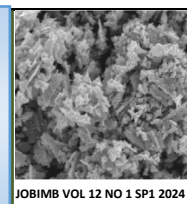


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Active Food Packaging from Alginate-Based Film Containing Onion Peel Extract (*Allium cepa*)

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ABSTRACT

Consumers wanting safe and eco-friendly food packaging have led to better active packaging materials. Alginate is a polysaccharide extracted from seaweed and has the potential to be considered a promising material for packaging applications; however, its application is limited due to poor mechanical properties and high water vapor (WVP). The mechanical and barrier properties can be altered by adding or blending with other materials, such as the incorporation of bioactive compounds from onion peel extract (*Allium Cepa*). This study was designed to extract onion peel and test its antioxidant and antimicrobial activities; alginate-based film incorporated different concentrations of onion peel extract (12.5%, 25%, and 50%) (w/v) and determined its antioxidant or antimicrobial activity and physicochemical properties. Results demonstrated that the onion peel extract and alginate-based films containing onion peel extract show antioxidant activity; however, no antimicrobial activity was detected. When the concentration of onion peel extract (*Allium Cepa*) in alginate-based film increased, it significantly improved the alginate-based film's mechanical properties, colour, solubility, and biodegradability. However, the water vapour permeability was reduced by increasing the onion peel extract. In conclusion, adding onion peel extract improved the antioxidant activity, colour, mechanical strength, solubility, and biodegradability characteristics of alginate-based films compared to control. Hence, this film has the potential to be used as active packaging.

INTRODUCTION

Food packaging plays a crucial role in preserving food quality, safety, and shelf life [1]. However, the use of conventional food packaging materials contributed to environmental pollution, which led to an increasing demand for the development of active packaging from natural sources [2]. Alginate is a bio-based polymer approved by Food and Drug Administration to be used in medical applications [3]. It can form strong and flexible films, making it suitable for packaging materials [4]. Alginate films have demonstrated a good ability to encapsulate bioactive compounds [5], and characteristics including good permeability, solubility, and improved mechanical properties make them suitable for future films, coatings, food packaging [6].

Onion peel from *Allium Cepa* contains high amounts of phenolic and flavonoids, including quercetin [7], which has antimicrobial and antioxidant properties [8]. By incorporating onion peel extracts, it is possible to develop active food packaging films via an eco-friendly approach that can protect food from external factors and provide added benefits such as antioxidant activity and antimicrobial properties. These properties help extend the shelf life of packaged food and minimize synthetic additives' use.

This study aims to extract onion peel and evaluate its antioxidant and antimicrobial properties. Subsequently, alginate-based films will be produced by incorporating different concentrations of onion peel extract (12.5%, 25%, and 50%) (w/v) and analyze the antioxidant and

antimicrobial activities and the physicochemical properties of these films.

MATERIALS AND METHODS

Materials

Onion peel purchased from the local supermarket, 70% ethanol (HmbG Chemicals, Hamburg, Germany), Glycerol USP Grade 99.7% purity (R&M chemicals, Darmstadt, Germany), and sodium alginate Food Grade E401 (Daily Chem, Henan, China).

Onion peel extract and alginate-based film preparation

The preparation of onion peel extract was referred to Wang et al. [9]. The onion peels were cleaned and dried at 45°C for 48 hours. Onion skin powder (50 g) was weighed and a 70% ethanol solution was poured in a ratio of 1:2 (w:v). The solution was extracted at 25°C for 2 h, then centrifuged at 3000 rpm for 10 min. The supernatant was concentrated and freeze-dried to get the ethanol extract from the onion peel. Then, the powder was kept at -20°C until further use. The alginate-based film containing onion peel extract was developed using a method by Santos et al. [10].

Sodium alginate (2 g) was homogenized in 100 mL of distilled water for 1 h at 70 °C stirred at 1000 rpm, followed by the addition of 0.5 g glycerol. After cooling to 40 °C, different concentrations (12.5%, 25%, and 50%) (w/v) of onion peel powder were added and homogenised. Then, the films were kept in desiccators for 24 h. The same method was used to develop a control film but without the addition of onion peel powder.

Antioxidant assay

The DPPH radical scavenging activity method was based on Santos et al. [10]. The onion peel extracts (3 mL) were mixed with 1 mL of ethanolic solution of DPPH radical. The mixture was incubated for 30 min at 35°C and the absorbance was obtained at 517 nm using UV-1900i Shimadzu (Japan) spectrophotometer.

