cineol	8.03	6.84	LOC
8	*p*-cymene	10.00	10.88	M
9	α-terpinene	10.99	1.03	M
10	Unknown	12.28	0.92	-
11	Linalool	14.61	20.98	LOC
12	Unknown	15.44	3.99	-
13	Terpinene-4-ol	17.19	1.92	LOC
14	Linalyl acetate	23.41	1.82	M
15	Eugenol	25.47	0.99	LOC

RT, retention time measured on BPX5 capillary column, M, momoterpinene hydrocarbon; LOC, light oxygenated compound.

Antimicrobial activity of marjoram essential oil

Antifungal activity

Marjoram essential oil inhibited the growth of *Aspergillus niger*, *Aspergillus flavus*, *Fusarium moniliform*, *Penicillium expansum*, *Pichia anomala*

and *Rhodotorula minuta*. The minimum inhibitory concentrations (MICs) varied from (300 µl / 100 ml) for *A. niger* and *P. expansum* to (350 µl / 100 ml) for *F.moniliform*, while MIC value for *A. flavus* was found to be (400 µl / 100 ml) as shown in Table (2) and figure (1).

Table (2): Percentage of inhibition of growth of the mycelium by marjoram essential oil at different concentrations in the culture medium against fungal strains.

Fungal strains	µl of marjoram oil / 100 ml medium								
	100	150	200	250	300	350	400	450	500
A. niger	6.4 Aa	14.9 Ab	19.1 Ac	25.5 Ad	100* Be	100 Be	100 Ae	100 Ae	100 Ae
A. flavus	27.7 Ca	29.2 Ba	33.7 Bb	70.0 Bc	76.1 Ad	82.8 Ae	100* Af	100 Af	100 Af
F. moniliform	19.4 Ba	35.5 Cb	58.1 Cc	77.4 Cd	79.0 Ad	100* Bf	100 Af	100 Af	100 Af
P. expansum	22.5 Ba	55.0 Db	67.5 Dc	69.0 Bc	100* Be	100 Be	100 Ae	100 Ae	100 Ae

* Minimum inhibitory concentration (MIC).
Means of 5 replicates having same capital letters in same column and small letters in Same row are not differ significantly (P>0.01).

Table (3) revealed that marjoram essential oil inhibited the growth of *pichia anomala* and *Rhodotororula minuta* with diameters of inhibition zones 29.25 and 28.3 (mm), respectively, at 20 µl oil / disc. While at concentrations of 100 and 120 µl oil / disc, the growth of *Pichia anomala* and *Rhodotorula minuta* were completely inhibited, respectively, as seen in Figure (2). These results are in accordance with the findings of Charai *et al.* (1996) and Omer *et al.* (1997). As well as Daferera *et al.* (2000) who mentioned that the radial growth, conidial germination and production of *Penicillium digitatum* were inhibited completely by marjoram essential oil at relatively low concentration, while Daferera *et al.* (2003) found that marjoram oil inhibited *Fusarium* sp. at 300 µg / ml.

Table (3): Zones of growth inhibition (mm) showing by activity of marjoram essential oil at different concentrations in the culture medium against yeast strains.

Yeast strains	µl of marjoram oil/ disc of 13 mm diameter							
	20	40	60	80	100	120	140	160
Pichia anomala	29.25 Aa	33.5 Aab	42.0 Ab	72.0 Bc	90.0* Bd	90.0 Ad	90.0 Ad	90.0 Ad
Rhodotorula minuta	28.3 Aa	36.5 Aa	48.5 Ab	62.5 Ac	73.8 Ad	90.0* Ae	90.0 Ae	90.0 Ae

* Minimum inhibitory concentration (MIC).
Means of 5 replicates having same capital letters in same column and small letters in same row are not differ significantly (P>0.01).

Antibacterial activity:

The inhibition zone diameters (mm) produced by marjoram essential oil are shown in Table (4) and Figure (3). From these data it could be seen that the essential oil inhibited the growth of *B. cereus* and *E.coli*. Furthermore, at concentrations of 100 and 160 µl oil / disc, the growth of *B. cereus* and *E. coli* was completely inhibited, respectively. These results are in agreement with those of Abdallah (2000) who stated that the marjoram essential oil was highly active against both Gram-positive and Gram-negative bacteria.

Table (4): Zones of growth inhibition (mm) showing by the antibacterial activity of marjoram essential oil at different concentrations in the culture medium against bacterial strains.

Bacterial strains	µl of marjoram oil / disc of 13 mm diameter							
	20	40	60	80	100	120	140	160
B. cereus	32.0 Aa	45.2 Ab	50.0 Abc	53.0 Ac	90.0* Ad	90.0 Ad	90.0 Ad	90.0 Ad
E. coli	30.0 Aa	43.3 Ab	49.0 Abc	50.0 Abc	58.0 Bcd	60.0 Bde	72.0 Be	90.0* Af

* Minimum inhibitory concentration (MIC).

Means of 5 replicates having same capital letters in same column and small letters in same row are not differ significantly (P>0.01).

