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Original article

Fabrication, characterisation and antimicrobial activity of electrospun *Plantago psyllium* L. seed gum/gelatine nanofibres incorporated with *Cuminum cyminum* essential oil nanoemulsion

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Summary *Plantago psyllium* L. seed gum (PPSG)/gelatine nanocomposites containing *Cuminum cyminum* essential oil (CCEO) were prepared via electrospinning, and the antibacterial properties of the electrospun nanofibres were assessed against *Staphylococcus aureus*. The nanoemulsion was prepared by adding CCEO to the PPSG/gelatine mixture and sonicated. Uniform nanofibres resulted from the nanoemulsion containing 1.5% PPSG, 8% gelatine and 3% CCEO, and no chemical reactions between the components of the electrospun nanofibres were detected. Growth inhibition zone diameter indicated that the electrospun nanofibres containing at least 3% CCEO had the most significant inhibitory effect on the growth of *S. aureus*. The electrospun PPSG/gelatine-CCEO nanocomposites are capable of being used as a biodegradable material in food packaging as well as in edible coatings for the preservation of food products.

Keywords Electrospun nanofibres, gelatine, nanoemulsion, *Plantago psyllium* L. seed gum, *Staphylococcus aureus*.

Highlights

- The electrospinnability of *Plantago psyllium* L. seed gum (PPSG) was improved by gelatine as a co-polymer for biodegradable nanocomposite production.
- CCEO-loaded electrospun nanofibres of PPSG/gelatine have high antimicrobial properties against *Staphylococcus aureus*.
- Incorporation of CCEO in the form of nanoemulsion in PPSG/gelatine electrospun nanofibres increased its stability.
- PPSG/gelatine electrospun nanofibres containing CCEO have high potential application in active food packaging and edible coating.

Introduction

Electrospinning involves using electrical forces to produce polymeric fibres (natural or synthetic) with diameters in the range of tens of nanometres, and it has major advantages compared to other common methods of producing films, composites or polymer fibres, including ease of work, affordability, applicability for a wide range of materials and high level of versatility (Ashammakhi *et al*., 2022). Electrospun polymer nanofibres have unique properties such as high surface-to-volume ratio, adjustable porosity and the capability of producing nanocomposite fibres (Wei *et al*., 2022). While most polymers can produce nanofibres, the development of biocompatible fibres is of high value. Natural polymers such as gelatine have better biocompatibility and are safer than synthetic polymers. Gelatine can be derived from collagen-related hydrolysis in the bones, skin, cartilage and soft animal tissues, including those that are prevalent in birds, livestock and water-dwelling animals. The considerable attention given to gelatine is due to its environmental compatibility, degradability and low cost. The high production capacity of electrospun gelatine nanofibres is due to the high proportion of proteins in their composition with a secondary structure of β-sheets. So, unlike short peptides and globular proteins, gelatine is a good choice for the production of uniform electrospun nanofibres. Due to its favourable thermal and mechanical properties, gelatine is a suitable material for the production of biodegradable

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nanocomposites and environmentally compatible bio-based products (Sakai *et al.*, 2018; Hajji *et al.*, 2022).

Recently, electrospinning native gums and mucilages originating from plants has attracted increasing interest. *Plantago psyllium* L. is an important source of natural mucilage, and the seed coat of this species is a rich source of water-soluble fibre. PPSG is a suitable source for producing edible films that are completely soluble in water regardless of the plasticisers (Halász *et al.*, 2022). Among the limited number of studies on the production of nanofibres from natural gums, Golkar *et al.* (2019) fabricated nanofibres from *psyllium major* seed gum using polyvinyl alcohol (PVA) as a co-polymer. Due to the synthetic nature of PVA and the difficulty in electrospinning of plant gums alone, the application of natural edible polymers such as gelatine, as an auxiliary polymer, could be highly suggested because of their good electrospinning capability.

Nanoencapsulation is a method for controlling the release of active agents such as antimicrobials, vitamins, fats and antioxidants. It involves introducing such substances as a core into nanostructures which not only carry and protect but also release them under specified conditions (Ashrafizadeh *et al.*, 2019). To incorporate an active compound with a polarity different from that of the continuous phase of nanofibres, the substance could first be nanoencapsulated, then trapped in the structure of the nanofibres through electrospinning. When the active ingredient is encapsulated in the structure of nanoemulsions, it functions more effectively compared to its free state. The antimicrobial activity of the nanoemulsions containing anise essential oil was higher than that of the free essential oil (Topuz *et al.*, 2016).

