ASEAN
Journal of Scientific and Technological Reports
Online ISSN:2773-8752

Research article

Antioxidant Activity of Banana Peel Waste, the Development and Stability Evaluation of Facial Toner Containing Banana Peel Extract

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Citation:
Numrueng, J.; Binlateh, N.; Chana, N.; Sangkharak, K. Antioxidant activity of banana peel waste, the development and stability evaluation of facial toner containing banana peel extract. *ASEAN J. Sci. Tech. Report.* **2024**, *27*(6), e255304. https://doi.org/10.55164/ajstr.v27i6.255304.

Article history:
Received: August 2, 2024
Revised: September 20, 2024
Accepted: October 4, 2024
Available online: October 9, 2024

Abstract: The banana processing industry produces many by-products, mainly banana peel. Banana peel waste, after banana processing, can be a good source of bioactive compounds. Extraction of phenolic compounds using optimum extraction conditions enhances the yield and quality of the products. This study evaluated optimizing the extraction time for the maximum extraction yield from banana peels, consequently lowering the overall process cost. In addition, the application of increasing the value of banana waste was also evaluated. The optimum conditions were achieved using 95% ethanol with a solid-to-liquid ratio of 1:5, 25 ± 5 °C under various extraction times (0-96 h). The responses, such as total phenol content (TPC), total flavonoid content (TFC), and DPPH inhibition activity, were measured by spectrophotometric analysis. The optimal incubation time at 72 h was found to be more effective compared to the others. The values of TPC, TFC, and DPPH inhibitory activity at optimized conditions were 8.23 ± 0.42 mg gallic acid equivalent (mg GAE)/g, 8.18 ± 0.08 mg quercetin equivalent (mg QE)/ g, and 93.96%, respectively. The ethanolic extract of banana peel had an inhibition concentration (IC_{50}) of 48.35 ± 0.88 μg/mL. After that, banana peel extract was subjected to study the potential for cosmetic application. The extract was applied as an ingredient in facial toner. The toners were preliminarily characterized. Banana peel waste possesses reasonable antioxidant activity and shows high stability over time. The results showed high potential for cosmetic applications using banana peel extract. In addition, using banana peel waste reduces agricultural waste in the environment.

Keywords: Antioxidant activity; Banana peel; Banana processing; Cosmetic product; Facial toner

1. Introduction

The fruit processing industry produces a large volume of fruit waste, such as seeds, peels, pomaces, and press cakes. More than 25-40% of fruit residues were left after fruit process [1]. Most fruit residues are often thrown into the landfill without proper treatment. Therefore, it produces air pollution and greenhouse effect [1]. Banana chips, a famous product from Phatthalung

province (Thailand), also produce a lot of peel. It has been reported that 40% of the overall weight of fresh bananas belongs to banana peel [2]. Recently, research and development focused on transforming agricultural waste into valuable products. Namwa (Musa ABB cv'. Kluai Namwa) is a significant fruit rich in antioxidant compounds and natural bioactive such as phenolic, flavonoids, minerals, vitamins, and anthocyanin [3]. These compounds exhibit potential application in various fields, such as the cosmetic, pharmaceutical, and food industries [4]. Therefore, the main focus is the extraction of bioactive materials such as phenolic and flavonoids in banana peels. Therefore, the optimization condition which produces a high yield is still required. Islam et al. [1] reported that products' extraction yield and quality increased when banana peel was extracted under suitable conditions.