The antimicrobial activity of marjoram oil could be referred to the action of phenolic compounds of the oil on cellular membrane, destroying its permeability, releasing intracellular constituents and causing membrane malfunction in respect to electron transport, nutrients uptake, nucleic acid synthesis and ATP ase activity (Skandamis *et al.*, 1999 and Fisher, 2002).

Physico-chemical properties of marjoram essential oil during storage

Physical properties

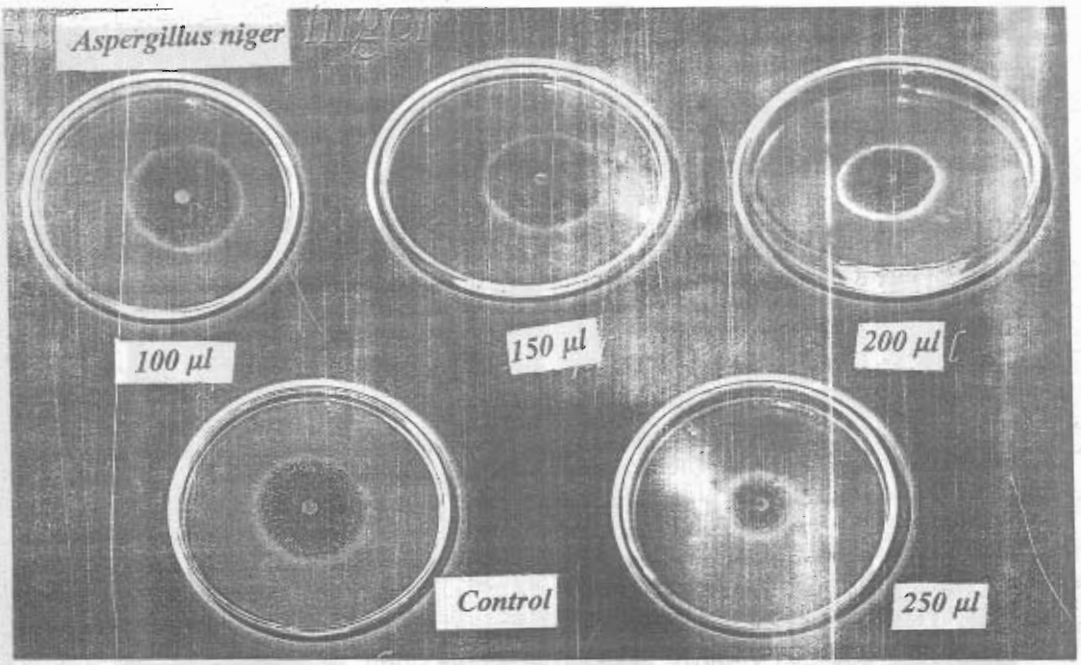
Specific gravity

Data in Table (5) showed very slight increases in specific gravity. Changes in the specific gravity of marjoram essential oil during storage in three types of containers were found to be in a sequence: aluminum bottles › colorless glass bottles › brown glass bottles. The same trend was also found with samples stored in refrigerator.

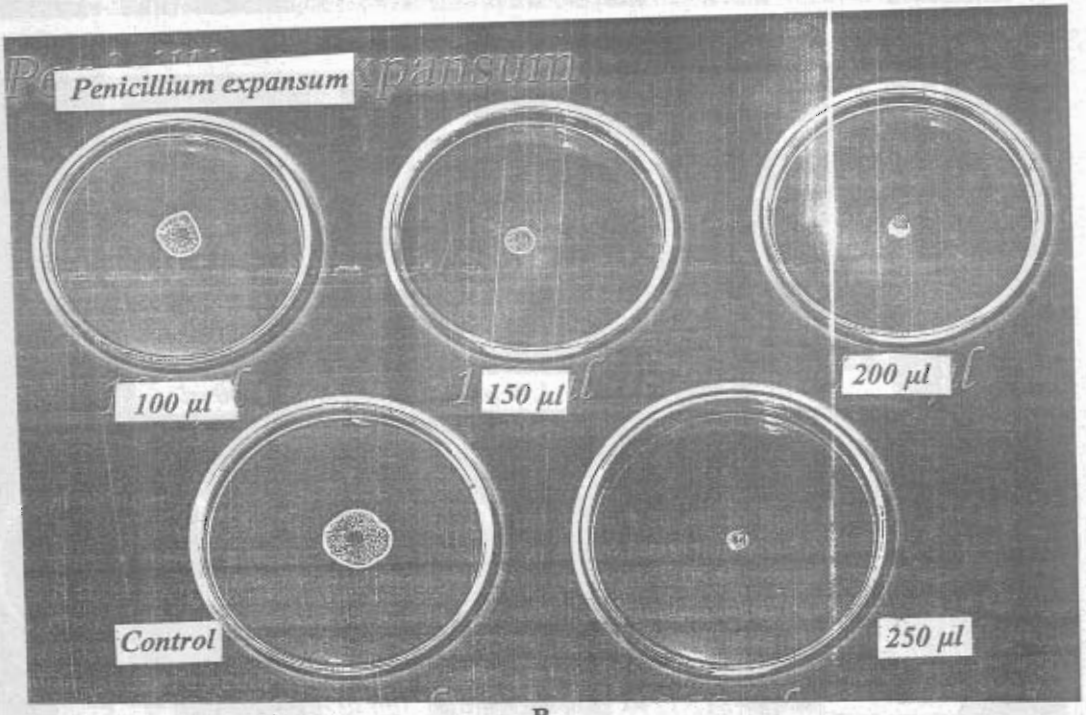
These data are in agreement with Maneva *et al.* (1985) who mentioned that the changes in the physico-chemical properties of Lavender oil were more pronounced when the samples kept in metal containers and added that glass containers were more suitable for the preservation of oil.

