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ARAŞTIRMA MAKALESİ/RESEARCH ARTICLE

COMPARATIVE EVALUATION OF TWO COSMETIC OILS: ALMOND and AVOCADO

Yasemin YAZAN[1], Sefa AVCIER

ABSTRACT

The basic characteristics of cosmetic oils are needed to be determined since they greatly influence the colloidal, formulation and application characteristics of the emulsions prepared. Basic properties of almond oil, viscosity, surface tension, spreadability, polarity, pour and cloud points, and emolliency effect on human skin have been determined and compared to a reference, avocado oil. These properties are considered as the minimum requirements for further studies on cosmetic formulation and application.

Key Words: Almond Oil, Avocado Oil, Characterization, Evaluation on Skin.

İKİ KOZMETİK YAĞIN KARŞILAŞTIRMALI DEĞERLENDİRİLMESİ: BADEM YAĞI VE AVOKADO YAĞI

ÖZ

Kozmetik yağların temel özelliklerinin belirlenmesi, bu yağlarla hazırlanan emülsiyonların kolloidal, formülasyon ve uygulanma özelliklerini büyük oranda etkilediği için gereklidir. Badem yağının temel özellikleri olan viskozite, yüzey gerilim, yayılabilirlik, polarite, damlama ve bulanma noktaları ve insan cildi üzerindeki nemlendirme ve yumuşatma etkisi saptanmış ve referans yağ avokado ile karşılaştırılmıştır. Bu özellikler, kozmetik formülasyon ve uygulamada daha ileri çalışmalar için minimum gereksinimlerdir.

Anahtar Kelimeler: Badem Yağı, Avokado Yağı, Karakterizasyon, Ciltte Değerlendirme.

1. INTRODUCTION

Cosmetic oils need to be characterized and distinguished completely for formulation purposes and performance of the product. Oils are one of the major constituents of cosmetic emulsions. Like all ingredients of a specific formulation, oils have to be evaluated comprehensively including economical, dermatological, toxicological, ecological and certainly physicochemical aspects. Subjective data of sensory description, psychophysical scaling, consumer hedonic evaluation and product optimization were found to be in correlation with the characteristics and amount of the components in the formulation (Yazan, 1999).

Determining the exact physico-chemical properties of cosmetic oils are relevant for the colloid chemistry as well as for the sensory properties of emulsion preparations (Dietz, 1999a; Roehl and Brand, 1991). Basic properties, namely, *viscosity, surface tension, pour and cloud points, spreadability and polarity* are the parameters used to define cosmetic oils.

The purpose of this study was to determine the physico-chemical characteristics of almond oil which has been used in our previous study and to compare them to those of a reference, avocado oil (Yazan, 1995). Since cosmetic oils are classified as liquid lipophilic emollients, the emolliency characteristics of the two oils were also tested on human volunteer skin.

1 Anadolu Üniversitesi, Eczacılık Fakültesi, Farmasötik Teknoloji ABD, Kozmetoloji Bilim Dalı, 26470, Eskişehir-TURKEY.
Tel: 222.335 05 80 (10 lines) ext. 3631, 3656. **E-mail:** yyazan@anadolu.edu.tr.

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2. MATERIALS and METHODS

Materials

Almond oil (Tıp-Tek, Turkey), avocado oil (Novarom, The Netherlands) and nile red (Aldrich, England) were used for evaluations.

Apparatus

Water bath (PolyScience 9005) and a rheometer (Brookfield Rheometer DV III) were used. Corneometer, Sebumeter and Skin-pH meter were all Courage&Khazaka.

Methods

Rheological Analysis

The rheological testing was performed using a thermo-controlled stress rheometer in the cone and plate geometry. The cone used had an angle of 1.565°, radius of 1.2 cm and a shear rate of 3.84XN (N=rpm). Approximately 0.2 g samples and a constant temperature of 25°C were used for tests. Tests were repeated two times, each containing 9 values of shear rate.

Following the determination of the flow type, flow curves were fit to one of the available mathematical models.