Furthermore, the potential application of banana extract is also an exciting topic. The application of plant extract in the cosmetic field is increasing due to the high growth of the cosmetic and beauty market [5]. Banana peels (especially yellow-colored peels) are rich in flavonoids and phenolics. In addition, banana peel components are hydrophilic (producing an attractive force on water molecules), which is suitable for application in the cosmetic fields, such as lotion and moisturizer [6]. It has been reported that banana extract-containing lotion can be controlled and cure the damage and inflammation of free radicals in cells. Lotion supplemented with banana extract is soft, smooth, non-sticky, and works at the cellular level. The pH of the lotion was between 5.0 and 5.5, within the pH range of the human skin acid mantle (4.5-6.5). Therefore, the lotion will not harm the skin acid mantle layer [7]. The moisturizer supplemented with banana peel had no side effects on human skin was reported. It was an oil-in-water emulsion type within 4-5 months of shelf life [8]. The moisturizer prepared from banana peels (Kepok) effectively prevented xerosis (skin dryness). The addition of banana peel in herbal face packs and masks was also reported. The herbal face pack has enhanced the smoothness and softness of the face. The face pack was affordable, had no side effects, and was eco-friendly [9]. A gel face mask of banana peel (Ambon variety) was found easy to peel off. It is a rich source of vitamin B6, sugars, proteins, phosphorus, vitamin C, saponins, and tannins. This mask helped to reduce fine lines and wrinkles and glow the skin [10]. Banana peel-off gel mask and shampoo were made in Indonesia with the Kepok variety, a rich source of antioxidants [11]. The extraction of bioactive compounds was done using the conventional maceration method. Antioxidants shield the scale from UV radiation and free radicals so scalp health can be maintained. Banana peels have the potential to be used as a raw material for anti-hair-loss shampoos since flavonoids stimulate and repair damaged hair structure [12]. Facial toner, liquid, is often used daily to clean and refresh the skin. In addition, it helps to balance the facial pH after cleaning with soap. However, there are some reports that commercial facial toners irritate the skin. Therefore, the addition of plant extract with antioxidant activity shows several advantages. Banana peel extracts contain various bioactive compounds that have nutritional and medicinal properties. The key components in banana peel extract include phenolic compounds, vitamins, carotenoids, minerals, phytosterols, tryptophan, and antioxidants. Therefore, there are numerous benefits to using banana toners, such as hydrating skin, balancing pH levels, reducing aces and pores, neutralizing free radicals and protecting cells from oxidative damage, anti-aging, anti-inflammatory, and leaving skin feeling refreshed [13]. Therefore, this current study aimed to increase the extraction yield of banana peel waste by varying the incubation time. After that, evaluation of antioxidative activities. In addition, banana extract was used as an ingredient in facial toner. The stability and antioxidant activity of the toner were determined.

2. Materials and Methods

2.1 Raw materials processing

Fresh, ripe, and disease-free bananas (Musa ABB cv'. Kluai Namwa) were kindly provided by Pansa Interfood, Co. Ltd. (Phatthalung, Thailand). The banana peel waste, the residue after banana processing, was collected and cleaned to eliminate all contaminants using tap water. Furthermore, the cabinet drier (50 ± 5 ^{o}C) removed superficial water. The peel was dried until the 13% of moisture content was obtained. Afterward, the dried sample was ground, sieved, and packed in a high-density polyethylene bag. The ground peel was kept at -18 ^{o}C until use [1].

2.2 Effect of incubation time

The effect of time was studied. Ten grams of peel powder was added to an Erlenmeyer flask and shaken in the water bath. Then, the effect of incubation time was varied from 0-96 h while the other parameters were fixed using 95% ethanol with a solid-to-liquid ratio of 1:5, 25 ± 5 °C [1]. The optimal time, which yields the highest content of extraction yield, was selected and used throughout this study. The percentage of extraction yield was evaluated and compared.

$$\text{The percentage of extraction yield} = \frac{\text{Weight of solvent-free extract (g)}}{\text{Weight of dried extract (g)}} \text{ x } 100$$

Afterward, the sample was extracted under optimal conditions, filtrated, and evaporated using a rotary evaporator (49 °C). After that, propylene glycol was added to adjust the sample volume to 10 mL. The banana was extracted at 4 °C for an analysis of phenolic, flavonoid, and antioxidant activity.

2.3 Total phenolic content (TPC) determination

Folin-Ciocalteu assay was used to determine the TPC content [14]. Sample (0.5 mL), Folin-Ciocaltue reagent (0.5 mL), and 7.5% Na_2HCO_3 solution (1 mL) were added. Distilled water was added to adjust the mixture volume to 10 mL. Afterward, the vortex was used to mix the sample (3 s). The mixture was left in the dark (35 min) before centrifugation at 4,000 xg for 10 min. The TPC was determined at 750 nm using a UV-Vis spectrophotometer. The standard curve (R^2 = 0.9986) of various concentrations of gallic acid from 0 to 200 µM was used to calculate TPC. The unit of TPC was expressed in mg GAE/g.