Refractive index

The refractive index increased after 8 months of storage at room temperature from 1.4750 to 1.4760 with the sample stored in brown glass bottles, while the oil sample in aluminum bottles had the highest increase in refractive index. However, the storage in refrigerator improved the changes in the refractive index through 8 months of storage from 1.4750 at zero time to 1.4758 as compared with values of refractive index at room temperature as shown in Table (6).

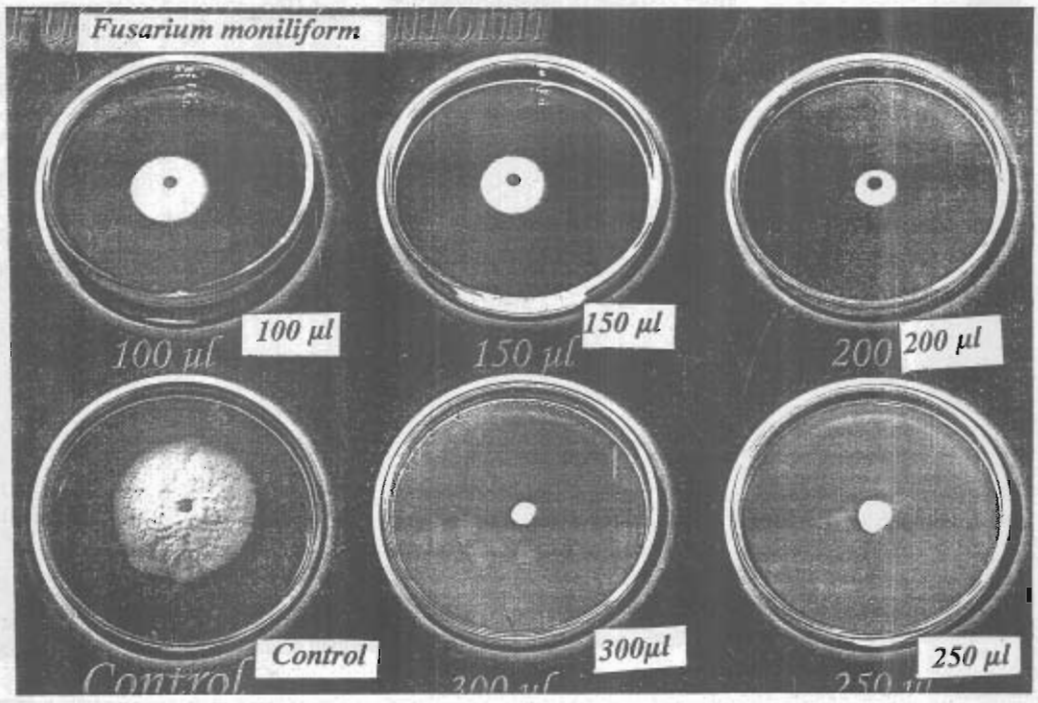


A

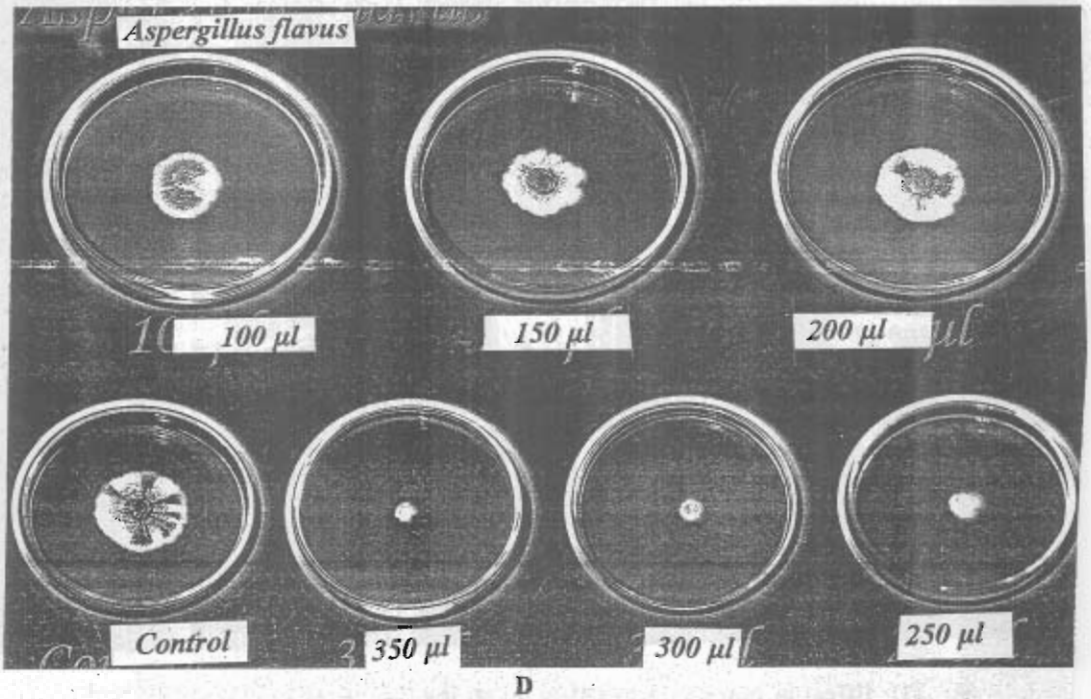


B

Fig. (1): Effect of marjoram essential oil on the inhibition of fungi growth at different concentrations, A: *Aspergillus niger* and B: *Penicillium expansum*.



