Community-Based Development of Riceberry Extract-based Health Products: A Model for Sustainable Agriculture and Public Health

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KEYWORDS

Riceberry Extract, Cosmetic Products, Sunscreen, Matte Lipstick, Serums, Encapsulation

ABSTRACT:

This study investigates the development of health product prototypes using Riceberry extract for cosmetics, including matte lipstick, sunscreen, serum, and encapsulated products. The research assessed product retention, irritation, and efficacy through a series of tests involving raw material selection, extract preparation, and cell toxicity evaluations. The inhibition of melanin production in melanoma cells (B16F10) was also examined, followed by formula development and safety assessments. Toxicity testing showed that Riceberry extract and Kojic acid, at concentrations ranging from 0.0001 to 1 mg/ml, were non-toxic to melanoma cells, with survival rates of 96.29±2.59% and 97.39±1.38%, respectively. At 1 mg/ml, Riceberry extract reduced melanin production by 20.60±3.67% without affecting tyrosinase synthesis in melanoma cells. Among the sunscreen, peel-off mask, and encapsulation formulations, Formula 4 demonstrated the highest stability, maintaining a pH of 4.44 and showing no delamination under accelerated conditions. While some volunteers experienced mild irritation, statistical analysis revealed significant pH changes before and after freeze-thaw cycles. The study concluded that the products were stable, effective, and safe for use. Furthermore, the development of Riceberry extract-based health products holds potential for adding value, creating job opportunities, and supporting agricultural careers, particularly for rice farmers. Community engagement played a crucial role in the success of the product development process, with active public participation in the co-creation of prototypes.

1. Introduction

Rice has been a staple food for humanity from ancient times to the present. It is one of the fastest-growing food sources in Africa, while many countries in Latin America, the USA, and Australia have large rice-growing regions (Muthayya, Sugimoto, Montgomery, & Maberly, 2014). In Thailand and other Southeast Asian countries located in the Mekong River Basin, it serves not only as a primary

food source but also as a key economic crop, ranking among the top exports of each country (Nara, Mao, & Yen, 2014). For instance, the Mekong Delta, often referred to as the "Rice Bowl of Vietnam," is in the heart of the world's second-largest rice-producing nation (Le Coq, Trébuil, & Dufumier, 2004). Therefore, rice is critical to food security in many low-income, food-deficit nations (Kuenzer & Knauer, 2012).

Given its vital role in food security and the economy, rice cultivation has resulted in a wide diversity of rice species and varieties across the globe. As a crop that has been cultivated for thousands of years, rice belongs to the genus *Oryza* within the family *Gramineae*. Globally, rice species fall into three major groups: *Oryza sativa L.* (the most widely cultivated), *Oryza glaberrima S.* (African rice), and wild rice varieties (Nayar, 2014). In Thailand, rice is classified into three primary types based on morphology: *indica*, *japonica*, and *javanica* (Rice Department, Ministry of Agriculture and Cooperatives, 2005).

Rice extracts have been found to be non-toxic to humans, making them suitable for the development of anti-aging cosmetics. Cytotoxicity tests using human fibroblast cells demonstrated that rice extracts are safe for topical application, with whole rice extracts maintaining over 50% cell viability at a concentration of 400 µg/ml, with LP exhibiting the highest cell viability among the extracts tested (Teeranachaideekul et al., 2018). Additionally, rice bran, which contains 8-10% oil, is rich in fat-soluble antioxidants, including gramisterol, gamma-oryzanol, vitamin E, beta-carotene, and lutein (Posuwan et al., 2013). These compounds are known to contribute to health benefits such as reducing hyperlipidemia, a major risk factor for cardiovascular diseases.

The high antioxidant properties of various rice species (*Oryza sativa* L.) can also stimulate melanogenesis, increasing the potential for added value in Thai rice. These properties are beneficial in hair treatment formulations for cosmetic products (Soradech, 2016). Research also indicates that anthocyanins from *Oryza sativa* L. have anti-inflammatory properties and anti-aging potential by modulating type I collagen gene expression and suppressing H2O2-induced NF-κB activation in skin fibroblasts (Palungwachira et al., 2019).

