Preparation Of Edible Coating Incorporated With Lemon Balm (Melissa Officinalis L.) For Extending Shelf Life Of Tofu

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Abstract: Fresh tofu samples were prepared and immersed in different solutions containing gelatin (1 and 2%) and Melissa officinalis L. oil (0.1, 0.3 and 0.5%) as antimicrobial activity. The samples stored up to 14 days under cooling conditions (4˚C). Melissa officinalis L. oil was chemically and microbiologically analyzed. Rheological properties and thixotropic effect were determined. The results indicated that blends of gelatin and Melssa officinalis L. oil exhibited dilatant flow behavior and all samples showed thixotropic effect. The effect of edible coating on weight loss, moisture content, texture properties, microbiological tests, and sensory evaluation of tofu samples were determined during storage period as an indication for shelf life and quality of tofu samples.

Keywords: antimicrobial activity, edible coating, Melissa oil, microbiological test, rheological properties, texture properties, tofu

1. INTRODUCTION

Tofu is the most well-known and common soya food, it has been consumed for may be 2000 years, in Asia, it has been consumed for may be 2000 years, in Asia, it has become well-known and respected in much of the world during the last twenty years, it is similar to existing dairy milk cheese products such as paneer, peynir in India and Turkey, and is processed in the same way, it provides an excellent soy protein alternative to many traditional foods. Edible coating was used to extend shelf-life of food products and act as selective barriers to oxygen uptake, moisture transfer, lipid oxidation, losses of volatile aromas and flavors [1] Essential oil has high hydrophobicity, but can diffuse, dissolve and permeate into the most common polymers [2]. Therefore, application of essential oils can have great potential in polymer systems. The application of edible coating incorporated with essential oil on tofu and strawberry was found to be effective in delaying the microbial degradation of tofu and strawberry with minimum inhibition concentration which will be incorporated with edible coating agent was (0.6%) lemon peel essential oil for tofu and (1%) lemon peel essential oil for strawberry [3]. Incorporating antimicrobial compounds into edible films or coatings provides a novel way to improve the quality and shelf-life of ready-to-eat foods [4].
We still need new methods of reducing or eliminating food spoilage and food-borne pathogens, possibly in combination with the existing approaches [5].

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The demand for non-toxic, natural preservatives has been rising with increased awareness and reports of ill effects of synthetic chemicals present in food. Furthermore, emergence of food-borne pathogens has lately become a major public health concern [6] Melissa officinalis L. oil is a perennial edible herb native to the Mediterranean region. The plant is cultivated in various parts of the world and grows especially in western Asia, south-western Serbia and North Africa. It is considered as an important medicinal plant largely used in traditional medicine, for the treatment of headaches, indigestion, colic, nervousness, cardiac failure and depression [7] Melissa Officinalis L. oil possesses antibacterial properties and has the potent antibacterial properties against some representative food-borne pathogens. Therefore, they could be used as possible food antimicrobial preservative in food industry, but the in vivo studies should be done to evaluate the probable adverse effect on food sensory properties [8]. Romeo et al., (2008) reported that Melissa officinalis L. oil showed antibacterial effect against Staphylococcus aureus, Bacillus cereus, Bacillus subtilis, Bacillus pumilis, Pseudomonas aeruginosa, Salmonella poona, Eschrichia coli and Listeria innocua. However, lemon balm oil activity against fungi Fusariumoxy, sporumalbedinis, F. oxyxporumlini, Mucorramannianus, was also found. Melissa Officinalis L. is a safe plant if used in concentrations of 500 – 600 mg without any pathological symptoms and has many uses in the industry such as medicine, perfume, cosmetic, and food [9], [10] The aim of the work is to extend shelf life of tofu during storage under cooling conditions (4˚C) by using gelatin as edible coating incorporated with Melissa officinalis L. oil as antimicrobial agent.

2 MATERIAL AND METHODS

2.1 Material

Tofu were prepared at food research Institute, ARC, (soybean factory), Gelatin and glycerol was purchased from Achmetic company.

2.2 Methods

2.2.1 Extraction of Melissa officinalis L.

The leaves of Melissa officinalis L. oil was extracted using water steam distillation according to Akdag and Qzturk [11]

2.2.2 Chemical composition of Melissa officinalis L. oil:
The essential oil of Melissa officinalis L. oil was analyzed for their components using gas chromatography–mass spectrometry analysis (GC-MS) according to the method outlined by Fan et al., [12].

2.2.3. Preparation of tofu samples
Tofu samples were coated with different solutions of gelatin (1 and 2%) with addition of different concentrations of Melissa officinalis L. oil (0.1, 0.3 and 0.5%) then stored up to 14 days in refrigerator. The analyses were done every two days for coated and uncoated samples. All tests were done in duplicate. The tofu samples were divided to 8 batches. As seen in table (1) every batch was dipped in the corresponding edible coating.

