

Article

Development and Clinical Efficacy Evaluation of Facial Toner Containing *Houttuynia cordata* Thunb

Oraphan Anurukvorakun * and Sarunpat Numnim

Department of Cosmetic Science, Phranakhon Rajabhat University, Bangkok 10220, Thailand; sarunpat76@gmail.com

* Correspondence: oraphan@pnru.ac.th; Tel.: +66-94-556-8638

Abstract: The goal of this research was to develop a reliable oil-controlling toner for facial skin with a natural product, *Houttuynia cordata* Thunb extract (HCE). The developed HCE facial toner showed high stability and had a high satisfaction level. Clinical studies revealed that the sebum value of the skin after using the developed HCE toner for eight weeks decreased (4.6-times lower), which was statistically significant (p -value < 0.05) when compared to the HCE-free toner. The sebum amount on the facial skin after using the HCE toner decreased by approximately two-times compared to the HCE-free toner. In addition, the skin moisture content increased statistically significantly (p -value < 0.05) from the eighth week of treatment compared to the HCE-free toner and was 1.5- and 1.4-times higher for the left and right cheeks, respectively. The average moisture content of the facial skin treated with the HCE toner increased by 2- and 1.4-times compared to the treatment with the HCE-free toner for the left and right cheeks, respectively. Consequently, the HCE toner had anti-sebum and moisturizing efficacy, and the increased reliability of the natural product meant that it could soon be a premium commercial product.

Keywords: *Houttuynia cordata* Thunb; clinical studies; anti-sebum; moisturizing



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1. Introduction

Facial toners are utilized as cosmeceutical products and have several functions, for example rehydrating the skin, balancing the skin's pH, tightening skin pores, relieving irritation, and antisepsis [1]. Cleansing faces with a high-pH cleanser might upset the skin. Therefore, toners have been developed to balance the skin's pH [2]. The main ingredients found in toners are beta hydroxy acid (BHA) and alpha hydroxy acid (AHA). Currently, toners are supplemented with ingredients with functions other than cleaning the face, such as adding moisturizers to reduce the occurrence of pimples and control oiliness on the skin. Oily skin usually refers to a facial condition where the skin has a shiny appearance and greasiness due to excessive sebum production and secretion. This aesthetic problem leads to skin disorders such as acne [3,4]. Therefore, utilizing cosmetics to reduce oiliness is challenging. Important components in toners include essential oils, antioxidants, vitamins, and herbal extracts.

Houttuynia cordata Thunb (*H. cordata*; Saururaceae) is found in Asian regions. Studies of *H. cordata* or heartleaf (leaves are heart-shaped) show its benefits for oily, dehydrated, and acne-prone skin. *H. cordata* extract (HCE) contains humectants and is excellent for skin hydration and maintaining the skin's moisture [4,5]. It also has powerful anti-allergic properties and is beneficial for dermatitis-/eczema-prone skin. Phenolic compounds from HCE, such as alkaloids and flavonoids (hyperoside, afzelin, and quercetin) are beneficial as active ingredients for cosmetics [4,6,7]. Moreover, many studies have found that HCE contains compounds with antioxidant properties [8], antibacterial properties (strong anti-microbial effects against the bacteria most commonly contributing to acne: *Propionibacterium acnes* and *Staphylococcus epidermidis*) [9], antiviral activity [10–12], anti-inflammatory properties [13,14], anti-skin-aging properties [15,16] and anti-allergic effects [15,17]. Some

compounds have also been found to be severe acute respiratory syndrome coronavirus 2 inhibitors (SARS-CoV-2 inhibitors) [18]. In addition, *H. cordata* is a suitable ingredient in cosmetic creams for dry and rough skin and preventing chapped skin [19]. *H. cordata* is also suitable for the development of a toner to control oiliness and add moisture to the face. Nevertheless, there are few research reports on HCE facial toners, and there is a lack of information on safety and quality-control standards. Therefore, further study should be encouraged to test the efficacy of products developed in human clinical trials. Clinical studies require modern equipment and ethics committees in order to meet ethical and safety standards (Declaration of Helsinki). These clinical studies can increase the reliability of and prospects for herbal cosmetics.

Consequently, the ultimate goal of this research was to develop an oil-controlling and moisture-adding facial toner product containing *H. cordata* and to confirm its anti-sebum efficacy and hydration effects by conducting clinical trials on volunteers.

2. Materials and Methods

2.1. *H. cordata* Preparation and Extraction

Fresh leaves of *H. cordata* were purchased from Ton Rak Khon Kaen Herbal Shop, 600 Moo 27, Ban Non-Muang Sila, Muang Khon Kaen District, Khon Kaen Province 40000. They were examined for biological characteristics and their scientific name identified. They were then cleaned and decontaminated. The herbs were set aside and dried at 50 °C to prepare them for extraction.

Then, 50 g of the grinding sample was extracted by the maceration method using 600 g ethanol (95% ethanol). Then, the slurry was sonicated for 30 min, after which the resulting solution was filtered through a filter bag, and the filtrate was concentrated by evaporating with a rotary evaporator under a vacuum (rotary evaporator at a temperature of 50 °C, vacuum of 180 mbar, and rotation of 50 rpm). Finally, the extract was dried in a hot-air oven at 50 °C.

2.2. Facial Toner Formulation

The oil-controlling and moisture-adding facial toners were prepared as two formulations: with and without HCE as F1 and F2, respectively. Deionized water was introduced in two phases (A and B) to facilitate solubility and compatibility. The deionized water contained the highest percentage of any facial toner formula. The facial toners were formulated by mixing the ingredients, as in Table 1. Phase A was mixed well by stirring and heating for 50 °C. It was then cooled to 30 °C, and Phase B was added slowly, while stirring continuously until well combined. Then, Phase C, perfume, and phenoxyethanol, were gradually added to Phase AB. Lastly, the pH values of the facial toners were adjusted to 5.5 using 10% citric acid. In this work, proper facial toners were those that did not leave a greasy feeling on the skin, felt light-weight, and left the skin feeling supple.