More specifically, red and purple rice varieties, such as Riceberry, have a high concentration of combined phenols and flavonoids, offering significant antioxidant capabilities compared to lighter-colored rice or other grains (Min et al., 2012). Red rice contains up to 752.1 mg/100g of polyphenols, 250.36 mg/100g of anthocyanins, and 63.3 µg/100g of beta-carotene. These compounds, including beta-carotene and lutein, have been shown to reduce the incidence of colorectal and breast cancer (Somintara et al., 2016). Furthermore, anthocyanins from red rice can inhibit the growth and aggregation of calcium oxalate crystals, potentially preventing kidney stone formation (Khawsuk et al., 2018).

Riceberry was introduced to the Thai rice market over a decade ago, gaining recognition for its distinctive appearance, nutritional value, and health benefits. Its bran is rich in antioxidants, anti-inflammatory agents, and other health-promoting substances that help reduce the risk of various diseases (Vanavichit, 2020).

The extraction of chemical compounds from Riceberry rice bran reveals bioactive compounds, including beta-carotene and lutein, which are absent in white rice. Other compounds such as apigenin, phytosterols, and triterpenes like lupeol exhibit chemoprotective properties in human cell lines,

including Caco-2 (colon cancer) and MCF-7 (breast cancer), with the most significant effects observed in the HL-60 cell line. Notably, gramisterol has been shown to prevent acute myeloid leukemia (AML) and protect the impaired immune system in leukemic mice (Somintara et al., 2016).

Research on cancer prevention has shown that supplementing Riceberry rice bran (up to 41% by weight) in a high-fat diet for streptozotocin-induced diabetic rats reduces hyperglycemia, hyperlipidemia, oxidative stress, and inflammation, as evidenced by improvements in biochemical parameters like blood glucose and insulin levels. These effects are attributed to increased antioxidant levels, which enhance insulin resistance and reduce beta-cell death, ultimately improving liver and pancreatic function (Prangthip et al., 2013).

Furthermore, riceberry rice bran oil (RBBO) increases high-density lipoprotein (HDL, or "good" cholesterol) levels while reducing low-density lipoprotein (LDL, or "bad" cholesterol) in streptozotocin-induced diabetic rats. Specifically, after 12 weeks of treatment, RBBO significantly reduced malondialdehyde levels and restored the levels of superoxide dismutase, catalase, glutathione peroxidase, coenzyme Q10, and oxygen radical absorbance capacity (ORAC) in diabetic rats (Posuwan et al., 2013).

Despite Riceberry rice's recognized health benefits, its cultivation remains limited, especially in Sing Buri Province where the lowland areas along the Chao Phraya, Noi, and Lopburi Rivers can be found (Kasetsart University, ORSTOM, 1996). While many farmers in the province have organized into groups to cultivate chemical-free rice, including jasmine and sticky rice, the production of Riceberry is still relatively low. Although demand for Riceberry rice is increasing among health-conscious consumers (Chancharoonpong, Mungkung, & Gheewala, 2021), efforts to enhance its value through product diversification have been minimal.

To address this gap, the research team proposes utilizing leftover Riceberry rice residue and bran to develop value-added health products. These could include cosmetics such as sunscreen creams that offer UV protection, prevent sunburn and dark spots, and potentially reduce the risk of skin cancer. Additionally, the potential applications of Riceberry rice extend to traditional medicine and spa products, which could further capitalize on its health benefits.

This initiative aligns with Sing Buri Province's economic strategy to enhance the value of agricultural products and stimulate local sales (Strategic and Information Group for Sing Buri Province, 2019). In collaboration with a community enterprise group in Bang Rachan District, which has expertise in producing health products and handicrafts, the project aims to develop three spa products. Alongside product development, the team seeks to secure patents, publish research findings in academic journals, and establish product standards for commercialization. Furthermore, the project will facilitate knowledge transfer to other community-based enterprise groups, fostering economic growth and promoting sustainable agricultural practices in the region.

