



Bioactive Goat Milk Innovation for Lipstick and Lip Balm

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ABSTRACT

The growing demand for natural-ingredient cosmetics creates opportunities to transform agricultural and livestock-based resources into innovative, value-added products. This study proposes Bioactive Goat Milk Innovation for Lipstick and Lip Balm, an initiative to develop goat milk-derived ingredients for two lip care applications. The research employs an experimental development approach involving raw material preparation, formulation design, manufacturing, and product validation. Goat milk powder is proposed as a characteristic ingredient, combined with cosmetic-grade waxes, oils, butters, and approved pigments. The lip balm formulation focuses on lip conditioning and moisture protection, while the lipstick formulation combines conditioning properties with decorative color. Product evaluation will include organoleptic characteristics, homogeneity, physical performance, ingredient compatibility, microbiological quality, stability, packaging compatibility, and user acceptability, subject to appropriate safety requirements. As the formulations have not yet been experimentally validated, product performance and commercial feasibility remain to be established. The innovation has the potential to diversify goat milk utilization beyond conventional dairy products, create additional value for livestock producers, and support entrepreneurship at the intersection of livestock production and the cosmetics industry. This research may also provide a foundation for future investigations into the potential role of goat milk-derived bioactive ingredients in protecting lip tissue against oxidative stress and UV-induced damage associated with lip cancer, although any cancer-preventive effects must be established through rigorous scientific testing. Further laboratory validation, regulatory assessment, and economic evaluation are required to determine its suitability for commercialization.

Keywords: Goat Milk; Bioactive Ingredients; Lip Balm; Lipstick; Cosmetic Formulation; Product Innovation; Sustainable Entrepreneurship

Field: Cosmetic Science; Formulation Technology; Biotechnology; Natural Product Development; Agricultural and Livestock Product Diversification; Sustainable Entrepreneurship; Applied Research; Product Innovation

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INTRODUCTION

The cosmetics industry is increasingly shifting toward natural, sustainable, and value-added ingredients that combine functionality with environmental responsibility (Rocca et al., 2022). Consumers are becoming more interested in beauty products that offer moisturizing properties while incorporating naturally derived ingredients. This trend creates opportunities for agricultural and livestock-based resources to be transformed into innovative cosmetic products with higher economic value (Premi et al., 2026). One promising resource is goat milk, which contains proteins, lipids, vitamins, and other components that may contribute to skin conditioning and moisturizing formulations.

Bioactive Goat Milk Innovation for Lipstick and Lip Balm explore the potential of goat milk as a value-added ingredient in lip care products. By integrating goat milk-derived ingredients with cosmetic-grade oils, butters, waxes, and approved pigments, this innovation aims to develop lipstick and lip balm formulations that combine functional performance, product differentiation, and natural ingredient appeal. Unlike conventional

lip care products that primarily compete through color, texture, or branding, goat milk-based formulations offer an opportunity to establish a distinctive product identity linked to livestock-based bioresources and sustainable product development.

The disruptive potential of this innovation lies in connecting the livestock sector with the cosmetics industry through a new approach to agricultural and animal-derived resource utilization (Chatrabhuij et al., 2025). It creates opportunities for goat milk producers and small and medium-sized enterprises to diversify their revenue streams beyond fresh milk and conventional dairy products (Madududu et al., 2024). Furthermore, the initiative supports value-added processing, local entrepreneurship, and the development of innovative products that can serve emerging natural beauty markets.

To achieve commercial viability, the formulations must undergo systematic evaluation of stability, microbiological quality, ingredient compatibility, and consumer acceptability. Particular attention must be given to the safe incorporation of goat milk-derived ingredients, as well as compliance with applicable cosmetic regulations. Through formulation research, product testing, and scalable manufacturing strategies, this innovation has the potential to transform goat milk into a differentiated cosmetic ingredient and create new economic opportunities at the intersection of sustainable livestock production and the beauty industry.

LITERATURE REVIEW

Goat Milk as a Source of Bioactive Compounds

Goat milk has attracted increasing scientific interest because of its nutritional composition and potential applications in functional products, nutraceuticals, and cosmetics. It contains proteins, lipids, fatty acids, oligosaccharides, vitamins, and minerals that contribute to its biological and physicochemical properties. (dos Santos et al., 2023) reviewed goat milk as a natural source of bioactive compounds, highlighting the importance of bioactive peptides, phospholipids, and short- and medium-chain fatty acids. These components provide a scientific basis for investigating goat milk as a value-added raw material beyond conventional dairy applications (Suhardjo et al., 2026).

Furthermore, (Ncube et al., 2025) discussed the potential cosmetic and health applications of goat milk, including the possible moisturizing, antioxidant, antimicrobial, and anti-inflammatory activities associated with certain milk components. However, the presence of bioactive compounds does not automatically demonstrate that a finished cosmetic product will deliver measurable benefits. Their effectiveness depends on processing conditions, ingredient concentration, formulation compatibility, and stability. Therefore, the development of goat milk-based lip care products requires experimental validation rather than relying exclusively on the nutritional properties of the raw material.