2.3. Accelerated Stability Studies

The stability study was conducted using a slightly modified method based on several publications [19–21]. An accelerated stability study was conducted under the heating/cooling process. The heating/cooling process was achieved by storing the developed products in a fridge/incubator. The storage temperatures changed between 4 ± 2 °C and 45 ± 2 °C every 24 h for each cycle. The stability study was conducted for six cycles. The stability at ambient temperature was examined for six cycles as well. Then, 10 g of the developed products from each stored cycle was centrifuged at 3000 rpm for 30 min (Centrifuge, Benchtop Rotofix 32A, Bangkok, Thailand). The phase separation and the changes were observed. Besides, the pH values of the developed toners were examined and reported using a pH meter (Bench Top pH Meter, ST300 Ohaus, Shanghai, China) to demonstrate their stability.

Table 1. The ingredients, percentages, and functions of the facial toner.

Ingredient	Phase	Formula (% w/w)		Function
		F1	F2	
Deionized water	A	47.39	47.42	Solvent
Hydroxyethyl cellulose	A	0.10	0.10	Film-forming
PEG-40 hydrogenated castor oil	A	0.75	0.75	Surfactant—cleansing Surfactant—emulsifying
Deionized water	B	47.4	47.42	Solvent
Glycerin	B	3.00	3.00	Humectant
Panthenol	B	0.30	0.30	Skin-conditioning
Polyquaternium-51	B	0.50	0.50	Skin-conditioning
<i>Houttuynia cordata</i> Thunb extract	B	0.05	-	Active Ingredient
Fragrance	C	0.01	0.01	Perfume
Phenoxyethanol	C	0.50	0.50	Preservative
Citric Acid 10%	D	q.s.	q.s.	pH adjuster

2.4. Clinical Test of Facial Toner Efficiency

2.4.1. Volunteer Recruitment

- The study was conducted according to the Declaration of Helsinki [22], and the protocol was authorized by The Ethics Committee of Phranakhon Rajabhat University, Bangkok, Thailand (approved study code: AF05-06; study code: 02.022/6). All subjects were required to sign a consent form to participate in this study. The volunteers had the right to withdraw from the test without consequences or penalties, at any time.
- Inclusion criteria: Twenty-one healthy male and female volunteers, aged 18 years and over, did not have skin diseases and abnormalities such as rashes, erythema, or eczema pregnant, or still had to breastfeed. All volunteers were informed of the test objectives and procedures; for example, during the test, volunteers must use the product every day, once a day, avoid the risk of using other facial products, and avoid working outdoors for a long time, and the volunteers must be aware of the potential side effects. The volunteers must pass allergy and irritation tests as mentioned in Section 2.4.2 before participating in the treatment with the developed products for two months. All subjects were required to give informed consent before participating in the study. The investigators adhered to all criteria and procedures for submitting research applications on human subjects.
- Exclusion criteria: Subjects had a history of corticosteroid or antihistamine use two weeks before the trial.
- Withdrawal criteria of the study: Subjects experienced an allergic reaction to the product during the test, became pregnant, or did not have time for the test.
- Termination of study criteria: subjects had an allergic reaction to the product.

The study flowchart of the participants is shown in Figure 1, describing the trial process.

For clinical testing, the sixteen volunteers who passed through irritation and allergy testing were divided into two groups of 8 volunteers. Each group was treated separately daily with the facial toner with each formulation (F1 and F2 with and without HCE) and observed for eight weeks of follow-up. The study was randomized and placebo-controlled. The volunteers were requested to use ten drops of facial toner, which were absorbed on a cotton pad, once in the morning over eight weeks. All volunteers were allergy-free for one week and had not used steroids and topical products for oily or greasy face treatment for four weeks before the study. The volunteers were requested not to apply any products to the face the night before starting the measurement. The evaluation was planned and conducted at Weeks 0, 5, 6, 7, and 8 using the Sebumeter® SM 815 (Courage+Khazaka electronic GmbH, Ossendorf, Germany) to measure sebum content and the Corneometer® CM 825, Ossendorf, Germany) to measure skin hydration.

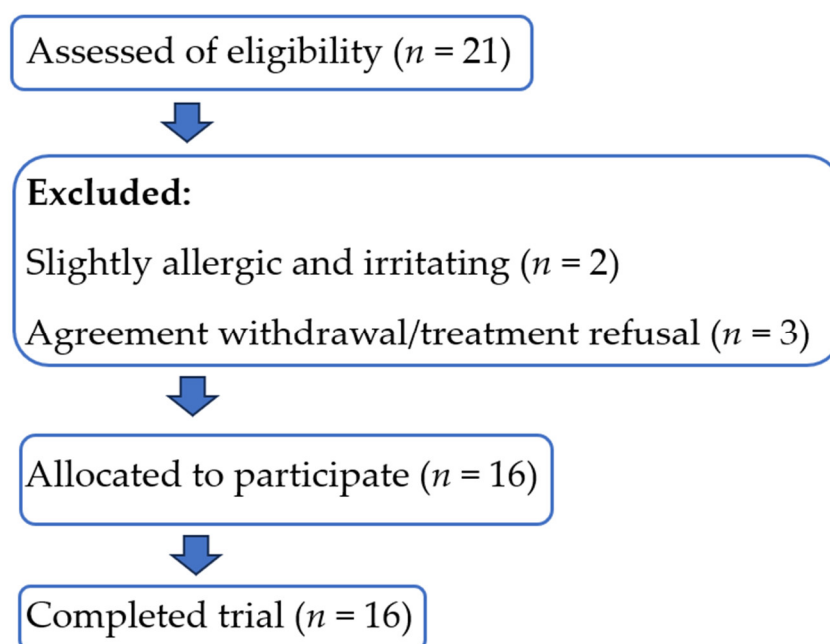


Figure 1. The study flowchart of the participants.

2.4.2. Patch Test

The irritation and allergic reactions were evaluated using patch testing [23–25]. The researchers recruited the volunteers and conducted the following. All volunteers were informed of the objectives, possible adverse effects, and test procedures and were rewarded for their participation. The approved study code from The Ethics Committee of Phranakhon Rajabhat University, Bangkok, Thailand, AF05-06, was 02.022/6. All volunteers gave consent before entering the study. Volunteers had the right to withdraw from the test at any time without consequence or penalty.