2. Objectives

This research aims to analyze the chemical properties of Riceberry extracts and develop health products for Thai massage and spa businesses through a participatory process involving the community enterprise group in Bang Rachan District, Sing Buri Province.

3. Methods

This research focuses on analyzing the chemical composition of Riceberry extracts to develop health products for Thai massage and spa businesses. The process began with sourcing and cleaning herbs from natural sources, followed by chopping them into small pieces and drying them in an oven at 50°C. The dried herbs were then weighed according to specified amounts, coarsely ground using a disk mill, and macerated with 95% ethanol for three days. The mixture was filtered through filter paper, and the residue was re-macerated and filtered twice more. The resulting extracts were combined and concentrated using a rotary evaporator. The percentage yield (%Yield) was calculated, and the antioxidant activity was assessed using the DPPH assay to measure free radical scavenging ability. The total phenolic content was also determined. Additionally, various tests were conducted to evaluate the quality and efficacy of the products, including toxicity testing, elastase inhibition, wound healing activity in human skin cells, freeze-thaw stability testing, and irritancy testing.

Percentage Yield Calculation

The following formula for calculating the % yield of plant extract (Phrompittayarat et al., 2007) compares the amount of extract obtained with the initial amount of plant material used to determine production efficiency:

$$\% \text{ yield} = (\text{weight of plant extract} / \text{dry weight of plant material}) \times 100$$

Antioxidant Activity Assessment Using the DPPH Assay

The DPPH (2,2-diphenyl-1-picrylhydrazyl) assay evaluates a substance's ability to scavenge free radicals. DPPH• is a stable, nitrogen-centered free radical with a violet color in solution. When a free radical scavenger is added, the solution's absorbance at 517 nm decreases, which is measured using a spectrophotometer. The reaction follows this equation (Blois, 1958):

$$DPPH\bullet + H \rightarrow DPPH - H$$

The percentage inhibition of free radicals was calculated using the following formula:

$$\% \text{ inhibition} = [(A \text{ control} - A \text{ test sample}) / A \text{ control}] \times 100$$

where:

A test sample = Absorbance value of the DPPH solution with the test sample

A control = Absorbance value of the DPPH solution without the test sample

The extract's radical scavenging activity was tested at various concentrations, and the SC_50 value (the concentration required to scavenge 50% of the DPPH radicals) was determined (Manosroi et al., 2010).

Total Phenolic Content Determination

The total phenolic content of plant extracts was analyzed using the Folin-Ciocalteu colorimetric method (Miliauskas et al., 2004). This method determined the concentration of phenolic compounds by measuring absorbance of the sample at a specific wavelength and comparing it to a standard curve using gallic acid. The calculation follows the formula:

$$A = [(C \times V \times F) / (W)] \times 1000$$

where:

A = Total phenolic content (mg/g of sample)

C = Concentration from the standard curve (mg/L)

V = Volume of the sample extract (mL)

F = Dilution factor

W = Weight of the sample (g)

The concentration of the sample extract (C) obtained from the standard curve was used in the formula to determine the total phenolic content of the sample.

Cytotoxicity and Wound Healing Testing

Cytotoxicity testing involved filtering the sample solution through a 0.2-micron membrane to remove microorganisms. The filtered solution was diluted in a cell culture medium and tested using the Sulforhodamine B (SRB) assay (Vichai & Kirtikara, 2006). The percentage of cell survival was compared to the control group, and the highest non-toxic concentration was selected for wound-healing tests.

For wound healing assessment, a scratch test was performed using cultured human skin cells. The migration of cells across the scratch was monitored at different time intervals and compared to the control and vitamin C-treated groups (Muhammad et al., 2013).

Safety and Physical Stability Testing

Safety and stability testing of the developed products included:

Physical Stability Assessment

The gel texture, phase separation, and odor were evaluated as part of the physical stability assessment. pH testing was conducted immediately after preparation and after one week of storage at room temperature.

Accelerated Stability Testing

The product underwent five freeze-thaw cycles, stored at 4°C for 24 hours and then at 45°C for another 24 hours per cycle. Stability was assessed based on observed changes.

