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A comparative study of the rheological and sensory properties of a petroleum-free and a petroleum-based cosmetic cream

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Synopsis

A petroleum-free skin cream was developed using food-grade ingredients. The rheological and sensorial properties of this petroleum-free skin cream were compared to a commercially available petroleum-based skin cream. Specifically, large-amplitude oscillatory shear (LAOS) characterization of the two skin creams was performed. The petroleum-free skin cream showed similar linear and nonlinear viscoelastic rheological properties, comparable skin hydration functions, and consumer acceptance as the commercially available skin cream. A schematic diagram aiming to correlate the physical and sensorial properties of skin cream was also proposed at the end of the work. Results of this work could provide the cosmetic industry necessary information for the development of alternatives for petroleum-based skin creams.

INTRODUCTION

A growing consumer preference toward sustainable and natural cosmetic products nowadays has been driving the cosmetic industry to look for naturally derived replacements for petroleum-based products. Petrolatum and mineral oil have been widely used in skin creams and lotions because of their excellent moisture barrier function to prevent the skin from drying out (1). However, petrolatum and mineral oil can contain carcinogenic contaminants such as polycyclic aromatic compounds if improperly refined. Thus, in Europe, these materials are classified as carcinogenic if the full refining history is unknown (2). Additionally, petrolatum and mineral oil do not meet the standard of "natural" in cosmetics because they undergo chemical treatment during the refining process (1). Many attempts have been made to develop petroleum-free cosmetics, and our group has developed an oleogel using ethyl cellulose, food emulsifiers, and plant oils, which has desirable properties in cosmetic applications and is efficient in reducing water vapor transmission rate (3).

In addition to this oleogel, a monoglyceride (MG)-structured emulsion, which was originally developed as a low-fat shortening in baked goods (4,5), also showed desirable

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cosmetic properties when its water content was increased. This MG-structured emulsion contains approximately 5% (w/w) saturated MGs, 0.25% (w/w) coemulsifier, 20% (w/w) oil, and 70% (w/w) water. Potassium sorbate is also added at 0.1% (w/w) as an antifungal agent. The structure of this MG-structured oil-in-water (o/w) emulsion has been well characterized by our group (6,7). It has a unique architecture where oil droplets are surrounded firstly by an MG monolayer and then alternating water and MG bilayers (4,6). Such onion-like structure allows this emulsion to entrap large amount of water within, thus providing desirable cosmetics properties such as semisolid spreadable texture and a skin moisturizing effect.

MGs have polymorphic and mesomorphic properties (8–12). The hydrated lamellar phase of MGs is the desirable phase for this emulsion, because it provides the emulsion with desirable texture (6,13,14) and could significantly increase the water content of the stratum corneum compared with nonlamellar MG structures (15). Additionally, the physical properties of this MG-structured emulsion are not largely affected by the type of oils; therefore, a large variety of oil and oil-soluble active ingredients can be encapsulated within its structure (5,16,17). The stability of this MG-structured emulsion has also been examined and it is stable for up to 8 weeks at 45°C (14). Higher stability could be achieved with the use of higher content of coemulsifier sodium stearoyl lactylate (SSL) and the addition of texture modifiers such as xanthan gum (14).

Previous work done on the characterization and evaluation of this MG-structured emulsion only focused on its application in food systems. This work, therefore, is an interdisciplinary study and will evaluate cosmetic properties and consumer acceptance of the MG-structured emulsion, by comparing it with a commercially available petroleum-based cosmetic skin cream.

In the development of cosmetic products, sensory evaluation is one of the most important methods used to evaluate skin feel and consumer acceptance. Properties of cosmetic lotions are affected by complex factors such as emulsifier (18), emollient (19), thickener (texture modifier) (20–23), water and oil content, and emulsion structure. Parameters in the sensory evaluation of skin lotions have been well established, where some common attributes include appearance, pickup, and rubout (24,25). The major drawback of sensory evaluation is that it is time consuming and expensive. In order to be more cost and time efficient, alternative methods have recently been employed in the characterization of the behavior of skin care products. Rheology and texture analysis are two of the common physical measures in the characterization of physical properties of food products, and they have been applied in cosmetic science to help predict the sensory properties of cosmetic creams and lotions (21,24,26–28).