2.4 Total flavonoid content (TFC) determination

The TFC was determined in a falcon tube by mixing banana extract (1 mL), distilled water (4 mL), and 5% $NaNO_2$ (0.3 mL). The mixture was left at room temperature for 5 minutes before adding 10% AlCl3 (0.3 mL). Then, the sample was kept at room temperature (1 min) before 1 M NaOH (2 mL) and distilled water (2.4 mL) was added [15]. The sample was mixed using a vortex and then centrifugated at 4,000 *x*g for 10 min. The mixture was left in the dark (15 min) before being determined at 510 nm using a UV-Vis spectrophotometer. The standard curve (R^2 = 0.9930) of quercetin at various concentrations from 0 to 100 µM was used to determine TFC. The unit of TFC was expressed in mg QE/g.

2.5 Antioxidant activity determination

DPPH scavenging assay was used to determine antioxidant activity in this current study [16]. Firstly, 0.1 mL of various concentrations of banana peel extract from 62.5 to 500 mg/mL was added and mixed with 0.1 mM DPPH solution (0.2 mL) in methanol [16]. The sample was left at room temperature for 1 h in a dark place (25 ± 5 °C). The antioxidant activity was measured at 517 nm using a UV-Vis spectrophotometer and calculated.

$$\text{The percentage of scavenging of DPPH} = \frac{\text{The initial absorbance at 0 h} - \text{The final absorbance at 1 h}}{\text{The initial absorbance at 0 h}} \text{ x } 100$$

In addition, the IC_{50} value of peel extract was calculated. All samples were analyzed in triplicate and on average. The concentration of peel extract, which inhibits a percentage of DPPH scavenging by 50%, was compared with standard ascorbic acid.

2.6 Functional group determination

The Fourier determined the functional group of peel extract transform infrared spectrometry (Perkin Elmer, USA) at a wavenumber between 4,000 to 400 cm^{-1} at room temperature (25 ± 5 °C) [17].

2.7 Facial toner containing banana peel extract preparation

The various formulas for facial toners were designed following Sadsyam et al. [5] (Table 1). Then, each formula was characterized, and the suitable formula was chosen due to the suitable value of polydispersity

index (PDI) and zeta potential. In this current study, particle size (PS), PDI, and zeta potential were determined using photon correlation spectroscopy (PCS) [18].

2.8 Physical and stability of facial toner determination

The toner was prepared and kept for 24 hours before determining physical characteristics, including color, texture, pH, odor, and phase separation [19]. In addition, the stability of the facial toner was tested using a three-cycle acceleration test. For the 1st cycle, the sample was placed at 4 °C for 48 h and at 45 °C for 48 h. The similar steps were repeated for 2nd and 3rd cycles. The physical characteristics and antioxidant activity were determined after the end of each cycle [19].

2.9 Statistical analysis

Extraction yield, TPC, TFC, and antioxidant activity were expressed as the mean ± standard deviation. One-way analysis of variance (ANOVA) was used to determine whether there were significant differences in mean values between different samples, followed by Tukey's honestly significant differences (HSD) multiple rank test at 95% ($p < 0.05$).

Table 1. The formula design of facial toner containing banana peel extract.

Materials	Unit	Concentration (%w/v)						Utility
		S1	S2	S3	S4	B1	B2	
Banana peel extract (0.1 mg/mL)	mL	0.001	0.001	0.002	0.002	0.000	0.000	Active ingredient
Olive oil		2	2	2	2	2	2	Solvent
Propylene glycol		2	4	2	4	2	4	Co-solvent, Preservative
Glycerine		4	4	4	4	4	4	Humectants, Preservative
70% Sorbitol		3	3	3	3	3	3	Humectant, Thickening agent
Phenoxyethanol		0.3	0.3	0.3	0.3	0.3	0.3	Preservative
Vitamin E		0.3	0.3	0.3	0.3	0.3	0.3	Antioxidant
Purified water was added to		100						
Adjust pH to		4.7-5.7						

While S1 and S2 contained similar volumes of banana extract (0.001 mL) with different volumes of propylene glycol at 2 and 4 mL, respectively.
S3 and S4 contained similar volumes of banana extract (0.002 mL) with different volumes of propylene glycol at 2 and 4 mL, respectively.
B1 and B2 contained no banana extract with different volumes of propylene glycol at 2 and 4 mL, respectively.