Cytotoxicity and Skin Irritation Testing

To evaluate cytotoxicity and skin irritation potential, a 5% Riceberry extract concentration was prepared in a cell culture medium. Cytotoxicity was tested using the SRB assay, with absorbance measured via spectrophotometry. Then, the percentage of cell survival was compared to the control group.

For skin irritation testing, a closed patch test was conducted on ten healthy adult volunteers (five males and five females, aged 20–35 years). The upper back was marked with three 2×2 cm test areas, spaced 3 cm apart. The skin was cleaned with saline solution and dried before applying three different formulations: saline solution, massage oil, and a face mask containing the extract. The skin was

observed immediately and 12 hours post-application for signs of irritation such as itching, clear vesicles, or rash.

Additionally, the products' physical stability was evaluated by monitoring gel appearance, phase separation, and pH levels both immediately after preparation and after one week of storage.

In summary, the products derived from Riceberry extract were assessed for cytotoxicity and skin irritation using both in vitro and in vivo methods, while their physical stability were also evaluated.

Table 1 Formulation Development of Sunscreen Cream from Riceberry Extract

Ingredients	Amount %w/w				
	Formula				
	1	2	3	4	5
Titanium Dioxide 15nm Liquid	10	10	10	10	10
Zinc Oxide 35nm Liquid	10	10	10	10	10
Silicone Blender	1	2	3	4	5
Ethylhexylglycerin (Mild Preserve)	1	1	1	1	1
Silicone Gel	26	27	28	29	30
Distilled Water	46.75	44.75	42.75	40.75	38.75
Beige Iron Oxides EasyMix™	0.15	0.15	0.15	0.15	0.15
Fragrance	0.1	0.1	0.1	0.1	0.1
Riceberry Extract	5	5	5	5	5

Table 2 Product Development of Encapsulated Riceberry Extract

Ingredients	Amount %w/w				
	Formula				
	1	2	3	4	5
Water	86.86	85.76	84.66	83.56	82.46
Propanediol	3	3	3	3	3
Carbopol	0.1	0.2	0.3	0.4	0.5
PE 9010 Preservative	0.8	0.8	0.8	0.8	0.8
Polysorbate 20	2	2	2	2	2
NaOH	0.14	0.14	0.14	0.14	0.14
Gold Color	2	2	2	2	2
Red Color	2	2	2	2	2
Fragrance	0.1	0.1	0.1	0.1	0.1
Riceberry Extract	3	4	5	6	7

Table 3 Product Development of Encapsulated Riceberry Extract

Ingredients	Amount %w/w				
	Formula				
	1	2	3	4	5
Fragrance	0.1	0.1	0.1	0.1	0.1
Riceberry Extract	3	4	5	6	7
Fragrance	0.1	0.1	0.1	0.1	0.1
Riceberry Extract	3	4	5	6	7
Fragrance	0.1	0.1	0.1	0.1	0.1
Riceberry Extract	3	4	5	6	7
Fragrance	0.1	0.1	0.1	0.1	0.1
Riceberry Extract	3	4	5	6	7

The statistical data analysis was conducted using the Paired t-Test, and a significant difference was observed with a p-value of <0.05.

4. Results

The results of the chemical analysis of riceberry extract are as follows:

Toxicity Test: Cytotoxicity to Melanoma Cells (B16F10)

The cell toxicity testing revealed that the Riceberry extract and Kojic acid, at concentrations ranging from 0.0001 to 1 mg/ml, were not toxic to melanoma cells (B16F10). At a concentration of 1 mg/ml, the cell survival rates were 96.29±2.59% and 97.39±1.38%, respectively (see Table 4).

Table 4 Toxicity Test

Sample	Percentage of Cell Survival				
Concentration (mg/ml)	0.0001	0.001	0.01	0.1	1
Riceberry Extract	102.39± 0.74	101.15± 1.47	100.09± 1.09	98.08± 1.43	96.29± 2.59

Assay for Inhibition of Melanin Production in Cell Cultures

The riceberry extract, at a concentration of 1 mg/ml, inhibited melanin synthesis in B16F10 melanoma cells by 20.60±3.67%. In contrast, kojic acid at the same concentration inhibited melanin synthesis by 56.80±3.64%.

