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Report

Water-Loss Prevention and Water-Holding Capacity of Jojoba Oils

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The seeds of jojoba (*Simmondsia chinensis* (Link) Schneider) contain approximately 50% of a unique oil known as jojoba oil. It is primarily composed of liquid wax monoesters, whose structure is similar to that of the wax component of human sebum and is widely employed as a cosmetic ingredient. Two types of jojoba oil are used in cosmetics: unrefined jojoba oil called "golden" jojoba oil and refined jojoba oil. Human sebum protects the epidermis by forming an emulsion with water, preventing water loss. In this study, the water-loss prevention and water-holding capacities of golden jojoba oil were measured and compared with those of refined jojoba oil and other oils. Golden jojoba oil exhibited the highest water-loss prevention and water-holding properties among the oils examined. These results suggest that golden jojoba oil is a useful cosmetic ingredient. Conversely, refined jojoba oil exhibited high water-loss prevention, albeit with the lowest water-holding capacity. These findings suggest that the minor components lost during the refining process are responsible for the high water-holding capacity of golden jojoba oil. When the methanol extract of golden jojoba oil was added to refined jojoba oil to examine water-loss prevention and water-holding capacity, no significant difference emerged between the two. Although the water-holding capacity of the refined jojoba oil increased, it remained lower than that of golden jojoba oil. These results suggest that, in addition to the minor substances in the methanol extract, other substances may contribute to the exceptional water-holding capacity of golden jojoba oil.

Key words refined jojoba oil, golden jojoba oil, water-loss prevention, water-holding capacity

INTRODUCTION

Jojoba (*Simmondsia chinensis* (Link) Schneider) is an evergreen shrub native to the Sonoran Desert that is cultivated in arid regions such as Egypt, Israel, and Peru. It has attracted considerable attention as a useful plant for desert greening because of its low water requirements.[1)] Its seeds contain approximately 50% of a golden liquid wax monoester known as jojoba oil, comprising aliphatic alcohols (mainly C20:1 and C22:1) and fatty acids (mainly C20:1).[2,3)] Jojoba oil is unique because unlike other seed oils investigated to date, its main components are not triglycerides.

Unrefined jojoba oil is called "golden" jojoba oil because of its color. Recently, we showed that golden jojoba oil exhibits high oxidation stability and antioxidant activity, whereas refined jojoba oil, which is clear and lacks pigments and other minor components of golden jojoba oil, has high oxidation stability but lower antioxidant activity.[1,4)] These findings suggest that components other than wax monoesters, which are lost during the process of refining golden jojoba oil, are responsible for its antioxidant activity.[1,4)]

Wax esters, triglycerides, and squalene are the three major lipid components of human sebum.[5)] The structure of the wax monoesters in jojoba oil is similar to that of the wax ester components of sebum. In addition to this structural similarity, jojoba oil is characterized by low viscosity and excellent spreadability and lubricity.[6,7)] When applied to the skin, it blends well with sebum, providing a light, non-greasy feel. Consequently, both golden and refined jojoba oils are extensively used as cosmetic ingredients.[8)]

Sebum protects the epidermis by forming an emulsion with water on the epidermis, preventing water loss.[9)] Therefore, the water-loss prevention and water-holding capacity of cosmetic oils are essential properties that complement sebum functions. Owing to their hydrophobic structure, oils can prevent water loss by covering the skin surface, thereby preventing transdermal evaporation of moisture from inside the skin.[10)] In addition, water-holding capacity, which refers to the ability to retain water, is occasionally employed as an indicator of water retention in oils.[11)] Oils with high water-holding capacity can have an emollient effect on the skin.[12)] We believe that these two properties can serve as useful indicators to assess the performance of cosmetic oils. The objective of this study was to characterize the performance of golden jojoba oil as a cosmetic oil by quantifying its water-loss prevention and water-holding capacity and comparing it with refined jojoba oil and other oils.

MATERIALS AND METHODS

Oils Golden jojoba oil (Saraya Co. Ltd., Lot. No. L201002), olive oil (NIKKOL Olive Oil, Nikko Chemicals Co., Ltd.), Vaseline (Japanese Pharmacopeia, Kenei Pharmaceutical Co., Ltd.), squalene (Cica Special Grade, Kanto

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Chemical Co., Inc.), and squalane (NIKKOL Sugar Squalane, Nikko Chemicals Co., Ltd.) were used. Refined jojoba oil was derived from golden jojoba oil that had undergone refining via activated carbon treatment and decompression deodorization by an external refining manufacturer.