Previous work has built up the relationship between some of the rheological parameters and sensory properties in cosmetic creams, with emphasis on the viscosity and viscoelastic properties (23,27). In these works, the skin feel after the application of a skin cream was divided into two parts, primary skin feel and secondary skin feel, in order to correlate various rheological parameters with the sensorial properties (27). Primary skin feel describes how the product feels when removed from the container, and how hard to spread the product when rubbing onto the skin; while secondary skin feel describes the sensation at the end of the application such as the oiliness, greasiness, and softness. Primary skin feel is correlated with the onset of flow and dynamic viscosity of a product, whereas secondary skin feel is correlated with its steady-state viscosity measured at high shear rates (27). Studies show that lotions with high yield stress but low yield strain are desirable to consumers, because the high yield stress allows the cream to maintain its structure upon pickup when transferring from the container to the skin; while the low yield strain allows quick break down and easy spread out of the product for fast absorption (29). Results obtained from oscillatory rheological measurements were shown to be significantly correlated to firmness, thickness, resistance, spreadability, stickiness, and slipperiness. Perceptions of these qualities typically increase with the storage modulus (G') at 100% strain (24,30). Integrity of shape and penetration force of skin lotions were also predicted by a combination of rheological and textural parameters (24).

Most rheological characterizations of skin creams were focused on linear viscoelastic properties [small-amplitude oscillatory shear (SAOS)]. Although they were shown to be correlated to sensorial properties of skin creams, they may not be sufficient to fully characterize the skin feel upon the application of skin lotions at high shear rates (500–5000/s) (27). Nonlinear viscoelastic properties [large-amplitude oscillatory shear (LAOS)] of cosmetic materials under high shear rates have not been well characterized. The objective of this work is to compare the rheological properties between a commercially available petroleum-based skin cream and a novel petroleum-free skin cream, focusing on the nonlinear viscoelastic properties of the samples.

MATERIALS AND METHODS

SAMPLE PREPARATION

The petroleum-free skin cream was prepared by following the method used by Wang and Marangoni (14). It is an o/w emulsion structured with glycerol monostearate (GMS) using SSL as the coemulsifier. The water phase contained 69.83% (w/w) of water, 0.1% (w/w) potassium sorbate, and 0.07% (w/w) xanthan gum. The oil phase was composed of 25% (w/w) oil and 5% (w/w) emulsifiers mixed with 19:1 (w/w) MG: SSL.

The oil phase used in the emulsion was Neobee® M-5 oil from Stepan Company (Northfield, IL) kindly supplied by Charles Tennant & Company Limited (Weston, ON, Canada). The GMS used was Alphadim 90 SBK and the SSL used was Emplex Sodium Stearoyl Lactylate, both provided by Caravan Ingredients (Lenexa, KS). The xanthan gum used was FASTir® Xanthan EC (TIC GUMS, White Marsh, MD), and the potassium sorbate was purchased from Sigma-Aldrich Canada Co. (Oakville, ON, Canada).

The petroleum-based skin cream was a Vaseline™ fragrance-free hypoallergenic intensive rescue repairing moisture lotion (Unilever Canada Inc., Toronto, ON, Canada) purchased from a local drugstore. Its ingredients are aqua, glycerin, petrolatum, stearic acid, glycol stearate, dimethicone, isopropyl isostearate, dihydroxypropyltrimonium chloride, hydroxyethyl urea, tapioca starch, cetyl alcohol, glyceryl stearate, magnesium aluminum silicate, stearamide AMP, carbomer, isopropyl myristate, cedrol, triethanolamine, disodium ethylenediaminetetraacetic acid, phenoxyethanol, methylparaben, and propylparaben.

The petroleum-free skin cream will be referred to as “experimental” while the petroleum-based skin cream will be called the “control” in this article.

DETERMINATION OF THE WATER CONTENT IN THE COMMERCIAL SKIN CREAM

The water content of the petroleum-based skin cream was determined by placing it in an oven set at 105°C for 24 h. Samples were weighed before and after drying in the oven and the water loss was calculated from the difference between the initial and final weights. Samples were prepared and measured in triplicate and the average percentage weight loss was reported as the water content.

BRIGHT-FIELD LIGHT MICROSCOPY

The microstructure of the experimental and control skin cream was observed using bright-field light microscopy. Samples were observed with a Leica DMRXA2 microscope (Leica Microsystems Canada Inc., Richmond Hill, ON, Canada), and images were taken with a CCD camera (RETIGA 1300i, Burnaby, BC, Canada) controlled by Volocity 6.2.1 software (PerkinElmer, Woodbridge, ON, Canada). The average emulsion droplet size of the two samples was computed from thresholding the images with Image J software (National Institution of Health, Bethesda, MD).

