AMERICAN JOURNAL OF PHARMTECH RESEARCH
Journal home page: http://www.ajptr.com/

Formulation and Evaluation of Facial Clay Cleansers by Using Zinc PCA and Kaolin Clay

G Govinda Reddy*, Karthik KA, Chaithanya Jeer, Chitrakala, D Madhu Sree, B Santhosh Kumar
Department of Pharmaceutics, Togari Veeramallappa Memorial College of Pharmacy, Ballari - 583104 Karnataka, India

ABSTRACT

Facial cleansers remove excess oil and impurities while maintaining skin comfort. Zinc PCA was selected for its sebum-regulating properties, and kaolin clay was used as an adsorbent. To formulate and evaluate eight clay-based facial cleansers containing Zinc PCA and kaolin clay using xanthan gum or guar gum as thickening agents. The formulations (F1–F8) were prepared using a simple mixing method. Zinc PCA (0.5%), kaolin clay (5%), glycerin (10%), disodium EDTA (0.3%), cocamidopropyl betaine (6%), and sodium benzoate (0.5%) were kept constant. Xanthan gum concentrations ranged from 0.2% to 0.5% in F1–F4, while guar gum concentrations ranged from 0.4% to 0.7% in F5–F8. The formulations were evaluated for FTIR compatibility, appearance, homogeneity, pH, viscosity, spreadability, washability, phase separation, and foam height. All formulations appeared milky, cloudy, and off-white, with visual homogeneity. The pH ranged from 5.16 to 5.51, viscosity from 260 to 2100 mPa·s, and foam height from 1.40 to 4.53 cm. Spreadability values ranged from 220.8 to 528.57 g·cm/s. No phase separation was observed in F1–F4, whereas F5–F8 showed separation. F2 and F7 were identified as preferred candidates based on the overall evaluation. Zinc PCA–kaolin clay facial cleansers were successfully formulated. However, guar-gum formulations require further optimization to improve stability. Long-term stability, safety, and efficacy studies are necessary before confirming their skin benefits.

Keywords: Sebum Regulation; Skin Barrier; Adsorbent; Xanthan Gum; Guar Gum;

*Corresponding Author Name: G Govinda Reddy
Received 12 September 2026, Accepted 06 October 2026

Please cite this article as: Reddy GG *et al*., Formulation and Evaluation of Facial Clay Cleansers by Using Zinc PCA and Kaolin Clay.American Journal of PharmTech Research 2026.

INTRODUCTION

Skin and the skin barrier

The skin is the body's external protective organ and provides a barrier between internal tissues and the environment. Its main anatomical layers are the epidermis, dermis and hypodermis. The epidermis forms the outer protective surface; its stratum corneum consists of flattened, keratin-containing cells surrounded by intercellular lipids. This arrangement helps limit excessive water loss and protects against external irritants. The dermis provides structural support and contains connective tissue, vessels, nerves and skin appendages. The hypodermis contains adipose and loose connective tissue and contributes to cushioning, insulation and movement of the skin over deeper tissues [1,2].

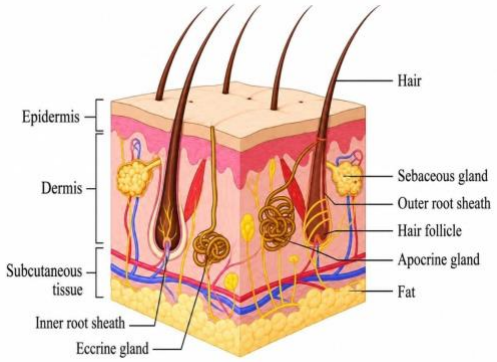


Figure 1: A Cross section of the Human Skin

A topical cleanser comes into contact primarily with the skin surface and the stratum corneum. A suitable product should remove unwanted surface materials without unnecessarily disrupting the barrier. The sensation of tightness, dryness or irritation can be influenced by the surfactant system, the amount of cleansing, the formulation pH, the frequency of use and the condition of the individual's skin. Therefore, the development of a facial cleanser should consider not only its ability to generate foam but also its rinsability, consistency, physical stability and compatibility with routine facial use [1,6].

Skin types and oily skin

Skin is commonly described as normal, oily or dry for practical cosmetic purposes, although individual skin characteristics can overlap and change with age, climate and product use. Normal skin generally has a balanced surface appearance and does not show pronounced oiliness or scaling. Dry skin may feel tight or rough and can display flaking when its water and lipid balance is disturbed. Oily skin often appears shiny, particularly around the forehead, nose and chin, and may have visibly enlarged pores. The presence of

oil alone does not establish a dermatological diagnosis; a cleanser formulated for oily skin should be designed for routine cleansing rather than presented as a treatment for a disease. The project focuses on excess surface sebum and the formulation of a cleanser intended for oily skin. It does not include a clinical trial on people with acne, rosacea or seborrheic dermatitis. These conditions can involve multiple biological and environmental factors, so the formulation results should not be interpreted as evidence that the product prevents or treats them [3,7]

Sebum: composition and function

Sebum is a lipid-rich secretion produced by sebaceous glands associated with hair follicles. Its reported components include triglycerides and their breakdown products, wax esters, squalene, cholesterol and cholesterol esters. Composition and production vary among individuals and anatomical sites. Sebum contributes to lubrication of skin and hair and forms part of the surface lipid environment. It should not be treated as an undesirable substance in itself: the skin requires an appropriate balance of surface lipids and hydration to maintain comfort and barrier function [2,7].

Visible oiliness occurs when the quantity and distribution of surface lipids produce a glossy appearance. Sebaceous activity is influenced by hormonal signals, age, genetics and other physiological factors. Changes in climate and temperature may affect the perception of oiliness, while stress and dietary factors have been investigated as possible contributors in some contexts. These influences are complex and cannot be controlled solely by a topical cleanser. A cleanser can remove some surface oil at the time of washing, but the current project did not measure sebum output before and after application on human skin.