C



D

Fig. (1 Cont.): Effect of marjoram essential oil on the inhibition of fungi growth at different concentrations, C: *Fusarium moniliform* and D.: *Aspergillus flavus*.

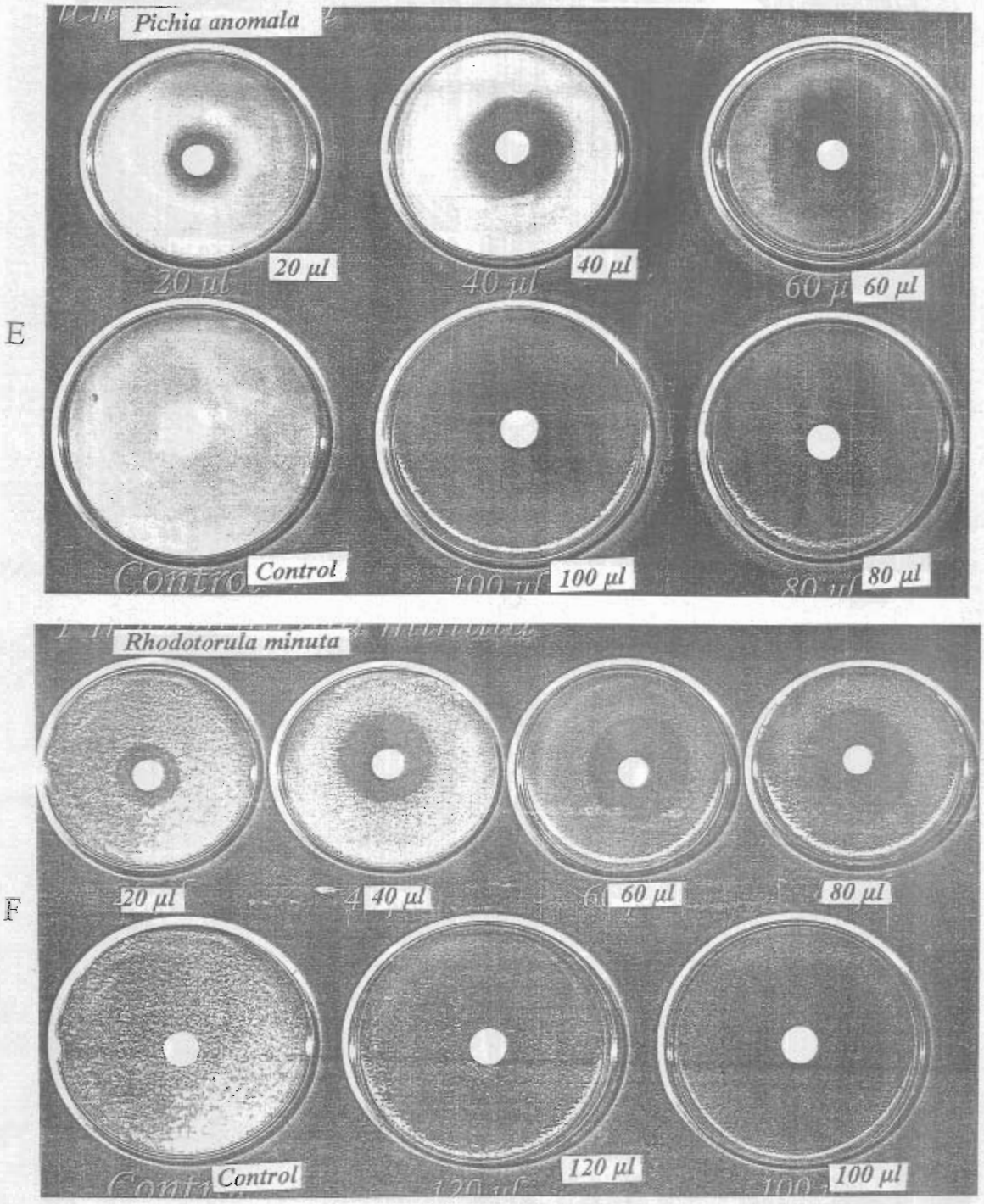
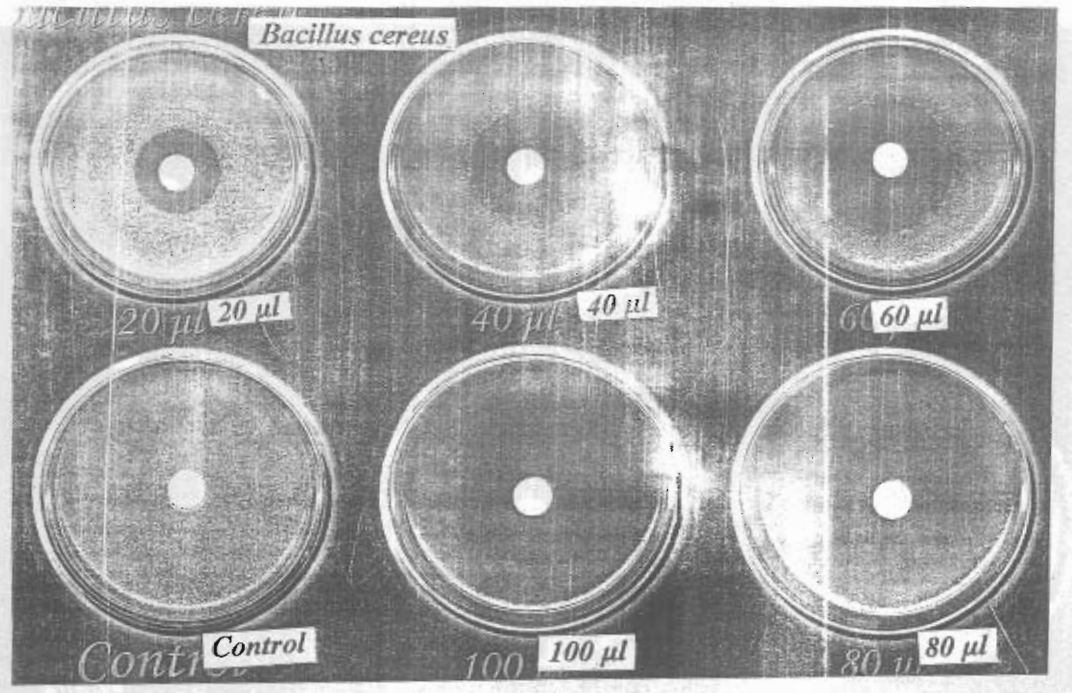
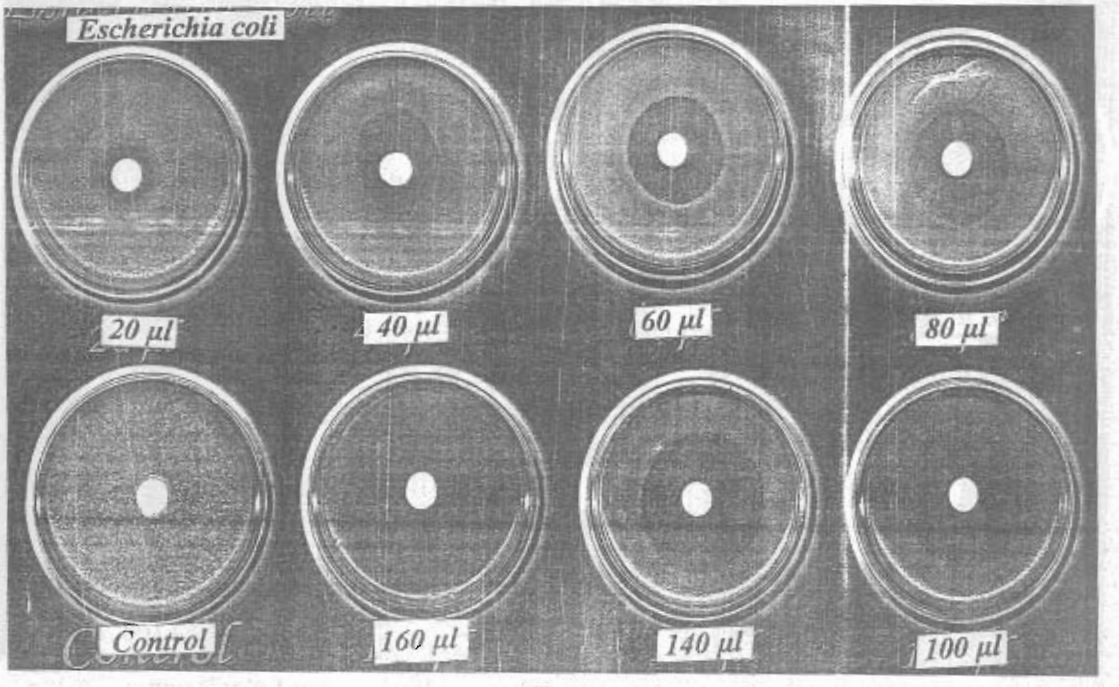


Fig. (2): Zones of growth inhibition (mm) showing by activity of marjoram essential oil at different concentrations in the culture medium µl / disc against yeast strains, E: *Pichia anomala* and F: *Rhodotorula minuta*.



G



H

Fig. (3): Effect of marjoram essential oil on growth inhibition of *Bacillus cereus* (G) and *Escherichia coli* (H) at different concentrations.

Table (5): Effect of storage period, storage temperature and type of container on specific gravity of marjoram essential oil.

