



Characteristics, Stability, and Permeation of Yellow Pumpkin Seed Cream (*Cucurbita moschata*) with Variations of Stearic Acid and Glyceryl Monostearate

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ABSTRACT

Purpose of the study: This study aimed to formulate pumpkin (*Cucurbita moschata*) seed powder cream with variations in stearic acid and glyceryl monostearate concentrations, evaluate its physical characteristics, stability, safety and irritation potential, skin-moisturizing effectiveness, and active-compound permeation, while providing foundational implications for stable and effective plant-based topical cosmetic formulations.

Methodology: Pumpkin seed powder was formulated into cream with variations of stearic acid and glyceryl monostearate. The formulations were evaluated for organoleptic properties, pH, viscosity (Brookfield viscometer), skin moisture (CR-302 skin analyzer), active-compound permeation (PermeGear Franz diffusion cell), and stability (cycling test). Data were analyzed using IBM SPSS Statistics version 25 with the Shapiro-Wilk test, Levene's test, two-way ANOVA, and Bonferroni post hoc test.

Main Findings: Pumpkin seed powder met the required quality standards based on moisture content, microbial quality, and particle size. All cream formulations were homogeneous, stable, non-irritating, and complied with physical-quality requirements. Formulations with higher emulsifier concentrations significantly improved skin moisture, oil balance, and skin softness ($p < 0.05$), while active-compound permeation increased progressively during diffusion.

Novelty/Originality of this study: Previous studies focused on pumpkin seed extract or oil, whereas the direct incorporation of yellow pumpkin seed powder and the systematic evaluation of stearic acid and glyceryl monostearate variations on cream stability and skin permeation remained insufficiently explored. This study demonstrates the use of yellow pumpkin seed powder as a natural anti-aging ingredient by systematically comparing how emulsifier variations affect physicochemical characteristics, stability, skin-moisturizing performance, and in vitro skin permeation, providing comprehensive evidence for topical product development.

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1. INTRODUCTION

The skin is the outermost organ of the human body that functions as a protector against various environmental factors so that the changes that occur in the skin are easy to observe. As we age, the skin undergoes a skin aging process which is characterized by a decrease in skin elasticity, firmness, and moisture [1], [2]. In Indonesia, attention to skin aging is increasing, especially in women. Although signs of aging generally begin to appear around the age of 30, as many as 57% of Indonesian women have noticed the appearance of signs of aging since the age of 25 [3], [4]. This condition suggests that skin aging can occur early due to various internal and external factors.

One of the factors that plays an important role in the skin aging process is skin moisture. Decreased moisture content in the stratum corneum causes the skin to become dry, rough, less elastic, and triggers the formation of fine lines as a sign of premature aging [5], [6]. Therefore, modern anti-aging approaches are largely geared towards maintaining skin hydration and improving the function of the skin barrier through the use of appropriate topical products [7], [8]. Emulsion-based topical preparations, such as creams, are widely used in skincare because they can help retain moisture [9]. The cream was chosen because it has more occlusive properties so that it can maintain skin hydration for longer [10]. Based on the type of emulsion, topical preparations are differentiated into water-in-oil emulsions (A/M or water in oil/W/O) and oil-in-water (M/A or oil in water/O/W). A/M type emulsions provide a longer moisturizing effect as the oil phase becomes a continuous phase, while M/A type emulsions provide a lightweight, non-sticky sensation, and are more comfortable to use for daily use [11], [12]. The choice of emulsion type is an important factor because it affects the stability of the preparation, the comfort of use, and the ability to retain skin moisture.

Cream preparations generally have a higher oil phase content so that they are able to form an occlusive layer that can reduce transepidermal water loss (TEWL) and maintain skin hydration for longer [13], [14]. However, the use of some synthetic active ingredients in anti-aging products is known to potentially cause side effects, such as irritation, redness, and itching in certain individuals [15], [16]. This encourages the development of natural-made cosmetics that are safer and more comfortable to use.

The use of plants as natural ingredients has long been practiced for various health purpose through the processing of medicinal plants [17]. One of the natural ingredients that has the potential to be developed as an active ingredient in cosmetics is yellow pumpkin seeds (*Cucurbita moschata*). So far, the use of yellow pumpkin has focused more on the flesh, leaves, and skin, while the seeds have not been optimally utilized in cosmetic formulations [18], [19]. Yellow pumpkin seeds are known to contain bioactive compounds in the form of linoleic acid, vitamin E (tocopherol), and phytosterols that play a role in maintaining the function of the skin barrier, protecting skin lipids, and supporting moisture through inhibiting the degradation of hyaluronic acid [20]. The antioxidant content also has the potential to maintain skin elasticity, increase moisture, and strengthen skin barrier function [21], [22].

