Check for updates

Original Research Article

Design of Chinese Medicinal "Curcumin" Ointment and Study its Antioxidant or Anti-bacterial Properties Compared with a Commercial Product*

Pharmacognosy Magazine
22(3) 998–1008, 2026
© The Author(s) 2025
Article reuse guidelines:
in.sagepub.com/journals-permissions-india
DOI: 10.1177/09731296251384395
journals.sagepub.com/home/phm
Sage

Mei Tsz Lai[1], Siu Kan Law[1], Sze Wing Ng[1], Yanping Wang[2] and Xiao Xiao Wu[3]

Abstract

Background: Many cosmetic products possess antioxidant and anti-bacterial properties. However, they are chemically synthesized products. This research project focuses on "organic" and "natural" for skin care products. "Organic" is derived from living matter, such as the Chinese medicinal plant, "*Curcuma longa* L." "Natural" exists in or is derived from nature, and is not made or caused by humankind, as these have some advantages.

Objectives: The research aimed to design and develop a Chinese medicinal ointment using "natural curcumin extract powder (NCP)" with 98% purity of a bioactive ingredient, "curcumin," as well as evaluate its antioxidant and anti-bacterial properties. The NCP ointments have active ingredients with different percentages, including 1%, 3%, and 5%, compared to Thailand's commercial "extract curcuma" (TP) product.

Materials and Methods: These Chinese medicinal NCP ointments were conducted with four qualitative and quantitative tests, such as physical (creams or ointments selection and pH), chemical experiments for structural determination and isolation of an active ingredient (phytochem constituents, ultraviolet–visible [UV–vis] and high-performance liquid chromatography-diode array detector [HPLC-DAD] or high-performance liquid chromatography-mass spectrometry [HPLC-MS]), antioxidant properties (DPPH assay), and biological anti-bacterial properties (agar assay) against *Staphylococcus aureus*.

Results: NCP ointments were made by mixing "curcumin" and "emulsifying ointment BP." The pH values of 1%, 3%, and 5% NCP ointments were 5.83 ± 0.02, 5.67 ± 0.04, and 5.43 ± 0.04, which were more acidic and similar to TP ointment. These showed positive results on the lead tetra acetic acid test and the Horizon test, indicating the presence of alkaloids, phenolic, and terpenoids, respectively, but TP ointment showed a negative result on the Horizon test. The NCP ointments were confirmed by the UV–vis with a broad peak absorption at 425 nm, and identified by the HPLC-DAD and HPLC-MS through the calculations to ensure the concentrations of 1%, 3%, and 5% NCP ointments. In contrast, TP ointment cannot be confirmed to contain the active ingredient, "curcumin." NCP ointments possessed DPPH scavenging with 19.07% ± 0.0012%, 28.42% ± 0.012%, and 49.01% ± 0.0055%, respectively. The DPPH scavenging of 5% NCP ointment was twice that of TP ointment. 1%, 3%, and 5% NCP, TP ointments with anti-bacterial properties were 165.67 ± 4.04, 141.33 ± 5.51, 88.00 ± 9.85, and 4.00 ± 1.00. These inhibited the growth of *S. aureus*, and the anti-bacterial properties were much lower than those of the TP ointment.

Conclusion: 1%, 3%, and 5% NCP ointments have been successfully developed and confirmed by the analysis of UV–vis, HPLC-DAD, and HPLC-MS. The NCP ointments have antioxidant and anti-bacterial properties. However, because the components differ, NCP ointments have higher antioxidants but lower anti-bacterial properties than TP ointments. TP ointment is alcohol-based, whereas NCP ointments are "organic-based" and "natural-based," which possess the equivalent skin care functions concerning the targets of this research project.

Keywords

Chinese medicinal plants, curcumin, antioxidant, anti-bacterial properties

Received 20 January 2025; **revised** 25 April 2025; **accepted** 08 September 2025

* This manuscript is part of the Ms. Mei Tsz Lai, 2025 BSc (Hons) Chinese Medicinal Pharmacy, Final Year Project (THEi).

Mei Tsz Lai and Siu Kan Law are considered to be co-first authors.
[1]Department of Food and Health Sciences, The Technological and Higher Education Institute of Hong Kong, Tsing Yi, New Territories, Hong Kong SAR, China
[2]School of Nursing and Health Sciences, Hong Kong Metropolitan University, Hong Kong SAR, China
[3]Medical Laboratory of Shenzhen Luohu Hospital Group, Shenzhen, Guangdong, China

Corresponding authors:
Siu Kan Law, Department of Food and Health Sciences, The Technological and Higher Education Institute of Hong Kong, Tsing Yi, New Territories, Hong Kong SAR, China.
E-mail: siukanlaw@hotmail.com
Xiao Xiao Wu, Medical Laboratory of Shenzhen Luohu Hospital Group, Shenzhen, Guangdong 518000, China.
E-mail: wuxiaoxiaocuhk@gmail.com

Creative Commons Non Commercial CC BY-NC: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 License (http://www.creativecommons.org/licenses/by-nc/4.0/) which permits non-Commercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the SAGE and Open Access pages (https://us.sagepub.com/en-us/nam/open-access-at-sage).

Introduction

Chinese medicinal "curcumin" ointment is an "organic" skincare product containing an active ingredient from the natural plant, "*Curcuma longa* L." In Asian countries, it is widely used as an herbal medicine (Law et al., 2020) due to its broad spectrum of pharmaceutical activities, notably its antioxidant and anti-bacterial effects (Dai et al., 2022; Dehzad et al., 2023). The advantages of organic ointments are that they are naturally available minerals, are not genetically modified, and do not contain sulfates, parabens, or other harmful chemical substances. Most importantly, limited toxicity and increased effectiveness (Abbasi et al., 2020).

Growing evidence has shown that curcumin or turmeric is regarded as an attractive alternative to conventional drugs, such as corticosteroids and antibiotics, because of its characteristics as a safe and well-tolerated natural substance (Di Lorenzo et al., 2023). It has prospective wound-healing activity against chronic wounds. Topical curcumin formulations provide better delivery at wounded sites (Mohanty & Sahoo, 2017).

