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Eco-Friendly Synthesis of Selenium and Zinc Nanoparticles with Biocompatible *Sargassum latifolium* Algae Extract in Preservation of Edible Oils

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ABSTRACT

The antioxidant activity of *Sargassum latifolium* algae extract as well as the eco-friendly synthesis of selenium and zinc nanoparticles with biocompatible *Sargassum latifolium* extract were studied in the current research. Selenium and zinc nanoparticles showed a spherical shape and had an average particle size of 22.31 to 95.16nm when they are studied using transmission electron microscope. HPLC technique was used to identify the phenolic components in *Sargassum latifolium* algae extract, myricetin was the predominant polyphenol in concentration of 139.63 ppm, followed by neringein, kampherol, rosemarinic acid, salicylic acid and quercitin in concentrations of 51.89, 38.20, 30.10, 27.95, and 18.07 ppm, respectively. While, the rest of polyphenols were ranged from 12.95 ppm for p-coumaric acid to 1.45 ppm for ferulic acid. On the other hand, quinol, catechol, chlorgenic, vanillin, rutin, ellagic acid, and cinnamic acid were absent in the algae extract. *Sargassum latifolium* algae extract as well as synthesis selenium and zinc nanoparticles were added as natural antioxidants to corn and soybean oils in concentrations of 200, 400, and 800 ppm and its antioxidant activity was compared with TBHQ as synthetic one. Rancimat time at 110ºC which indicated that induction period of control oils were varied from10.70 and 5.53 hours for corn oil and soybean oil, respectively. However, the treated samples with TBHQ exposed from 13.30 to 7.03 hours for both oils, respectively. Addition of *Sargassum latifolium* algae extract with different concentrations increase the induction periods to 28.95 and 9.87 hours for corn and soybean oils, respectively. The highest stability times were achieved when corn and soybean oils were treated with synthesis selenium nanoparticles at a concentration of 800 ppm, which were 31.78 and 12.50 hours, respectively. Synthesis zinc nanoparticles could be involved in the bio-reduction reaction in a concentration of 800 ppm to prevent oils oxidation and rancidity as reported for 26.00 and 11.13 hours for corn and soybean oils, respectively. So, *Sargassum latifolium* algae extract as well as selenium and zinc nanoparticles could be recommended as natural antioxidant for both corn and soybean oils due to their advantage effects on the oxidative and thermal stabilities of these oils.

Keywords: *Sargassum latifolium*, algae, oil preservation, antioxidant, selenium, zinc, nanoparticles

INTRODUCTION

There is a growing interest in the use of renewable resources in the development of preserving oils from deterioration. The oxidative deterioration of fats and oils in foods is responsible for rancid odors and flavors, with a consequent decrease in nutritional quality and safety caused by the formation of secondary, potentially toxic, compounds. The addition of antioxidants is required to preserve flavor and color as well as to avoid vitamins destruction. For instance, one useful strategy to reduce food deterioration is based on the utilization of artificial antioxidants. The most often used artificial antioxidants to protect food products are butylated hydroxyl toluene (BHT), butylated hydroxyl anisole (BHA), tertiary butylhydroquinone (TBHQ), and propyl gallate (PG). But their use is restricted due to possible toxicity and carcinogenesis effects (Babbar *et al*., 2011). Natural antioxidant agents are increasingly perfect as food added substances because they are more beneficial, more secure than artificial ones, and more readily acceptable to consumers (El-Gammal, 2016).

Corn oil is considered nutritious due to its high content of polyunsaturated fatty acids (PUFA), mainly linoleic acid (18:2). However, due to its high PUFA content, it is even more susceptible to oxidative degradation leading to rancidity, off-flavors, and discoloration (Baştürk *et al*., 2018). Soybean oil presents a good nutritional profile due to its composition rich in PUFA. Alone or in a mixture, soybean oil is commonly used for frying as well as for cooking. However, this makes it unstable under heating conditions resulting in a rapid quality deterioration following the oxidation process (Cheng *et al*., 2017). When the soybean oil was exposed to high temperatures, new oxidant compounds is very rapid formed such as hydro-peroxides which are rapidly decompose at temperature above 150ºC faster than their formation process and this explain its absent at higher temperature (Marmesat *et al*., 2010).

