EVALUATION OF ELECTROSPRAYING PARAMETERS FOR W/O EMULSION BASED EDIBLE COATINGS

Hulya Cakmak[a,b], Seher Kumcuoglu[b], Sebnem Tavman[b]

[1]Hitit University Department of Food Engineering, Corum, Turkey

[2] Ege University Department of Food Engineering, Izmir, Turkey, sebnem.tavman@ege.edu.tr

ABSTRACT

The shelf life of fresh-cut or minimally processed fruits can be extended by application of edible films or coatings. However, storage stability of the fruit is significantly affected from the coating application method.

In this study, electrospraying parameters of different w/o emulsion based coatings were evaluated. Emulsions were composed of 80% (w/w) refined olive oil phase with 5% (w/w) emulsifier (of total water and oil mass), while the water phase included 16% (w/w) maltodextrin (MD), whey protein isolate (WPI) or maltodextrin+whey protein isolate mixture (1:1). The electrical conductivity, and contact angles of the emulsions were found significantly different, however the viscosity and surface tension values were in same group except control emulsion ($p>0.05$). These emulsions were electrosprayed over glass slides for determination of droplet diameter at several feed flow rate between 0.6 to 4.5 ml/h and the voltages for obtaining stable cone-jet geometry were determined. The results showed that the voltage required for stable cone-jet geometry of control emulsion was lower due to its higher electrical conductivity. However the average droplet diameter of emulsion with MD+WPI was comparably lower although it has the lowest electrical conductivity. At the stable cone-jet geometry, 13 kV voltage was applied for this emulsion and the lowest average diameter (0.789±0.504 µm) was obtained at 3.5 ml/h flow rate. Therefore the flow rate of the emulsions for edible coating application was determined as 3.5 ml/h. Although the average droplet diameters of these emulsions were varied between 0.789- 1.210 µm, there was no significant difference observed in the water loss of fresh-cut apple slices. It was concluded that electrical conductivity of the emulsions were effective on required voltage for obtaining stable cone-jet geometry, however the average droplet diameters at these voltages did not create any difference with respect to water loss from electrospray coated apple slices.

MATERIALS & METHODS

Refined olive oil was kindly supplied by TARIS Zeytin ve Zeytinyagi Tarim Satis Kooperatifleri Birligi (Izmir), polyglycerol polyricinoleate (PGPR) with of HLB 1.5-2.0 from Elvan Gida San. ve Tic. A.S. (Istanbul), DE 5-7 maltodextrin (Paselli™, MD6) from Avebe Nisasta Ltd. Sti., Izmir), and whey protein isolate (Hipro Isowhey, Istanbul), respectively.

Emulsion preparation

W/o primary emulsions given in Table 1 were prepared by using rotor-stator homogenizer (IKA, T25 Ultra-turrax, Germany) as stated in the study of Cakmak et al. (2017).

Electrical conductivity, Viscosity, Surface Tension & Contact Angle Measurement

Electrical conductivity of the olive oil and emulsions were measured with a hand held conductivity meter (Stanhope-Seta, JF 1A-HH, Surrey, UK) at 25°C working within the range of 0-2000 pS/m .

Viscosity of emulsions was measured at 25°C with a stress-controlled rheometer (DHR3, TA Instruments, USA). The flow ramp test was applied between 0.01 to 200 1/s shear rate.

The surface tension of oil or emulsions against air interface was measured at 25°C according to Wilhelmy plate method by using Krüss K20 Easy dyne (Krüss Gmbh, Germany) tensiometer.

Contact angle measurement was measured with Ramé-Hart goniometer (Ramé-Hart Inc., USA).

Electrospraying

The vertical electrospraying equipment shown in Fig.1. was used for electrospraying experiments similar to the study of Cakmak et al. (2018).

Calculation of Average Droplet Diameter

Droplet diameter of electrosprayed emulsions are analyzed using a motorized fluorescence microscope (PSARON® FLOPTIK, Turkey) with CVA Control software, and the image analysis was performed with CVA 2016 particle analyzer (vers. 1.0.2).

Table 1. Electrosprayed emulsion formulations

Emulsion no	Olive oil (w/w ,%)	Water (w/w, %)	PGPR (w/w, % of water+oil)	MD (w/w, % of water)	WPI (w/w, % of water)	MD+WPI (w/w, % of water)
1	80	20	5	0	0	0
2	80	20	5	16	0	0
3	80	20	5	0	16	0
4	80	20	5	0	0	16

*MD; maltodextrin, WPI; whey protein isolate, MD+WPI; 1:1 mix. of MD and WPI.