Optimization of the bioactive potential of yellow pumpkin seeds requires a stable and effective topical delivery system. In emulsion preparations such as creams, the stability of the formulation is affected by the use of emulsifiers that function to reduce the interface tension between the oil and water phases so as to form a homogeneous and stable emulsion system [23]. In cream formulations, stearic acid and glyceryl monostearate are commonly used emulsifiers because they are able to produce a stable, smooth, emollient texture of the cream, and affect the viscosity and penetration of the active ingredient on the skin [24], [25]. Stearic acid serves as a thickening agent and stabilizing agent of emulsions, while glyceryl monostearate acts as a non-ionic emulsifier that helps maintain the stability of oil and water phase dispersion [26], [27].

Based on previous studies, yellow pumpkin seeds (*Cucurbita moschata*) have been developed as active ingredients in topical preparations, including creams [28] and seed oil [29]. However, the direct use of yellow pumpkin seed powder in cream formulations and the effects of variations in stearic acid and glyceryl monostearate on the physicochemical characteristics, stability, safety, and skin permeation of the preparation have not been comprehensively studied. Therefore, this study proposes the direct incorporation of yellow pumpkin seed powder into cream formulations with variations in stearic acid and glyceryl monostearate. The aim of this study was to evaluate the physical quality, stability, safety, effectiveness in increasing skin moisture, and in vitro release/permeation of yellow pumpkin seed powder cream.

The skin is the outermost organ of the human body that serves as a protective barrier against environmental factors, and as people age, it undergoes structural changes characterized by decreased elasticity, firmness, and moisture. While signs of skin aging typically appear around age 30, studies indicate that many individuals notice early signs much earlier, largely driven by moisture loss in the stratum corneum that leads to dryness, roughness, and fine lines. To combat premature aging, modern approaches rely on emulsion-based topical preparations such as creams, which provide occlusive properties to reduce transepidermal water loss and maintain hydration. Although synthetic anti-aging ingredients are common, they frequently carry risks of adverse side effects such as skin irritation and redness, thereby sparking interest in safer, plant-based cosmetic alternatives. Yellow pumpkin seeds (*Cucurbita moschata*) represent a promising natural active ingredient rich in linoleic acid, vitamin E, and phytosterols, which protect skin lipids, preserve skin barrier function, and support

moisture retention. However, optimizing such bioactive ingredients requires a stable topical delivery system governed by suitable emulsifiers like stearic acid and glyceryl monostearate (GMS), which control emulsion texture, viscosity, and active ingredient permeation. Despite previous investigations into topical formulations containing yellow pumpkin seed extract or seed oil, the direct incorporation of yellow pumpkin seed powder along with the systematic evaluation of how varying concentrations of stearic acid and glyceryl monostearate affect physicochemical characteristics, stability, and skin permeation remains insufficiently explored.

This research gap is critical because emulsifier composition directly dictates the physical stability and performance of topical emulsions. Therefore, the objectives of this study were to formulate a yellow pumpkin seed powder cream using different concentrations of stearic acid and glyceryl monostearate, evaluate its physical characteristics, stability, safety/irritation potential, skin-moisturizing effectiveness, and active-compound permeation, and establish a foundational rationale regarding how emulsifier variations influence emulsion performance. The novelty of this work lies in evaluating these precise emulsifier variations on yellow pumpkin seed powder cream, contributing significantly to the field by providing comprehensive, evidence-based guidelines for developing stable, safe, and effective plant-based topical cosmetic formulations.

2. RESEARCH METHOD

The active ingredient used in this study was yellow pumpkin seed powder (*Cucurbita moschata*). The other ingredients included stearic acid and glyceryl monostearate (GMS) as emulsifiers; triethanolamine (TEA) as an emulsifier; cetyl alcohol, beeswax, and olive oil as the oil/emollient phase; glycerin and propylene glycol as humectants; phenoxyethanol as a preservative; carmine as a colorant; baby powder essence as a fragrance; and Aquadest as a solvent. The study was conducted at Biomedical Laboratory 4, Faculty of Medicine and Health Sciences, Adiwangsa University of Jambi, from January 15, 2025 to June 15, 2026. Tools used include glassware, homogenizers, cream containers, pH meters, parchment paper, drip pipettes, steam cups, spatulas, sieve shakers, Brookfield viscometers, CR-302 skin analyzers for skin moisture measurement, and PermeGear Franz diffusion cells for permeation tests of active compounds.

This study was a laboratory experimental study with a quantitative approach to evaluate the physical characteristics, stability, safety and irritation, skin-moisturizing effect, and in vitro permeation of active compounds from yellow pumpkin seed powder (*Cucurbita moschata*) cream with variations in GMS and stearic acid concentrations. Ten cream formulas were prepared, consisting of F0 as the control formula and F1–F9 as treatment formulas. A total of 20 volunteers aged 20–30 years were recruited and randomly assigned to 10 groups, with two volunteers in each group. Each group received one formula, and the volunteers applied the assigned preparation to a predetermined skin area using a standardized amount of preparation, at a specified frequency, for 14 days. The application area, amount of preparation, frequency of use, and duration of application were standardized for all volunteers. Compliance was monitored by providing instructions on the application procedure and recording the use of the preparation throughout the study period. Volunteers were selected based on inclusion criteria, including healthy skin in the test area, absence of skin irritation or disorders, willingness to participate for 14 days, and provision of informed consent. Volunteers with cuts, allergies, infections, or irritation in the test area, as well as those using medications or skincare products that could affect the results, were excluded. The sample size was determined based on the allocation of two volunteers for each of the 10 formulas, resulting in a total of 20 volunteers, while random allocation was used to minimize selection bias. Skin-moisture measurements were performed before and during treatment, while in vitro permeation was evaluated using Franz diffusion cells. Data were analyzed using IBM SPSS Statistics.