Surface Tension

Surface tension (or surface energy) is defined as the work required to increase the area of a surface isothermally and reversibly by unit amount (Shaw, 1992). Capillary rise method is the most accurate method for determining surface tensions, when performed properly. This method of measurement allows to follow slow time effects since no surface disturbance is involved (Buckton, 1995).

Capillary rise method at 25±1°C was used in this study to determine the surface tension of almond and avocado oils, and water. Diameter of the capillary was measured using a compass and following the determination of densities of the two oils, surface tensions were calculated. Each measurement was repeated 5 times and the mean was taken.

Spreadability

The method proposed by Roehl and Brand (Roehl and Brand, 1991) was used to test the spreadability of the two oils using glass plates coated with gelatine.

1 % aqueous solution of gelatine was prepared by gentle heating. Microscopic slides which have a flat, glass surface were wetted uniformly with the gelatine solution. The film was allowed to solidify on a tray floating on an ice bath for 1 hr. The film was then dried at room temperature for 2 days followed by storage at 25°C, dust-free cabin for 24 hr. The spreadability tests were performed in a conditioned room of 40 % relative humidity and 25°C temperature. Coated glass plates were placed on milimeter graph paper on a flat surface. 10 μL of the oil to be tested was put on the plate using a microliter pipette. After 5 minutes, the diameter of the circular spreading area was read. The test was repeated 5 times and the mean measurements were then assigned to the given standards (Dietz, 1999a).

Pour Point and Cloud Point

Pour point specifies the temperature at which the oil solidifies and is defined as the temperature on cooling, with 3°C added thereto, at which the substance is no longer able to flow (DIN ISO 3016).

Cloud point of an oil is defined as the temperature at which the substance becomes turbid on cooling (EN 23015) (Dietz, 1999a). The determination of pour and cloud points of the almond and reference oils was performed in a water bath (± 0.1°C). The two tests were repeated three times.

Polarity

The method proposed recently to set up a scale of polarity for cosmetic oils with the help of the solvatochromic dye, nile red, was used to determine the polarity of almond and avocado oils (Dietz, 1999b). The test was repeated three times for each oil.

12 mg nile red was weighed into a 10 mL volumetric flask and made up with chloroform. From this stock solution, 50 μL was transferred into a 10 mL volumetric flask and chloroform was evaporated ensuring the even distribution of the dye on the glass wall. The oil to be tested was then filled up to 10 mL and agitated for 12 hr using a small magnetic bar, until the dye had dissolved completely. UV spectrum was determined with UV-spectrophotometer (Shimadzu UV-160 A) with the pure oil as reference.

Dermatological Tests

Since cosmetic oils are classified as liquid lipophilic emollients, the emolliency characteristics of the two oils were tested on human skin (Goldemberg, 1971).

10 female volunteers were involved in emolliency tests. Following the confirmation of the unity of forearms, 2 cm X 2 cm areas on each forearm were labeled for application of the two oils. Water and oil content, and pH values of the specified regions were measured as basic values. Measurements were repeated after the application of oils at half, 1^{st}, 3^{rd} and 6^{th} hours. Results were compared using SPSS (Univariate ANOVA and Post Hoc Tests) to investigate any variance between the hours for each oil and using independent samples t-test to investigate the variance between the two oils, on the computer.

3. RESULTS and DISCUSSION

Rheological Analysis

Rheology of dispersed systems is among their most important physical properties, which influences not only the physical stability of the system, but also the performance, quality and utility of the product (Mitsui, 1998).

It is known that the greater the viscosity of the oil, the greater is the viscosity of the emulsion. It was also found that there is a high level of correlation between the viscosity of cosmetic oils and subjectively experienced greasiness (Zeidler, 1992).

Continuous phase plays the dominant role in the rheology of emulsion even though each component contributes to the emulsion's rheology. Viscosity of the emulsion is directly proportional to the viscosity of the continuous phase. The dispersed phase affects the rheology of the emulsion by its volume concentration, globule size, viscosity and chemical constitution (Zeidler, 1992). Emulsions show a wide range of rheological properties, depending on the nature of the dispersed globules they contain and on the composition of the dispersion media (Radebaugh, 1996).