Cumin (*Cuminum cyminum*) is an annual, small, herbaceous plant that is ~60 cm tall. CCEO contains pinene, terpineol-alpha, apigenin, etc. which bring its unique aroma and are responsible for its antimicrobial properties (Motamedifar *et al.*, 2015). CCEO has a powerful antibacterial and antivirulence effect against multidrug-resistant *Staphylococcus aureus* through the mechanism of cell wall deformation and cell destruction (Sharifi *et al.*, 2021). *Staphylococcus aureus* is a microorganism that can be found mostly in food, and is one of the most common causes of food poisoning (Bigham *et al.*, 2021). Even though herbal extracts and essential oils have good potential for use in foods due to their antimicrobial and natural properties, their volatile nature usually limits their use in processed foods. Encapsulating the essential oils in the structure of nanoemulsions, then trapping them in nanofibres may be a solution (Afshar *et al.*, 2018). Therefore, this study was performed to produce PPSG/gelatine nanocomposites containing CCEO nanoemulsion. For this purpose, the electrospinning technique was employed, and the resulting nanocomposites were evaluated for their antimicrobial properties against *S. aureus*.

Materials and methods

Materials

The seeds of *P. psyllium* L. were purchased from a local grocery store. Type B gelatine (with a bloom of 220–240) was donated by Gelatin Halal Co. Tween 20, glacial acetic acid (100%), Baird parker agar and nutrient agar were supplied from Merck (Germany). *Cuminum cyminum* essential oil was purchased from Herbal Exir Co. *Staphylococcus aureus* (ATCC 29213) was provided by a microbiology laboratory. Double-distilled water was employed for the extraction of the gum and solution preparation.

Gum extraction

PPSG was extracted based on a previously reported method with slight changes (Behbahani *et al.*, 2017). The gum was extracted from the whole seeds of the plant with deionised water at 60:1 solvent:seed ratio at 75 °C. The slurry of the seed and water was agitated with an electrical paddle mixer during the whole process (30 min). For separating the mucilage from the swollen seeds, the seeds were passed through a domestic juicer. The obtained mucilage was filtered, dried in an oven at 45 °C overnight, grounded, packaged inside impermeable polyethylene bags and eventually kept under dry and cool conditions.

Preparation of PPSG/gelatine/CCEO nanoemulsion

The solutions of gelatine and PPSG were prepared as previously explained by Mohajeri *et al.* (2022). The solutions were combined with one another as a continuous phase. Various amounts of CCEO (1.5%, 3%, 4.5% and 6%) and Tween 20 (0.2%) were added as emulsifiers. The dispersions were blended and homogenised with a rotor–stator homogeniser at 8000 rpm for 5 min to get a homogeneous emulsion. The coarse emulsion was sonicated by an ultrasonic homogeniser equipped with a cylindrical titanium probe (19 mm in diameter) for 15 min at a frequency of 25 kHz and a maximal power output of 750 W. Water was circulated in the jacketed vessel to inhibit temperature increase above 25 °C.

Nanoemulsion droplet size distribution

The mean size and distribution of the droplets of the nanoemulsions were quantified through dynamic light scattering (DLS). The size of the droplets was determined at 25 °C. Three samples of each nanoemulsion were 10-fold diluted using ultrapure water and then introduced into the laser chamber. The refractive index (RI) of nanoemulsions was determined using an ATAGO refractometer model Master-22, and its value (1.330 for all CCEO concentrations) was entered in the settings of the DLS device to calculate the average droplet size.

Determination of flow behaviour

The apparent viscosity and flow behaviour of the samples were determined by a viscometer equipped with a heating water circulator and temperature jacket to keep the temperature constant at 25 ± 0.2 °C. The flow characteristics of the nanoemulsions were determined using a spindle in the shear rate range of 1–100 s^{-1}.

Electrospinning

The nanofibres were prepared using an electrospinning apparatus at ambient temperature. The device was composed of a high-voltage supply and a syringe pump with a feeding rate of 1–100 mL h^{-1}. The process parameters included PPSG concentration (1.5%), gelatine concentration (8%), CCEO concentrations (1.5%, 3%, 4.5% and 6%), voltage (18 kV), tip to collector distance (15 cm) and flow rate (1 mL h^{-1}).

Scanning electron microscopy

Scanning electron microscopy (SEM) was utilised to assess the morphology of the nanofibres. A sputter coater was used to apply an ultrathin layer of gold (20 nm) to the samples. Image J was used to quantify the average diameters of the nanofibres.