One of the most important functions of selenium and zinc is their roles as an antioxidant and their abilities to reduce the risk of cancer. Selenium and zinc play an active role in protecting heart health and strengthening the immune system. It also preserves the health of red blood cells by preventing accumulation and plaque in blood veins. It should be noted that although selenium and zinc acting as an antioxidant, its primary function is as an element or as a building stone or as a compound in the formation of an enzyme glutathione (peroxidase glutathione) known to protect cells from damage and that means that the selenium and zinc to be able to convert the atoms of the free radicals contributes to lower rates of cancer, it also protects against skin damage and skin cancer and reduces inflammation skin (Prasad, 2018).

Nanotechnology is defined as the study and use of structures between 1 nanometer and 100 nanometers in size. Scientists have been studying and working with nanoparticles for centuries, but the effectiveness of their work has been hampered by their inability to see the structure of nanoparticles. In recent decades the development of microscopes capable of displaying particles as small as atoms has allowed scientists to see what they are working with. The ability to see nano-sized materials has opened up a world of possibilities in a variety of industries and scientific endeavors.

Nanotechnology is helping to considerably improve, even revolutionize, many technology and industry sectors: information technology, homeland security, medicine, transportation, energy, food safety, and environmental science, among many others (Rashid and Ahmad, 2019).

Sargassum is a genus of brown seaweed (Phaeophyceae) in the Sargassaceae family, contains approximately 400 species (Mattio and Payri, 2011). Sargassum is found throughout all oceans and consumed as food and medicines in many cultures. Bioactive compounds such as meroterpenoids, phlorotanins, fucoidans, sterols and glycolipids, have been identified from this genus. A wide range of pharmacological properties of the Sargassum spp. extracts or isolated pure components have been recognized. These include anticancer, antibacterial, antifungal, anti-viral, anti-inflammatory, anticoagulant, antioxidant, hypoglycaemic, hypolipidemic, antimelanogenic, anti-boneloss, hepatoprotective and neuroprotective activities which suggests that Sargassum is a rich source of health maintaining and promoting agents (Iqbal *et al*., 2008). Though, Sargassum species are considered as a potential renewable marine resource for many biotechnological applications (Mason *et al*., 2012).

So, the current study was performed to evaluate the *Sargassum latifolium* algae extract as well as the eco-friendly bio-synthesis of selenium and zinc nanoparticles with biocompatible *Sargassum latifolium* algae extract as natural antioxidants and compared its effect with TBHQ on the stabilities of both corn and soybean oils.

MATERIALS AND METHODS

Materials

Algae *Sargassum latifolium* was collected from the red sea through National Institute of Oceanography and Fisheries in Hurghada (NIOF). Then, raw algae was washed with distilled water and dried in shade away from sunlight to final moisture content was set to 8.5 ± 0.5% according to El-Refai *et al*, (2018).

Selenium dioxide (SeO_2, Merck Schuchardt OHG, Germany), zinc sulphate ($ZnSO_4$, BDH Chemical Co., England) were purchased from El-Nasr Pharmaceutical Chemicals Company, Mansoura, Egypt.

Refined, bleached, and deodorized (RBD) corn oil, soybean oil (mixed of both soybean and sunflower oil in recommended manufacturing ratios for edible oils), and tertiary butylhydroquinone (TBHQ) were kindly gift form Arma Company for Oils, 10th of Ramadan City, Egypt.

Preparation of investigated algae extract.