3. Results and Discussion

3.1 Effect of incubation time

The effect of incubation time was demonstrated. The extraction yield increased with the increased time from 0 to 72 h. The highest yield (5.36%) was observed at 72 h incubation time (Table 2). However, the extraction yields slightly decreased after 96 h of incubation time. The prolonged incubation time may result in a decrease in yield. This is caused by oxidation and degradation of the desired compound [20].

Table 2. The effect of incubation time on banana peel extraction yield.

Time (h)	Extraction yield (%)
0	2.08 ± 0.98[a]
12	2.32 ± 1.00[b]
24	3.02 ± 0.58[c]
48	3.96 ± 0.88[d]
72	5.36 ± 0.94[f]
96	4.55 ± 0.79[e]

Data are represented as mean ± standard derivation (SD); letters in the same column with different superscript(s) are significant ($p < 0.05$).

The extraction yield was not different from a previous study in which 2.54-5.76% of the extraction yield was obtained using ethanol as a solvent [19]. As a result of this study, extraction time highly affected the yield. It provided extracts with greater yield and antioxidant activity for extended periods. Some bioactive compounds might require longer to dissolve fully in the solvent, leading to a high concentration of extraction yield and antioxidants. A similar result was observed in lemongrass (*Cymbopogon citratus*) leaves, which gave the highest yield and TPC at 93.8 °C, 3.7 min [21]. However, a longer extraction time at 96 h proportionally decreased the yield in the extract. Certain compounds, such as polyphenols, are sensitive to heat, light, and oxygen. Extended extraction times can cause oxidative degradation, reducing the overall yield and antioxidant activity. However, a lower yield was obtained in this study compared to others. The extraction of banana peel using the vacuum microwave method gave the highest yield at 13.03% with conditions at 60 °C and 20 min [22]. In addition, the yields of the extractions from three varieties of banana peels, including *Musa acuminata, Musa sapientum* L, and *Musa balbisiana*, ranged from 6.67-9.80% using 95% ethanol for 3 weeks. Therefore, the extraction yield is mainly affected by various parameters, including banana species, extraction solvent, and method [23]. Therefore, the incubation time at 72 h was selected and used for banana peel extract in this study.

3.2 Total phenolic content (TPC), total flavonoid content (TFC), and antioxidant activity

The TPC of banana peel extract using 95% ethanol as a solvent at 72 h incubation time was determined. The TPC was 8.32 ± 0.42 mg GAE/g. Zhang et al. [24] reported that the TPC in banana peel was 4.95-47 mg GAE/g dry matter. Therefore, the TPC in this current study was in the range. However, the TPC in banana peel was 1.5-3 fold higher than pulp [25]. High TPC in banana peel waste showed an excellent ability to apply peel waste in the cosmetic sector. Adeel et al. [26] reported that 100% ethanol is suitable for extracting TPC from banana peel. The highest TPC was obtained when 100% ethanol was used as extraction solvent, followed by 100% acetone. At the same time, 80% methanol yielded the lowest TPC [27]. In addition, TFC was also determined in banana peel extract. Flavonoids, important phytochemical compounds, have been reported for their ability to be utilized in the cosmetic industry [1]. The TFC extracted from banana peel waste was 8.18 ± 0.08 mg QE/g. However, the TPC and TFC of banana peel waste were lower than those obtained from the enzymatic-assisted method [1]. The high TPC (25.37 mg GAE/g) and TFC (13.99 mg QE/ g) were obtained. The TPC, TFC, and antioxidant activity from banana peel were summarized (Table 3), and the values were compared with other reports. This result is due to the effect of extraction conditions, which play a vital role in the extraction of TPC and TFC [28].

In this current study, 93.96% of DPPH scavenging activity was detected from peel extract. High antioxidant activity is related to the amount of TPC and TFC in extracts [14]. It can be concluded that banana peel extract showed great bioactive properties directly related to the ability to eliminate free radical reactions [14]. A linear regression method calculates the IC50 value of banana extract and standard ascorbic acid. The concentration of banana peel was varied from 5-100 µg/mL. The IC_{50} values of the tested extract and standard ascorbic acid were 48.35 ± 0.08 and 0.97 ± 0.08 µg/mL, respectively (Table 4). The TPC, TFC, and antioxidant activity indicated that banana peel extract contained bioactive compounds and could be applied in cosmetics.

