



# Characterization of *Gomphrena globosa* L. Flower Extract and Anti-Acne of Formulated Cream Against *Cutibacterium acnes*

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**Keywords:** Anti-acne activity, Cream formulation, *Cutibacterium acnes*, *Gomphrena globosa* L.

**Abstract:** *Cutibacterium acnes* is a cause of acne. Conventional treatments often lead to side effects and bacterial resistance, necessitating natural alternatives. Globe Amaranth (*Gomphrena globosa* L.) shows potential as an anti-acne agent. This study employed an in vitro experimental laboratory design to evaluate the anti-acne activity of *G. globosa* L. flower extract formulated cream against *C. acnes* using the well diffusion method. Antibacterial activity was tested using KN (base cream), KP (1% clindamycin cream), F1 (10%), F2 (15%), and F3 (20%), and the data were analyzed using SPSS statistical analysis. Results indicated that the ethanolic extract of GA flowers has an  $IC_{50}$  of 85.483 ppm, TPC of  $60.456 \pm 0.589$  mg GAE/g, and TFC of  $34.390 \pm 0.989$  mg QE/g. It exhibited antibacterial activity against *C. acnes*, with inhibition zone diameters of  $6.693 \pm 0.2$  mm for the 15% formula and  $7.382 \pm 0.22$  mm for the 20% formula. The antibacterial activity is believed to be driven by the presence of secondary metabolites, particularly phenols and flavonoids identified in the extract.

## Introduction

Acne is the most commonly encountered skin infection. The most frequent trigger for acne is the proliferation of the bacterium *Cutibacterium acnes*. This bacterium triggers comedogenesis by activating the sebaceous glands through increased lipogenesis in the sebum, while simultaneously stimulating innate immune mechanisms (1). In 2024, the global prevalence of acne was 20.5%. The highest % was found in the adolescent group (aged 16 to 24 years), reaching 28.3%, and remained significantly high in the adult group (aged 25 to 39 years) at 19.3% (2).

Recommended acne treatments include topical medications such as retinoids, benzoyl peroxide, and antibiotics (3). However, side effects from retinoid use, such as dry skin and peeling, occur frequently. Furthermore, these drugs fall under categories C and X, making them necessary to avoid during pregnancy (4). The side effects of benzoyl peroxide include allergic contact dermatitis, dryness, erythema, and burning sensations (5). Erythromycin is the most commonly used antibacterial in acne treatment due to its ability to reduce *C. acnes* colonization in the pilosebaceous follicles. Nevertheless, research has shown that approximately 60% of *C. acnes* strains have developed resistance to erythromycin, a condition that can lead to therapeutic failure (6).

These conditions have driven the need to search for safer alternative treatments with minimal risks, such as traditional medicine. Traditional medicines, including plant-based remedies, consist of substances or combinations of materials that have been used for generations for healing and continue to be practiced in accordance with societal norms (7). With advancements in pharmaceutical science, traditional medicine can be developed into modern dosage forms, such as topical cream preparations. Topical cream formulations may improve the practicality of application and facilitate the distribution of bioactive compounds on the skin surface. Cream formulations are generally well accepted by patients because they are easy to apply, non-greasy, and suitable for prolonged use. Plants containing secondary metabolites including flavonoids, tannins, and antioxidant compounds are known to possess pharmacological activity as anti-acne agents due to their roles in inhibiting bacterial growth, reducing inflammation, and suppressing sebum production. Traditional medicinal plants contain various secondary metabolites, including flavonoids, tannins, and phenolic compounds, which have been reported to exhibit antibacterial, anti-inflammatory, and antioxidant activities that may support anti-acne treatment (8, 9). Among the potential Indonesian plants containing these compounds is the GA (*Gomphrena globosa* L.).

GA, or more commonly known in Bali as the *Ratna* flower, is widely found and cultivated by local farmers, ensuring its abundant availability. GA extract demonstrates effective antibacterial inhibition against *C. acnes*, particularly at a 75% concentration, which yielded a moderate inhibition zone of 11 mm (10). Furthermore, anti-acne activity testing of a GA ointment formulation against *Staphylococcus aureus* showed that a 9% concentration produced an inhibition zone diameter of  $11.4 \pm 0.52$  mm, also categorized as moderate (11). Research concerning GA extract generally focuses on its pharmacological activities, specifically as an antioxidant or antibacterial agent. However, there are limited studies developing this extract into topical dosage forms. Therefore, this study aimed to develop a topical anti-acne cream containing GA flower extract and evaluate its antibacterial activity against *C. acnes in vitro*.

## Experimental Section

### Materials

The GA (*Gomphrena globosa* L.) used in this study consisted of fresh flowers with the petals still attached to the flower heads, characterized by a bright purple color. The samples were obtained from local farmers in Sanur Kaja Village, Bali Province. The identification was conducted at the Mathematics and Natural Sciences, Laboratory Unit, IAIN Syekh Nurjati Cirebon, under certificate number 24/In.08/LB.1.1/PP.009/02/2026.