Rationale for a clay-based cleanser

A facial cleanser typically combines a vehicle with one or more cleansing agents and, depending on the design, humectants, thickeners, stabilizers and preservatives. Surfactants help loosen and disperse oily material so it can be rinsed away. The amount and type of surfactant influence foaming, cleansing and skin feel. A thickener provides body and can help keep dispersed particles distributed throughout the product. Humectants such as glycerin are included to support moisture retention and improve the feel of a formulation. Preservatives are used to help protect suitable aqueous products against microbial growth, although preservative effectiveness must be verified experimentally [6,8].

Clay-based cosmetic preparations use mineral particles as adsorbent components. Kaolin is a clay mineral primarily associated with hydrated aluminium silicate. In cosmetic

preparations, it is used to provide an absorbent, opaque and clay-like character. The behaviour of a clay suspension depends on particle characteristics, concentration, wetting, polymer selection, the aqueous phase and processing. A formula can appear uniform immediately after preparation yet later show sedimentation or separation; visual inspection at one time point therefore provides only limited information about shelf stability [10].

In this work, kaolin clay was held at 5% in all eight formulations. Zinc PCA was included at 0.5% as the selected sebum-regulating/skin-conditioning ingredient. The formulation strategy was to hold the main ingredients constant while changing the polymer type and concentration, then compare basic physical properties. This design gives a practical first screen of formulation behaviour but does not isolate the effect of polymer type perfectly, because the xanthan-gum and guar-gum concentration ranges were not identical.

Zinc PCA

Zinc PCA is a zinc salt associated with pyrrolidone carboxylic acid, a compound related to components of the skin's natural moisturizing factor. Cosmetic literature describes zinc-containing ingredients and PCA salts in skin-conditioning applications [4,12,13]. Zinc PCA was selected in the project because it is used in formulations intended for oily skin. The present study did not quantify its release, penetration, biological activity or effect on human sebum production. Consequently, its inclusion should be understood as a formulation choice rather than proof of a clinically demonstrated outcome.

Kaolin clay

Kaolin is a fine, pale clay material used in several cosmetic and pharmaceutical preparations. Its particles can adsorb some surface materials and contribute to the opacity and texture of a product. The mineral itself is not a substitute for a surfactant: clay adsorption and surfactant-assisted removal are distinct formulation functions. The distribution of clay particles is important because visible aggregates or gritty texture may reduce consumer acceptability. The project reported that the prepared samples appeared homogeneous by visual inspection, but it did not report particle-size distribution or microscopic assessment of the suspension [10].

Choice of thickening agents

Xanthan gum is a microbial polysaccharide used to increase viscosity and stabilize aqueous systems. Its rheological behaviour can be affected by concentration, ionic conditions, mixing and the presence of other ingredients. Guar gum is a galactomannan polysaccharide obtained from guar seed and is also used as a thickener and suspending agent. Both

polymers can change the movement of a clay-containing preparation during dispensing, spreading and rinsing. Their effects are not necessarily equivalent at the same mass concentration, and direct comparisons require carefully controlled polymer levels and identical measurement conditions [9,15,16,31,33,35].

Viscosity that is too low may allow rapid settling or make the product difficult to control during use. Excessive viscosity can make a cleanser difficult to dispense, spread or rinse. Spreadability and viscosity should therefore be considered together rather than as independent goals. The project compared xanthan gum at 0.2%, 0.3%, 0.4% and 0.5% with guar gum at 0.4%, 0.5%, 0.6% and 0.7%. The resulting data are descriptive and should be interpreted with the concentration difference in mind.

Study rationale and significance

The practical rationale was to develop a simple clay-based cleanser containing a selected sebum-related ingredient and to examine whether two accessible hydrocolloid thickeners could provide acceptable physical characteristics. The study evaluated appearance, homogeneity, pH, viscosity, spreadability, washability, phase separation and foam height. These parameters are useful in early formulation screening because they identify obvious handling or stability concerns before more demanding tests are undertaken.

The study is exploratory. It did not include a validated instrumental sebum measurement, a controlled human-use study, microbiological challenge testing, irritation testing, long-term stability testing or comparison with a marketed cleanser. Such work would be necessary to establish product safety, preservative performance, shelf life and real-world sebum-related performance. The results are therefore presented as initial formulation data, not as clinical evidence.

Aim and Objectives

Aim: To formulate and evaluate clay-based facial cleanser preparations containing Zinc PCA and kaolin clay.

Specific objectives:

- To conduct a preliminary FTIR comparison of selected ingredients and physical mixtures for changes in characteristic absorption bands.
- To prepare formulations using xanthan gum or guar gum at different concentrations while keeping the other listed ingredients constant.
- To evaluate the formulated facial clay cleansers.

MATERIALS AND METHOD

Study design

This was an in-vitro formulation and preliminary physicochemical evaluation study based on the project report. Eight clay-based cleanser formulations were prepared using a simple mixing method. The formulation series was divided into two groups: F1–F4 contained xanthan gum, and F5–F8 contained guar gum. Zinc PCA, kaolin clay, glycerin, EDTA, cocamidopropyl betaine and sodium benzoate were held at the same nominal concentrations in all formulations. The original project report did not provide a complete record of batch replication for every evaluation parameter; therefore, the values below are reported as recorded and are not presented as mean ± standard deviation unless the source supplied replicate data.

Materials

The ingredients listed in the formulation chart were Zinc PCA, kaolin clay, glycerin, xanthan gum, guar gum, disodium EDTA, cocamidopropyl betaine, sodium benzoate and distilled water. The project report identified Purenso Global, Ahmedabad, India, as the supplier of Zinc PCA. The full supplier, grade and lot details for all other ingredients were not consistently specified in the article data available for this draft and should be added from laboratory records before submission.