The riceberry extract demonstrated 0.36 times the inhibitory effect on melanin synthesis in B16F10 cells compared to kojic acid (see Table 5).

Table 5 Melanin Pigment Inhibition Test

Sample	% Inhibit Melanin Pigmentation	Potency (Times that of Kojic Acid)
Riceberry Extract	20.60±3.67	0.36
Kojic Acid	56.80±3.64	-

The results of testing the five riceberry formulas are presented in Table 6.

Table 6 Experimental Results of All Five Formulas

Property	Formulas				
	1	2	3	4	5
Color	bright white	bright white	bright white	bright white	bright white
Smell	Rice berry	Rice berry	Rice berry	Rice berry	Rice berry
Clarity	low	low	not clear	low	not clear
Texture	very fluid	fluid	cream	cream	sticky

Evaluation of Product Stability Through Five Freeze-Thaw Cycles

According to the table displaying the observation of layer separation in the skincare products made with riceberry extract, it was found that none of the five formulations showed any layer separation after undergoing five freeze-thaw cycles (see Table 7).

Table 7 Observation of Layer Separation in Skincare Products Containing Riceberry Extract

Cycle	1 (-2)	2 (-1)	3 (Middle)	4 (-Ext)	5 (+1)	6 (+2)
1	not separated	not separated	not separated	not separated	not separated	not separated
2	not separated	not separated	not separated	not separated	not separated	not separated
3	not separated	not separated	not separated	not separated	not separated	not separated
4	not separated	not separated	not separated	not separated	not separated	not separated
5	not separated	not separated	not separated	not separated	not separated	not separated

The pH value of Riceberry sunscreen products (Table 8) and the comparison of pH values before and after freeze-thaw cycles (Table 9) are presented below.

Table 8 pH Values of Riceberry Sunscreen Products

Formula	1st Time	2nd Time	3rd Time
1 (-1)	4.61	4.65	4.64
2(-2)	4.81	4.83	4.79
3 (-Ext)	4.56	4.5	4.55
4 (+1)	4.46	4.44	4.47
5 (+2)	4.67	4.66	4.65

Table 9 Comparison of pH Values Before and After Freeze-Thaw Cycles

		SS	df	MS	F	Sig.
pH Before	Between Groups	.238	5	.048	122.160	.000
	Within Groups	.005	12	.000		
	Total	.242	17			
pH After	Between Groups	.299	5	.060	132.911	.000
	Within Groups	.005	12	.000		
	Total	.304	17			

Human Irritation Test of the Products

A human irritation test was conducted on 10 participants using saline, a base, and riceberry extract, with a testing duration of 12 hours. The results were interpreted according to the guidelines of the International Contact Dermatitis Research Group (ICDRG) (see Tables 10–13).

Table 10 Level of Severity and Interpretation

Level of Severity	Interpretation
NA	Non-active
+	Weak Reaction (red rash but no blisters)
++	Strong Reaction (red rash with small blisters)
+++	Extreme Reaction (a large clear blister and ulcer)

IR	Irritation Reaction

Table 11 Results of the Skin Irritation Test with Saline

NO.	After 12 Hours of Saline Testing				
	NA	**+**	**++**	**+++**	**IR**
1	√	-	-	-	-
2	√	-	-	-	-
3	√	-	-	-	-
4	√	-	-	-	-
5	√	-	-	-	-
6	√	-	-	-	-
7	√	-	-	-	-
8	√	-	-	-	-
9	√	-	-	-	-
10	√	-	-	-	-

Table 12 Results of the Skin Irritation Test with Cosmetic Base

NO.	After 12 Hours of Cosmetic Base				
	NA	**+**	**++**	**+++**	**IR**
1	√	-	-	-	-
2	√	-	-	-	-
3	√	-	-	-	-
4	√	-	-	-	-
5	√	-	-	-	-
6	√	-	-	-	-
7	√	-	-	-	-
8	√	-	-	-	-
9	√	-	-	-	-
10	√	-	-	-	-