Almond and avocado oils tested in this study showed Newtonian flow as can be followed in **Figure 1.** Almond oil follows the regression of y=0.561x-7.773 where y is the shear stress (dyn.cm^{-2}), x is the shear rate (sec^{-1}), with a correlation coefficient of 0.999; while avocado oil follows the regression of y=0.997x-6.088 with a correlation coefficient of 0.999. Cosmetic oils are usually Newtonian liquids with relatively low viscosities (Dietz, 1999a). Shear thinning indices of almond and avocado oils were found to be 1.01 and 0.99, respectively. These values also confirm the Newtonian characteristic of the two oils since the values are nearly 1.

Newtonian liquids show an ideal flow where shear stress is proportional directly to the shear rate:

$$\sigma = \eta \gamma \qquad (1)$$

where σ is the shear stress, γ is the shear rate and η is the absolute viscosity (Yazan, 1999). Viscosity is independent of the shear rate (**Equation 1**) and was found to be 54.6 and 98.4 mPas s for almond and avocado oils, respectively.

Surface Tension

The interaction between two different liquid phases forms the basis of emulsion science. The tendency for one liquid to spread over another, which is oil and water in our case, is designated by a spreading coefficient, S. The spreading coefficient is (Buckton, 1995):

$$S = W^{adh} - W^{coh} \qquad (2)$$

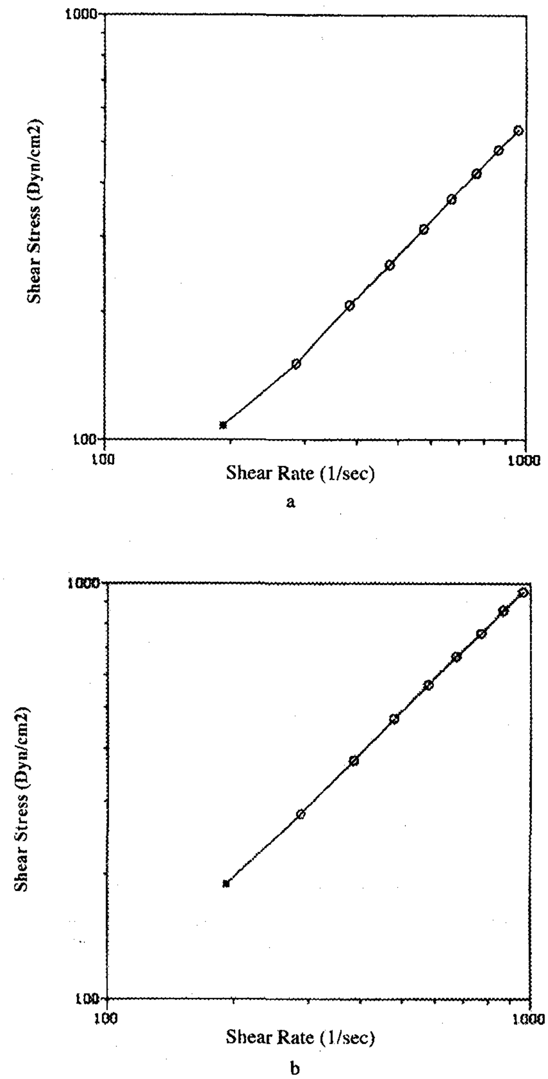

Figure1. Rheograms of Almond (a) and Avocado (b) Oils.

Where, W^{adh}, work of adhesion is the work required to separate the unit area of the two liquids by pulling them apart; and W^{coh}, work of cohesion, is the work required to separate the unit area of liquid surface from itself (Buckton, 1995).

For liquids 1 and 2:

$$W_{12}^{adh} = \gamma_1 + \gamma_2 - \gamma_{12} \qquad (3)$$

Where γ_1 is the surface tension of 1, γ_2 is the surface tension of 2, and γ_{12} is the interfacial tension between 1 and 2.

$$W_1^{coh} = 2\gamma_1 \qquad (4)$$

$$W_2^{coh} = 2\gamma_2 \qquad (5)$$

Spreading coefficient calculated using Formulas (3), (4) and (5) indicates how readily oil can spread on water. Calculation of this parameter leads then to a formulation of stable emulsion systems. Both values of W^{adh} and W^{coh} were the same each for almond and avocado oils and were calculated to be 72.6 and 69.2, respectively. Spreading coefficients calculated for the two oils were found to be 0, which indicates that almond and avocado oils do not spread over water.