During the patch test method, ten drops of the developed toner were kept on the inside of the arm and in contact with the skin under a $5.5 \times 6.5 \text{ cm}^2$ occlusive patch. After skin contact for a specified period of time (30 min), the patch was opened and any symptoms of skin irritation were observed. The skin's irritation was indicated by different ratings, such as without irritation, redness, edema, or redness.

2.4.3. Efficacy Evaluation through Modern Non-Invasive Measurements of the Skin

All volunteers were evaluated for all facial greasiness with the Sebumeter® SM 815 at the baseline or before treatment with the facial toners. The subjects were acclimatized and their faces were cleaned with the cleanser provided in the waiting room ($T^\circ = 20\text{--}22^\circ \text{C}$, humidity 40–60%) for 30 min [26] before the measurement was carried out under the same condition for every evaluation.

It takes 28 days for basal cells to migrate through the epidermis and remove the epidermal layer in humans [27]. Therefore, the evaluation was planned and conducted at Weeks 0, 5, 6, 7, and 8. The sebum content of the three different spots on the T-zone: forehead, cheek, and chin, was analyzed. The undesirable effects were observed, if any, including erythema, edema, scaling, itching, stinging, burning, tightness, or prickling of the skin, and rated as none, mild, severe, or very severe. The evaluation was conducted at the location and with the same lighting at each evaluation by the Sebumeter® SM 815 under the same conditions as the baseline. Anti-sebum efficacy was calculated [28] as follows:

$$\text{Anti-sebum efficacy (\%)} = 100 - \left(\frac{St}{S0} \right) \times 100$$

where St = Sebum content (g/cm^2) at time interval and S_0 = Sebum content (g/cm^2) at baseline.

Additionally, an evaluation of skin hydration was conducted as well. The right and left face were measured separately to determine the skin hydration. The skin's electrical properties depend on the water content of the stratum corneum of the epidermis. Epidermal hydration was analyzed for both groups by measuring the electrical capacitance with the Corneometer[®]CM 825. The principle of the method relies on the difference between the dielectric constant of water (81) and other substances by measuring the capacitance of a dielectric medium [25]. The Corneometer[®]CM 825 contains two electrodes with different electrical charges that form an electromagnetic field, which determines the dielectricity of the stratum corneum. The depth of measurement was low (the first 10–20 μm of the stratum corneum) due to the construction of the measuring head of the Corneometer[®]CM 825. The range of variation of the values of skin hydration degree was between 0 and 130 arbitrary units (a.u.) at the standard working conditions ($T^\circ = 20\text{--}22^\circ\text{C}$, humidity 40–60%). The variations of the values of the skin hydration degree were the following: under 30 a.u.—very dry, between 30 and 45 a.u.—dry, 45 a.u.—sufficiently hydrated, or normal skin higher than 40 a.u. [26,29].

Three repeated measurements were performed at each test, and the means and standard deviations are reported. The paired samples t -test (SPSS Version 26.0) was used to indicate a statistically significant difference.

2.5. Preference Test

For the satisfaction test, both developed facial toners (F1 and F2) were tested by each volunteer (20 people) without knowing the details of each product, using a five-point rating scale questionnaire. The five-point rating scale questionnaire consisted of two parts: personal data: questions in the personal data section were about sex, age, and skin type, and the questions concerning toner products were about spreadability, skin absorption, greasiness, color, and odor. The five-point rating scale ranged from 1 (strongly dissatisfied) to 5 (strongly satisfied). The developed products' preference was also compared to the commercial product in the blinded experiment [30]. Product preference test: The volunteers tested products that contained HCE (F1) and did not contain HCE (F2), and the third was a commercial product (F3).

3. Results

3.1. *H. cordata* Preparation and Extraction

The percentage yield of the *H. cordata* extraction was calculated by the following Equation (1). The percentage yield of the extraction was 3.85%.

$$\text{Percentage of yield} = \frac{\text{crude extract of the } H.\text{cordata}(\text{g})}{\text{initial weight of the } H.\text{cordata}(\text{g})} \times 100 \quad (1)$$

The appearance of the extracted powder is shown in Figure 2. The appearance of the extracted *H. cordata* was dark yellow.

3.2. Facial Toner Formulation

Proper facial toners are absorbed quickly, do not have a greasy feeling, and feel soft and supple when touched. The developed facial toners were successfully formulated by mixing the ingredients following Table 1 (Section 2.2). The successfully developed facial toners are presented in Figure 3 as two formulations, with and without HCE, respectively. Furthermore, F1 and F2 were tinted close to the same color using cosmetic-grade pigment.

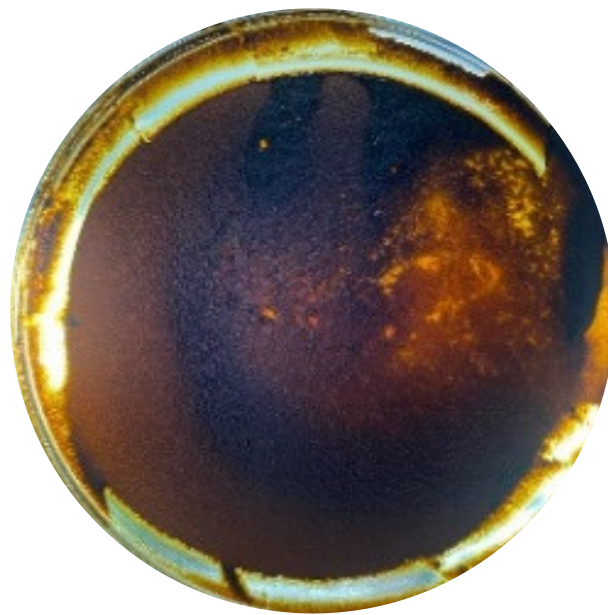


Figure 2. The appearance of the extracted *H. cordata*.