Method for Preparing the Methanol Extract of Golden Jojoba Oil Equal volumes of methanol were added to 100 mL of golden jojoba oil and shaken vigorously. The resulting mixture was centrifuged at 3000 × *g* for 20 min, and the upper layer (methanol layer) was collected. The lower layer (oil layer) was re-extracted three times with methanol. The combined methanol layers were concentrated in vacuo to obtain a methanol extract. The resulting methanol extract (468 mg) was stored at -20°C until use.

Measurement of Water-Loss Prevention Distilled water (30 g) was placed in a 5 K standard bottle. After sealing the top of the bottle mouth with filter paper (No. 5C, ADVANTEC), 200 µL of each oil sample was applied to the filter paper surface. The bottle was placed in an incubator (set at 40°C), and its weight was measured after a certain period of time (1, 2, and 20 h after).[12] The amount of water lost by evaporation was then calculated, and the water-loss prevention of each sample was evaluated by inhibiting the passage of water vapor through the filter paper. Vaseline was spread using a microspatula because it solidified when applied to the filter paper, and the amount of Vaseline applied was approximately half that of the other oils. The methanol extract of golden jojoba oil was added to refined jojoba oil at a concentration of 0.4%. The experiment was conducted with five replicates.

Measurement of Water-Holding Capacity While stirring 10 g of the sample at 400 rpm in a water bath at 40°C, distilled water was added 0.5 g at a time until the oil and water layers separated.[12] The percentage of water-holding was calculated as follows:

$$\text{Water-holding rate} = \text{Amount of water-holding} \div \text{Sample weight} \times 100\ (\%)$$

Squalane was used instead of squalene, because we assume cosmetics manufacturing in this experiment. Squalane is commonly used for cosmetics manufacturing, because it is known to be oxidatively stable, unlike squalene. The methanol extract of golden jojoba oil was added to refined jojoba oil at concentrations of 0.08%, 0.24%, and 0.4%, respectively. Experiments were performed in triplicate.

Statistical Analysis Statistical analysis was performed to evaluate for significant differences in both water-loss prevention and water-holding capacity measurements. Microsoft® EXCEL 2019 was used to perform Tukey's test. Statistically significant difference was recognized when $p < 0.05$.

RESULTS AND DISCUSSION

Comparison of Water-Loss Prevention among Oils Golden jojoba oil exhibited the highest prevention of water loss after 20 h; however, no significant difference was observed between refined jojoba oil, olive oil, and Vaseline (Fig. 1A). In contrast, squalene exhibited the lowest water-loss prevention after 20 h. This suggests that the water-loss prevention provided by squalene decreased owing to oxidative deterioration, as squalene is known to be unstable to oxidation.[13] Vaseline exhibited the lowest prevention of water loss after 1 and 2 h. This can potentially be attributed to its smaller application amount compared to the others.

When a 0.4% methanol extract of golden jojoba oil was added to refined jojoba oil, no significant change was observed in water-loss prevention after 1, 2, and 20 h (Fig. 1B). These results suggest that the methanolic extract was not involved in the prevention of water loss. This is consistent with the finding of no significant difference in water-loss prevention between golden and refined jojoba oils.

Comparison of Water-Holding Capacity among Oils Golden jojoba oil exhibited significantly higher water-holding capacity than all the other oils. In contrast, the water-holding capacity of the refined jojoba oil was significantly lower than that of the other oils (Fig. 2A). These findings suggest that wax monoester, which is the main component of jojoba oil, has a low water-holding capacity, and that minor components of golden jojoba oil lost in refined oil may be responsible for the high water-holding capacity of golden jojoba oil.