Table 3. The total phenolic content (TPC), total flavonoid content (TFC), and antioxidant activity of banana peel extract.

Banana species/Extraction condition	TPC (mg GAE/g)	TFC (mg QE/g)	Antioxidant activity (%)	Ref
Musa acuminata cv. Sagor/1.0% Viscozyme® concentration, 9 h, 55 °C, the solute-liquid ratio 1:25	25.37	13.99	81.59	[7]
Ripe *Musa acuminata* L, cv cavendshii /80% methanol, room temperature, 3 h	5.85	2.26	45.08	[29]
Ripe *Musa acuminata* colla. AAA, cv 'Berangan'/80% methanol, room temperature, 3 h	0.92	0.72	40.01	
Musa sp./Ethyl acetate	4.63	5.86	-[a]	[30]
Musa omini (paranta)/70% ethanol, soxhlet 10 to 15 cycles	3.83	2.53	25.44	[31]
Dwarf cavandish/70% ethanol, soxhlet 10 to 15 cycles	3.36	2.43	30.27	
Musa ABB cv'. Kluai Namwa/95% ethanol, 72 h, solid-to-liquid ratio of 1:5, 25 ± 5 oC	8.32 ± 0.42	8.18 ± 0.08	93.96	**This study**

-[a]: not report

Table 4. The percentage of inhibition concentration of banana peel extract.

Concentration (µg/mL)	% Inhibition	IC_{50} (µg/mL)	
		Banana peel extract	Standard (Ascorbic acid)
5	13.62	48.35 ± 0.08	0.97 ± 0.08
10	18.06		
30	36.77		
40	44.42		
80	75.42		
100	91.34		

3.3 Functional group characterization of banana peel extract

The FT-IR spectrum of banana peel extract is shown in Fig 1. The presence of strong hydroxyl groups, C-H stretching, and the carbonyl group stretching was detected at 3355, 2922, and 1708 cm^{-1}, respectively. The band of absorbed water (1644 cm^{-1}) and C-H bending (1375 cm^{-1}) were also observed. Moreover, the stretching of C-O and C-OR at 1245 and 1035 cm^{-1} were also presented, respectively. A similar spectrum was also reported by El-Din et al. [28]. The most intense and broadest peak at 3355 cm^{-1} indicates coinciding vibrations of O-H (hydroxyl) stretching of alcohols and phenol and N-H (amine) of amino acid. Therefore, the extract had antioxidant activity.