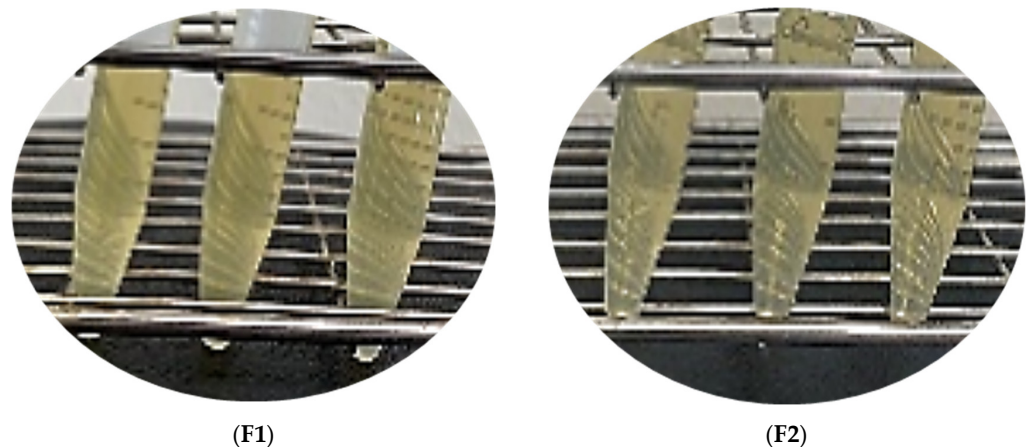


Figure 3. The appearance of HCE toner (F1) and HCE-Free toner (F2).

3.3. Accelerated Stability Studies

Samples subjected to changes in temperature can reveal instability quicker than samples stored continuously in one condition. Therefore, the accelerated stability test of this study was performed by heating/cooling for six cycles, as mentioned in Section 2.3. The stability of the developed facial toner was observed by the pH values, color, odor, lamination, turbidity, and precipitation. After the stability test, the pH values of the formulations were within the range of the skin's pH (5.0–6.0). The pH of the skin surface, or stratum corneum (SC), is typically in the range of 5.0–6.0, as the acid mantle. Maintaining the pH of the SC in the typical range of 5.0–6.0 is very important to provide an effective barrier and maintaining physiological processes, and forming a stabilized double-lamellar structure in these mildly acidic conditions and micellization occurs for $\text{pH} > 6.0$, while a disordered structure occurs for $\text{pH} < 4.5$ [31]. Moreover, the viscosity was suitable for skin application. There was no change in the developed facial toner's appearance, phase separation, and turbidity. Besides, the results showed no phase separation and precipitation for every cycle, confirmed by centrifugation.

The stability test results of the developed facial toner and placebo facial toner are shown in Table 2. The results revealed the stability of the developed toners with and without HCE (F1 and F2), respectively.

Table 2. Stability test results of the developed facial toner containing HCE and the placebo facial toner.

Formulations				F1				F2						
Cycles	0	1st	2nd	3rd	4th	5th	6th	0	1st	2nd	3rd	4th	5th	6th
pH (Average ± SD)	5.57 ± 0.04	5.50 ± 0.10	5.61 ± 0.06	5.51 ± 0.02	5.48 ± 0.00	5.48 ± 0.01	5.43 ± 0.05	5.57 ± 0.02	5.59 ± 0.07	5.57 ± 0.07	5.56 ± 0.05	5.57 ± 0.03	5.61 ± 0.03	5.56 ± 0.06
Color					Unchanged						Unchanged			
Odor					Unchanged						Unchanged			
Phase separation					No						No			
Turbidity					No						No			
Precipitation					No						No			

Note: Number of experiments: 3; data given as the mean $\pm$ SD.

3.4. Clinical Test of Facial Toner Efficiency

The volunteers' reduction in excess sebum after eight weeks of treatment with the HCE toner (F1) was -43.00 g/cm^2 , while the highest reduction in sebum with the treatment with the placebo toner (F2) was -2.33 g/cm^2 . The sebum content analysis results showed that the averages for the treatment with the toner containing HCE (F1) decreased the oiliness by -14.17 , -7.55 , -20.63 , and -31.26 in the 5th, 6th, 7th, and 8th weeks, respectively. There was a statistically significant difference in the eighth week (p -value < 0.05) compared to the baseline (before treatment), while for the placebo toner (F2) treatment, the average sebum content decreased by -1.04 and -4.71 , -7.96 , and -14.79 in the 5th, 6th, 7th, and 8th weeks, respectively. There was a statistically significant difference in the eighth week (p -value < 0.05) compared to the baseline (before treatment), as shown in Table 3. Additionally, the anti-sebum efficacy in the eighth week for the facial toner containing HCE (F1) calculated as Equation (1) was 78%, while for the placebo toner (F2) was 49.3%.

Table 3. Sebum content in eight weeks.

Average (Sebumeter)	F1 Treatment	F2 Treatment
	(g/cm ²) (Average $\pm$ SD)	(g/cm ²) (Average $\pm$ SD)
Baseline	39.88 $\pm$ 35.71	30.00 $\pm$ 18.03
After 5 weeks	25.71 $\pm$ 27.79	28.96 $\pm$ 25.32
Difference (after 5 weeks—baseline)	-14.17 ± 41.63	-1.04 ± 9.01
p -Value (compared within groups after 5 weeks and baseline)	0.36	0.91
After 6 weeks	32.33 $\pm$ 18.35	25.29 $\pm$ 14.78
Difference (after 6 weeks—baseline)	-7.55 ± 45.54	-4.71 ± 5.02
p -Value (compared within groups after 6 weeks and baseline)	0.65	0.38
After 7 weeks	19.25 $\pm$ 14.07	22.04 $\pm$ 14.48
Difference (after 7 weeks—baseline)	-20.63 ± 36.67	-7.96 ± 5.98
p -Value (compared within groups after 7 weeks and baseline)	0.16	0.23
After 8 weeks	8.63 $\pm$ 8.12	15.21 $\pm$ 8.05
Difference (after 8 weeks—baseline)	-31.26 ± 36.64	-14.79 ± 16.23
p -Value (compared within groups after 8 weeks and baseline)	0.05	0.04
The maximum sebum reduction after the 8-week treatment compared to the baseline for the HCE toner group was -43.00 g/cm^2 , while for the placebo toner group was -2.33 g/cm^2 .		

Note: Number of experiments: 3; data are given as the mean $\pm$ SD. p -value by the paired t -test: compared within groups with the baseline.