OSCILLATORY RHEOMETRY

The linear and nonlinear viscoelastic properties of the skin creams were determined using an Anton Parr MCR 302 dynamic rheometer controlled with RheoCompass software (Version 1.13, Anton Parr, Graz, Austria). The temperature of the plate was set at 25°C. The geometry used for the measurements was 2° plate and cone geometry with 50 mm diameter (Model CP50-2, Anton Parr). Strain sweep from 0.01% to 5000%, covering the linear and non-linear viscoelastic region (LVR) of the samples, was performed at frequencies of 0.05, 0.25, 0.5, 0.75, and 1.0 Hz. Storage modulus (G'), loss modulus (G''), and yield stress of samples were determined at all the frequencies. The yield stress was specifically determined as the value of stress at which G' deviated from the LVR. The overshoot of G'' was calculated from the difference of the value of G'' before it deviated from the LVR and the local maximum G'' before crossing over with G'. The cage modulus of was calculated from the slope of the stress–strain curve at zero stress, following the method used by Rogers *et al*. (31).

CONSUMER ACCEPTANCE TESTS

Consumer liking tests between the two samples were conducted using randomized double-blind tests in November 2014 when the weather is cold and dry. The use of human subjects for consumer acceptance and skin condition was approved by the research ethics boards of University of Guelph. Coded samples were presented to 60 panelists who were University of Guelph students and employees age between 18 and 50 years. Volunteers were informed and agreed to participate the study. Panelists were asked to apply the skin cream samples on the back of their left and right hands, and the side to apply each sample was randomized to eliminate contribution of hand dominance. Panelists were also required to score how much they liked the appearance, texture, and skin feel of each skin cream during pickup and rubout, by score out on a 5-point hedonic scale, where 1 is not like at all and 5 is like very much. The overall liking and likelihood of purchase of each lotion were also evaluated on a 9-point hedonic score (1 is not like at all and 9 is like very much). The panelists were also invited to comment on the texture and skin feel of each sample. An overall preference of the control or the experimental sample was asked at the end of test. Results were automatically analyzed and generalized with COMPUSENSE® five 5.0 (Compusense Inc, Guelph, ON, Canada).

MEASUREMENT OF SKIN HYDRATION

The experimental and control samples were applied to the inside of the left and right forearms of 10 panelists. The panelists were randomly selected from the 60 people who participated in the consumer-liking test and agreed to join further studies on skin conditions. Panelists were asked to stay in air-conditioned office area (20–22° C) for at least 30 min before applying skin lotions. Skin hydration and oiliness were measured before applying the lotion, right after applying the lotion, and 1 and 2 h after applying the lotion with a handheld skin sensor (Triplesense, SCHOTT MORITEX Corporation, Saitama, Japan). Changes in skin hydration and oiliness comparing to untreated skin throughout the 2 h after applying the skin creams were calculated for each participant. The average percentage increased after application of the skin creams obtained from the skin sensor from all the panelists were calculated and presented. Panelists whose untreated skin had zero oiliness were assigned with oiliness of 1 for calculating percentage increase in oiliness.

Two-way analysis of variance (ANOVA) at 95% confidence level using Sidak's multiple comparison tests were performed to determine whether significant differences exist between the two skin cream samples in terms of skin hydration and oiliness after application.

RESULTS AND DISCUSSION

FORMULATION AND MICROSTRUCTURE OF THE LOTIONS

The measured water content of the control sample was 87.13% ± 0.13% (w/w), with the remaining ~12 % (w/w) being other ingredients, mainly oil and emulsifier. Comparing the two samples, the control skin cream contained less oil than the experimental sample, which had 25% (w/w) oil. Both samples showed monodisperse structures under bright-field light microscopy (Figure 1). The control sample had smaller droplet size (below 2 μm diameter) than the experimental sample, with exploded starch granules with diameters of 20–40 μm as observed in the image (Figure 1A). The experimental sample had droplets that are slightly bigger than the control sample, and the average droplets size was ~4 μm diameter.

RHEOLOGICAL CHARACTERIZATION OF THE TWO SKIN CREAMS

The G' and G'' measured in the strain sweep from 0.01% to 5000% at 0.05 Hz of the two skin cream samples are presented in Figure 2. The two lotions were both in a gel-like

