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Polysaccharide-Rich Fermentation Broth from Prinsepia utilis Royle Pomace Exhibits Instant Skin Firming Effects

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Abstract

Objective: *Prinsepia utilis* Royle, an endemic oil plant in Yunnan known locally as the Anas fruit, yields a seed oil widely used in skincare for its moisturizing and protective properties. However, the pomace remaining after oil extraction, despite containing many active ingredients, is often incinerated or used as low-value compost. In this study, we fermented *P. utilis* Royle pomace using *Saccharomyces cerevisiae* and characterized the polysaccharides present in the resulting fermentation broth. Specifically, this study aimed to evaluate the instant skin firming and hydrating effects of polysaccharide-rich fermentation broth obtained through *Saccharomyces cerevisiae* fermentation of the pomace.

Methods: *P. utilis* Royle pomace was fermented using *Saccharomyces cerevisiae* to obtain a polysaccharide-rich fermentation broth. A randomized, double-blind, placebo-controlled clinical trial was conducted to assess the effects of topical application of 1% and 5% fermentation broth lotions compared to a placebo lotion on facial skin.

Results: Both 1% and 5% fermentation broth lotions demonstrated significant instant improvements in skin hydration (MMV) compared to the placebo group. Skin elasticity parameters, including R2, R7, and Q1, also showed significant enhancement in the fermentation broth groups relative to the placebo group.

Conclusion: The polysaccharide-rich fermentation broth obtained from *P. utilis* Royle pomace exhibits promising instant skin hydrating and firming effects. This study demonstrates the potential for sustainable valorization of agricultural byproducts in cosmetic applications through bioprocessing.

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1. Introduction

Prinsepia utilis Royle (photoed in Figure 1), an endemic oil plant in Yunnan known locally as the Anas fruit. This species holds dual significance in regional ethnobotanical traditions, being documented in Dian Nan Ben Cao (A Compendium of Southern Yunnan Medicinal Herbs) for its multifunctional applications as both a nutritional resource and therapeutic agent. Classical pharmacological records attribute its bioactive properties to heat-clearing, detoxification, blood circulation activation, and anti-edematous effects. Its seed oil as a lipid-rich matrix containing tocopherols, unsaturated fatty acids (linoleic acid >60%), and phytosterols. These constituents underpin its growing utilization in dermatological formulations, where it demonstrates clinically validated emollient efficacy and stratum corneum barrier-enhancing capabilities[1,2]. Notably, the oil's unique fatty acid profile aligns with skin lipid composition, suggesting biomimetic compatibility that enhances its transdermal delivery and moisturizing performance[3,4]. The main active components of *Prinsepia utilis* Royle include polyphenols, unsaturated fatty acids, sterols, polysaccharides, and so on. Modern phytochemical analyses have identified that the essential component *Prinsepia utilis* Royle polysaccharides greatly reduced transepidermal water loss (TEWL) and improved the damaged epidermal barrier. Mechanistically, *Prinsepia utilis* Royle polysaccharides could promote the expression of claudin family proteins and enhance the expression of members of TJ family, which are primarily concentrated in the granular layer of the epidermis. The polysaccharides penetrated into the granular layer of the epidermis and then improved the function of the skin barrier, thus promoting the enhancement of the apparent barrier of the skin, including improvements in moisture retention, resistance, and epidermal thickness as well as decreased permeability[5,6]. However, the pomace remaining after oil extraction, despite containing many active ingredients, is often incinerated or used as low-value compost, which is rich in polysaccharides. In this study, we fermented *P. utilis* Royle pomace using *Saccharomyces cerevisiae*, fermentation flowchart as shown in Figure 2, and characterized the polysaccharides present in the resulting fermentation broth. The instant skin-firming and hydrating effects of polysaccharide-rich fermentation broth obtained through *Saccharomyces cerevisiae* fermentation of the pomace were evaluated. Both 1% and 5% fermentation broth lotions exerted significant instant improvements in skin hydration (MMV) compared to the placebo group. Skin elasticity parameters, including R2, R7, and Q1, also displayed significant enhancement in the fermentation broth groups. This study demonstrates the potential for sustainable valorization of agricultural byproducts in cosmetic applications through bioprocessing and significantly improves the utilization rate of resources.

Figure 1. The picture of *Prinsepia utilis* Royle.

Figure 2. Fermentation process flowchart.

2. Materials and Methods

2.1 Fermentation

P.utilis Royle pomace was fermented using *Saccharomyces cerevisiae* for 56 h to obtain a polysaccharide-rich fermentation broth. The *Saccharomyces cerevisiae* (Number 2.243) was purchased from Guangdong Microbial culture collection center.