The overall efficacies for controlling the oil (decreasing the sebum) by the toner containing HCE (F1) were better than the placebo (F2), which could reduce the oiliness about two-times better than F2 at the eighth week of treatment, as shown in Figure 4. The clinical studies revealed that the sebum value of the skin after using the developed toner for eight weeks decreased (4.6-times lower) statistically significantly (p -value < 0.05) compared with before using the toner.

The results of skin moisture analysis on the left side of the face with the Corneometer® CM 825 head showed that the hydration value of the volunteer's left face after eight weeks, treated with the HCE toner, could increase to a maximum of 57.23 a.u. The maximum increased hydration value, treated with the placebo toner (F2), was 1.27 a.u. The averages for the treatment with the toner containing HCE had increased values in moisture of 7.29, 14.42, 20.33, and 30.44 after treatment for 5, 6, 7, and 8 weeks, respectively. There was a

statistically significant difference from the 6-week treatment (p -value < 0.05) compared to the baseline (before treatment). The placebo toner provided a statistically significant difference after the 8-week treatment (p -value < 0.05) compared to the baseline (before treatment), as shown in Table 4.

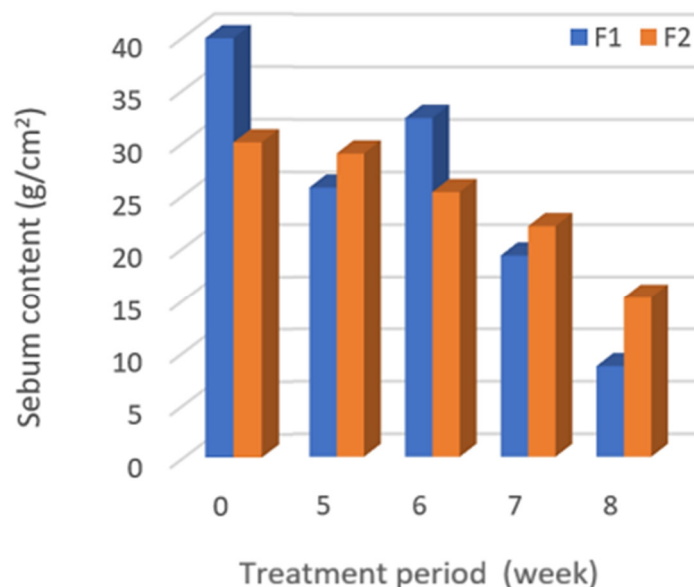


Figure 4. After treatment with the F1 and F2 toners, the sebum content at different treatment periods (week).

Table 4. The left side of the facial skin's moisture content in eight weeks.

Average (Corneometer® CM 825)	F1 Treatment	F2 Treatment
	Arbitrary Units (Average ± SD)	Arbitrary Units (Average ± SD)
Baseline	58.55 ± 15.94	76.15 ± 12.46
After 5 weeks	65.84 ± 11.68	55.05 ± 14.79
Difference (after 5 weeks—baseline)	7.29 ± 14.46	−21.10 ± 16.66
<i>p</i> -Value (compared within groups after 5 weeks and baseline)	0.20	0.01
After 6 weeks	72.97 ± 7.66	60.88 ± 17.66
Difference (after 6 weeks—baseline)	14.42 ± 14.91	−15.27 ± 18.46
<i>p</i> -Value (compared within groups after 6 weeks and baseline)	0.03	0.05
After 7 weeks	78.88 ± 8.87	79.76 ± 8.70
Difference (after 7 weeks—baseline)	20.33 ± 18.60	3.61 ± 13.37
<i>p</i> -Value (compared within groups after 7 weeks and baseline)	0.02	0.47
After 8 weeks	88.99 ± 7.49	90.39 ± 7.49
Difference (after 8 weeks—baseline)	30.44 ± 18.28	14.24 ± 10.89
<i>p</i> -Value (compared within groups after 8 weeks and baseline)	0.00	0.01

The maximum increase in hydration of the volunteers' left faces after eight weeks of treatment with the HCE toner was 57.23 a.u., while that for the placebo toner (F2) treatment was 1.27 a.u.

Note: Number of experiments: 3; data are given as the mean ± SD. *p*-value by paired *t*-test: compared within groups with the baseline.

The results of skin moisture analysis on the right side of the face with the Corneometer® CM 825 head showed that the hydration value of the volunteer's right face after eight weeks of treatment with the HCE (F1) toner increased to a maximum of 41.63 a.u. The maximum increase in the hydration value with the placebo toner (F2) was 5.97 a.u. The averages for the treatment with the toner containing HCE had increased values in moisture as 7.01, 8.39, 17.12, and 24.23 after treatment for 5, 6, 7, and 8 weeks, respectively. Furthermore, there was a statistically significant difference from the fifth week (p -value < 0.05) compared to the baseline (before treatment). Treatment with the placebo toner provided a statistically significant difference after the seventh week of treatment (p -value < 0.05) compared to the baseline (before treatment), as shown in Table 5.

Table 5. The right side of the facial skin's moisture content in eight weeks.

Average (Corneometer® CM 825)	F1 Treatment	F2 Treatment
	Arbitrary Units (Average $\pm$ SD)	Arbitrary Units (Average $\pm$ SD)
Baseline	63.31 $\pm$ 10.40	74.15 $\pm$ 12.68
After 5 weeks	70.32 $\pm$ 13.78	62.36 $\pm$ 13.86
Difference (after 5 weeks—baseline)	7.01 $\pm$ 8.28	−11.79 $\pm$ 16.37
p -Value (compared within groups after 5 weeks and baseline)	0.05	0.08
After 6 weeks	71.70 $\pm$ 6.61	69.80 $\pm$ 16.31
Difference (after 6 weeks—baseline)	8.39 $\pm$ 8.59	−4.35 $\pm$ 15.61
p -Value (compared within groups after 6 weeks and baseline)	0.03	0.46
After 7 weeks	80.43 $\pm$ 10.40	82.95 $\pm$ 6.65
Difference (after 7 weeks—baseline)	17.12 $\pm$ 7.81	8.80 $\pm$ 10.06
p -Value (compared within groups after 7 weeks and baseline)	0.00	0.04
After 8 weeks	87.54 $\pm$ 8.36	91.01 $\pm$ 4.68
Difference (after 8 weeks—baseline)	24.23 $\pm$ 10.43	16.86 $\pm$ 12.91
p -Value (compared within groups after 8 weeks and baseline)	0.00	0.01

The maximum increase in hydration of the volunteers' left faces after eight weeks of treatment with the HCE toner was 41.63 a.u., while that for the placebo toner (F2) treatment was 5.97 a.u.