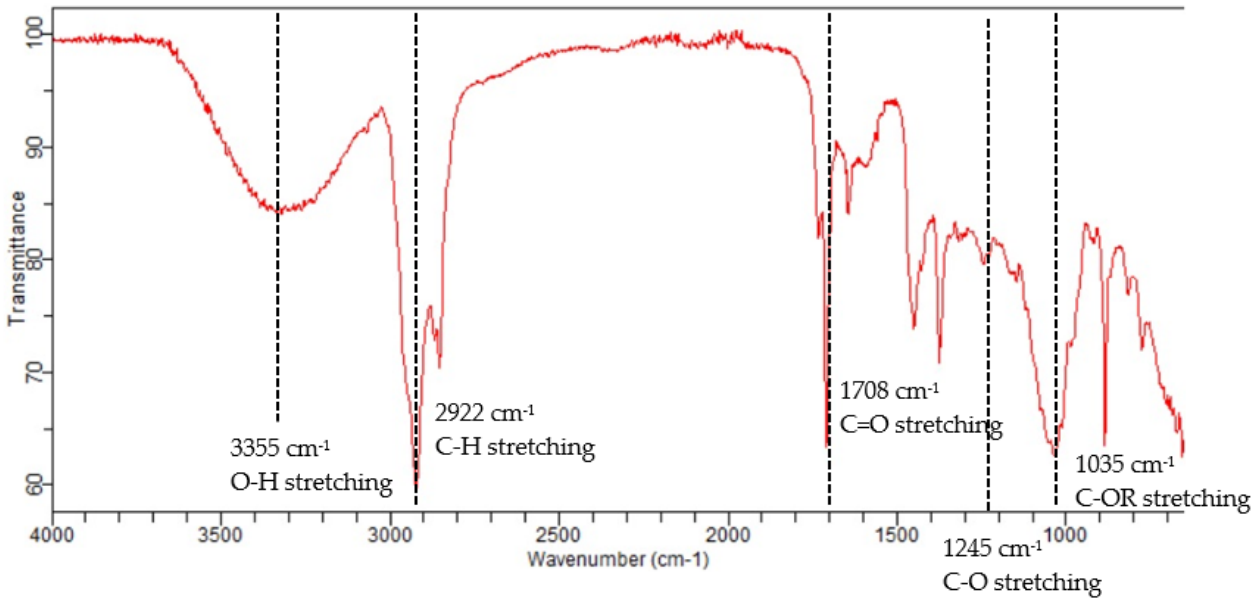

Figure 2. FT-IR spectrum of banana peel extract using 95% ethanol, solid-to-liquid ratio 1:5, 72 h incubation time.

3.4 Facial toner preparation

A facial toner containing banana peel extract was prepared using a different formula (Table 1). The physical characteristics of all formulas are yellow and mildly fragrant. In addition, all products are smooth, non-sticky, and easy to absorb (Fig 3). The pH for all products was in the range of 5.0-6.5. pH value is crucial because it guarantees the toner is in the proper pH range for the best possible skin health and efficacy. Therefore, all formulas are suitable for use. Therefore, the particle size and PDI were characterized.

All toner products showed an average particle size, PDI, and a zeta potential within the 1229-1740 nm range, 0.74-1.00 and -35.2 to -23.6 mV, respectively (Table 5). The value of PDI was limited from 0-1 for homo and hetero size distributions of emulsion. The PDI is related to particle size, while the large one is strongly scattered light more than the small one [32]. A PDI lower than 0.2 means a homogeneous size distribution of the product. At the same time, the heterogeneous size of particles in the product gives a higher PDI. Therefore, it is crucial to select a minimum PDI [33]. Zeta potential corresponds to the stability of facial toner [34]. Therefore, zeta potential is also another important selected criterion. The zeta potential at +/- 30 mV indicates no particle surface change, stable colloidal dispersion, and good facial toner performance. Therefore, low PDI (0.87) and the most potent negative zeta potential (- 26 mV) were found in the S2 formula. Therefore, the S2 formula was selected and used for the stability study. Several factors influence particle sizes, PDI, and zeta potential, such as pH, chemical composition and concentration, agitation, and temperature. Each of these parameters can interplay with the others [35].

