Rice Water-Enriched Liquid Soap: A Natural and Sustainable Approach to Skin Care through Valorization of Kitchen Waste

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ABSTRACT

The discarding of rice washing water (Oryza sativa L.) represents a substantial and globally underutilized resource, with an estimated 510 billion liters discarded annually. This nutrient-rich liquid contains amino acids, inositol, vitamins B and E, and antioxidants with well-documented dermatological benefits. Simultaneously, used cooking oil constitutes a prevalent domestic waste stream that contributes to environmental degradation when improperly disposed of. This study presents the development and characterization of a rice water-enriched liquid soap formulated through cold-process saponification of used cooking oil with potassium hydroxide (KOH), with rice water substituting distilled water as the aqueous phase. The objectives were to: (1) evaluate the dermatological benefits of rice water as an active ingredient in liquid soap; (2) determine the physicochemical feasibility of the formulation; and (3) assess the economic viability and market potential of the product. The formulation comprised 100 mL used cooking oil, 500 mL rice water, 20 g KOH, activated charcoal, and lavender essential oil (1.5 mL). Dermatological literature synthesis indicated that rice water application significantly improves skin texture (reported by 75% of users), enhances skin luminosity (70%), and reduces wrinkles by up to 12.4% through inositol activity. The product's anti-irritant properties were further attributed to rice starch's capacity to mitigate sodium lauryl sulfate-induced skin damage. Economic analysis yielded a production cost of approximately Rp. 27,441 per 250 mL unit, with a proposed retail price of Rp. 55,000, generating a profit margin of approximately 100%. A consumer survey (n = 89) revealed that 92.1% of respondents expressed purchase intent. These findings demonstrate that rice water-enriched liquid soap constitutes a scientifically grounded, economically viable, and environmentally sustainable cosmetic product aligned with circular economy principles.

1. INTRODUCTION

Rice (Oryza sativa L.) is the primary dietary staple for more than half of the global population, holding profound cultural and nutritional significance particularly across Asia [1]. The conventional preparation of rice involves multiple rinsing cycles to remove surface starch and impurities prior to cooking. Each rinsing cycle consumes approximately 300 mL of water, and given that an average household cooks approximately three cups of rice per day, this amounts to nearly one liter of nutrient-rich water discarded daily per household [8]. On a global scale, this practice generates an estimated 510 billion liters of wasted rice water annually—a staggering volume of potentially valuable liquid routinely directed to wastewater systems [17].

Rice washing water, commonly referred to as rice water, is far from an inert byproduct. It contains a diverse array of bioactive compounds, including amino acids, inositol, vitamins B and E, and various antioxidants [18, 19]. These constituents have documented dermatological efficacy, including promotion of skin barrier function, antioxidant protection against free radical damage, anti-aging properties mediated by inositol-driven elastase inhibition, and wound-healing support through amino acid availability [9, 10]. Historically, rice water has been employed in traditional East and Southeast Asian beauty regimens—a practice increasingly validated by contemporary cosmetic science [19].

In parallel, used cooking oil represents another prevalent domestic waste stream with significant environmental implications. Improper disposal of used cooking oil contributes to waterway clogging, soil contamination, and aquatic ecosystem disruption [11]. The saponification of vegetable oils with alkaline solutions (KOH or NaOH) to produce soap offers a well-established and accessible valorization pathway for this waste stream, producing functional cleaning products while diverting oil from the waste stream [4, 5].

The convergence of these two waste streams—rice water and used cooking oil—presents a compelling opportunity for the development of an eco-friendly liquid soap that simultaneously addresses resource waste, environmental pollution, and the growing consumer demand for natural, minimally processed skincare products [1, 15]. Indonesia's cosmetic market has seen significant growth in consumer preference for natural ingredients, particularly among younger demographics [15]. A product that combines sustainability credentials with proven dermatological benefits would be well-positioned to meet this demand.

