ELEMENTIS
SPECIALTIES

A Comparison of Meadowfoam Seed Oil and Jojoba Oil

Introduction

Oils are one of the most common group of materials used in the personal care industry. They provide emolliency, to impart protection to the skin while also giving good lubrication and a positive feel to the skin. They can help provide consistency to the texture of products and also help to replace the oils found in the skin that may have been lost through use of harsh cleansing preparations.

Natural oils are essential ingredients for formulation chemists. Plant oils are esters of Glycerine and fatty acids which form Triglycerides. Natural oils can also contain various smaller components, such as free fatty acids, Phospholipids, Tocopherols and Hydrocarbons.

Jojoba Oil was initially introduced in the 1970s to replace Sperm Whale Oil and its derivatives in the cosmetic and personal care industries.

Structurally Jojoba Oil shows similarities to the human skin oil (sebum). It is therefore speculated that applying Jojoba Oil to human skin may send a biological message to the skin that it has produced enough sebum, thus balancing its oil production.

Jojoba Oil is actually a liquid wax ester and not an oil. It is a natural emollient and can be used to provide a protective coating on the skin, giving good spreadability. It is also useful as a hair conditioning agent.

Although Jojoba Oil has many benefits for the consumer, it is very expensive. It can cost a third more than Meadowfoam Seed Oil and supply can become restricted. For this reason we would like to propose the use of Meadowfoam Seed Oil as an alternative to Jojoba Oil.

Jojoba and Meadowfoam Plants

The Simmondsia Chinensis is an evergreen, drought resistant shrub commonly known as Jojoba, which is native to Arizona, California and Mexico, see Figure 1. It can grow to between 0.6 - 5 meters high and the roots can become up to 10 meters long. Jojoba is dioecious (has male and female reproductive plants). The Jojoba shrub has a life span of 100 - 200 years. The fruits of the Jojoba shrub are thinly shelled nuts.

Figure 1. Jojoba Shrub and Fruit

3 - 5 years after sowing the Jojoba nuts the Jojoba shrub is ready to start producing fruit. This takes another 6 - 7 months in dry conditions for the nuts to become ripe enough to harvest in September - October each year thereafter.

After 5 years each Jojoba shrub yields 400 - 500 g of nuts. After 12 years this increases to 2 - 4 kg of nuts and after 25 years a Jojoba shrub can produce 13 kg of nuts.

Figure 2. Meadowfoam Plant

The Limnanthes Alba is a flowering plant commonly known as Meadowfoam, see Figure 2. It is a herbaceous winter plant, which means that it has a soft green stem and all its parts above ground level die after it has finished growing. It is native to California and Oregon, where it preferentially grows in moist environments. It is an annual plant which can grow to 30 cm tall and the petals on the flowers can become 1 - 1.5 cm long.

The seeds of the Meadowfoam plant, seen in Figure 3, are about 3 mm in diameter and contain 20 - 30% Meadowfoam Seed Oil, whereas the nuts of the Jojoba shrub, seen in Figure 4, are about 12 mm long and contain about 48 - 56 % Jojoba Oil.

Figure 3. Meadowfoam Seed

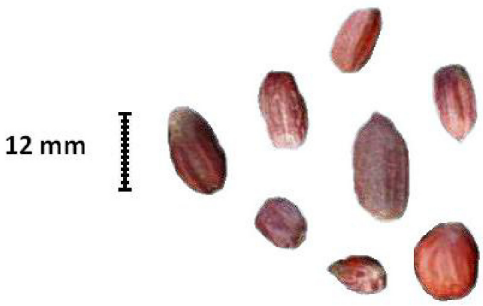

Figure 4. Jojoba Seed

Jojoba Oil and Meadowfoam Seed Oil Processing

FANCOR® Meadowfoam Seed Oil is removed from the Limnanthes Alba (Meadowfoam) seed using a mechanical crushing process. Elementis Specialties does not use an external heat source to aide the process. The product is then neutralised, lightened in colour and deodorised in order to produce the final refined Meadowfoam Seed Oil. Unlike other FANCOR® Meadowfoam Seed Oil is not produced via solvent extraction so is a natural product which has been refined in a natural way. This green processing method has enabled Elementis Specialties to gain Ecocert certification status for FANCOR® Meadowfoam Seed Oil.

Jojoba Oil can be made through either the solvent extraction process or cold pressing process like FANCOR® Meadowfoam Seed Oil. Some grades of Jojoba Oil also have Ecocert certification status, but not all.

Jojoba Oil has the INCI Name:

Simmondsia Chinensis (Jojoba) Seed Oil.

FANCOR® Meadowfoam Seed Oil has the INCI Name:

Limnanthes Alba (Meadowfoam) Seed Oil.

Jojoba and Meadowfoam Seed Oil Composition

Jojoba Oil is composed of different wax esters of C_{18-22} Omega-9 fatty acid (98 %) with a fatty alcohol.

FANCOR® Meadowfoam Seed Oil has unique structure not found in any other naturally occurring substance. It contains approximately 95 % C_{20-22} fatty acids.

The typical fatty acid profiles of Jojoba Oil and Meadowfoam Seed Oil are as follows:

	Jojoba Oil	Meadowfoam Seed Oil
Oleic Acid C18:1	14 %	-
Eicosenoic Acid C20:1	70 %	61%
Docosenoic Acid (Erucic Acid) C22:1	16 %	16 %
Docosadienoic Acid C22:2	-	18 %