2.2 Polysaccharide content

The phenol-sulfuric acid method was applied to detect total sugar content. The content of reducing sugar was determined by 3, 5-dinitrosalicylic acid (DNS) method[7]. Glucose standard solution was used to draw the standard curve.

Calculate the total sugar content ($W_{\text{total sugar}}$) in the test sample (mg/mL) according to the following formula:

$$W_{\text{total sugar}} = \frac{c \times V1 \times V3}{V2 \times V4}$$

c——The concentration of total sugar in the test solution of the test sample calculated from the standard curve, mg/L
V1——Volume of the liquid to be measured, mL
V2——The sampling volume of the test solution in the solution to be tested, mL
V3——The dilution volume of the test solution, mL
V4——The sampling volume of the test sample, mL

Calculate the reducing sugar content ($W_{\text{reducing sugar}}$) in the test sample (mg/mL) according to the following formula:

$$W_{\text{reducing sugar}} = \frac{c \times V1 \times V3}{V2 \times V4}$$

c——The concentration of reducing sugar in the test solution of the test sample calculated from the standard curve, mg/L
V1——Volume of the liquid to be measured, mL
V2——The sampling volume of the test solution in the solution to be tested, mL
V3——The dilution volume of the test solution, mL

V4——The sampling volume of the test sample, mL

Calculate the polysaccharide content ($W_{polysaccharide}$) in the test sample (mg/mL) according to the following formula:

$$W_{polysaccharide} = W_{total\ sugar} - W_{reducing\ sugar}$$

2.3 Facial skin efficacy test

The firming effect of fermentation broth on facial skin was examined by the probe Cutometer MPA580 jointly. Water parameter (MMV) was tested by Cornermeter CM825 Skin Moisture Tester. A randomized, double-blind, placebo-controlled clinical trial was conducted to assess the effects of topical application of 1% and 5% fermentation broth lotions compared to a placebo lotion on facial skin. A total of 30 eligible subjects, aged from 30 to 60 years, were randomly and equally divided into 3 groups. A placebo control group (no fermentation broth) and two experimental groups (1% and 5% fermentation broth) were set up for blinded experiments.

2.4 Statistical Analysis

Data are expressed as mean ± SD of at least three experiments performed in duplicate. Statistical significance was evaluated using *t*-test. $^*P < 0.05$ was considered a mark of statistical significance.

3. Results

3.1 Polysaccharide content

The polysaccharide content of the fermentation broth is greater than 13 mg/mL.

3.2 Skin hydration test

The experimental results demonstrated significant temporal variations in Moisture Measurement Value (MMV) following topical application of both 1% and 5% fermented emulsions (Figure 3). Statistical analysis revealed pronounced differences ($p < 0.001$) in hydration efficacy between the active formulations and placebo controls across all measured time intervals (1-, 2-, 4-, and 8-hour post-application), indicating sustained moisturizing properties for both concentrations. Quantitative analysis of hydration dynamics (Figure 4) showed substantial MMV elevation in treated areas following fermented emulsion application. Compared to baseline measurements (0 hour), the mean percentage changes in MMV reached 102.55%, 114.67%, 94.77%, and 96.17%, at 1 h, 2 h, 4 h, and 8 h, respectively. Similarly, the 5% formulation induced significant MMV increases with mean change rates of 103.31%, 113.17%, 95.42%, and 88.06% at respective time points.

The rate of change of MMV value (ΔMMV value) = (MMV value after using the product－MMV value before using the product)/MMV value before using the product ×100%

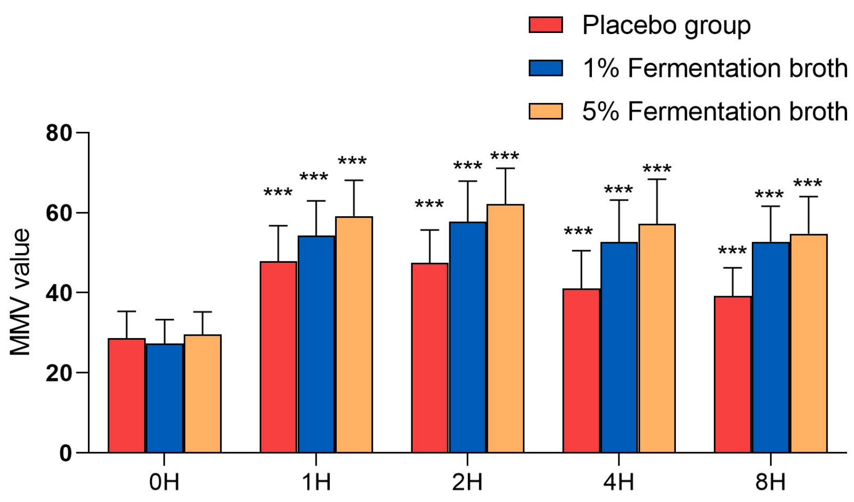

Figure 3. Effects of fermentation broth lotion on skin hydration. MMV values were assessed by Cornermeter CM825 Skin Moisture Tester. Compared with the 0 h, ***P<0.001, n=30.