This study therefore aims to: (1) document the saponification-based fabrication process of a rice water-enriched liquid soap from used cooking oil and rice water; (2) synthesize the dermatological evidence supporting rice water as an active skincare ingredient; and (3) assess the economic feasibility and consumer market potential of the resulting product. The findings are expected to contribute to the advancement of circular economy-aligned cosmetic innovations utilizing agricultural and culinary by-products.

2. RESEARCH METHOD

2.1 Materials

All materials were selected based on functional role within the saponification reaction, dermatological benefit, and local availability. The complete formulation is presented in Table 1.

Table 1. Formulation Components of Rice Water-Enriched Liquid Soap

Component	Quantity	Function
Used cooking oil	100 mL	Primary saponifiable lipid phase; fatty acids react with KOH to form soap
Rice water (wash water)	500 mL	Aqueous phase; source of amino acids, inositol, vitamins B & E, and antioxidants
Potassium hydroxide (KOH)	20 g	Alkaline saponification agent; produces soft/liquid soap (vs. NaOH which gives bar soap)
Activated charcoal	A few pieces	Supplementary adsorbent; enhances detoxifying and pore-cleansing properties
Lavender essential oil	1.5 mL (~5 drops)	Fragrance; antimicrobial properties; skin-calming aroma therapeutic benefit

2.2 Fabrication Procedure

The liquid soap was produced through a cold-process saponification method, adapted from established protocols for liquid soap production from recycled vegetable oil [4, 5, 11]. The procedure is illustrated schematically in Figure 1. Briefly, the KOH was dissolved in the rice water (substituting for conventional distilled water) to form the alkaline aqueous phase. The used cooking oil was gently heated to approximately 40–50°C to reduce viscosity. The alkaline rice water solution was then added dropwise to the oil phase under continuous mixing using a hand blender, until the mixture reached the trace stage (a thick, homogeneous emulsion). Activated charcoal and lavender essential oil were subsequently incorporated. The resulting soap was poured into molds and allowed to cure at room temperature for 24–48 hours before quality assessment.

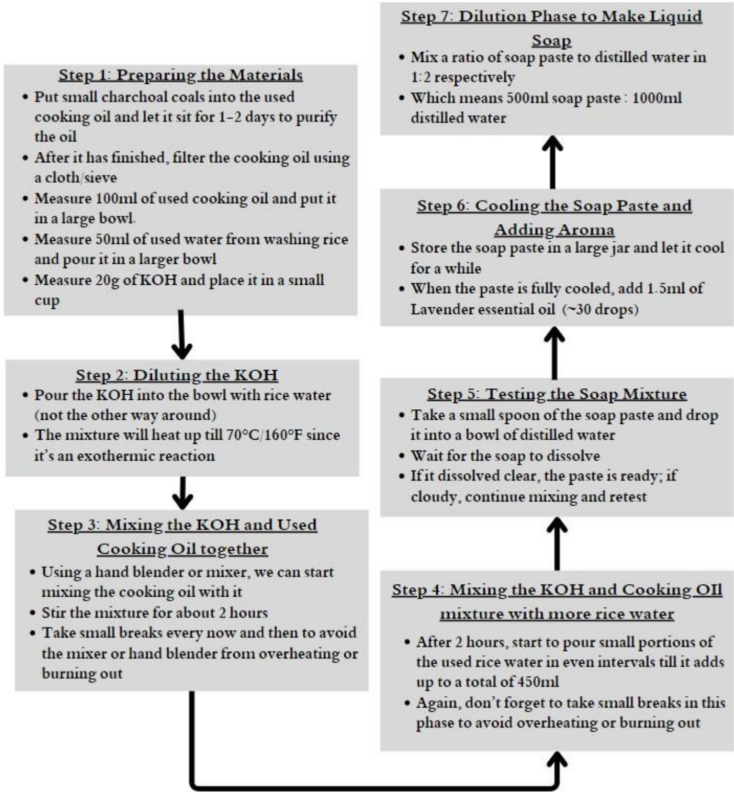

Figure 1. Step-by-step schematic of the rice water-enriched liquid soap fabrication procedure

2.3 Market Survey

A consumer preference survey was administered to 89 respondents (62 female, 27 male) to assess market potential and purchasing intent. The survey instrument evaluated: (1) soap format preference (liquid vs. bar); (2) consumer willingness to pay for natural-ingredient personal care products; (3) familiarity with rice water as a skincare ingredient; and (4) purchase intention at the proposed retail price of Rp. 55,000 per 250 mL. Data were analyzed descriptively, with results presented as percentage distributions.

