COSMETIC EVALUATION OF SOME COMMERCIAL SHAMPOOS

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Abstract

Aims. *The purpose of this study was to evaluate some characteristic of several commercial shampoos available in Romania, on the base of scientifically measurable properties.*

Materials and methods. *Five commercial shampoos were chosen: for all hair types (A), for normal hair (B), for greasy hair (C), for normal to dry hair (D) and a baby shampoo (E). The following characteristics were tested: detergency evaluation, the foam quality, the ability to reduce the surface tension, the pH and the viscosity.*

Results. *When referring to detergency evaluation, shampoo A and C were the most detergent, followed by B, E and D. The ability to generate foam was quite close for all studied shampoo in distilled water and in tap water, but reduced in tap water with sebum. The most important foaming ability was observed for shampoo E, even in tap water and tap water with sebum. In the presence of artificial sebum a good foaming ability was remarked for shampoos E, B and C. For all studied shampoos a reduction of the surface tension of water was obtained as an indication of their detergent action. The pH values were slightly acidic and viscosity values in the range of 1250-9000 cP.*

Conclusions. *Knowing the characteristics of a shampoo as regarded to their performance, related especially to their detergency, but also to their sensorial attributes related mainly to foam quantity and quality as well as their tolerance, facilitates personalized shampoo recommendations, so that they fit to the demands and the needs of each person.*

Keywords: shampooing, detergency, foaming, pH, viscosity.

EVALUAREA COSMETICĂ A UNOR FORMULĂRI DE ŞAMPOANE

Rezumat

Obiective. *Obiectivele studiului au fost de a evalua o serie de caracteristici ale unor formulări de şampoane disponibile pe piaţa cosmetică din România, pe baza unor proprietăţi măsurabile.*

Material şi metodă. *S-au testat cinci tipuri de şampoane: pentru toate tipurile de păr (A), pentru păr normal (B), pentru păr gras (C), pentru păr normal şi uscat (D) şi un şampon pentru copii (E). S-au efectuat teste pentru determinarea următoarelor caracteristici: capacitatea de îndepărtare a sebumului, calitatea spumei produse, pH-ul, capacitatea de reducere a tensiunii superficiale şi vâscozitatea.*

Rezultate. *Rezultatele determinărilor efectuate au arătat că cea mai bună capacitate de a îndepărta sebumul au prezentat produsele A şi C, urmate în ordine de B, E şi D. Capacitatea de spumare a fost apropiată în cazul tuturor şampoanelor studiate atât în apă distilată cât şi în apă curentă, fiind redusă în cazul adăugării sebumului artificial la soluţia de şampon preparată în apă curentă. Cea mai bună capacitate de spumare o are şamponul E, pentru care volumul de spumă s-a păstrat şi în apă cu sebum, urmat de şampoanele B şi C. Toate şampoanele au realizat o reducere a tensiunii superficiale, datorită detergenţei lor. Valorile de pH înregistrate s-au situat*

în domeniul slab acid, iar valorile de vâscozitate în domeniul 1250-9000 cP.

Concluzii. *Aceste caracteristici pot aprecia performanța şampoanelor, raportată atât la capacitatea lor de spălare cât şi la unele atribute senzoriale ce țin în special de cantitatea şi calitatea spumei şi la toleranța şamponului, permițând o recomandare personalizată care să satisfacă cerințele fiecărei persoane.*

Cuvinte cheie: şampoane, capacitate de îndepărtare a sebumului, spumare, pH, vâscozitate.

INTRODUCTION

Hair cleansing is very important in order to obtain a satisfying aspect. Most of the shampoos are formulated as aqueous solutions or as emulsions, both containing mixture of surfactants (synthetic or natural) as cleansing agents, other excipients (viscosity controlling agents, foaming agents, preservatives etc) and active ingredients. The surfactants are responsible for the cleaning and lathering ability of the shampoo, as well as its skin tolerance [1,2,3].