Based on the traditional Chinese medicine (TCM) theory, the nature of curcumin is pungent, bitter, and warm (Sharifi-Rad et al., 2020). It eliminates stasis and activates qi-flow, inducing menstruation to relieve pain (Li et al., 2021). Curcumin's mechanisms include downregulating cyclooxygenase-2 (COX-2) for antioxidant function (Sobolewski et al., 2010) and causing bacterial membrane disruption for the anti-bacterial function against *Staphylococcus aureus* (Tyagi et al., 2015).

Curcumin is a cosmetic product derived from Chinese medicine. It is believed to reduce facial hair growth, alleviate acne, and improve complexion (Shaffrathul et al., 2007). Some women in Tamil Nadu apply turmeric to their faces daily before taking a bath since it is a cutaneous antioxidant that prevents the rancidity of lipids when added to moisturizers (Draelos et al., 2010). Unlike Western cosmetic products, which are often synthetic products and may contain chemicals that cause sensitive skin or allergies, this product is natural and does not cause skin irritation. Furthermore, synthetic cosmetic products may also cause environmental problems, such as the disposal of synthetic makeup products that cannot decompose or biodegrade, contributing to long-term waste pollution (Cubas et al., 2022).

This research article aimed to develop and formulate a Chinese medicinal ointment using "curcumin" and evaluate its antioxidant and anti-bacterial properties. The methodology consists of four major components, including "physical" tests such as cream selection, and pH analysis for the curcumin ointment; "chemical" analysis involving structural determination of phytochemical constitutes using the testing reagents and UV spectroscopy, as well as isolation of active ingredient by high-performance liquid chromatography-diode array detector (HPLC-DAD) analysis to confirm the 1%, 3%, and 5% of curcumin ointments; evaluation of its antioxidant properties using DPPH assay, and assessment of its biological anti-bacterial properties through agar assay against *S. aureus* and *Escherichia coli* to the different percentage of curcumin ointments, as well as compare to Thailand's commercial "curcumin extract" product.

Materials and Methods

Processed curcumae longae rhizomae (PCLR) pieces were bought from Hong Kong Natural Pharmaceutical Company Limited. 98% natural curcumin extract powder (NCP) was purchased from Shaanxi Yupeptide Biotechnology Co., Ltd. Aqueous creams or ointments were bought from a health and beauty chain store. Ethanol and acetic acid (HPLC grade) were obtained from Anaqua Global International Inc., Ltd. Acetonitrile (HPLC grade) was purchased from RCI Labscan, Ltd. 95% 2,2-diphenyl-1-picrylhydrazyl (free radical) powder was purchased from Alfa Aesar. Difco™ Nutrient Agar BD was procured. *S. aureus* ATCC® 23235 was obtained from Thermo Fisher Scientific Inc., USA. All chemicals used were of analytical grade and were used as received without any further purification.

Preparation of the Curcumin Powder

Two types of curcumin powders from PCLR pieces and 98% NCP were used.

30–60 g of PCLR pieces were ground into powder with a particle size of 50 mesh using a Gaoxin GX-08 blender (Figure 1) and placed in a sealed bag, which prevented raw material contamination and air oxidation as well as inhibited the growth of microbial, for example, mold. 98% NCP was used directly as it was already a sieved powder (Figure 2).

Physical Experiments

Creams or Ointments Selection

A fragrance-free cream was chosen through a careful sniff test. The selected cream or ointment was required to be free of alcohol-based components, scent, and a greasy texture. Details regarding the comparison information of cream or ointment selection were reviewed in the results and discussion sections.

pH Value of NCP Ointment

A pH measurement was carried out using a pH meter. 1 g of ointment was weighed and dissolved in 10 mL of distilled water. The ointment was sonicated for 5 min and filtered. The pH value of the ointment was recorded.

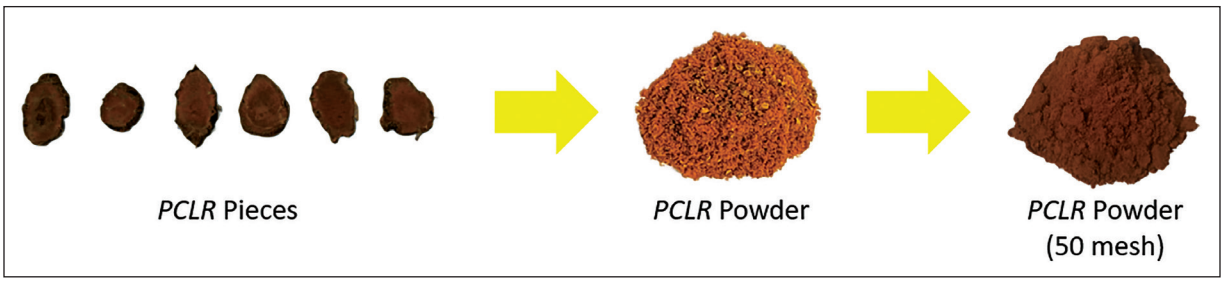


Figure 1. Preparation of *Processed Curcumae Longae Rhizoma* (PCLR) Powder in 50 Mesh.

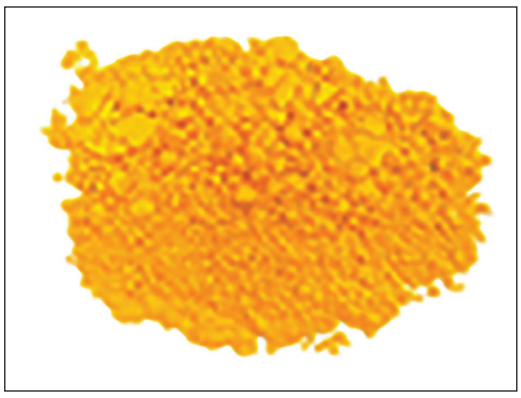


Figure 2. 98% Natural Curcumin Extract Powder (NCP).

Chemical Experiments

Determination of Phytochemicals Constitutes

Lead Tetra Acetic Acid Test

1 mL of lead tetra acetate solution was treated with 0.5 mL of sample extract, precipitate formation was indicated by the presence of phenolic compounds and tannins (Kancherla et al., 2019).

Horizon Test

1 mL of trichloroacetic acid was added to 1 mL of extract. The presence of terpenoids was confirmed by the formation of a red precipitate (Kancherla et al., 2019).

