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The effect of biopolymer coating on the antioxidant properties of nanoencapsulated sage extract to increase the stability of sunflower oil under accelerated temperature conditions

Safarpour, B. [1], Esmailzadeh Kenari, R.[2*], Farmani, J. [3]

1. PhD student , Department of Food Science & Technology, Faculty of Agricultural Engineering, Sari Agricultural Sciences and Natural Resources University, Sari, Iran.
2. Professor, Department of Food Science & Technology, Faculty of Agricultural Engineering, Sari Agricultural Sciences and Natural Resources University, Sari, Iran.
3. Associated Professor. Student of Food Science and Technology, Department of Food Science & Technology, Faculty of Agricultural Engineering, Sari Agricultural Sciences and Natural Resources University, Sari, Iran.

ABSTRACT

Sunflower oil is one of the most important vegetable oils with high nutritional value, which is unfortunately sensitive to oxidation due to unsaturated fatty acids. In this study, sage leaf extract was obtained using ultrasound bath and ethanol solvent: water (70:30) at 35 ° C for 30 min at 35 KHz. The total phenolic content of extract was 31.12 mg GA/g. Antioxidant activity of 50, 100, 200 and 250 ppm of sage extract was measured by beta-carotene/linoleic acid bleaching assay and oxidative stability index. The results showed that increasing in the concentration of extract increased the antioxidant activity and oxidative stability index. Sage extract (250 ppm) was used for encapsualtion in the wall of qadomehshahri seed gum/whey protein isolate at 1: 0, 1: 1 and 0: 1 ratio. The particle size of the nanocapsule varied between 217.4 and 0.270 nm, and the nanocapsule prepared withqodomehshahrihad the largest size and the nanocapsule prepared with composition of gum and protein isolate had the smallest size. In order to intensify the oxidation process, sunflower oil without antioxidants, oils containing free extracts and TBHQ was placed in an oven at 60 ° C for 24 days. Peroxide, para-anisidine and Totox value of the samples were measured. The results showed that oil oxidation in samples containing encapsulated extract was less than the control, and oil containing free extract and TBHQ. At the end of storage time, the peroxide and paraanisidine value in oil samples containing encapsulated extract was less than oil containing synthetic TBHQ antioxidant and free extract. Also, among the walls used for encapsulating of sage extract, a composite wall made of qodomehshahri seed gum and whey protein isolate is the best coating for encapsulation the extract to increase the shelf life of sunflower oil.

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*Corresponding Author E-Mail:
Reza_kenari@yahoo.com

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1. Introduction

Vegetable oils are known as sources of energy and essential fatty acids for the body, and because they are important precursors of hormones, they play an important role in human nutrition. Vegetable oils also contain triacylglycerols and small amounts of tocopherol, sterols and pigments [1]. The use of oilseeds in the human food industry, as well as the use of their flour for animal feed, as well as the use in the pharmaceutical, cosmetic and health industries, has made farmers to have a great desire to plant them. Meanwhile, sunflower is one of the most important oilseeds in the world, which has increased due to its suitability for agricultural needs, high yield of oil, high nutritional value and lack of anti-nutritional factors [2].

Sunflower with scientific name (*Helianthus annuus*) an annual plant with a straight stem, rough and 2 meters high, which is continuously cultivated in wide areas of different countries. This plant is one of the most important oil products in the world. Sunflower seeds are rich in phosphorus, manganese, zinc, potassium and unsaturated fatty acids and omega 6 (linoleic acid) [3]. The importance of fats is from the point of view of energy production, which produces more than twice as much energy as proteins and carbohydrates, and also provides fat-soluble vitamins [4]. Vegetable oils are destroyed during thermal processes such as frying and lose their quality and nutritional value. As oxidation progresses, they produce toxic and dangerous compounds that are harmful to human health. Therefore, it is necessary to prevent this process or delay the start of the process by increasing the stability of the oil. The most common way to prevent the oxidation process is to use antioxidants. Studies have shown that synthetic antioxidants have adverse effects, and for this reason, today, it is tried to use plant sources as antioxidants [5].

The possible toxicity and carcinogenicity of common synthetic antioxidants such as BHA, BHT, PG and TBHQ have led researchers to use natural antioxidants. Tocopherols, phenolic compounds, glutathiones, ascorbic acid, carotenoids and anthocyanins can be mentioned among the most important natural antioxidant compounds used in food [6]. Phenolic compounds prevent the oxidation of oils by different mechanisms, the most common of which is the inactivation of free radicals and the formation of complexes with metal ions [7]. Plants are a rich source of natural antioxidants. Therefore, many studies have been conducted on plants to increase food safety and reduce the risk of cancer in order to use them as natural antioxidant compounds. Medicinal plants contain a wide range of phenolic compounds, including phenolic acids, flavonoids, and tannins, and the existence of this Phenolic compounds have given them high antioxidant properties [8].

Incorporation of natural bioactive compounds into food products to obtain new functional foods (such as oils, beverages, baking and dairy products) has become a rapidly growing market worldwide, with vegetable oils being the fastest growing category. . Consequently, recent studies have focused on the potential of phytochemicals as natural sources of health-promoting compounds for the design and production of functional foods [9]. Currently, the most important leading challenge in the field of adding bioactive compounds to food products is the issue of insoluble extracts in oil due to their polar nature, consuming a high amount of extract to achieve optimal stability, their rapid oxidation in the presence of light and oxygen, and The change in the color and taste of the oil [10]. One of the most important methods to protect bioactive compounds in food systems is the use of microcoating process. By means of this technology, a cover is placed around the food and the core compounds are prevented from environmental stresses such as oxidation, light, heat and pH [11].

One of the types of plants that has always been of interest is the sage plant with the scientific name*Sage officinalis*) is from the mint family. Out of a thousand species of this plant, about 17 species are unique to Iran. Sage is a plant with many branches, it is 30 to 60 cm high and has a bushy appearance. The root of the plant is brown and has numerous, branched, four-cornered and hairy stems [12]. Sage has been used in traditional medicine since ancient times due to its medicinal properties. This plant grows in the form of a car in dry and stony places and barren slopes in most parts of Asia and North Africa. The aerial parts of the plant, especially sage leaves, contain

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compounds with antioxidant properties, the most important of which are tannins, flavonoids, tocopherol, rosmarinic acid, and ascorbic acid. Rosmarinic acid is a phenolic compound with high antioxidant and biological activity [13].