Sargassum latifolium algae extract was prepared at Agricultural Chemistry Department, Faculty of Agriculture, Mansoura University, Mansoura, Egypt, according to the previously described method by Dent *et al.,* (2013). Accurately 100g of algae powder was soaked in 1L of ethanol (30%) and the extraction were performed in a water bath shaker (Memmert WB14, Germany) at 60°C for 30 minutes. After that, it was filtered using No. 1 Whatman filter paper in Büchner funnel. Afterwards, the filtrate volume was adjusted to a litter with deionized H_2O and stored at -18°C till use.

Fractionation and identification of phenolic compounds for *Sargassum latifolium* algae extract.

Phenolic compounds were identified using high performance liquid chromatography (HPLC) Technique at Food Safety and Quality Control (FSQC) Laboratory, Faculty of Agriculture, Cairo University, Egypt, according to Yang *et al*., (2013). Retention time and peak area were used to calculate the concentrations of phenolic compounds content by analyzing the data of Hewllet packed software.

Synthesis of selenium and zinc nanoparticles

The metals of selenium and zinc nanoparticles were prepared at Agricultural Chemistry Department, Faculty of Agriculture, Mansoura University, Mansoura, Egypt, as indicated by the technique depicted by Devasenan *et al*., (2016). An aqueous solution of metal salts, such selenium and zinc sulfate with a concentration of 1 mmol was prepared utilizing deionized H_2O. The response blend was held under mixing for 2 hours at room temperature. The subsequent nanoparticles were incorporated in an equimolar proportion of (1:1) for both selenium and zinc nanoparticles.

Nanoparticles characteristic *via* UV-Vis spectroscopy

Pure selenium and zinc ions reduction as well as the coverage of the resulting nanoparticles were monitored according to El-Refai *et al*, (2018) using the ATI Unicom UV-Vis Spectrophotometer at Faculty of Science, Mansoura University, Mansoura, Egypt.

Nanoparticles characteristic *via* transmission electron microscope (TEM)

The obtained nanoparticles physical properties and morphological data were characterized using transmission electron microscopy, TEM (JEOL TEM-2100) at Electron Microscope Unit, Central Laboratory, Fact. of Agric., Mansoura Univ., Mansoura, Egypt (El-Refai *et al*, 2018).

Nanoparticles characteristic *via* Zeta potential.

Zeta potential analysis is a technique for determining the surface charge of nanoparticles in suspensions using Malvern Instruments Ltd Zeta Potential Ver. 2.3 according to Bhattacharjee (2016) at Electron Microscope Unit, Central Laboratory, Fact. of Agric., Mansoura Univ., Mansoura, Egypt.

Oxidative stability of corn and soybean oils by rancimat method

The oxidative stability of oil samples was determined by rancimat method using Metrohm 892 and induction period (IP) was conducted with rancimat at 110˚C for both oil samples using three concentrations of 200, 400, 800ppm compared with TBHQ in recommended manufacturing concentration of 200ppm. For simplicity, all treatments were distributed to four treatments namely, T1: Oil treated with Algae extract, T2: Oil treated with Algae+SeNP, T3: Oil treated with Algae+ZnNP and T4: Oil treated with TBHQ.

The oxidative stability of oil samples was determined according to AOAC (1997) at Food Technology Research Institute (FTRI), Agricultural Research Center (ARC), Egypt. All the samples were studied at the same temperatures of 110˚C under a constant air flow (20 L/h). The induction periods [h] were printed automatically by the apparatus software with the accuracy of 0.005. During the rancimat test, oil samples were taken and content of primary oxidation products (PV) generated during heating and aeration was tested.

RESULTS AND DISCUSSION

Oils and fats peroxides are produced from reaction of unsaturated fatty acids with oxygen molecules, which resulting problems in the manufactures of oils and fats. Oxidation does not cause deterioration of the quality of oils and fats but causes chemical damage resulting in free radicals, which lead to the staining of oils and fats. Antioxidants play a role in the protection of oils and fats from oxidation by interaction with free radicals, or oxygen in the food, or act as a solvent for metals. Antioxidant activity depends on the structure of the molecule and the number of hydroxyl groups and its location in polyphenols structure (Kim, 2005).