Table 13 Results of the Skin Irritation Test with Riceberry Extract-based Cosmetic Products

NO.	After Testing with Riceberry Extract-based Cosmetic Products for 12 Hours				
	NA	**+**	**++**	**+++**	**IR**
1	√	-	-	-	-
2	√	-	-	-	-
3	-	√	-	-	-
4	√	-	-	-	-
5	√	-	-	-	-
6	√	-	-	-	-
7	-	√	-	-	-
8	√	-	-	-	-
9	√	-	-	-	-
10	√	-	-	-	-

Table 13, presenting the results of the skin irritation test on saline, base, and riceberry sunscreen cream (made from Riceberry extract), conducted over 12 hours, shows that Volunteers 3 and 7 exhibited mild positive reactions, while the other participants showed no signs of itching or irritation.

The participatory process of the community enterprise group in Bang Rachan District, Sing Buri Province, focused on health product innovations using Riceberry for Thai massage and spa businesses. The goal was to provide practical solutions for the health and well-being of local villagers. This process facilitated the transfer of knowledge related to public health products within the community, addressing physical, mental, and economic health needs. The community's participatory approach included shared decision-making, joint planning, mutual benefit-sharing, participatory monitoring and evaluation, and collaborative problem-solving (Phukamchanoad, 2023; 2024; 2025).

A case study was conducted to develop health products from Riceberry, including sleeping masks, clay facial masks, and lipsticks, using 100 grams of Riceberry. The following steps were followed in the process:

1) The villagers prepared 100 grams of Riceberry.
2) The villagers gathered the necessary equipment, including two stainless steel mixing bowls and a weighing scale.
3) The researcher and the research team prepared 12 chemical materials, as listed in Table 14.

Table 14 List of Chemicals for Mixing with Riceberry to Make Sleeping Masks, Clay Facial Masks, and Lipsticks

NO.	Item	Amount (grams)
1	DI water	29.05
2	Butylene Glycol	0.3
3	Base Cream	23
4	Nature Clay Mask Powder	19.4
5	Kaolin	12
6	French Green Clay	3
7	Bentonite	7
8	Beta Hydroxy Acids	2
9	D-panthenol 50p	1
10	Glycerin	1.5
11	Menthol Solution	0.15
12	Fragrance	0.1

The preparation steps are described below:

First, DI water, butylene glycol, base cream, beta hydroxy acids, D-panthenol 50p, glycerin, menthol solution, and fragrance were added into Container 1.

Next, nature clay mask powder, kaolin, French green clay, and bentonite were added into Container 2.

Lastly, the mixture from Container 1 was gradually poured into Container 2 and stirred until well combined. This process resulted in health products, including sleeping masks, clay facial masks, and lipsticks.

Additionally, the villagers were actively involved in every step of the research process, working alongside the researchers to ensure the accuracy and reliability of the results. Their participation was crucial, as health-related issues directly impact the public and overall well-being, making their role in the research process indispensable. The following diagram (Figure 1) illustrates their involvement.