### Preparation and Extraction

The flower petals were separated from the flower heads and washed under running water. They were then dried using a dehydrator at a temperature of 40 °C until completely dry. Subsequently, the moisture content was measured using a moisture analyzer. The dried plant material was weighed and placed into a maceration vessel. Ethanol 96% was added as a solvent at a ratio of 1:20 (12, 13). The maceration process was conducted for  $3 \times 24$  h, with periodic stirring every 24 h. After the first maceration stage was completed, the mixture was filtered using filter paper. The remaining residue was remacerated using ethanol 96%. The filtrate from the s maceration was then combined with the first filtrate and evaporated in an oven at 50 °C. This process produced a thick extract of GA. To calculate the extraction efficiency, the yield % was determined using the **Equation 1** (14).

### Phytochemical screening

#### Flavonoids

A 1 mL aliquot of the extract solution was transferred into a test tube, followed by the addition of three drops of concentrated hydrochloric acid (HCl) and 0.5 g of magnesium ribbon/turnings. The mixture was observed for

any color changes, where the appearance of an orange coloration indicated the presence of flavonoids (15).

#### Tannins

Approximately 0.5 g of the extract was dissolved and boiled in 20 mL of distilled water within a test tube. After boiling, the mixture was filtered, and a few drops of iron (III) chloride (FeCl<sub>3</sub>) solution were added to the filtrate. The formation of a distinctive blue-black color was recorded as a positive result for the presence of tannins (11).

#### Saponins

The presence of saponins was determined by placing 0.5 g of the extract into a test tube and adding an appropriate volume of hot distilled water. The mixture was then shaken vigorously. The formation of a persistent foam layer that remained stable for more than 10 min indicated a positive result for saponins (11).

#### Terpenoids

A total of 2 g of the extract was subjected to the Liebermann-Burchard test. The extract was treated with the Liebermann-Burchard reagent, and the formation of a reddish-brown or purple ring at the interface was used to confirm the presence of terpenoids (15).

#### Determination of Total Flavonoid Content

A quercetin stock solution (1000 ppm) was prepared by dissolving 10 mg of quercetin in 10 mL of 96% ethanol. This solution was diluted to 100 ppm, from which a series of working standards (15, 25, 50, 75, and 100 ppm) were prepared using 96% ethanol. For color development, 1 mL of the 100 ppm standard was mixed with 1 mL of 10% AlCl<sub>3</sub> and 1 mL of 5% acetic acid. After 30 min of incubation, the  $\lambda_{\max}$  was determined. The absorbance of the serial working standards was then measured at this  $\lambda_{\max}$  to construct the calibration curve. The GA extract was dissolved in 96% ethanol to obtain a 100 ppm test solution. 1 mL of this solution was reacted with 1 mL of 10% AlCl<sub>3</sub> and 1 mL of 5% acetic acid, then incubated for 30 min. The absorbance was measured at  $\lambda_{\max}$  in triplicate. The TFC was calculated and expressed as mg of quercetin equivalent per g of extract (mg QE/g) (16). The absorbance values were recorded, and the TFC was calculated using **Equation 2** (17), where TFC = total flavonoid content, C = quercetin concentration obtained from the calibration curve (mg/L), V = total volume of the extract solution (L), DF = dilution factor, and m = weight of the extract used (g).

#### Determination of Total Phenolic Content

A 7.5% Folin-Ciocalteu reagent and a 1% NaOH solution were prepared using distilled water. Gallic acid was used as the reference standard, with a stock solution of 400 ppm (10 mg in 25 mL methanol) subsequently diluted to a series of working standards (5, 15, 30, 50, 70, and 100

$$\text{Yield (\%)} = \frac{\text{Weight of extract obtained (g)}}{\text{Weight of dried starting material (g)}} \times 100 \quad (\text{Eq. 1})$$

$$\text{TFC (mgQE/g)} = \frac{C \times V \times DF}{m} \quad (\text{Eq. 2})$$

ppm). To determine the  $\lambda_{\max}$ , 1 mL of the 70 ppm gallic acid standard was reacted with 5 mL of 7.5% Folin-Ciocalteu reagent for 8 min, followed by the addition of 4 mL of 1% NaOH. After a 1 h incubation, the absorbance was scanned around 730 nm. The same procedure was applied to all working standards to construct the calibration curve. The extract (0.2 g) was dissolved in 20 mL of methanol and stirred magnetically for 30 min to obtain a 1000 ppm solution. This solution was then diluted to 100 ppm. 1 mL of the sample was reacted with the Folin-Ciocalteu reagent and NaOH using the same incubation parameters as the standards. The absorbance was measured at  $\lambda_{\max}$ , in triplicate. The total phenolic content was expressed as mg of gallic acid equivalent per g of extract (mg GAE/g). The absorbance values were recorded, and the TPC was calculated using **Equation 3** (18), where TPC = total phenolic content, C = gallic acid concentration obtained from the calibration curve (mg/L), V = total volume of the extract solution (L), DF = dilution factor, and m = weight of the extract used (g).