Yellow pumpkin seed powder quality testing

Moisture content test One gram of the powder was weighed and placed in a moisture analyzer. The moisture content was determined at 105 °C until a constant weight was achieved. The resulting moisture content (%) was then recorded [30], [31], [32].

Microbiological tests include Total Plate Number (ALT), Khar Mold Number (AKK), and *Staphylococcus aureus* [33]. The ALT and AKK tests were carried out by a multi-stage dilution method using 0.9% NaCl, then the sample was inoculated in Nutrient Agar (NA) media for bacterial growth and Potato Dextrose Agar (PDA) for mold and yeast growth. Incubation is carried out according to the conditions of each medium, then the number of colonies is calculated and declared as CFU/g [15], [30], [34], [35].

The particle size test was carried out by weighing 100 g of powder, then sifted using a sieve shaker with a mesh size of 20–80 for 15 minutes. Next, the percentage of powder weight retained in each mesh is calculated against the total weight [30].

The cream is formulated in five formulas (F0–F4) using a stearic acid base as an emulsifier to produce water-in-oil cream (A/M) and five formulas (F0–F4) using glyceryl monostearate (GMS) as an emulsifier to produce water-in-water (M/A) oil-in-water cream. The composition of each formula is presented in Table 1.

Table 1. Formulation of yellow pumpkin seed powder cream (*Cucurbita moschata*)

Ingredients	Stearic Acid Cream (A/M)					Glyceryl Monostearate Cream (M/A)					Function
	F0	F1	F2	F3	F4	F0	F1	F2	F3	F4	
Yellow pumpkin seed powder	3	3	3	3	3	3	3	3	3	3	Active substances
Stearic acid	-	0,5	1	2	3	-	-	-	-	-	Emulsifier
Glyceryl monostearate	-	-	-	-	-	-	1	2	3	4	Emulsifier
Acetyl alcohol	2	2	2	2	2	2	2	2	2	1	Emulsifier
Beeswax	3	3	3	3	3	3	3	3	3	3	Emollient
Olive oil	9	9	9	9	9	4	4	4	4	4	Emollient
Triethanolamine	0,2	0,2	0,2	0,2	0,2	1,5	1,5	1,5	1,5	1,5	Emulsifier
Glycerin	5	5	5	5	5	5	5	5	5	5	Hufixan
Phenoxytanol	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	Preservatives
Propylene glycol	6	6	6	6	6	6	6	6	6	6	Hufixan
Carmine	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	Dye
Baby powder essence	QS	QS	QS	QS	QS	QS	QS	QS	QS	QS	Aroma
Aquadest ad	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	Solvents

The cream is made by the melting method. The oil phase consisting of stearic acid or glyceryl monostearate, cetyl alcohol, beeswax, and olive oil is melted separately from the water phase consisting of triethanolamine, glycerin, propylene glycol, phenoxyethanol, carmine, and aquadest. Once both phases reach the appropriate temperature, the water phase is gradually added to the oil phase while homogenizing until a homogeneous preparation is formed.

Organoleptic tests are performed by visually observing the color, smell, and shape of the preparation [36], [37], [38]. The pH test is carried out by dispersing 1 g of the preparation in 100 mL of aquadest, then measured using a pH meter [39]. The pH value is adjusted to the skin pH range of 4.5–6.5 [40], [41]. The homogeneity test is carried out by visually observing the preparation to determine the distribution of ingredients evenly and ensuring that there are no lumps [40], [42]. The spreadability test was performed by placing 0.5 g of the preparation in the center of a glass plate and covering it with another glass plate. A load of 150 g was placed on the upper plate and allowed to stand for 1 minute. The diameter of the spread preparation was then measured at several points and the average diameter was calculated. The test was performed in three repetitions for each formula. The spreadability was considered acceptable when the average diameter was within the range of 5–7 cm [36], [43]. The adhesion test was carried out by applying a load of 250 g to 0.5 g of the preparation for 5 seconds, then the time of release of the preparation was recorded. The adhesion criterion used is >1 [36], [43]. The viscosity test was performed using a Brookfield spindle number 4 viscometer at speeds of 6 and 12 rpm. Tests were carried out to determine the viscosity characteristics of the preparations with a viscosity range of 2,000–50,000 cPs [44], [45]. The irritation test was carried out by applying the preparation to the inside of the volunteer's forearm, then observed once a day for three days. The preparation is stated to be non-irritating if it does not provoke erythema, pruritus, or edema [46], [47].