Ingredient	Nominal level	Role in formulation
Zinc PCA	0.5%	Selected sebum-regulating / skin-conditioning ingredient
Kaolin clay	5%	Mineral adsorbent; contributes clay-based cleansing character
Glycerin	10%	Humectant and wetting aid for polymer dispersion
Xanthan gum	0.2–0.5% in F1–F4	Thickener / rheology modifier
Guar gum	0.4–0.7% in F5–F8	Thickener / suspending aid
Disodium EDTA	0.3%	Chelating agent
Cocamidopropyl betaine	6%	Amphoteric surfactant / cleansing and foaming
Sodium benzoate	0.5%	Preservative; efficacy not verified in this study
Distilled water	q.s. to 100 mL	Vehicle

Equipment

Equipment reported in the project included an analytical balance, magnetic stirrer, digital pH meter, Dolphin digital rotational viscometer and PerkinElmer Spectrum Two FTIR spectrometer. The viscosity procedure used spindle No. 2 and a 300 mL container holding 100

mL of sample; the project report noted a measurement at 12 rpm when discussing F2 and F7. Equipment calibration records, temperature during measurement and the exact spindle speed used for every formulation were not supplied in the extracted results and should be verified before publication.

Formulation design

The eight formulations used the same nominal amounts of the core ingredients and differed in the selected thickener. Xanthan gum was used in the first four formulations at 0.2%, 0.3%, 0.4% and 0.5%. Guar gum was used in the next four formulations at 0.4%, 0.5%, 0.6% and 0.7%. The quantity of distilled water was adjusted to make a final volume of 100 mL.

Sl. No.	Ingredients	F1	F2	F3	F4	F5	F6	F7	F8
01.	Zinc PCA	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
02.	Kaolin clay	5%	5%	5%	5%	5%	5%	5%	5%
03.	Glycerin	10%	10%	10%	10%	10%	10%	10%	10%
04.	Xanthan gum	**0.2%**	**0.3%**	**0.4%**	**0.5%**	-	-	-	-
05.	Guar gum	-	-	-	-	**0.4%**	**0.5%**	**0.6%**	**0.7%**
06.	EDTA	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
07.	Cocamid opropyl betaine	6%	6%	6%	6%	6%	6%	6%	6%
08.	Sodium benzoate	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
09.	Distilled water	q.s to 100ml	q.s to 100ml	q.s to 100ml	q.s to 100ml	q.s to 100ml	q.s to 100ml	q.s to 100ml	q.s to 100ml

Note: Percentages are reproduced from the project formulation chart. The original report does not consistently specify whether all percentage values are w/w or w/v; this basis should be clarified from the original batch records before a manuscript is submitted.

Method of preparation

The reported preparation was carried out using a simple mixing method. First, the required quantity of distilled water was placed in a beaker on a magnetic stirrer. Disodium EDTA (0.3%) was dissolved completely, followed by the addition of glycerin (10%) with mixing. The selected thickener was then dispersed gradually. The report describes allowing approximately 20–30 minutes for hydration and gel formation. This hydration step is important because direct addition of a dry hydrocolloid to a highly viscous aqueous system can produce lumps with incompletely hydrated material.

Kaolin clay (5%) was added slowly to the gel base under continuous stirring to minimize aggregation and to promote distribution of the mineral particles. Cocamidopropyl betaine (6%) was incorporated slowly to reduce excessive foam during manufacturing. Zinc PCA (0.5%) and sodium benzoate (0.5%) were then added and mixed until the preparation appeared

uniform. Distilled water was used to make the final volume up to 100mL. The finished preparation was visually checked for obvious lumps and uneven distribution.

For reproducibility, a future study should document the order and duration of every addition, stirring speed, temperature, vessel geometry, batch size, pH-adjustment procedure if any, and the interval between preparation and testing. The project report did not identify a pH-adjusting agent or provide a detailed mixing-speed record, so these details are not inferred in this article.

Preliminary FTIR compatibility assessment

The project used Fourier-transform infrared spectroscopy to compare individual materials and selected physical mixtures. Potassium bromide was mixed with the sample at a reported 9:1 ratio before spectra were recorded. Individual spectra were obtained for Zinc PCA, kaolin clay, xanthan gum and guar gum, and spectra were also examined for combinations containing Zinc PCA, kaolin clay and either xanthan gum or guar gum. The comparison focused on the presence or absence of characteristic bands and possible shifts in the reported ranges.

Visual appearance and homogeneity

The colour and general appearance were examined visually. For the homogeneity test, a small quantity of the suspension was placed on a clean glass slide and spread to inspect consistency, visible lumps, aggregates and obvious separation. These are qualitative assessments; the project did not report instrumental colour measurements or microscopy-based particle distribution.

pH determination

A digital pH meter with a glass electrode was used according to the procedure described in the project report. The meter was calibrated using standard buffer solutions, and the electrode was immersed in the sample to obtain a reading. The eight reported values were recorded without reported replicate standard deviations. The pH values should be treated as measured observations for the tested batches rather than as evidence of skin compatibility in all users.

Viscosity determination

Viscosity was measured using a Dolphin digital rotational viscometer. Spindle No. 2 was used, with 100 mL of cleanser placed in a 300 mL container. The spindle was positioned vertically near the center of the sample without touching the container bottom. The project report describes increasing angular velocity to assess rheological behaviour and refers to measurements at 12 rpm when identifying F2 and F7 as having suitable viscosity. Because

the complete speed-by-speed data are not available in the article extract, the values reported in Table 3 are reproduced as the project's recorded viscosity values and are not used to claim a fully characterized flow model.