Determination of Ultraviolet–visible (UV–vis) Spectroscopy — Raw Materials Test

Preparation of Standard and Sample Solutions

A stock solution of 1,000 ppm curcumin, either in curcumin standard, 98% NCP, or PCLR, was prepared by accurately measuring 20 mg and dissolving it in 20 mL of ethanol. Curcumin standard and 98% NCP were diluted to 10 ppm, while PCLR was diluted to 40 ppm. The sample solution was filtered through a 0.45 μm polytetrafluoroethylene (PTFE), then 1 mL of each corresponding solution was pipetted and transferred to the UV cuvette for measurement.

Determination of High Performance Liquid Chromatography - Diode Array Detector (HPLC-DAD)

Preparation of Standard Solutions

20 mg of curcumin was weighed accurately and dissolved in 20 mL of ethanol to make a stock solution with a concentration of 1 mg/mL. The stock solution was then diluted into five proportions, including 5, 10, 20, 40, and 80 mg/L, then sonicated for 10 min to ensure the curcumin standard was completely dissolved.

Preparation of Sample Solutions

20 mg of PCLR pieces/98% NCP/Thailand's commercial "curcumin extract" product (TP) was weighed accurately and dissolved in 20 mL of ethanol to prepare a solution with a concentration of 1 mg/mL. This solution was sonicated for 10 min and then centrifuged at 3,000 rpm for another 5 min. The test solution was finally filtered through a 0.45 μm PTFE filter to remove the contaminants and impurities.

HPLC Requirements and Conditions

The HPLC used a column of Eclipse Plus C18 (4.6 × 250 mm length) with 5 μm diameter. Eluent C consisted of a 1:1 ratio of acetonitrile/H_2O and 2% acetic acid. It was run in isocratic elution. Column temperature was maintained at room temperature, around 25°C–30°C. The HPLC was equipped with a diode array detector and measured absorbance at 425 nm for both standard and sample solutions (Gulcin & Alwasel, 2023). Triplicate injections of the same sample were performed to assess repeatability.

Preparation of NCP Ointments

The concentrations of curcumin extracts in each ointment were selected as 1%, 3%, and 5%. Emulsifying ointment BP was mixed with the corresponding concentrations of 98%

NCP. The mixtures were stirred gently, sonicated for 30 min, and sealed with aluminum packaging boxes with a total volume of 10 g for each ointment. The final ointments were stored in the fridge overnight before use.

Antioxidant Test (DPPH Assay)

3.9432 mg of DPPH was weighed and dissolved in 100 mL of ethanol. It is sonicated for 5 min to prepare a 0.1 mM stock solution. 2.5 g of 1%, 3%, and 5% of NCP ointments were dissolved in 2.5 mL of ethanol. They were sonicated and centrifuged for 5 min, then filtered. An equal volume of the sample solution was added to the DPPH solution. The mixture was vortex-mixed well and kept in the dark for 30 min. The absorbance was measured and recorded at 517 nm. By using the equation to calculate the percentage of DPPH scavenging:

$$\left(A_0 - A_s / A_0\right) \times 100\%$$

where control (A_0): ethanol and DPPH, sample (A_s): sample and DPPH (Mishra et al., 2004).

Biological Experiments

Preparation of Agar Plate

23 g of nutrient agar powder was weighed and dissolved in 1 L of deionized water. It was stirred, heated thoroughly, and boiled at 121°C for 15 min. The dissolved agar was autoclaved. After autoclaving, it was poured into the Petri dishes slowly and evenly to prevent any bubbles. The agar was cooled to room temperature, incubated further for 10 min for solidification, and then covered with the lids. Agar plates were sealed tightly and stored in the fridge before use.

Serial Dilution of S. aureus

9 mL of deionized water was pipetted into four test tubes. 1 mL of *S. aureus* solution with a concentration of 10^{-1} CFU/mL was pipetted into the first test tube and shaken thoroughly. 1 mL of the solution from the first test tube was then pipetted into the second test tube, shaken thoroughly again, resulting in a concentration of 10^{-2}, and so on. The dilution steps were repeated until a concentration of 10^{-4} CFU/mL was achieved.

Anti-bacterial Assay

100 µL of the prepared *S. aureus* suspension (~10^{-4} CFU/mL) was evenly spread on the Petri dishes. There were three controls, including *S. aureus, S. aureus* with ethanol, and *S. aureus* in ointment without ethanol as the controls. Then, 50 µL of 1%, 2%, and 5% NCP ointments were spread onto the Petri dishes evenly and correspondingly. The plates were incubated for 24 h at 37°C in a constant temperature biochemical incubator (Elbing & Brent, 2019). After 24 h, the production of colony forming units (CFU) was observed. This experiment was repeated three times.

Thailand's Commercial Product

The Thailand ointment product (TP) (Figure 3) was purchased online. Its active ingredient was "curcumin" for skin care. Other ingredients included Cetyl alcohol, Ceteareth 20, glycerin stearate, salicylic acid, sodium lauryl sulfate, phenoxyethanol, chlorhexidine, vitamin B2, iodopropynyl butyl carbamate, and distilled water. This product was used as a benchmark for comparison with the 1%, 3%, and 5% of NCP ointments.

Statistical Analysis

The statistical values were reported as the Means ± Standard Deviations (±SD) of three separate experiments. Results were analyzed using Statistical Package for the Social Sciences (SPSS) software.

Results

Physical Experiments

Creams or Ointments Selection

Five creams or ointments were selected and compared from the market (Table 1).

pH Value of NCP Ointments

The pH values of 1%, 3%, and 5% NCP ointments were 5.83 ± 0.02, 5.67 ± 0.04, and 5.43 ± 0.04, respectively. However, the pH value of TP ointment (5.44 ± 0.04) was quite similar to the 5% NCP ointment (5.43 ± 0.04) (Table 2 and Figure 4).



Figure 3. Thailand Ointment Product (TP).

Table 1. List of Creams or Ointments with Different Ingredients.

	Name of Creams or Ointments	Ingredient (s)
1	Aqueous cream (Species 1)	Aqua (purified water), petrolatum, cetearyl alcohol, paraffinum liquidum, sodium lauryl sulfate
2	Aqueous cream BP (Species 2)	White soft paraffin (15% w/w), emulsifying wax (9% w/w), liquid paraffin (6% w/w), cetostearyl alcohol, sodium laurilsulfate, phenoxyethanol, purified water
3	Aqueous cream BP (Species 3)	Emulsifying wax (9.0% w/w), liquid paraffin (6.0% w/w), white soft paraffin (15.0% w/w), methyl paraben (0.15% w/w), propyl paraben (0.08% w/w).
4	Emulsifying ointment BP (Species 4)	Aqua (purified water), petrolatum, cetearyl alcohol, paraffinum liquidum, phenoxyethanol, sodium lauryl sulfate
5	Emulsifying ointment BP (Species 5)	Emulsifying wax (30% w/w), white petroleum jelly (50% w/w), liquid paraffin (20% w/w)

Table 2. pH Values of Controls, NCP, and TP Ointments.