Marine organisms are a rich source of novel and biologically active metabolites, producing potential bioactive compounds of interest in the pharmaceutical industry. Phenol compounds suggested to be the major bioactive components of algal cells and could have an activating or inhibiting effects on microbial growth depending on their constitution and concentration (Moubayed *et al*., 2017).

Fractionation and identification of phenolic compounds for *Sargassum latifolium* algae extract.

In this investigation, twenty four authentic polyphenol compounds were used to identify the phenolic compounds content in *Sargassum latifolium* algae extract. Data in Table (1) showed the quantitative analysis of polyphenols in *Sargassum latifolium* algae extract by HPLC technique. It could be noticed that myricetin was the predominant polyphenol in concentration of 139.63 ppm, followed by neringein, kampherol, rosemarinic acid, salicylic acid and quercitin in concentrations of 51.89, 38.20, 30.10, 27.95 and 18.07 ppm, respectively. While, the rest of polyphenols were ranged from 12.95 ppm for p-coumaric acid to 1.45 ppm for ferulic acid. On the other hand, quinol, catechol, chlorgenic, vanillin, rutin, ellagic acid and cinnamic acid were absent in *Sargassum latifolium* algae.

The current tendency is to replace the artificial antioxidents like Butylated hydroxyanisole (BHA) and Butylated hydroxyl toluene (BHT) etc. with phenolic compounds extracted from natural sources with comparable antioxidant power and better safety attributes. The antioxidant power of caffeic acid for example was well substantiated scientifically was found to have better stabilizing effect than BHA on the thermal oxidation of cod liver oil (Mathew *et al*., 2015).

The phenolic compound antioxidant activity is reasonably related to the substitutions on the aromatic ring and the structure of the side chain. The structure antioxidant activity relationship approach is considered to be useful for food, cosmetic, and pharmaceutical applications as it provides evidence about the potency of natural phenolic constituents (Bountagkidou *et al.* 2010).

A previous agreement study (Liu *et al*., 2012) reported that the extraction percentage of phenolic compounds from plants are highly depends on the extraction solvent nature. In addition, the extract phenolic content presented a positive relationship with their antioxidant capacities.

Table 1. Fractionation and identification of phenolic compounds for *Sargassum latifolium* algae extract.

Compound	Concentration [ppm]
Pyrogallol	8.96
Quinol	-
Gallic acid	3.99
Catechol	-
p-Hydroxy benzoic acid	7.38
Caffeine	4.48
Chlorgenic acid	-
Vanillic acid	3.86
Caffeic acid	2.62
Syringic acid	2.02
Vanillin	-
p-Coumaric acid	12.95
Ferulic acid	1.45
Benzoic acid	11.72
Rutin	-
Ellagic acid	-
o-Coumaric acid	3.76
Salicylic acid	27.95
Myricetin	139.63
Cinnamic acid	-
Quercitin	18.07
Rosemarinic acid	30.10
Neringein	51.89
Kampherol	38.20
Total	369.01

Nanoparticles characteristic *via* UV-Vis spectroscopy

The biopreparation of the nanoparticles has been explained by checking the UV–Vis spectra. According to Fig. (1), the greatest assimilation crest, recorded at 280 nm, is because of the trademark surface plasmon reverberation of the delivered metal nanoparticles. The readied selenium and zinc nanoparticles were observed to be entirely steady because of conceivable nearness of polyphenolic mixes present in the green growth remove that counteract amassing. Polyphenols are a cell reinforcement operator with explicit concoction structure has a basic job in the decrease procedure for blend of metal nanoparticles. The properties of orchestrated nanoparticles were analyzed as a component of UV illumination. The utilization of UV–Vis spectroscopic investigation is a viable strategy for exhibiting the nearness of metal nano-structures [Sun *et al*., (2002) and Darroudi *et al*., (2011)]. The UV illumination job was affirmed to depict the advancement of selenium and zinc decrease within the sight of green growth remove at surrounding temperature.