Fourier-transform infrared spectroscopy spectroscopy analysis

Fourier-transform infrared spectroscopy (FT-IR) was conducted in transmittance mode to analyse the chemical structure of pure gelatine, PPSG, CCEO and the PPSG/gelatine electrospun nanofibres containing CCEO. Two milligrams of each powdered sample was grounded with 100 mg of potassium bromide and pressed into pellets before the test. The spectra were recorded in a frequency range of 4000–400 cm^{-1}. For the acquisition of all spectra, the instrument was purged for 20–30 min with >99.99% analytical grade nitrogen gas to eliminate possible interferences from the air's carbon dioxide (CO_2) and atmospheric water vapour (H_2O).

CCEO release profile

To evaluate the controlled release profile of CCEO, same-size pieces of PPSG/gelatine mats (2 × 2 cm^2) were immersed into 25 mL ethanol:water solution at 50:50 ratio. During the immersion (48 h), 3 mL of the releasing medium was taken out every 6 h and replaced with 3 mL of fresh solution to maintain the constant volume. The amount of CCEO released was determined by using a Ultraviolet–Vis spectrophotometer at a wavelength of 260 nm (Dadras Chomachayi *et al.*, 2018).

Hydrophilicity and hydrophobicity measurements

The water contact angle of PPSG/gelatine nanocomposite containing different concentrations of CCEO was evaluated to determine the hydrophobicity of the samples. Firstly, the nanocomposite samples were cut into square samples (1 × 1 cm^2). Then, a drop of deionised water was placed on the centre of each sample. The angle between the water droplets and the fibre mat was measured using a digital camera and analysed by ImageJ software with four repetitions.

Antimicrobial activity of emulsion loaded with electrospun nanofibres

The antimicrobial activity of the nanofibres was quantified by disc diffusion in an agar medium. *Staphylococcus aureus* (29213 ATCC) was cultured in the specific culture medium, Parker agar board, for isolation. Next, it was brushed onto the nutrient agar medium. After 24 h, the medium was transferred to an incubator at 37 °C to prepare a standard 0.5 McFarland suspension whose absorbance value was set in the range of 0.08–0.1 at 630 nm using a spectrophotometer. To determine the antimicrobial activity, 10 µL of the resulting solution was cultured on a nutrient agar medium by the surface plate method. The nanofibres were loaded with the nanoemulsion containing CCEO at 1.5%, 3%, 4.5% and 6% (w/w), which were prepared in the form of discs (6 mm in diameter) using a sterile punch adjacent to a flame. Two discs of nanocomposite without nanoemulsified CCEO were prepared, and one of them was used as a control sample, while the other disc was immersed in pure CCEO for 5 s. They were placed on a plate by sterile forceps and incubated at 37 °C. After 24 h, the inhibition zone diameter of each sample was measured by a calliper with an accuracy of 0.02 mm.

Statistical analysis

All measurements were performed in triplicate. JMP software was applied for the analysis of the data through one-way analysis of variance (ANOVA) at 95% confidence level. All the data were expressed as mean ± standard deviation.

Results and discussion

Nanoemulsions droplet size and distribution

For all samples, the droplet sizes of the nanoemulsions were less than 100 nm, which increased with increasing concentration of CCEO (Fig. 1a). The increase in the nanoemulsion droplet sizes was probably due to the lowered level of the emulsifier contribution to the stabilisation of the CCEO droplets. Faraji *et al.* (2021) reported that at high oil volume fractions, the amount of emulsifier was insufficient to cover the newly formed oil particles, so that the small particles coalesced to form larger ones, thereby increasing the particle sizes of the emulsion. The small droplet sizes indicate that the essential oil was distributed evenly. Accordingly, the essential oil can have a homogeneous dispersion in the nanofibre. An emulsion system can be made more stable against phase separation when the droplet sizes of the emulsion become smaller (McClements, 2006), as the small sizes make them stable against coalescence and, the coalescence rate occurs more rapidly than the dispersed phase particle fusion and phase separation, which results from the force of the droplet weight. The smaller the size of the nanoemulsion particles, the easier its movement in the nozzle, which is accompanied by high shear force, and the nanoemulsion maintains its stability at the end of the nozzle, where a smaller amount of essential oil evaporates between the nozzle and the collector when leaving the nozzle, resulting in nanofibres with more effective substances (Coelho *et al.*, 2021).