Sample	DI Water (Control)	Ointment (Control)	1% NCP	3% NCP	5% NCP	TP
1	7.01	6.84	5.81	5.7	5.39	5.44
2	7.05	6.86	5.85	5.69	5.42	5.48
3	7.03	6.85	5.83	5.62	5.47	5.41
Average	7.03	6.85	5.83	5.67	5.43	5.44
Standard deviation (σ)	0.02	0.01	0.02	0.04	0.04	0.04

Note: NCP: Natural curcumin extract powder.

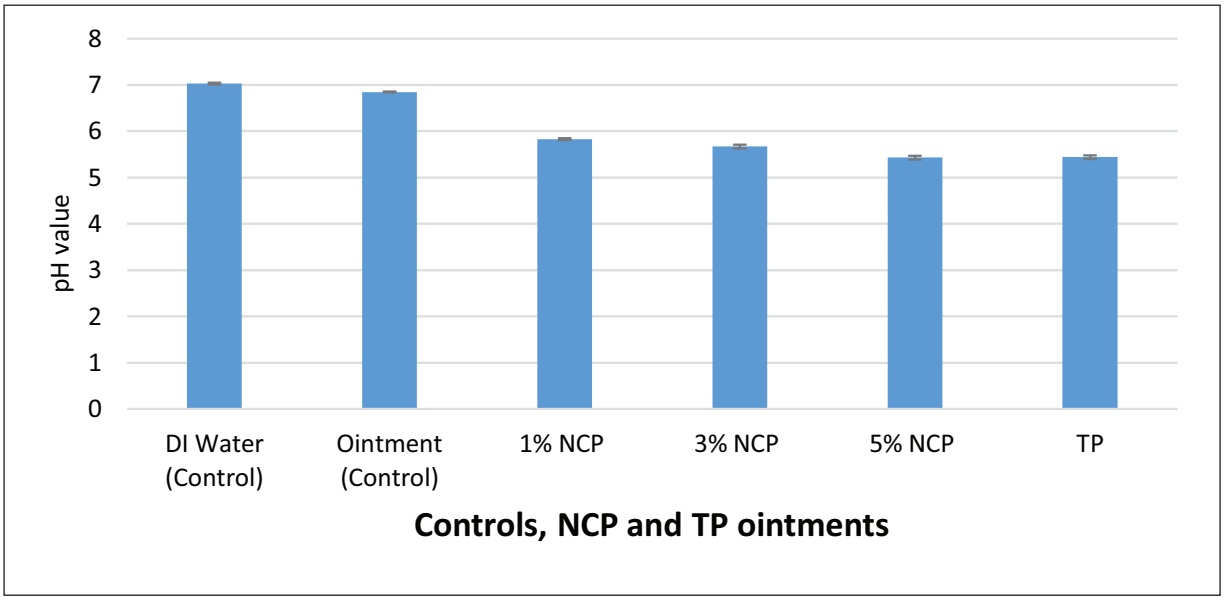


Figure 4. pH Values for the Controls, NCP, and TP Ointments.

Note: NCP: Natural curcumin extract powder.

Chemical Experiments

Determination of Phytochemical Constituents

The 98% NCP extract (control), 1%, 3%, and 5% NCP ointment, as well as the TP ointment, showed positive results in the lead tetra acetic acid test, except the ointment (control). Ointment alone and TP ointment demonstrated negative results in the horizon test (Table 3 and Figure S1).

Determination of UV–Vis Spectroscopy

The UV absorbance spectrum of curcumin standard (10 ppm), 98% NCP extract (10 ppm), and PCLR pieces (40 ppm) all showed a maximum absorption peak at 425 nm (Figure S2). The curcumin standard had the highest absorbance, nearly 2,000, compared to the 98% NCP extract with around 1,700 absorbance in the same concentration at 10 ppm. However, the absorbance of PCLR pieces was the

Table 3. Different Types of Ointments for the Lead Tetra Acetic Acid Test, and Horizon Test.

Phyto constituents	Control	98% NCP Extract (Control)	Ointment (Control)	1% NCP Ointment	3% NCP Ointment	5% NCP Ointment	TP Ointment
Phenolic (Lead tetra acetic acid test)	–	+	+	+	+	+	+
Triterpenoids (Horizon test)	–	+	–	+	+	+	–

Note: NCP: Natural curcumin extract powder; 98% NCP Extract (Control); "+": Dark orange precipitate for Lead tetra acetic acid test, "+": Yellow precipitate for Horizon test. Others "+": White precipitate; "-": Colorless.

Table 4. Calculations of Emulsifying Ointment BP for NCP.

Standard deviation (σ)	Extracted Curcumin Solution Added (μL)	Weight of Ointment (g)
1%	50 μL (0.04 g)	3.86
3%	150 μL (0.12 g)	3.78
5%	250 μL (0.19 g)	3.70

Note: NCP: Natural curcumin extract powder.

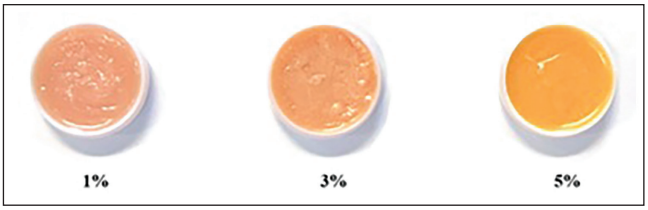


Figure 5. Natural Curcumin Extract Powder (NCP) Ointments.

lowest, and it required a higher concentration of 40 ppm for analysis.

Determination of HPLC-DAD

A calibration curve of curcumin standard (Figure S3) was established from the concentration of 5 ppm to 80 ppm, with the equation $y = 102.86x - 41.626$, with $R^2 = 0.9999$.

The quantitative relationship between curcumin content standard, 98% NCP, and PCLR pieces was determined (Figures S4 and S5).