This paper was realized in order to answer at one of the most frequent questions asked to the pharmacist: which is "the best" product for hair care? In fact there is not a „best product", there is only „the suitable product", suitable for a specific hair and scalp condition when we speak about shampoos. This selected product should have a good ability to remove dirt and oil from scalp and hair, a good rinsing ability and to make the hair manageable, flexible, shiny and good smelling.

In order to differentiate several shampoo formulations, using scientific arguments, the most important characteristics of a shampoo are evaluated by performing several rapid, simple and reproducible tests:

- Detergency, which is a characteristic who may appreciate the cleansing ability of a shampoo, influencing also the scalp tolerance, knowing that a great detergence is responsible of drying effect, irritation, and may lead to a scaly condition or even to an increasing of sebum secretion on the scalp;

- Surface tension measurements, knowing that the ability to reduce the superficial tension of the solution is related to the cleansing ability of the solution [4,5];

- Foaming ability and foam stability. These characteristics are very important for consumer perception regarding a shampoo, even if they don't have a great influence on the cleansing properties of the product. A great volume of lather is usually correlated by the consumer with a "better" product. In fact lather and its stability are important because this may reduce the hair deterioration during the washing process, by reducing the friction which is several hundred times more important on wet hair than on dry hair [5,6];

- The pH value of the shampoo which, besides the surfactant system of the formulation, contribute also to the scalp compatibility of the product [3] but influences also the level of eye irritation;

- The viscosity of the product, which influences several shampoo attributes: the stability of the product, the facility of use (removal from the package and spreading on the hair) [4].

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MATERIALS AND METHODS

For this study we selected five shampoo formulations: A - a shampoo with stinging nettle (Urtica dioica) extract and pro vitamin B5, suitable for all hair types; B – a shampoo with chamomile (Matricaria chamomilla) extract suitable for normal hair; C – a shampoo with seven plant extracts (Rosmarinus officinalis, Chamomilla recutita, Equisetum arvense, Salvia officinalis, Urtica dioica, Melissa officinalis, Humulus lupulus), suitable for oily hair, D – a shampoo with lipid supplement, for frequent use and irritable scalp, suitable for normal and dry hair and E – a baby shampoo with chamomile (Matricaria chamomilla) extract.

Detergency evaluation

In order to evaluate the detergency the ability of the shampoo to remove the sebum from the hair was tested, using a gravimetric method. We used an artificial sebum formula [4,7,8] that contained similar ingredients than in human sebum: olive oil and cholesterol (20%), coconut oil, fatty acids (stearic and oleic), paraffin wax 15%. Caucasian normal hair tresses obtained from beauty salons were used; none of the tresses were chemical treated (by dying or permanent waving). The hair was prewashed with a solution 1% of sodium laurylsulfate, followed by rinsing, and then the hair was allowed to dry at room temperature for 24 hours.

A sample of this hair was accurately weighted and then was treated with a 10% sebum solution in chloroform for 20 minutes, under intermittent shaking at maximum pulse (Glas-Col Multipulse Vortexer, Terre Haute, USA). Each of the tresses was divided in two by precise weighting. The first half was washed with a 0.1 g of the tested shampoo, using the finger method [5], and then the hair was dried at room temperature followed by drying at 50^0C, for 6 hours. The sebum remained in the test swatch after washing was extracted with chloroform (25 ml, under continuous shaking for 30 minutes in a closed flask). The sebum content of this solution was determined by weighting after evaporation to dryness of the organic solvent. The control swatch was not washed with the shampoo, the sebum remained on the hair

was determined similarly. The detergency was calculated as percentage of sebum removed after washing. Different hair tresses were used to evaluate the detergency of each shampoo; each test was performed 3 times.