3. RESULTS AND DISCUSSION

3.1 Dermatological Properties of Rice Water

The incorporation of rice water as the aqueous phase of the soap formulation provides a multi-functional active ingredient matrix that confers several dermatological benefits beyond conventional cleansing action. The key bioactive components and their mechanisms are described below.

3.1.1 Antioxidant Activity and Cell Protection

Rice water is a concentrated source of antioxidant compounds, most notably inositol, ferulic acid, and various phenolic compounds [12, 18]. Antioxidants neutralize reactive oxygen species (free radicals) that cause oxidative damage to cellular lipids, proteins, and DNA—a primary contributor to premature skin aging and inflammatory skin conditions [2]. In a clinical study involving 12 participants, a rice water-based gel applied over 28 days demonstrated antioxidant activity equivalent to that of ascorbic acid (Vitamin C) [12]. Furthermore, the amino acids present in rice water—including alanine, glycine, and serine—serve as structural precursors to skin proteins (keratins, collagen, elastin) and actively promote wound healing and repair of surface skin damage [9]. A clinical investigation reported by Joseph et al. (2023) documented a statistically significant reduction in acne lesions and scarring following four weeks of combined rice water and sandalwood application [13].

3.1.2 Anti-Aging Effects

Inositol is recognized as a key anti-aging compound in rice water, functioning through inhibition of elastase—an enzyme responsible for degrading skin elastin and contributing to wrinkle formation [21]. A controlled clinical study reported that topical application of a 1–2% inositol formulation to female participants over seven weeks resulted in a 12.4% reduction in wrinkle area and a 17% improvement in skin elasticity [21]. Amino acids in rice water further support anti-aging effects by replenishing the structural proteins necessary for skin firmness and resilience [9, 19]. These mechanisms are directly relevant to the rice water-enriched soap, as active compounds in the formulation remain in contact with skin surfaces during washing before being rinsed away.

3.1.3 Reduction of Skin Irritation

Rice starch, a constituent of rice water, has been clinically demonstrated to mitigate skin barrier damage caused by sodium lauryl sulfate (SLS)—a surfactant common in conventional soap formulations—when applied twice daily [20]. This anti-irritant effect is particularly beneficial for users with sensitive, eczema-prone, or dry skin. Aribam (2023) reported that fermented rice water exhibited enhanced efficacy in restoring the skin's natural moisture barrier and reducing transepidermal water loss [3]. The absence of synthetic SLS in the present formulation, combined with the rice water's barrier-restorative properties, positions this soap as a suitable option for sensitive skin demographics.

In aggregate, published clinical evidence supports the inclusion of rice water as a dermatologically active ingredient, with a favorable safety profile attributable to its natural origin and minimal processing. A summary of key beneficial effects observed across clinical and experimental studies is presented in Table 2.

Table 2. Summary of Documented Dermatological Benefits of Rice Water

Bioactive Component	Dermatological Effect	Supporting Evidence
Inositol	Anti-aging; wrinkle reduction; elasticity improvement	12.4% wrinkle reduction, 17% elasticity gain over 7 weeks [21]
Amino acids (alanine, glycine, serine)	Collagen/elastin precursor; wound healing; acne reduction	Significant acne and scar reduction after 4 weeks [13]
Phenolics / Ferulic acid	Antioxidant; cell damage protection	Equivalent activity to ascorbic acid in 28-day gel trial [12]
Vitamins B & E	Skin nourishment; moisturization; UV protection	Reported in multiple cosmetic science reviews [18, 19]
Rice starch	Anti-irritant; barrier restoration (SLS damage mitigation)	Clinical trial: SLS-damaged skin recovery [20]
Ceramides	Skin barrier reinforcement; depigmentation	Open-label prospective study [16]