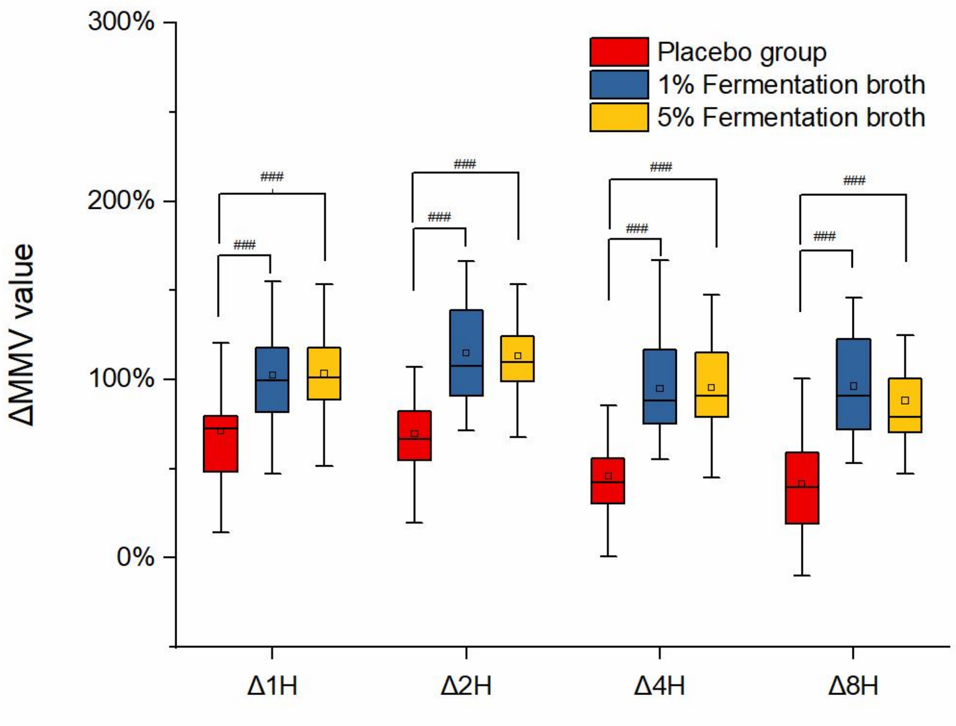

Figure 4. Change rate of skin hydration MMV values with administration of 1%, 5% fermented broth lotion or placebo for 1 h, 2 h, 4 h, and 8h . Compared with the 0 h, ###P<0.001, n=30.

3.2 Skin elasticity test

Biomechanical assessment of periocular skin elasticity was conducted using the Cutometer MPA580 probe following topical application of 5% fermented broth lotion. Quantitative analysis revealed significant improvements in key viscoelastic parameters, R2, R7, and Q1, at both post-application intervals. As demonstrated in Figure 5, relative to baseline measurements, the treatment group exhibited marked elevation in R2/R7/Q1 values at

15-minute post-application, with mean percentage increases of 13.78%, 11.41%, and 12.95%, respectively. This effect progressed at 30-minute post-application, where mean change rates further increased to 19.70%, 17.97%, and 18.41% for R2, R7, and Q1 parameters.