Surface tensions of almond and avocado oils, and water were calculated to be 36.3 mN/m, 34.6 mN/m and 158.7 mN/m, respectively **(Table 1).** The value found for avocado oil is in accordance with the literature (Dietz, 1999a).

Spreadability

Since spreadability depends on external conditions such as temperature and atmospheric humidity, in vitro spreadability values were determined in a conditioned room of 52 % relative humidity and 23°C temperature. The spreadability of tested oils were assigned to a group according to the diameter found (Dietz, 1999a):

Diameters of the spreading areas were found to be 7.6 mm± 0.4 (SE) for almond oil while it was 7.8 mm± 0.3 (SE) for avocado oil. These values show that both oils belong to Group I.

I	<10 mm	Low spreadability
II	10-13 mm	Moderate spreadability
III	13-16 mm	Good spreadability
IV	16-19 mm	Very good spreadability
V	>19 mm	Super spreadability

The spreadability of an oil is in correlation with the subjective evaluation of penetration capability into *Stratum corneum* and the time course of the greasy feeling (Dietz, 1999a).

The low spreadability of oils can be improved easily by the addition of alkyl-substituted silicones which acts as a surface active agent and thus modifies the surface tension (Zeidler, 1992).

Pour Point and Cloud Point

Direct relationship between freeze stability of water-in-oil emulsions and pour point of the oils were reported (Hameyer, 1992). Therefore, it was concluded that if the pour point of the oil is low, solidification point of the emulsion will be low and thus the freeze stability of the emulsion will be better.

Pour point of almond oil was found to be –20°C while it was –15.5°C for avocado oil. Cloud points of almond and avocado oils were –18.5°C and –13.5°C, respectively.

Polarity

The polarity of the oil phase has a great influence on the formulation and properties of cosmetic emulsions. Polarity of the oil phase is considered as an essential factor for the stability of water-in-oil emulsions (Dietz, 1999b).

Polarity of almond oil was found to be almost the same as avocado oil, as can be predicted. Both oils were considered as highly polar. Polar oils may enhance the solubility of oil-soluble cosmetic ingredients. Heat stability of emulsions prepared with strongly polar and non-polar oils were found to give emulsions with poor stability which is generally experienced with natural oils (Dietz, 199a).

Table 1. Basic Properties of Almond and Avocado Oils.

INCI Name	Viscosity (25°C) (mPas.s) ±Standard Error (n=9)	Surface Tension (mN/m) ±Standard Error (n=5)	Spreada-bility (mm) ±Standard Error (n=5)	Solvato-chromism (nm) (n=3)	Pour Point (°C) ±Standard Error (n=3)	Cloud Point (°C) ±Standard Error (n=3)
Almond Oil	54.6 ± 0.4	36.3 ± 2.6	7.6 ± 0.4	523.3 ±3.5	-20 ± 1.0	-18.5 ± 1.5
Avocado Oil	98.4 ± 0.2	34.6 ± 1.7	7.8 ± 0.3	529.5 ±2.1	-15.5 ± 1.5	-13.5 ± 1.5
Statistical Evaluation	P>0.05 (t= -96.581)	P>0.05 (t= 0.544)	P>0.05 (t= -0.365)	P>0.05 (t= -2.058)	P>0.05 (t= -2.496)	P>0.05 (t= -2.357)

p>0.05: non-significant variance

The method used in this study, to determine the polarity of the two oils, is simple and reliable since we use UV-spectrophotometer.

The results of this study have been summarized in **Table 1**. It seems possible to distinguish the cosmetic oils according to their basic properties. These properties must be considered as the minimum requirements before further studies on formulation, manufacture and application.

Dermatological Tests

Subjective data of sensory description, psychophysical scaling, consumer hedonic evaluation and product optimization were found to be in correlation with the characteristics and amount of the components in the formulation (Miner, 1993).