Antimicrobial assay

The antimicrobial activity of onion peel extract was assessed using agar discs-diffusion against *Escherichia coli*. First, a cotton swap swabbed *Escherichia coli* (1 mL) (~106 CFU/mL) on Mueller Hinton Agar. Then, paper discs were introduced and treated with 20 µl of onion peel extract twice. After 24 h of incubation at 37°C, the inhibition zone (mm) around the disc was measured. A similar procedure was repeated on the alginate-based film containing peel onion extracts, which were cut into 15 mm disc sizes.

Colour profile, mechanical properties, solubility test, FTIR, vapour permeability test, and biodegradability rate test

The colour profile of the film was determined using Konica Minolta (Mississauga, Canada) colorimeter. The films were then placed against a white paper to measure the color and expressed as L*, a* and b* values. The mechanical properties were determined using a Texture Analyzer TA.XT Texture Stable Microsystem Ltb., U.K.

The films were cut into 7x1 cm, while the texture analyser was set at 2 mm/s, with a clamping distance 50 mm. The Fourier-Transform Infrared Spectroscopy (FTIR) spectra were measured with FTIR-i610, Japan spectrometer. The films were placed on the ATR accessory with the wavenumber range between 4000 cm⁻¹ to 650 cm⁻¹. The solubility test followed the method by Santos et al. [10]. The film was cut into 2x2 cm and dried at 105 °C for 24 h.

The film was immersed in water and homogenised for 20 min at 150 rpm. The films were dried again to get the final dry weight. The water vapour permeability test was referred to Pangnakorn et al. [11]. Plastic cups were added with 10 g of NaCl. Then, the cups were covered with film samples, sealed using parafilm. The cups were placed in desiccators and weighed every 24 h for 2 weeks. The biodegradability rate was carried out using Karnnet et al.'s method [12]. The films were cut into 2x2 cm and dried in a desiccator until the weight was constant. The samples were then buried in soil for 18 days. The biodegradability rate was reported as a weight loss percentage (W%).

RESULT AND DISCUSSION

Table 1 illustrates the antioxidant activity of the extract and alginate-based film containing different concentrations of onion peel extract. The increased extract significantly increased the DPPH radical scavenging activity (p<0.05). Sharma et al. [13], suggested that the total phenolic acids present in onion peel extract are responsible for its antioxidant capacity.

Table 1. Antioxidant and antimicrobial activity of the extract and alginate-based film containing different concentrations of onion peel extract.

Sample concentration (%)	DPPH radical scavenging activity (%)		Inhibition Zone (mm)	
	Extract	Film	Extract	Film
Pure Extract	82.6 ± 2.2 ^a	-		
50	69.8 ± 0.7 ^b	64.2 ± 6.1 ^a	6.0 ± 0.0	6.0 ± 0.0
25	52.5 ± 3.9 ^c	45.7 ± 7.3 ^b	6.0 ± 0.0	6.0 ± 0.0
12.5	29.4 ± 7.6 ^d	19.0 ± 4.0 ^c	6.0 ± 0.0	6.0 ± 0.0

Note:

Values are expressed in mean ± standard deviation for 4 replications (n=4) for the onion peel extract and (n=3) for the film

Values with different superscript letter within column are significantly different at p < 0.05

Table 1 also shows the extract's antimicrobial activity and alginate-based film containing different concentrations of onion peel extract. No inhibition was observed against *Escherichia coli* by onion peel extract and alginate film containing different concentrations of onion peel extract. The absence of inhibition may be due to the concentration of phenolic compounds in the onion peel extract being too low to effectively inhibit the growth of the tested bacteria [14]. Gonelimali et al. [15], mentioned that the antimicrobial activity of an extract is typically proportional to its concentration. **Table 2** illustrates the color profile of alginate-based film containing different concentrations of onion peel extract. The increasing onion peel extract into the alginate-based film significantly (p<0.05) decreased the lightness.

The onion peel extract may be attributed the increase in the darkness. On the other hand, a* and b* value significantly ($p < 0.05$) increased as the concentration of onion peel extract increased. This indicated that the color of the alginate-based films getting redder and yellower. This can be attributed to the presence of flavonoid compounds e.g. anthocyanins, which are responsible for the red color of the onion skin [16].

Table 2. Color profile and mechanical properties of alginate-based film containing different concentrations of onion peel extract.