Flow behaviour of PPSG/gelatine solution and nanoemulsion containing CCEO

For all samples, a rise in shear rate caused a decrease in apparent viscosity (Fig. 1b). Akbari *et al.* (2016) declared that the apparent viscosity of the emulsions containing whey protein, sage seed gum and sunflower oil decreased in response to the increase in shear rate. As the shear rate increases, the emulsion droplets move in the direction of the flow, thus reducing the resistance to flow and decreasing the apparent viscosity. The decline rate of the apparent viscosity was higher in the emulsions containing CCEO compared with the PPSG/gelatine solution (Fig. 1b) in which there is only one phase, and the spindle must pass through the aqueous phase containing the biopolymers. Meanwhile, an emulsion has both the aqueous and oil phases with a surfactant in between, so that the spindle can easily move between the molecules of the two phases, reducing the interfacial tension by the surfactant, which also decreases the flow resistance of the spindle. In fact, a decrease in the flow resistance against the spindle lowers the apparent viscosity. All samples were pseudoplastic or capable of being diluted by shear ($n < 1$). Fitting different rheological models to the shear stress–shear rate data showed that the power-law model best fitted to the rheological data of PPSG/gelatine/CCEO nanoemulsion and PPSG/gelatine solution because both the coefficient of determination (R^2) and root mean squared error (RMSE) of this model were smaller than others, while also lacking negative coefficients. Hematian Sourki *et al.* (2021) examined the flow properties of oil-in-water emulsions containing hull-less barley β-glucan and soy protein isolate. They realised that the power-law model was appropriate for explaining the flow behaviour of the emulsion samples.

The viscosity and flow behaviour of electrospinning solutions directly affect the quality of nanofibres. If the consistency of the solutions is high, it is difficult to draw the solution at the nozzle tip which affects the morphology and increases the size of nanofibres

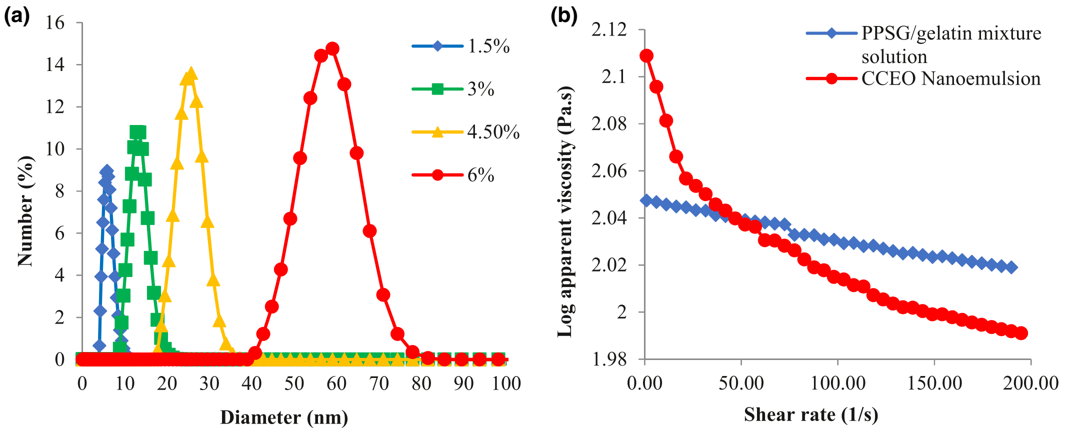

Figure 1 (a) Average particle size distribution of the nanoemulsion containing 8% gelatine, 1.5% PPSG and different concentrations of CCEO, (b) Apparent viscosity–shear rate profile of PPSG/gelatine mixture solution and nanoemulsion containing CCEO.

(Aydogdu *et al.*, 2019). The high thickness of nanofibres reduces their practical properties. The use of hydrocolloids in electrospinning solutions worsens this due to their thickening properties; therefore, the characteristics of the flow behaviour of the solutions should be examined before electrospinning, so that the solutions either have Newtonian or quasi-Newtonian flow behaviour or have a relatively low consistency.