Milk Proteins and Their Potential in Cosmetic Applications

Milk proteins have been investigated for their functional and biological properties in cosmetic and dermatological applications. (Kazimierska & Kalinowska-Lis, 2021) reviewed milk proteins, including casein, alpha-lactalbumin, beta-lactoglobulin, lactoferrin, and lysozyme, describing their biological activities and potential uses in skin care. Certain milk proteins and their derivatives have been associated with antioxidant, antimicrobial, and skin-conditioning functions.

In goat milk-based cosmetics, these proteins may provide an additional functional dimension to product development (Junaedi et al., 2024). Nevertheless, protein functionality can change during processing, drying, heating, and storage. The stability of proteins in a wax-and-oil-based lip balm or lipstick must therefore be assessed. A suitable ingredient form, such as a cosmetic-grade milk powder or standardized milk-derived ingredient, may facilitate formulation development. Claims regarding specific skin benefits should only be made when supported by appropriate evidence from the finished product.

Lip Balm Formulation and Moisturizing Function

Lip balm is a topical cosmetic product primarily designed to condition the lips and reduce moisture loss. Its formulation commonly combines waxes, oils, and butters to establish the required consistency, spreadability, and protective properties. Waxes contribute structural integrity, while oils and butters provide emollient characteristics and improve application. Formulation balance is essential because excessive wax can produce a hard texture, whereas excessive oil may cause softness, greasiness, or poor product stability.

Research on lip balm formulation has also emphasized the importance of evaluating microbiological quality and physical stability. For example, the study published in *Research, Society and Development* (2020) investigated lip moisturizers containing cinnamon-derived ingredients and assessed microbiological safety and

accelerated and extended stability. Although this study did not investigate goat milk, it demonstrates the relevance of product-specific testing when developing innovative lip care formulations.

For goat milk lip balm, the main technical challenge is the compatibility of milk-derived ingredients with the predominantly lipid-based formulation. Liquid milk introduces water and may require an emulsion system, appropriate preservation, and additional stability controls. A dried milk-derived ingredient may simplify formulation, but it does not eliminate the need for microbiological, stability, and safety assessments. Accordingly, the formulation should be optimized for consistency, spreadability, odor, appearance, and product integrity during storage.

Goat Milk-Based Lipstick and Cosmetic Innovation

Lipstick differs from lip balm because it must provide both lip conditioning and decorative color. Its formulation generally includes waxes, oils, emollients, and approved pigments, with their proportions determining hardness, color intensity, application, and wear performance. Introducing goat milk-derived ingredients into lipstick creates an opportunity to differentiate the product through its ingredient origin and connection to livestock-based bioresources.

The use of milk-derived ingredients in cosmetics is supported by broader literature on milk proteins and their potential dermatological applications (Kazimierska & Kalinowska-Lis, 2021). However, evidence from skin creams, soaps, or other cosmetic preparations cannot automatically be transferred to lipsticks. Lipstick formulations have distinct requirements concerning pigment dispersion, thermal stability, texture, color consistency, and incidental oral exposure during normal use.

Consequently, goat milk lipstick development should investigate the effect of milk-derived ingredient concentration on product hardness, melting behavior, color uniformity, spreadability, and storage stability. Only pigments and other ingredients permitted for the intended cosmetic use should be selected. The resulting formulation must demonstrate acceptable performance and safety before commercial application.

Sustainable Value Addition and the Circular Bioeconomy

The development of goat milk-based cosmetics represents a potential diversification strategy for livestock enterprises (Jahrizal et al., 2025). Conventional dairy businesses primarily generate revenue through fresh milk and processed dairy products. Converting suitable milk-derived ingredients into cosmetic products may open additional market opportunities and increase the value obtained from the livestock production chain.

The review by *Therapeutic Effect of Goat Milk and Its Value-Addition: Current Status and Way Forward* (2024) highlights the broader potential for value addition to goat milk through applications beyond conventional consumption. Extending this approach to cosmetics could connect livestock production, ingredient processing, formulation research, and consumer product manufacturing.

From a circular bioeconomy perspective, the opportunity lies in developing additional products from responsibly sourced and quality-controlled milk ingredients while improving resource utilization. However, the environmental benefits should not be assumed automatically. They depend on the energy required for processing and drying, packaging materials, transportation, production waste, and the sourcing of other ingredients. A future sustainability assessment could compare the environmental footprint of the proposed products with that of conventional lip care alternatives.

Product Safety, Quality, and Regulatory Requirements

Product safety is a central requirement for the development of goat milk-based lipstick and lip balm. Since milk is a biological material, the selection and processing of the ingredient must address microbial contamination, compositional variability, and storage stability. Products intended for application to the lips also require careful evaluation of ingredient suitability for the intended use.