The cream-type test is performed by adding methylene blue to the preparation. Colors that are evenly spread indicate the M/A type, while colors that are clumped or separate indicate the A/M type [44], [48], [49]. The stability test was carried out using a cycling test for three cycles, namely storage at 4°C for 24 hours and then continued at 40°C for 24 hours. Observations include color, smell, shape, and pH of the preparation [50], [51].

An effectiveness test was conducted by applying each preparation to the volunteers' inner arm area for 14 days. Measurements were taken on day 0 as baseline, day 7, and day 14 using CR-302 *Skin Analyzer*. Prior to measurement, volunteers were acclimatized for 15 minutes in a room with a temperature of $25 \pm 2^\circ\text{C}$ and a relative humidity of 40–60%, and no other products were allowed to be used in the test area. Measurements are taken at the same point and under controlled room conditions. Each point was measured three times with the same tool position and pressure, then the average value was used as a result of the measurement. If there is a noticeable difference in results, the measurement is repeated and a consistent value is used for analysis. The observed parameters include moisture content (*Humidity*), oil (*oil*), and skin softness (*Softness*). Changes in skin moisture on days 7 and 14 compared to baseline values on day 0 [46], [52].

The in vitro release/permeation test was performed using a PermeGear Franz diffusion cell equipped with a cellulose membrane. The receptor compartment was filled with 5 mL of phosphate buffer (pH 7.4) and maintained at $37 \pm 0.5^\circ\text{C}$ with continuous stirring at 250 rpm. A total of 0.5 g of the preparation was placed in

the donor compartment. Samples were withdrawn from the receptor compartment at 15, 30, 60, 90, and 120 minutes and immediately replaced with an equal volume of fresh receptor medium. The total phenolic content released through the cellulose membrane was determined using a UV–Vis spectrophotometer at a wavelength of 761 nm, with gallic acid as the standard. A gallic acid calibration curve was prepared, and the linear regression equation and coefficient of determination (R^2) were obtained. The total phenolic content was calculated from the regression equation and expressed as mg gallic acid equivalent (GAE). The cumulative amount of phenolic compounds released was calculated based on the concentration obtained at each sampling time and expressed as the cumulative amount released per unit area of the diffusion membrane. Statistical analysis was performed to determine whether differences in the amount of phenolic compounds released among formulas and sampling times were statistically significant ($p < 0.05$). This test represents an in vitro release/permeation study through a cellulose membrane and does not directly demonstrate penetration of the compounds into human skin [53], [54].

The skin-moisturizing and in vitro release/permeation data were analyzed parametrically using the Shapiro–Wilk test for normality and Levene’s test for homogeneity of variance. Data that met the assumptions were further analyzed using Two-Way ANOVA, followed by a Bonferroni post hoc test to determine significant differences between formulas and observation times. Statistical analysis was performed using IBM SPSS Statistics, with a significance level of $p < 0.05$.

3. RESULTS AND DISCUSSION

Quality of Yellow Pumpkin Seed Powder

The results of the moisture content, microbiology, and particle size of yellow pumpkin seed powder are presented in Table 2, Table 3, and Figure 1.

Table 2. Results of the moisture content test of yellow pumpkin seed powder (*Cucurbita moschata*)

Parameters	Results	Requirements
Moisture Rate	5,93%	$\leq 10\%$

Table 3. Microbiological test results of yellow pumpkin seed powder (*Cucurbita moschata*)

Test Type	Sample	Dilution	Number of Colonies	Summing up
ALT	Pumpkin Seed Powder	10^{-1}	I II	
			39	37
			3.8 $\times 10^2$	
		10^{-2}	33	35
			3.4 $\times 10^3$	
		10^{-3}	31	32
AKK	Pumpkin Seed Powder	10^{-1}	I II	
			16	14
			1.5 $\times 10^2$ CFU/g	
		10^{-2}	13	15
			1.4 $\times 10^3$ CFU/g	
		10^{-3}	11	10
			1 $\times 10^4$ CFU/g	

Table 4. *Staphylococcus aureus* test results of yellow pumpkin seed powder (*Cucurbita moschata*)

Parameters	Results	Requirements
<i>Staphylococcus aureus</i>	Negative (-)	Negative/g