Table 1. Fatty Acid composition of Jojoba Oil and Meadowfoam Seed Oil

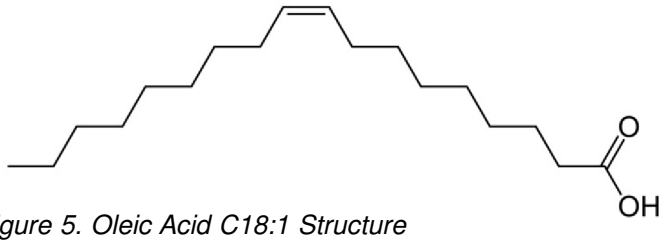

Figure 5. Oleic Acid C18:1 Structure

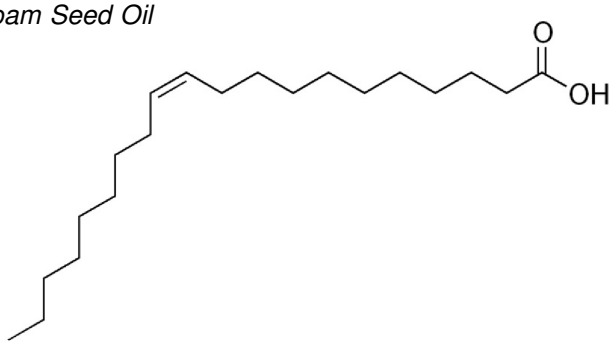

Figure 6. Eicosenoic Acid C20:1 Structure

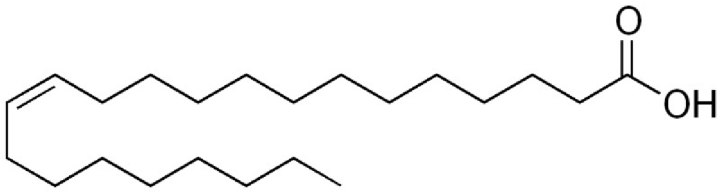

Figure 7. Docosenoic Acid (Erucic Acid) C22:1 Structure

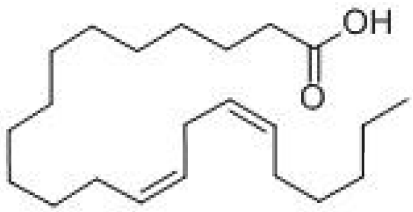

Figure 8. Docosadienoic Acid C22:2 Structure

From this direct comparison above we can see that Jojoba Oil and Meadowfoam Seed Oil have similar levels of the various fatty acids. The main difference is that Jojoba Oil contains the C_{18} fatty acid (Oleic Acid) whereas Meadowfoam Seed Oil contains the C_{22} fatty acid (Docosadienoic Acid).

This means that both oils have a similar smooth application on the skin, with the Meadowfoam Seed Oil offering a slightly richer feel.

Methodology for Determining the Oxidative Stability Index

The Oxidative Stability Index (OSI) determines the relative resistance of an oil to oxidation. Most oils are prone to oxidation and the speed at which this happens depends on the degree of unsaturation in the product and the presence of any antioxidants.

The Oxidative Stability Index was determined using the Oxidative Stability Instrument manufactured by Omnion, as seen in Figure 9, using the American Oil Chemists' Society (AOCS) official method number Cd 12b-92.

The temperature is set at 130°C. A stream of air is passed through the oil in the sealed test tube and then passed into another sealed test tube containing distilled water, as shown in Figure 10. The conductivity of the water is constantly monitored. During the test the conductivity of the water remains consistent until a sudden increase in conductivity is measured. This value in hours is recorded as the Oxidative Stability Index.

Figure 9 Omnion Oxidative Stability Instrument

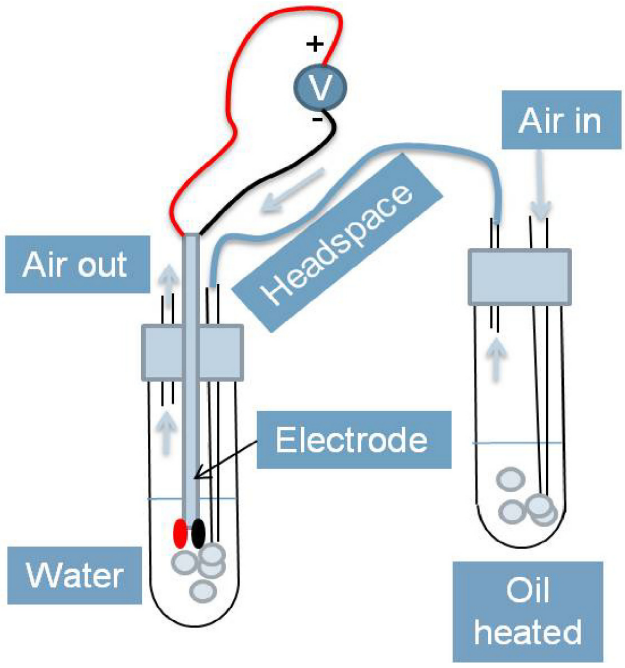

Figure 10. Oxidative stability testing process

Oxidative Stability Index Comparison

Meadowfoam Seed Oil is the most stable vegetable oil in the world. It contains powerful natural antioxidants and most importantly the unsaturated double bonds on the fatty acids are located at the Δ5 and Δ13 position. This combination of lack of conjugated double bonds and carrying its natural antioxidants delivers extraordinary oxidative stability, thus making it resistant to heat breakdown and oxidation.

Meadowfoam Seed Oil is a highly stable oil from nature and will actually extend the shelf life of less stable ingredients when added.

When tested at 130°C Meadowfoam Seed Oil has an average Oxidative Stability Index of 15 hours, whereas Jojoba Oil only has an Oxidative Stability Index of 9.5 hours, see Figure 11.