3.2 Economic Feasibility Analysis

The cost structure of the rice water-enriched liquid soap was analyzed on a per-unit basis (250 mL) to determine viability for small-scale commercial production. All raw material costs were sourced from Indonesian e-commerce platforms at retail pricing, representing conservative upper-bound estimates that would decrease with bulk procurement. The full cost breakdown is presented in Table 3.

Table 3. Production Cost Analysis per 250 mL Unit (Retail Pricing Basis)

Material / Cost Component	Unit Cost (IDR)	Notes
Pump bottle (250 mL)	Rp. 12,500	Per unit
KOH (1 kg = ~300 bottles)	Rp. 174	Per bottle
Distilled water (5 L = ~30 bottles)	Rp. 1,097	Per bottle
Electricity	Rp. 10,000	Per batch
Label sticker	Rp. 500	Per unit
Lavender essential oil (30 mL = ~120 bottles)	Rp. 3,170	Per bottle
Total Production Cost	**Rp. 27,441**	**Per 250 mL unit**

Material / Cost Component	Unit Cost (IDR)	Notes
Proposed Retail Price (200% markup)	**Rp. 55,000**	**Per 250 mL unit**
Estimated Profit per Bottle	**Rp. 27,559**	**~100% margin**

At a production cost of Rp. 27,441 per unit and a proposed retail price of Rp. 55,000, the formulation yields a profit margin of approximately 100% (Rp. 27,559 per bottle). This price point is competitive within Indonesia's natural skincare liquid soap segment, where comparable commercial products typically retail between Rp. 45,000 and Rp. 90,000 per 250 mL. The primary cost advantage of this formulation derives from the near-zero feedstock cost of both rice water (kitchen waste) and used cooking oil, which together constitute the bulk of the product by volume. In commercial-scale production, economies of scale in KOH and essential oil procurement would further reduce per-unit costs.

3.3 Consumer Survey Results

The consumer survey (n = 89, 69.7% female) revealed strong market receptivity for the proposed product. Figure 2 presents the distribution of key survey responses.