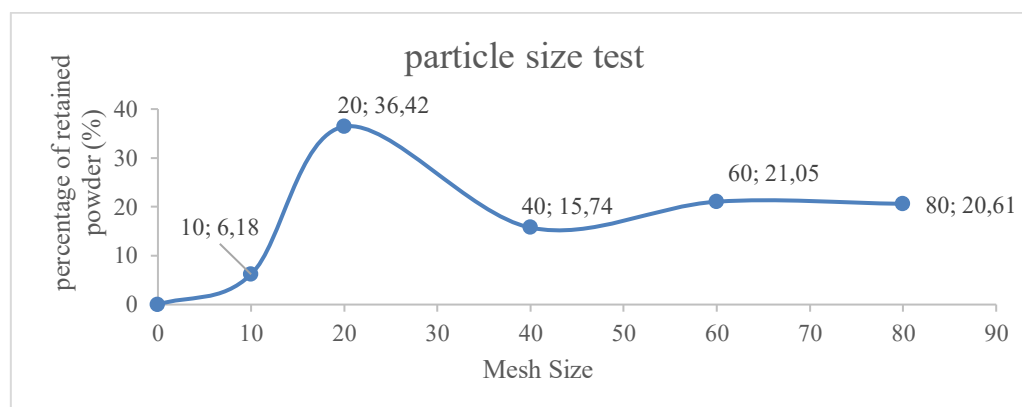


Figure 1. Graph Results of Yellow Pumpkin Seed Powder Particle Size Test

The test results showed that the moisture content of yellow pumpkin seed powder was 5.93%, which meets the quality requirement for simplicia of less than 10%. This low moisture content is important for minimizing the risk of microbial growth and maintaining the stability of the powder during storage. This result is consistent with Wandira et al. (2023), who reported that low moisture content can help prevent fungal growth during storage. The moisture content obtained in this study was also below the specified limit, indicating that the yellow pumpkin seed powder had adequate moisture quality for use as a raw material in topical preparations.

The microbiological test showed ALT values ranging from 3.8×10^2 to 3.1×10^4 CFU/g and AKK values ranging from 1.5×10^2 to 1×10^4 CFU/g at different dilution levels. The ALT values were below the specified limit of $\leq 10^7$ CFU/g, while the highest AKK value was 1×10^4 CFU/g, which was within the specified limit of $\leq 10^4$ CFU/g. In addition, the test for *Staphylococcus aureus* showed a negative result, meeting the requirement of negative/g. These results indicate that the yellow pumpkin seed powder met the microbiological quality requirements for use as a raw material in topical formulations. This finding is consistent with Said et al. (2023), who reported that microbial contamination within the permitted limits and the absence of pathogenic bacteria indicate the microbiological safety of the material. The present study similarly demonstrated acceptable microbiological quality, particularly through the absence of *S. aureus* and microbial counts that remained within the specified limits. Therefore, the microbiological results support the suitability of yellow pumpkin seed powder as a raw material for topical formulations.

Particle size testing was carried out to determine the fineness and uniformity of the yellow pumpkin seed powder. The highest fraction was obtained at mesh 20 (36.42%), followed by mesh 60 (21.05%), mesh 80 (20.61%), and mesh 40 (15.74%). Although mesh 20 had the highest percentage, the mesh 80 fraction was selected for formulation because its finer particles were considered more suitable for incorporation into the cream base and could facilitate uniform dispersion of the powder. This finding is consistent with Syam [55], who reported that finer and more uniform particle sizes can improve the quality and homogeneity of topical preparations. Therefore, the selection of mesh 80 in this study was based on its suitability for formulation rather than its fraction percentage, supporting the uniform distribution of yellow pumpkin seed powder in the cream base.

Physical, Stability, and Safety Evaluation of Creams

The results of the organoleptic test (Table 5) showed that all formulas had a pink color, a distinctive baby powder scent, and a semi-solid consistency. No changes in color, aroma, or consistency were observed during storage, indicating good physical stability. The pink color was attributed to the addition of carmine. These findings are consistent with Kusmita et al. [42], who stated that organoleptic stability is indicated by the absence of changes in physical characteristics during storage. Although stearic acid and GMS produced different emulsion types, namely W/O and O/W, respectively, both maintained stable organoleptic characteristics. The pH results showed values of 4.6–5.6 for stearic acid-based creams and 4.5–5.5 for GMS-based creams. All values were within the skin pH range of 4.5–6.5, indicating suitability for topical application. Differences in pH may be influenced by the type and concentration of emulsifiers and other components in the formulation. This finding is consistent with Lukić et al. [56], who reported that topical formulations should have a pH compatible with skin conditions to ensure safety and comfort.

The results of the homogeneity test (Table 6) showed that all formulas remained homogeneous before and after the cycling test, with no coarse particles or lumps. The pumpkin seed powder with a mesh size of 80 was evenly distributed in both emulsion systems. This finding is consistent with Ginting and Siregar [57] and Deniansyah and Pujiastuti [58], who stated that homogeneous formulations are characterized by uniform distribution of components and the absence of coarse particles. The spreadability test showed values of 5.30–5.53 cm for stearic acid-based creams and 5.67–6.16 cm for GMS-based creams. All formulas met the 5–7 cm requirement. GMS-based creams showed greater spreadability than stearic acid-based creams, which may be associated with their lower viscosity. This is consistent with Dewi Astuti and Dita [59] and Ali et al. [60], who reported that higher viscosity tends to reduce the spreadability of topical preparations.

The adhesion test showed values of 2.47–5.59 seconds for stearic acid-based creams and 2.40–4.66 seconds for GMS-based creams. All formulas met the requirement of >1 second. Stearic acid-based creams showed higher adhesion, which was associated with their higher viscosity. These findings support the relationship between viscosity, spreadability, and adhesion and are consistent with Inayatillah et al. [61] and Witanti and Endriyatno [40], who reported that increased viscosity can increase the adhesion of topical preparations. The results of the viscosity test (Table 7) showed that increasing concentrations of stearic acid and GMS tended to increase cream viscosity due to the formation of a stronger emulsion structure. Stearic acid-based creams showed higher viscosity than GMS-based creams, which may be related to their different emulsion systems. The lower viscosity observed at 12 rpm than at 6 rpm indicated pseudoplastic flow, which can facilitate spreading during application. These findings are consistent with Nurfitri & Endriyatno [62], who reported that emulsifier concentration influences the viscosity and physical characteristics of topical preparations.