Preparation of NCP Ointments

The concentrations of curcumin extracts for each ointment were selected as 1%, 3%, and 5%. The emulsifying ointment BP was mixed with the corresponding concentrations of 98% NCP (Table 4 and Figure 5).

Antioxidant Effect (DPPH Assay)

The DPPH scavenging activities for 1%, 3%, and 5% NCP ointments were 19.07% ± 0.0012%, 28.42% ± 0.012%, and 49.01% ± 0.0055%, respectively. Ointment alone was 7.23% ± 0.0012% and the TP ointment was 21.29% ± 0.071% of DPPH scavenging, while 5% NCP ointment showed the highest antioxidant effect (Table 5 and Figure S6).

Biological Experiments

Agar Plate-Anti-bacterial Property

A set of seven types of agar plates was designed to determine the anti-bacterial properties (Figure S7).

Based on the finding, the number of colony-forming units (CFU) of 1%, 3%, and 5% NCP ointments decreased proportionally, which were 165.67 ± 4.04, 141.33 ± 5.51, and 88.00 ± 9.85, respectively (Figure S8 and Table 6). The 5% NCP exhibited the most potent anti-bacterial effect on *S. aureus*, but it was weaker than that of the TP ointment.

Discussion

Physical Experiments

Creams or Ointments Selection

"Emulsifying ointment BP" was the optimal because it is free of alcoholic components. As alcohol-based ointments may cause adverse effects such as skin irritations or allergic contact dermatitis (Lachenmeier, 2008). It contained emulsifying wax, which acted as a moisturizer with the help of white petroleum jelly to enhance its function on the skin (Barnes et al., 2021; Kamrani et al., 2024). Liquid paraffin did not affect skin hydration and only limited the transepidermal water loss (Balaskas et al., 2011).

pH Value of NCP Ointment

An optimal pH value of skin on the face and body lies between 4.7 and 5.75 (Lambers et al., 2006). The skin's natural pH is mildly acidic. According to the results, the pH values of NCP ointments were 5.83 ± 0.02, 5.67 ± 0.04, and 5.43 ± 0.04, which were more acidic than those of the control and ointment alone. The 5% NCP exhibited the strongest acidity. The presence of natural acidic compounds on the skin surface can help to maintain the skin's physicochemical properties and protective functions (Farage et al., 2018).

Chemical Experiments

Determination of Phytochemical Constituents

The ointment (control) contained the liquid paraffin with the ring structure (Figure S9). However, the TP ointment

Table 5. Antioxidant Effect on DPPH Scavenging (%) of NCP and TP Ointments.

Sample	Control (Ethanol and DPPH)	Ointment (Control)	1% NCP	3% NCP	5% NCP	TP
1	1.298	1.235	1.113	1.021	0.831	1.162
2	1.349	1.237	1.112	1.001	0.832	1.153
3	1.349	1.235	1.125	1.022	0.841	1.148
Average	1.332	1.236	1.117	1.015	0.835	1.150
DPPH scavenging (%)	–	7.23	19.07	28.42	49.01	21.29
Standard deviation (σ)	–	0.0012	0.0072	0.012	0.0055	0.071

Note: DPPH: 2,2-Diphenyl-1-picrylhydrazyl; NCP: Natural curcumin extract powder.

Table 6. Average Number of Colony Forming Units (CFU) for NCP and TP Ointments Against *Staphylococcus aureus*.

	Number of Colony Forming Units (CFU)			Average of CFU with Standard Deviation
	Trial 1	Trial 2	Trial 3	
(a) *S. aureus* (control)	723	692	662	692.33 ± 30.50
(b) *S. aureus* and ethanol (control)	334	374	422	376.67 ± 44.06
(c) *S. aureus* and ointment without ethanol (control)	301	226	225	250.67 ± 43.59
(d) *S. aureus* and 1% NCP ointment	170	165	162	165.67 ± 4.04
(e) *S. aureus* and 3% NCP ointment	136	141	147	141.33 ± 5.51
(f) *S. aureus* and 5% NCP ointment	99	80	85	88.00 ± 9.85
(g) *S. aureus* and TP ointment	4	3	5	4.00 ± 1.00

Note: NCP: Natural curcumin extract powder.

belongs to the "Ginger" family, it also has a ring structure, and it is speculated that the possible structure was 6-shogaol (Figure S10).

Due to their phenolic structures in curcumin (Figure S11), liquid paraffin (Figure S12), and 6-shogaol (Figure S13) (Zhou et al., 2022), all showed positive results in the lead tetra acetic acid test.

Only the ointment base control and the TP ointment yielded a negative result in the horizontal test, indicating the absence of terpenoids. This is consistent with the fact that curcumin is composed of curcuminoids (González-Sarrías et al., 2013), which can exist in diketo and enol tautomeric forms (Figure S14) (Lee et al., 2013).

Based on the above findings, there were two phytochemical constituents, curcumin and 6-shogaol, in NCP and TP ointments, respectively.

Determination of UV–Vis Spectroscopy

The UV absorbance spectrum of curcumin standard (10 ppm), 98% NCP extract (10 ppm), and PCLR pieces (40 ppm) all showed a maximum absorption peak at 425 nm. This wavelength falls within the blue light region, an important characteristic that may enhance its effectiveness in targeting pathogenic microorganisms such as *S. aureus* (Comeau & Manso, 2023).

Determination of HPLC-DAD

The calibration curve of curcumin standards, 98% NCP, and PCLR pieces was established. However, for the HPLC-DAD analysis of PCLR pieces (Figure S15), it was not only the curcumin (Figure S16) but also the bisdemethoxycurcumin (BDMC) (Figure S17) and demethoxycurcumin (DMC) (Figure S18) (Chen et al., 2018) that were compared to the 98% NCP. It contained one shape peak identified as curcumin (Figure S19).

Based on the HPLC-DAD analysis for 98% NCP and PCLR pieces, curcumin was identified as a constituent in both samples (Figure S20).

It also indicated that PCLR pieces are not suitable to make ointment because the concentration of curcumin was not high enough, which also consisted of the other two curcuminoids, including BDMC and DMC. Meanwhile, the antioxidant efficacy of curcumin was better than that of both BDMC and DMC (Jayaprakasha et al., 2006).