Storage temperature	Room temperature (30 ±2°C)			Refrigerator temperature (5 ±2°C)		
Type of containers / Storage period (month)	A*	B	C	A	B	C
Zero	0.8938	0.8938	0.8938	0.8938	0.8938	0.8938
2	0.8955	0.8961	0.8965	0.8967	0.8942	0.8960
4	0.8955	0.8969	0.8967	0.8972	0.8964	0.9000
6	0.8959	0.8979	0.8999	0.8983	0.8967	0.9017
8	0.8978	0.8986	0.9098	0.8980	0.8980	0.9027

* A: brown bottles, B: colorless bottles, C: aluminum bottles.

Oda (1982) found that the geranium and cumin oils, which were stored in glass containers, were well preserved and there were no major changes took place in the refractive index, optical rotation and ester number, while storage in aluminum containers caused partial hydrolysis of esters.

Table (6): Effect of storage period, storage temperature and type of container on refractive index of marjoram essential oil.

Storage temperature	Room temperature (30 ±2°C)			Refrigerator temperature (5 ±2°C)		
Type of containers / Storage period (month)	A*	B	C	A	B	C
Zero	1.4750	1.4750	1.4750	1.4750	1.4750	1.4750
2	1.4751	1.4752	1.4754	1.4750	1.4750	1.4760
4	1.4752	1.4758	1.4760	1.4751	1.4752	1.4766
6	1.4758	1.4760	1.4765	1.4755	1.4755	1.4770
8	1.4760	1.4765	1.4770	1.4758	1.4759	1.4778

* A: brown bottles, B: colorless bottles, C: aluminum bottles.

Optical rotation

Data in Table (7) revealed that values of optical rotation were constantly decreased during the storage period at room and refrigerator temperatures. The changes in optical rotation were more pronounced in the oil samples which were stored in aluminum containers than in brown glass containers. The decrease in optical rotation might be due to that the essential oil lost some of its optically active constituents during the extended period. The obtained values were within the cited data by Refaat *et al.* (1990), similar results were obtained by Oda (1982).

Chemical properties

Ester number

There was a great and rapid decrease in the ester number of the oil samples which were stored at room temperature. On the other hand, the ester number of marjoram oil during storage in refrigerator was somewhat stable. The

highest decrease in the ester number was found at the end of the experiment (6.2, 6.0 and 3.2) for the oil samples stored in brown glass bottles, colorless bottles and aluminum bottles, respectively, (Table 8). Abou El-Fotouh (1977) confirmed the destruction of ester constituents of lemongrass and cumin seed oils during storage under similar conditions.

Table (7): Effect of storage period, storage temperature and type of container on optical rotation of marjoram essential oil.

Storage temperature	Room temperature (30 ±2°C)			Refrigerator temperature (5 ±2°C)		
Type of containers / Storage period (month)	A*	B	C	A	B	C
Zero	21°7`	21°7`	21°7`	21°7`	21°7`	21°7`
2	21°7`	21°6`	21°4`	21°3`	21°6`	21°6`
4	21°1`	21°1`	20°8`	21°7`	21°6`	21°5`
6	20°9`	20°7`	19°1`	21°5`	21°3`	21°5`
8	20°1`	20°3`	17°8`	21°3`	21°1`	21°1`

* A: brown bottles, B: colorless bottles, C: aluminum bottles.

Table (8): Effect of storage period, storage temperature and type of container on ester number of marjoram essential oil.

Storage temperature	Room temperature (30 ±2°C)			Refrigerator temperature (5 ±2°C)		
Type of containers / Storage period (month)	A*	B	C	A	B	C
Zero	13.7	13.7	13.7	13.7	13.7	13.7
2	12.6	8.4	5.7	13.6	13.7	13.3
4	7.1	7.3	4.8	13.6	13.6	13.3
6	6.7	6.8	3.9	13.6	13.5	13.2
8	6.2	6.0	3.2	13.5	13.5	13.0

* A: brown bottles, B: colorless bottles, C: aluminum bottles.

Acid number

The data also indicated that there was continuous increase in the acid number of the oil samples which were stored at room temperature for 8 months than those stored in refrigerator temperature. The acid number was 0.3 at the beginning of the experiment while was increased after 8 months of storage to 1.90 as shown in Table (9).This might be due to the partial hydrolysis of oil samples during storage at room temperature.

Organoleptic evaluation of pickled cucumber

The scores of sensory properties of pickled cucumber are shown in Tables (10, 11, 12, 13 and 14). It was found that, pickled cucumber contained high concentrations of marjoram oil (100-160 µl / 100 ml brine solution) gave

higher scores for taste, texture, appearance, flavor and color than that of the lower concentrations (60-80 µl oil / 100 ml). The control sample (without addition of marjoram oil) had the lowest values for most sensory properties.

Table (9): Effect of storage period, storage temperature and type of container on acid number of marjoram essential oil.

Storage temperature	Room temperature (30 ±2°C)			Refrigerator temperature (5 ±2°C)		
Type of containers / Storage period (month)	A*	B	C	A	B	C
Zero	0.30	0.30	0.30	0.30	0.30	0.30
2	0.30	0.30	0.30	0.30	0.35	0.36
4	0.37	0.46	0.96	0.40	0.36	0.36
6	0.40	0.53	1.30	0.40	0.36	0.67
8	0.60	0.60	1.90	0.40	0.40	0.72

* A: brown bottles, B: colorless bottles, C: aluminum bottles.