ISO 17516:2014 provides guidance on microbiological limits for cosmetic products, while ISO 22716:2007 establishes guidelines for good manufacturing practices covering cosmetic production, quality control, storage, and shipment. These standards provide useful reference points for designing a quality assurance framework. Applicable Indonesian cosmetic requirements, including BPOM provisions on product safety, ingredient restrictions, manufacturing, and notification, must also be considered before commercialization.

Product development should therefore include physical stability testing, microbiological evaluation, packaging compatibility, and a safety assessment appropriate to the final formulation. Where relevant, testing should examine changes in odor, color, texture, melting behavior, and product integrity under different storage conditions. Any claims relating to moisturizing, antioxidant, or other functional effects should be proportionate to the evidence obtained from the actual formulation.

Research Gap and Novelty

Existing literature establishes that goat milk contains bioactive compounds with potential value in cosmetic and dermatological applications. Research also provides a foundation for understanding milk proteins, lipids, and the formulation principles governing lip balms and lipsticks (Couceiro et al., 2025). Nevertheless, these bodies of literature do not, by themselves, establish the effectiveness or commercial readiness of a specific goat milk-based lip care product (Renaldo, Jahrizal, et al., 2026).

A key research opportunity is the integration of goat milk-derived ingredients into two distinct cosmetic formats: a moisturizing lip balm and a color-producing lipstick. The development process must determine whether the selected ingredients can be incorporated without compromising product stability, sensory properties, color performance, or safety.

The proposed innovation, *Bioactive Goat Milk Innovation for Lipstick and Lip Balm*, addresses this opportunity by combining livestock-based bioresources with cosmetic formulation and value-added product development. Its potential novelty lies in the formulation approach, the selection and standardization of milk-derived ingredients, the evaluation of product performance, and the integration of these products into a diversified goat milk value chain (Renaldo, Junaedi, et al., 2026). The innovation should not be considered scientifically validated until the formulations have been developed and tested.

The proposed research can be organized around four objectives: (1) identifying suitable goat milk-derived ingredients for lip care applications; (2) developing and optimizing lip balm and lipstick formulations; (3) evaluating their physical stability, microbiological quality, safety, and user acceptability; and (4) assessing their potential for scalable production and commercial value addition. These objectives establish a practical foundation for translating goat milk bioresources into differentiated cosmetic products.

METHODOLOGY

3.1. Research Design

This study employs an experimental research design to develop and validate goat milk-based lip balm and lipstick formulations (Junaedi et al., 2026). The research consists of raw material preparation, formulation development, product manufacturing, quality evaluation, stability testing, and preliminary commercialization assessment (Totaro et al., 2026).

The experimental approach aims to determine whether goat milk-derived ingredients can be incorporated into lip care products while maintaining acceptable physical characteristics, product stability, microbiological quality, and user acceptability. Two products will be developed: goat milk lip balm, intended primarily for lip conditioning, and goat milk lipstick, intended to combine lip conditioning with decorative color (Nyoto et al., 2026).

The research will be conducted in a cosmetics formulation laboratory using cosmetic-grade ingredients, standardized procedures, and appropriate quality control methods.

3.2. Materials and Equipment

The primary material will be standardized, cosmetic-suitable goat milk powder obtained from a traceable supplier. Fresh goat milk may be used for preliminary ingredient characterization, but it will not be added directly to the initial anhydrous prototypes.

Other materials will include beeswax, candelilla wax, carnauba wax, shea butter, cocoa butter, castor oil, jojoba oil, vitamin E, and approved lip-safe pigments. The specific ingredient grades and permitted uses will be documented before formulation.

Equipment will include an analytical balance, temperature-controlled heating equipment, stainless-steel mixing vessels, a thermometer, spatulas, a homogenizing or milling device suitable for the formulation, lipstick molds, lip balm containers, and laboratory instruments for stability and microbiological testing.

3.3. Preparation of Goat Milk Ingredients

Goat milk will be sourced from a supplier capable of providing documented quality and traceability. The ingredient will be evaluated for appearance, odor, moisture content, storage conditions, and relevant microbiological specifications.

A standardized goat milk powder suitable for the intended cosmetic application will be selected to reduce the formulation challenges associated with liquid milk. The powder will be stored according to supplier recommendations and protected from moisture and contamination.

Before incorporation, the powder will be inspected for visible particles and agglomeration. Where necessary, a suitable particle-size reduction or dispersion procedure will be used. The material will not be assumed to be sterile merely because it is powdered.

3.4. Formulation Development

Two prototype formulations will be prepared. The following compositions are proposed as initial experimental starting points and must be optimized through laboratory testing.