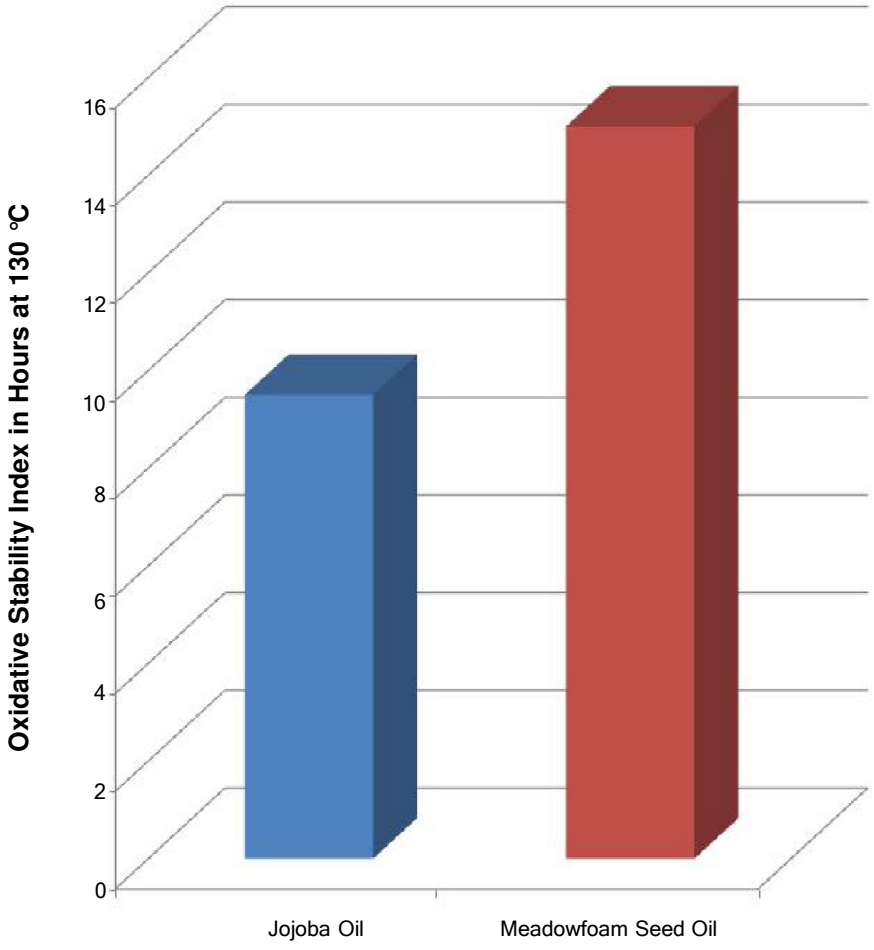

Figure 11. Oxidative Stability Index comparison of Meadowfoam Seed Oil and Jojoba Oil

Jojoba Oil and Meadowfoam Seed Oil Appearance

Jojoba Oil is a wax ester with a melting point of 7°C, which means that it is liquid at room temperature. Jojoba Oil can come in various shades, but it is most commonly clear and yellow, as shown in Figure 12.

FANCOR® Meadowfoam Seed Oil is a slightly golden coloured clear liquid oil, even though it has a high molecular weight. Meadowfoam Seed Oil tends to be lighter than Jojoba Oil. Both oils can be seen in Figure 12.

Flowcurves of the individual oils were measured using a Paar Physica MCR 300 Rheometer. The flowcurves, seen in Figure 13, show that Meadowfoam Seed Oil has a slightly higher viscosity than Jojoba Oil. This is probably due to the Meadowfoam Seed Oil containing slightly more fatty acids with a higher carbon chain length.

Figure 12. Comparison of appearance of Jojoba Oil and Meadowfoam Seed Oil

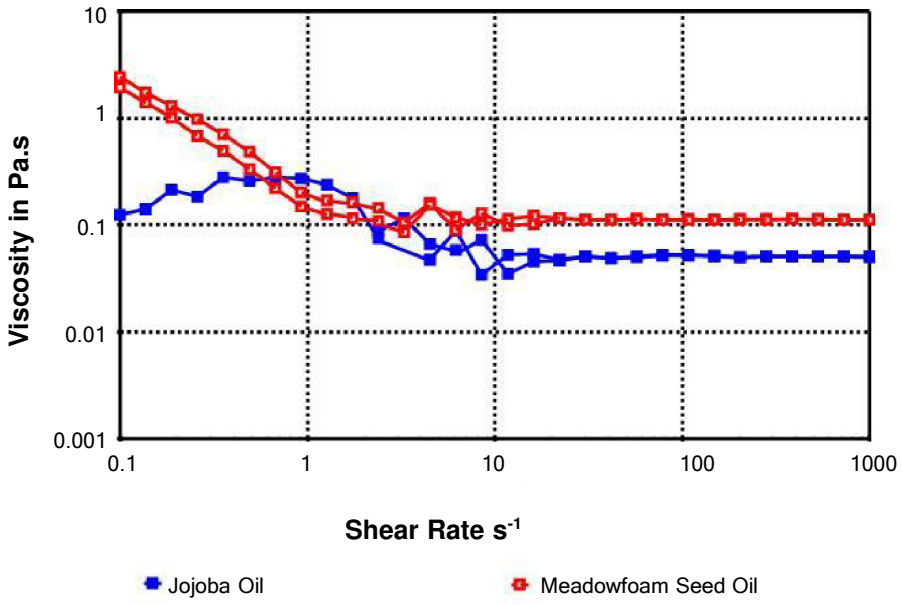

Figure 13. Flowcurve comparison of Jojoba Oil and Meadowfoam Seed Oil

Skin Feel Test Method

To measure the skin feel of Jojoba Oil and Meadowfoam Seed Oil they were each applied to 2 pieces of paper with a film thickness of 30 µm and left to dry. One piece of paper was cut to the same size as the sled and attached to this. The coefficient of friction was measured using a friction/peel tester, with a stroke length of 50mm at 0.125Hz with an applied load of 2N.

Figure 14. Thwing-Albert Friction/Peel Tester Model 225-1

Coefficient of Friction Comparison

The results of the coefficient of friction testing showed that Jojoba Oil produces a coefficient of friction of 0.07 and Meadowfoam Seed Oil gave a coefficient of friction of 0.2.

This is reinforced by the feel of the individual oils when applied to the skin. As we have seen previously Jojoba Oil and Meadowfoam Seed Oil have similar levels of the two fatty acids, Eicosenoic Acid, $C_{20:1}$, and Docosenoic Acid (Erucic Acid), $C_{22:1}$. The difference appears in the third main fatty acid in each oil. Jojoba Oil contains the C_{18} fatty acid, Oleic Acid, whereas Meadowfoam Seed Oil contains the C_{22} fatty acid Docosadienoic Acid.