Objective evaluation, in contrast, lacks in most of the cosmetic product and ingredient evaluation studies. The results of the objective measurements performed for the two oils are presented in **Table 2** and **Figure 2**.

The moisturizing effect leads to the reduction in the cohesion of the corneocytes and thus to fine skin texture. Delay in the loss of normal functions of the skin can be maintained by correct usage of the correct cosmetic products. Correct formulations can only be obtained by including the correct raw materials. Almond and avocado oils are among the oils which are frequently incorporated into cosmetic formulations owing to their cosmetic efficiency. Skin moisture does not show any variance between half, 1st, 3rd and 6th hours both due to almond oil ($F_{(3,27)}=1.975$; $p>0.05$) and avocado oil ($F_{(3,27)}=2.000$; $p>0.05$). Avocado oil seems to add to skin moisture in the tested period whi-

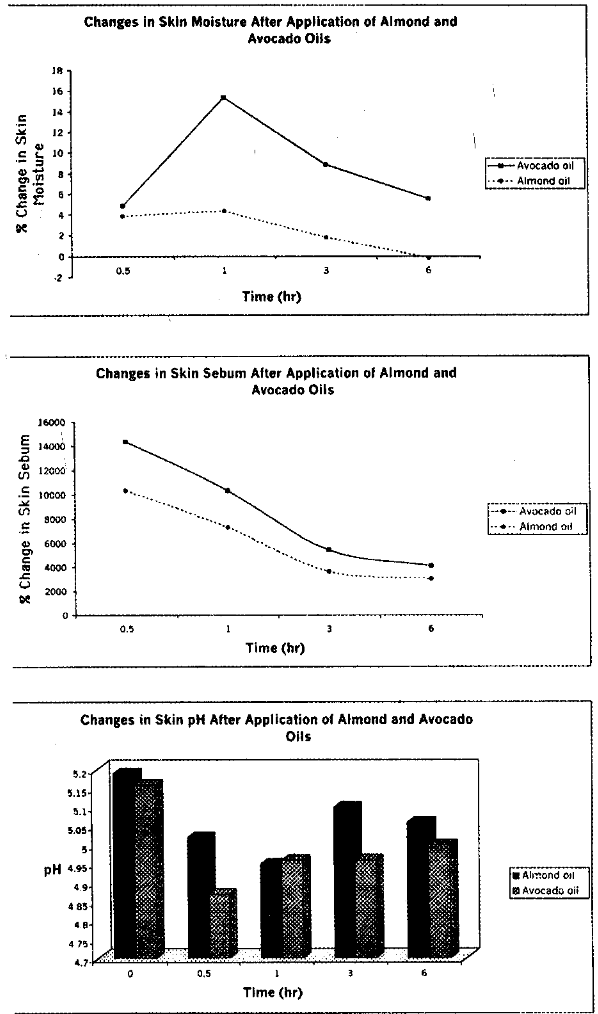

Figure 2. Changes In Skin Moisture, Sebum and pH After Application of Almond and Avocado Oils.

Table 2. Changes in Skin Moisture, Sebum and pH After Application of Almond and Avocado Oils.

	% Change in Skin Moisture ± Standard Error				% Change in Skin Sebum ± Standard Error				Skin pH ± Standard Error				
	0.5 hour	**1st hour**	**3rd hour**	**6th hour**	**0.5 hour**	**1st hour**	**3rd hour**	**6th hour**	**0 hour**	**0.5 hour**	**1st hour**	**3rd hour**	**6th hour**
Almond Oil (n=10)	3.87 ± 2.20	4.39 ± 1.34	1.81 ± 1.85	-0.19 ± 1.82	10333.6 ± 3715.3	7308.1 ± 2772.5	3656.7 ± 1241.9	3027.9 ± 1129.2	5.19 ±4.07 X10^{-2}	5.02 ± 4.16 X10^{-2}	4.95 ± 4.53 X10^{-2}	5.10 ± 3.59 X10^{-2}	5.06 ± 2.67 X10^{-2}
Avocado Oil (n=10)	0.95 ± 5.73	11.08 ± 2.81	7.08 ± 1.62	5.75 ± 2.76	4039.8 ± 1389.6	3029.3 ± 1158.3	1792.8 ± 657.3	1104.3 ± 391.3	5.16 ±4.27 X10^{-2}	4.87 ± 4.96 X10^{-2}	4.96 ± 4.00 X10^{-2}	4.96 ± 4.99 X10^{-2}	5.00 ± 4.47 X10^{-2}
Statistical Evaluation	p> 0.05	p> 0.05	p> 0.05	p> 0.05	p> 0.05	p> 0.05	p> 0.05	p> 0.05	p> 0.05	p< 0.05	p> 0.05	p> 0.05	p> 0.05
t value	0.475	2.151	2.149	1.797	1.587	1.424	1.326	1.610	0.509	2.318	0.165	1.952	1.152