A. Goat Milk Lip Balm

Ingredient	Function	Concentration (% w/w)
Beeswax	Structure and consistency	18.0
Candelilla wax	Hardness and texture	4.0
Shea butter	Emollient	20.0
Cocoa butter	Emollient and structure	15.0
Castor oil	Emollient and powder dispersion	25.0
Jojoba oil	Emollient	16.0
Goat milk powder	Characteristic milk-derived ingredient	1.5
Vitamin E	Antioxidant for the oil phase	0.5
Total		100.0

B. Goat Milk Lipstick

Ingredient	Function	Concentration (% w/w)
Beeswax	Structure and consistency	12.0
Candelilla wax	Hardness and texture	5.0
Carnauba wax	Hardness and heat resistance	3.0
Castor oil	Emollient and pigment dispersion	30.0
Jojoba oil	Emollient	10.0
Shea butter	Emollient	12.0
Cocoa butter	Emollient and structure	10.0
Approved lip-safe pigments	Color	15.0
Goat milk powder	Characteristic milk-derived ingredient	1.0
Vitamin E	Antioxidant for the oil phase	0.5
Formulation adjustment oil	Optimization of texture and processing	1.5
Total		100.0

All percentages are expressed as weight percentages. The formulation adjustment oil should be selected from the existing compatible oil phase, such as castor oil, and the final composition recalculated accordingly. The pigment blend must consist only of colorants permitted for the intended cosmetic application and exposure.

These formulations are not ready-to-market recipes. In particular, milk powder may introduce moisture, disperse unevenly, or affect product texture. The concentrations and manufacturing parameters will therefore be adjusted according to laboratory results.

3.5. Manufacturing Procedure

3.5.1. Preparation of Goat Milk Lip Balm

First, the required quantities of beeswax, candelilla wax, shea butter, cocoa butter, castor oil, and jojoba oil will be weighed using an analytical balance.

Second, the waxes and butters will be heated in a temperature-controlled vessel until fully melted. The mixture will be stirred continuously to obtain a uniform oil phase while avoiding unnecessary overheating.

Third, the goat milk powder will be evaluated for compatibility and moisture content. A small portion of the castor oil will be used to prepare a smooth preliminary dispersion of the powder. If the powder cannot be dispersed uniformly or its moisture characteristics are unsuitable, the formulation will be revised rather than proceeding with an unstable batch.

Fourth, the powder dispersion will be incorporated into the melted base under controlled mixing. The mixture will be maintained at a temperature that allows pouring while minimizing unnecessary thermal exposure of the milk-derived ingredient. Vitamin E will be added according to the ingredient supplier's recommended processing conditions.

Fifth, the mixture will be stirred until visually uniform and poured into clean, suitable lip balm containers. The containers will be allowed to cool under controlled conditions before being closed and labeled with the formulation code, batch number, and manufacturing date.

3.5.2. Preparation of Goat Milk Lipstick

First, the waxes, butters, and oils will be weighed separately. The waxes and butters will be melted under controlled heating and combined with the liquid oils.

Second, the approved pigments will be dispersed in a suitable portion of castor oil. A suitable milling or homogenizing process will be used to reduce visible pigment agglomerates and improve color uniformity.

Third, the goat milk powder will be evaluated for compatibility with the lipstick base. The powder will be incorporated as a controlled dispersion only if acceptable homogeneity and moisture specifications can be achieved. Vitamin E will be added under the recommended processing conditions.

Fourth, the pigment dispersion and remaining ingredients will be combined with the melted base. The mixture will be stirred thoroughly, with temperature and mixing speed controlled to minimize air incorporation and prevent premature solidification.

Fifth, the mixture will be poured into appropriate lipstick molds, cooled under controlled conditions, and transferred into suitable lipstick containers. Each batch will be inspected for surface defects, color consistency, structural integrity, and ease of application.

For both products, the actual manufacturing temperature, mixing duration, and cooling conditions will be recorded during preliminary trials and standardized once a reproducible process has been established.

3.6. Experimental Treatments and Replication

The formulations will be prepared in independent batches to assess reproducibility. A minimum of three independently manufactured batches per selected formulation is proposed for preliminary development.

Where resources permit, a control formulation without goat milk powder will be prepared using the same base ingredients and manufacturing procedure (Meriaux et al., 2025). The control will allow the influence of the milk-derived ingredient on texture, appearance, stability, and application characteristics to be evaluated.

The study may also compare different goat milk powder concentrations. The final concentrations will be selected based on ingredient compatibility, product performance, and preliminary safety assessment rather than assuming that a higher concentration necessarily produces greater benefits.

3.7. Product Validation and Quality Evaluation

3.7.1. Organoleptic Evaluation

Each prototype will be evaluated for appearance, color, odor, texture, and visible homogeneity. The lip balm will be examined for graininess, oil separation, and surface defects. The lipstick will be assessed for color uniformity, smoothness, surface cracking, and structural integrity. Observations will be documented using standardized evaluation sheets and photographic records.

3.7.2. Physical and Performance Testing

The lip balm will be evaluated for consistency, spreadability, ease of application, and resistance to deformation during normal handling.