TABLE (1)
EDIBLE COATING SOLUTIONS

Sample	Coating solution composition
C	Uncoated samples
1M	1% gelatin +0.1 Melissa oil
2M	1% gelatin +0.3 Melissa oil
3M	1% gelatin +0.5 Melissa oil
4M	2% gelatin +0.1 Melissa oil
5M	2% gelatin +0.3 Melissa oil
6M	2% gelatin +0.5 Melissa oil

2.2.4 Weight loss
Weight loss was determined by individually cheese weighing with analytical balance at the beginning and during the storage period. The percentage of the relative weight loss (ΔW) was calculated based on the following equation (1), according to Marta, [13]

$$\Delta W\% = \frac{I_{wo} - F_{wi}}{I_{wo}} \qquad (1)$$

Where, Iwo is the initial cheese weight and Fwi is the final cheese weight at time, i.

2.2.5 Moisture content
The initial moisture content of fresh tofu samples before drying was determined according to A.O.A.C [14]

2.2.6 Texture properties
Coated and Uncoated Tofu Texture properties were determined using model (FTC, Food Technology Corporation TMS-Pro, strling,Virginia, USA) to perform textural analysis.

2.2.7 Rheological properties of different blends
The rheological properties of prepared edible coatings were studied to investigate the flow behavior of blends which is important factor for food coating materials. Rheological parameters (Shear stress, Shear rate and viscosity) of different concentrations of gelatin (1 and 2%) with the addition of different concentrations of Melissa officinalis L. (0.1, 0.3 and 0.5%) were determined. The viscosity, shear rate and shear stress were measured using Brookfield Engineering (labs DV-III Ultra Rheometer), the blends were placed in a small sample adapter, the viscometer was operated between10 and 100 rpm, the data were obtained directly from the instrument. SC4-21 spindle was selected for the measurement [15].

2.2.8 Microbiological analysis
Tofu samples were analyzed for total aerobic plate counts, yeast and molds, coliforms, and coagulase-positive staphylococci according to procedures outlined in the Compendium of methods for the Microbiological Examination of Foods with some modifications [16]. Briefly, tofu (5g) was mixed with 45mL of 0.1% peptone water (10−1 dilution) and serially diluted up to 10−10 dilutions with peptone water (0.1%). From these, appropriate dilutions were used for plating. Total bacterial count: One milliliter from each dilution was pour plated in duplicate on plate count agar and incubated at 37◦C for 48 h. Psychrophilic bacteria: Psychrophilic bacteria were determined as recommended by A.P.H.A. and Difco, [17], [18] Yeasts and molds: The determination of yeasts and molds counts was carried out using malt agar medium according to the methods outlined by Difco Manual, [18] Coliform group: Coliform group was determined using MacConkey agar medium [18] Staphylococci: determined as recommended by Difco, [18]

2.2.9 Assessment of antimicrobial activity of gelatin incorporated with Melissa oil
Antimicrobial activity of Melissa officinalis L. oil concentration (0.1, 0.3 and 0.5%) with gelatin (1 and 2%) samples was determined using six pathogenic bacterial strains, two pathogenic fungal strains and one pathogenic yeast strain. Microbial suspensions were prepared in sterile saline 0.9% and adjusted as inoculum to a final concentration of 1.0 x 108 cfu/ mL. Disc diffusion method was used and, the plates were incubated at 37˚C overnight for bacteria at 28˚C for 3 days for fungi. The inhibition zones were recorded in mm for replicates that were prepared for each treatment, [19]

2.2.10 Sensory evaluation
Tofu samples coated with different concentration of gelatin and the addition of Melissa officinalis L. oil were evaluated for their sensory characteristics i.e. color, texture, flavor, odor, shape and overall acceptability according to the method of Idowu, [20].

3 RESULTS AND DISCUSSION
Melissa officinalis L. oil was analyzed for its components, the principal components of the essential oil was presented in Table (2). Eighteen components were identified, represented 98.11% of the total oil. The results indicated that the major components were 6-octenal, 3,7-dimethyl-, R (17.55%) followed by limonene oxide (15.69%), geranyl acetate (15.25%), trans-rose oxide (15.01%), isopulegone (8.73%), linalool oxide (8.2%), (Z)2,6-Octadien-1-ol, 3,7-dimethyl, (5.34%) and myrtenol (3.19%). Some researches differs among them in the composition and proportions of the essential components of essential oil extracted from the leaves of Melissa as a result of several considerations, including the location of the oil in the plant, the agricultural area, weather factors and the method of extracting the essential oil, [21].

TABLE (2)
CHEMICAL COMPOSITION OF MELISSA OFFICINALIS L.

Peak	components	RT, (min)	RA, (%)
1	Beta-Pinene	9.143	0.33
2	Benzene, methyl(1-methylethyl)	10.629	0.76
3	D-Limonene	12.413	0.25
4	Linalool oxide (2)	12.605	8.2
5	1,6-Octadien-3-ol, 3,7-dimethyl	14.197	1.41
6	Cyclohexanol,5-methyl-2-(1-methylethenyl)-	14.779	0.97
7	6-Octenal, 3,7-dimethyl-, (R)	15.421	17.55
8	Levomenthol	16.843	0.88
9	Beta-Citronellol	17.099	1.55
10	(Z) 2,6-Octadienal, 3,7-dimethyl	17.198	1.29
11	Citral	17.536	1.48
12	(Z) 2,6-Octadien-1-ol, 3,7-dimethyl	17.921	5.34
13	Cis- verbenol	18.516	0.23
14	Myrtenol	18.924	3.19
15	Geranyl acetate	20.095	15.25
16	Isopulegone	20.369	8.73
17	Limonene oxide	21.092	15.69
18	Trans-rose oxide	21.471	15.01
Total %			98.11