Phenolic compounds are sensitive to environmental stresses such as oxygen, moisture, heat, light, enzymes, pH, and the like, and microcoating protects these compounds from the aforementioned stresses, controlled release, prevents strong flavors and odors of phenolic compounds, and increases the efficiency of compounds. Phenolic is stored during storage [14].

A wide variety of technologies have been developed for the encapsulation of polyphenols, including spray drying, coacervation, emulsions, liposomes, micelles, nanoparticles, freeze drying, and microencapsulation by yeast. Each of these has specific strengths and weaknesses in microencapsulation, protection, delivery, ease of use, biodegradability, and biocompatibility. In the meantime, emulsions are widely used as one of the most popular microencapsulation and delivery systems for a wide range of lipophilic, hydrophilic and amphoteric bioactive molecules in are considered In addition, some polyphenols encapsulated by emulsions showed higher biological activities compared to pure free molecules [15].

Microencapsulation of effective compounds in water-in-oil (W/O) or oil-in-water (O/W) nanoemulsions can increase the protection of compounds and their properties such as antioxidant activity, solubility and stability. Proteins and polysaccharides can be used as hydrophilic emulsifiers in the production of water-in-oil-in-water (W/O/W) emulsions, which in turn increase the functional characteristics of effective compounds and improve their controlled release [16].

The material used as a wall should be able to cover the core material in a spherical structure with maximum efficiency and prevent inappropriate processes such as oxidation of the core material against oxygen in the form of protective walls. This increases the shelf life of core materials [17, 18]. In this regard, various materials have been used, among which biopolymers have received much attention due to their properties such as suitable emulsifying properties, increased viscosity, ability to form a film, solubility in food and water [19, 20]. Recent investigations showed that the microcoating of effective compounds in double-layer W/O/W nanoemulsions with biopolymer coatings could successfully preserve the core compounds and their controlled release [16, 21].

Choosing the right wall material is essential to achieve a successful micro coating. Whey proteins as a byproduct of the cheese industry have been widely used in food formulations. The main components of whey proteins are beta lactoglobulin, alpha lacta albumin, bovine serum albumin and immunoglobulins. The significant surface activity properties of whey protein concentrate and whey protein isolate introduce them as suitable wall materials for encapsulation. There are several reports on the use of whey protein concentrate and isolate alone or in combination with other biopolymers for encapsulation of bioactive compounds [22]. Considering the wide use of gums in the industry and the high cost of these compounds, finding new sources for the production of hydrocolloids has always been of great importance. Many native seeds of Iran contain valuable gums. Among these gums, the gum is obtained from the seeds of Gadumeh Shahri. The seed of Shahri is egg-shaped and brown with a thin coating and mucilage. This seed produces mucilage when soaked in water, which has a relatively high viscosity and is able to stabilize and stabilize the dispersed phase droplets in the oil-in-water emulsion [23]. Although many researches have been done in the field of using micro-coated extracts to increase the shelf life of vegetable oils, but so far the properties of nano-coated sage extract in the wall of whey protein isolate and the gum of Qadumeh Shahri seeds as a natural antioxidant have been studied. The study is not included. Using the results of this research, it is possible to use the potential of different plants as natural antioxidants as well as micro mulching as a method to increase the antioxidant efficiency of plants. Therefore, the purpose of this research is extracting sage extract using ultrasound and investigating the antioxidant properties of the extract, nano-coating of sage extract using a combined protein/polysaccharide coating and investigating the antioxidant effect of sage extract

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in increasing the shelf life of sunflower oil as a natural antioxidant.

2- Materials and methods

2-1- Materials

Sage leaf was collected from its natural habitat in Mazandaran province. Antioxidant-free sunflower oil was obtained from North Kisht and Sanat oil factory. Reagents and chemicals were purchased from Merck (Darmstadt, Germany) and solvents were purchased from Charlo (Barcelona, Spain). Gadomeh Shahri seed gum was obtained from Reyhan Gam Parsian Company in Tehran.

2-2-Methods

2-2-1-Extraction of sage leaf extract

The leaves of the sage plant were dried in the shade for 1 week immediately after preparation until the moisture content was below 10%. Dried sage was turned into powder using a mill (Habi, Pars-Khazar, Iran). The resulting powder was passed through a sieve with a 200 μm mesh to separate coarse particles. 50 grams of powdered sage leaves were mixed with 250 ml of ethanol:water (70:30) solvent. Extraction was performed using an ultrasonic bath (6.5l200 H, Dakshin, India) at a temperature of 35°C for 30 minutes and a frequency of 35 kHz. The resulting mixture was filtered using Whatman No. 1 paper and then placed in a rotary evaporator (RE 120, Flowil, Switzerland) to perform solvent extraction at 35 °C. The final extract was stored at -18°C [11].

2-2-2- Total phenol measurement of sage extract

To measure the total phenolic content of the extract, first, 2.5 ml of Folin Ciocaltio phenolic reagent (0.2 normal) was added to 0.5 ml of the extract and mixed well, and then 2 ml of 7.5% sodium carbonate added to it. This mixture was kept at room temperature in the dark for 20 minutes. After this time, the absorbance of the mixture was read by an optical spectrometer (Cintra 6, GBS scientific, Australia) at a wavelength of 760 nm. The total amount of phenolic compounds was calculated based on the gallic acid standard curve [24].

2-2-3-Measuring the antioxidant properties of sage extract

The beta-carotene:linoleic acid decolorization method was used to measure the antioxidant activity of sage extract. For this purpose, a base solution of beta-carotene-linoleic acid was prepared as follows: 5 mg of beta-carotene was dissolved in 10 ml of chloroform, 600 microliters of the prepared solution was mixed with 40 mg of linoleic acid and 400 mg of Tween 40. added. Then, chloroform was separated by vacuum evaporation and 100 ml of hydrogen peroxide was added to it and vigorously stirred. 5 ml of the emulsion prepared above was transferred to the test tube and 200 microliters of the extract was added to the test tube. A sample without extract was also considered as a control composition. All steps were performed in the case of TBHQ as a standard antioxidant. The optical absorption of the samples was read with an optical spectrometer at a wavelength of 470 nm at zero time and also after 24 hours of incubation at room temperature. The antioxidant capacity of the extract was expressed as the inhibition percentage [25].