The lipstick will be assessed for hardness, application smoothness, color transfer, breakage resistance, and uniformity of the applied color. Appropriate instrumental or standardized laboratory methods will be selected for each property.

Where relevant, melting or softening behavior will be measured using a method suitable for the formulation. The results will be compared with the control formulation and the predetermined product specifications.

3.7.3. Homogeneity and Ingredient Compatibility

The products will be inspected for visible particles, agglomeration, sedimentation, oil bleeding, and other evidence of incompatibility. Microscopic examination or particle-size assessment may be used where appropriate.

For lipstick, particular attention will be given to pigment dispersion and the possibility that milk powder may interfere with color consistency. For lip balm, the study will assess whether the milk-derived ingredient affects texture, spreadability, or the integrity of the wax-and-oil structure.

3.7.4. Microbiological Quality and Safety

Microbiological testing will be performed by a qualified laboratory using methods appropriate to the product category and applicable cosmetic standards, including ISO 17516 where relevant. The evaluation will consider total microbial counts and specified microorganisms according to applicable requirements.

Because the prototypes are predominantly anhydrous, their water activity and moisture characteristics will also be investigated. Low water activity may reduce microbial growth potential, but it does not demonstrate that a product is free from contamination or that preservation is unnecessary. The need for a preservation system will be determined through a documented risk assessment and appropriate testing.

Ingredient safety, foreseeable incidental ingestion during normal lip use, packaging compatibility, and applicable regulatory requirements will also be considered. No prototype will be distributed for consumer use before adequate safety and quality requirements have been satisfied.

3.7.5. Stability Testing

Stability testing will be conducted to investigate changes in product quality during storage. Samples will be stored under defined conditions appropriate to the intended packaging and product type.

The proposed preliminary assessment will include:

- Room-temperature storage under controlled conditions.
- Elevated-temperature storage to assess potential heat-related changes.
- Temperature cycling, where appropriate, to investigate physical instability.
- Centrifugation or other suitable accelerated screening methods, where technically applicable.

Samples will be examined at predetermined intervals for changes in color, odor, texture, homogeneity, hardness, oil separation, and packaging integrity. Microbiological testing will be performed at appropriate stages based on the risk assessment.

Accelerated testing can identify potential formulation weaknesses, but it does not automatically establish a commercial shelf life. Shelf-life claims will require adequate supporting data from an appropriate stability program.

3.7.6. User Acceptability

After preliminary laboratory quality and safety requirements have been met, a structured user-acceptability assessment may be conducted under an appropriate ethical and safety protocol.

Participants may evaluate texture, ease of application, appearance, color preference, odor, and overall product acceptability using a predefined rating scale. Participation will be voluntary, and relevant consent and exclusion criteria will be established.

The assessment will not be used as a substitute for laboratory safety testing or as evidence of clinical efficacy.

3.8. Data Analysis

Quantitative results will be summarized using means, standard deviations, and relevant descriptive statistics. Results from the experimental formulations will be compared with the control formulation where available.

If multiple concentrations are tested, an appropriate statistical method, such as analysis of variance, may be applied after checking the relevant assumptions. Non-parametric alternatives will be considered when the data do not satisfy those assumptions.

Qualitative observations will be analyzed descriptively to identify recurring formulation problems, including poor dispersion, inconsistent color, excessive hardness, or physical instability. The results will guide subsequent optimization of the formulations.

3.9. Formulation Optimization and Acceptance Criteria

The most promising formulation will be selected using predefined criteria covering physical appearance, homogeneity, application performance, microbiological quality, stability, and packaging compatibility.

Formulations that exhibit unacceptable contamination, instability, ingredient incompatibility, or safety concerns will be rejected or reformulated. The final prototype will be considered successfully developed only when it meets the established laboratory specifications and the applicable safety requirements.

The selected formulation will then be documented in a standardized manufacturing procedure, including ingredient specifications, processing parameters, batch records, quality control checkpoints, and packaging requirements.

3.10. Research Workflow

The overall research process will follow these stages:

1. Selection and characterization of goat milk-derived ingredients.
2. Development of initial lip balm and lipstick formulations.
3. Preparation of control formulations and experimental batches.
4. Laboratory evaluation of physical properties and product performance.
5. Microbiological, safety, and stability assessment.
6. Optimization based on experimental findings.
7. User-acceptability assessment, where appropriate.
8. Finalization of the formulation, manufacturing procedure, and commercialization recommendations.

This methodology is intended to establish a reproducible experimental foundation for transforming goat milk-derived ingredients into innovative lip care products. The findings will determine whether the proposed formulations can progress from laboratory prototypes toward further product development and regulatory evaluation.

RESULTS AND DISCUSSION

4.1. Potential Development of Goat Milk-Based Lip Care Products

The proposed research establishes a potential pathway for transforming goat milk into value-added cosmetic products, specifically lip balm and lipstick. The formulation concept combines goat milk-derived ingredients with waxes, oils, butters, and, in the case of lipstick, approved cosmetic pigments (Renaldo, Musa, et al., 2026). This approach represents a potential diversification of goat milk utilization beyond conventional dairy products.