RT(min)=retention time, RA=peak area relative to the total peak area

3.1 Rheological properties of Samples

Rheological properties of different samples coated by gelatin (1 and 2%) with the addition of different concentrations of Melissa officinalis L. oil (0.1, 0.3 and 0.5%) were determined using Brookfield rheometer DVIII Ultra. Figure (1) showed that the blend of gelatin with the Melissa officinalis L. oil exhibited dilatant fluid as apparent viscosity increased with increasing shear rate (n>1). The power law model (equation 1) was applied in order to describe the flow behavior of different coating solutions at the tofu cheese surfaces by determining the consistency index (k) and the power law factor (n), according to the following equation (2):

$$\tau = k\gamma^{n} \qquad (2)$$

Where, τ is the shear stress Pa, γ. is the shear rate 1/sec, K is the consistency coefficient, n is the flow behavior index. High values of consistency index were obtained for 2% gelatin with the addition of 0.3% Melissa oil coating solutions (0.1993) against 0.004 as the lowest value for 1% gelatin with the addition of 0.3% Melissa officinalis L. oil as shown in table (3). The power law factor dilatant flow behavior (n > 1) was observed for all the coating solutions, and the dilatant behavior decreased for samples with 2% gelatin with the addition of 0.3 and 0.5% Melissa oil. According to these findings it was possible to predict that during coating application, more viscous solutions would exhibit higher adherence to cheese surfaces than the less viscous ones, which could result in very distinct coating thickness among cheeses if a dipping process is used.

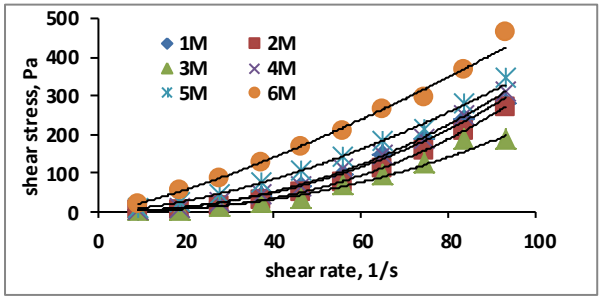

Fig. 1*. Shear rate-shear stress relation for gelatin blend with Melissa oil*

TABLE (3)
POWER LAW PARAMETERS

Treatments	k	n
1M	0.0182	2.1372
2M	0.004	2.4543
3M	0.0097	2.1871
4M	0.0176	2.1574
5M	0.1993	1.6343
6M	0.0516	1.3241

3.1.1 Thixotropic effect

Thixotropic or “hysteresis” loops were obtained for the tested coating samples. Thixotropy is a shear thinning time dependent property exhibited by some fluids when shaken, stirred or agitated; the longer the fluid is subjected to shear stress the lower its viscosity. A fluid is said to be thixotropic when it takes a specific time to return to equilibrium viscosity when exposed to change in shear rate, [22], [23]. The results shown in figures (2-7) indicated that all samples exhibited thixotropic behavior due to the gap between the forward and backward graphs. It was observed that samples coated with 1% gelatin and different concentrations of Melissa officinalis L. oil (0.1, 0.3 and 0.5%) showed the higher thixotropic effect, whereas thixotropy was recorded as the resultant area between the upward and downward curves, [13].