2-2-4- Oxidation stability index measurement

Oxidative stability index of sage extract in sunflower oil was measured with a Rancimat machine (MetrohmRancimat model 743 Herisau, Switzerland). In this way, five milligrams of sage extract was added to five grams of refined sunflower oil without antioxidants. Then, the oxidative stability index in terms of (hours) was tested at 110 degrees Celsius with an air flow rate of 15 liters per hour [26]. After conducting the mentioned tests, sage leaf extract at a concentration of 250 ppm, which had the highest amount of phenolic compounds and antioxidant properties, was selected for nanomicro coating.

2-2-5-nanocapsulation of sage leaf extract

Whey protein isolate and Gadome Shahri seed gum solution in different ratios (1:0, 1:1 and 0:1) were used as coating. First, 0.05 grams of coating powder was dispersed in deionized water at 30 degrees Celsius and after cooling overnight, it was mixed to perform hydration. Then, 10 ml of sage extract was mixed with 40 ml of Tween 80 and 50 ml of sunflower oil with a magnetic stirrer at a speed of 100 rpm for 15 minutes. After that, the formed emulsion was homogenized again using an Ultrathorax homogenizer (IKA

Labortechnik, Selangor, Malaysia) at 15,000 rpm for 10 minutes, and then the coating solution was added to the nanoemulsion at a ratio of 5:1 [2]. The nanoemulsions were dried using a freeze dryer (SP Scientific, Gardiner, NY, USA) at -50 degrees Celsius and a pressure of 0.017 MPa for 48 hours. The particle size of nanoemulsions was measured using laser light scattering method by Mastersizer (Malvern instrument Ltd. UK).

2-2-6-Oil storage in accelerated conditions

In order to intensify the oxidation process, sunflower oil without antioxidants, oils containing nano-encapsulated extract, free extract at a concentration of 250 ppm and TBHQ at a concentration of 100 ppm were poured into a closed dark glass bottle and then stored in an oven at a temperature of 60 degrees Celsius for 24 days. became In order to check the antioxidant power of the extract and the performance of nano-coating in reducing the oil oxidation process, the oils were sampled every 4 days (0, 4, 8, 12, 16, 20 and 24 days). Table 1 shows the codes of treatments investigated in the research.

Table 1 Code and formulation of sunflower oil samples.

Concentration (ppm)	Type of antioxidant	Code of oil samples
-	Without antioxidant	CONT
100	TBHQ	TBHQ
250	Free sage extract	FREE
250	Encapsulated sage extract in qodumeh seed gum	SCUM
250	Encapsulated sage extract in whey protein isolate	WHEY
250	Encapsulated sage extract in qodumeh seed gum and whey protein isolate	COMP

2-2-7-Peroxide index measurement

To measure the peroxide index, saturated solution of potassium iodide and 1% starch glue solution were prepared. 5 grams of oil were weighed in a 250 milliliter Erlenmeyer flask, and then 30 milliliters of acetic acid and chloroform solution (with a ratio of 3 to 2) was added to it and completely

They were mixed together. Then 0.5 ml of saturated potassium iodide solution was added to it and placed in the dark for 1 minute. after

After removing from the dark, 30 ml of distilled water was added. Then it was titrated with 0.1 normal tetrazole thiosulfate until the yellow color disappeared. During the titration, the mixture was vigorously stirred until the iodine was separated from the chloroform layer. Then 0.5 ml of starch identification reagent was added and the titration continued until the blue color disappeared. Along with the sample, the control titration (mixture of acetic acid and chloroform without oil) was also performed. Finally, the peroxide number was calculated using the relationship of peroxide number = (volume of thiosulfate consumed in milliliters x molarity of sodium thiosulfate x 1000)/ weight of oil in grams and expressed in milliequivalents of peroxide per 1000 grams of oil [27].

2-2-8-measurement of paraanisidine index

The para-anisidine test measures secondary oxidation products. 4 grams of oil sample was weighed in a 25 ml volumetric flask and then dissolved in some isooctane and made up to volume with it. The wavelength of the device was set to 350 nm. Then the tube containing isooctane (control) was placed in the device and the absorbance was set to zero. The absorbance of the oil solution was read at 350 nm in an optical spectrometer (A_b). In a test tube with a lid (tube A), 5 ml of oil solution was poured and in the second test tube (tube B), 5 ml of isooctane was poured, then 1 ml of anisidine reagent was added to each of the tubes and the tubes were They were shaken well. After 10 minutes, the absorbance at 350 nm was first set to zero by placing the cell containing the adapter in test tube B (control solution) in the optical spectrometer. Then the absorbance of test tube solution A (reduced oil solution) was read in the optical spectrometer and its absorbance was indicated by As. The anisidine index was calculated according to the following equation:

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$$25 \times \frac{\frac{1}{2(As - Ab)}}{W}$$

As = absorption of lipid solution after reaction with paraanisidine
Ab = Absorption of fat solution
W= sample weight
1.2 is the correction factor for diluting the sample solution with one milliliter of reagent. To prepare the paraanisidine reagent, 0.125 grams of it was dissolved in a 50 ml volumetric flask with glacial acetic acid and brought to volume [27].

2-2-9-Totox index measurement

Total oxidation was calculated using para-anisidine index and peroxide index and was calculated through the following equation:

Anisidine index + peroxide index x 2 = Totox index

2-3-Statistical analysis

The statistical analysis of the results obtained from the various tests of the present study was done by comparing the means of ANOVA, in the form of a completely randomized experimental design, and using Duncan's test at a confidence level of 95% ($P<0.05$). The results were compared with each other in order to reduce the error in three repetitions using SPSS version 20 software. Excel version 2013 software was used to draw the graphs.

3. Results and Discussion

1-3- The amount of phenolic compounds and antioxidant properties of sage extract

The total amount of phenolic compounds of sage extract was calculated to be 31.12 mg of gallic acid per gram. Nutrizio et al. (2020) reviewed high voltage electrical discharge and a common method for extracting bioactive compounds from sage. They reported the amount of phenolic compounds equivalent to 19.67 and 42.13 mg of gallic acid per gram for conventional and electrical extraction, respectively [13]. In a research, the amount of phenolic compounds of the aqueous extract of sage, which was prepared by hot water extraction method, was 89.65 mg/g, and this amount of phenolic compounds for sage extract extracted by the conventional method was 73.7 mg of catechin/g. dry gram reported [28].