Morphological characterisation of electrospun nanofibres

Electrospun nanofibres from nanoemulsions containing 8% gelatine, 1.5% PPSG and 3% CCEO were morphologically uniform and had no beads (Fig. 2a). The nanofibres produced from electrospinning the dispersion containing 8% gelatine and 1.5% PPSG were elongated and finely established with smooth and uniform surfaces with no beads (Fig. 2b). Although the fibres of the PPSG/gelatine solution had a linear elongated appearance, the nanofibres created a shuffled webbed network. Gordon *et al.* (2015) reported on producing hydrophilic nanofibres from nanoemulsion containing PVA *via* electrospinning, where axial dents were observed on the surface of the nanofibres upon the addition of oil droplets to polymer solution to create the nanoemulsion. Higher oil concentrations (>10.6 wt%) caused some of these dents to extend and disrupt the cylindrical shape of the nanofibres.

Nanofibre average diameter

The nanofibres from the electrospinning of PPSG/gelatine/CCEO and PPSG/gelatine solutions had an average diameter of 101.47 ± 2.71 nm and 93.80 ± 3.69 nm respectively. This indicated that adding the essential oil (as the dispersed phase) and surfactant to the polymer solution could increase the diameter of the nanofibres, which was probably due to the ability of CCEO to reduce the electrical conductivity and, thus, the length of the polymer jet during electrospinning. This can be considered a reason for the increase in the nanofibre diameterTavassoli-Kafrani *et al.* (2018) reported that the addition of orange essential oil to gelatine raised the average diameter of the cross-linked nanofibres. The diameter of the nanofibres obtained from the nanoemulsion was larger than that of the fibres manufactured from gelatine and gelatine–tannic acid. This could be due to the ability of orange essential oil to lower the electrical conductivity of solutions, as the decrease in electrical conductivity causes a reduction in the elongation of the polymer jet. Ultimately, these criteria and the effective voltage contribute to an increase in nanofibre diameter. Similarly, Dabbagh Moghaddam *et al.* (2019) reported on adding *Zataria multiflora* essential oil to zein polymer solution to produce a nanoemulsion, whereby the electrospun nanofibres showed a significant increase in diameter.

Fourier-transform infrared spectroscopy

FT-IR absorption bands of pure gelatine at 1644 and 1546 cm^{-1} correspond with amide I and amide II respectively (Fig. 3a). These bands were also observed in the electrospun nanofibres of PPSG/gelatine, indicating the absence of a chemical reaction between gelatine and PPSG, as well as no particular change in their chemical structures. These bands confirm the presence

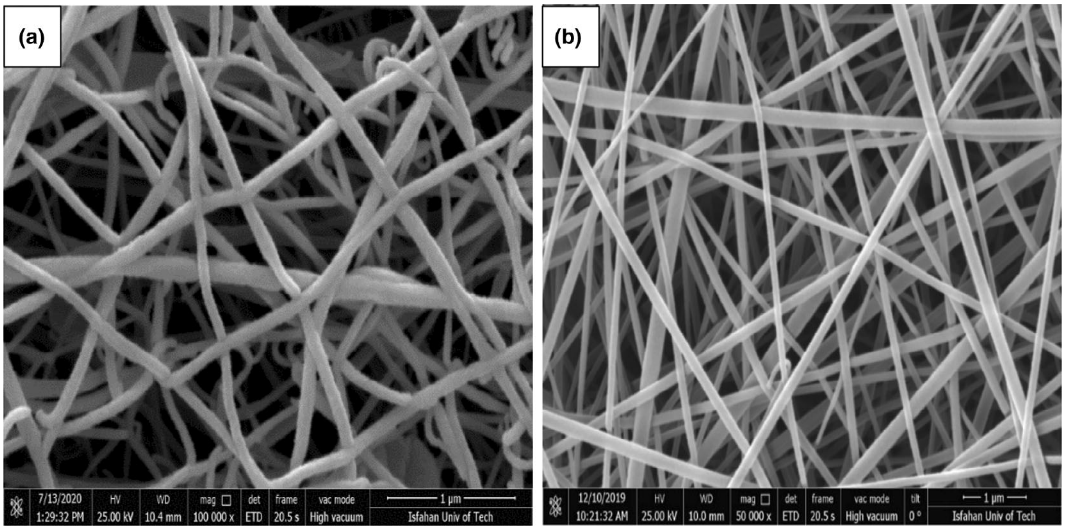

Figure 2 Morphological characteristics of electrospun nanofibres from electrospinning of (a) PPSG/gelatine/CCEO nanoemulsion and (b) PPSG/gelatine mixture solution.

