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Evaluation of basic properties of jojoba oil for confirming the suitability for use in cosmetic products

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Abstract

Golden liquid wax reserved in the seeds of *Simmondsia chinensis (Link) Schneid* (common name: Jojoba)**,** the only species of family Simmondsiaceae, has chemical and rheological properties resembling to those of sperm whale oil. The purpose of this study was to evaluate the physicochemical properties of jojoba oil. The basic properties of jojoba oil included rheological properties, surface tension, spread ability, pour point, cloud point, acid value, peroxide value and saponification value. Viscosity of jojoba oil was found to be 5.37 ±0.05 mPas.Sec. Surface tension, spread ability, pour point, cloud point, acid value, peroxide and saponification values were 49.00 ±0.33 m N/m, 7±0.2 mm, 4.2±0.5ºC, 9.7±0.5ºC, 0.561 mg/g KOH, 0.87 meq/Kg, 84.15 mg / g KOH, respectively. All evaluated properties of jojoba oil confirmed its safety and suitability for further use in cosmetic products.

Keywords

Jojoba oil
Physicochemical properties
Cloud point
Spreadability
Viscosity
Peroxide value
Saponification value
cosmetics.

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Introduction

Jojoba oil is an odorless (Le Dréau et al., 2009) essential oil (Li, 2000). It is a mixture of long chain liquid wax esters which are linearly arranged (Rabasco Álvarez & González Rodríguez, 2000). Its esters have a carbon chain length of C38 to C44 and it is composed of C20:1 C22:1 and C24:1 fatty acids and fatty alcohols (Evans, 2009). Two ester molecules that contain 40 and 42 carbon atoms, make up to 80% of the oil, that's why jojoba oil is called wax (Le Dréau et al., 2009). Jojoba wax is commonly called as oil due to its liquid form at room temperature (Spadaro et al., 1960).

Jojoba plant is cultivated specifically for its seeds that contain oil making up to 50% of its total dry weight (Wisniak, 1994). It is a medicinal (Hall, 2007) and industrial crop (Osman, 2002). Native Americans had been used jojoba oil for different conditions of all types of skin. In Europe, Japan, Israel and Mexico cosmetic manufacturers have been used jojoba oil and its derivatives (Wickens, 2001). Uniqueness of jojoba oil is due to its molecular simplicity, stability under high temperature and pressure, tolerance for drought conditions (Jahromi & Fard, 2013) and unsaturation characteristics. During long storage period it does not go rancid (Agrawal *et al*., 2007).

Linearity and close-range composition are the two main properties that make jojoba oil unique in its characteristics. Two double bonds separated by ester bond are the three active centers in the jojoba oil molecule that are the source of a large number of intermediates or final products such as semi soft and hard waxes, additives for high temperature and high pressure applications, extract-ants for nuclear industry etc. (Wisniak, 1994).

The botanical name of jojoba is *Simmondsia chinensis (Link) schneid*. Other common names of jojoba are; goat nut (McMinn, 1951; Mirov, 1952; Dodge, 1958; Balls, 1972; Duke & Beckstrom-Sternberg, 2000), coffee berry (Mirov, 1952; Dodge, 1958; Minnich & Vizcaíno, 1998), bucknut, bushnut, coffee bush, goat berry, hohowai (original indian name) (Mirov, 1952), jojobe, nut bush, pig-nut, quinine nut, sheep nut wild hazelnut (Daugherty et al., 1958; Dodge,

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1958) deer nut (Dodge, 1958), lemon leaf (Sherbrooke & Haase, 1974), cocoba, cocovas (Dodge, 1958). It is a single member of its single species of its only genus of family either Buxaceae or Simmondsiaceae (Sherbrooke & Haase, 1974).

Current work was designed; to evaluate different basic properties of jojoba oil extracting through jojoba seeds produced in Pakistan to confirm the suitability of oil for cosmetic use.

Materials and Methods

Jojoba oil was a kind gift from Arid zone research center, Bahawalpur. The chemicals (ethanol, ether, ethylene glycol, sodium hydroxide, potassium hydroxide, chloroform, acetic acid) were the products of Merck, Germany while sodium thiosulphate, potassium iodide, potassium di-chromate, starch indicator and phenolphathalein indicator were purchased from Sigma chemical industries

Physical properties of jojoba oil: To measure the rheological value of jojoba oil a method proposed by Li *et al*. (1992) was used. Rheological test of viscosity of oil was performed by using a Brookfield RVDV III Ultra Rheometer with spindle IV. Range of speed was selected 100 – 190 revolutions per minute.