In the beta-carotene: linoleic acid decolorization method, the antioxidant activity of the target compound is measured by the inhibition rate of linoleic acid oxidation. In the beta-carotene-linoleic acid model system, beta-carotene quickly becomes colorless in the absence of antioxidants, which is due to the oxidation of beta-carotene and linoleic acid and the formation of free radicals. The free radical of linoleic acid is created after the hydrogen atom is separated by unsaturated beta-carotene molecules. Then beta-carotene itself is oxidized and decomposed to some extent, and its orange color is lost, which can be evaluated by the meter [29, 30]. The results related to the decolorization of beta-carotene: linoleic acid of different concentrations of sage extract are shown in Figure 1. As can be seen, with increasing the concentration of sage extract from 50 to 250 ppm, the amount of antioxidant property has increased and the difference is statistically significant. At a concentration of 250 ppm, no statistically significant difference was observed between the synthetic antioxidant TBHQ and sage extract. Therefore, this concentration was chosen for nano-microcoating. In various studies, the beta-carotene:linoleic acid decolorization method has been used to evaluate the antioxidant activity of the extracts of rose flower [11], green tea [31], and the results of the present study are consistent with them.

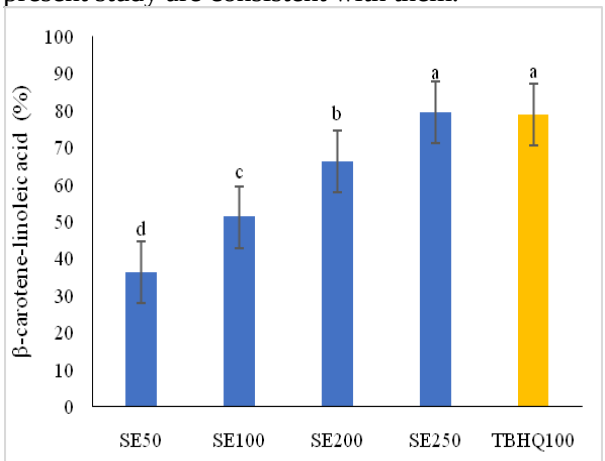

Fig 1 The rate of discoloration of β-carotene: linoleic acid of sage extract

2-3- Oxidative stability

Oxidative stability is an important parameter for measuring vegetable and animal oils and fats. Evaluation of the oxidation stability of oil with induction period using Rancimet device based on

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the electrical conductivity of water leads to the formation of short chain compounds from heated oils at temperatures higher than 110 degrees Celsius [26]. The results related to the oxidative stability of sage extract in different concentrations are shown in Figure 2. As can be seen, with the increase in the concentration of the extract, its oxidative stability has increased and a statistically significant difference has been created. The results of other studies also show that the use of sage extract [26] and Shatra Golrez [11] in sunflower oil leads to an increase in the oxidation stability of the oil. In a research, the effect of corn oil on increasing the oxidative stability of sunflower oil was investigated, and the results showed that the presence of bioactive compounds in corn oil leads to an increase in the oxidative stability of the oil, which is consistent with the results of the present study [32].

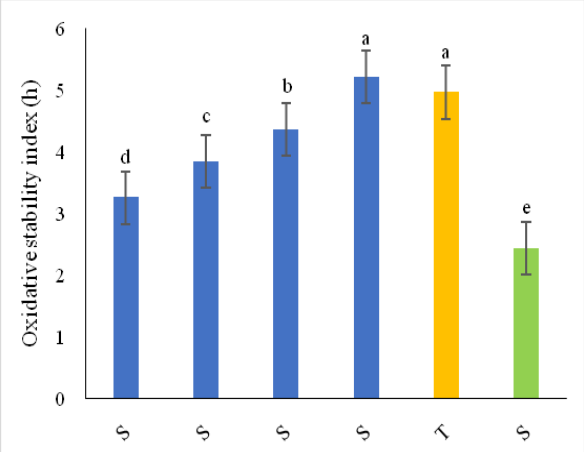

Fig 2 Oxidative stability index (OSI) of sage extract

3-3- Nanocapsule particle size

Dynamic light scattering is the most common technology for determining the size of nanoparticles and submicrons dispersed in a liquid. This technology relies on the interaction of light with particles. The light scattered by nanoparticles in suspension vibrates with the passage of time and the diameter of the particles can be specified again [33]. The results related to the particle size of different nanocapsules are shown in Figure 3. As can be seen, the largest particle size (270 nm) is related to the nanocapsule with the wall of Qadumeh Shahri gum, and the smallest size (217.4 nm) is related to the composite coating. Application of ultrasonic process and high pressure homogenizer leads to the creation of nanometer sized particles [14]. Other researches have also reported the nanometer size for the nanocapsules of different plant extracts in the walls made of native seed gum or the mixed walls of protein gum [2, 11, 34-36].

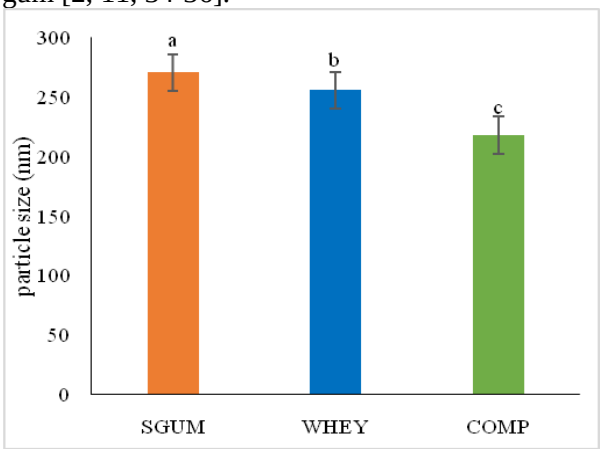

Fig 3 Particle size of nanocapsules. SGUM, WHEY and COMP are encapsulated sage extract in qodumeh seed gum,whey protein isolate and composite of qodumeh seed gum and whey protein isolate, respectively.