This gives both oils a similarly smooth application on the skin, with the Meadowfoam Seed Oil offering a slightly richer feel. This is shown in the results for the coefficient of friction in Figure 15. The higher coefficient of friction is caused by the heavier feel of the Meadowfoam Seed Oil, which is imparted by the longer chain Docosadienoic Acid.

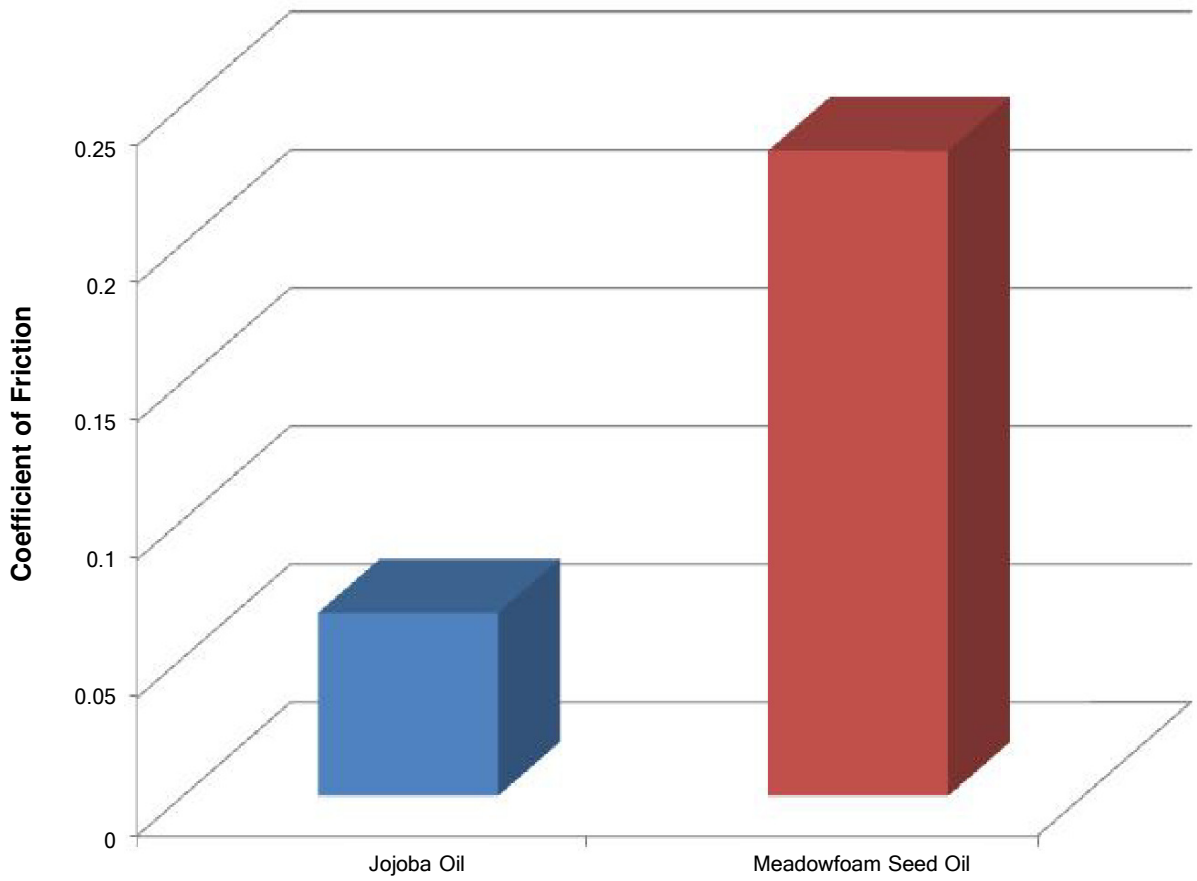

Figure 15. Coefficient of Friction comparison of Meadowfoam Seed Oil and Jojoba Oil

Formulation Comparison

Various formulations were made, one with FANCOR® Meadowfoam Seed Oil and one with Jojoba Oil for comparison testing.

Formula 1: Skin Lotion

Ingredient	Supplier	Formula 1	Formula 2
PHASE A		**% w/w**	**% w/w**
Deionised Water		75.5	75.5
PHASE B			
FANCOR® Meadowfoam Seed Oil (Limnanthes Alba (Meadowfoam) Seed Oil)	**ELEMENTIS Specialties**	**16.0**	**-**
Simmondsia Chinensis (Jojoba) Seed Oil		-	16.0
BENTONE GEL® VS-5PC V (Cyclopentasiloxane, Disteardimonium Hectorite and Propylene Carbonate)	**ELEMENTIS Specialties**	**2.0**	**2.0**
Tegosoft DEC (Deceyl Cocoate)	Evonik	3.0	3.0
Abil EM 90 (Cetyl PEG/PPG-10/1 Dimethicone)	Evonik	2.0	2.0
White Beeswax (Beeswax)	Strahl & Pitsch	0.5	0.5
PHASE C			
Germaben II (Propylene Glycol, Diazolidinyl Urea, Methylparaben and Propylparaben)	ISP	1.0	1.0
	Total	100.0	100.0

Procedure

1. Heat Phase A to 70-75°C.
2. Combine Phase B and heat to 70-75°C.
3. Add Phase B to Phase A with high shear mixing (i.e. Silverson Homogeniser).
4. Cool with propeller stirring.
5. At 45°C add Phase C and mix until homogeneous.