Note: Number of experiments: 3; data are given as the mean $\pm$ SD. p -value by paired t -test: compared within groups with the baseline.

The overall efficacies for increasing skin moisture of the toner containing HCE (F1) were better than the placebo (F2). The skin moisture could be increased 2- and 1.4-times more than the HCE-free toner for the left and right cheeks in the eight weeks of treatment, as shown in Figure 5.

3.5. Preference Test

The satisfaction with the developed facial toner containing HCE as F1 (4.50) was higher than the placebo toner (F2) (4.25). It was less than the commercial toner (F3) (4.55). However, the overall satisfaction with the facial toner containing HCE (F1) and the commercial toner (F3) was not a statistically significant different (p -value > 0.05) using the paired samples t -test, as shown in Table 6.

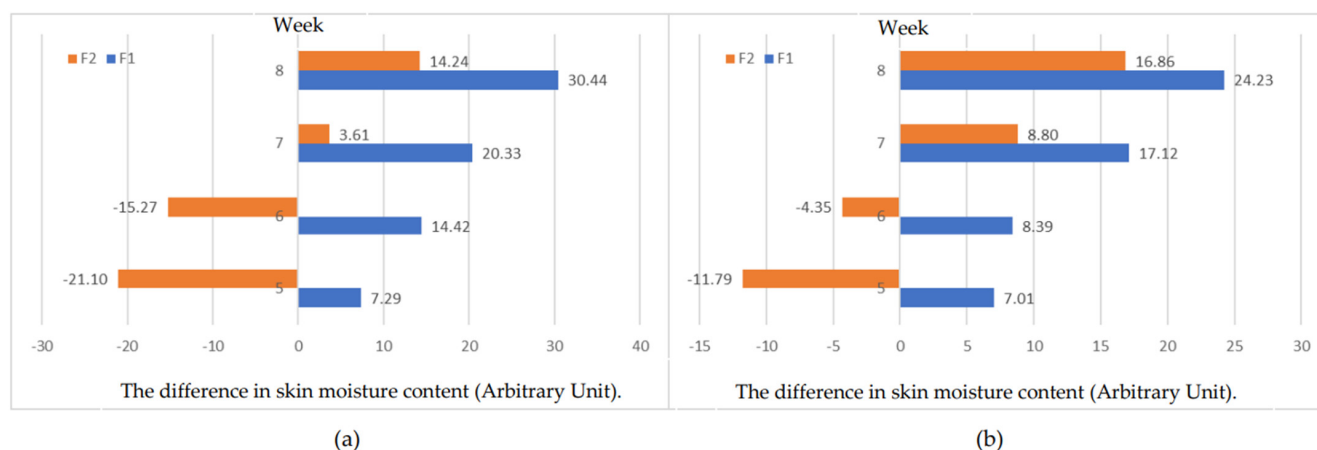


Figure 5. The difference in skin moisture content after 5–8-week treatment: (a) measurement from the left side of the face; (b) measurement from the right side of the face.

Table 6. Average product satisfaction in each aspect.

Preference	Preference of Average ($n = 20$)		
	F 1	F2	F3
1. Spreadability	4.60 ± 0.50	4.45 ± 0.76	4.65 ± 0.57
2. Skin absorption	4.60 ± 0.50	4.25 ± 0.72	4.60 ± 0.60
3. Greasiness	4.35 ± 0.81	4.40 ± 0.75	4.45 ± 0.76
4. Color	4.40 ± 0.82	4.15 ± 1.04	4.65 ± 0.75
5. Odor	4.55 ± 0.60	3.95 ± 0.83	4.40 ± 0.60
Overall	4.50	4.25	4.55

Note: Data are given as the mean $\pm$ SD.

4. Discussion

Scientific evidence will enhance the reliability of natural products and help them become premium commercial products in the future. This study is the first report to reveal the efficacy of an HCE facial toner. The HCE, widely known as the queen of all spot treatments [32], was developed as an oiliness-controlling and moisture-adding facial toner, and its efficacy was studied regarding its anti-sebum efficacy and hydration effects by conducting clinical trials.

The developed HCE facial toner showed high stability under accelerated heating/cooling testing and revealed a high satisfaction level for spreadability, skin absorption, greasiness, color, and odor. The developed HCE (F1) toner has significantly improved anti-sebum performance. The HCE toner could reduce the amount of sebum by 4.6-times after using the developed toner for eight weeks. There was a statistically significant difference in the eighth week (p -value < 0.05) compared to before the treatment. The sebum content of skin treated with the HCE toner was decreased by approximately two-times compared to the skin treated using the HCE-free toner at Week 8. This oiliness controlling of the developed facial toner may be due to quercetin, the flavonoid in *H. cordata* extract [4,6]. Quercetin significantly reduces cholesterol levels [33,34], where cholesterol is a component of sebum [35]. The results were consistent with reports that the extract works well for acne-prone skin while gently controlling the sebum [9].

Additionally, the average skin moisture content of the treatment with the HCE facial toner was approximately 2- and 1.4-times higher than that of the HCE-free toner for the left and right cheeks, respectively. This might be the result of polysaccharides from *H. cordata* extract, i.e., macromolecules from various sugar units such as galacturonic acid, galactose, rhamnose, arabinose, glucuronic acid, glucose, xylose, and mannose in

HCE [36–38]. Polysaccharides and sugars in skincare are excellent humectants and skin hydrators, meaning they help the skin hold onto water [39]. The results were consistent with several research reports [40,41].

In conclusion, the natural extract (*H. cordata* extract) was confirmed through the stability and efficacy of its anti-sebum and moisturizing by clinical trials for this study. Therefore, the HCE facial toner in this work demonstrates its readiness and credibility to become a premium commercial product.