3-4- peroxide index

Peroxide index is a measure of peroxides and hydroperoxides created in the initial stage of oil oxidation changes. Hydroperoxides, as the primary product of oil oxidation, can become secondary volatile or non-volatile products, which will destroy the nutritional properties of the oil [37]. has been It can be seen that in all the investigated samples, the peroxide number has increased with the increase of the oil storage time, and the difference of this parameter is significant except for day 0 and 4 of storage in different storage times. The highest peroxide value was related to the control oil sample. Except for day zero, the control sample had statistically significant differences with samples containing antioxidants in other storage times. No statistically significant difference was observed between the samples containing TBHQ and the oil sample containing the extract in a free and micro-coated form on the 4th day of the storage period. The oil samples containing micro-coated extract had no statistically significant difference in terms of peroxide number, but the oil sample containing nano-micro-coated extract in the combined coating had a lower peroxide number. Oil samples containing free extract and TBHQ had no statistically significant difference until

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day 12, and after that the difference became significant. The number of peroxide in the FREE sample was always higher than that of the containing oil sample. The lower number of peroxides at the beginning of the storage period in the oil samples containing micro-encapsulated extract is related to the amount of phenolic compounds present on the surface of the capsules and then due to the release of phenolic compounds during the storage period. Jafari et al. (2022) showed an increasing trend for sunflower oil samples during the greenhouse period. Also, oil samples containing nano-coated rosemary extract had a lower peroxide number, which is in line with the results of the present study [2]. Ahmadi-Komazani et al. (2017) showed that when lettuce waste is used in tallow olein oil, the oxidation rate of the oil is lower and as a result the peroxide value of the oil is lower [38]. The results of other researches also show that the use of fine-coated extracts of Iranian angelica [34], marigold [11], rosemary leaves [2] and sesame [39] and extracts of lettuce waste [38], pea pods [37], leaves Sekbineh [40] and Balang skin [41] have led to the reduction of peroxide value in oil samples.

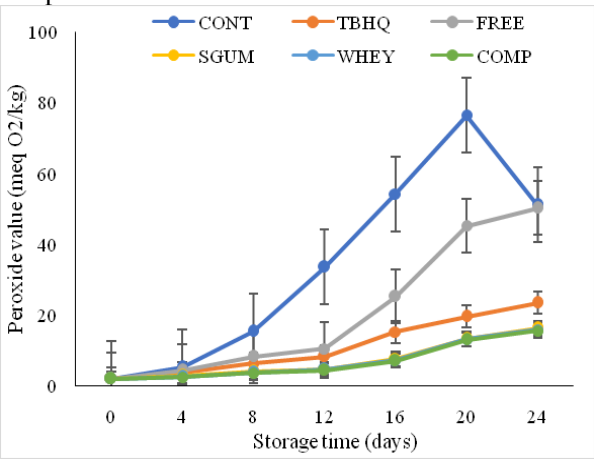

Fig 4 Change in the peroxide value of sunflower oil during storage.

3-5-para-anisidine index

The para-anisidine index measures the secondary oxidation products resulting from the breakdown of lipids by hydroperoxidase into carbonyl compounds, ketones, and aldehydes, mainly 2-alkenal and 2,4-alkynynal [42]. These products eventually lead to the creation of pungent aroma in the oil [37]. The results related to the changes in the para-anisidine index of different oil samples during the storage period are shown in Figure 5. It can be seen that in all the investigated samples, with the increase in oil storage time, the para-anisidine index increased and a statistically significant difference was created. The control sample had the highest para-anisidine index. Among the samples containing antioxidants, the oil sample containing the natural antioxidant free extract of sage had the highest para-anisidine index during the storage period. The control sample had the highest amount of para-anisidine index and had a statistically significant difference with the antioxidant-containing samples in all other storage times except day zero. Although the oil sample containing nano-microcoated sage extract in the composite wall had a lower para-anisidine number, it did not have a statistically significant difference with the oil sample containing nano-microcoated extract in the wall of Qadumeh Shahri gum or whey protein isolate. Faria et al. (2020) reported similar results in line with the results of this research. In their research, the antioxidant activity of Canfora coffee and Arabica coffee extracts encapsulated in sunflower oil samples was higher than the control sample and oil samples containing BHT synthetic antioxidant [42]. While Chang et al. (2015) declared the effect of using mango peel extract to reduce the oxidation of sunflower oil at a temperature of 65 degrees Celsius and a time of 24 days to be negative [43]. In another research, Zhang et al. (2010) investigated the antioxidant effects of rosemary extract in reducing oxidation in sunflower oil and it was found that the antioxidant activity of rosemary extract in oil is more than synthetic antioxidants [44]. Jaafari et al. The sunflower oil containing rosemary nano and micro-coated extract was less than the control samples, it contained synthetic antioxidant and free extract [2], which is in line with the results of the present study. The increase of the para-anisidine index indicates the expansion of the spontaneous oxidation reaction and the increase of secondary products resulting from the decomposition of hydroperoxides and carbonyl compounds with the passage of time. One of the reasons for the higher paraanisidine index in oil samples containing free sage extract can be related to the presence of suspended particles of the extract in the oil and causing errors when measuring the intensity of absorption. Ganjlo et

al. (2018) also reported that the number of paraanisidine in the sunflower oil sample containing pea pod extract was lower than that of the control sample [37].

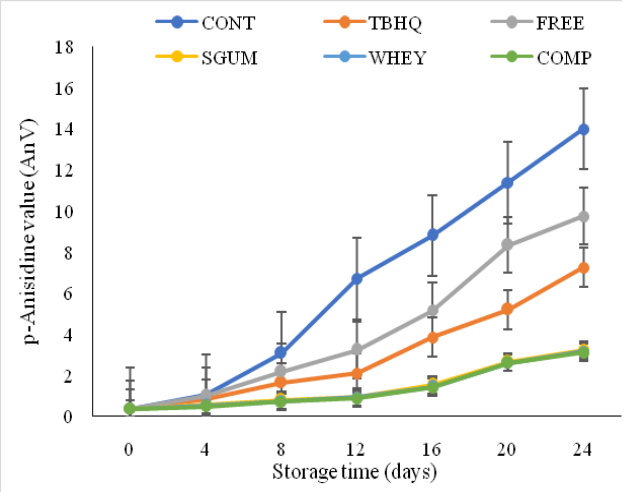

Fig 5 Change in the p-Anisidine value of sunflower oil during storage.

3-6-Totox index

Totox index is a measure of the sum of the primary and secondary products of the oxidation process of edible fats and oils. The lower the Totox index, the higher the stability of the oil against oxidation [37]. The results related to the changes in the Totox index of different oil samples in Figure 6 show the increasing trend in all samples. The control sample had the highest Totox index and the oil sample containing sage extract finely coated in the composite wall had the lowest Totox index. Considering that the Totox index is obtained from twice the peroxide index and the paraanisidine index, the results obtained are consistent with the values of the compounds obtained from the primary and secondary oxidation of the oil. Similar results have been reported for fennel extract in soybean oil [45], pea pod extract in sunflower oil [37], lettuce waste extract in Talwa Oleimen [38] and scallion peel extract in sunflower oil [41].