Physical Properties

Appearance	White Cream
pH	6.22
Viscosity - Brookfield RV, Spindle 6, 10rpm (cps)	28500

Formula 2: Sunscreen Oil Spray

Ingredient	Supplier	Formula 1	Formula 2
PHASE A		**% w/w**	**% w/w**
FANCOR® Meadowfoam Seed Oil (Limnanthes Alba (Meadowfoam) Seed Oil)	**ELEMENTIS Specialties**	**11.0**	**-**
Simmondsia Chinensis (Jojoba) Seed Oil		-	11.0
Cyclopentasiloxane		66.5	66.5
Eusolex OCR (Octocrylene)	Azelis	10.0	10.0
Eusolex 2292 (Ethylhexyl Methoxycinnamate and BHT)	Azelis	7.5	7.5
Eusolex OS (Ethylhexyl Salicylate)	Azelis	5.0	5.0
	Total	100.0	100.0

Procedure

1. Combine Phase A and mix until a clear solution is obtained.

Physical Properties

Appearance	Clear liquid spray
pH	N/A
Viscosity - Brookfield DV-II+, Spindle 7, 5rpm (cps)	N/A

Formula 3: Lipstick

Ingredient	Supplier	Formula 1	Formula 2
PHASE A		**% w/w**	**% w/w**
FANCOR® Meadowfoam Seed Oil (Limnanthes Alba (Meadowfoam) Seed Oil)	**ELEMENTIS Specialties**	**25.0**	**-**
Simmondsia Chinensis (Jojoba) Seed Oil		-	25.0
Ricinus Communis (Castor) Seed Oil		30.8	30.8
Koster Keunen Candelilla Wax (Euphorbia Cerifera (Candelilla) Wax)	Koster Keunen	7.0	7.0
Microcrystalline Wax		3.0	3.0
Koster Keunen Carnauba Wax (Copernicia Cerifera (Carnauba) Wax)	Koster Keunen	2.0	2.0
Ozokerite		2.0	2.0
Tocopheryl Acetate		0.1	0.1
Propylparaben		0.1	0.1
PHASE B			
Ricinus Communis (Castor) Seed Oil		15.0	15.0
Red 7 Lake		3.0	3.0
Red 6 Lake		1.0	1.0
Red 33 Lake		1.0	1.0
PHASE C			
Talc		10.0	10.0
	Total	100.0	100.0

Procedure

1. Combine Phase A and heat to 85°C.
2. Mill Phase B and add to Phase A and mix until uniform.
3. Add Phase C and mix until uniform.
4. Pour into mould and cool.

Physical Properties

Appearance	Solid red stick
pH	N/A
Viscosity - Brookfield DV-II+, Spindle 7, 5rpm (cps)	N/A

Formula 1: Skin Lotion Comparison

The skin lotion with Meadowfoam Seed Oil is a white cream compared to the skin lotion with Jojoba Oil, which looks like a yellow lotion, see Figure 15.

Figure 15. Skin lotions with Meadowfoam Seed Oil and Jojoba Oil

Flowcurve measurements for the skin lotions are shown in Figure 16. We can see that the skin lotion with Meadowfoam Seed Oil has a higher overall viscosity. This gives it a slightly richer texture.

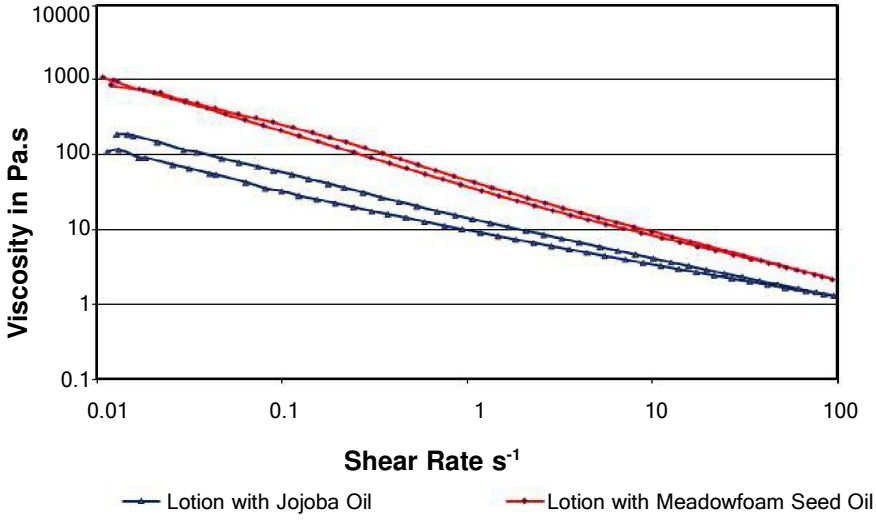

Figure 16. Flowcurve comparison of skin lotion with Meadowfoam Seed Oil and Jojoba Oil

Frequency sweeps were measured for the skin lotions with Meadowfoam Seed Oil and Jojoba Oil, see Figure 17. At low angular frequencies, representing the long-term behaviour of the emulsions, both the skin lotion with Meadowfoam Seed Oil and with Jojoba Oil showed good stability, with G', the storage (elastic) modulus, being higher than G", the loss (viscous) modulus. At high angular frequencies, which represent short-term behaviour, where short impact force is applied to the products, the skin lotion with Meadowfoam Seed Oil showed stability, whereas the skin lotion with Jojoba Oil had a higher G" than G', which could be an indication of instability in the formulation.

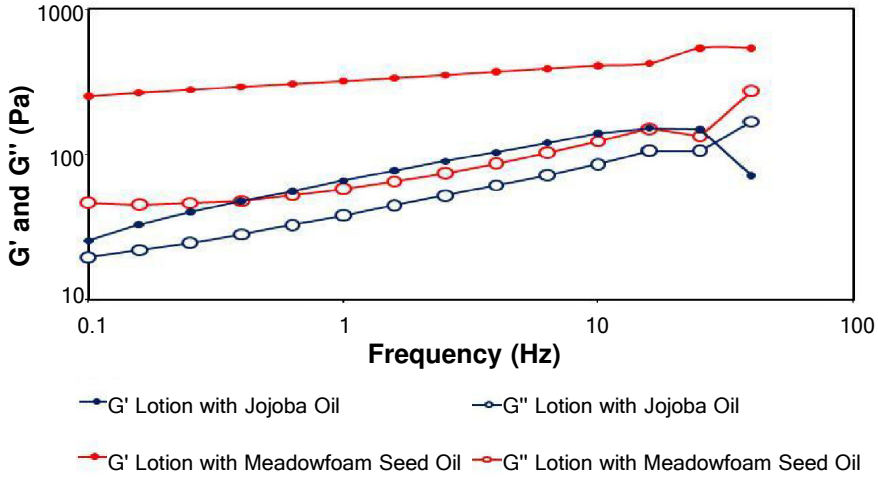

Figure 17. Frequency Sweep Comparison of skin lotion with Meadowfoam Seed Oil and Jojoba Oil