### Antioxidant Activity Assay

The antioxidant activity of GA extract was evaluated using the DPPH (2, 2-diphenyl-1-picrylhydrazyl) radical scavenging assay. A stock extract solution (1000 ppm) was prepared in 96% ethanol and subsequently diluted to a 100 ppm working solution. A series of test concentrations (10, 15, 20, 25, 30, 35, 40, 45, 50, and 55 ppm) were then prepared. For the radical solution, a 100 ppm DPPH stock was prepared and diluted to a 40 ppm working solution. The  $\lambda_{\max}$  was determined by scanning the 40 ppm DPPH solution within the range of 400–800 nm, using 96% ethanol as the blank. To measure the control absorbance, 2 mL of 40 ppm DPPH was mixed with 2 mL of 96% ethanol, vortexed, and incubated for 30 min before measuring its absorbance at  $\lambda_{\max}$ . For the antioxidant test, 2 mL of the 40 ppm DPPH solution was mixed with 2 mL of each extract concentration. The mixtures were vortexed

and incubated in the dark for 30 min. The absorbance was then measured using a UV-Vis spectrophotometer at the determined  $\lambda_{\max}$ . The % of inhibition was determined using **Equation 4** (19). The IC50 value was determined through linear regression analysis IC50, where the sample concentration was plotted on the x-axis and the % of inhibition on the y-axis. A lower IC50 value indicates stronger antioxidant activity (13).

### Cream Formulation and Physical Quality Evaluation

The cream formulations are detailed in **Table 1**. The preparation followed a standard fusion method. The oil phase (stearic acid, cetyl alcohol, and propylparaben) and the aqueous phase (triethanolamine, glycerin, methylparaben, propylene glycol, and distilled water) were heated separately to 70°C until fully melted. The aqueous phase was then gradually added to the oil phase under continuous stirring to ensure a uniform emulsion. Separately, the ethanolic extract of GA was diluted with 96% ethanol and homogenized in a pre-heated mortar to prevent clumping. The cream base was incorporated incrementally into the extract while being stirred constantly until a homogeneous preparation was achieved. The final cream was then transferred into appropriate containers for further evaluation (20).

### Organoleptic Test

The evaluation was systematically conducted through a rigorous visual and sensory assessment of the GA extract cream, specifically focusing on key organoleptic parameters such as color and aroma. The final observation results indicated that each prepared formulation demonstrated excellent physical and chemical stability, with no significant changes in color or aroma throughout the entire 21-day storage period (21).

$$\text{TPC (mgQE/g)} = \frac{C \times V \times DF}{m} \quad (\text{Eq. 3})$$

$$\text{Percentage Inhibition (\%)} = \frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \times 100 \quad (\text{Eq. 4})$$

**Table 1.** Cream formulation of *Gomphrena globosa* extract.

Ingredients	Concentration (%)			Function
	F1	F2	F3	
GA Extract ( <i>Gomphrena globosa</i> L.)	10	15	20	Active ingredient
TEA (Triethanolamine)	2	2	2	Emulsifying agent, alkalizing agent
Stearic acid	8	8	8	Creamy base, emulsifying agent
Propylene glycol	7	7	7	Humectant
Cetyl alcohol	4	4	4	Emulsifying agent, stiffening agent
Glycerine	4	4	4	Humectant
Methylparaben	0.2	0.2	0.2	Preservative
Propylparaben	0.02	0.02	0.02	Preservative
Ethanol 96%	qs.	qs.	qs.	Extract solvent
Aquadest	10	10	10	Vehicle

### Homogeneity Test

Performed by applying 1 g of the cream onto a glass plate. The formulation is considered homogeneous if it shows no visible signs of clumping particles or unmixed components. This test was conducted on days 0, 7, 14, and 21 of the storage period (21).

### pH Measurement

Determined by diluting 1 g of the cream with 10 mL of distilled water in a beaker. The probe of a digital pH meter was then immersed into the diluted mixture, and the stabilized value displayed on the monitor was recorded. The evaluation was conducted on days 0, 7, 14, and 21 of the study (21).

### Spreadability Test

Conducted by placing 0.5 g of the cream formulation onto the center of a transparent glass plate or watch glass layered with graph paper. A s glass plate was placed on top and allowed to stand for 60 s. Subsequently, weights of 50 g, 100 g, and 150 g were added sequentially, with each load applied for 60 s. The spreadability was determined by measuring the average diameter or the area of distribution after each weight addition. The evaluation was conducted on days 0, 7, 14, and 21 of the study (21).