Spreadability

Spreadability was assessed using the procedure cited in the project report and values were expressed as g·cm/s. The numerical values are reproduced in Table 3. The complete apparatus dimensions, applied load, distance and timing details were not present in the article data extracted for this draft. Since spreadability results depend on the method and the formula used to calculate the endpoint, the authors should confirm the exact protocol and unit notation from the laboratory notebook before publication.

Washability

Washability was assessed by applying the preparation to the dorsal surface of the hand and rinsing with water. The source used a qualitative scoring system in which +++ represented excellent washability and ++ represented good washability. No instrument-based residue measurement or blinded observer assessment was reported; the ratings are therefore presented as qualitative observations.

Phase separation

The formulations were inspected for visible phase separation during the observation period described in the project report as 24 hours at room temperature. F1–F4 were reported to show no phase separation, whereas F5–F8 showed separation. The observation period is short and should not be interpreted as a formal shelf-life or stability study. Further tests should assess sedimentation, redispersibility, centrifugation response, temperature cycling and storage over a longer period.

Foaming ability

The reported foam test involved mixing 5 mL of formulation with an equal volume of water, shaking for 30 seconds, allowing the sample to stand for one minute and measuring foam height. Three trial heights were recorded for each formulation, and the average was provided in the project report. Foam height indicates foam generation under the stated conditions but does not directly measure cleansing efficacy, mildness, ease of rinsing or consumer preference.

Data presentation

Results are reported descriptively using the values supplied in the project report. No inferential statistical testing is presented because the full replicated dataset, variance

estimates and complete experimental design were not available. Interpretations focus on observed ranges and differences between the two formulation series.

RESULTS

FTIR compatibility

The project report compared the characteristic absorption bands of Zinc PCA, kaolin clay and the selected polymers with those in the corresponding physical mixtures. The recorded values included a C–H stretching band around 2927.7 cm^{-1} for Zinc PCA and around 2924.98 and 2925.94 cm^{-1} for xanthan gum and guar gum, respectively. For the clay-containing samples, an Al–OH-related band was recorded near 948.49 cm^{-1} for kaolin clay and near 948.56 and 948.6 cm^{-1} in the two mixture samples. O–H stretching was reported in the broad 3200–3700 cm^{-1} region, and Si–O stretching was reported around 1051 cm^{-1} for kaolin clay and around 1050.95 cm^{-1} in the mixture.

Functional groups	Standard Value (cm^{-1})	Zinc PCA	Kaolin Clay	Xanthan gum	Guar gum	Sample 5	Sample 6
C-H(stretching)	2850-3000	2927.7	---	2924.98	2925.94	2926.8	2927.5
COO^-(stretching)	1400-1650	1418.98	---	1618.44	1023.44	---	---
Al-OH(stretching)	900-1000	---	948.49	---	---	948.56	948.6
O-H(stretching)	3200-3700	---	3674.65	3417.04	3419.75	3674.64	3395.97
Si-O(stretching)	1000-1100	---	1051	---	---	1050.95	1050

The authors of the original project interpreted the retained bands as indicating no notable interaction among the selected materials under the conditions of the preliminary spectral assessment. A journal article should avoid the stronger wording “confirmed stability,” because compatibility screening by FTIR is not equivalent to a stability study. The spectra should be supplied as figures and peak assignments verified against the original instrument files if the manuscript is submitted.

Appearance and homogeneity

All eight preparations were described as milky, cloudy and off-white. The source reported that the formulations appeared uniform, with no visible lumps or aggregates at the time of inspection. The result suggests that the selected preparation sequence was adequate for producing visually uniform samples at the time of testing. It does not establish that the clay remained uniformly suspended during prolonged storage, as separation was subsequently observed in the guar-gum series.

Parameter	F1–F4 (xanthan gum)	F5–F8 (guar gum)
Colour / appearance	Milky, cloudy, off-white	Milky, cloudy, off-white
Visual homogeneity	Reported homogeneous	Reported homogeneous at initial inspection
Visible lumps / aggregates	None reported	None reported



Figure 2: Determination of pH of formulations

Formulation	F1	F2	F3	F4	F5	F6	F7	F8
pH	5.30	5.24	5.16	5.51	5.21	5.30	5.28	5.29

The pH values ranged from 5.16 to 5.51, a total span of 0.35 pH units. F3 had the lowest recorded value (5.16), and F4 had the highest (5.51). The values were close to one another despite the change in thickener type and concentration. This narrow range suggests that the measured pH did not vary markedly across the tested batches. However, pH alone cannot establish that a cleanser is non-irritating or suitable for every skin type; safety depends on the complete formula, exposure, use conditions and individual sensitivity.

Viscosity

Formulation	Thickener	Viscosity (mPa·s)
F1	Xanthan gum 0.2%	260
F2	Xanthan gum 0.3%	320
F3	Xanthan gum 0.4%	395
F4	Xanthan gum 0.5%	450
F5	Guar gum 0.4%	1420
F6	Guar gum 0.5%	1485
F7	Guar gum 0.6%	1600
F8	Guar gum 0.7%	2100

Within the xanthan-gum series, recorded viscosity increased from 260 mPa·s in F1 to 450 mPa·s in F4. Within the guar-gum series, it increased from 1420 mPa·s in F5 to 2100 mPa·s in F8. The data show a concentration-associated increase in viscosity within each polymer series. Across the two series, the guar-gum preparations had higher recorded values than the xanthan-gum preparations, although this comparison is confounded by the different concentration ranges and potentially by measurement conditions. F2 (320 mPa·s)

and F7 (1600 mPa·s) were described in the original project as having suitable viscosity at the reported setting.