Specific gravity of jojoba oil was calculated after measuring the density of oil and water by using density bottle. Spreadability of oil was performed by using glass plates coated with gelatin; the method proposed by Roehl & Brand (1991). Falling drop method was used to determine the surface tension between jojoba oil and water. Stalagmometer was used for counting the number of drops of jojoba oil and that of water. Pour point and cloud point of jojoba oil was determined according to ASTM standards 1983.

Physicochemical properties of jojoba oil: Peroxide value, acid and saponification number of jojoba oil were estimated according to the official methods of AOAC 1999 (Horwitz & Latimer, 2000).

Results and Discussion

Physical properties of jojoba oil: Viscosity of jojoba oil has been measured at 100-190rpm speed (with increment of 10) and mean value found to be 5.37 cp. Results for rheological parameters of jojoba oil are shown in Tables 1, 2 and Figure 1.

To know about the flow behavior of oil and ultimately the viscosity of cosmetic emulsion, it is of utmost importance to search Newtonian or Non-Newtonian behavior of oil. It is an important physical property. When power law is applied, if the flow index of liquid is 1 then it is Newtonian and if value deviates from1 then liquid shows non-Newtonian behavior. In the present study jojoba oil has flow index of 1 that confirms its Newtonian behavior and confidence of fit is 99.5 showing it is maximum fit.

Table 1: Rheological parameters of jojoba oil at 25°C.

Viscosity (cp)	Speed (RPM)	% torque (%)	Shear stress ($D/cm^{2)}$	Shear rate (1/sec)	Temperature
5.40	100	4.37	10.81	200	25.03
5.36	110	4.82	11.79	220	24.98
5.42	120	5.31	13.02	240	25.00
5.38	130	5.73	14.00	260	24.98
5.35	140	6.12	14.98	280	24.98
5.32	150	6.53	15.96	300	24.95
5.37	160	7.01	17.19	320	24.95
5.42	170	17.47	18.42	340	24.93
5.39	180	18.90	19.40	360	24.98
5.36	190	20.31	20.38	380	24.90

Table 2: Rheological analysis of jojoba oil.

Parameters	Values
Temperature	25°C
Flow index	1.00
Consistency index	5.51cp
Confidence of fit	99.5%
Yield stress	$0.03D/cm^2$
Plastic viscosity	5.37cp

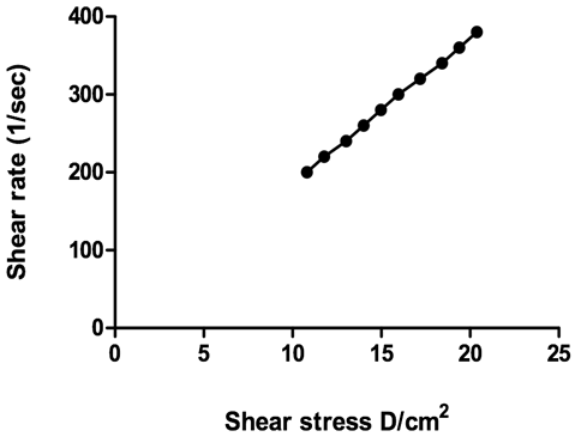

Fig. 1: Rheogram of Jojoba Oil.

It has been reported that higher the viscosity of oil, higher will be the viscosity of emulsion prepared by it and thus there is a correlation between the viscosity of cosmetic oil and the experienced greasiness (Akhtar *et al*., 2006). It has been confirmed in present work as jojoba oil showed low viscosity and the emulsion containing jojoba oil has been found to be less viscous. It has been reported that saturation, unsaturation, position of hydroxyl group in the fatty acids chains and the chain length influence the viscosity of oils, that shows oil having longer chain length will have greater viscosity such as in the case of olive, almond, sesame, cottonseed and sunflower oils. But exceptions are there; as in the case of paraffin oil that is long chain fatty acid but viscosity is found to be low (7.11 cp).

Physicochemical properties of jojoba oil: Mean value of Specific gravity of jojoba oil was found to be

Table 3: Basic properties of jojoba oil.

Viscosity +SE cp n=10	Specific Gravity +SE n=5	Spreadability +SE (mm) n=5	Surface Tension +SE mN/m n=5	Pour point +SE ˚C n=3	Cloud point +SE ˚C n=3	Peroxide value+SE meq/kg n=3	Acid value+SE mg/gKOH n=3	Saponification value+SE mg/gKOH n=3
5.37±0.05	1.13±0.03	7±0.2	49.20±0.04	4±0.4	10±0.5	o.87±0.5	o.561±0.03	84.15±1.15

1.13±0.03. It showed that molecules of jojoba oil are more closely packed. In a study specific gravity of paraffin oil was found to be 0.999 and that of coconut oil was 0.9138. Spreadability of oil depends upon external environment temperature and relative humidity. Diameter of spreading area of jojoba oil has been found to be 7 mm ±0.2 (SE). This value shows that jojoba oil has low spreadability.