Sample	L*	a*	b*	Tensile Strength (MPa)	Elongation Break %
Control	98.4 ± 1.0 ^a	0.5 ± 0.1 ^d	2.4 ± 0.1 ^d	0.007 ± 0.001 ^b	72.0 ± 4.4 ^b
12.5	92.9 ± 1.3 ^b	2.5 ± 0.1 ^c	11.9 ± 0.6 ^c	0.007 ± 0.004 ^b	74.0 ± 4.6 ^b
25	86.9 ± 1.4 ^c	5.4 ± 0.2 ^b	24.4 ± 0.7 ^b	0.008 ± 0.005 ^b	82.0 ± 9.2 ^b
50	77.7 ± 1.2 ^d	13.2 ± 0.6 ^a	42.8 ± 0.9 ^a	0.023 ± 0.004 ^a	118.3 ± 8.7 ^a

Note:

Values are expressed in mean ± standard deviation for 4 replications (n=4)

Values with different superscript letter within column are significantly different at $p < 0.05$

Table 2 also shows the mechanical properties of the alginate-based film containing different concentrations of onion peel extract. The tensile strength and elongation at the break of the developed films increased ($p < 0.05$) as the concentration of the onion peel extract increased. Improvement in mechanical properties can be attributed to the formation of a strong and cohesive cross-linked structure in the films. The interactions between the alginate chains and the components of the onion peel extract, such as hydrogen bonds and hydrophobic interactions, may have contributed to this effect [17]. These interactions enhance the overall strength and integrity of the films.

Table 3 shows the solubility rate of alginate-based film containing different concentrations of onion peel extract. The solubility rate of the films decreased ($p < 0.05$) as the concentration of the onion peel extract increased. It has been suggested that the presence of carboxylic acids in purple onion peel extract may contribute to the reduction in solubility [18]. When mixed with alginate, the connections of the biopolymer networks are strengthened, leading to a decrease in the solubility index [19].

Table 3. Solubility rate and Water Vapour Permeability Rate (WTR) of alginate-based film containing different concentrations of onion peel extract.

Sample	Weight Solubility		WTR (%)	
	(mg)	(%)	Day 1	Day 3
Control	52.7	99.9 ± 0.1 ^a	0.032 ± 0.002 ^{ab}	0.035 ± 0.006 ^b
12.5	35.6	91.8 ± 2.9 ^b	0.028 ± 0.005 ^b	0.036 ± 0.004 ^{ab}
25	41.9	36.9 ± 1.3 ^d	0.031 ± 0.002 ^{ab}	0.037 ± 0.007 ^a
50	60.2	44.9 ± 0.1 ^c	0.033 ± 0.001 ^a	0.038 ± 0.006 ^a

Note:

Values are expressed in mean ± standard deviation for 4 replications (n=4)

Values with different superscript letter within column are significantly different at $p < 0.05$

Table 3 also shows the water vapour permeability rate of alginate-based film containing different concentrations of onion peel extract. In general, the water vapour permeability rate of the films increased as the concentration of the onion peel extract increased. This might be due to the incorporation of onion peel extract, which causes water molecules to easily transfer through the film. The incorporation of plant extract might weaken the intermolecular interactions in the film network, and these changes in the internal structure of the films may favour

solvent mobility and facilitate water diffusion in the polymeric matrix [11].

Table 4 shows the biodegradability rate of alginate-based film containing different concentrations of onion peel extract. The biodegradability rate of films decreased ($p < 0.05$) as the concentration of the onion peel extract increased, indicating that adding onion peel extract slowed the degradation rate. This may be attributed to stronger bond-to-bond interactions within the polymer network, which inhibited the biodegradation rate [20].

Table 4. Biodegradability of alginate-based film containing different concentrations of onion peel extract.

Sample	Day 1	Day 3	Day 6
Control	47.80 ± 5.29 ^b	53.55 ± 4.56 ^b	95.40 ± 1.62 ^a
12.5	54.10 ± 6.43 ^a	60.90 ± 0.65 ^{ab}	67.72 ± 3.22 ^b
25	46.10 ± 4.09 ^b	56.96 ± 1.87 ^{ab}	72.41 ± 1.42 ^b
50	41.30 ± 1.28 ^b	60.65 ± 0.40 ^a	73.12 ± 2.81 ^b

Note:

Values are expressed in mean ± standard deviation for 4 replications (n=4)

Values with different superscript letter within column are significantly different at $p < 0.05$

CONCLUSION

The onion peel extract demonstrated an antioxidant activity; however, no antimicrobial activity was observed. The addition of onion peel extract showed significant improvement in the alginate-based films, such as increased antioxidant activity, colour, mechanical strength, solubility, and biodegradability characteristics compared to control films. Hence, an alginate-based film containing onion peel extract has the potential to be used as active packaging.

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