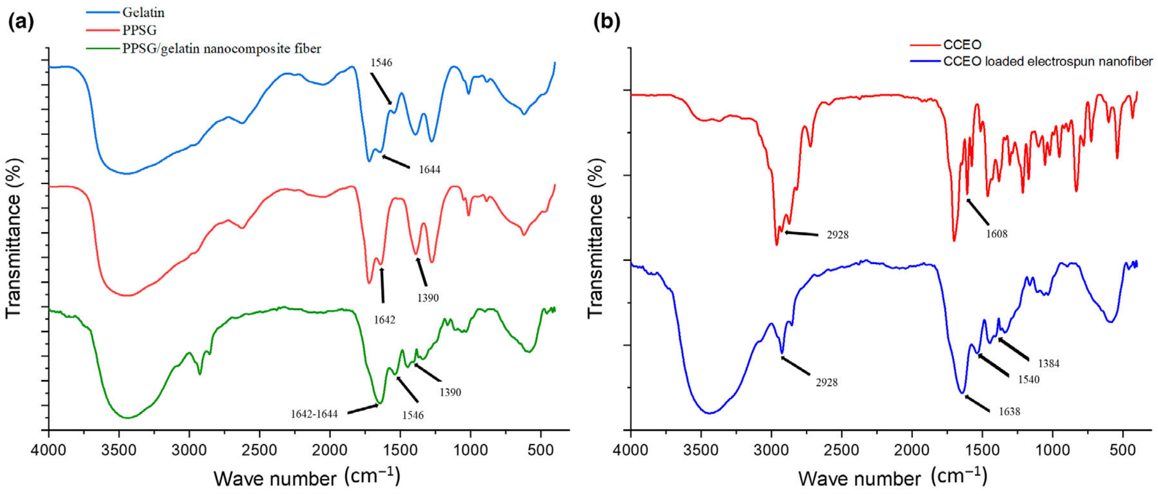

Figure 3 The FT-IR spectrum of (a) PPSG, gelatine and PPSG/gelatine nanocomposite fibre, (b) CCEO and CCEO loaded electrospun nanofibre.

of gelatine. The specific wavenumber of amide I represents the symmetrical stretching vibration of C = O hydrogen bonding coupled with COO. The specific wavenumber of amide II results from the symmetrical bending vibration of the N–H groups and the stretching vibration of the C–N groups (Hoque *et al*., 2010). The smaller the intensity of the absorption peaks of amides, the greater the irregularity of the gelatine (i.e. a loss of triple helix) (Muyonga *et al*., 2004). In the present study, no absorption band was observed in relation to amide III, similar to commercial gelatine (da Almeida *et al*., 2012).

For pure PPSG, the wavenumbers of 1642 and 1390 cm^{-1} correspond to C–OO symmetric and asymmetric stretching vibrations and C–O–C stretching vibration respectively (Fig. 3a). These two types of bonds are prominent in the structure of Plantago major seed mucilage (Golkar *et al*., 2019). The absorption at 1642 and 1390 cm^{-1} can be ascribed to the presence of PPSG in the nanofibres. These absorption bands also indicate no chemical change in the structure of PPSG and no chemical reaction between the PPSG and gelatine in the nanofibres.

As mentioned earlier, the bands at 1644 and 1540 cm^{-1} refer to the presence of gelatine in the nanocomposite fibres containing CCEO (Fig. 3b). A comparison between pure PPSG and the nanofibres containing CCEO showed that the absorption at 1644 cm^{-1} is related to the symmetric and asymmetric stretching vibrations of C–OO. The absorption at 1370 cm^{-1} is associated with the stretching vibration of C–O–C bonds. Due to the steric hindrance created by the presence of gelatine, this peak actually shifted from 1380 to 1370 cm^{-1}. The presence of PPSG in the nanofibres containing CCEO was validated.

Pure CCEO spectra showed different absorption peaks at different wavenumbers, revealing the presence of different compounds in the essential oil of *C. cyminum* (Fig. 3b). Ravi *et al*. (2013) reported more than 14 volatile compounds in CCEO, although its chemical composition can vary depending on the cultivar and soil conditions, climate and plant nutrition, which has a significant effect on the spectral differences in different studies.

For the electrospun nanofibres from the emulsion containing CCEO, the absorption peaks of pure CCEO were observed in the same wave numbers or with a slight shift in CCEO loaded electrospun nanofibre sample (Fig. 3b). The absorption peak at 2928 cm^{-1} is related to the stretching bonds of aromatic –CH, which indicates the presence of CCEO. The absorption peak at 1638 cm^{-1} is probably related to the stretching bonds of C=O, the absorption of which occurred at a higher wavenumber due to the inhibitory effects caused by other functional groups.