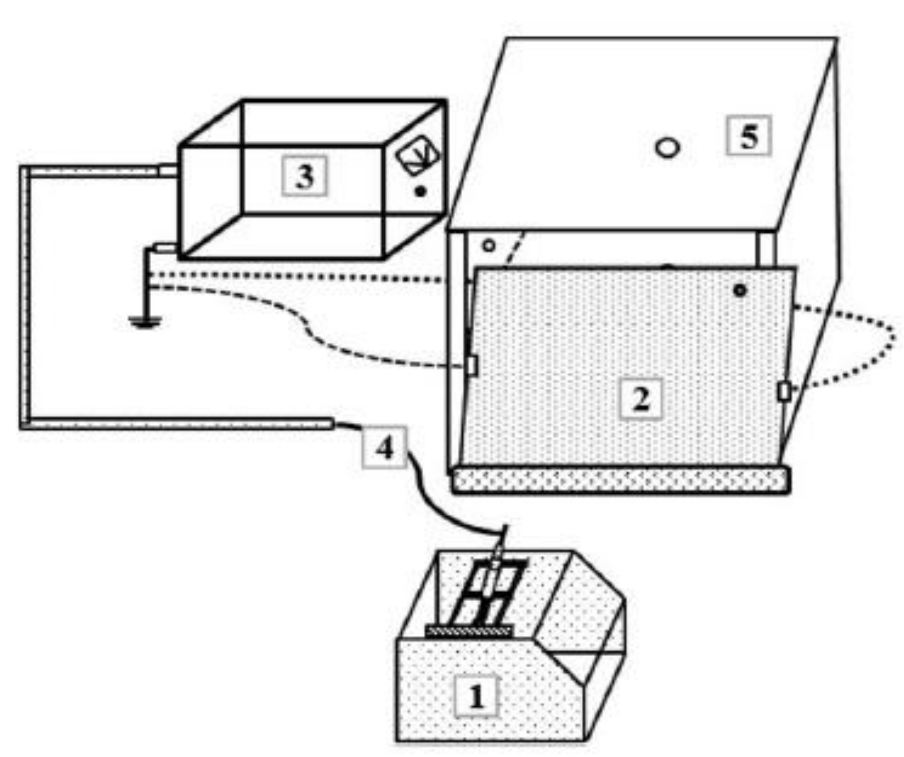


FIGURE 1 Vertical electrospraying equipment (1: syringe pump, 2: collector, 3: high voltage supply, 4: high voltage probe, 5: wooden shelf)

RESULTS and DISCUSSION

The stable cone-jet geometry was observed at lower voltage for Emulsion 1 which had the highest electrical conductivity, although the average droplet diameter was not lower than other emulsions (Table 2). At same voltage, the lowest average diameter was observed at 3.5 ml/h flow rate (Table 3). When the electrosprayed emulsions were compared, the lowest average droplet diameter was observed in Emulsion 4. At same flow rate, stable cone-jet geometry was obtained at higher voltage application with respect to the lower electrical conductivity and viscosity of Emulsion 4. At higher flow rates, required voltage for stable cone geometry formation is higher, therefore the average droplet diameter gets gradually lower (Ganan-Calvo et al., 1997). And increasing voltage helps to get mono-modal droplet diameter with a narrow diameter distribution (Jayasinghe, 2006).

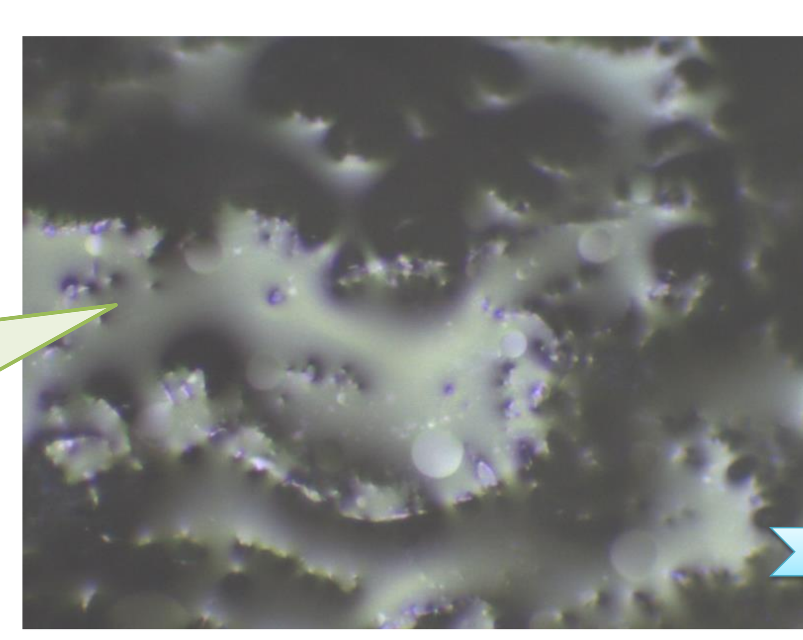
Table 2. Properties of the emulsions

Emulsion no	Electrical conductivity (pS/m)	Viscosity (mPa.s)	Surface tension (mN/m)	Contact angle (°)
1	>2000	113.64	33.3	35.1
2	1159.6	107.68	33.4	40.2
3	908.4	107.93	33.1	42.1
4	838.9	107.59	33.2	46.8

Table 3. Average droplet diamater of electrsprayed emulsions

Emulsion no	Flow rate (ml/h)	Voltage (kV)	Average Diameter (µm)
1	0.9	11	1.121±0.934
1	2	11	1.537±1.398
1	3.5	11	0.993±0.612
1	4.5	11	1.783±2.089
2	0.6	12	1.505±0.863
2	1.5	12	1.664±1.331
2	3.5	12	0.899±0.611
2	4.5	12	1.073±0.700
3	0.6	12	1.268±0.857
3	1.5	12	1.255±0.804
3	3.5	12	1.210±0.729
3	4.5	12	1.331±0.717
4	0.6	13	0.937±0.667
4	1.5	13	0.875±0.588
4	3.5	13	0.789±0.504
4	4.5	13	0.961±0.875

Electrospray coated pineapple surface



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