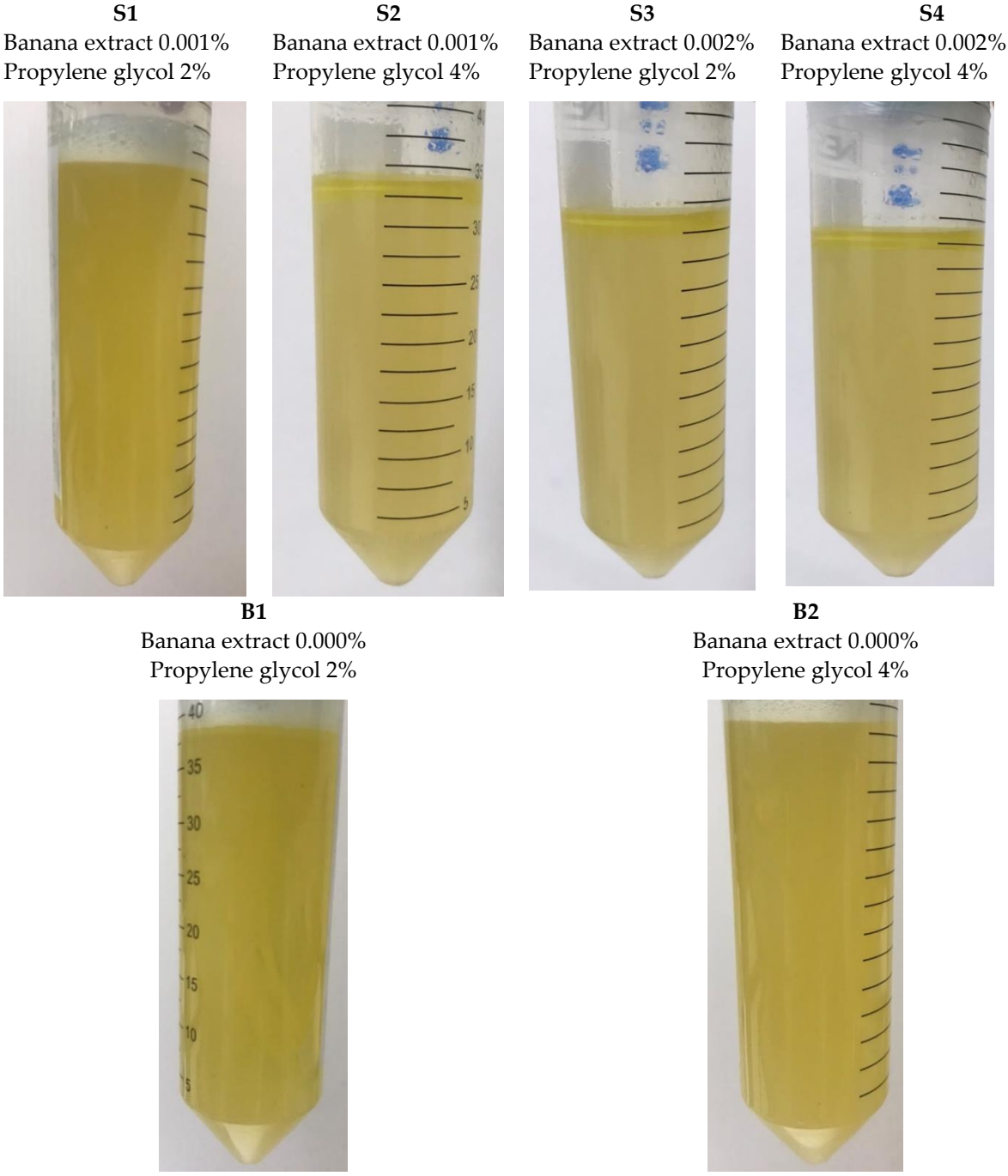

Figure 3. The facial toner contains banana peel extract, different extracts, and propylene glycol.

Table 5. Average droplet size (z-average), polydispersity index (PDI), zeta potential, and conductivity of facial toner in different formulas.

Formula	Z-Average size diameter (nm)	Polydispersity Index (PDI)	Zeta potential (mV)	Conductivity (mS/cm)
S1	1229 ± 99.46	0.89 ± 0.17	-24.5 ± 0.27	0.07 ± 0.000
S2	1740 ± 73.59	0.87 ± 0.16	-26.3 ± 0.42	0.05 ± 0.001
S3	1433 ± 69.76	0.74 ± 0.12	-23.6 ± 0.48	0.10 ± 0.002
S4	1513 ± 74.96	1.00 ± 0.00	-35.2 ± 0.46	0.09 ± 0.002
B1	482.9 ± 24.45	0.66 ± 0.10	-57.5 ± 0.47	0.07 ±0.002
B2	3477 ± 96.02	0.58 ± 0.14	-29.3 ± 0.65	0.12 ± 0.001

Data are represented as mean ± standard derivation (SD)

3.5 Stability test

The facial toner (S2 formula) was subjected to a stability test using the accelerated stability test. The test was repeated by heating/cooling at 4 °C and 45 °C for three cycles. For the 1st cycle, the sample was placed at 4 °C for 48 h and at 45 °C for 48 h. The similar steps were repeated for 2nd and 3rd cycles. The product that retains the desired properties after three cycles may have a reasonable degree of confidence in its stability. After that, the stability of facial toner, including physical characteristics and antioxidant activity, was measured. The pH values of the S2 formulation remained 5.20-5.50 (Table 6). However, the pH decreased from 5.50 to 5.20 with an increase in the tested cycle. The pH was similar to the range of facial skin pH (5.0-6.0). The remaining pH of the facial toner at 5.0-6.0 indicated the product's potential to maintain the physiological processes and provide an effective barrier. Moreover, the pH stability of the toner product showed the forming of a stabilized double-lamella structure in these mildly acidic conditions, and micellization occurs for pH > 6.0. In contrast, a disordered structure occurs for pH < 4.5 [36]. The stability of banana toner was also compared with commercial toner (BP pineapple toner). A similar result was obtained.