The calculations for the concentration of 1%, 3%, and 5% NCP ointments cannot be directly based on the standard curve (Figure S21): $y = 102.51x - 53.651$, as the range of concentrations and their corresponding peak areas were too large for accurate interpolation.

These data points did not fall within the linear range of the calibration curve, but it was shown a trend for the peak area,

which was double increased for each point of concentration, therefore, the peak area (mAU*s) of concentration (ppm) from 2.5 to 0.078 was estimated and divided by half starting from the above standard curve at concentration 5 ppm with 466.35413 peak area.

The standard curve (Figure S22) calculation: $y = 93.271\ x - 0.0019$, from 0.078 to 2.5 ppm.

Based on the standard curve calculations, 1%, 3%, and 5% of NCP ointments were near the expected percentage concentrations (Table 7), confirmed by the HPLC-DAD analysis (Figures S23–S26).

The TP ointment did not contain any curcumin, which was identified by the HPLC-DAD analysis (Figure S27). As discussed above in determining phytochem constituents, TP ointment may belong to 6-shogaol (Comeau & Manso, 2023).

Preparation of NCP Ointments

To prepare the NCP ointments, the calculations in Table 4 were followed. 1%, 3%, and 5% NCP and TP ointments were further confirmed by the HPLC-MS analysis (Figures S27–S31) compared with the 10 ppm curcumin standard (Figure S32). From the results, it was identified that 1%, 3%, and 5% NCP consisted of the active ingredient, "curcumin" (MS 369.1), however, TP ointment did not have, with the 2-panadol (MS 223.1) only, because of the 6-shogaol dehydration by acetic acid in the HPLC mobile phase.

Based on the previous studies, the reason for making 1%, 3%, and 5% curcumin ingredients from 0.5% to 1% in topical treatments was significant positive results for skin, mucosae, cancerous lesions, and psoriasis. 3% of curcumin topical dosage also significantly improved the anti-inflammatory responses (Frei et al., 2023). 5% of curcumin topical cleansing wash demonstrated better performance on wound healing (Haesler et al., 2022). However, if the dose of curcumin were higher than 5%, the effectiveness would be decreased (Di Lorenzo et al., 2023). Thus, the concentration of curcumin in the ointments would be designed for 1%, 3%, and 5% to develop significant antioxidant and anti-bacterial ointments.

Antioxidant Test (DPPH Assay)

Due to their curcumin content, 1%, 3%, and 5% NCP ointments possessed strong antioxidant properties. Curcumin is an antioxidant that can prevent lipid peroxidation and decrease mitochondrial determinations through oxygen consumption, the activity of aconitase and antioxidant enzymes, GSH content, membrane potential, calcium retention, and ATP content (Molina-Jijón et al., 2011). The antioxidant property of 5% NCP ointment was twice that of the TP ointment because it did not contain curcumin.

Biological Experiments

Agar Plate-Anti-bacterial Property

1%, 3%, and 5% NCP ointments inhibited the growth of *S. aureus* with an inhibition percentage of 76.07%, 79.59%, and 87.29%, which was higher than the ethanol at 45.59% and the ointment alone at 63.79% (Table 8).

The 5% NCP ointment possessed stronger anti-bacterial properties, reducing *S. aureus* by more than 47.20% compared to 1% NCP ointment. It also decreased the *S. aureus* to 37.73% in contrast to 3% NCP ointment. Compared to 3% and 1% NCP ointment, 3% NCP ointment decreased *S. aureus* to 14.69% (Table 9).

As the NCP ointments contained curcumin, this compound is an anti-bacterial agent that may bind to FtsZ proteins to suppress the assembly of FtsZ protofilaments. This binding prevented the formation of the Z-ring, leading to inhibition of cytokinesis and bacterial proliferation (Rai et al., 2008).

Table 7. 1%, 3%, and 5% of NCP Ointments.

Expected Curcumin Ointment Concentration (%)	1%	3%	5%
Peak area (mAU*s)	7.64614	24.47472	49.97375
Calculated curcumin ointment concentration (%)	0.008 (~1%)	0.026 (~3%)	0.054 (~5%)

Note: NCP: Natural curcumin extract powder.

Table 8. Inhibition Percentage (%) of Different Ointments.

	Average of CFU with Standard Deviation	**Inhibition Percentage (%)**
(a) *S. aureus* (control)	692.33 ± 30.50	–
(b) *S. aureus* and ethanol (control)	376.67 ± 44.06	45.59
(c) *S. aureus* and ointment without ethanol (control)	250.67 ± 43.59	63.79
(d) *S. aureus* and 1% NCP ointment	165.67 ± 4.04	76.07
(e) *S. aureus* and 3% NCP ointment	141.33 ± 5.51	79.59
(f) *S. aureus* and 5% NCP ointment	88.00 ± 9.85	87.29
(g) *S. aureus* and TP ointment	4.00 ± 1.00	99.42

Note: NCP: Natural curcumin extract powder.

Table 9. Inhibition Percentage (%) for Different Ointments.

	Comparison of the Inhibition Percentage (%)
5% NCP versus 1% NCP ointment	47.20
5% NCP versus 3% NCP ointment	37.73
3% NCP versus 1% NCP ointment	14.69

Note: NCP: Natural curcumin extract powder.

Curcumin also inhibited the mecA gene transcription, causing reduced expression of PBP2α proteins. This MRSA was sensitive to the anti-bacterial action of β-lactam antibiotics (Rai et al., 2008). The binding between curcumin and peptidoglycan on the *S. aureus* cell wall triggered damage to the cell wall and membrane, leading to cell lysis of *S. aureus* (Tyagi et al., 2015).

TP ointment had the strongest anti-bacterial properties, but this is not associated with curcumin. Probably, it inhibited or killed the *S. aureus* by the other components, such as phenoxyethanol. Phenoxyethanol is an alcohol ingredient with a rapid bactericidal effect, achieving a 99.9% kill rate in 5 min at a concentration of 1% (w/v) (Wilson et al., 1990). Since the 1%, 3%, and 5% NCP ointments did not contain alcohol ingredients, their anti-bacterial properties were lower than those of the TP ointment, as NCP ointments focused on "organic" and "natural" production.