Gggg

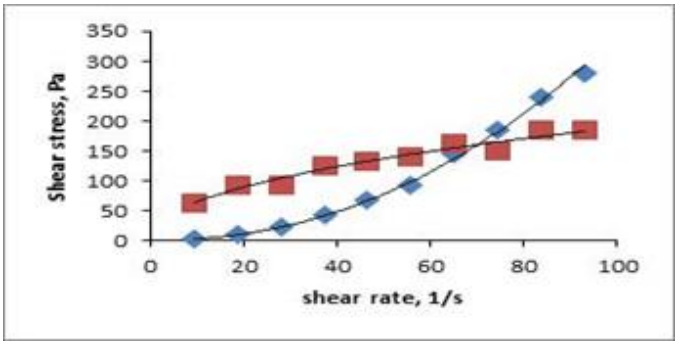

Fig. 2*. Thixotropic effect for tofu sample 1*

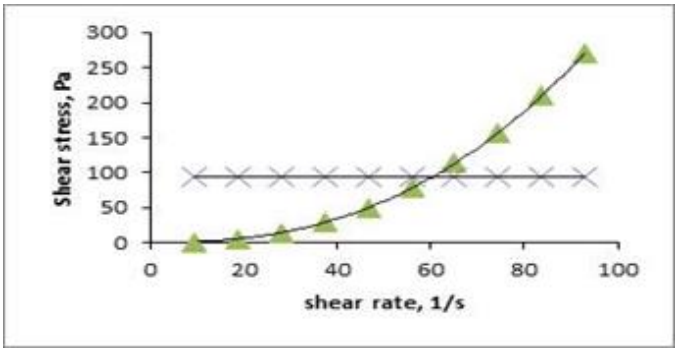

Fig. 3. *Thixotropic effect for tofu sample 2M*

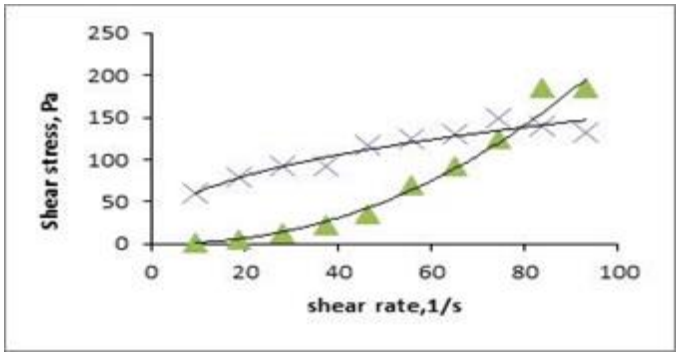

Fig. 4. *Thixotropic effect for tofu sample 3M*

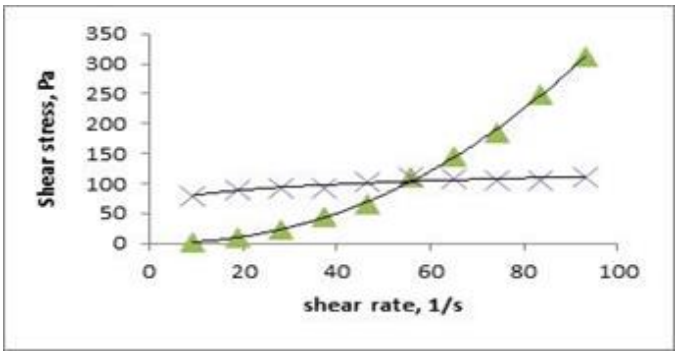

Fig. 5. *Thixotropic effect for tofu sample 4M*

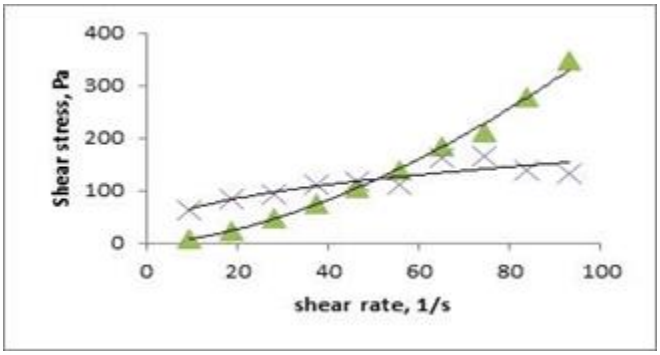

Fig. 6. *Thixotropic effect for tofu sample 5M*

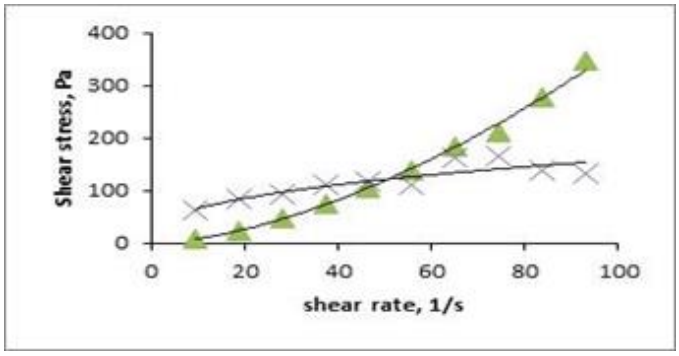

Fig. 7. *Thixotropic effect for tofu sample 6M*

3.2 Weight loss of tofu samples

Figure (8) showed the effect of coating by gelatin with the addition of Melissa oil on tofu during storage up to 14 days. The results indicated the increase of weight loss for all samples studied. The highest weight loss (15.02%) was found for control samples, while the lowest (7.2%) was for sample 6M.

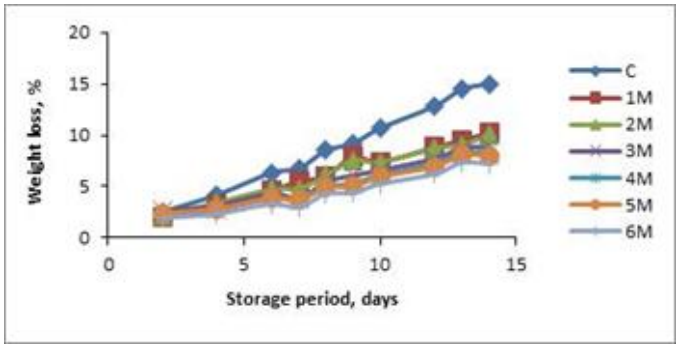

Fig. 8. *Weight loss for coated and uncoated tofu samples*

3.3 Moisture content of tofu

Figure (9) showed the effect of coating blends on moisture content of tofu during storage. The results indicated that control sample had the lowest moisture content (72%) and the moisture contents were increased for coated samples. Tofu moisture content decreased during storage from 81 to 72% for control sample and from 85 to 75%, 84.6 to 77%, 87 to 80%, 87 to 80%, 84.7 to 79% and 85 to 80% for coated samples 1M, 2M, 3M, 4M, 5M and 6M, respectively.