### Antibacterial Activity Assay

The antibacterial inhibition zone of the GA extract cream was evaluated using the well diffusion method. A 0, 2 mL bacterial suspension of *C. acnes* was inoculated into a petri dish containing 20 mL of sterile, molten Mueller Hinton Agar (MHA) that had not yet solidified. The dish was swirled gently to ensure a homogeneous mixture of the bacteria and the medium before being allowed to solidify. Subsequently, three wells were created in the agar with equidistant spacing. Each well was filled with 50  $\mu$ L of the respective samples: the extract creams at concentrations of 10%, 15%, and 20%, clindamycin cream 1% as the positive control, and cream base as the negative control. The plates were then incubated at 37°C for 24 h under anaerobic conditions. The antibacterial activity was determined by measuring the diameter of the clear inhibition zones formed around each well (22).

### Data Analysis

The physical quality parameters of the cream were analyzed descriptively and presented in narrative and tabular formats. For the antibacterial activity, statistical analysis was performed using SPSS software. Data normality was assessed using the Shapiro-Wilk test, with a significance level set at  $p > 0, 05$ . Since the data were not

normally distributed, the Kruskal-Wallis test was employed to determine significant differences in inhibition zones across formulas, followed by the Mann-Whitney test for *post-hoc* pairwise comparisons.

## Results and Discussion

### Extraction

A total of 1.977 g of GA petals were obtained for drying using a dehydrator at 40 °C until a dried plant material was formed. Drying at 40 °C effectively preserves phytochemicals while significantly reducing drying time compared to shade drying after drying (23). A 177.57 g of dried plant material was obtained. The moisture content was measured using a moisture analyzer, yielding a value of 8.05%. Other studies have shown that GA flowers possess a moisture content of 8.17%, indicating that these research results are relatively comparable and fall within the appropriate range (12). Since the GA dried plant material already possessed a small size and soft texture, further size reduction was not performed. The influence of particle size on extract yield shows no significant difference between coarse and fine powders (24). In this study, a ratio of 1:20 was employed, meaning each 1 g of material was extracted with 20 mL of solvent (12, 13). This process produced 32.02 g of viscous extract, with a yield % of 18.03%. The yield value indicates the quantity of compounds successfully transferred from the plant material into the solvent; therefore, a higher yield signifies that a greater amount of chemical components has been dissolved and extracted (23)

### Phytochemical screening

The phytochemical screening results indicated that the ethanolic extract of GA tested positive for all groups of secondary metabolites evaluated (see **Table 2**). Other studies utilizing the same extraction method also reported the presence of these identical secondary metabolites (12). This consistency supports the finding that GA contains secondary metabolites with potential antibacterial properties.

### Determination of Total Flavonoid Content

The determination of TFC was conducted using the colorimetric method, where in the sample was reacted with  $AlCl_3$  under acidic conditions.  $AlCl_3$  forms a complex with flavonoids, such as quercetin, causing the solution to turn yellow and allowing it to be measured within the visible light spectrum. The addition of acetic acid serves to maintain acidic conditions, ensuring the stability of the color formation. Quercetin was utilized as the standard because it belongs to the flavonoid class (25). The determination of the  $\lambda_{max}$  yielded a result of 415 nm with

**Table 2.** Results of the phytochemical screening.

Phytochemical	Observation	Result
Flavonoid	Orange colour	Presence
Tannins	Blue-black colour	Presence
Saponin	Foaming more than 1 min	Presence
Terpenoid	Brown ring at the junction of two layers and the upper layer turns green	Presence

an absorbance value of 2.199 (see **Figure 1**). In this study, the results of the TFC were  $20.144 \pm 0.096$  mgQE/g (see **Table 3**). This indicates that each 1 g of extract or sample contains flavonoids equivalent to 20.144 mg of Quercetin Equivalent.

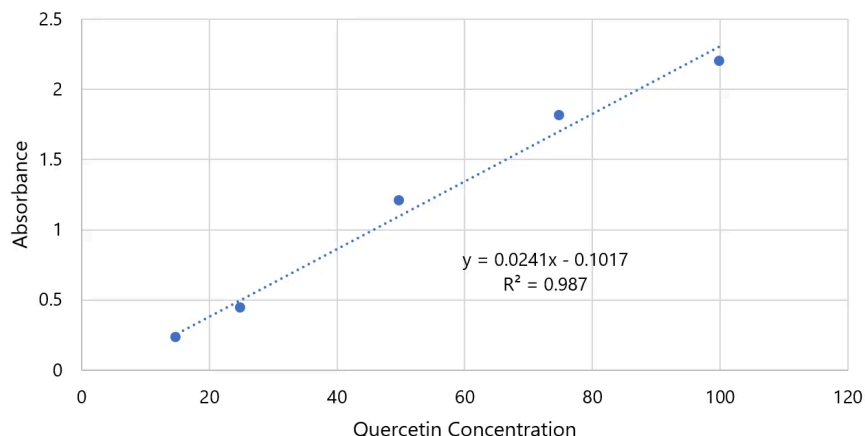
**Determination of Total Phenolic Content**