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References

1. Chatur, V.M.; Walode, S.G.; Awate, S.A.; Gandhi, M.U.; Thorat, V.S. Formulation and physical characterization of herbal face gel toner. *World J. Adv. Res. Rev.* **2021**, *11*, 138–145. [CrossRef]
2. Science Behind Skin: The Importance of Balancing Your Skin's pH. Available online: <https://yeouth.com/blogs/news/science-behind-skin-the-importance-of-balancing-your-skin-s-ph> (accessed on 13 April 2023).
3. Wu, Y.; Niu, Y.; Zhong, S.; Liu, H.; Zhen, Y.; Saint-Leger, D.; Verschoore, M. A preliminary investigation of the impact of oily skin on quality of life and concordance of self-perceived skin oiliness and skin surface lipids (sebum). *Int. J. Cosmet. Sci.* **2013**, *35*, 442–447. [CrossRef]
4. Hazarika, N.; Archana, M. The Psychosocial Impact of Acne Vulgaris. *Indian J. Dermatol.* **2016**, *61*, 515–520. [CrossRef]
5. Park, C.I. Study on the Effects of *Houttuynia Cordata* Extracts on Emulsions. *Korea J. Herbol.* **2010**, *25*, 92850731.
6. Zillich, O.V.; Schweiggert-Weisz, U.; Eisner, P.; Kerscher, M. Polyphenols as active ingredients for cosmetic products. *Int. J. Cosmet. Sci.* **2015**, *37*, 455–464. [CrossRef]
7. Lee, J.H.; Ahn, J.; Kim, J.W.; Lee, S.G.; Kim, H.P. Flavonoids from the aerial parts of *Houttuynia cordata* attenuate lung inflammation in mice. *Arch. Pharm. Res.* **2015**, *38*, 1304–1311. [CrossRef]
8. Panzella, L. Natural phenolic compounds for health, food and cosmetic applications. *Antioxidants* **2020**, *9*, 9050427. [CrossRef]
9. Phosri, S.; Kiattisin, K.; Intharuksa, A.; Janon, R.; Nongkhai, T.A.; Theansungnoen, T. Anti-Aging, Anti-Acne, and Cytotoxic activities of *Houttuynia cordata* extracts and phytochemicals analysis by LC-MS/MS. *Cosmetics* **2022**, *9*, 9060136. [CrossRef]
10. Wu, L.S.; Si, J.P.; Yuan, X.Q.; Shi, X.R. Quantitative variation of flavonoids in *Houttuynia cordata* from different geographic origins in china. *J. Nat. Med.* **2009**, *7*, 40–46.
11. Lu, Y.; Wang, X.; Chen, D.; Chen, G. Polystyrene/graphene composite electrode fabricated by in situ polymerization for capillary electrophoretic determination of bioactive constituents in *Herba Houttuyniae*. *Electrophoresis* **2011**, *32*, 1906–1912. [CrossRef]
12. Ling, L.J.; Lu, Y.; Zhang, Y.Y.; Zhu, H.Y.; Tu, P.; Li, H. Flavonoids from *Houttuynia cordata* attenuate h1n1-induced acute lung injury in mice via inhibition of influenza virus and toll-like receptor signaling. *Phytomedicine* **2020**, *67*, 153150. [CrossRef]
13. Rafiq, S.; Hao, H.; Ijaz, M.; Raza, A. Pharmacological effects of *Houttuynia cordata* Thunb (*H. cordata*): A comprehensive review. *Pharmaceuticals* **2022**, *15*, 1079. [CrossRef]
14. Li, J.; Zhao, F. Anti-inflammatory functions of *Houttuynia cordata* Thunb. and its compounds: A perspective on its potential role in rheumatoid arthritis. *Exp. Ther. Med.* **2015**, *10*, 3–6. [CrossRef] [PubMed]
15. Fu, J.; Dai, L.; Lin, Z.; Lu, H. *Houttuynia cordata* Thunb: A review of phytochemistry and pharmacology and quality control. *Chin. Med.* **2013**, *4*, 101–123. [CrossRef]