Surface tension measurements

The surface tension measurement was performed using Traube stalagmometer on a 10% shampoo solution prepared in distilled water, at 20^{0}C. The number of solution drops between two points previously set was counted (three times for each shampoo solution), then the surface tension was calculated according to the next formula: $\sigma = \rho \cdot g \cdot V/2 \cdot \pi \cdot r \cdot n$, where σ – surface tension, ρ – the density of measured liquid, V – volume of the liquid, r – radius of the tube, n – number of drops counted. The reference liquid was distilled water.

Foam quality evaluation

In order to appreciate the foam quality, the volume of foam, its stability and density were evaluated. The tests were carried out on a 10% solution of the tested shampoo prepared in tap water, in distilled water and in tap water with in which 0.5% of the 10% solution of the artificial sebum was added. The foam was obtained using a stirrer (DLS Stirrer, Velp Scientifica, Italy) at 500 rpm for 10 seconds, on 50 ml of shampoo solution. The foam obtained was placed in a graduated cylinder and its volume was measured immediately, and after 3 and 6 minutes. The foam density was evaluated only on a 10% solution of the shampoo prepared in tap water. The test was performed in a graduate cylinder on the foam obtained in the same conditions as previous. We measured the time required to a rubber stopper, with smaller diameter than the cylinder, to pass between two points previously set, and then the speed of fall is calculated. The time of stopper fall depends on upward pressure which varies inversely proportional with the size of bubbles. Dense foam has small size bubbles, so when the speed of fall is longer, the foam is denser. The tests were performed three times for each shampoo [9,10].

The pH measurement

The pH measurement is performed on the undiluted shampoo, using a pH-meter (Hanna HI 8424, USA); three determinations were done for each shampoo.

Viscosity measurement

The viscosity profiles at several rotation speed of the spindle between 1-100 rpm, at 23.2 ± 0.4^{0}C were determined using a rotational viscometer (Brookfield, DVIII Ultra, USA, spindle 64). Measurements were performed three times for each shampoo.

RESULTS AND DISCUSSION

Detergency evaluation

Figure 1 shows that detergency varies with the shampoo formulation, depending on hair type for which the shampoo was formulated.

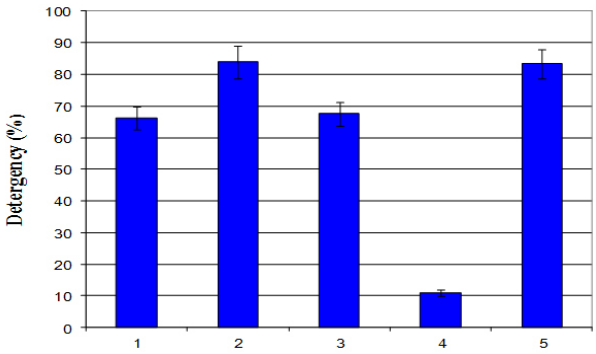

Figure 1. Shampoo detergency evaluation: 1 – all hair types shampoo (A), 2 – normal hair shampoo (B), 3 – oily hair shampoo (C), 4 – dry hair shampoo (D), 5 – baby shampoo (E).

Thus, the greatest (above 80%) detergency was obtained for the shampoo formulated for normal hair (B) and also for the baby shampoo (E). Both these shampoos are designed for normal condition of hair and scalp, so the main function of these products is cleansing. For the baby shampoo the detergent chosen is of natural origin, with a very good eye and skin tolerance despite an important detergency. In order to keep the healthy condition of hair and scalp is important to recommend the use of these products at sufficient time intervals (at 5-7 days). A reduced detergency (about 20% smaller than shampoos B ad E) was determined for all hair types shampoo (A) and oily hair shampoo (C), but still enough to accomplish the cleansing process. A 5 times smaller detergency was determined for the dry hair shampoo (D), a dermocosmetic product which is designed to be frequently used and even on irritated scalp (producer's recommendations). Knowing that surfactants may be irritants on scalp, it is important to reduce their concentration in shampoo in order to ensure a good tolerance. As we observed, consequently the detergency is reduced at about 10%. The sebum removal ability of this shampoo may be less important, but it is compensated by a more frequent use (even daily).