Release profile of CCEO

Nearly 50% of the nanoemulsified CCEO was released from the mats during the first 12 h (Fig. 4a). With increasing time, the release rate of CCEO from the mats decreased. The highest and lowest reduction rate of CCEO release was for concentrations of 1.5% and 6%, respectively, so that in the concentration of 6% of CCEO, after 48 h of immersion, the release of CCEO continued, while in the concentration of 1.5%, the release rate of CCEO almost reached to zero after 36 h. The presence of larger amounts of CCEO in the structure of PPSG/gelatine nanocomposites makes the functional characteristics of these types of mats to be

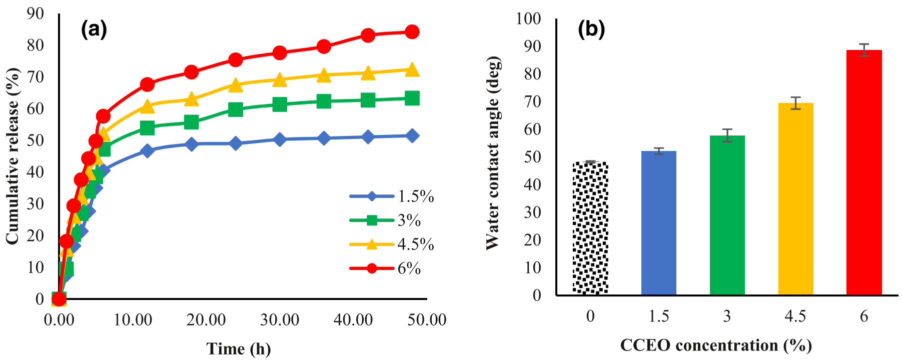

Figure 4 (a) Release profile of different concentrations of CCEO from PPSG/gelatine nanocomposite, (b) water contact angle of CCEO loaded PPSG/gelatine electrospun nanocomposite fibre.