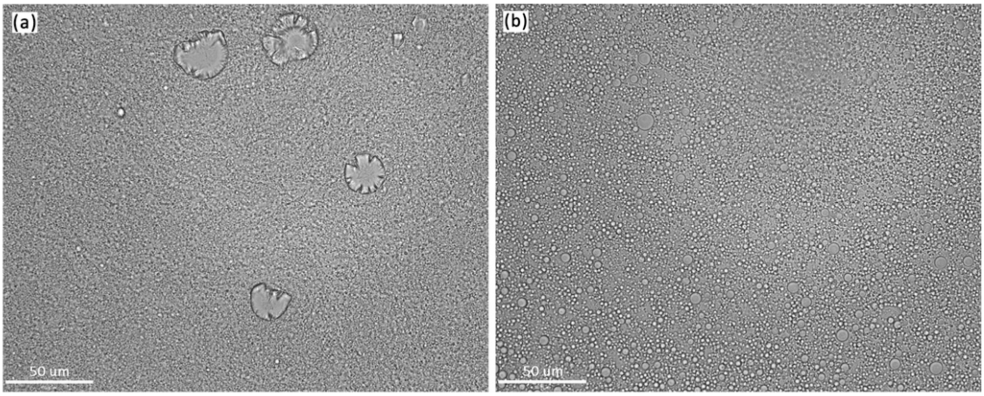

Figure 1. Bright field light microscopy images of (A) the commercially available petroleum-based skin cream and (B) the experimental petroleum-free skin cream (scale bar 50 μm).

structure, as indicated by a higher G' than the G'' in the LVR. After the strain amplitude was increased beyond the linear limit, the G' decreased and the G'' showed a weak strain overshoot and increased to a local maximum value before further decreasing and crossing over G' (32,33). Both the G' and the G'' decreased in the two skin creams when the shear strain was further increased, leading to the breakdown of their gel-like structures.

The G', G'', yield point, and G'' overshoot of the two samples measured at different frequencies are presented in Figure 3. The G' and G'' of both the samples showed frequency dependency (Figure 3A). The G' of the petroleum-based sample increased from ~550 to ~880 Pa and that of the control sample increased form ~600 to ~990 Pa when increasing the frequency from 0.05 to 1.0 Hz. The G'' of the control skin cream increased from ~120 to ~220 Pa, whereas that of the experimental sample decreased from ~150 to ~100 Pa. The yield point of the two samples did not show strong changes with frequency when considering the error, as shown in Figure 3B; however, the experimental sample had a lower yield point (14.7 ± 5.9 Pa) than the control (29.6 ± 6.1 Pa). The G'' overshoot of the experimental sample increased from ~20 to ~177 Pa when increasing the frequency from 0.05 to 1.0 Hz; however, the overshoot was not observed to change with frequency in the control skin cream (Figure 3C).

Differences in the rheological parameters of the two skin creams could be a result of their formulation and structure. The experimental petroleum-free skin cream has xanthan gum added as a stabilizer and texture modifier, which possibly affected the flow behavior

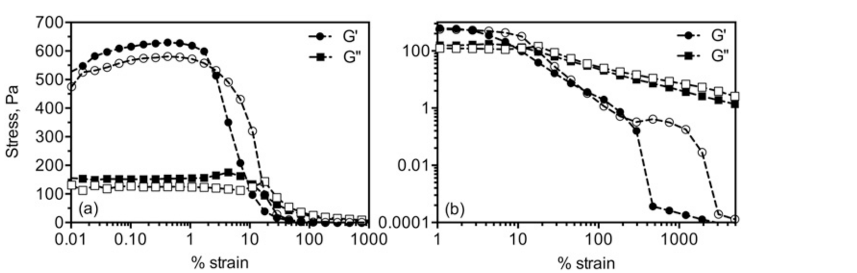

Figure 2. Storage modulus (G') and loss modulus (G'') as a function of strain amplitude measured at a 0.05 Hz. Modulus at (A) 0.01–1000 % strain and (B) 1–5000% strain. Solid symbols, experimental petroleum-free skin cream; empty symbols, commercially available petroleum-based skin cream.

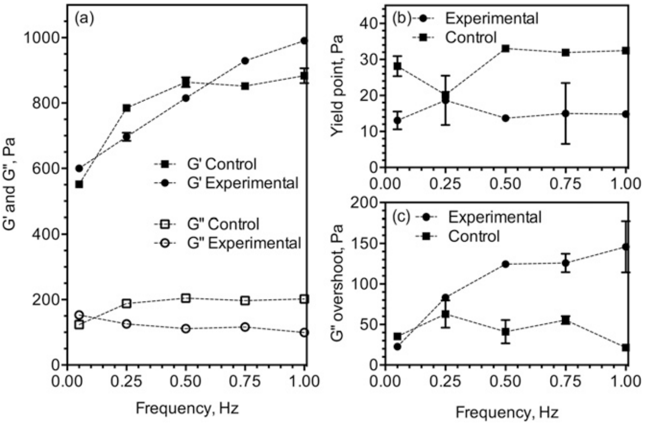

Figure 3. (A) Storage modulus (G') and loss modulus (G''), (B) yield point, and (C) G'' overshoot after the yield point obtained in the linear region measured at the frequencies from 0.05 to 1.0 Hz.