Surface tension measurements

Table I presents the results obtained for several parameters of shampoos: surface tension, viscosity and pH. A reduced surface tension contributes to the cleansing ability of the shampoo in two ways: first by facilitating the spread of the aqueous solution and increasing its wetting ability for the surface and second by facilitating the removal of environmental dirt from hair by keeping it in suspension [11,12]. In our study, all shampoo solutions had smaller values of surface tensions as compared to the determined value for the surface tension of water which is 73 N/m*10^3, varying between 39.28 N/m*10^3, (shampoo D) and 41.63 N/m*10^3 (shampoo A), as we can observe from table I. Thus we can assume a slightly better wetting ability and environmental dirt removal for shampoo D, followed by the shampoo B and then shampoos C, E, A which had solutions

with very close values of surface tension.

Some authors tried to associate the surface tension values of several shampoo solutions with their detergency [4], but in the literature there are few studies concerning both parameters. They claimed a good detergent action for surface tension values between 32-37 N/m *10^3, but they didn't find any correlation between detergency values and surface tension values. Others authors claimed a very good detergent action for a nonionic surfactant solution (ethoxylated cocoamine, with 5 molecules of ethylene oxide) which has surface tension values about 40-45 N/m *10^3, but they didn't offer information about sebum removal ability of this solution [13].

In our study, also we could not find a correlation between surface tension and detergency, so we can affirm that both determinations are important in order to appreciate the cleansing ability of the shampoos.

Table I. Parameters values for shampoo characterisation (A – all hair types shampoo, B – normal hair shampoo, C – oily hair shampoo, D – dry hair shampoo, E – baby shampoo).

Shampoo	Surface tension (N/m) ·10^3	Viscosity (cP, at 10 rpm)	pH
A	41.63 ± 1.527	4259±13.435	6.92 ± 0.056
B	40.35 ± 0.577	2519±25.760	5.61 ± 0.070
C	41.03 ±0.577	6599±39.357	5.21 ± 0.063
D	39.28 ±1.000	9058±65.760	6.69 ± 0.169
E	41.26 ± 0.577	1260±14.142	4.75 ± 0.098

Foam quality evaluation

Figure 2, 3 and 4 present the foaming ability and stability for the shampoo solutions prepared in distilled water, tap water and tap water with sebum respectively. In these testing, a good quality shampoo ensures a foam volume of at least 100 ml. When tests were performed in distilled water or tape water, for all tested shampoo the resulted foam volume was above 100 ml, this value being stable at least 6 minutes (the time estimated to be necessary for hair washing process), so all these products were good regarding this parameter. This fact is due to the presence of on foam stabilizing ingredient in shampoos (cocamide monoethanolamide).

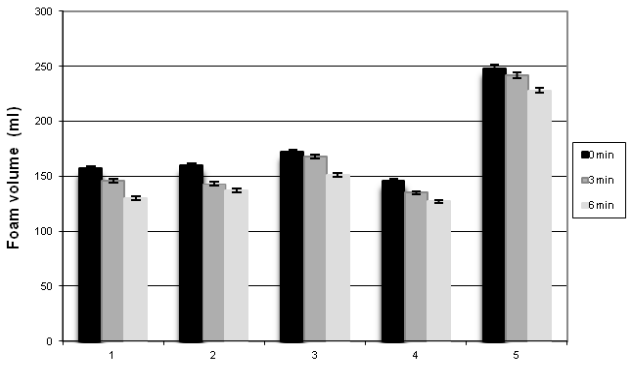

Figure 2. Foaming ability and foam stability of shampoo solution in distilled water: 1 – all hair types shampoo (A), 2 – normal hair shampoo (B), 3 – oily hair shampoo (C), 4 – dry hair shampoo (D), 5 – baby shampoo (E).