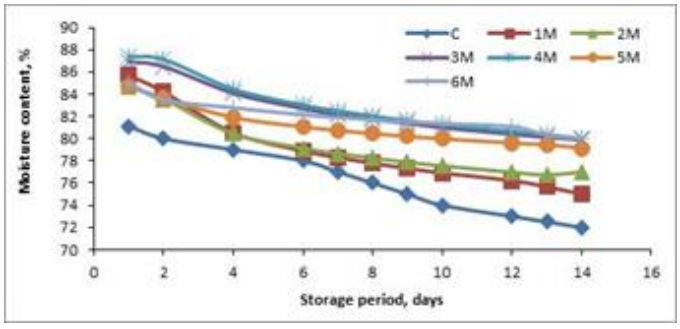

Fig. 9. *Moisture content for coated and uncoated tofu samples*

3.4. Texture properties during storage of Tofu

The different physical properties of tofu coated with gelatin with the addition of Melissa officinalis L. oil such as hardness, adhesiveness, cohesiveness, springiness, gumminess and chewiness were analysed using texture analyser. The results indicated that all texture properties increased with increasing storage time for all samples studied as shown in figures (10-15). Hardness is defined as the maximum force necessary to attain a given product deformation. The results showed that hardness of coated and uncoated tofu samples increased during storage till 14 days. The highest value of hardness (21.2 N) was observed for control sample after storing for 14 days, this may be due to the high moisture content of tofu, while tofu coated with gelatin (1 and 2%) with Melissa oil (0.1, 0.3 and 0.5%) showed hardness values lower than control (8.16, 9.32, 8.20 8.04 5.25 and 13.04 N, respectively) as shown in figure (10) Adhesiveness is defined as the negative force area for the first bite and represents the work required to overcome the attractive forces between the surface of a food and the surface of other materials with which the food comes into contact. The results observed that the highest value of adhesiveness ratio was for sample coated with 2% gelatin and 0.5% Melissa officinalis L. (6M) oil after storage for 14 days as shown in figure (11). Cohesiveness measured as the rate at which the material disintegrates under mechanical action. The results indicated that the highest value of cohesiveness ratio (2.73) was for sample (6M) while the other samples of coated tofu showed approximately the same values during storage time until 14 days as shown in figure (12). The highest value of springiness (11.27 mm) was for sample (4M) oil after 14 days of storage, while the other samples of coated tofu showed approximately the same values as shown in figure (13). The highest value of gumminess (16.55 N) was observed for sample (6M) after 14 days of storage and the lowest value (4.2 N) was for the sample (4M). The highest value of chewiness (51.5 mj) was observed for sample (6M) after 14 days of storage the lowest value (13.02 mj) was for the sample (4M).