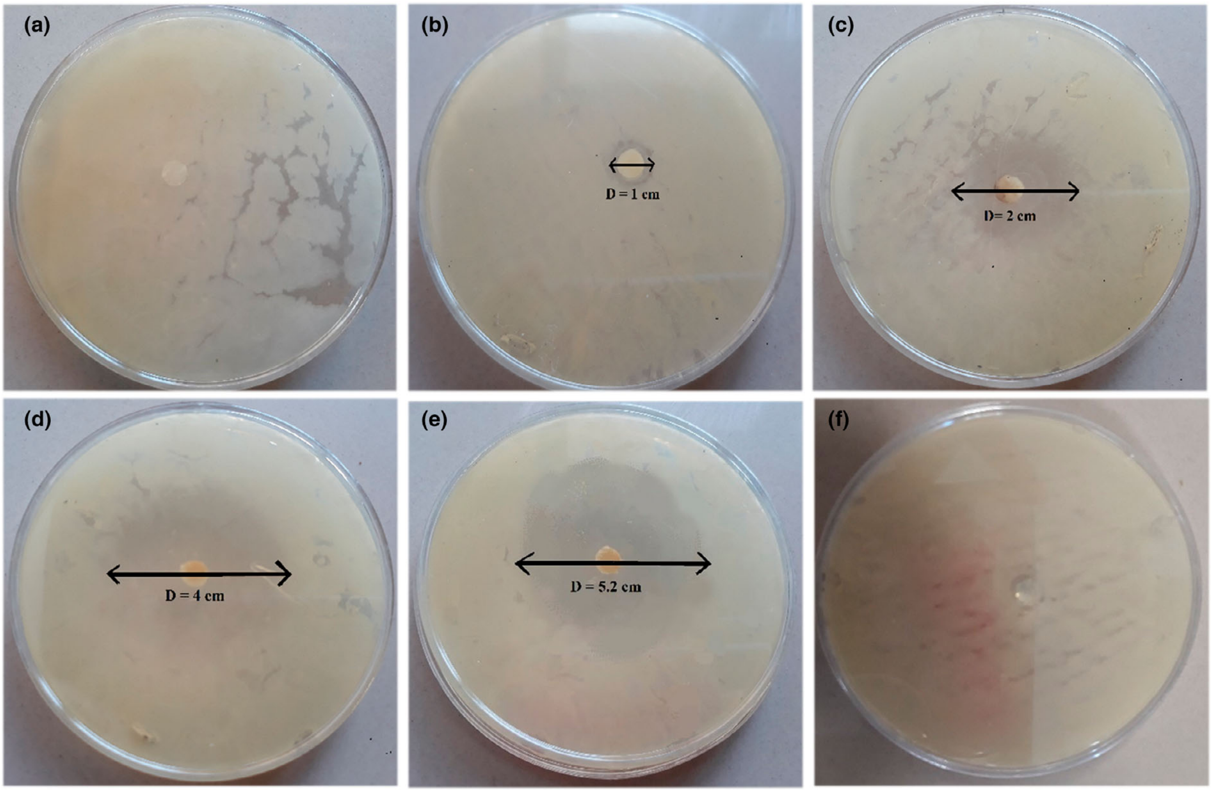

Figure 5 Growth inhibition zone caused by the PPSG/gelatine nanocomposite containing different concentrations of CCEO; (a) 1.5%, (b) 3%, (c) 4.5%, (d) 6%, (e) disc immersed in CCEO and (f) control (nanocomposite without CCEO).

preserved over a longer period of time and if they are used for food packaging, the shelf life of food may increase significantly.

Water contact angle measurement

Water contact angle was determined to evaluate the change in the hydrophobicity of the surfaces of nanocomposite mats. Water contact angle value of the PPSG/gelatine nanocomposite at the optimum concentration (gelatine 8%, PPSG 1.5%) (control sample) was 48.26 + 0.32. After adding CCEO, it increased significantly, indicating the increase of hydrophobicity due to the hydrophobic nature of CCEO (Fig. 4b). Increasing the hydrophobicity of PPSG/gelatine nanocomposites could increase their stability against migrated moisture from food products in contact with them.

Antimicrobial effects of nanofibres containing CCEO

The results of the antimicrobial impacts of the nanofibres containing CCEO on *S. aureus* showed that the average diameter of growth inhibition zone for the concentrations of 3%, 4.5% and 6% CCEO was 1, 2 and 4 cm respectively (Fig. 5). 1.5% of CCEO and control sample had no effect on the growth of *S. aureus* and increasing the concentration of CCEO intensified its inhibitory effect on the growth of *S. aureus*. Concentrations less than 1.5% were also examined, although they did not cause a zone of inhibition, which indicated how ineffective these concentrations were on the growth of *S. aureus*. Tabatabaei Yazdi *et al.* (2014) reported that the lethal effect of CCEO on *Bacillus cereus* made this essential oil applicable as an antimicrobial and preservative in the food industry. An increase in the concentration of CCEO caused significantly larger zones of inhibition. The immersed disc in pure CCEO had the greatest growth inhibition zone, which indicated the high power of CCEO in preventing the growth of *S. aureus*. CCEO contains pinene, terpineol-alpha, apigenin and some other volatile compounds, which in addition to the special aroma also have antimicrobial properties (Haghirossadat *et al*., 2010). Generally, these compounds cause the death of Gram-positive and Gram-negative bacteria by making holes in the cell membrane and destroying the outer membrane respectively.

Conclusions

This research considered the flow behaviour of PPSG/gelatine solution and PPSG/gelatine/CCEO nanoemulsion. The results showed that all the samples were non-Newtonian shear-thinning fluids ($n < 1$), which means they were pseudoplastic fluids. Evaluating the morphology of the nanofibres showed that the solution of PPSG/gelatine/CCEO mixture could form biodegradable and edible nanocomposites that are suitable for food coating applications. All the compounds and metabolites retained their initial chemical structure, and no chemical interaction occurred between the bonds of the different compounds. The nanofibres of PPSG/gelatine can be introduced as suitable substrates for CCEO coating, thereby serving as an antimicrobial agent against *S. aureus*.

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Author contributions

Parisa Mohajeri: Data curation (equal); formal analysis (equal); writing – original draft (equal). **Abdollah Hematian Sourki:** Conceptualization (lead); formal analysis (equal); funding acquisition (lead); writing – original draft (equal). **Alireza Mehregan Nikoo:** Data curation (supporting); formal analysis (supporting). **Yavuz Nuri Ertas**: Conceptualization (equal); formal analysis (supporting); funding acquisition (lead); project administration (lead); writing – original draft (lead); writing – review & editing (lead).

Conflict of interest

The authors declare that they have no conflicts of interest.

Ethical guidelines

Ethics approval was not required for this research.

Peer review

The peer review history for this article is available at https://publons.com/publon/10.1111/ijfs.16324.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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