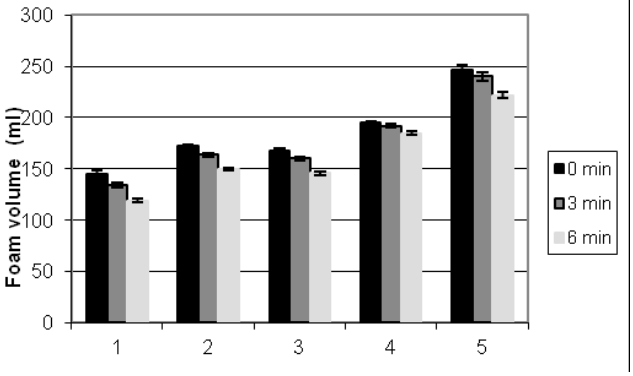

Figure 3. Foaming ability and foam stability of shampoo solution in tap water: 1 – all hair types shampoo (A), 2 – normal hair shampoo (B), 3 – oily hair shampoo (C), 4 – dry hair shampoo (D), 5 – baby shampoo (E).

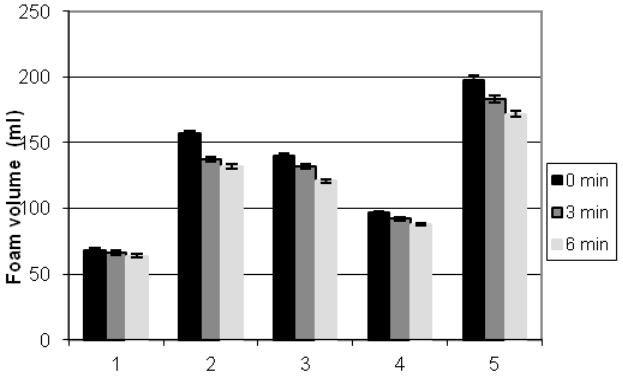

Figure 4. Foaming ability and foam stability of shampoo solution in tap water with sebum: 1 – all hair types shampoo (A), 2 – normal hair shampoo (B), 3 – oily hair shampoo (C), 4 – dry hair shampoo (D), 5 – baby shampoo (E).

When artificial sebum was added to the shampoo's solution, only products B, C and E realized and kept a foam volume above 100 ml. The foaming ability was much reduced for product A, being three times smaller in the presence of sebum. In this case the consumers could not be satisfied with the foam volume obtained with the usual quantity, they may be tempted to increase the quantity and so the irritation potential of shampoo to the scalp is greater. The foaming ability and stability was very good for the baby shampoo in all determinations, so we can use even a small quantity of this product to obtain the desired feeling.

Figure 5 presents the speed fall of the rubber stopper, in order to appreciate the shampoo's density, the parameter who gives to the consumer the best perception regarding the foam quality. We found for the shampoo for dry hair (D) the smallest speed fall of the rubber stopper, which can be correlated with the greatest foam density, followed by the baby shampoo (E), and then close values for the three other shampoos. Also, Shampoo D has in its formulation the greatest number of oily substances who contributes to

this increase of foam density and gives to the product an opalescent aspect.

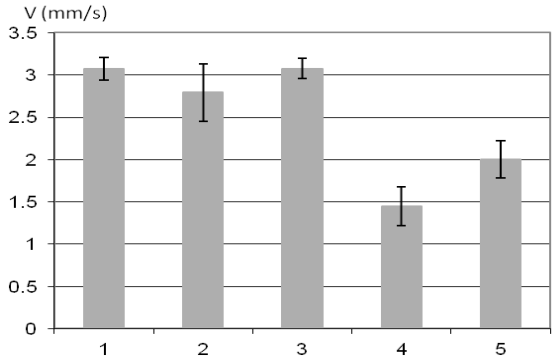

Figure 5. Speed fall of the rubber stopper for: 1 – all hair types shampoo (A), 2 – normal hair shampoo (B), 3 – oily hair shampoo (C), 4 – dry hair shampoo (D), 5 – baby shampoo (E).