The TPC was determined using the Folin-Ciocalteu method, which relies on the reduction of phosphomolybdic-phosphotungstic reagents by phenolic compounds in an alkaline environment to form a blue-colored complex. The intensity of this color, measured

spectrophotometrically, is directly proportional to the concentration of phenolics present (26, 27). Gallic acid served as the standard reference. The  $\lambda_{max}$  for gallic acid was found to be 756.5 nm with an absorbance of 0.349 (see **Figure 2**). The analysis revealed a TPC of  $60.32 \pm 0.48$  mgGAE/g as seen in **Table 4**, indicating that each g of extract contains phenolic compounds equivalent to 60.32 mg of Gallic Acid Equivalent (GAE).

**Antioxidant Activity Assay**

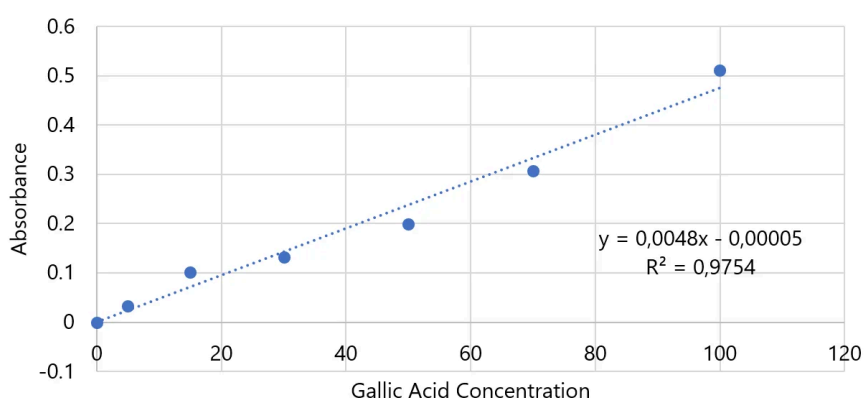
This antioxidant activity is presumed to stem from secondary metabolite contents, such as flavonoids, which



**Figure 1.** Relationship between quercetin concentration and absorbance.

**Table 3.** Absorbance data and TFC of the samples.

Sample (100 ppm)	Sample Absorbance	x concentration (mg/L)	TFC (mgQE/g)	TFC ± SD
1	0.019	5.008	20.033	20.144 ± 0.096
2	0.02	5.05	20.199	
3	0.02	5.05	20.199	



**Figure 2.** Relationship between gallic acid concentration and absorbance.

**Table 4.** Absorbance data and TPC of the samples.

Sample (100 ppm)	Sample Absorbance	x concentration (mg/L)	TPC (mgGAE/g)	TPC ± SD
1	0.072	15.010	60.042	60.32 ± 0.48
2	0.073	15.219	60.875	
3	0.072	15.010	60.042	

exert antioxidant effects by donating hydrogen atoms and scavenging free radicals (28). The  $\lambda_{max}$  for the 40 ppm DPPH solution, measured within the 400–800 nm range, was determined to be 517 nm with an absorbance value of

0.769 (see Table 5). Subsequently, the DPPH absorbance at the 517 nm wavelength was recorded at 0.398. The IC<sub>50</sub> value of the GA ethanolic extract was derived from the linear regression equation of concentration versus %

Table 5. DPPH assay results across sample concentration series.

Concentration (ppm)	Absorbance			Average Absorbance	Standard Deviation	% Inhibition
	1	2	3			
10	0.315	0.314	0.315	0.315	0.001	20.938
30	0.286	0.285	0.287	0.286	0.001	28.141
50	0.251	0.252	0.251	0.251	0.001	36.851
55	0.247	0.249	0.246	0.247	0.002	37.856

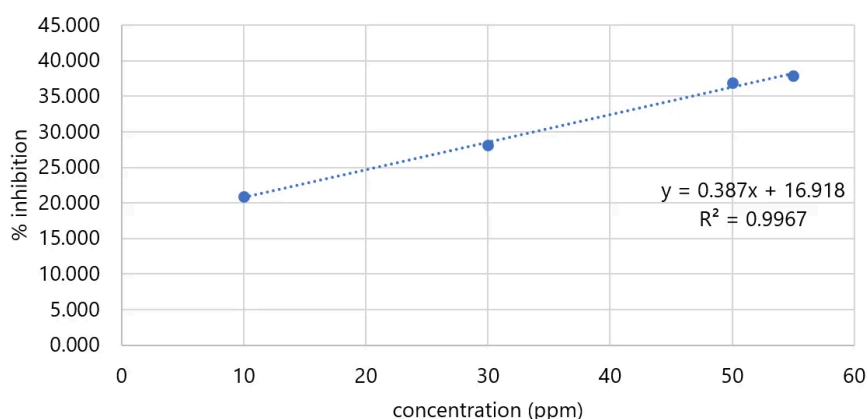


Figure 3. Correlation between extract concentration and % inhibition.