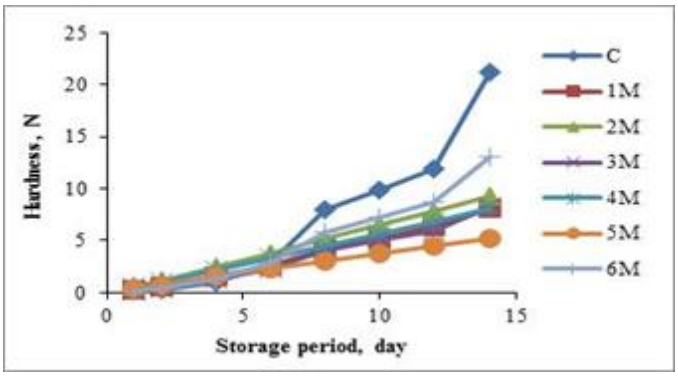

Fig. 10. *Hardness for coated and uncoated tofu samples*

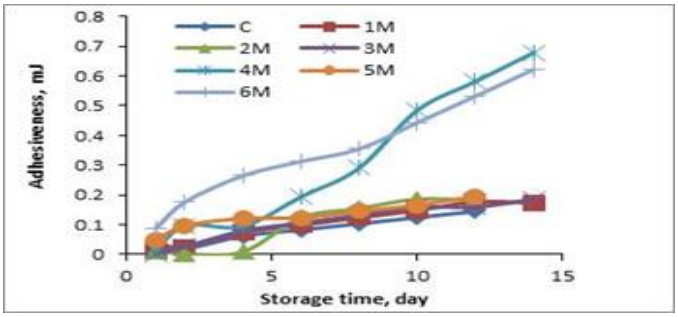

Fig. 11. *Adhesiveness for coated and uncoated tofu samples*

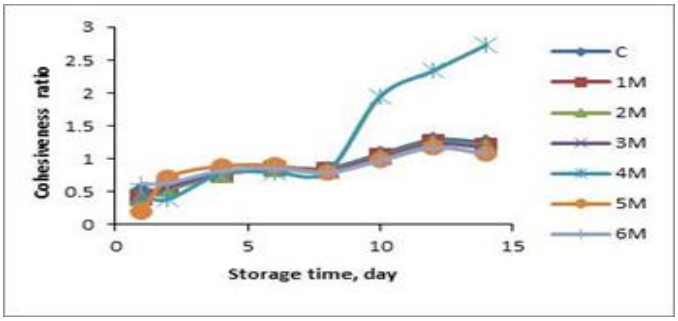

Fig. 12. *Cohesiveness for coated and uncoated tofu samples*

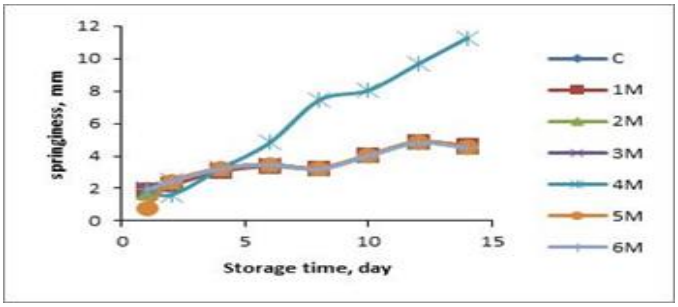

Fig. 13. *Springiness for coated and uncoated tofu samples*

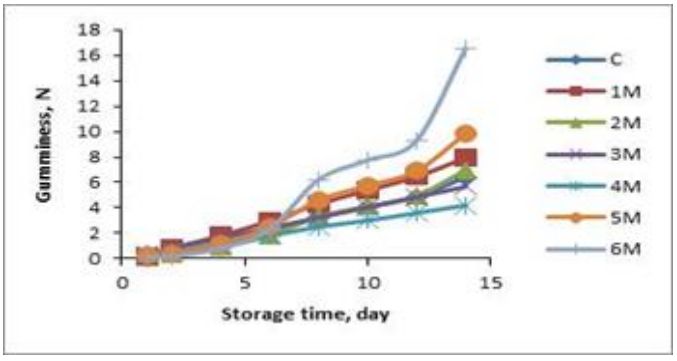

Fig. 14*. Gumminess for coated and uncoated tofu samples*

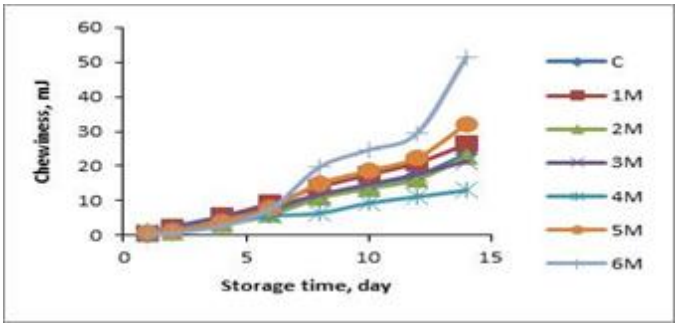

Fig. 15. *Chewiness for coated and uncoated tofu samples*

3.5 Microbial analysis

The results presented in Tables (4-6) showed the changes in microbial count of coated and uncoated tofu. There was a gradual increase in total bacterial count in control samples up to 5x104 and 11 x10^9 after 2, 6 days of storage respectively, after that Too Numerous to Count (TNTC) total bacteria until 14 days. Samples of tofu coated with gelatin with addition of Melissa officinalis L. oil showed a decrease for the count of total bacteria with respect to control sample, Pontecorvo and Bourne, [24] reported that freshly prepared tofu had 3.0 × 10^4 CFU/g which was reduced to 1.12 × 10^3 CFU/g after ten days of storage at 24 ˚C in 4% NaCl and 10% lemon juice. Concerning yeast and mould there are no growth was observed until 12 days of storage for tofu samples coated with 2% gelatin + 0.5% Melissa officinalis L. oil compared with control sample which showed yeast and mould growth after 2 days (5x102). However, psychrophilic bacteria showed no growth after 14 days of storage in tofu samples coated coating with 1% or 2% gelatin with addition 0.5% Melissa officinalis L. oil. From the results (not tabulated) it could be found that Coliforms was not detected in any of the studied samples but appear in control sample after 14 days at levels of 4 x101 (cfu/g). No characteristic black colonies of Staphylococcus aureus formed on Baird Parker agar and that was confirmed by Gram staining but it appeared with control sample after 14 days of storage at level of (3 x101) cfu/g.