Viscosity measurement

Shampoos must have a good consistency in order to facilitate their use, low enough to ensure a facile removal from the package and facile spreading to the hair, but high enough to prevent them from reaching the eyes.

As we can see from figure 6, shampoo D had the highest viscosity, followed by shampoos C and A. Shampoos B and E were less viscous, having a reduced variation of viscosity values over the studied range of rotation speed. In order to better observe the differences between shampoos, the viscosity at a low rotation speed (10 rpm) were compared, as we found in the literature that the shear rates applicable to the flow from the bottle are about 5-10 rpm [14]. The results are presented in table I.

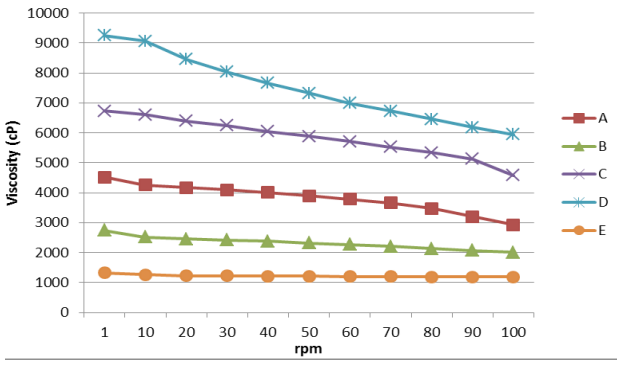

Figure 6. Viscosity profile of tested shampoos.

Shampoo A, C and D with viscosity values between 4000-9000 cP were easily manageable, while shampoos B and especially E were to fluid. We consider that viscosity values under 1250 cP are not appropriate for a shampoo, especially for a baby shampoo, because it is difficult to take from the package the desired amount and it flows very easily and can get into the baby's eyes. Visually it can be related the viscosity values with the aspect of the shampoo, generally the opalescent products have greater viscosity values.

The pH measurement

The pH value for a shampoo is important because it influences the hair quality and the tolerance at skin and eye level. Usually, the shampoo pH values are between 5 and 7. Acidic ingredients will harden and contract the hair, while alkali ingredients expand and soften the hair shaft. Many clarifying shampoos use alkaline ingredients to swell the hair shaft and allow the surfactants to penetrate more deeply. Persons who use these shampoos need to use also an acidic conditioner to protect the capillary fiber by contracting it and keeping the moisture inside [15].

The pH values determined for the tested shampoos are presented in Table I. As we can see, all values are in the range 5 to 7, they will not affect either the skin or capillary fiber, but for shampoos A and D it may be necessary to use an acidic conditioner, applied only on hair, in order to give it a better aspect and to facilitate the combing.

CONCLUSIONS

Several commercial shampoos were tested in order to characterize them. The recommendations that can be made to the consumers based on the results are:

- Shampoo A, recommended by the producer for all hair types, is suitable only for normal hair, its characteristics are not suitable for oily hair (due to the reduced ability of foaming in water with sebum, the consumer will use a greater quantity to obtain the desired foam volume, in time this may lead to scalp irritation) neither for dry hair (the pH value is too big, for dry hair is rather recommended a shampoo with more acidic value);
- Shampoo B, recommended by the producer for normal hair is suitable for this hair type, but mentioning to wash the hair at interval of 5 days at least;
- Shampoo C, recommended by the producer for oily hair is appropriate, as long it is used at 4-5 days interval due to its detergency.
- Shampoo D, recommended for dry hair is suitable for this hair type concerning most of its characteristics, but it has a very low detergency which may not be enough for a proper cleaning, especially if it not used daily as his producer advices. It may be necessary to alternate once a month with another shampoo with the shampoo B for example;
- Shampoo E, formulated for babies, has a high detergency so it is important not to be used daily and a very low viscosity which makes it very difficult to use. A dosing system will be recommended to increase the manageability of this shampoo.

Thus, knowing the characteristics of the shampoos, the personalized recommendations are facilitated so that they fit to the demands and the needs of each person.

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