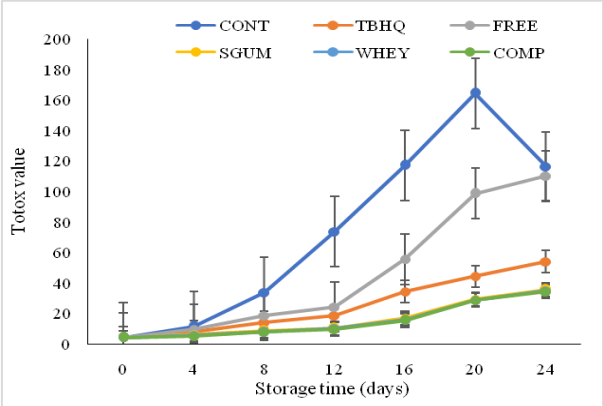

Fig 6 Change in the Totoxvalue of sunflower oil during storage.

4- The final conclusion

The antioxidant property of sage leaf extract in free form and micro-encapsulated in the coating of the gum of the seed of the city, whey protein isolate and their equal combination in order to increase the shelf life of sunflower oil under accelerated temperature conditions (60 degrees Celsius for 24 days) were investigated. took The results showed that sage leaf extract contains phenolic compounds equal to 31.12 mg of gallic acid per gram, and it showed antioxidant properties in beta-carotene: linoleic acid staining methods and oxidative stability. In the beta-carotene decolorization test, the antioxidant activity of sage leaf extract increased from 36.19% to 79.32% in concentrations of 50 and 250. The process of increasing the oxidative stability from the concentration of 50 to 250 mg/liter of the extract was from 3.25 hours to 4.96 hours. Performing the microencapsulation process using the gum of Gadumeh Shahri seed, whey protein isolate and their combination led to the protection of sage leaf extract during greenhouse storage of the oil under accelerated conditions, and microencapsulation was considered an effective method in increasing the antioxidant activity of the extract. In this respect, the synthetic antioxidant TBHQ was weaker than the finely coated sage extract in reducing the oxidation of sunflower oil, but it was better than the free extract. So that at the end of the 24th day of the storage period, the value of peroxide number and paraanisidine number in the oil samples containing synthetic antioxidant TBHQ was equal to 23.35 milliequivalents of oxygen per

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kilogram of oil, and 7.23, respectively. While these values are equal to 16.19 milliequivalents of oxygen per kilogram of oil and 3.23 for the oil samples containing nano-coated sage extract in the wall of urban Qadumeh seed gum, respectively, and for the oil samples containing micro-coated sage extract in the wall of water protein isolate. Cheese is equal to 15.76 milliequivalents of oxygen per kilogram of oil and 3.15 milliequivalents of oil, respectively, and for oil samples containing sage extract finely coated in the combined wall of urban Qadomoh seed gum and whey protein isolate, it is equal to 15.50 milliequivalents of oxygen, respectively. per kilogram of oil and it was 3.10. The results of this research show the use of sage leaf extract coated in the gum of the city Qadumeh seed and whey protein isolate as a natural antioxidant.

5-Resources

[1] Hojjati, M. (2021). Quality characteristics of oils prepared in lubrication stores in the presence of the customer. *Journal of Food Science & Technology (2008-8787), 17*(108), 1-15.

[2]Jafari, S. Z., Jafarian, S., Hojjati, M., Najafian, L. (2022). Evaluation of antioxidant activity of nano-and microencapsulated rosemary (Rosmarinus officinalis L.) leaves extract in cress (Lepidium sativum) and basil (Ocimum basilicum) seed gums for enhancing oxidative stability of sunflower oil. *Food science & nutrition*, 1-9.

[3] Seiler, G. J., Qi, L. L., Marek, L. F. (2017). Utilization of sunflower crop wild relatives for cultivated sunflower improvement. *Crop Science, 57*(3), 1083-1101.

[4] Deshpande, S. S. New York, USA. (2002). Toxic metals, radionuclides, and food packaging contaminants. 783-810.

[5] Ansari Vida, Amiri Sedigheh, Radi Mohsen, Foroud., B. (2020). Antioxidant activity of microemulsion extract of green tea in rapeseed oil. *Innovation in Food Science and Technology (Food Science and Technology, 11*(1), 97-110.

[6] Shahidi, F., & Ambigaipalan, P. J. (2015). Phenolics and polyphenolics in foods, beverages and spices: Antioxidant activity and health effects–A review. *18*, 820-897.

[7] Duthie, G. G., Gardner, P. T., Morrice, P. C., McPhail, D. B. (2016). The Contribution of dα-Tocopherol and dγ-Tocopherol to the AntioxidantCapacity of Several Edible Plant Oils. *8*(02), 41.

[8] Hojjati, M., & Alizadeh Behbahani, B. (2021). . Investigation of the effect of extraction method with water and methanol solvents on antioxidant and antimicrobial properties of red plant extract: In vitro study. . *Iranian Food Science & Technology Research Journal*, *17*(2), *83-91*.

[9] Blasi, F., & Cossignani, L. (2020). An overview of natural extracts with antioxidant activity for the improvement of the oxidative stability and shelf life of edible oils. *Processes*, *8*(8), 956.

[10] Khazaei, K. M., Jafari, S., Ghorbani, M., Kakhki, A. H. (2014). Application of maltodextrin and gumArabic in microencapsulation of saffron petal's anthocyanins and evaluating their storage stability and color. *Carbohydrate polymers*, *105*, 57-62.

[11] Razavi, R., Kenari, R. E. (2021). Antioxidant evaluation of Fumaria parviflora L. extract loaded nanocapsules obtained by green extraction methods in oxidative stability of sunflower oil. *Journal of Food Measurement and Characterization*, *15*, 2448-2457.

[12] Ghasemloo, E., Rahnema, M., Bigdeli, M. (2015). The effect of hydroalcoholic extract of salvia officinalis on brain edema and neurologic deficits in rat stroke model.*Journal of Rafsanjan University of Medical Sciences*, *15* (2), 139-150.

[13] Nutrizio, M., Kljusurić, J. G., Sabolović, M. B., Kovačević, D. B., Šupljika, F., Putnik, P., Maltar-Strmečki, N. (2020). Valorization of sage extracts (Salvia officinalis L.) obtained by high voltage electrical discharges: Process control and antioxidant properties. *Innovative Food Science & Emerging Technologies*, *60*, 102284.

[14] Razavi, R., Kenari, R. E., Farmani, J., Jahanshahi, M. (2020). Fabrication of zein/alginate delivery system for nanofood model based on pumpkin. *International journal of biological macromolecules*, *165*, 3123-3134.