TABLE (4) *ASSESSMENT OF TOTAL BACTERIAL COUNT (CFU/G) OF TOFU TREATMENTS UNDER COOLING CONDITIONS (4°C) FOR 14 DAYS.*

Storage period (days)	Treatments						
	C	1M	2M	3M	4M	5M	6M
Fresh	6x10	4 x10	3 x10	2 x10	3.5x 10	4 x10	2x10
2	5x10^4	2.5 x10^3	2.5 x10^2	6 x10	3x10^3	3.5x10_2	5.5 x10
4	6x10^6	2 x10^4	2 x10^2	7x10^2	2.5x10_4	7 x10^2	6 x10^2
6	11x10^9	1.5 x10^5	1.5 x10^3	9 x10^2	2.5x10_5	2.5 x103	8 x10^2
8		6.5 x10^7	6 x10^4	1x10^3	7x10^6	5 x10^4	2 x10^3
10	TNTC	9x10^8	9 x10^4	4 x10^3	8 x10^7	8 x10^4	5 x10^3
12		6x10^8	5 x10^5	5 x10^3	6 x10^8	6 x10^8	7 x10^3
14		7x10^8	7x10^6	9 x10^3	6 x10^8	8 x10^6	8 x10^3

Too Numerous to count (TNTC)

TABLE (5)
ASSESSMENT OF YEASTS AND MOLDS (CFU/G) OF STORED TOFU UNDER COOLING CONDITIONS (4°C) REFRIGERATION FOR 14 DAYS.

Storage period (days)	Treatments						
	C	1M	2M	3M	4M	5M	6M
Fresh	ND	ND	ND	ND	ND	ND	ND
2	5x10^2	ND	ND	ND	ND	ND	ND
4	8x10^2	ND	ND	ND	ND	ND	ND
6	6.5 x10^4	4 x10^1	ND	ND	5 x10^1	ND	ND
8	11 x10^7	7 x10^2	4 x10^1	ND	6.5 x10^2	2 x10^1	ND
10	7 x10^9	8 x10^2	5 x10^2	ND	9 x10^2	4 x10^2	ND
12	TNTC	6x10^3	4 x10^3	6 x101 2 x102	7x10^3	8 x10^2	ND
14		9 x10^3	6 x10^3		8 x10^3	4 x10^3	2 x10^2

- Too Numerous to count (TNTC)
- ND: not detected

TABLE (6)
ASSESSMENT OF PSYCHROPHILIC BACTERIA (CFU/G) OF COATED AND UNCOATED TOFU SAMPLES UNDER COOLING CONDITIONS (4°C) FOR 14 DAYS.

Storage period (days)	Treatments						
	C	1M	2M	3M	4M	5M	6M
Fresh	ND	1M	2M	3M	4M	5M	6M
2	ND	ND	ND	ND	ND	ND	ND
4	2 x10^1	ND	ND	ND	ND	ND	ND
6	4 x10^2	ND	ND	ND	ND	ND	ND
8	9 x10^2	ND	ND	ND	ND	ND	ND
10	2 x10^3	ND	ND	ND	ND	ND	ND
12	5 x10^3	ND	ND	ND	ND	ND	ND
14	6 x10^4	ND	ND	ND	ND	ND	ND

-ND: not detected

The Melissa essential oil exhibited a strong activity against all the strains tested in concentration 0.5%, the inhibition zones ranged between 16 and 25 mm. Generally, the essential oils are more active against Gram-positive bacteria than against Gram-negative ones. In our case, Melissa officinalis L. oil is more active against the Gram negative ones. This result agreed with Fahima et al., [25]. The anti-yeast activity was potent against the human pathogenic Candida albicans (21mm) with sample (6M). The two treatments of (3M) and (6M) had the same results with the tested phytopathogenic fungi Fusariumoxysporum (19 mm). This anti-yeast activity may be related to the major compounds of the oil (citral, citronellal and caryophyllene oxide). The antibacterial activity of Melisa officinalis L. oil was reported by several researches [26], [27], [28], [29].

3.6 Sensory evaluation

The tofu coated with different concentrations of gelatin and Melisa officinalis L. oil were subjected to sensory evaluation for their color, texture, taste, odor, shape and overall acceptability during storage for 11 days at 4˚C. The obtained data were statistically analyzed and the results are shown in Table (7). The results showed that all treatments had high scores and were significantly different from control for all the previous mentioned parameters from zero time till 11 days. At

zero time, overall acceptability scores of 2M, 3M, 4M, 5M and 6M were found to be not significantly different in between. After 7 days all parameters scores of control were dramatically decreased. This decrement was represent 31 - 40% while, a slight decrease for other treatments was found. After 11 days, the control sample was rejected due to the appearance of signs of microbial corruption and these signs did not appear on other treatments. The results showed also a decrease in the scores of all parameters after 11 days of storage. However, the results in the same Table indicated that control sample recorded the lowest score for taste and odor due to the presence of undesirable odor compared to other treatments this means that addition of Melissa essential oil lead to disappear of such odor.

TABLE (7)
SENSORY EVALUATION OF COATED AND UNCOATED TOFU SAMPLES

Treatments	Zero time					
	color	Texture	Taste	odor	shape	Overall Acceptability
C	8. 20± 0.04d	8. 10± 0.09f	7. 30± 0.09c	6. 30± 0.02e	8. 10± 0.04e	8. 70± 0.01c
1M	9 .71± 0.02a	9. 70± 0.11a	9.1± 0.07b	8.5± 0.14d	8.8± 0.04d	9.20± 0.15b
2M	9. 30± 0.02b	9.01± 0.02e	9.1± 0.02b	9.6± 0.01b	9.2± 0.07c	9.7±0.01a
3M	9 .30± 0.19b	9.13± 0.014d	9.9± 0.01a	9.1± 0.02c	9.4± 0.03b	9.7±0.02a
4M	9 .74± 0.07a	9.50± 04c	9. 10± 0.02b	9.2± 0.03c	9.5± 0.04b	9.7±0.00a
5M	9 .10± 0.00c	9.62± 02b	9.90. ±0.03 a	9.6± 0.02b	9 .30± 0.01c	9.7±0.03a
6M	9 .11± 0.01c	9,45± 0.01c	9.9± 0.02a	9.9± 0.02a	9.7± 0.03a	9.7±0.02a