Goat milk contains proteins, lipids, and other compounds that have attracted scientific interest because of their potential biological and functional properties (dos Santos et al., 2023). Milk proteins have also been investigated for their possible applications in cosmetics and dermatology (Kazimierska & Kalinowska-Lis, 2021). These findings provide a scientific rationale for investigating goat milk-derived ingredients in lip care

products. Nevertheless, the presence of potentially beneficial compounds in raw milk does not establish the efficacy of a finished lipstick or lip balm. Such benefits must be evaluated in the final formulation.

The proposed products offer different functional objectives. Lip balm is intended primarily to condition the lips and help reduce moisture loss, whereas lipstick must provide consistent color, acceptable texture, and suitable application performance in addition to lip conditioning. Therefore, the two formulations require separate optimization and validation procedures.

4.2. Formulation Characteristics of Goat Milk Lip Balm

The proposed lip balm formulation consists of waxes, emollient oils, butters, goat milk powder, and vitamin E (Renaldo et al., 2025). The waxes provide structure and help maintain the product's shape, while the oils and butters contribute to spreadability and a smooth application. The goat milk-derived ingredient provides the product's distinguishing feature and creates an opportunity for further investigation of milk-based cosmetic formulations.

The principal formulation challenge is achieving a homogeneous and physically stable product. Goat milk powder may introduce moisture, agglomerate, or disperse unevenly within an oil-based formulation. These characteristics may affect the product's texture, appearance, and storage stability. Accordingly, ingredient compatibility must be assessed before the formulation is considered successful.

A suitable prototype should demonstrate uniform appearance, acceptable consistency, ease of application, and no unacceptable evidence of oil separation or grain formation. Comparative testing against a control lip balm without goat milk powder would help establish whether the inclusion of the milk-derived ingredient changes these properties.

The moisturizing performance of the final product should also be assessed using an appropriate method. The presence of oils and butters can support an emollient and protective function, but specific claims regarding improved hydration or other biological effects should not be made without relevant experimental evidence.

4.3. Formulation Characteristics of Goat Milk Lipstick

The proposed goat milk lipstick formulation incorporates waxes, oils, butters, pigments, and goat milk powder. Compared with lip balm, lipstick requires more stringent control of color uniformity, hardness, structural integrity, and application characteristics.

Castor oil can serve as a liquid medium for dispersing suitable pigments, while waxes and butters contribute to the structure of the finished product. The addition of goat milk powder introduces a formulation variable that may influence the appearance, texture, and physical stability of the lipstick. Therefore, the powder concentration and dispersion procedure should be optimized alongside the wax-to-oil ratio and pigment composition.

A successful formulation should exhibit consistent color, a smooth surface, suitable hardness, and uniform transfer during application. Potential defects include pigment agglomeration, excessive hardness, breakage, surface cracking, and changes in texture during storage. These properties must be examined experimentally rather than assumed from the ingredient composition.

The lipstick's performance will depend on the interactions among all formulation components. Consequently, goat milk powder should be considered one component of a multivariable formulation system rather than an ingredient that automatically improves product quality.

4.4. Comparative Product Evaluation

The proposed evaluation framework distinguishes the principal requirements of lip balm and lipstick.

Evaluation parameter	Goat milk lip balm	Goat milk lipstick
Appearance and homogeneity	Uniform texture and appearance	Uniform color and pigment dispersion
Consistency	Suitable softness and spreadability	Suitable hardness and structural integrity
Application performance	Smooth application and comfortable feel	Smooth application and consistent color transfer

Evaluation parameter	Goat milk lip balm	Goat milk lipstick
Physical stability	No unacceptable oil separation or grain formation	No unacceptable cracking, bleeding, or deformation
Microbiological quality	Compliance with applicable specifications	Compliance with applicable specifications
Packaging compatibility	No leakage or container deterioration	No deformation or incompatibility with the lipstick mechanism
User acceptability	Texture, odor, and comfort	Texture, color, odor, and comfort

This comparison highlights the need for product-specific quality criteria. Although both products use a similar foundation of waxes and oils, their functional requirements differ. A formulation suitable for lip balm may not provide the hardness, pigment dispersion, or color performance required for lipstick.

4.5. Stability, Microbiological Quality, and Product Safety

Stability and microbiological quality are critical considerations because goat milk is a biological raw material. Even when a dried milk-derived ingredient is used, its initial microbiological quality, residual moisture, processing history, and storage conditions may affect the finished product.

The predominantly oil-based nature of the proposed formulations may limit the availability of water for microbial growth. However, an anhydrous formulation cannot automatically be considered microbiologically safe. Contamination may be introduced through raw materials, equipment, manufacturing practices, or packaging. The formulation's moisture characteristics and water activity should therefore be assessed where appropriate.