The results of the irritation test (Table 8) showed that none of the formulas caused redness, itching, edema, or soreness. This indicates that differences in emulsifier type and emulsion structure did not cause observable irritation under the test conditions. The acceptable pH values may also have contributed to topical compatibility. These findings are consistent with Nurfitri & Endriyatno [62], who reported that variations in emulsifier concentration did not cause erythema or edema. The methylene blue test confirmed that all stearic acid-based formulas (F0–F4) were W/O emulsions, indicated by uneven color distribution, whereas all GMS-based formulas (F0–F4) were O/W emulsions, indicated by even color distribution. These results were consistent with the formulation design. The novelty of this study lies in the comparative evaluation of W/O and O/W pumpkin seed powder creams formulated using stearic acid and GMS, respectively, with emphasis on their physical characteristics and stability. The comparison showed that both emulsion systems could produce creams with acceptable organoleptic properties, pH, homogeneity, spreadability, adhesion, viscosity, and irritation characteristics.

The results of the stability test during the three cycle cycles of the test (Table 9 and Table 10) showed that all formulas remained physically stable, with no changes in color, aroma, shape, homogeneity, or phase separation. Although slight increases in pH occurred in some formulas, all values remained within the acceptable skin pH range. These findings are consistent with Mansuada et al. [63], who stated that stability can be evaluated based on organoleptic characteristics, homogeneity, and pH. The comparative findings provide practical insight into the selection of emulsifiers and emulsion systems for optimizing the physical characteristics and stability of pumpkin seed powder creams.

Effectiveness of Increasing Skin Moisture and Permeability

Data were analyzed using SPSS. The Shapiro–Wilk test showed that the data for moisture, oil, and skin softness were normally distributed ($p > 0.05$), while Levene’s test indicated homogeneous variances ($p > 0.05$). Therefore, the data were analyzed using Two-Way ANOVA. The analysis showed that formulation, application time, and the interaction between formulation and time had significant effects on moisture, oil, and skin softness ($p < 0.05$). The statistical results are presented as mean $\pm$ SD, together with the number of observations (n), degrees of freedom (df), F-values, and p-values in the corresponding tables.

Bonferroni post-hoc analysis showed significant differences between the F1–F4 formulations and the F0 control in both the stearic acid and glyceryl monostearate (GMS) groups ($p < 0.05$). Skin analyzer measurements showed that moisture, oil, and softness increased after 14 days of application, with the improvement becoming more evident from day 7. In the stearic acid group, F4 showed the greatest improvement in the combined moisture, oil, and softness parameters compared with F1–F3, whereas in the GMS group, F4 showed the greatest improvement compared with F1–F3. Thus, F4 was considered the most effective formulation within each emulsifier group based on the highest improvement in these three parameters after 14 days of application, rather than being directly compared between the stearic acid and GMS groups. The increased emulsifier concentration in F4 may improve the cream’s ability to form a protective layer on the skin surface, thereby helping maintain skin moisture and hydration.

The results of the in vitro release/permeation test (Table 11) showed that the total phenolic content released through the cellulose membrane was normally distributed (Shapiro–Wilk, $p > 0.05$) and had homogeneous variances (Levene’s test, $p > 0.05$), indicating that the data met the assumptions for Two-Way ANOVA. The analysis showed that formulation, observation time, and the interaction between formulation and time significantly affected the total phenolic content released ($p < 0.05$). The results of the Bonferroni post-hoc test are presented as mean differences and adjusted p-values for each pairwise comparison. The amount of phenolics released increased with observation time, and F4 showed the highest total phenolic content released at the end of the observation period. These findings indicate that differences in emulsifier concentration and cream formulation may affect the release of phenolic compounds through the cellulose membrane. Because the test used a cellulose membrane, the results represent in vitro release/permeation through the membrane and should not be interpreted as direct evidence of penetration into human skin.