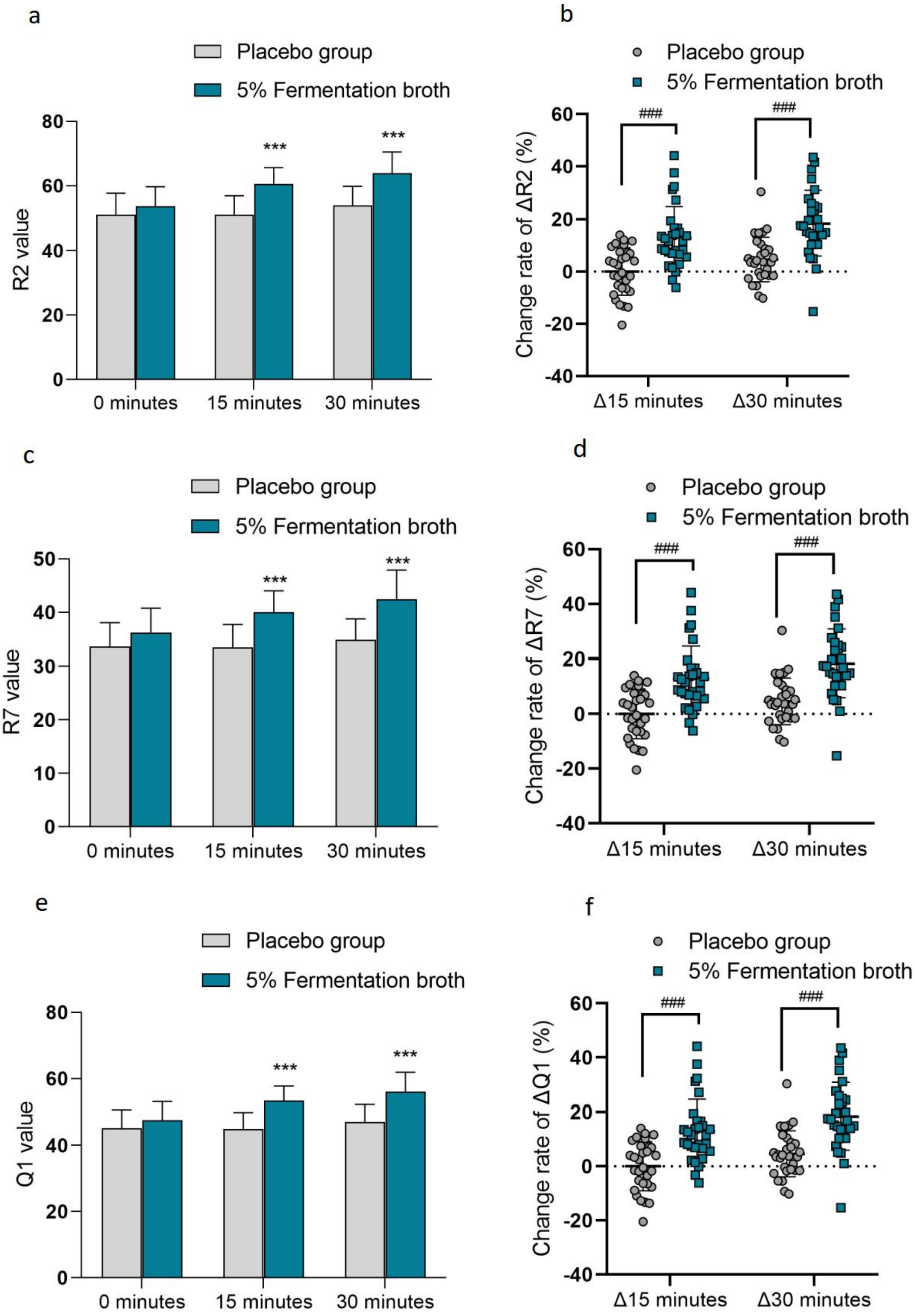

Figure 5. Effects of 5% fermented broth lotion on instant skin elasticity. (a) R2 values were assessed by the probe Cutometer MPA580 jointly. (b) change rate of skin elasticity R2 values with administration of 5% fermented broth lotion or placebo for 15 minutes and 30 minutes. (c) R7 values were assessed. (d) change rate of skin elasticity R7 values. (e) Q1 values were assessed. (f) change rate of skin elasticity Q1 values. Compared with the 0 minute, $^{***}P<0.001$, n=30. Compared with placebo group, $^{\#\#\#}P<0.001$, n=30.

4. Discussion

The global generation of plant residues exceeds hundreds of million tons annually, presenting dual challenges of environmental burden and resource underutilization. Plant residues can produce methane when landfilled, and incineration releases particulate matter and carbon dioxide. These substances can cause damage and burden the environment. Notably, these byproducts harbor bioactive constituents, including polyphenols and polysaccharides, which exhibit potential as natural antioxidants, nutraceuticals, and cosmeceutical ingredients. Strategic extraction and valorization of these functional compounds could mitigate ecological impacts while enabling high-value applications, thereby advancing circular bioeconomy principles.

In the current study, we fermented *Prinsepia utilis* Royle pomace with *Saccharomyces cerevisiae* to obtain a fermentation broth rich in polysaccharides that can be used in skin care products. The polysaccharide content of the fermentation broth is greater than 13 mg/mL. Topical application of 1% and 5% fermented emulsions induced marked increases in Moisture Measurement Value (MMV) across all monitored intervals (1, 2, 4, and 8 h post-application), confirming concentration-dependent hydration effects. Furthermore, biomechanical assessments revealed substantial improvements in viscoelastic parameters (R2, R7 , and Q1) for the 5% formulation group, indicating rapid skin-firming effects.

5. Conclusion

In summary, polysaccharide-rich *Prinsepia utilis* Royle pomace fermentation broth exerted superior instant skin-firming and hydrating effects. This study demonstrates the potential for sustainable valorization of agricultural byproducts in cosmetic applications through bioprocessing and significantly improves the utilization rate of resources.

Acknowledgments

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Conflict of Interest Statement

The authors declare no conflict of interest.

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