Stability testing should investigate changes in appearance, odor, texture, hardness, and packaging integrity under defined storage conditions. Microbiological evaluation should follow applicable cosmetic standards and the product's risk assessment. ISO 17516 provides a reference for microbiological limits, while ISO 22716 provides guidance on good manufacturing practices for cosmetics.

The results of these assessments will determine whether the formulation requires modification, additional preservation measures, or changes to the manufacturing procedure. Commercial readiness should only be considered after appropriate quality, safety, stability, and regulatory requirements have been met.

4.6. Innovation and Disruptive Potential

The proposed innovation offers a potential connection between livestock production and the cosmetics industry. Traditional goat milk enterprises primarily focus on fresh milk and dairy-based products. Developing lip balm and lipstick may create additional product categories and new opportunities for value addition.

The innovation's potential disruptive characteristic lies in the integration of a locally sourced animal-derived ingredient into a specialized consumer product category (Montoya et al., 2024). Rather than relying exclusively on conventional dairy markets, producers could explore opportunities in natural-ingredient cosmetics, subject to product performance, safety, consumer demand, and applicable regulations.

The concept may also create opportunities for collaboration among goat milk producers, cosmetic formulators, research institutions, and manufacturing partners. Such collaboration could support ingredient standardization, formulation development, product testing, and market introduction.

However, commercial success will depend on more than the novelty of the ingredient. Production costs, raw material consistency, packaging, regulatory compliance, consumer acceptance, and the ability to demonstrate meaningful product differentiation will all influence market potential.

4.7. Limitations and Future Research

The principal limitation of the present development stage is the absence of experimental results from manufactured and validated prototypes. The proposed formulations are starting compositions that require laboratory optimization. Their physical stability, microbiological quality, application performance, and safety have not yet been established.

Future research should investigate different concentrations and suitable forms of goat milk-derived ingredients, compare experimental products with control formulations, and quantify their effects on texture, stability, and application performance. Where moisturizing or other functional benefits are claimed, appropriate testing should be conducted using validated methods.

Further work should also examine production feasibility, raw material standardization, packaging selection, cost of goods, and consumer preferences. A subsequent sustainability assessment could determine whether the proposed products offer measurable environmental or economic advantages over relevant alternatives.

4.8. Summary of Discussion

The proposed goat milk lip balm and lipstick represent a promising concept for value-added utilization of goat milk-derived ingredients. Existing literature supports investigating milk proteins and other milk components in cosmetic applications, while established formulation principles provide a basis for developing the two products.

Nevertheless, the innovation's success will depend on demonstrating that goat milk-derived ingredients can be incorporated without compromising formulation stability, microbiological quality, safety, and user acceptability. Experimental validation is therefore the essential next step before claims of product efficacy, commercial readiness, or disruptive market impact can be substantiated.





CONCLUSION

Conclusion

The development of bioactive goat milk-based lipstick and lip balm represents a potential innovation in the value-added utilization of goat milk. By incorporating goat milk-derived ingredients into cosmetic formulations, this concept aims to connect livestock production with the beauty and personal care industry. The proposed lip balm focuses on lip conditioning and moisture protection, while the lipstick combines lip conditioning with decorative color.

The innovation offers an opportunity to diversify goat milk applications beyond conventional dairy products and develop differentiated cosmetics using locally sourced bioresources. However, the successful development of these products depends on appropriate ingredient selection, formulation optimization, physical stability, microbiological quality, and safety validation. Since the proposed formulations have not yet been experimentally validated, their performance and commercial readiness cannot be conclusively established.

Overall, goat milk-based lip care products offer a promising direction for applied research and product innovation. Further laboratory testing and commercialization studies are necessary to determine their feasibility and potential contribution to sustainable livestock-based entrepreneurship.

Implications

Economic Implications

The proposed innovation may create additional revenue opportunities for goat milk producers by expanding the range of products derived from goat milk. Developing cosmetic ingredients and finished lip care products could support product diversification, improve value addition, and create opportunities for small and medium-sized enterprises.

Technological Implications

The project encourages collaboration between dairy processing and cosmetic formulation technologies. Standardized ingredient preparation, controlled mixing, quality assurance, and stability testing will be essential to achieving reproducible product quality. These processes may also strengthen local capabilities in applied research and cosmetic product development.

Social and Entrepreneurial Implications

The innovation could support local entrepreneurship by connecting livestock farmers, research institutions, cosmetic manufacturers, and marketing partners. It may also create opportunities for skills development in product formulation, quality management, packaging, and commercialization.

Environmental Implications

Diversifying goat milk applications may contribute to more efficient resource utilization. Nevertheless, environmental benefits will depend on the sourcing and processing of ingredients, energy consumption, packaging, transportation, and production waste. A lifecycle assessment would be required to substantiate claims of environmental sustainability.