Treatments	4 days					
	color	Texture	Taste	odor	shape	Overall Acceptability
C	7.0 ±0.33c	7.2± 0.04e	6.6± 0.03d	6.5± 0.06d	7.1± 0.08d	7.2±0.03e
1M	9.0± 0,03b	8.4± 0.04d	8.1± 0.03c	9. 20± 0.05b	9.01± 0.01c	8.5±0.01d
2M	9 .00± 0.01b	9.3± 0.03b	9. 20± 0.01a	9.1±0 .08c	9.3± 0.01b	9. 0± 0.11c
3M	9.6± 0.02a	9 .0± 0.01c	9.1± 0.00b	9.2± 0.02b	9.00± 0.10c	9.0±0.02c
4M	9.0 ±0.02b	9.32± 0.05b	9.2± 0.07a	9.1± 0.02c	9 .30± 0.02b	9.05±0.06a
5M	9.0± 0.01b	9.32± 0.07b	9.2± 0.03a	9.2±0 .08b	9.3± 0.07b	9. 00± 0.01c
6M	9.6± 0.02a	9.7± 0.02a	9.2± 0.04a	9.5±0 .02a	9.8±0 .01a	9.3 ±0.02b

Treatments	7 days					
	color	Texture	Taste	odor	shape	Overall Acceptability
C	5.2± 0.02c	5.2± 0.02c	4.05± 0.03d	5.04± 0.06d	5.2± 0.05d	5.22±0.12d
1M	8.4± 0.01b	8.11± 0.03b	7.2± 0.09c	7.30± 0.14c	8.2± 0.08b	8.21±0.01c
2M	8.03± 0.03b	9.32± 0.04a	8.11± 0.05b	8.13± 0.01b	7.02± 0.05c	8.23±0.02b
3M	9.05± 0.01a	9.3± 0.01a	9.21± 0.06a	9.22± 0.03a	8.2± 0.03b	9.12±0.2a
4M	8.2± 0.02b`	8.15± 0.02b	7.09± 0.05	8.11± 0.09b	7.04± 0.04c	8.21±0.04b
5M	8.02± 0.01b	8.14± 0.01b	8.11± 0.01b	7 .00± 0.15	8.2± 0.05b	8.21±0.01b
6M	9.06± 0.01a	9. 20± 0.05a	9.1± 0.02a	9.2± 0.03a	9.03± 0.02a	9 .10± 0.1a

Treatments	11 days					
	color	Texture	Taste	odor	shape	Overall Acceptability
C	Not detected according high microbial examination					
1M	6.2± 0.01d	1M	6.2± 0.03c	5.1± 0.09d	6.11± 0.03d	6.25±0.02c
2M	6.5± 0.02c	2M	6.3± 0.05b	6.1± .003c	7 .20± 0.01b	6. 20± 0.15c
3M	7. 20± 0.05b	3M	5.5± 0.03c	7.33± 0.01a	7.21± 0.04b	7.2±0.01a
4M	7.4± 0.01a	4M	7.18± 0.04a	6.11± 0.03c	7. 20± 0.05b	7.2±0.03a
5M	6.6± 0.05c	5M	6.09± 0.11	7.32± 0.03a	6.32± 0.02c	6.55±0.03b
6M	7. 20± 0.01b	6M	7 .10± 0.01a	7.09± 0.02b	7.43± 0.01a	7.23±0.05a

4. CONCLUSION

Tofu samples were coated with gelatin solution (1 and 2%) with the addition of Melissa officinalis L. oil (0.1, 0.3 and 0.5%), samples were divided into 7 batches. The essential oil was analysed for their components, eighteen components were identified. The effect of addition of Melissa officinalis L. oil on rheological properties of edible solutions, the results indicated that all samples exhibited dilatant flow behavior and thixotropic effect. Weight loss and moisture content of coated and uncoated tofu samples were determined; the lowest weight loss was for (6M) sample, while the moisture content decreased during storage. The effect of edible coating on texture properties was determined; the results indicated that the lower hardness was for uncoated tofu sample while the highest value of adhesiveness, cohesiveness, gumminess, chewiness was for sample (6M) and sample (4M) had the lowest springiness value. Using gelatin incorporated with Melissa officinalis L. oil affects the microbial analysis and extend shelf life of tofu samples up to 12 days. Sensory evaluation was done and the results indicated that all treatments showed high scores and were significantly different from control for all the previous mentioned parameters from zero time till 11 days.

5. ACKNOWLEDGEMENTS

We sincerely express our indebtedness to Dr. Ghada Mohamed Youssef, Professor of Food Technology, Department of Special Food and Nutrition, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt, for her constant advice and kind assistance.

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