[15] Lu, W., Kelly, A. L., Miao, S. (2016). Emulsion-based encapsulation and delivery

[DOR: 20.1001.1.20088787.1402.20.136.8.6]
[DOI: 10.22034/FSCT.20.136.91]

[DOR: 20.1001.1.20088787.1402.20.136.8.6]

[DOI: 10.22034/FSCT.20.136.91]

systems for polyphenols. *Trends in food science & technology, 47*, 1-9.

[16] Esfanjani, A. F., Jafari, S. M., Assadpoor, E., Mohammadi, A. (2015). Nano-encapsulation of saffron extract through double-layered multiple emulsions of pectin and whey protein concentrate. *Journal ofFood Engineering, 165*, 149-155.

[17] Lim, H.-K., Tan, C.-P., Bakar, J., (2012). Effects of different wall materials on the physicochemical properties and oxidative stability of spray-dried microencapsulated red-fleshed pitaya (Hylocereus polyrhizus) seed oil. *5*(4), 1220-1227.

[18] Gharsallaoui, A., Roudaut, G., Chambin, O., Voilley, A., Saurel, R. J. F.(2007). Applications of spray-drying in microencapsulation of food ingredients: An overview. *40*(9), 1107-1121.

[19] Shu, B., Yu, W., Zhao, Y., Liu, X. (2006). Study on microencapsulation of lycopene by spray-drying. *76*(4), 664-669.

[20] Sun, C., Gunasekaran, S., Richards, M. P (2007). Effect of xanthan gum on physicochemical properties of whey proteinisolate stabilized oil-in-water emulsions. *21*(4), 555-564.

[21] Mohammadi, A., Jafari, S. M., Esfanjani, A. F., Akhavan, S. (2016). Application of nano-encapsulated olive leaf extract in controlling theoxidative stability of soybean oil. *Food Chemistry, 190*, 513-519.

[22] Tavares, L., Noreña, C. P. Z. (2019). Encapsulation of garlic extract using complex coacervation with whey protein isolate and chitosan as wall materials followed by spray drying. *Food Hydrocolloids, 89*, 360-369.

[23] Ghobadi, M., Koocheki, A., Varidi, M.J., Varidi, M. (2021). Encapsulation of curcumin using grass pea (Lathyrus sativus) protein isolate/Alyssum homolocarpum seed gum complex nanoparticles.*Innovative Food Science & Emerging Technologies*, 102728.

[24] Doymaz, İ., Karasu, S. (2018). Effect of air temperature on drying kinetics, colour changes and total phenolic content of sage leaves (Salvia officinalis). *Quality Assurance and Safety of Crops & Foods, 10*(3), 269-276.

[25] Dias, L. S., Menis, M. E., Jorge, N. (2015). Effect of rosemary (Rosmarinus officinalis) extractson the oxidative stability and sensory acceptability of soybean oil. *Journal of the Science of Food and Agriculture, 95*(10), 2021-2027.

[26] Upadhyay, R., Mishra, H. N. (2015). Multivariate analysis for kinetic modeling of oxidative stability and shelf life estimation of sunflower oil blended with sage (Salvia officinalis) extract under Rancimat conditions. *Food and Bioprocess Technology, 8*(4), 801-810.

[27] Chen, X., Zhang, Y., Zu, Y., Yang, L., Lu, Q., Wang, W. (2014). Antioxidant effects of rosemary extracts on sunflower oil compared with synthetic antioxidants. *International Journal of Food Science & Technology, 49*(2), 385-391.

[28] Kontogianni, V. G., Kasapidou, E., Mitlianga, P., Mataragas, M., Pappa, E., Kondyli, E., Bosnea, L. (2022). Production, characteristics and application of whey protein films activated with rosemary and sage extract in preserving soft cheese. *LWT, 155*, 112996.

[29] Bahramikia, S., Yazdanparast, R. (2008). Effect of hydroalcoholic extracts of Nasturtium officinale leaves on lipid profile in high-fat diet rats. *115*(1), 116-121.

[30] Farhoosh, R., Tavakoli, J., Khodaparast, M. H. H. (2008). Chemical composition and oxidative stability of kernel oils from two current subspecies of Pistacia atlantica in Iran. Joural of American oil chemistrysociety, 85(8), 723.

[31] Kaviarasan, S., Sivakumar, A., Barik, A., Kunwar, A., Naik, G., Priyadarsini, K. (2011). Potent radical scavenging ability of sunphenon: a green tea extract. Journalof Food Biochemistry, 35(2), 596-612.

[32] Tavakoli, J., Hajpour Soq, K., Yousefi, A., Estakhr, P., Dalvi, M., Mousavi Khaneghah, A. (2019). Antioxidant activity of Pistacia atlantica var mutica kernel oil and it's unsaponifiable matters.*Journal of Food Science and Technology*, 56(12): p. 5336-5345.

[33] Ganji, S., Sayyed-Alangi, S. Z. (2017). Encapsulation of ginger ethanolic extract in nanoliposome and evaluation of its antioxidant activity on sunflower oil. *Chemical Papers, 71*(9), 1781-1789.

[34] Esmaeilzadeh Kenari, R., Amiri, Z. R., Motamedzadegan, A., Milani, J. M., Farmani, J., & Farahmandfar, R. (2020). Optimization of Iranian golpar (Heracleum persicum) extract

encapsulation using sage (Salvia macrosiphon) seed gum: chitosan as a wall materials and its effect on the shelf life of soybean oil during storage. *Journal of Food Measurement and Characterization*, 1-12.

[35] Rezaei Savadkouhi, N., Ariaii, P., Charmchian Langerodi, M. (2020). The effect of encapsulated plant extract of hyssop (Hyssopus officinalis L.) in biopolymer nanoemulsions of Lepidium perfoliatum and Orchis mascula on controlling oxidative stability of soybean oil. *Food science & nutrition, 8*(2), 1264-1271.

[36] Roshanpour, S., Tavakoli, J., Beigmohammadi, F., Alae, SH. (2021). Improving antioxidant effect of phenolic extract of Mentha piperita using nanoencapsulation process. *Journal of Food Measurement and Characterization*, 15(1): p. 23-32.

[37] Ganjloo, A., Bi Maker, M., Ghorbani, M. (2018). Investigation of the effect of pea pod extract on the oxidative stability of sunflower oil under accelerated conditions. . *Journal of Food Processing and Storage, 10*(2), 19-32.