Conclusion

1%, 3%, and 5% NCP ointments have been successfully developed, and the presence of the active ingredient "curcumin" was confirmed by the UV–vis, HPLC-DAD, and HPLC-MS analysis. These ointments demonstrated both antioxidant and anti-bacterial properties. The 5% NCP ointments have higher antioxidants but lower anti-bacterial properties than TP ointments, as their active ingredients and components differ. TP ointment is an alcohol-based, chemically synthesized product, whereas the NCP ointments are "organic," "natural," and consist of an active ingredient, "curcumin," which possesses the same skin care functions concerning the targets of this research project.

Future Aspects

Curcumin is a well-known food and TCM substance, exemplifying the concept of food and medicine homology. This research project is just a starting milestone for marking ointment with antioxidant and anti-bacterial properties on the skin. Furthermore, it is beneficial to have an "organic" and "natural" ointment for skincare. However, much more work is needed, especially for safety assessments, such as clinical studies on human skin.

Abbreviations

HPLC-DAD: High-performance liquid chromatography-diode array detector; HPLC-MS: High-performance liquid chromatography-mass spectrometry; NCP: Natural curcumin extract powder; *S. aureus: Staphylococcus aureus*; TCM: Traditional Chinese medicine; UV–vis: Ultraviolet–visible.

Acknowledgments

The authors thank Miss Rachel Ching Yee Kwok and Mr. Chi Yung Ng for assistance with the Microbiological test and HPLC-DAD/MS analysis, respectively.

Author's Contribution

Siu Kan Law: Conceptualization, Methodology, Formal analysis, Writing—Original draft, Supervision. Mei Tsz Lai: Methodology, Investigation. Sze Wing Ng: Conceptualization, Data curation. Yanping Wang: Writing—Review & editing. Xiao Xiao Wu: Funding, Supervision.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Basic and Applied Basic Research Foundation of Guangdong Province (2022A1515111117), Nanshan District Health System Major Science and Technology Project (NSZD2023031).

Ethical Approval and Informed Consent

None.

ORCID iD

Siu Kan Law https://orcid.org/0000-0002-0454-2048

References

Abbasi, M. S., Rahmati, J., Ehsani, A. H., Takzare, A., Partoazar, A., & Takzaree, N. (2020). Efficacy of a natural topical skin ointment for managing split-thickness skin graft donor sites: A pilot double-blind randomized controlled trial. *Advances in Skin and Wound Care*, *33*(7), 1–5. https://doi.org/10.1097/01.ASW.0000666916.00983.64

Balaskas, E., Szepietowski, J. C., Bessis, D., Ioannides, D., Ponticelli, C., Ghienne, C., Taberly, A., & Dupuy, P. (2011). Randomized, double-blind study with glycerol and paraffin in uremic xerosis. *Clinical Journal of the American Society of Nephrology*, *6*(4), 748–752. https://doi.org/10.2215/CJN.05490610

Barnes, T. M., Mijaljica, D., Townley, J. P., Spada, F., & Harrison, I. P. (2021). Vehicles for drug delivery and cosmetic moisturizers: Review and comparison. *Pharmaceutics*, *26*(12), 2012. https://doi.org/10.3390/pharmaceutics13122012

Chen, Y. C., & Chen, B. H. (2018). Preparation of curcuminoid microemulsions from *Curcuma longa* L. to enhance inhibition effects on the growth of colon cancer cells HT-29. *RSC Advances*, *8*(5), 2323–2337. https://doi.org/10.1039/c7ra12297g

Comeau, P., & Manso, A. (2023). A systematic evaluation of curcumin concentrations and blue light parameters towards antimicrobial photodynamic therapy against cariogenic microorganisms. *Pharmaceutics*, *15*(12), 2707. https://doi.org/10.3390/pharmaceutics15122707

Cubas, A. L. V., Bianchet, R. T., Reis, I. M. A. S. D., & Gouveia, I. C. (2022). Plastics and microplastics in the cosmetic industry: Aggregating sustainable actions aimed at alignment and interaction with UN sustainable development goals. *Polymers (Basel)*, *14*(21), 4576. https://doi.org/10.3390/polym14214576

Dai, C., Lin, J., Li, H., Shen, Z., Wang, Y., Velkov, T., & Shen, J. (2022). The natural product curcumin as an antibacterial agent: Current achievements and problems. *Antioxidants (Basel)*, *11*(3), 459. https://doi.org/10.3390/antiox11030459

Dehzad, M. J., Ghalandari, H., Nouri, M., & Askarpour, M. (2023). Antioxidant and anti-inflammatory effects of curcumin/turmeric supplementation in adults: A GRADE-assessed systematic review and dose–response meta-analysis of randomized controlled trials. *Cytokine*, *164*, 156144. https://doi.org/10.1016/j.cyto.2023.156144

Di Lorenzo, R., Forgione, F., Bernardi, A., Sacchi, A., Laneri, S., & Greco, G. (2023). Clinical studies on topical curcumin. *Skin Pharmacology and Physiology*, *36*(5), 235–248. https://doi.org/10.1159/000535100

Draelos, Z. D. (2010). Nutrition and enhancing youthful-appearing skin. *Clinics in Dermatology*, *28*, 400–408. https://doi.org/10.1016/j.clindermatol.2010.03.019

Elbing, K. L., & Brent, R. (2019). Growth of *E. coli* on solid media. *Current Protocols in Molecular Biology*, *125*(1), e82. https://doi.org/10.1002/cpmb.82

Farage, M. A., Hood, W., Berardesca, E., & Maibach, H. (2018). Intrinsic and extrinsic factors affecting skin surface pH. *Current Problems Dermatology*, *54*, 33–47. https://doi.org/10.1159/000489516

Frei, G., Haimhoffer, Á., Csapó, E., Bodnár, K., Vasvári, G., Nemes, D., Lekli, I., Gyöngyösi, A., Bácskay, I., Fehér, P., & Józsa, L. (2023). *In vitro* and *in vivo* efficacy of topical dosage forms containing self-nanoemulsifying drug delivery system loaded with curcumin. *Pharmaceutics*, *15*(8), 2054. https://doi.org/10.3390/pharmaceutics15082054

González-Sarrías, A., Larrosa, M., García-Conesa, M. T., Tomás-Barberán, F. A., & Espín, J. C. (2013). Nutraceuticals for older people: Facts, fictions and gaps in knowledge. *Maturitas*, *75*(4), 313–334. https://doi.org/10.1016/j.maturitas.2013.05.006

Gulcin, İ., & Alwasel, S. H. (2023). DPPH radical scavenging assay. *Processes*, *11*, 2248. https://doi.org/10.3390/pr11082248