Formula 1: Skin Lotion Panel Testing

Panel testing was carried out to evaluate the various properties of the skin lotions with FANCOR® Meadowfoam Seed Oil and Jojoba Oil. Ten volunteers were given samples of both lotions to test and evaluate. The lotions were labelled A and B. Lotion A was the skin lotion with Jojoba Oil and Lotion B was the skin lotion with FANCOR® Meadowfoam Seed Oil. Panellists were asked to apply a small amount of Lotion A to the left hand using three fingers to spread it and apply a small amount of Lotion B to the right hand using three fingers. This was to be repeated every time the panellist washed their hands until the lotion had been finished. Panellists used the lotions at least three times per day. They were then asked to fill in the following questionnaire:

QUESTION 1: For **appearance**, what do you feel? a. A and B are very different. b. A and B are only slightly different. c. A and B are indistinguishable. QUESTION 2: For **stickiness**, what do you feel? a. A is much stickier than B. b. B is much stickier than A. c. A is slightly stickier than B. d. B is slightly stickier than A. e. A and B are indistinguishable. QUESTION 3: For **drag**, what do you feel? a. A has much more drag than B. b. B has much more drag than A. c. A has slightly more drag than B. d. B has slightly more drag than A. e. A and B are indistinguishable.	QUESTION 4: For **shine**, what do you feel? a. A has much more shine than B. b. B has much more shine than A. c. A has slightly more shine than B. d. B has slightly more shine than A. e. A and B are indistinguishable. QUESTION 5: For **skin softness**, what do you feel? a. A is much softer than B. b. B is much softer than A. c. A is slightly softer than B. d. B is slightly softer than A. e. A and B are indistinguishable. QUESTION 6: For **skin moisturisation**, what do you feel? a. A is much better than B. b. B is much better than A. c. A is slightly better than B. d. B is slightly better than A.	QUESTION 7: **Overall**, which best describes your perception of the lotions? a. A is much better than B. b. B is much better than A. c. A is slightly better than B. d. B is slightly better than A. e. A and B are indistinguishable. Comments:

Formula 1: Skin Lotion Panel Testing Results

The results of the panel testing were correlated and individual graphs were created to achieve a better impression of the results of the feedback.

In Figure 18 we can see the results from Question 1 where the panellists were asked to assess the products based on their appearance. One person could not tell any difference between the skin lotions with Meadowfoam Seed Oil and Jojoba Oil, but most people see a slight difference in appearance and three people thought the products looked very different.

In Question 2 panellists assessed the stickiness of the two skin lotions. The results of this can be seen in Figure 19. Four people found Lotion A, the skin lotion with Jojoba Oil, to be stickier than Lotion B, the skin lotion with Meadowfoam Seed Oil, but overall the panellists could not tell the difference.

In Figure 20 we can see the results from Question 3 asking the panellists to evaluate the drag created by both skin lotions. Overall the panellists could not tell the difference between the drag of the two products.

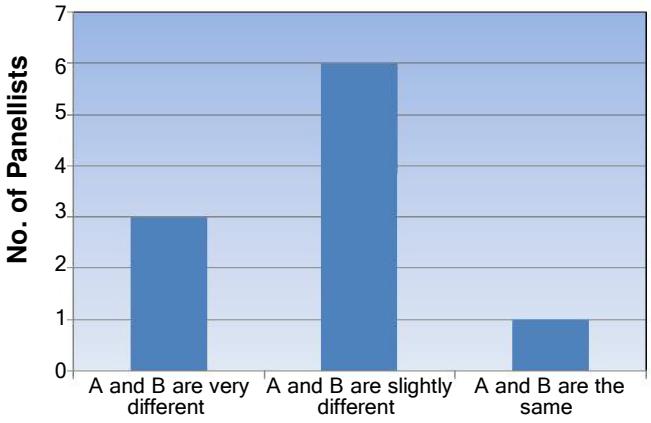

Figure 18. Assessment of appearance.

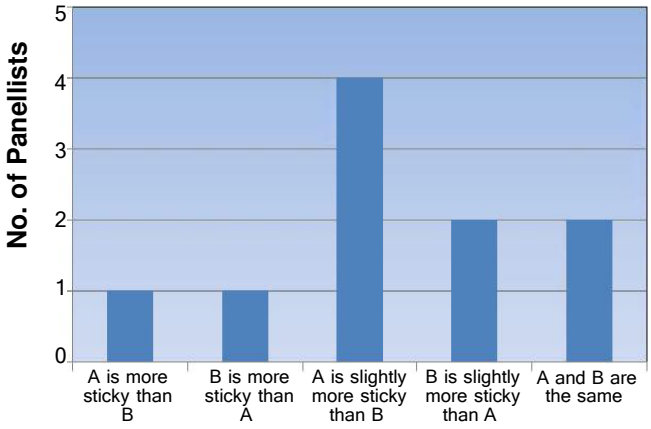

Figure 19. Assessment of stickiness

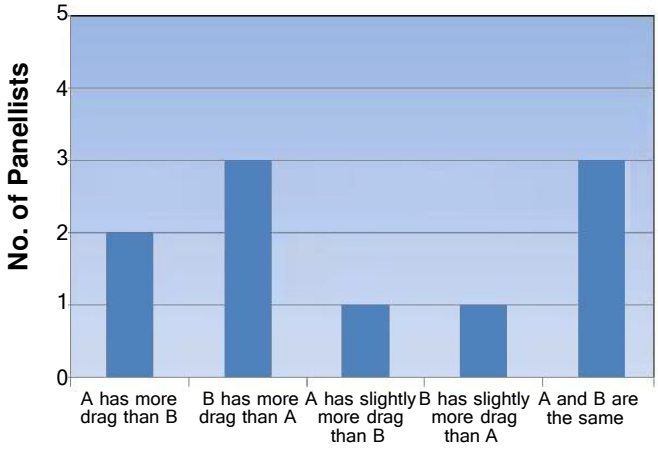

Figure 20. Assessment of drag

Formula 1: Skin Lotion Panel Testing Results

The results from Question 4 can be seen in Figure 21. The panellists were asked to assess the shine of the products. Overall the panellists saw similar shine for both samples.