Table 6. Physical quality evaluation of GA extract cream.

Characteristics	Formulation	Results on Day -				Information
		0	7	14	21	
Texture	F1	Semisolid	Semisolid	Semisolid	Semisolid	qualify
	F2	Semisolid	Semisolid	Semisolid	Semisolid	
	F3	Semisolid	Semisolid	Semisolid	Semisolid	
Color	F1	light brown	light brown	light brown	light brown	qualify
	F2	brown	brown	brown	brown	
	F3	dark brown	dark brown	dark brown	dark brown	
Aroma	F1	like extract	like extract	like extract	like extract	qualify
	F2	like extract	like extract	like extract	like extract	
	F3	like extract	like extract	like extract	like extract	
Homogeneity	F1	homogeneous	homogeneous	homogeneous	homogeneous	qualify
	F2	homogeneous	homogeneous	homogeneous	homogeneous	
	F3	homogeneous	homogeneous	homogeneous	homogeneous	
pH	F1	6.55	6.59	6.60	6.63	SD = 0.033
	F2	6.31	6.32	6.34	6.38	SD = 0.031
	F3	6.12	6.16	6.20	6.27	SD = 0.064
Spreadability (cm)	F1	5.5	5.6	5.5	5.5	SD = 0.050
	F2	5.7	5.6	5.5	5.5	SD = 0.096
	F3	5.8	5.7	5.7	5.6	SD = 0.082

inhibition (see **Figure 3**). The calculation for the IC50 value is presented below. With an IC50 value of 85.483 ppm, the ethanolic extract of globe amaranth flower exhibited antioxidant activity. Differences in IC50 values compared to previous studies, which reported values ranging from 49.9 ppm to 62.50 µg/mL, may be influenced by variations in extraction methods and experimental condition (13, 29). This further validates the species as a significant natural antioxidant resource.

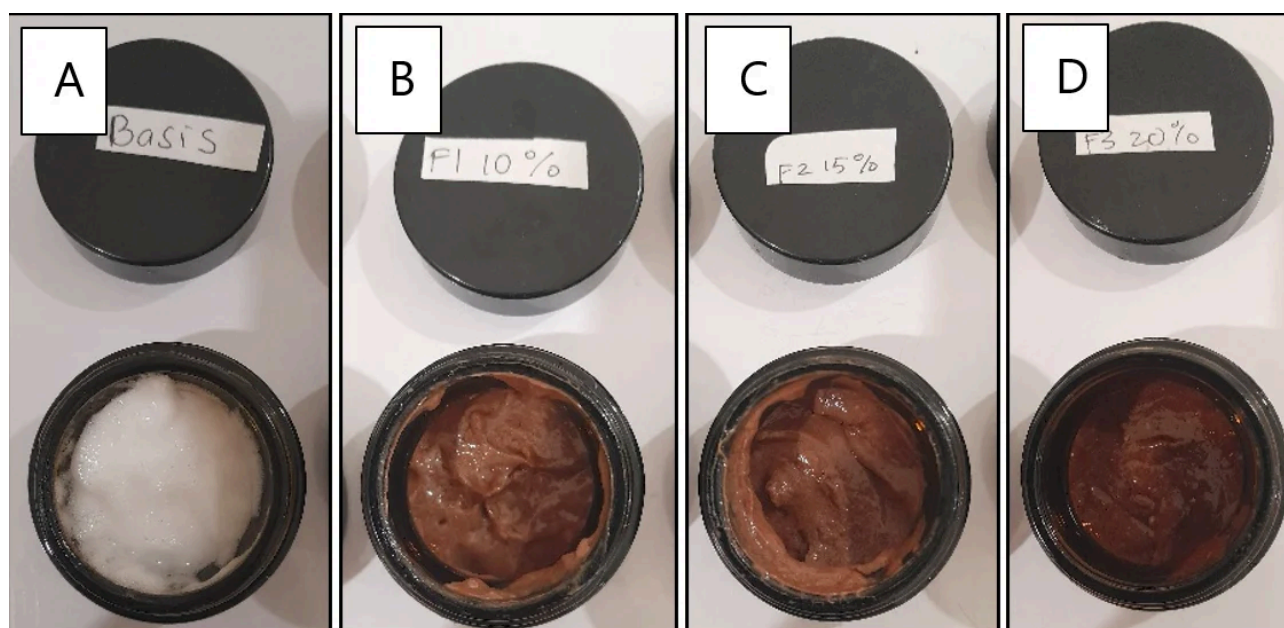
### Cream Formulation and Physical Quality Evaluation

All physical quality parameters complied with the required standards. The pH values were within the SNI 16-4399:

1996 range of 4.5–8.0, and the spreadability values fell within the ideal range of 5–7 cm (30). Physical quality parameter of the GA extract cream can be seen in **Table 6** and the visual image can be seen in **Figure 4**.