Spreadability

Formulation	Spreadability (g·cm/s)
F1	440
F2	370
F3	295.3
F4	220.8
F5	528.57
F6	493.3
F7	350
F8	255.17

Spreadability ranged from 220.8 to 528.57 g·cm/s. F5 had the highest recorded value (528.57), followed by F6 (493.3) and F1 (440). F4 had the lowest value (220.8). Within the xanthan-gum group, spreadability decreased as the gum concentration increased. A similar overall decrease was observed across the guar-gum series as concentration increased from 0.4% to 0.7%. This pattern is consistent with the recorded rise in viscosity within each series, although the method and units require verification before direct quantitative comparisons are made.

Washability

Formulation	Washability score	Interpretation used in source
F1	+++	Excellent
F2	+++	Excellent
F3	++	Good
F4	++	Good
F5	+++	Excellent
F6	+++	Excellent
F7	+++	Excellent
F8	++	Good

F1, F2, F5, F6 and F7 were rated +++, interpreted as excellent washability. F3, F4 and F8 were rated ++, interpreted as good washability. Thus, every formulation was reported to rinse reasonably well under the qualitative test, but the ratings do not quantify residue, rinsing time or skin feel.

Phase separation



Figure 03: Phase separation test for F1, F2, F3 and F4



Figure 04: Phase separation test for F5, F6, F7 and F8

Formulation	Observation reported	Interpretation
F1–F4 (xanthan gum 0.2–0.5%)	No visible phase separation during the reported observation period	Better short-term visual integrity under the test conditions
F5–F8 (guar gum 0.4–0.7%)	Phase separation observed	Further optimization of polymer system and suspension stability required

The difference in observed phase separation is an important outcome. The xanthan-gum series showed no visible separation during the stated short observation period, whereas all four guar-gum formulations showed separation. The available results do not establish the mechanism. Potential factors to investigate include polymer hydration, clay wetting, polymer–electrolyte interactions, viscosity at low shear, particle settling and the order of ingredient addition. These are hypotheses for future testing, not mechanisms demonstrated by the present experiment.

Foam height

Formulation	Trial 1 (cm)	Trial 2 (cm)	Trial 3 (cm)	Average (cm)
F1	4.2	4.4	4.1	4.23
F2	3.4	3.5	3.4	3.43
F3	2.9	2.8	2.9	2.87
F4	1.5	1.3	1.4	1.40
F5	4.6	4.7	4.3	4.53
F6	4.2	4.3	4.4	4.30
F7	3.3	3.4	3.3	3.33
F8	2.2	2.3	2.2	2.23

Average foam height ranged from 1.40 to 4.53 cm. F5 produced the highest average foam height (4.53 cm), followed by F6 (4.30 cm) and F1 (4.23 cm). F4 produced the lowest foam height (1.40 cm). F2 and F7 showed intermediate averages of 3.43 and 3.33 cm, respectively. The recorded data indicate that all preparations produced some foam under the stated test conditions. Foam volume should not be used alone as a measure of cleansing efficacy or mildness, and the observed trend should be confirmed using a standardized method with controlled shaking energy and vessel geometry.

Overall screening of formulations

The original project identified F2 and F7 as preferred formulations after considering pH, viscosity, spreadability, washability, phase separation and foam ability. F2 contained 0.3% xanthan gum and had a pH of 5.24, viscosity of 320 mPa·s, spreadability of 370 g·cm/s, excellent qualitative washability, no reported phase separation in the xanthan series and average foam height of 3.43 cm. F7 contained 0.6% guar gum and had a pH of 5.28, viscosity of 1600 mPa·s, spreadability of 350 g·cm/s, excellent washability and average foam height of 3.33 cm; however, it belongs to the guar-gum group in which phase separation was observed.

Attribute	F2	F7
Thickener	Xanthan gum 0.3%	Guar gum 0.6%
pH	5.24	5.28
Viscosity (mPa·s)	320	1600
Spreadability (g·cm/s)	370	350
Washability	+++	+++
Phase separation	Not observed in group	Observed in group
Average foam height (cm)	3.43	3.33

F2 and F7 therefore represent the project's selected candidates, but the selection should be interpreted cautiously. F7's reported phase separation is a meaningful limitation and would need to be resolved before it could be considered a stable product candidate. A transparent optimization approach should define in advance the acceptable ranges for viscosity and spreadability, weight the importance of physical stability, and repeat all critical measurements across independently prepared batches.

DISCUSSION

Interpretation of the overall findings

This study prepared eight clay-based cleanser formulations using fixed levels of Zinc PCA, kaolin clay, glycerin, EDTA, cocamidopropyl betaine and sodium benzoate while varying the type and concentration of thickener. The preparations had a narrow pH range, were

described as visually homogeneous at initial inspection and produced measurable foam. These findings suggest that the basic mixing procedure produced testable cleanser-like dispersions. However, the different outcomes for short-term phase separation indicate that the polymer system is a key variable requiring further investigation.

The findings should be read as a first-stage formulation screen. Physical appearance, pH, viscosity, spreadability, washability and foam height are useful product-development observations, but they do not directly establish the claimed biological effect of regulating sebum. The study did not measure sebum levels on skin or assess user experience in a controlled design. It also did not include microbiological testing or a formal stability protocol. Accordingly, the results support selection of candidates for further development rather than a conclusion that an optimized, safe or clinically effective cosmetic product has been established.

pH and potential skin suitability

All measured pH values fell between 5.16 and 5.51. The narrow range indicates that the tested batches had similar measured acidity. A mildly acidic product pH is often considered during facial cleanser development because the skin surface is typically acidic, but the product's pH alone cannot predict tolerability. Surfactant concentration and identity, contact time, frequency of use, impurities, preservative system and the user's barrier condition can all influence irritation. In future work, the pH should be measured in replicate at a controlled temperature, with the electrode calibration and measurement procedure documented.