Table 6. Stability test results of the developed facial toner containing banana peel extract.

Cycle	**0**	**1st**	**2nd**	**3rd**
pH (Average ± SD)	5.50 ± 0.02	5.31 ± 0.01	5.20 ± 0.02	5.20 ± 0.02
Color	Yellow	Yellow	Yellow	Yellow
Odor	Mildly fragrant	Mildly fragrant	Mildly fragrant	Mildly fragrant
Turbidity	No	No	No	No
Phase separation	No	No	No	No
Precipitation	No	No	No	No
TPC (mg GAE/g)	8.23 ± 0.42	3.62 ± 0.18	3.59 ± 0.10	3.60 ± 0.12
Antioxidant activity (%)	93.96 ± 0.12	90.33 ± 0.10	90.15 ± 0.21	88.99 ± 0.13

Data are represented as mean ± standard derivation (SD)

After the third cycle of the stability test, no changes were observed in color and odor. In addition, the facial toner had no turbidity, phase separation, or precipitation. The TPC and antioxidant activity of the facial product were also measured. The result found that the TPC and antioxidant activity decreased with an increase in the tested cycle. The TPC increased from 8.23 ± 0.42 mg GAE/g to 3.62 ± 0.18, 3.59 ± 0.10 and 3.60 ± 0.12 mg GAE/g after 1st, 2nd and 3rd cycle, respectively. However, a slight decrease in antioxidants from 93.96 ± 0.12% to 90.33 ± 0.10, 90.15 ± 0.21, and 88.99 ± 0.13% was detected after 1st, 2nd and 3rd cycles, respectively. The high stability of facial toner was detected under three cycles of accelerated heating/cooling analysis.

The use of banana peel can have positive implications. Firstly, the banana peel may benefit the environment by using secondary processing materials. Secondly, it may provide a new perspective for consumers and producers concerning developing value-added products. In addition, banana peel showed the potential economic implications while it can be a suitable, less costly alternative to chemical-based substances. Recycling banana peels can effectively reduce waste and help implement efficient waste management practices. These by-products have been reported to be abundant and available for industrial scale-up [6].

4. Conclusions

This study showed the benefits of banana peel extract, which can be used as an ingredient in facial toners. The optimal incubation time obtained for maximum yield was observed at 72 h. High values of TPC (8.23 ± 0.42 mg GAE/g), TFC (8.18 ± 0.08 mg QE/g), and antioxidant (93.96%) were observed. In addition, the IC_{50} of banana extract was similar to ascorbic acid. Therefore, banana peels could be a good source of bioactive compounds that can be extracted and utilized in various fields, especially cosmetic applications. The facial toner preparation also showed significantly high stability, with a strong antioxidant effect. The banana (Musa ABB cv'. Kluai Namwa) peel, a massive by-product, is an excellent source of high-value raw materials for cosmetic industries. This is the first report to reveal the use of banana peel extract in facial toner by recycling agricultural waste. The results enhanced the reliability of banana peel extract and helped them become premium commercial products in the future. However, the properties of peel extract, such as antimicrobial and anti-aging activity, should be studied in more detail. This will provide a more comprehensive understanding of the potential benefits of using banana peel extract in skincare products. In addition, using

banana extract in the cosmetic field requires careful consideration to ensure safety, efficacy, and stability. Therefore, using plant extracts in cosmetic formulations needs to be ensured, maximizing their beneficial properties while minimizing risks to consumers.

5. Acknowledgements

The authors thank the Department of Chemistry, Faculty of Science and Digital Innovation, Thaksin University, for providing essential research facilities. Financial support for this work was received from the bachelor's program in Chemistry and Innovation, Faculty of Science and Digital Innovation, Thaksin University.

Author Contributions: Conceptualization: K. S., J. N.; Methodology: J. N., N. B., and N. C.; Formal analysis and investigation: J. N., N. B., and K. S.; Writing — original draft preparation: J. N.; Writing — review and editing: K. S.; Supervision: K. S. and N. C., Projection administration: K. S.

Funding: This research was funded by the bachelor's program in Chemistry and Innovation, Faculty of Science and Digital Innovation, Thaksin University.

Conflicts of Interest: The authors declare no conflict of interest.

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