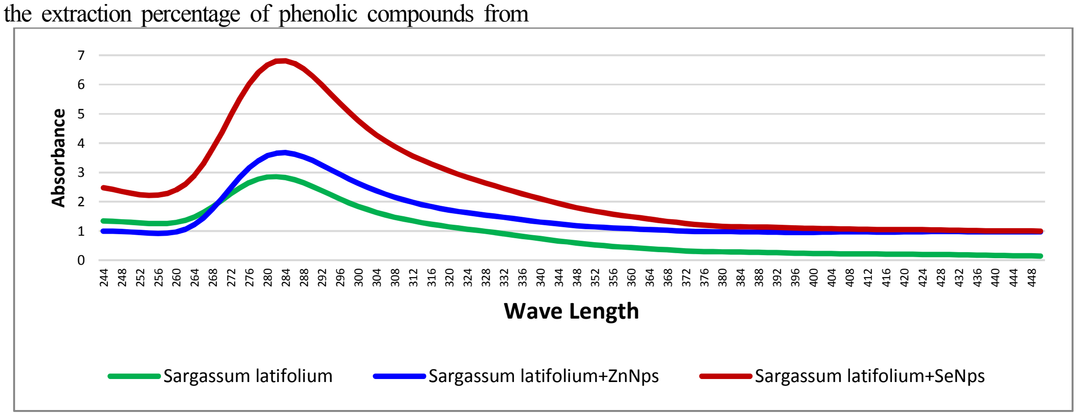

Fig. 1. UV-Vis spectroscopic measurements of *Sargassum latifolium* algae extract and its nanoparticles.

Nanoparticles characteristic *via* transmission electron microscope (TEM)

Selenium and zinc nanoparticles that were synthesized by different methods have diverse chemical as well as physical properties, such as high photostability, coefficient of electrochemical coupling, wide radiation absorption range, and chemical stability. The varieties of selenium and zinc nanoparticles applications had been confirmed to be depending on controlling their physical as well as chemical properties, e.g. surface condition, size, shape, size dispersion, and crystalline structure (Salih *et al*., 2016).

Nanoparticles prepared using algae extract were characterized by TEM measurements to evaluate the SeNP and ZnNP presence. An estimation of the synthesized nanoparticles particles size, shape, and aggregation were done. Figures (2 and 3) show the conducted TEM at 100 nm magnification value for the synthesized nanoparticles. The particles size was ranged from 22.31 to 95.16 nm for both selenium and zinc nanoparticles. The shape of particles was spherical, smooth and granular shape with square aggregation and less numbers were tetragonal. Smaller particles causing more surface area which a reason to more effective responses. These results were in accordance with Diler *et al*., (2012) and Elumalai *et al*., (2015).

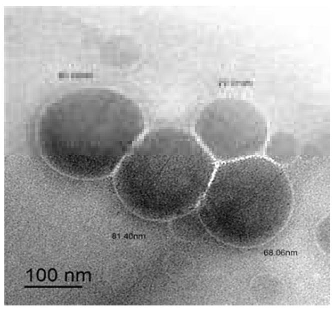

Fig. 2. TEM micrographs and size distributions for selenium nanoparticles synthesized by algae extract at 100nm magnification value.

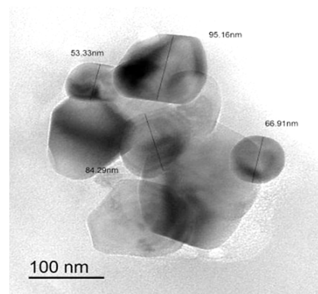

Fig. 3. TEM micrographs and size distributions for zinc nanoparticles synthesized by algae extract at 100nm magnification value.