p>0.05: non-significant variance; p<0.05: significant variance le almond oil shows low contribution. However, when compared statistically, there is no significant variance between the two oils considering the moisture content of the skin.

On the contrary, almond oil seems to add to skin sebum more than avocado oil (**Table 2**). Statistically speaking, there is no variance between the two oils. There is significant variance between sebum percentages due to almond oil ($F_{(3.27)}$=6.554; p<0.01) and this variance is between half and 3rd, 6th hours. There is no variance between the other hours. When avocado oil was tested for variance at all hours, significant variance was also found related to sebum contribution ($F_{(3.27)}$=7.156; p<0.01). This variance was found to be between half and 3rd, 6th hours, and between 1st and 6th hours.

Exposure of the skin to cosmetic materials which has a pH value out of the skin pH value range, may lead to damages and premature ageing. It can be followed in **Table 2** that skin pH values have not shown dramatic changes for the two oils in a 6-hour application. However, when tested statistically, skin pH values vary significantly at all hours when compared to the pH values measured before application of almond ($F_{(3.27)}$ =9.362; p<0.001) and avocado ($F_{(3.27)}$ =6.437; p<0.01) oils. There is a variance between the two oils only at half an hour at comparison of the skin pH due to almond and avocado oils.

4. CONCLUSION

Almond and avocado oils both belong to the same chemical class of oils: naturals. Selection of a reference oil from the same class allows the investigation of any similarity and characteristic behaviour.

Viscosities and surface tensions of almond oil and the reference are both high resulting in low spreadability. Spreading coefficients on water are 0 for both oils. High surface tension together with high viscosity contributes to the tackiness of a substance, as in our case.

Since the pour points of the two oils were found to be low, it can be concluded that the emulsions prepared using those oils can be stored at low temperatures without any phase separation.

Polarities of almond and avocado oils are high. This fact may lead to low heat stability of the emulsions prepared using those oils.

Considering the dermatological comparison of almond and avocado oils, there seems to be no difference in their moisturizing efficacy, sebum content contribution and effect on skin pH values.

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Yasemin Yazan, was born in April, 1953. After graduation from Hacettepe University-Faculty of Pharmacy with masters degree in 1976, she began working at Anadolu University-Faculty of Pharmacy in 1981. She completed her Ph.D. study, achieved at Hacettepe University-Faculty of Pharmacy, in 1987 and she was appointed *assistant professor* the same year. She has attended a cosmetology course at Paris-Sud University in 1990 and has been enrolled in several cosmetic projects at the same University since then. Yasemin Yazan has become *associate professor* in 1994 and *full professor* in 2000. She is an active member of 7 national and international societies and founder of Turkish Association of Pharmaceutical Teknology Scientists, Turkish Association of Cosmetic Scientists, and Eskişehir Branch of Turkish Association of University Women. She is acting as a member of 'Drug Licensing Technical Committee' at Turkish Ministry of Health, at the moment. Her foreign languages are english and french. She is married and has two children.

Sefa Avcıer, was born in April, 1962. After graduation from Anadolu University-Faculty of Science, Department of Chemistry in 1989, she worked as a quality conrol analyst in 1989-1990 and as a production manager in 1990-1995 at Tek Kozmetik Sanayi A.Ş., İstanbul. She is working as an expert of cosmetics at Deparment of Cosmetology, Faculty of Pharmacy, Anadolu University, Eskişehir since 1996. She is an active member of 2 national and 1 international societies. She is married and has one daughter.