Rheology, viscosity and spreadability

Viscosity increased with polymer concentration in both formulation series, while spreadability generally decreased. This inverse pattern is practically important: a thicker cleanser may be easier to hold and may slow the settling of particles, but it can require more force to spread and rinse. A formulation intended for routine facial use should balance these attributes rather than maximize either one. The large difference between the viscosity values of the two polymer series cannot be attributed solely to polymer identity because the concentrations differed and complete measurement settings were not available for all readings.

Rheological characterization should be strengthened in a future study by recording viscosity at multiple spindle speeds or shear rates, reporting temperature, specifying the instrument model and calibration, and assessing whether viscosity changes after standing.

If the material is thixotropic or shear-thinning, measurements should be collected using a reproducible pre-shear and rest protocol. Such data would make it possible to relate structure at rest to dispensing and spreading under use conditions. The current report's qualitative description of pseudoplastic behaviour should be treated as preliminary because a complete flow curve is not included in the article data.

Comparison of xanthan gum and guar gum series

The xanthan-gum series had lower recorded viscosity values and did not show visible separation during the reported observation period. The guar-gum series had higher recorded viscosity values, but phase separation was observed in all four preparations. These results show why viscosity alone should not be considered a sufficient measure of suspension stability. A formulation can have a relatively high apparent viscosity yet still undergo separation if particle wetting, polymer hydration, yield stress or interactions within the system are not adequate.

The polymer comparison was not designed as a fully matched concentration study: xanthan gum was tested at 0.2–0.5%, whereas guar gum was tested at 0.4–0.7%. A rigorous comparison would prepare both polymers at overlapping concentrations and hold the other variables constant. The mixing order and hydration conditions should also be controlled. It may be useful to test intermediate levels, combinations of gums or alternative suspending agents, but these should be approached as new experiments and not assumed to improve stability without data.

Significance of phase separation

The lack of visible separation in F1–F4 is encouraging for short-term physical appearance, but a 24-hour observation is not enough to establish shelf stability. The observation of separation in F5–F8 suggests that the guar-gum series requires further work before selection for product development. Additional observations should include the amount and appearance of separated material, sedimentation volume, ease of redispersion and whether repeated shaking restores uniformity. Centrifugation, freeze–thaw cycling and storage at different temperatures can provide useful stress screens, while real-time stability testing is needed to support shelf-life decisions.

The mechanism of separation was not established in the current project. The article therefore avoids assigning a specific cause. Future experiments could evaluate clay dispersion, wetting, polymer hydration, electrolyte sensitivity, preservative compatibility

and the effect of mixing sequence. A suitable design would change one factor at a time or use a planned factorial approach, record the response quantitatively and repeat each batch.

Foaming and washability

Cocamidopropyl betaine was included as an amphoteric surfactant, and all formulations produced measurable foam. The average foam height differed across formulations, with F5 showing the highest and F4 the lowest value. Since the surfactant concentration was nominally constant, differences may relate to interactions with polymer, clay dispersion and sample handling; however, the present data do not establish the mechanism. The shaking procedure is also sensitive to the operator, vessel dimensions and timing, so standardized equipment and a defined shaking energy would improve comparability.

Qualitative washability ratings were good or excellent for every formulation. This suggests that the preparations could be rinsed from the hand under the conditions used for the project test. It does not demonstrate that they leave no residue, are non-irritating or are preferred by users. Future evaluation could include a standardized rinse protocol, residual-film assessment, skin-feel questionnaire and controlled tolerability testing after appropriate ethical and safety review.

Role of the selected ingredients

The formula combined a mineral adsorbent, a sebum-related ingredient, a surfactant, a humectant, polymers, a chelating agent, a preservative and water. The roles assigned to these ingredients are consistent with the formulation rationale described in the project. Nevertheless, ingredient function at the individual level does not guarantee performance of the complete product. For example, sodium benzoate was included as a preservative, but the study did not perform a microbial limit test or preservative efficacy/challenge test. Its inclusion cannot therefore be interpreted as proof that the product is microbiologically protected.

Similarly, glycerin was included as a humectant, but hydration or moisturization was not measured. Zinc PCA was included based on its cosmetic use in sebum-related formulations, but no biological endpoint was tested. Kaolin was included as an adsorbent, but the project did not quantify oil adsorption by the final formulation. Future work should link ingredient rationale to measurable endpoints and avoid making claims that go beyond the experiments conducted.

Comparison with literature and formulation context

Published reviews describe facial cleansers as systems whose effects depend on surfactants, formulation structure and the interaction with the skin barrier [6]. Reviews of sebum biology emphasize that sebum has normal protective functions and that sebaceous activity is influenced by several factors [2,7]. Literature on zinc-containing cosmetic ingredients and PCA salts provides a rationale for considering Zinc PCA in personal-care formulations [12,13], while work on clay-based cosmetic preparations supports further investigation of clay mineral properties and their influence on formulation behaviour [10]. These sources provide background for ingredient selection; they do not validate the specific formulation tested here.

The present work adds descriptive data for eight formula variations, including pH, viscosity, spreadability, qualitative washability, visible phase separation and foam height. Its principal practical observation is that the xanthan-gum series maintained visual integrity during the reported short observation period, whereas the guar-gum series did not. Further studies should compare the selected formulations against a suitable marketed reference under the same methods and include objective endpoints rather than relying only on visual and qualitative assessment.

Practical implications for formulation development

The data suggest that F2 is a reasonable candidate for further testing because it combined a measured pH of 5.24, a moderate recorded viscosity of 320 mPa·s, spreadability of 370 g·cm/s, excellent washability and no reported separation in the xanthan-gum series. F7 was selected in the original project because its recorded pH, viscosity, spreadability, washability and foam height were considered suitable; however, the phase-separation observation in the guar-gum group is a critical caveat. It would be premature to recommend F7 as a stable formula without reformulation or further investigation.