Nanoparticles characteristic *via* Zeta potential

The nanoparticle surface state and prediction of the nanoparticle long term stability was understudying using Zeta Potential. The surface charge of the nanoparticle attracts a thin layer of opposite charge ions. Zeta Potential, the electric potential at the boundary of the double layer of ions travels, technique was used to determine the nanoparticles surface charge. Zeta potential has values that typically ranged from +100 mV to -100 mV. Figures (4 and 5) showed that synthesized selenium and zinc nanoparticles using algae extract has Zeta Potential value of -4.07 and -5.33 mV which were high stability because nanoparticles with Zeta potential values lower than +25 mV or greater than -25 mV typically have high degrees of stability as stated by Soheyla and Foruhe (2013).

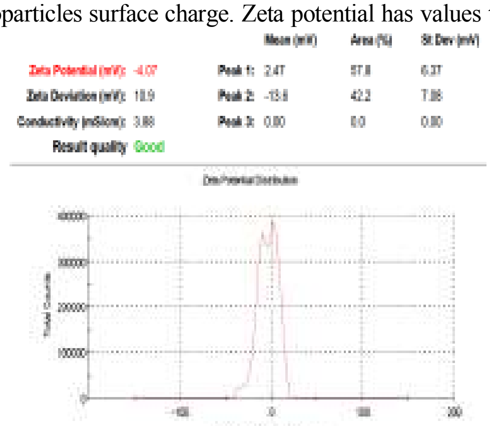

Fig. 4. Zeta potential distribution for Selenium nanoparticles synthesized by algae extract.

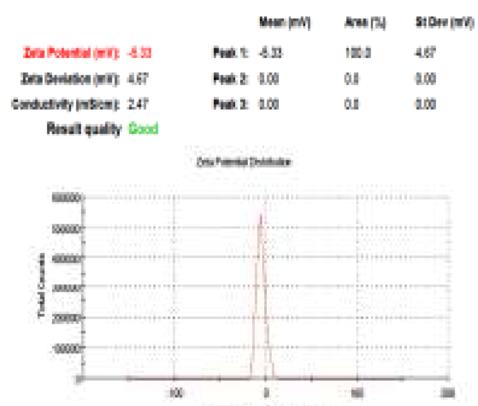

Fig. 5. Zeta potential distribution for zinc nanoparticles synthesized by algae extract.

Oxidative stability of corn and soybean oils by rancimat method

The degree of oxidation resistance was measured with rancimat method. This method examines the edible oils oxidative stability as well as it predicts the induction period of the oil, which is represent the required time for the hydroperoxides, produced by the oil oxidation, decomposition (Sadoudi *et al*., 2014).

Data in Table (2) and Fig. (6) presented the induction periods at 110ºC for control and treated oils with *Sargassum latifolium* algae extract, biosynthetic selenium and zinc nanoparticles as natural antioxidants in concentrations of 200, 400 and 800 ppm, and TBHQ as artificial antioxidant in manufacture recommended concentration of 200 ppm. The induction period of control oils were varied from10.70 and 5.53 hours for corn oil and soybean oil, respectively. However, the treated samples with TBHQ exposed to 13.30 and 7.03 hours for corn oil and soybean oil, respectively.

From the same table and figure, it was clear that additions of *Sargassum latifolium* algae extract with different concentrations increase the induction periods to 28.95 and 9.87 hours for corn and soybean oils, respectively, comparing with control oils and treated oils with TBHQ. This antioxidant activity of the algae extract is related to its high content of bioactive flavonoid and phenolic compounds (Liu *et al*., 2012).

Corn and soybean oils treated with synthetic selenium nanoparticles with *Sargassum latifolium* extract at a concentration of 800 ppm showed the highest stability times, which were 31.78 and 12.50 hours of storage, respectively, compared to control and TBHQ-treated samples. This might be due to the fact that selenium nanoparticles bind to the essential compounds and the functional groups, so the phenolic, flavonoids, and terpenoids bound to the surface of the selenium nanoparticles. Also, the *Sargassum latifolium* algae extract improves the bio-reduction reaction when nanoparticles were biosynthesized.