of the sample. Previous studies have shown that emulsions structured with xanthan gum were less affected by increasing probe speed or the container's diameter during texture analysis due to the shear thinning behavior of this polysaccharide (21–23). The overshoot behavior of G'' suggests that clusters of globules in the experimental skin cream potentially interact with each other and undergo structural rearrangement under shear (33), and such interaction is enhanced at higher frequencies, leading to an increased G'' overshoot. On the other hand, the yield stress observed from the control petroleum-based skin cream can be caused by its three-dimensional network structure that resists flow (28,34). However, the overshoot of G'' was independent of frequency and no structural rearrangement took place upon the application of shear. Additionally, the higher frequency dependency of the yield point of the experimental skin cream than the control is possibly caused by its bigger droplet size, as higher force is needed to break or move larger droplets to reach a liquid-like flow behavior.

A consequence of these differences in rheological properties was the noticeable difference in skin feel of the samples, as determined by sensory evaluation (27). Comments from panelists showed that the experimental lotion was harder to spread at the beginning but became "thinner" after a few rubs. Such skin feel of the experimental skin cream is possibly attributed to its higher G' at increased frequency but lower yield point, making it more elastic and harder to spread at first, however, becoming thinner than the control sample after the yield point. On the other hand, no structural rearrangement took place in the control skin cream, making it easier to spread during the first few rubs.

The shape of Lissajous curve demonstrates the onset of plastic response with increasing strain amplitude (35). Measurements obtained at lower frequencies are able to reflect more recovery of the material under shear compared with curves obtained at higher frequencies (36). Therefore, Lissajous curves obtained at 0.05 Hz for the two samples were compared in Figure 4. Both the skin creams showed narrow elliptical Lissajous patterns at strain amplitudes of 0.1% and 1% (Figure 4A and B), indicating that they were both in the LVR and had similar solid-like behavior (33). As the strain amplitude was increased to 10% (Figure 4C), the Lissajous curve of the control sample was still in an elliptical shape, but showed a larger internal area (i.e., opened up) than those at lower frequencies. On the other hand, Lissajous curves of the experimental sample became

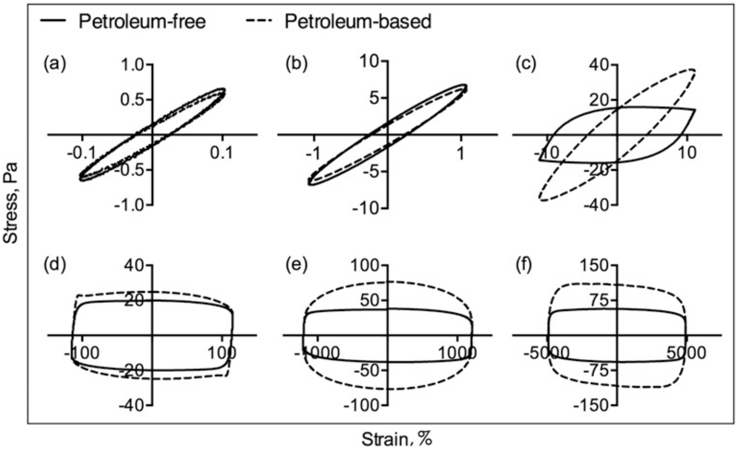

Figure 4. Lissajous curves of lotion samples measured at fixed frequency (0.05 Hz) at (A) 0.1%, (B) 1%, (C) 10%, (D) 100%, and (E) 1000% strain.

tilted, adopting a rectangular shape with sharper angles at higher strains. Such changes in the shape of the Lissajous curves suggest that they were in a transition stage from linear to non-LVR and both skin creams were transforming from a gel-like solid to a yield fluid (36). The faster opening-up of the experimental sample suggests that it behaves like a plastic material at lower strains than the control sample. Nonlinear behavior was clearly observed at 100% strain in both samples (Figure 4C), where the rectangular Lissajous curves suggested yield fluid properties (36). Both skin lotions are described as gel like, with a weak strain overshoot. Their rectangular Lissajous curves are likely caused by the sliding of layers of emulsion droplets upon the application of shear which results in the breaking down of the emulsion structure (32). Upon further increase of the strain to 1000% and higher frequencies (Figure 4E and F), the experimental sample remained as a yield fluid, indicated by rectangular Lissajous plots; however, the control sample became more liquid like as suggested by elliptical curves with large internal areas (32,36,37).