The methanol extract of golden jojoba oil was added to refined jojoba oil at 0.08%, 0.24%, and 0.40% to examine the water-holding capacity of its minor components. Consequently, no significant increase in water-holding capacity was

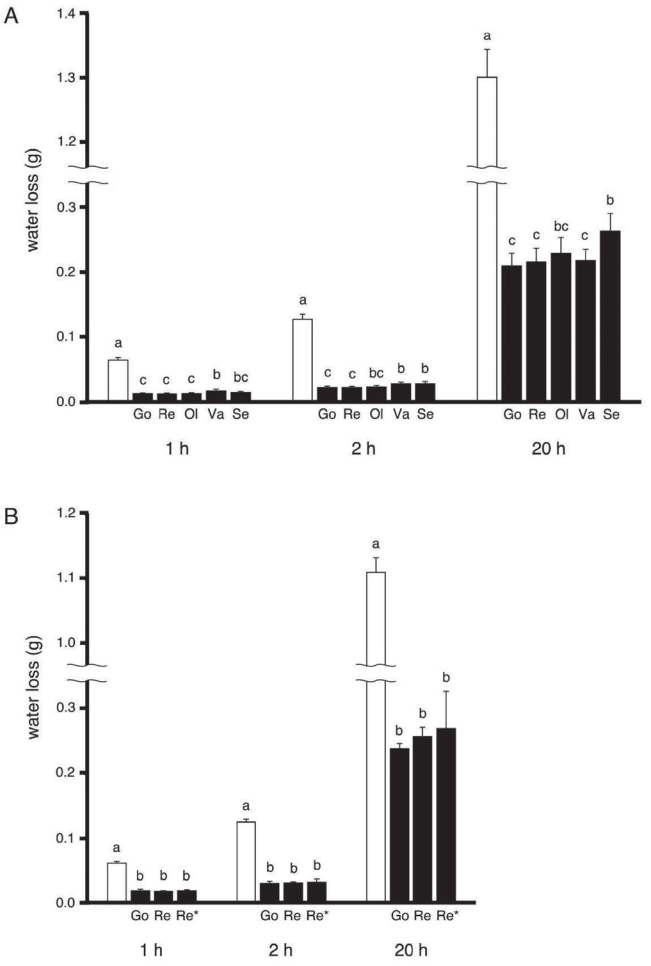

Fig. 1. Comparison of Water Loss among Oils

Water loss by evaporation at 1, 2, and 20 h after the start of the experiment. White bars indicate control with no oil applied, and black bars indicate golden jojoba oil (Go), refined jojoba oil (Re), olive oil (Ol), Vaseline (Va), squalene (Se), and refined jojoba oil + methanol extract 0.4% (Re*), respectively. Different oils (A) and jojoba oils (B) were compared. Different letters indicate significant differences [$p < 0.01$; between a and other letters, $p < 0.05$; between b and c. (Tukey's method)].