Furthermore, from the same table, it could be detected that the biosynthesis of zinc nanoparticles with *Sargassum latifolium* algae extract can be involved with the biological reduction reaction in a concentration of 800 ppm which prevents the oxidation and rancidity of the oils as reports for the stability time of 26.00 and 11.13 hours for corn and soybean oils, respectively.

The effectiveness of the biosynthesized zinc nanopraticles could be explained according to Sagar Raut *et al*. (2013), who declared that the interaction between zinc and phenolic acids, e.g. cinnamic, caffeic, and ferrulic acids, are the main corresponding mechanism for zinc nanopraticles stabilization.

Table 2. Oxidative stability of corn and soybean oils by rancimat method

Samples	Induction Periods (hrs)										
	T1			T2			T3			T4	Control
	200 ppm	400 ppm	800 ppm	200 ppm	400 ppm	800 ppm	200 ppm	400 ppm	800 ppm	200 ppm	-
Corn oil	14.34	27.17	28.95	25.47	29.78	31.78	17.52	22.04	26.00	13.30	10.70
Soybean oil	5.96	8.50	9.87	9.04	11.50	12.50	6.29	9.46	11.13	7.03	5.53

Where: T1: Oil treated with Algae extract, T2: Oil treated with Algae+SeNP, T3: Oil treated with Algae+ZnNP and T4: Oil treated with TBHQ

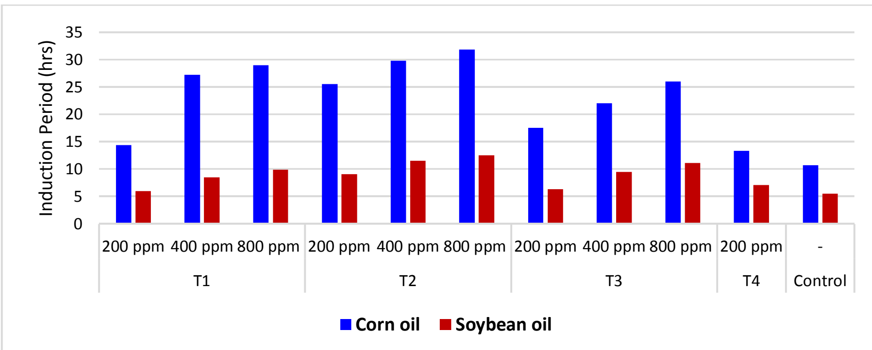

Fig. 6. Oxidative stability of corn and soybean oils by rancimat method.

CONCLUSION

From the present study, it could be concluded that *Sargassum latifolium* algae extract and eco-friendly biosynthesis of selenium and zinc nanoparticles with biocompatible *Sargassum latifolium* algae extract can stabilize corn and soybean oils very effectively in concentration of 800ppm followed by 400 and 200 ppm. They represent comparable stabilization efficiency against conventional synthetic antioxidants, i.e. TBHQ at its legal limit. It improves resistance of corn and soybean oils against thermal deteriorative changes. Besides this, polyunsaturated fatty acid content is saved appreciably by creating resistance in oil against oxidative rancidity. Therefore, on behalf of this study, *Sargassum latifolium* algae extract and synthesis of selenium and zinc nanoparticles can be recommended as a potential source of natural antioxidants for the stabilization of food stuff, especially unsaturated vegetable oils.

Conflict of Interest

The authors declare no conflict of interest.