Normalized Lissajous curves of the skin creams obtained at various strains and determined at different frequencies are presented as Pipkin diagrams (Figure 5). The experimental sample (Figure 5A) was in the LVR at frequencies of 0.1–1.00 Hz under 0.1–1.0% strain, reflected by narrow elliptical Lissajous curves. At 0.1% strain and frequencies between 0.25 and 1.00 Hz, saw-like curves were observed, which are possibly caused by low signal-to-noise ratio. Increasing the strain to 10%, caused the narrow elliptical curves of the experimental sample to open up, and sharp angles were formed at high strains, indicating that the sample shifted to the non-LVR. At 100% strain and 0.05 Hz, the experimental sample showed rectangular Lissajous curves, however, at higher frequencies the curves remain tilted. The yield liquid properties are therefore frequency dependent and are observed at lower % strain when measured at low frequencies. Increasing the strain on the experimental sample to higher than 1000%, caused the Lissajous curves to adopt a rectangular shape, but became wavy at frequencies higher than 0.5 Hz, suggesting possible sliding or breaking of the emulsion structure, as observed in previous results.

For the control skin cream, a similar Pipkin diagram was observed (Figure 5B). However, the narrow elliptical curve started to open up at 1% strain, earlier than that of the

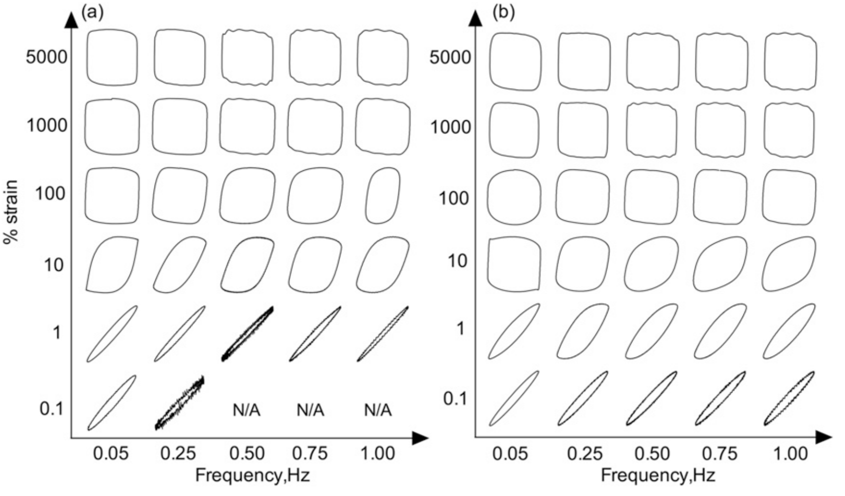

Figure 5. Pipkin diagram of the response of (A) the experimental skin cream and (B) the control skin cream to LAOS stress at different frequencies and stress amplitudes.

experimental sample (10%). Furthermore, elliptical curves of the control sample opened up more gradually when the strain was increased from 0.1% to 10%. This is possibly the reason for the ease of the initial spreading of the cream on the skin observed by the panelists in the consumer acceptance tests. The Lissajous curves observed for the control sample at 100% strain were all in rectangular shapes when measured at 0.25 Hz or higher, whereas those of the experimental samples displayed different shapes. Therefore, the nonlinear viscoelastic properties of the control skin cream were less frequency dependent at 100% strain than the experimental sample. The higher sensitivity to frequency of the experimental skin cream when compared to the control skin cream is possibly the result of the breakdown of clusters of emulsion droplets in its structure. The breakdown of the emulsion structure further leads to release of water, which provides a smooth (nongreasy) after-feel, as described by the panelists.

The stress–strain responses of the two skin creams were further characterized using the cage-based model developed by Rogers *et al.*(31) The cage-based model assumes that under shear flow, the movement of a particle is confined in a cage formed by its neighboring particles (31,38). The local cage modulus (G_{cage}) is defined from the slope of the stress–strain curve at vanishing stress [equation (1)], and is used to characterize the initial elastic strain of a suspension (31).

$$G_{\text{cage}} = \left.\frac{d\sigma}{d\gamma}\right|_{\sigma=0} \tag{1}$$

The calculated G_{cage} of the two cosmetic creams at 0.50 Hz are shown in Figure 6. In an emulsion system, we assume that the "cage" is formed by an emulsion droplet and surrounding droplets. G_{cage} of both the skin creams were close to the G' in the LVR and remained approximately constant when the strain amplitude was increased from 0.01% to 1%, indicating they are both elastic. Further increasing the strain lead to a decrease in G_{cage}, indicating these cages break and the skin creams yield and start to flow.