The next stage should prioritize reproducibility and stability over increasing foam or viscosity alone. At least three independently prepared batches of each shortlisted formulation should be evaluated using pre-specified methods. A formulation should advance only if it remains physically uniform, has a reproducible pH and viscosity, can be spread and rinsed acceptably, and passes relevant microbiological and safety checks. A formal decision matrix could be used to compare candidates with clearly defined criteria.

Limitations

- The study was a preliminary formulation evaluation and did not include a controlled human-use study.

- Phase separation was observed over a short period; long-term and accelerated stability studies were not reported.
- FTIR compatibility was a preliminary comparison and cannot independently establish comprehensive chemical stability.
- The two polymer series used different concentration ranges, so a direct polymer-to-polymer comparison is confounded.

Future scope

- Study can be carried out further by replacing the thickening agents.
- Studies can be carried out for other drugs which are having the properties of sebum regulation.
- The work can be extended by comparing formulated clay-based facial cleanser formulation with marketed clay-based facial cleanser.

CONCLUSION

Eight clay-based facial cleanser formulations containing 0.5% Zinc PCA and 5% kaolin clay were prepared using xanthan gum or guar gum as alternative thickeners. All formulations were described as milky, cloudy and off-white and visually homogeneous at initial inspection. Measured pH ranged from 5.16 to 5.51; recorded viscosity ranged from 260 to 2100 mPa·s; spreadability ranged from 220.8 to 528.57 g·cm/s; and average foam height ranged from 1.40 to 4.53 cm. Washability was rated good or excellent across all formulations.

The most important stability-related observation was that F1–F4, containing xanthan gum, showed no visible phase separation during the reported observation period, whereas F5–F8, containing guar gum, showed separation. F2 and F7 were identified in the original project as preferred formulations based on combined evaluation, but F7 requires particular caution because of the separation observed in the guar-gum series. The work supports further formulation optimization, not a definitive claim of product stability, safety or clinical sebum regulation. Replicated testing, longer-term stability, microbiological assessment, safety evaluation and a controlled comparison with marketed cleansers are recommended.

DECLARATIONS

Acknowledgements: The original project report acknowledges the guidance and support of the Department of Pharmaceutics, Togari Veeramallappa Memorial College of Pharmacy, Ballari, and assistance with FTIR analysis.

Conflict of interest: This draft does not assume that no conflicts exist.

Ethics statement: No human participants or animal experiments are described in the formulation data presented here. If additional human-use testing is conducted, the relevant ethical approval and consent details must be provided.

Data availability: The underlying batch records, raw spectra and original laboratory data should be retained by the authors. A data availability statement should be completed according to the journal's policy

REFERENCES

1. Khan B, Sayyed N, Khan J, Rathod S, Rai A, Facial Skin Cleansers. International Journal of Pharmaceutical Sciences 2023(6); 2404-2418.
2. Thiboutot MD. Regulation of human sebaceous glands. Journal of investigative dermatology. 2004 Jul 1;123(1):1-2.
3. Dall'Oglio F, Nasca MR, Gerbino C, Micali G. An overview of the diagnosis and management of seborrheic dermatitis. Clinical, cosmetic and investigational dermatology. 2022 Jan 1:1537-48.
4. Gupta M, Mahajan VK, Mehta KS, Chauhan PS. Zinc therapy in dermatology: a review. Dermatology research and practice. 2014;2014(1):709152.
5. Sarruf FD, Issa MG, Velasco MV, Rosado C, Baby AR. Clay-Based Cosmetic Formulations: Mineralogical Properties and Short-Term Effects on Sebum Regulation and Skin Biomechanics. Cosmetics. 2025 Oct 4;12(5):219.
6. Mukhopadhyay P. Cleansers and their role in various dermatological disorders. Indian journal of dermatology. 2011 Jan;56(1):2.
7. Li X, He C, Chen Z, Zhou C, Gan Y, Jia Y. A review of the role of sebum in the mechanism of acne pathogenesis. Journal of cosmetic dermatology. 2017 Jun;16(2):168-73.
8. Kim D, Seok JK, Kim M, Choi S, Hong J, Yoon YA, Chung H, Bae ON, Kwack SJ, Kim KB, Lee JY. Safety assessment of cocamidopropyl betaine, a cosmetic ingredient. Toxicological Research. 2024 Jul;40(3):361-75.
9. Raji HA, Moayed RZ, Nozari MA. The viscosity of xanthan gum grout with different pH and ionic strength. International Journal of Geotech Eng. 2021;15(1):38-47.
10. Murray HH. Traditional and new applications for kaolin, smectite, and palygorskite: a general overview. Applied clay science. 2000 Nov 1;17(5-6):207-21.