Health Research Implications

The development of bioactive goat milk-based lipstick and lip balm has potential implications for skin and lip care, particularly in exploring naturally derived ingredients for protective cosmetic formulations. Goat milk contains proteins, lipids, vitamins, and other bioactive compounds that may contribute to skin conditioning and antioxidant-related functions. Combined with appropriate oils, butters, and other cosmetic ingredients, these formulations could support lip moisturization and help maintain the skin barrier. In the longer term, this research may provide a foundation for investigating whether goat milk-derived ingredients, together with scientifically validated UV-protective components, can contribute to strategies for reducing UV-related damage to the lips, a potential risk factor for lip cancer. However, goat milk itself has not been established as an anticancer agent, and the proposed products cannot be claimed to prevent or treat skin or lip cancer without specific laboratory, clinical, and regulatory evidence. Beyond potential skin-care applications, the innovation could diversify goat milk utilization, increase value addition for livestock producers, encourage sustainable product development, and create new entrepreneurial opportunities within the natural cosmetics industry.

Limitations

Several limitations must be considered during the development of goat milk-based lipstick and lip balm. First, the proposed formulations remain experimental starting compositions. Their physical properties, ingredient compatibility, and performance have not yet been confirmed through laboratory testing.

Second, goat milk contains biological components whose characteristics may vary depending on animal nutrition, lactation stage, processing, and storage. This variability may affect the consistency and quality of the ingredient used in cosmetic production.

Third, incorporating goat milk powder into predominantly oil-based formulations may present technical challenges, including uneven dispersion, grain formation, moisture-related instability, and changes in texture. These challenges require systematic formulation optimization.

Fourth, the proposed products have not yet demonstrated microbiological safety, shelf-life stability, or consumer acceptability. Appropriate testing and compliance with applicable cosmetic regulations are necessary before commercialization.

Finally, the economic and environmental advantages of the innovation remain prospective. Production costs, market demand, manufacturing capacity, and environmental impacts must be assessed before its commercial potential can be confirmed.

Recommendations

The following recommendations are proposed to support further development of the innovation.

1. Standardize raw materials. Use traceable goat milk-derived ingredients with documented specifications, appropriate microbiological quality, and controlled moisture characteristics.
2. Optimize formulations. Evaluate different concentrations of goat milk powder and adjust the wax, oil, butter, and pigment composition to achieve suitable texture, stability, and application performance.
3. Establish quality control procedures. Develop standardized manufacturing instructions, batch records, ingredient specifications, and product acceptance criteria.
4. Conduct comprehensive validation. Perform physical stability testing, microbiological evaluation, packaging compatibility studies, and a documented safety assessment appropriate to the intended use.
5. Evaluate consumer acceptance. After preliminary safety requirements are met, assess preferences regarding texture, appearance, color, odor, and overall usability.
6. Assess commercial feasibility. Calculate raw material costs, manufacturing expenses, packaging costs, production capacity, and potential selling prices before selecting a commercialization strategy.

7. Ensure regulatory compliance. Consult the applicable Indonesian cosmetic requirements and work with qualified manufacturing partners where necessary. Commercial distribution should only proceed after the relevant safety, manufacturing, and product notification requirements have been satisfied.

Future Research

Future research should focus on transforming the proposed concept into a scientifically validated and commercially feasible cosmetic innovation. The first priority is to experimentally optimize the lip balm and lipstick formulations. Different concentrations and forms of goat milk-derived ingredients should be compared with control formulations that do not contain these ingredients. The influence of ingredient concentration on texture, homogeneity, hardness, pigment dispersion, and physical stability should be quantified.

Second, future studies should investigate the functional performance of the products using appropriate validated methods. For lip balm, research could examine moisture-related performance and skin-conditioning characteristics. For lipstick, studies could focus on color uniformity, application smoothness, structural integrity, and color retention. Any claims concerning antioxidant, antimicrobial, or other biological effects should be evaluated separately using methods relevant to the finished product.

Third, long-term and accelerated stability studies should be conducted to establish appropriate storage conditions and support future shelf-life determination. Microbiological testing, ingredient compatibility, and packaging performance should be evaluated throughout product development.

Fourth, consumer research should assess market preferences, acceptable price ranges, product positioning, and willingness to purchase goat milk-based cosmetics. Such research would help identify potential target markets and distinguish the products from conventional lip care alternatives.

Finally, future studies should investigate commercial-scale manufacturing, supply chain integration, and environmental performance. Collaboration between goat milk producers, cosmetic formulation laboratories, and qualified manufacturers could support pilot production and subsequent scale-up. A techno-economic assessment and lifecycle assessment would help determine whether the innovation offers measurable economic and environmental advantages.

Through these research directions, bioactive goat milk innovation for lipstick and lip balm could progress from an initial formulation concept toward a validated product platform that supports value-added livestock processing, cosmetic innovation, and sustainable entrepreneurship.

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