[38] Elhami Rad, A. H., Ghavami, M., Moridi Farimani, M., Armin, M. (2017). Extraction of antioxidant extract from lettuce waste by ultrasound and evaluation of its antioxidant activity. *Food Science and Nutrition, 14*(1), 21-38.

[39] Esmaeilzadeh Kenari, R., Razavi, R. (2022). Phenolic profile and antioxidant activity of free/bound phenolic compounds of sesame and properties of encapsulated nanoparticles in different wall materials. *Food science & nutrition, 10*(2), 525-535.

[40] Estakhr, P., Tavakoli, J., Beigmohammadi, F., Alae, SH (2020). Incorporation of the nanoencapsulated polyphenolic extract of Ferula persica into soybean oil: Assessment of oil oxidative stability. Food Science & Nutrition, 1(2), 1-10..

[41] Akhli Somayeh, Mirzaei Habibullah, Ibrahim., H. S. (2022). "Study of extraction of cranberry fruit extract by two methods of massage and ultrasound and its use in sunflower oil stabilization. Food Science and Nutrition, 19(1), 15-36.

[42] Faria, W. C. S., Oliveira, M. G., da Conceição, E. C., Silva, V. B., Veggi, N., Converti, A. Bragagnolo, N. (2020). Antioxidant efficacy and in silico toxicity prediction of free and spray-dried extracts of green Arabica and Robusta coffee fruits and their application in edible oil. *Food Hydrocolloids*, 106004.

[43] Chong, Y. M., Chang, S. K., Sia, W. C. M., Yim, H. S. (2015). Antioxidant efficacy of mangosteen (Garcinia mangostana Linn.) peel extracts in sunflower oil during accelerated storage. *Food bioscience, 12*, 18-25.

[44] Zhang, Y., Yang, L., Zu, Y., Chen, X., Wang, F., Liu, F. (2010). Oxidative stability of sunflower oil supplemented with carnosic acid compared with synthetic antioxidants during accelerated storage. *Food Chemistry, 118*(3)(3)8, 6256-662.

[45] Mazaheri Kalhoroodi, M., Basiri, A., Jalali Hossein. (2014). Investigation of antioxidant properties of fennel seed essential oil (Foeniculum vulgare) and its effect on oxidative stability of soybean oil. *Iranian Biosystems Engineering (Iranian Agricultural Sciences). 45*(2), 131-139 [In Persian].

[DOR: 20.1001.1.20088787.1402.20.136.8.6]

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تاثیر نوع پوشش بیوپلیمری بر خصوصیات پاداکسندگی عصاره مریم گلی نانوریزپوشانی شده جهت افزایش پایداری روغن آفتابگردان در شرایط دمایی تسریع شده

بهناز صفرپور[۱]، رضا اسماعیل زاده کناری[۲*]، جمشید فرمانی[۳]

۱- دانشجوی دکتری گروه مهندسی علوم و صنایع غذایی ،دانشکده مهندسی زراعی، دانشگاه علوم کشاورزی و منابع طبیعی ساری، ساری، ایران.

۲- استاد گروه مهندسی علوم و صنایع غذایی، دانشکده مهندسی زراعی، دانشگاه علوم کشاورزی و منابع طبیعی ساری، ساری، ایران.

۳- دانشیار گروه مهندسی علوم و صنایع غذایی، دانشکده مهندسی زراعی، دانشگاه علوم کشاورزی و منابع طبیعی ساری، ساری، ایران.

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* مسئول مکاتبات:

Reza_kenari@yahoo.com

چکیده

روغن آفتابگردان یکی از مهم‌ترین روغن‌های گیاهی و با ارزش تغذیه‌ای بالا است که متاسفانه به دلیل غیر اشباعیت به اکسایش حساس می‌باشد. در این پژوهش عصاره برگ مریم گلی با استفاده از فراصوت حمام و حلال اتانول:آب (۷۰:۳۰) در دمای ۳۵ درجه سانتیگراد و به مدت ۳۰ دقیقه در ۳۵KHz عصاره‌گیری شد. میزان ترکیبات فنولی عصاره ۳۱/۱۲ میلی گرم گالیک اسید بر گرم بود. فعالیت پاداکسندگی غلظت‌های ۵۰، ۱۰۰، ۲۰۰ و ۲۵۰ ppm از عصاره برگ مریم گلی از طریق روش بیرنگ شدن بتاکاروتن/لینولئیک اسید و پایداری اکسایشی اندازه گیری شد. نتایج نشان داد با افزایش غلظت عصاره فعالیت پاداکسندگی و پایداری اکسایشی افزایش یافت. عصاره برگ گیاه مریم گلی (۲۵۰ ppm) برای ریزپوشانی در دیواره صمغ دانه قدومه شهری/ایزوله پروتئینی آب پنیر با نسبت‌های ۱:۰، ۱:۱ و ۰:۱ مورد استفاده قرار گرفت. اندازه ذرات نانوکپسول بین ۲۱۷/٤ و ۲۷۰/۰ نانومتر متغیر بود و نانوکپسول تهیه شده از قدومه شهری بزرگ‌ترین اندازه و نانوکپسول تهیه شده از پوشش صمغ و ایزوله پروتئینی کوچک‌ترین اندازه را داشتند. به منظور تشدید فرآیند اکسایش، روغن آفتابگردان بدون پاداکسنده، روغن‌های حاوی عصاره آزاد، ریزپوشانی شده و TBHQدر آون در دمای ٦۰ درجه سانتیگراد به مدت ۲٤ روز قرار گرفت. اندیس پراکسید، پارا آنیزیدین و توتوکس نمونه‌ها اندازه‌گیری شد. نتایج نشان داد اکسیداسیون روغن در نمونه‌های حاوی عصاره ریزپوشانی شده برگ گیاه مریم گلی کمتر از نمونه شاهد، نمونه حاوی عصاره آزاد و TBHQاست. به طوریکه در پایان روز ۲٤ دوره نگهداری مقدار اندیس پراکسید، پاراآنیزیدین و توتوکس در نمونه‌های روغن حاوی عصاره نانوریزپوشانی شده کمتر از روغن حاوی پاداکسنده سنتزی TBHQ و عصاره آزاد بود. همچنین در بین دیواره‌های استفاده شده برای ریزپوشانی عصاره مریم گلی، دیواره ترکیبی از جنس صمغ قدومه شهری و ایزوله پروتئینی آب پنیر بهترین پوشش برای ریزپوشانی عصاره به منظور افزایش عمر ماندگاری روغن آفتابگردان می‌باشد.