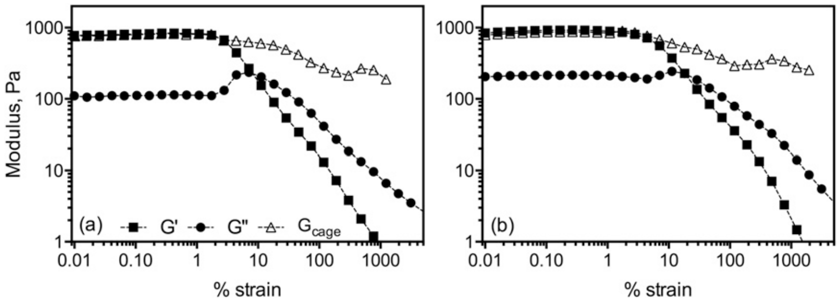

Figure 6. Calculated cage modulus (G_{cage}) of (A) the experimental and (B) the control skin cream at 0.50 Hz.

Unlike polymeric particle dispersion systems (31,38) and water-in-oil emulsions (36) previously investigated, the G_{cage} of the two skin creams studied in this work decreased in the LAOS region and did not recover. Such decrease of G_{cage} in an o/w emulsion systems suggests that "cages" formed by emulsion droplets do not reform after they break down, and the material loses its elasticity, displays more pronounced liquid-like behavior, and becomes spreadable. The liquid-like behavior inferred through the decreased G_{cage} is in agreement with the liquid-like behavior suggested by the open ellipse in the Pipkin diagram (Figure 5) when the applied strain exceeds 100%. Therefore, a decrease of G_{cage} upon increases in applied strain could be an essential rheological characteristic of spreadable emulsions.

The experimental (Figure 6A) and control (Figure 6B) skin creams showed similar changes in G_{cage} when the applied strain was increased, indicating therefore that the experimental skin cream and the commercial product have similar spread out and break down properties upon application.

SKIN HYDRATION AND CONSUMER ACCEPTANCE OF THE TWO SKIN CREAMS

The evaluation of skin condition within 2 h after application of control and experimental skin creams is shown in Figure 7. The two samples displayed a similar decrease in skin hydration after 2 h (Figure 7A), although the control showed a higher hydration level from the beginning to the end. A larger drop in % increase in skin hydration was observed on the skin area treated with the experimental skin cream than the area treated with the control skin cream. The oiliness dropped after application of both the skin creams within 1 h but remained at a constant level afterward (Figure 7B). Large variations in % change of skin hydration and oiliness were observed among the 10 panelists. However, based on statistical analysis from two-way ANOVA, no significant difference at 95% confidence level was observed in changes of skin hydration and oiliness after 1 min, 1 h, and 2 h after using the two skin creams. In terms of the efficacy of preventing water evaporation from human skin, petrolatum has been recognized as one of the most effective ingredients (1,39). It has been widely used in many cosmetic creams including the control skin cream investigated in this work. The petroleum-free experimental skin cream showed comparable skin hydration and oiliness to the control samples, suggesting that the barrier properties of the petroleum-free cream contribute to comparable increase in hydration with the commercial product.

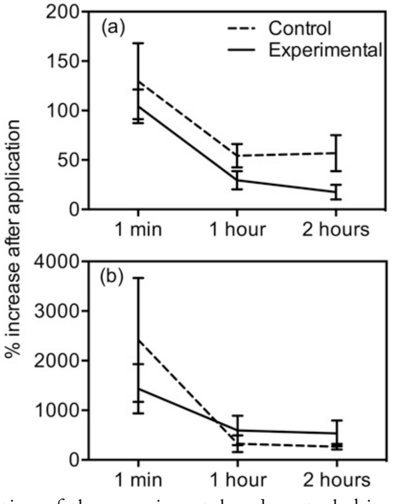

Figure 7. Moisture barrier function of the experimental and control skin creams on human skin. (A) Skin hydration and (B) oiliness measured in a 2-h period after applying the samples on panelists' forearms.

The experimental and the control skin cream also had similar consumer liking from the sensory evaluation (Figure 8A). The experimental lotion showed higher saleability, indicated by higher liking for purchase. However, in terms of overall preference or liking, 53.3% of the panelists prefer the commercial sample, whereas 46.7% prefer the experimental sample. In terms of the sensorial parameters evaluated, the experimental lotion was described to have higher greasiness and was considered more suitable for the wintertime, possibly due to its higher oil and emulsifier content. The similar consumer preference between the two samples therefore makes the experimental skin cream is potentially capable of competing with a successful commercial product, especially good for dry winter days as described by the panelists.