Table 5. Results of Cream Organoleptic Test

Parameters	Stearic Acid Cream Formula (A/M)					Glyceryl Monostearate (M/A) Cream Formula				
	F0	F1	F2	F3	F4	F0	F1	F2	F3	F4
Color	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink
Smell	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder
Shape	Semi-thick	Semi-compact	Semi-compact	Semi-compact	Solid	Semi-thick	Semi-compact	Semi-compact	Semi-compact	Solid

Table 6. Cream homogeneity test results

Parameters	Stearic Acid Cream Formula (A/M)					Glyceryl Monostearate (M/A) Cream Formula				
	F0	F1	F2	F3	F4	F0	F1	F2	F3	F4
Homogeneity	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous

Table 7. Cream viscosity test results at 6 and 12 rpm

Parameters	Stearic Acid Cream Formula (A/M)					Glyceryl Monostearate (M/A) Cream Formula				
	F0	F1	F2	F3	F4	F0	F1	F2	F3	F4
6 rpm	4.789cp	10.851cp	13.196cp	15.329cp	31.798cp	3.350cp	7.946cp	8.454cp	9.734cp	16.871cp
12 rpm	2.691cp	8.709cp	9.959cp	11.057cp	30.876cp	2.504cp	6.583cp	7.352cp	8.709cp	10.271cp

Table 8. Cream irritation test results

Volunteer	Stearic Acid Cream Formula (A/M)					Glyceryl Monostearate (M/A) Cream Formula				
	F0	F1	F2	F3	F4	F0	F1	F2	F3	F4
Age 20	-	-	-	-	-	-	-	-	-	-
Age 22	-	-	-	-	-	-	-	-	-	-
Age 25	-	-	-	-	-	-	-	-	-	-
Age 30	-	-	-	-	-	-	-	-	-	-

Table 9. Results of organoleptic cycling test (stability)

The Second Cycle	Parameters	Stearic Acid Cream Formula (A/M)					Glyceryl Monostearate (M/A) Cream Formula				
		F0	F1	F2	F3	F4	F0	F1	F2	F3	F4
1	Color	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink
	Smell	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder
	Shape	Semi-compact	Semi-compact	Semi-compact	Semi-compact	Semi-compact	Semi-thick	Semi-compact	Semi-compact	Semi-compact	Semi-compact
2	Color	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink
	Smell	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder	Typical Baby Powder
	Shape	Semi-compact	Semi-compact	Semi-compact	Semi-compact	Semi-compact	Semi-thick	Semi-compact	Semi-compact	Semi-compact	Semi-compact

The Seco nd Cycle	Paramet ers	Stearic Acid Cream Formula (A/M)					Glyceryl Monostearate (M/A) Cream Formula				
		F0	F1	F2	F3	F4	F0	F1	F2	F3	F4
3	Color	ct Pink Typic al	ct Pink Typic al	ct Pink Typic al	ct Pink Typic al	ct Pink Typic al	Pink Typic al	ct Pink Typic al	ct Pink Typic al	ct Pink Typic al	ct Pink Typic al
	Smell	Baby Powde r	Baby Powde r	Baby Powde r	Baby Powde r	Baby Powde r	Baby Powde r	Baby Powde r	Baby Powde r	Baby Powde r	Baby Powde r
	Shape	Semi- compa ct	Semi- compa ct	Semi- compa ct	Semi- compa ct	Semi- compa ct	Semi- thick	Semi- compa ct	Semi- compa ct	Semi- compa ct	Semi- compa ct

Table 10. pH test results during cycling

Formula	Stearic Acid Cream (A/M)					Glyceryl Monostearate Cream (M/A)				
	Cycle 1	Cycle 2	Cycle 3	SD	Anova	Cycle 1	Cycle 2	Cycle 3	SD	Anova
F0	4.6	4.7	4.8	4.70± 0.10	<0.001	4.6	4.7	4.9	4.73± 0.15	0.012
F1	4.9	5.1	5.4	5.13± 0.25	<0.001	4.9	5.2	5.3	5.13± 0.21	0.012
F2	5.1	5.2	5.4	5.23± 0.15	<0.001	5.2	5.3	5.5	5.33± 0.15	0.012
F3	5.4	5.5	5.7	5.53± 0.15	<0.001	5.1	5.3	5.4	5.27± 0.15	0.012
F4	5.5	5.7	5.8	5.67± 0.15	<0.001	5.1	5.4	5.6	5.37± 0.25	0.012

Table 11. Statistical results of the permeability of cream preparations

Formulation	Factor	F	df	p-value	Test Bonferroni	Mean Difference	p-value
Cream Asam Stearat	Formula	1,030,456	4	< 0.001	F0 vs F1	-3.17209	< 0.001
	Time	7,230,896	4	< 0.001	F0 vs F2	-6.43753	< 0.001
	Formula x Time	42,014	16	< 0.001	F0 vs F3	-10.51037	< 0.001
					F0 vs F4	-14.33037	< 0.001
Cream GMS	Formula	1,183,219	4	< 0.001	F0 vs F1	-4.11049	< 0.001
	Time	6,169,649	4	< 0.001	F0 vs F2	-7.32085	< 0.001
	Formula x Time	49,706	16	< 0.001	F0 vs F3	-12.6411	< 0.001
					F0 vs F4	-17.57	< 0.001