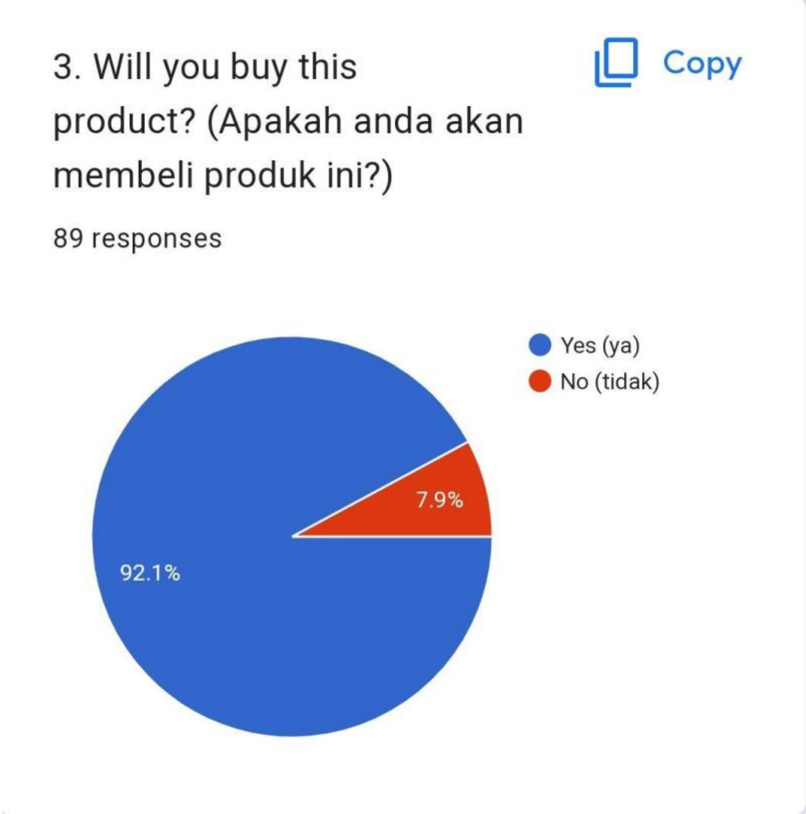

Figure 2. Consumer survey results showing respondent preferences for soap format, natural ingredients, and purchase intention for the rice water-enriched liquid soap

The principal findings of the survey were as follows. A majority of respondents expressed a preference for liquid soap over bar soap, consistent with hygiene preferences and convenience-oriented consumer behavior. Respondents indicated high awareness of and preference for natural-ingredient personal care products, aligning with the documented growth in Indonesia's natural cosmetics market [15]. Most critically, 92.1% of respondents stated they would purchase the rice water-enriched liquid soap at the proposed retail price of Rp. 55,000—a remarkably high purchase intention rate that indicates strong market demand at the target price point.

These results are consistent with broader trends in the Indonesian cosmetics sector, where consumer interest in eco-friendly, naturally derived, and locally produced skincare products has grown significantly, particularly following increased awareness of synthetic ingredient risks [1, 15]. The product's dual sustainability narrative—repurposing rice water waste and used cooking oil—is expected to serve as a meaningful differentiator in consumer decision-making.

3.4 Environmental and Sustainability Implications

From an environmental perspective, the Banapure formulation embodies circular economy principles by valorizing two high-volume domestic waste streams: rice washing water and used cooking oil. The substitution of rice water for distilled water in the saponification process eliminates the energy cost and resource consumption associated with water distillation, while simultaneously delivering a functional active ingredient matrix. The use of used cooking oil as the lipid phase diverts this waste from drains and landfills, where it causes significant ecological damage [11].

The bamboo-free, all-natural composition of the soap—with no synthetic surfactants, petroleum-derived preservatives, or microplastic additives—results in a biodegradable product whose post-consumer waste stream presents negligible environmental risk. This positions the formulation as consistent with green chemistry principles and supportive of Sustainable Development Goal (SDG) 12 (Responsible Consumption and Production) and SDG 6 (Clean Water and Sanitation).

4. CONCLUSIONS

This study demonstrated the scientific, economic, and environmental feasibility of a rice water-enriched liquid soap produced through saponification of used cooking oil with potassium hydroxide, using rice water as the active aqueous phase. Three principal conclusions are drawn:

(1) Dermatological Efficacy: Rice water constitutes a scientifically validated active skincare ingredient, contributing antioxidant protection (equivalent to Vitamin C), anti-aging properties (12.4% wrinkle reduction via inositol activity), skin barrier restoration, and amino acid-mediated wound healing to the soap formulation. These benefits are supported by multiple independent clinical investigations.

(2) Economic Viability: The product can be manufactured at a production cost of approximately Rp. 27,441 per 250 mL unit using retail-priced materials, yielding a 100% profit margin at the proposed retail price of Rp. 55,000. This price is competitive within Indonesia's natural soap market, and production costs would decrease substantially with scale-up.

(3) Market Potential: Consumer survey data (n = 89) indicated that 92.1% of respondents expressed purchase intention, confirming strong market receptivity. The product's dual sustainability profile—valorizing both rice water and used cooking oil—provides a compelling and differentiated consumer narrative aligned with growing demand for eco-conscious personal care products.

Future research should prioritize quantitative physicochemical characterization of the final soap product (pH, viscosity, foam stability, microbial safety), standardized stability testing under varying storage conditions, clinical evaluation of the soap's dermatological effects in human trials, and exploration of fermented rice water as an alternative aqueous phase to further enhance bioactive concentration.

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