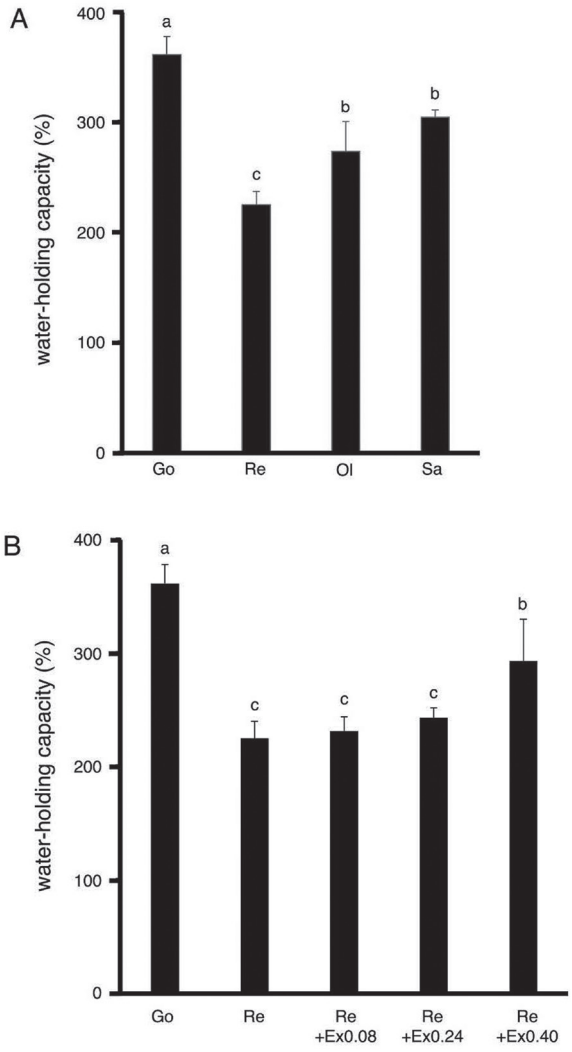

Fig. 2. Comparison of Water-Holding Capacity among Oils

Water-holding capacities of golden jojoba oil (Go), refined jojoba oil (Re), olive oil (Ol), squalane (Sa), and refined jojoba oil with 0.08%, 0.24%, or 0.4% methanol extract (Re + Ex0.08, Re + Ex0.24, Re + Ex0.40) are shown. Different oils (A) and jojoba oils (B) were compared. Different letters indicate significant differences [$p < 0.01$; between a and b (Go and Ol), as well as a and c, $p < 0.05$; between a and b (Go and Sa, or Go and Re + Ex0.40), as well as b and c. (Tukey's method)].

observed when the methanol extract was added at 0.08% and 0.24%; however, a notable increase was observed when it was added at 0.40% (Fig. 2B). Nevertheless, the water-holding capacity was still significantly lower than that of golden jojoba oil.

These results suggest that the high water-holding property of golden jojoba oil can be attributed not only to the minor components extracted by methanol but also to other minor components.

A water-loss prevention test was conducted to determine the degree of occlusion effect of oil components covering the filter paper surface (with a particle retention capacity of 1 μm) in preventing water from evaporating through the filter paper. In contrast, a water-holding capacity test was conducted to determine the degree of affinity between oil components and water in stirring conditions. These occlusive properties and affinity to water are contradictory properties of oils; however, both are crucial for cosmetic oils. An oil with a good balance between water evaporation control and water-holding properties is more suitable for cosmetics than that without this balance. In this study, oil components with different molecular structures such as triglycerides, wax esters, and hydrocarbons were examined. Except for oxidized squalene, our results suggest that water-loss prevention, that is, the occlusive property, of these oil components is nearly identical regardless of structural differences.

The water-holding capacity of golden jojoba oil was significantly higher than that of refined oil. This suggests that the high water-holding capacity of golden jojoba oil cannot only be attributed to its main component, wax ester, but also to other minor components with surface-active properties. Although quinones, glycosides, terpenoids, tocopherols, and sterols have already been reported as minor components of golden jojoba oil,[14,15] the relationship between these constituents and the water-holding capacity has not been elucidated, and further investigation is required. Lanolin is known to exhibit high water-holding capacity owing to the presence of free alcohol, fatty acids, etc., as revealed in a previous study.[16] The water-holding capacities of fats, oils, and waxes are related to their polarity and consistency, which can be estimated by measuring their dipole moments and dielectric constants.[16] In other words, molecular polarity is thought to be related to water-holding properties. This implies that the components contributing to the water-holding capacity of golden jojoba oil have molecular polarity and affinity for water, in addition to having surface-active properties. To extract components in golden jojoba oil that contribute to water-holding capacity, we performed methanol extraction because components extracted by methanol are assumed to be relatively polar, and found that methanol was not able to extract all of the components that contribute water-holding capacity in golden jojoba oil. The refined jojoba oil used in this study was obtained by treating golden jojoba oil with activated carbon and then deodorizing it under reduced pressure. These suggest that the components physically and chemically adsorbed by activated carbon and volatile ones removed by decompression deodorization, which include those not extracted by methanol, are involved in the water-holding capacity of golden jojoba oil.

These findings indicate that golden jojoba oil exhibits a high water-holding capacity in addition to strong water-loss prevention. The former is a feature not found in refined jojoba oil. Therefore, golden jojoba oil, which mainly comprises wax esters and contains other minor components, is an excellent cosmetic oil that has both water occlusive and water-holding properties, in addition to its oxidation stability and antioxidant properties.[1,4]

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Conflict of Interest Naoki Ichiyamagi, Masashi Yamamoto, and Yoshihiko Hirata are employees of Saraya Co., Ltd. Kiichi Fukui is a representative director and Suguru Tsuchimoto is the director of Simmond Co., Ltd. This study was funded by Saraya Co. Ltd.

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