Table (10): Effect of marjoram essential oil concentrations on taste of pickled cucumber during storage at room temperature.

Storage Period (weeks)	µl marjoram oil /100 ml brine solution						
	0	60	80	100	120	140	160
*Zero	9.0Ba	9.0Ba	9.0Ba	9.0Aa	9.0Ba	9.0Ea	9.0Ca
1	8.7Bc	8.2Bbc	8.1Bbc	8.3Abc	7.5Aab	7.0Aab	6.8Aa
2	8.7Ba	8.2Ba	8.0Ba	8.5Aa	8.0ABa	7.5ABa	7.5ABa
4	8.5Ba	8.1ABa	8.0Ba	8.5Aa	8.5ABa	7.9ABa	7.9ABa
6	8.2Ba	8.0ABa	8.0Ba	8.8Aa	8.9Ba	8.2ABa	8.3BCa
8	7.5Aa	7.8ABab	7.9ABab	8.8Ab	9.0Bb	8.8Eb	8.9Cb
10	7.2Aa	7.5ABa	7.5ABa	9.2Ab	9.0Bb	9.0Bb	9.0Cb
12	6.9Aa	7.2Aa	7.0Aa	9.5Ab	9.0Bb	9.0Bb	9.0Cb

* Zero: the beginning of storage period.
Means of 10 panelists having same capital letters in same column and small letters in same row are not differ significantly (P>0.01).

This may be due to the growth of undesirable yeasts and molds which able to produce cellulolytic and pectinolytic enzymes and caused softening and mushy in texture as mentioned by Vaughn (1985). These results are in harmony with that found by Stamer (1988) who reported that, the growth of *Rhodotorula* sp. and *Saccharomyces* sp.have been shown to degrade the texture of pickles by an active extracellular polygalacturonase enzyme system and caused softening and bloater defect. Storage of pickled cucumber contained 60 and 80 µl oil / 100 ml brine for 12 weeks recorded less scores than of pickled samples contained 100-160 µl oil / 100 ml brine. Generally, addition of different levels of marjoram oil (100-160 µl) into the brine solution improved sensory scores of pickled cucumber stored for 12 weeks as compared with other samples.

Table (11): Effect of marjoram essential oil concentrations on texture of pickled cucumber during storage at room temperature.

Storage period (weeks)	µl marjoram oil/100 ml brine solution						
	0	60	80	100	120	140	160
*Zero	9.1Ca	9.1Ca	9.1Ca	9.1Aa	9.1Aa	9.1Aa	9.1Aa
1	8.7Ca	8.8BCa	8.9Ca	9.0Aa	9.1Aa	9.1Aa	9.1Aa
2	8.6Ca	8.8Ca	8.8Ca	9.0Aa	9.0Aa	9.0Aa	9.0Aa
4	8.0Ca	8.5BCab	8.5BCab	9.0Ab	9.0Ab	9.0Ab	9.0Ab
6	7.0Ba	8.3Bb	8.1BCb	9.0Ab	9.0Ab	9.0Ab	9.0Ab
8	6.5Aa	7.9ABb	7.9Bb	9.0Ac	9.0Ac	9.0Ac	9.0Ac
10	6.2Aa	7.5ABb	7.5ABb	9.0Ac	9.0Ac	9.0Ac	9.0Ac
12	6.0Aa	6.9Aa	6.8Aa	9.0Ab	9.0Ab	9.0Ab	9.0Ab

Table (12): Effect of marjoram essential oil concentrations on appearance of pickled cucumber during storage at room temperature.

Storage Period (weeks)	µl marjoram oil /100ml brine solution						
	0	60	80	100	120	140	160
*Zero	9.0Da	9.0Ca	9.0Ca	9.0Aa	9.0Aa	9.0Aa	9.0Aa
1	9.0Da	9.0Ca	9.0Ca	9.0Aa	9.0Aa	9.0Aa	9.0Aa
2	8.9CDa	8.9Ca	8.9Ca	9.0Aa	9.0Aa	9.0Aa	9.0Aa
4	8.8CDa	8.8BCa	8.8BCa	9.0Aa	9.0Aa	9.0Aa	9.0Aa
6	8.2CDa	8.5BCa	8.5BCa	9.0Aa	9/0Aa	9.0Aa	9.0Aa
8	8.0Ca	8.0BCa	8.0BCa	9.0Aa	9.0Aa	9.0Aa	9.0Aa
10	7.0Ba	7.8ABa	7.7ABa	9.0Aa	9.0Aa	9.0Aa	9.0Aa
12	6.0Aa	7.0Ab	7.0Ab	9.0Ac	9.0Ac	9.0Ac	9.0Ac

Table (13): Effect of marjoram essential oil concentrations on flavor of pickled cucumber during storage at room temperature.