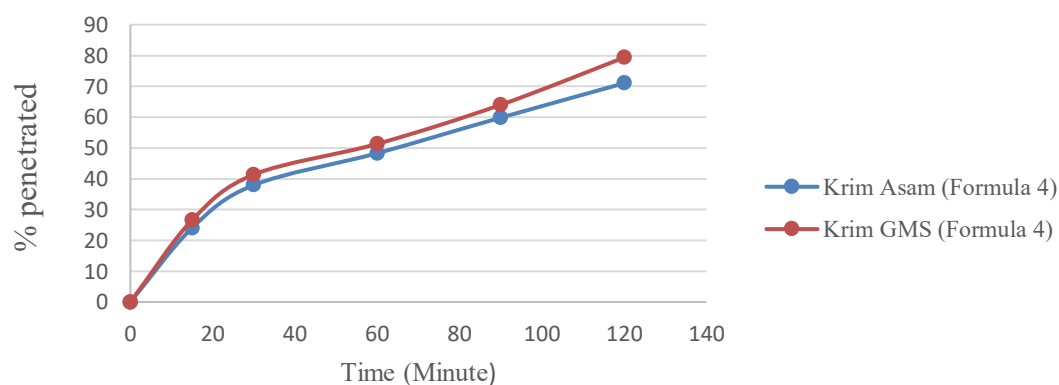


Figure 2. Graph % penetration of cream preparations with franz diffusion cells

The superior performance of formulation F4, characterized by the highest emulsifier concentrations, demonstrates that optimizing the oil-water interface enhances network viscosity and droplet stabilization to form

a robust occlusive film on the stratum corneum that reduces transepidermal water loss and sustains the release of bioactive compounds such as linoleic acid, vitamin E, and phenolic derivatives, aligning with prior investigations on plant-based lipids while bridging the gap between raw botanical valorization and practical cosmetic formulation through direct powder incorporation. These findings generalize broadly to natural seed-powder emulsions, implying that yellow pumpkin seed powder is a safe and eco-friendly alternative for anti-aging cosmetics, supported by the study's core novelty in systematically evaluating stearic acid and glyceryl monostearate variations on powder-based creams; however, limitations such as the use of a synthetic cellulose membrane instead of excised skin, a 14-day evaluation period, and a limited volunteer demographic indicate that future research should incorporate ex vivo skin permeation assays, accelerated stability tests, and extended clinical trials with diverse participant demographics to comprehensively validate its efficacy.

4. CONCLUSION

Yellow pumpkin seed powder (*Cucurbita moschata*) meets quality standards for moisture content, microbial contamination, and particle size, confirming its suitability as a raw material formulated into cream preparations using stearic acid and glyceryl monostearate (GMS) as emulsifiers. All cream formulas exhibited satisfactory physical characteristics and stable pH values during cyclic testing, with formula F4 recording values of 5.67 ± 0.15 for the stearic acid group and 5.37 ± 0.25 for the GMS group, differing significantly from other formulas ($p < 0.001$). Topical application for 14 days significantly improved skin moisture, oil balance, and softness ($p < 0.001$), with formula F4 demonstrating the highest mean improvement compared to controls across all tested parameters. Furthermore, *in vitro* release studies revealed that the cumulative amount of diffused phenolic compounds was significantly influenced by both formulation and observation time, with formula F4 yielding the highest release profile ($p < 0.001$). Conceptually, this study establishes that systematic variations in emulsifier type and concentration effectively modulate oil-water interfacial properties, network viscosity, and active compound release kinetics. Consequently, this work advances a new theoretical and practical framework demonstrating that the direct incorporation of yellow pumpkin seed powder into optimized emulsion systems (particularly formula F4) serves as a robust, safe, and viable concept for developing high-performance natural anti-aging topical cosmetics.

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AUTHOR CONTRIBUTIONS

Conceptualization, Peby Febriyanti, Rayssa Zaahida, and Sulistiyana; Methodology, Peby Febriyanti, Rayssa Zaahida, and Sulistiyana; Formal Analysis, Rayssa Zaahida and Sulistiyana; Investigation, Peby Febriyanti, Rayssa Zaahida, and Sulistiyana; Resources, Rayssa Zaahida and Sulistiyana; Data Curation, Peby Febriyanti; Writing – Original Draft Preparation, Peby Febriyanti, Rayssa Zaahida, and Sulistiyana; Writing – Review & Editing, Peby Febriyanti, Rayssa Zaahida, Sulistiyana, and Apt. Rahmadevi, S.Si., M.Farm.; Visualization, Rayssa Zaahida; Supervision, Apt. Rahmadevi, S.Si., M.Farm.; Project Administration, Sulistiyana; Funding Acquisition, None.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

INFORMED CONSENT STATEMENT

Approval after explanation was obtained from all volunteers before the study was carried out. Volunteers are provided with an explanation of the purpose and procedure of the study, the duration of use of the preparation, the benefits, potential risks or inconveniences that may occur, and the right to refuse or terminate participation in the study without consequences. This research has obtained an Ethical Feasibility Statement from the Health Research and Development Ethics Committee of the Jambi Ministry of Health Polytechnic with the number LB.02.06/2/0740/2026, which was set on June 4, 2026 and valid until June 4, 2027. All volunteers have had the opportunity to understand the research information and ask questions before giving consent. A total of 20 volunteers stated that they were willing to participate in the study voluntarily and had signed an informed consent form before the study began. All images in this article have been authorized and are the property of the authors.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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