### Antibacterial Activity Assay

The antibacterial assay revealed that the negative control (base cream) and Formula 1 (10% concentration) exhibited no inhibitory activity (see **Table 7**). However, Formula 2 and Formula 3 produced inhibition zones, with Formula 3 showing the highest inhibition zone diameter of 7.815 mm (see **Figure 5**). This concentration dependent response suggests that higher extract concentrations may enhance antibacterial activity, although the inhibition remained



**Figure 4.** GA flower extract anti-acne cream. (A) Base cream, (B) Formulation 1 (10% extract), (C) Formulation 2 (15% extract), and (D) Formulation 3 (20% extract).

**Table 7.** Antibacterial assay of the GA extract cream.

Sample	Average (mm) ± SD	Category
K-	0 ± 0	No inhibition
	0 ± 0	No inhibition
	0 ± 0	No inhibition
K+	27.9 ± 1.27	Very strong
	28.8 ± 0.25	Very strong
	28.0 ± 0.30	Very strong
F1	0 ± 0	No inhibition
	0 ± 0	No inhibition
	0 ± 0	No inhibition
F2	6.69 ± 0.33	Moderate
	7.10 ± 0.25	Moderate
	6.62 ± 0.02	Moderate
F3	6.93 ± 0.14	Moderate
	8.01 ± 0.29	Moderate
	7.25 ± 0.24	Moderate

lower than the positive control (1% clindamycin cream). The potent bioactivity of the GA extract is supported by its significant antioxidant capacity ( $IC_{50} = 85.483$  ppm) and high phenolic and flavonoid content (60.32 mg GAE/g and 20.144 mg QE/g, respectively). These compounds play a crucial role in anti-acne mechanisms; antioxidants suppress inflammatory cytokines and sebum production (9), while phenols and flavonoids disrupt *C. acnes* cell membranes and inhibit vital bacterial enzymes (31). Furthermore, the presence of tannins, saponins, and terpenoids contributes to bacterial growth suppression through lipase inhibition and increased membrane permeability, leading to cell lysis (8, 32).

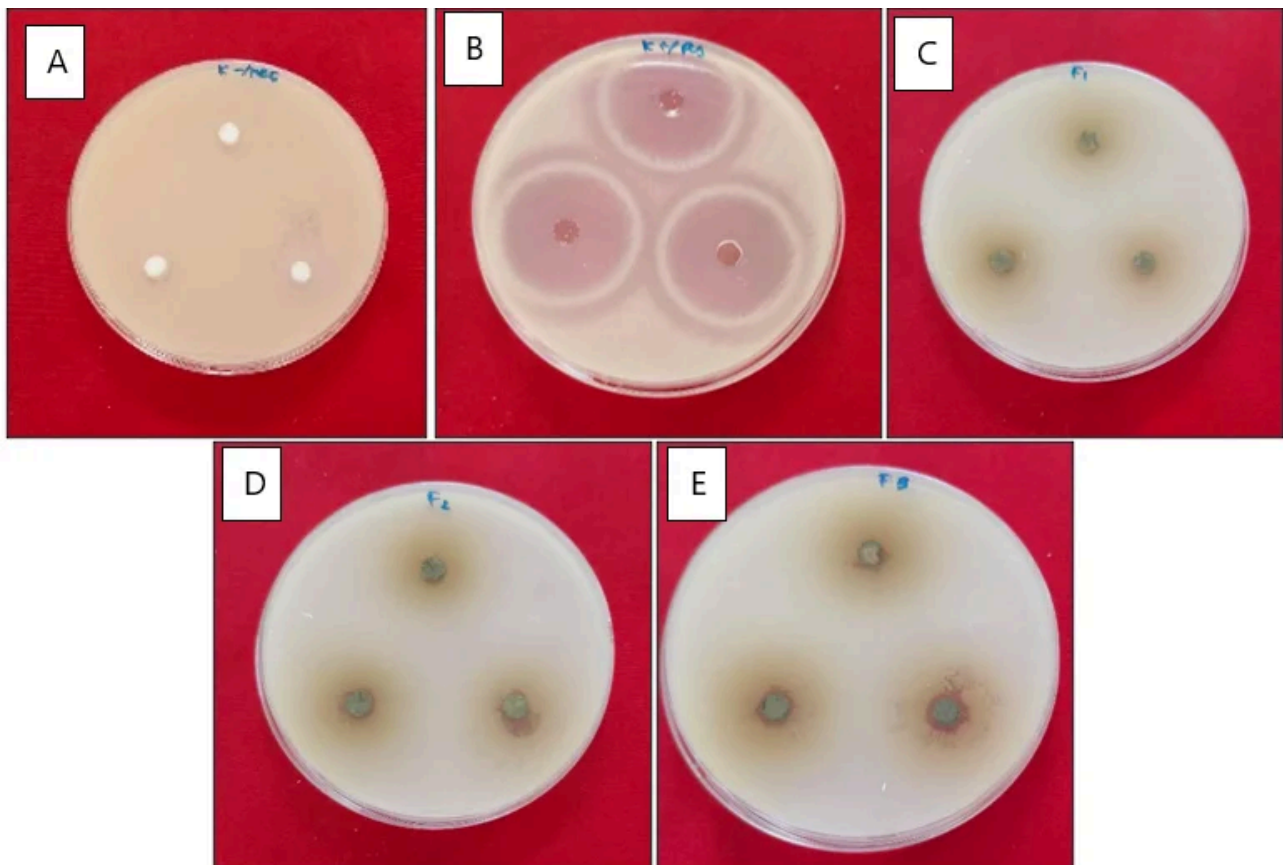
The antibacterial assay revealed that the negative control (base cream) and Formula 1 (10% concentration) exhibited no inhibitory activity. However, Formula 2 and Formula 3 produced inhibition zones, with Formula 3 showing the highest inhibition zone diameter of 7.815 mm. This concentration dependent response suggests that higher extract concentrations may enhance antibacterial activity, although the inhibition remained lower than the positive control (1% clindamycin cream). The potent