In Question 5 panellists assessed the skin softness produced by the two skin lotions. The results of this can be seen in Figure 22. Here most panellists could not feel any difference.

In Figure 22 we can see the results from Question 6 asking the panellists to evaluate the skin moisturisation given by both skin lotions. The results from the panel were inconclusive, which means that no real difference can be seen.

In Figure 24 we can see the overall assessment from the panellists. Generally people felt that the skin lotions with Meadowfoam Seed Oil and Jojoba Oil were very similar.

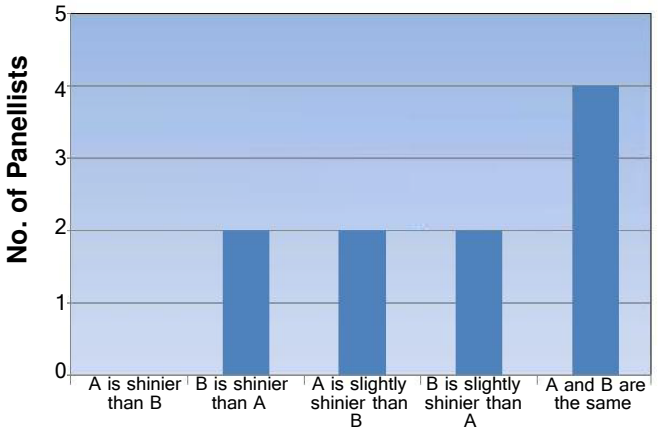

Figure 21. Assessment of shine.

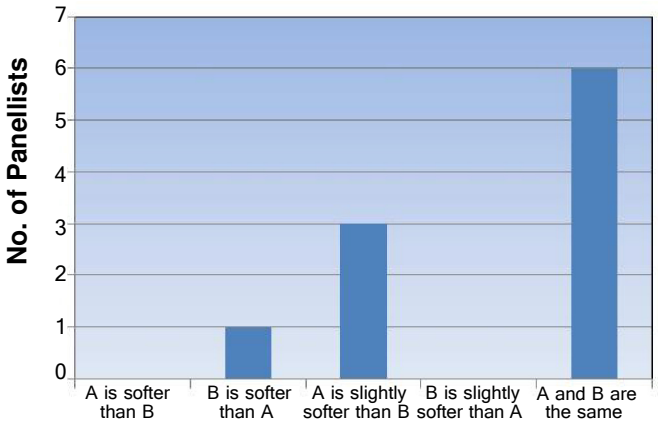

Figure 22. Assessment of skin softness

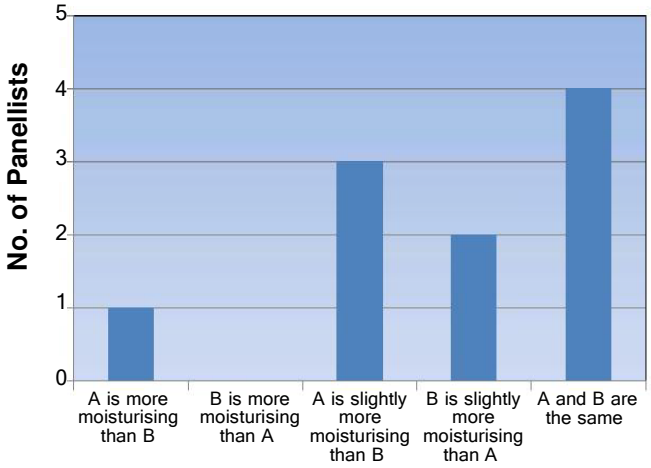

Figure 23. Assessment of skin moisturisation

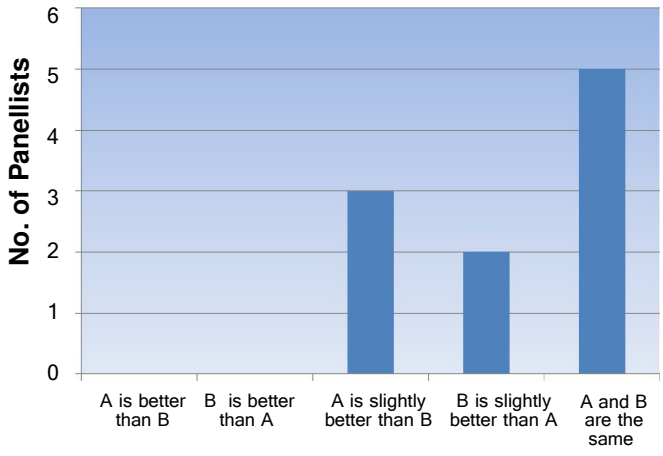

Figure 24. Overall assessment of the skin lotions

Formula 2: Sunscreen Oil Spray Comparison

In Figure 25 we can see the sunscreen oil sprays which were made with Meadowfoam Seed Oil or Jojoba Oil or neither oil. They all look very similar and have very similar feel properties.

Figure 25. Appearance of sunscreen oil sprays without test oil, with Jojoba Oil and with Meadowfoam Seed Oil

Formula 2: Sunscreen Oil Spray Comparison

Flowcurves were measured for all the sunscreen oil sprays. As can be seen in Figure 26, there was no real difference in the rheology of the products.