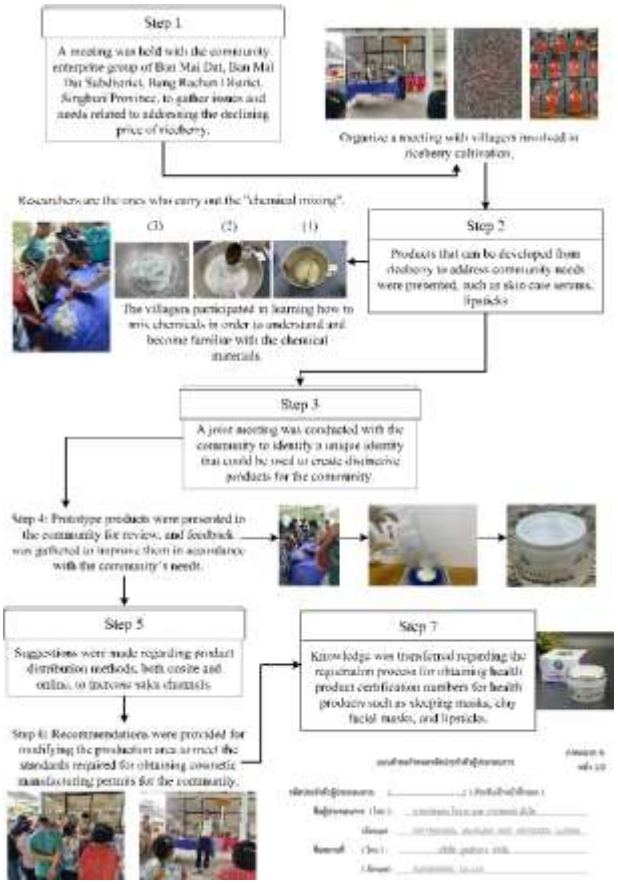

Figure 1 Collaborative Learning Process in the Community-based Development of Health Products

According to Figure 1, the participatory process of the Ban Mai Dat community enterprise group in Bang Rachan District, Sing Buri Province, in developing Riceberry-based health products involved 7 stages as follows.

Step 1 Community Engagement: A meeting was held with villagers to understand issues related to Riceberry pricing and explore potential product development.

Step 2 Product Ideation: Researchers introduced possible riceberry-based products, such as skincare serums and lipsticks.

Step 3 Community Identity: A joint meeting helped define a unique identity for the products.

Step 4 Prototyping: Prototype products were developed and presented for community review and feedback.

Step 5 Market Readiness: Suggestions were made to improve distribution channels, including online and onsite sales.

Step 6 Regulatory Compliance: Recommendations were provided to upgrade production areas to meet cosmetic manufacturing standards.

Step 7 Certification & Knowledge Transfer: Guidance was given on obtaining health product certification numbers for items like sleeping masks, clay facial masks, and lipsticks.

This participatory approach ensured community involvement at every stage, from development to commercialization.

5. Discussion and Conclusion

This study tested the toxicity of Riceberry extract and Kojic acid on B16F10 melanoma cells at concentrations ranging from 0.0001 to 1 mg/ml. The results showed that neither the Riceberry extract nor Kojic acid was toxic to the cells. At a concentration of 1 mg/ml, the cell survival rates were 96.29±2.59% for Riceberry extract and 97.39±1.38% for Kojic acid. Furthermore, the Riceberry extract inhibited melanin synthesis by 20.60±3.67% in B16F10 cells at the same concentration, although it did not affect tyrosinase enzyme production in these cells.

In the evaluation of five rice berry extract-based formulations, which included sunscreen, masks, and encapsulated products, Formula 4 showed the best stability with a pH of 4.44±0.03. No phase separation was observed during the stability testing. The skin irritation test revealed only mild reactions in Volunteers 3 and 7, while the others showed no signs of irritation or pruritus.

The freeze-thaw stability of the encapsulated formulation showed a statistically significant change in pH before and after the freeze-thaw cycle. However, there was no phase separation, and only a mild positive skin reaction was noted in Volunteer 7.

Similarly, in the mask formulation study, a statistically significant change in pH was observed before and after the freeze-thaw cycle. No phase separation occurred, and only mild positive reactions were seen in Volunteers 3 and 7 in the skin irritation test.

When researchers identified valuable and suitable substances for product development their potential health impacts on the public were considered. Since the raw materials used in the research were sourced from the community, the public was involved in the research process, ensuring they 'truly knew, understood, and had access to their resources.' Once the production process was completed, the public was more likely to embrace the transfer of innovations into real-world settings, as the outcomes—both direct and indirect—significantly influenced their daily lives, community health, and the local economy.

In conclusion, this study serves as a preliminary development of Riceberry extract-based products, including sunscreens, masks, and encapsulated formulations. Further research and product refinement are recommended. Since this is a prototype study, it is essential to involve the public—who benefit most from health products—throughout the research process. This underscores the crucial role of public involvement, as the impact of these products directly affects their daily lives and the broader community.

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