bioactivity of the GA extract is supported by its significant antioxidant capacity ( $IC_{50} = 85.483$  ppm) and high phenolic and flavonoid content (60.456 mg GAE/g and 34.390 mg QE/g, respectively). These compounds play a crucial role in anti-acne mechanisms; antioxidants suppress inflammatory cytokines and sebum production, while phenols and flavonoids disrupt *C. acnes* cell membranes and inhibit vital bacterial enzymes. Furthermore, the presence of tannins, saponins, and terpenoids contributes to bacterial growth suppression through lipase inhibition and increased membrane permeability, leading to cell lysis.

**Data Analysis**

Statistical analysis using the Kruskal-Wallis test showed a significant effect of formula variation on inhibition zone diameters ( $p = 0.008$ ). To determine the specific differences between groups, a Mann-Whitney U test was performed, as shown in the **Table 8**.

F1 differed significantly from K+, whereas F2 and F3 maintained no significant difference with the positive control. Comparatively, our 15% and 20% cream



**Figure 5.** Antibacterial activity GA flower extract anti-acne cream. (A) Control negative, (B) Control Positive, (C) Formulation 1 (10% extract), (D) Formulation 2 (15% extract), and (E) Formulation 3 (20% extract)

**Table 8.** Mann-Whitney test result.

Category	Significance (p)	Result	Information
K+ and F1	0.037	< 0.05	Significantly different
K+ and F2	0.050	≥ 0.05	Not significantly different
K+ and F3	0.050	≥ 0.05	Not significantly different

formulations demonstrated inhibitory effects equivalent to the 25% raw extract reported by Veronica *et al.* (2020). This suggests that the cream base may enhance the delivery and activity of the bioactive compounds, potentially allowing lower concentrations to produce comparable effects. Therefore, the cream formulation may offer practical advantages in topical application compared to unformulated extracts.

## Conclusion

In conclusion, the ethanolic extract of globe amaranth (*Gomphrena globosa* L.) contains essential secondary metabolites, including flavonoids, tannins, saponins, and terpenoids. Quantitative analysis revealed a total flavonoid content of  $20.144 \pm 0.096$  mg QE/g and a total phenolic content of  $60.32 \pm 0.48$  mg GAE/g, which contribute to its strong antioxidant activity  $IC_{50} = 85.483$  ppm. Furthermore, antibacterial assays against *Cutibacterium acnes* demonstrated that while the 10% cream formulation lacked inhibitory effects, the 15% and 20% concentrations exhibited moderate antibacterial activity with mean inhibition zones of 6.693 mm and 7.382 mm, respectively. These findings suggest that the formulated cream has significant potential as a natural anti-acne agent.

## Abbreviations

C. acnes = *Cutibacterium acnes*; GA = Globe Amaranth; TFC = Total Flavonoid Content; TPC = Total Phenolic Content; SD = Standard Deviation;  $\lambda_{max}$  = maximum Absorption Wavelength.

## Declaration

### Author Information

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**Contribution:** Resources, Writing – Original Draft, Conceptualization, Formal Analysis.

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**Contribution:** Conceptualization, Methodology, Resources, Validation.

### Conflict of Interest

The author(s) declare no conflict of interest.

### Data Availability

All data generated or analyzed during this study are included in this published article.

### Ethics Statement

Not applicable.

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## Additional Information

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