Haesler, E. (2022). WHAM evidence summary: Topical turmeric for wound healing. *WCET® Journal*, *42*(3), 38–41. https://doi.org/10.33235/wcet.42.3.38-41

Jayaprakasha, G. K., Rao, L. J., & Sakariah, K. K. (2006). Antioxidant activities of curcumin, demethoxycurcumin, and bisdemethoxycurcumin. *Food Chemistry*, *98*(4), 720–724. https://doi.org/10.1016/s0009-2797(99)00096-4

Kamrani, P., Hedrick, J., Marks, J. G., & Zaenglein, A. L. (2024). Petroleum jelly: A comprehensive review of its history, uses, and safety. *Journal of American Academy of Dermatology*, *90*(4), 807–813. https://doi.org/10.1016/j.jaad.2023.06.010

Kancherla, N., Dhakshinamoothi, A., Chitra, K., & Komaram, R. B. (2019). Preliminary analysis of phytoconstituents and evaluation of anthelminthic property of *Cayratia auriculata* (*in vitro*). *Maedica*, *14*(4), 350–356. https://doi.org/10.26574/maedica.2019.14.4.350

Lachenmeier, D. W. (2008). Safety evaluation of topical applications of ethanol on the skin and inside the oral cavity. *Journal of Occupational Medicine and Toxicology*, *3*, *26*. https://doi.org/10.1186/1745-6673-3-26

Lambers, H., Piessens, S., Bloem, A., Pronk, H., & Finkel, P. (2006). Natural skin surface pH is on average below 5, which is beneficial for its resident flora. *International Journal of Cosmetic Science*, *28*(5), 359–370. https://doi.org/10.1111/j.1467-2494.2006.00344.x

Law, S., Lo, C., Han, J., Yang, F., Leung, A. W., & Xu, C. (2020). Design, synthesis and characterization of novel curcumin derivatives. *Natural Products Chemistry and Research*, *8*(1), 367. https://www.longdom.org/open-access/design-synthesis-and-characterization-of-novel-curcumin-derivatives.pdf

Lee, W. H., Loo, C. Y., Bebawy, M., Luk, F., Mason, R. S., & Rohanizadeh, R. (2013). Curcumin and its derivatives: Their application in neuropharmacology and neuroscience in the 21st century. *Current Neuropharmacology*, *11*(4), 338–378. https://doi.org/10.2174/1570159X11311040002

Li, Y., Wu, Y., Li, Y., & Guo, F. (2021). Review of the traditional uses, phytochemistry, and pharmacology of Curcuma wenyujin Y. H. Chen et C. Ling. *Journal of Ethnopharmacology*, *269*, 113689. https://doi.org/10.1016/j.jep.2020.113689

Mishra, A., Dewangan, G., Singh, W. R., Hazra, S., & Mandal, T. K. (2004). A simple reversed phase high-performance liquid chromatography (RP-HPLC) method for determination of curcumin in aqueous humor of rabbit. *Journal of Advanced Pharmaceutical Technology & Research*, *5*(3), 147–149. https://doi.org/10.4103/2231-4040.137448

Mohanty, C., & Sahoo, S. K. (2017). Curcumin and its topical formulations for wound healing applications. *Drug Discovery Today*, *22*(10), 1582–1592. https://doi.org/10.1016/j.drudis.2017.07.001

Molina-Jijón, E., Tapia, E., Zazueta, C., El Hafidi, M., Zatarain-Barrón, Z. L., Hernández-Pando, R., Medina-Campos, O. N., Zarco-Márquez, G., Torres, I., & Pedraza-Chaverri, J. (2011). Curcumin prevents Cr(VI)-induced renal oxidant damage by a mitochondrial pathway. *Free Radical Biology and Medicine*, *51*(8), 1543–1557. https://doi.org/10.1016/j.freeradbiomed.2011.07.018

Rai, D., Singh, J. K., Roy, N., & Panda, D. (2008). Curcumin inhibits FtsZ assembly: An attractive mechanism for its antibacterial activity. *Biochemical Journal*, *410*(1), 147–155. https://doi.org/10.1042/BJ20070891

Shaffrathul, J. H., Karthick, P. S., Rai, R., & Srinivas, C. R. (2007). Turmeric: Role in hypertrichosis and acne. *Indian Journal of Dermatology*, *52*, 116.

Sharifi-Rad, J., Rayess, Y. E., Rizk, A. A., Sadaka, C., Zgheib, R., Zam, W., Sestito, S., Rapposelli, S., Neffe-Skocińska, K., Zielińska, D., Salehi, B., Setzer, W. N., Dosoky, N. S., Taheri, Y., El Beyrouthy, M., Martorell, M., Ostrander, E. A., Suleria, H. A. R., Cho, W. C., Maroyi, A., & Martins, N. (2020). Turmeric and its major compound curcumin on health: Bioactive effects and safety profiles for food, pharmaceutical, biotechnological

and medicinal applications. *Frontiers in Pharmacology*, *11*, 01021. https://doi.org/10.3389/fphar.2020.01021

Sobolewski, C., Cerella, C., Dicato, M., Ghibelli, L., & Diederich, M. (2010). The role of cyclooxygenase-2 in cell proliferation and cell death in human malignancies. *International Journal of Cell Biology*, *2010*, 215158. https://doi.org/10.1155/2010/215158

Tyagi, P., Singh, M., Kumari, H., Kumari, A., & Mukhopadhyay, K. (2015). Bactericidal activity of curcumin I is associated with damaging of bacterial membrane. *PLoS One*, *10*(3), e0121313. https://doi.org/10.1371/journal.pone.0121313

Wilson, M., Bansal, G., Stanley, A., & Newman, H. N. (1990). Susceptibility of oral bacteria to phenoxyethanol and phenoxyethanol/chlorhexidine combinations. *Journal of Periodontology*, *61*(8), 536–541. https://doi.org/10.1902/jop.1990.61.8.536

Zhou, X., Afzal, S., Wohlmuth, H., Münch, G., Leach, D., Low, M., & Li, C. G. (2022). Synergistic anti-inflammatory activity of ginger and turmeric extracts in inhibiting lipopolysaccharide and interferon-γ-induced proinflammatory mediators. *Molecules*, *27*, 3877. https://doi.org/10.3390/molecules27123877