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إستخدام التحضير الحيوى الصديق للبيئة من الجسيمات النانوية للسيلينيوم والزنك بمستخلص طحلب *Sargassum latifolium* في حفظ الزيوت الغذائية

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أجري هذا البحث بغرض دراسة النشاط المضاد للأكسدة في مستخلص طحلب *Sargassum latifolium* والتحضير الحيوى الصديق للبيئة من الجسيمات النانوية للسيلينيوم والزنك بمستخلص طحلب *Sargassum latifolium*. أظهرت الخواص التركيبية والبصرية للجسيمات النانوية بإستخدام الميكروسكوب الإلكتروني شكلاً كرويًا للجسيمات النانوية من السيلينيوم و الزنك ، وكان متوسط حجم الجسيمات ٢٢,٣١ إلى ٩٥,١٦ نانومتر. تم استخدام تقنية HPLC لتحديد المكونات الفينولية في مستخلص طحلب *Sargassum latifolium* ، وكان مركب ميرستين هو البوليفينول الغالب بتركيز ١٣٩,٦٣ جزء في المليون ، يليه ، نيرنجين ، كامفيرول ، حمض روزمارينيك ، حمض الساليسيليك ، كورسيتين بتركيزات ٥١,٨٩ و ٣٨,٢٠ و ٣٠,١٠ و ٢٧,٩٥ و ١٨,٠٧ جزء في المليون ، على التوالي. بينما تراوحت بقية البوليفينولات من ١٢,٩٥ جزء في المليون لحمض الكوماريك إلى ١,٤٥ جزء في المليون لحامض الفيروليك. من ناحية أخرى ، مركبات الكينول ، الكاتيكول ، الكلورنيك ، الفانيلين ، الروتين ، حمض الإلاجيك وحمض السيناميك لم تظهر في مستخلص طحلب *Sargassum latifolium*. تمت إضافة مستخلص طحلب *Sargassum latifolium* والجسيمات النانوية من السيلينيوم والزنك إلى زيوت الذرة وفول الصويا بتركيزات تتراوح بين ٢٠٠ و ٤٠٠ و ٨٠٠ جزء في المليون كمضادات أكسدة طبيعية مقارنة مع ثلاثي بوتيل هيدروكسي كوينون (TBHQ) كمضاد أكسدة صناعى. وبدراسة الثبات التأكسدى بطريقة الرانسيمات (rancimat) على درجة حرارة ١١٠ درجة مئوية مما يدل على أن فترة تخزين الزيوت تتراوح بين ١٠,٧٠ و ٥,٥٣ ساعة لزيت الذرة وزيت فول الصويا على التوالي ، مقارنة بالعينات المعاملة بـ TBHQ من ١٣,٣٠ إلى ٧,٠٣ ساعة. إضافة مستخلص طحلب *Sargassum latifolium* بتركيزات مختلفة يسبب زيادة فترات التخزين إلى ٢٨,٦٥ و ٩,٨٧ ساعة لزيوت الذرة وفول الصويا على التوالي. كما أظهرت زيوت الذرة وفول الصويا المعاملة بجزيئات السيلينيوم التخليقية مع مستخلص طحلب *Sargassum latifolium* بتركيز ٨٠٠ جزء في المليون أعلى أوقات الحفظ التي كانت ٣١,٧٨ و١٢,٥٠ ساعة من التخزين على التوالي. أظهرت الجسيمات النانوية للزنك المحضرة بمستخلص طحلب *Sargassum latifolium* عن طريق الاختزال الحيوي بتركيز ٨٠٠ جزء في المليون على منع أكسدة الزيوت لمدة ٢٦,٠٠ و ١١,١٣ ساعة على درجة حرارة ١١٠ درجة مئوية لزيوت الذرة وفول الصويا على التوالي. وعليه فإن إضافة الجسيمات النانوية للسيلينيوم والزنك المحضر بإستخدام مستخلص طحلب *Sargassum latifolium* إلى زيوت الذرة وفول الصويا أظهرت تأثيرًا إيجابيًا على الثبات التأكسدي والحراري لهذه المواد الخام ويمكن التوصية به كمضاد أكسدة طبيعى بديلاً عن مضادات الأكسدة الصناعية في الزيوت.