Subjective evaluation of penetration capability of oil in the *stratum corneum* of skin is correlated with the spreadability of oil. Although jojoba oil has low spreadability that is due to its structure having long chain fatty acids and that is related to enhance the penetration capability of oil in the skin. Spreadability of oils is correlated to viscosity and chain lengths. Generally, more viscous oils show less spreadability or vice versa and oils of long chain fatty acids also show low spreadability and vice versa. So, jojoba oil is unique in nature having low spreadability with low viscosity. The low spreadability of oils can be enhanced easily by the addition of alkyl-substituted silicones that act as surface active agents and modify the surface tension. Surface tension or interfacial tension can be understand by the work required to increase the area of a surface isothermally and reversibly by unit amount. The spreading tendency of one liquid over another liquid, that are water and oil in our case, can be designed by a spreading coefficient i.e;

$$S = W^{adh} - W^{coh}$$

Spreading coefficient S shows that how readily the oil can spread over water. Calculations using above equations then lead to the confirmation of formulation of stable emulsion system.

Surface tensions of various natural oils such as avocado oil, macadamia oil and almond oil were reported as 34.6mN /m, 33.03mN /m and 36.3mN /m (Akhtar *et al*., 2006). In this study density of jojoba oil has been found to be 0.8904 g/cm3 and surface tension of jojoba oil has been found to be 49.20±0.04 mN/m. It means jojoba oil has higher value of surface tension as compared to other natural oils. Cloud point is the temperature at which a substance starts to be turbid on dropping temperature, while pour point of oil is the temperature at which a substance starts to be solidified. Freeze stability of w/o emulsions and pour point of oils have direct relationship. Thus, it can be said that if the oil has low pour point value then the oil will have low solidification point, as a result freeze stability of oil will be good. Oil's viscosity has inverse relation with pour point and cloud point of oil. In the present study cloud point and pour point of jojoba oil were found to be 10°C and 4°C respectively. As viscosity of jojoba oil is found to be low (5.37 mPa) so pour point and cloud point values are high.

Initial changes in oxidative stability can be indicated by peroxide value. By monitoring the amount of hydroperoxides as a function of time, it is easy to assess whether the oil is in the position of growth or decay (Shahidi & Zhong, 2010).

Oils or fats may become rancid during storage due to the formation of peroxides at double bond by the action of microorganisms in the form of hydrolysis and atmospheric oxygen. Free acids are also liberated in this way. Oils with lower peroxide value show good shelf life of oil (Sandha & Swami, 2009). In this study average peroxide value of jojoba oil was found to be 0.87 meq /kg. It indicated that minimum oxidation had occurred. Thus, jojoba oil has good shelf-life. Acid value is the number of mg of KOH that is required to neutralize the free fatty acids present in one gram of oil or lipid. The acid value is dependent on the number of free fatty acids. Greater the number of free fatty acids in oil, more will be the acid value of the oil and vice versa. Free fatty acids indicate the age and quality of the fat and oil. Average acid value of jojoba oil is found 0.561 mg/g KOH. As acid value of jojoba oil is low so it can be said that it has a longer shelf life which is an important parameter from cosmetics point of view. Saponification Value is the number of mg of KOH that is required to convert 1 gram of the fat completely into soap and glycerin is called saponification value. Saponification value indicates the nature of the fatty acids present in fat or oil. It means longer the fatty acid chain, less acid will be liberated per gram of fat hydrolyzed. This property of oil or fat is specifically concerned with the solubility of the soap of that specific oil or fat in water. In this study average saponification value of jojoba oil was found 84.15 mg/g KOH. As the saponification value of oil, free from moisture and unsaponifiable matter is high, more soluble the soap will be that can be made from it. This is the basic parameter that makes jojoba oil suitable for making soaps, shampoos, hair conditioners, moistures etc. (Sandha & Swami, 2009). Results are shown in Table 3.

Conclusion: As a conclusion of this work, we find that jojoba oil has; low spread ability and low viscosity due to the long chain fatty acids, high pour point and cloud

point values that are related to low viscosity, high saponification value and low acid value that show good shelf life of oil, good oxidative stability of oil has been confirmed by low peroxide value. Surface tension value is slightly higher than other natural oils. Overall jojoba oil is found suitable for further use in cosmetic products.

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