16. Mapoung, S.; Umsumarng, S.; Semmarath, W.; Arjsri, P.; Srisawad, K.; Thippraphan, P.; Yodkeeree, S.; Dejkriengkraikul, P. Photoprotective Effects of a Hyperoside-Enriched Fraction Prepared from *Houttuynia cordata* Thunb. on Ultraviolet B-Induced Skin Aging in Human Fibroblasts through the MAPK Signaling Pathway. *Plants* **2021**, *29*, 10122628. [\[CrossRef\]](#)
17. Lee, J.S.; Kim, I.S.; Kim, J.H.; Kim, J.S.; Kim, D.H.; Yun, C.Y. Suppressing effects of *Houttuynia cordata* Thunb (Saururaceae) extract on Th2 immune response. *J. Ethnopharmacol.* **2008**, *1*, 34–40. [\[CrossRef\]](#)
18. Gurung, A.B.; Ali, M.A.; Lee, J.; Farah, M.A.; Al-Anazi, K.M.; Al-Hemaid, F. Identification of SARS-CoV-2 inhibitors from extracts of *Houttuynia cordata* Thunb. *Saudi J. Biol. Sci.* **2021**, *28*, 7517–7527. [\[CrossRef\]](#) [\[PubMed\]](#)
19. Timudom, T.; Chaiyasut, C.; Sivamaruthi, B.S.; Tiampasook, P.; Nacapunchai, D. Anti-Sebum efficacy of *Phyllanthus Emblica* L. (Embllica) toner on facial skin. *Appl. Sci.* **2020**, *10*, 8193. [\[CrossRef\]](#)
20. Chuarienthong, P.; Lourith, N.; Leelapornpisid, P. Clinical efficacy comparison of anti-wrinkle cosmetics containing herbal flavonoids. *Int. J. Cosmet. Sci.* **2010**, *32*, 99–106. [\[CrossRef\]](#)
21. Jarupinthusophon, S.; Preechataninrat, P.; Anurukvorakun, O. Development of Liquid Crystal Cream Containing Germinated Brown Rice. *Appl. Sci.* **2022**, *12*, 122111113. [\[CrossRef\]](#)
22. The World Medical Association's Declaration of Helsinki: Historical and Contemporary Perspectives. Available online: <https://www.yumpu.com/en/document/view/34939065/declaration-of-helsinki-historical-contemporary-perspective> (accessed on 13 April 2023).
23. Hafner, M.F.S.; Rodrigues, A.C.; Lazzarini, R. Allergic contact dermatitis to cosmetics: Retrospective analysis of a population subjected to patch tests between 2004 and 2017. *An. Bras. Dermatol.* **2020**, *95*, 696–701. [\[CrossRef\]](#)
24. Samanta, A.; Agarwal, K.; Naskar, B.N.; De, A. The role of patch testing with Indian cosmetic series in patients with facial pigmented contact dermatitis in India. *Indian J. Dermatol.* **2021**, *66*, 81–86.
25. Li, B.; Cheng, Y.; Tan, Y.; Wang, F.; Hu, W.; Wang, X.; Liu, W.; Krutmann, J.; Wang, S.; Zou, Y. Analysis of factors influencing patch test reactions: Results from a large- population-based study in Chinese. *J. Cosmet. Dermatol.* **2021**, *21*, 2183–2188. [\[CrossRef\]](#) [\[PubMed\]](#)
26. Constantin, M.M.; Poenaru, E.; Poenaru, C.; Constantin, T. Skin hydration assessment through modern non-invasive bioengineering technologies. *Maedica* **2014**, *9*, 33–38.
27. Milstone, L.M.; Hu, R.H.; Dziura, J.D.; Zhou, J. Impact of epidermal desquamation on tissue stores of iron. *J. Dermatol. Sci.* **2012**, *67*, 9–14. [\[CrossRef\]](#)
28. Meethama, P.; Kanlayavattanukul, M.; Lourith, N. Development and clinical efficacy evaluation of anti-greasy green tea toner on facial skin. *Rev. Bras. Farmacogn.* **2018**, *28*, 214. [\[CrossRef\]](#)
29. Vasques, L.I.; Leonardi, G.R. User experience in cosmetics: Perception analysis regarding the use of an anti-aging moisturizer. *Cosmetics* **2023**, *10*, 10010033.
30. Rungruangjit, W.; Chankoson, T.; Charoenpornpanichkul, K. Understanding different types of followers' engagement and the transformation of millennial followers into cosmetic brand evangelists. *Behav. Sci.* **2023**, *13*, 270. [\[CrossRef\]](#) [\[PubMed\]](#)
31. Kwon, S.S.; Kong, B.J.; Park, S.M. Physicochemical properties of pH-sensitive hydrogels based on hydroxyethyl cellulose-hyaluronic acid and for applications as transdermal delivery systems for skin lesions. *Eur. J. Pharm. Biopharm.* **2015**, *92*, 146–154. [\[CrossRef\]](#)
32. Ingredients *Houttuynia cordata* 95% Mask, Oil Control & Moisture Balancing Face Mask Sheet, Vegan, Cruelty-Free, Organic Clean Beauty, Fragrance-Free, Peta Approved, Eco-Friendly Pouch, 5 Sheets. Available online: <https://www.amazon.com/ONGREDIENTS-Houttuynia-Cruelty-Free-Fragrance-Free-Eco-Friendly/dp/B09R7FB3TL> (accessed on 13 April 2023).
33. Guo, W.; Gong, X.; Li, M. Quercetin Actions on Lipid Profiles in Overweight and Obese Individuals: A Systematic Review and Meta-Analysis. *Curr. Pharm. Des.* **2019**, *25*, 3087–3095. [\[CrossRef\]](#)
34. Tabrizi, R.; Tamtaji, O.R.; Mirhosseini, N.; Lankarani, K.B.; Akbari, M.; Heydari, S.T.; Dadgostar, E.; Asemi, Z. The effects of quercetin supplementation on lipid profiles and inflammatory markers among patients with metabolic syndrome and related disorders: A systematic review and meta-analysis of randomized controlled trials. *Crit. Rev. Food Sci. Nutr.* **2020**, *60*, 1855–1868. [\[CrossRef\]](#)
35. Pappas, A.; Johnsen, S.; Liu, J.C.; Eisinger, M. Sebum analysis of individuals with and without acne. *Dermato-Endocrinology* **2009**, *3*, 157–161. [\[CrossRef\]](#)
36. Liu, X.; Tian, J.; Pan, Y.; Li, Z.; Zhou, Z.; Pan, Z.; Tai, H.; Xing, Y. Structural characterization and biological activity of polysaccharides from stems of *Houttuynia cordata*. *Foods* **2022**, *11*, 11223622. [\[CrossRef\]](#)
37. Cheng, D.; Sun, L.; Zou, S.; Chen, J.; Mao, H.; Zhang, Y.; Liao, N.; Zhang, R. Antiviral Effects of *Houttuynia cordata* Polysaccharide Extract on Murine Norovirus-1 (MNV-1)—A Human Norovirus Surrogate. *Molecules* **2019**, *24*, 1835. [\[CrossRef\]](#) [\[PubMed\]](#)
38. Tian, L.; Zhao, Y.; Guo, C.; Yang, X. A comparative study on the antioxidant activities of an acidic polysaccharide and various solvent extracts derived from herbal *Houttuynia cordata*. *Carbohydr. Polym.* **2011**, *83*, 537–544. [\[CrossRef\]](#)
39. Kanlayavattanukul, M.; Lourith, N. *Biopolysaccharides for Skin Hydrating Cosmetics*; Springer: Berlin/Heidelberg, Germany, 2014. [\[CrossRef\]](#)

40. Yao, Y.; Xu, B. Skin health-promoting effects of natural polysaccharides and their potential application in the cosmetic industry. *Polysaccharides* **2022**, *3*, 818–830. [[CrossRef](#)]
41. Albuquerque, P.B.S.; Oliveira, W.F.D.; Silva, P.M.D.S.; Correia, C.T.D.S.; Kennedy, J.F.; Coelho, L.C.B.B. Skincare application of medicinal plant polysaccharides—A review. *Carbohydr. Polym.* **2022**, *277*, 118824. [[CrossRef](#)]

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