11. Wikipedia contributors. Kaolinite [Internet]. Wikipedia, The Free Encyclopedia. Available from: https://en.wikipedia.org/wiki/Kaolinite [Accessed 9 Jul 2026].
12. Abendrot M, Kalinowska-Lis U. Zinc-containing compounds for personal care applications. International journal of cosmetic science. 2018 Aug;40(4):319-27.
13. Fiume MM, Bergfeld WF, Belsito DV, Hill RA, Klaassen CD, Liebler DC, Marks Jr JG, Shank RC, Slaga TJ, Snyder PW, Gill LJ. Safety assessment of PCA (2-Pyrrolidone-5-carboxylic acid) and its salts as used in cosmetics. International journal of toxicology. 2019 Sep; 38(2_suppl):5S-11S.
14. Prachi PU, Sanap. AS. Formulation and development of face serum. International journal of creative research thoughts.2023; 11(6):833-845.Adam PG, Mhaske ST. Studies in rheological behaviour of guar gum solution. Macromolecules. 2014;10(1):1–6.
15. Adam PG, Mhaske ST. Studies in rheological behaviour of guar gum solution. Macromolecules. 2014;10(1):1–6.
16. Peric I, Nishimura T. Leveraging synergy between guar and xanthan gums: A modern formulation tool. HPC Today. 2023;18(1):24–29.
17. Hou X, Wei Z, Zouboulis CC, Ju Q. Aging in the sebaceous gland. Frontiers in Cell and Developmental Biology. 2022 Aug 17;10:909694.
18. Yoon SJ, Chu DC, Juneja LR. Chemical and physical properties, safety and application of partially hydrolized guar gum as dietary fiber. Journal of Clinical Biochemistry and Nutrition. 2008;42(1):1–7.
19. Shivani S, Sujata K, Neeta H, Sumedha M. Formulation and evaluation of herbal face serum. International journal of creative research thoughts.2024:6(9):986--989.
20. Indian Pharmacopoeia Commission. Xanthan Gum. In: Indian Pharmacopoeia. Vol.3. Ghaziabad (India): Indian Pharmacopoeia Commission, Ministry of Health and Family Welfare, Government of India; 2014. p. 2995–2997.
21. Asirvatham E, inventor; Advansix Resins, Chemicals LLC, assignee. Surfactants for personal care and cosmetic products. United States patent application US 17/196,886. 2021 Sep 16.
22. Schelges H, Scholz E, inventors; Henkel AG and Co KGaA, assignee. Natural cosmetic cleanser which is solid at room temperature. United States patent application US 16/659,958. 2020 Jun 11.
23. Sans A, Candolives M, Hauchecorne S, inventors. Mild, foaming cleansing composition. United States patent application US 12/056,616. 2009 Feb 5.

24. Prajakta S.T, Hrushikesh B.B, Suyog S, Manisha SG, Dr. Santosh SC. General review of face serum. World journal of pharmaceutical research. 2023;12(6):445-402.
25. https:/pubchem.ncbi.nlm.nih.gov/compound/92024769
26. Barel AO, Paye M, Maibach HI, editors. Handbook of cosmetic science and technology. CRC press; 2014 Apr 9.
27. Tadros TF. Rheology of dispersions: principles and applications. John Wiley & Sons; 2011 Jul 18.
28. Bakhrushina EO, Anurova MN, Zavalniy MS, Demina NB, Bardakov AI, Krasnyuk II. Dermatologic gels spreadability measuring methods comparative study. International Journal of Applied Pharmaceutics. 2022;14(1):164-8.
29. Barel AO, Paye M, Maibach HI, editors. Handbook of cosmetic science and technology. CRC press; 2014 Apr 9.
30. Tadros TF. Rheology of dispersions: principles and applications. John Wiley & Sons; 2011 Jul 18..
31. Sworn G. Xanthan gum. In: Phillips GO, Williams PA, editors. Handbook of Hydrocolloids. 2nd ed. Cambridge: Woodhead Publishing; 2009. p. 186-203.
32. L'Oréal. Low viscosity emulsion cosmetic composition. US Patent 12,036,304. 2024 Jul 16.
33. Fiume MM, Heldreth B, Bergfeld WF, Belsito DV, Hill RA, Klaassen CD, Liebler DC, Marks Jr JG, Shank RC, Slaga TJ, Snyder PW. Safety assessment of microbial polysaccharide gums as used in cosmetics. International journal of toxicology. 2016 Jul;35(1_suppl):5S-49S.
34. Burnett CL, Bergfeld WF, Belsito DV, Hill RA, Klaassen CD, Liebler D, Marks Jr JG, Shank RC, Slaga TJ, Snyder PW, Andersen FA. Final report of the Cosmetic Ingredient Review Expert Panel on the safety assessment of cocamidopropyl betaine (CAPB). International journal of toxicology. 2012 Aug;31(4_suppl):77S-111S.
35. Johnson Jr W, Heldreth B, Bergfeld WF, Belsito DV, Hill RA, Klaassen CD, Liebler DC, Marks Jr JG, Shank RC, Slaga TJ, Snyder PW. Safety assessment of galactomannans as used in cosmetics. International journal of toxicology. 2015 Jul;34(1_suppl):35S-65S.
36. Lanigan RS, Yamarik TA. Final report on the safety assessment of EDTA, calcium disodium EDTA, diammonium EDTA, dipotassium EDTA, disodium EDTA, TEA-EDTA, tetrasodium EDTA, tripotassium EDTA, trisodium EDTA, HEDTA, and

trisodium HEDTA. International journal of toxicology. 2002 Jan 1;21:95-142.

37. Belsito DV, Bhatia S, Bruze M, Fiume MM, Gerberick GF, Hontela A, et al. Safety assessment of salicylic acid, its salts and esters. International journal of toxicology. 2003;22(Suppl 3):1-108.
38. https://pmc.ncbi.nlm.nih.gov/articles/PMC4984879
39. Eloystina LJ, Aldila S, Girsang V, Sa'adah A. An Irritation Test of Optimum Preparation of Celery Extract Face Clay Cleanser With Sodium Lauryl Sulfate (SLS) and Cocamidopropyl Betaine (CAPB) as Surfactants: Irritation Test of Optimum Preparation of Celery Extract Face Clay Cleanser With Sodium Lauryl Sulfate (SLS) and Cocamidopropyl Betaine (CAPB) as Surfactants. Science and Community Pharmacy Journal.
40. Vandkar A, Shaikh R, Thombare R, Chivate A, Chivate N. Formulation and Analysis of Herbal Face Wash Using Luffa Cylindrica Seeds Oil Extract as a Soap Base