Storage Period (weeks)	µl marjoram oil/100 ml brine solution						
	0	60	80	100	120	140	160
*Zero	9.0Ca	9.0Da	9.0Da	9.0Aa	9.0Aa	9.0Ba	9.0Ca
1	8.8Cc	8.7Dc	8.7Dc	8.5Ac	7.8Aab	7.5Aa	7.0Aa
2	8.6Cb	8.7Db	8.7Db	8.5Ab	7.9Aab	7.8Aab	7.5ABa
4	8.6Cb	8.5Db	8.5Cb	8.6Ab	7.9Aab	7.9Aab	7.5ABa
6	8.1Ca	8.2CDa	8.2CDa	8.6Aa	8.0Aa	8.0Aa	7.7ABa
8	7.2Ba	7.5BCa	7.6BCab	8.8Ab	8.0Aab	8.0Aab	7.9ABab
10	7.0Ba	7.0Ba	7.2Bab	9.0Ac	8.1Abc	8.0Ab	8.0Bb
12	5.0Aa	6.0Ab	6.0Ab	9.0Ad	8.5Acd	8.0Ac	8.0Bc

* Zero: the beginning of storage period.

Means of 10 panelists having same capital letters in same column and small letters in same row are not differ significantly (P>0.01).

Table (14): Effect of marjoram essential oil concentrations on color of pickled cucumber during storage at room temperature.

Storage Period (weeks)	µl marjoram oil/100 ml brine solution						
	0	60	80	100	120	140	160
*Zero	9.1Ca	9.1Da	9.1Ca	9.1Aa	9.1Aa	9.1Aa	9.1Aa
1	8.5Ca	9.0Da	9.1Ca	9.1Aa	9.0Aa	9.0Aa	9.1Aa
2	8.5Ca	9.0Da	9.1Ca	9.0Aa	9.0Aa	9.0Aa	9.0Aa
4	8.6Ca	8.5CDa	8.7CBa	9.0Aa	9.0Aa	9.0Aa	9.0Aa
6	8.0BCa	8.3BCab	8.5BCab	9.0Ab	9.0Ab	9.0Ab	9.0Ab
8	7.2Ba	8.0BCa	8.0Ba	9.0Ab	9.0Ab	9.0Ab	9.0Ab
10	5.0Aa	7.5ABb	7.8ABb	9.0Ac	9.0Ac	9.0Ac	9.0Ac
12	5.0Aa	7.0Ab	7.2Ab	9.0Ac	9.0Ac	9.0Ac	9.0Ac

* Zero: the beginning of storage period.

Means of 10 panelists having same capital letters in same column and small letters in same row are not differ significantly (P>0.01).

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تخزين و تقييم و الاستفادة من الزيت العطرى لنبات البردقوش فى تخليل الخيار.

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فى هذا البحث تم دراسة التركيب الكيميائى و الخصائص المضادة للميكروبات للزيت العطرى للبردقوش المصرى و كذلك تم دراسة تأثيرظروف التخزين للزيت على الخصائص الفزيوكيميائية بالاضافة إلى تأثيره على الخصائص الحسيه للخيار المخلل. حيث تم إستخلاص الزيت العطرى باستخدام التقطير بالبخار ثم درست المكونات الكيميائية للزيت باستخدام تقنية كروماتوجرافيا الغاز.

وقد أظهرت نتائج التحليل الكروماتوجرافى أن الزيت العطرى غنى فى محتواه من :(linalool ٢٠,٩٨%) و limonene (١٦,٧٨) و β-pinene(١٢,٤٩%) و *p*-cymene (١٠,٨٨%) و α-pinene (٩,٦٩%) و 1,8-cineol (٦,٨٤%) حيث تمثل هذه المركبات ٨٣,٤٢% من إجمالي كمية الزيت.

و قد اظهرت الدراسة الميكروبية أن زيت البردقوش احدث تثبيط كلى للفطريات موضع الدراسة فى حدود التركيزات التى تتراوح بين ٣٠٠- ٤٠٠ ميكروليتر/ ١٠٠ ملليلتر بينه ، فى حين أنه ثبط الخمائر *Rhodotorula minuta*, *Pichia anomala* فى حدود التركيزات ١٠٠ ، ١٢٠ ميكروليتر / قرص على الترتيب. و كان اقل تركيز مثبط للبكتريا موضع الدراسة كالأتى : ١٠٠ ميكروليتر / قرص لبكتريا *B.cereus* و ١٦٠ ميكروليتر / قرص لبكتريا *E. coli*.

وقد اظهرت النتائج ايضا أن عينات الزيت المخزنه على درجة حرارة الغرفة تصاحبها تغيرات ملحوظة فى خواص الزيت مقارنة بتلك العينات المخزنة على درجة حرارة المبرد. وقد اوضحت نتائج التحكيم الحسى للخيار المخلل ان استخدام التركيزات المرتفعة التى تتراوح من ١٠٠ إلى ١٦٠ ميكروليتر لزيت البردقوش سجلت اعلى قيم فى الصفات الحسية للخيار المخلل والتى تشمل (الطعم ، القوام ، المظهر العام ، النكهه ، اللون) مقارنة بتلك العينات التى تحتوى على تركيزات منخفضة (٦٠ – ٨٠ ميكروليتر / ١٠٠ ملليلتر محلول تخليل) ، وعلى العكس من ذلك فإن عينة الكونترول سجلت اقل القيم لمعظم الصفات الحسية.