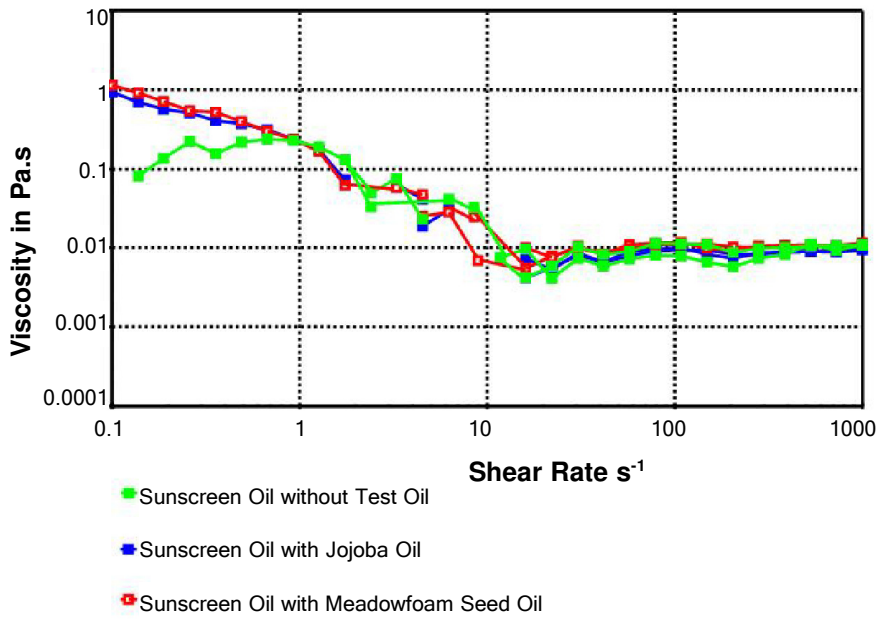

Figure 26. Appearance of sunscreen oil sprays without test oil, with Jojoba Oil and with Meadowfoam Seed Oil

The coefficient of friction was measured for the sunscreen oil sprays to assess the skin feel. In Figure 27 we can see that there is hardly any difference between the sunscreen oil spray with Jojoba Oil and the sunscreen oil spray with Meadowfoam Seed Oil.

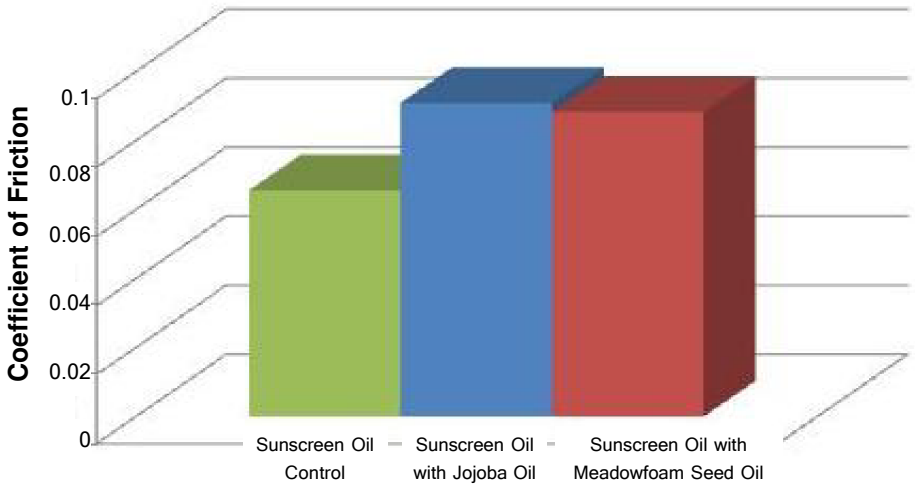

Figure 27. Coefficient of Friction comparison of Sunscreen Oils

Formula 3: Lipstick Comparison

In Figure 28 we can see lipsticks which were made with Meadowfoam Seed Oil or Jojoba Oil or neither oil. The lipstick with Jojoba Oil yielded a harder stick. The Meadowfoam Seed Oil gave a smoother appearance to the surface of the stick and also improved the release of the lipstick from the mould. The lipstick with Meadowfoam Seed Oil also gave more shine than the lipsticks with Jojoba Oil and without the test oils, see Figure 28.

Figure 28. Appearence of lipsticks without test oil, with Jojoba Oil and with Meadowfoam Seed Oil

Summary

FANCOR® Meadowfoam Seed Oil is a good high quality yet more economic alternative to Jojoba Oil. As Meadowfoam is an annual crop that is planted each year and yields seeds within months it is a more reliable oil source than Jojoba, which needs an initial growth period of 5 years before the seeds are produced which yield the oil. Below we have highlighted the similarities and enhanced performance characteristics of FANCOR® Meadowfoam Seed Oil compared to Jojoba Oil:

Similar Fatty Acid Composition

- Although slightly different the Jojoba Oil and Meadowfoam Seed Oil both have high levels of long chain fatty acids, which impart similar feel characteristics.

Improved Oxidative Stability Index

- FANCOR® Meadowfoam Seed Oil is the most stable vegetable oil in the world as it contains natural antioxidants and has a lack of conjugated double bonds. It has an oxidative stability index of about 15 hours at 130°C compared to 9.5 hours for Jojoba Oil, making it resistant to heat breakdown and oxidation. FANCOR® Meadowfoam Seed Oil can be used to increase the shelf life of less stable ingredients.

Improved Aesthetics

- Jojoba Oil tends to be medium to dark yellow in colour, whereas FANCOR® Meadowfoam Seed Oil is slightly lighter in colour and does not affect the end colour of the formulation as much as Jojoba Oil does.
- Meadowfoam Seed Oil can also increase the viscosity of formulations slightly, imparting a more luxurious feel and potentially improved storage stability.

Similar in Formulation Characteristics

- Panel testing showed that people could not really distinguish between two skin lotions with Jojoba Oil and Meadowfoam Seed Oil.
- When formulated into a Sunscreen Oil Spray both Oils gave similar properties.
- In a lipstick formulation with FANCOR® Meadowfoam Seed Oil gave slight improvements in stick texture and shine, as well as allowing for easier release from the lipstick mould.

Before using any of our products please consult our Safety Data Sheets.

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