(a)

	Control	Experimental
Appearance	7.35±0.13	6.92±0.17
Texture	6.48±0.20	6.93±0.17
Skinfeel	6.42±0.23	6.58±0.23
Overall	6.35±0.21	6.78±0.20
Purchase	5.98±0.23	6.98±0.22

(b)

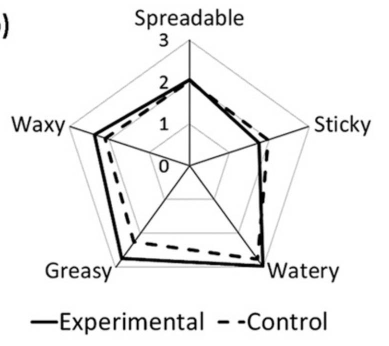

Figure 8. Consumer acceptance of the experimental skin cream compared with the control product. (A) Consumer liking scores of the skin creams and (B) comparison of different skin sensations after the application of the lotions.

EFFECT OF FORMULATION AND RHEOLOGICAL PROPERTIES ON SKIN SENSATION OF COSMETIC LOTIONS

The consumer perception of skin care products is affected by complex factors such as physical properties of products, touch behavior upon the application of products, and the time-varying pattern of mechanical stimulation of the skin surface (26). Changes in skin conditions from the application of skin care products also affect the sensation that consumers feel (26). Such complex physiological and psychological reactions toward the application of skin care products make it difficult to predict their sensorial properties from physical measurements.

Figure 9 presents a schematic diagram summarizing fundamental relationships between physical parameters and sensorial properties of topical skin cream based on the literature (24,27,28) and this study. The formulation and processing of skin cream products determine their structural and rheological properties, which in turn, affect skin feel upon application of the product. Oil content and texture modifiers (i.e., hydrocolloids and waxes), on the other hand, greatly affect the initial greasiness and oiliness of the product. Rheological parameters obtained in the LVR, especially the G', G'', yield stress, and yield strain, possibly determine the primary skin feel including hardness and initial spreadability of the skin cream. The G'' overshoot, frequency dependence and other factors obtained from LAOS experiments may suggest the spreadability and secondary skin feel after a few rubs.

CONCLUSION

Rheology and texture analysis have been widely used in the characterization of physical properties of food products, and recently, they have been employed in the characterization of cosmetic products. A petroleum-free skin cream has been developed using an

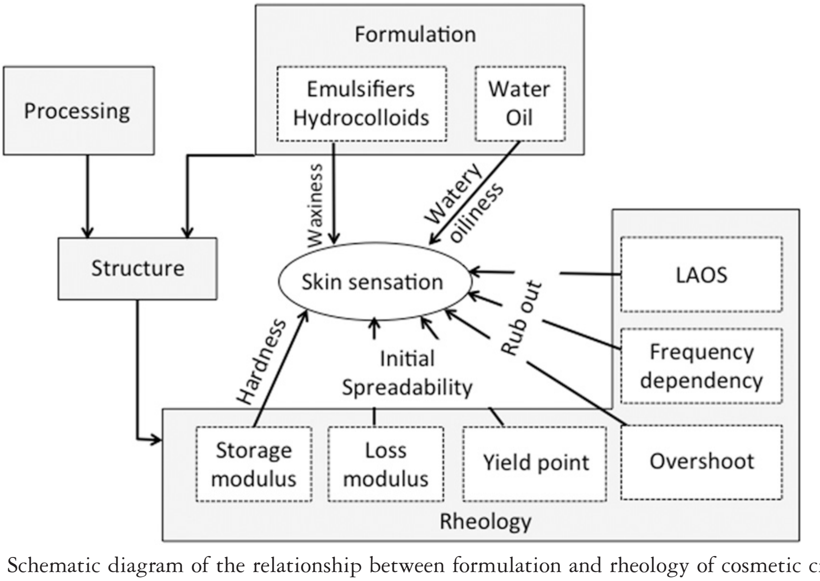

Figure 9. Schematic diagram of the relationship between formulation and rheology of cosmetic creams to the skin sensation.

MG-structured emulsion that was initially formulated as an alternative for low-fat shortenings. This work compared the rheological and sensorial properties of this experimental petroleum-free skin cream with a commercially available petroleum-based skin cream. The experimental skin cream showed similar linear and nonlinear viscoelastic rheological properties and comparable skin hydration, as well as consumer acceptance as the commercial product. A schematic diagram aiming to correlate the physical and sensorial properties of skin cream was also proposed at the end of the work.

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