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Free-choice-profile descriptive analysis of sticks with conditioning agents

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Synopsis

Nine formulations to be used as stick bases were manufactured using sodium stearate, propyleneglycol, and water, adding different concentrations of the following conditioning agents: octyldodecanol, PPG-5-ceteth-20, and PPG-15-stearyl ether. Free-choice-profile methodology was used to select the most adequate concentration of the agents in order to improve sensory properties. The sensory descriptors were grouped into four categories: stick aspect, sensations during application, sensations immediately after application, and sensations five minutes after application.

Formulations containing 4% and 6% octyldodecanol and 2% PPG-15-stearyl ether were considered inadequate, since they showed unwanted qualities such as exudation, a slow absorption rate, high oiliness, and residue. Formulations containing 2% octyldodecanol; 2%, 4%, and 6% PPG-5-ceteth-20; and 4% and 6% PPG-15-stearyl ether presented different characteristics regarding the four categories of descriptors evaluated, all of them being acceptable considering the properties sought.

INTRODUCTION

The current use of the stick form in a wide variety of cosmetic and dermatologic products offers advantages such as limiting the action site, clean application, and ease of transportation. A wide variety of bases, ranging from those that are highly lipophilic with an occlusive effect to easily washable emulsions, can be formulated, with active substances in suspension, dissolved, or in emulsions.

Get-type formulations offer the possibility of incorporating polar components and, at the same time, condition skin due to their moisturizing and emollient components. Previous studies on these gel-type formulations with sodium stearate, using propyleneglycol and water as solvents, showed that these types of samples present characteristics such as acceptable penetration, adequate aspect, and good stability over six months, but that they have poor slipperiness and are hard to the touch (1). To continue these studies,

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sticks were reformulated, reducing sodium stearate concentration and adding ingredients that might improve slipperiness while acting as skin conditioners. These characteristics require an appropriate sensory tool for evaluation.

Descriptive analysis is a method currently used in the sensory evaluation of food. In 1987, Aust *et al.* (2) applied this methodology to cosmetic emulsions, and recently Parente *et al.* (3) applied it to evaluate cosmetic ingredients. Conventional descriptive analysis methodologies such as flavor profile, texture profile, quantitative descriptive analysis (QDA), and Spectrum® constitute useful tools to solve diverse problems associated with quality control, shelf life, product development, and consumer preferences, but they demand an important number of training sessions (4–6). This technique involves the selection of terms and the development of a consensus list of descriptors. To avoid this long and difficult step, free-choice profile (FCP) has been proposed as an alternative (7).

In FCP, each judge chooses his or her own terms to describe perceived sensations (8,9). Williams and Arnold (10) showed that FCP with the scores analyzed by general procrustes analysis (GPA) gave results similar to those of conventional profiling and similarity scaling. Assessors are required to be objective, use intensity scales, and develop a list of attributes and a consistent vocabulary (11). It is interesting to explore the use of this technique to evaluate personal care products due to the advantages it offers and its widespread and successful use in food products (12–14).

The aim of the present work is to select agents with improved slipperiness and skin conditioning properties for stick formulations based in propyleneglycol and water, with sodium stearate as gelling agent, and to determine the adequate concentrations of the different conditioning agents using FCP methodology.

MATERIALS AND METHODS

SAMPLES

Formulations to be used as stick bases were manufactured using sodium stearate, propyleneglycol, and water (Table I), adding three different concentrations of each of the following conditioning agents (15,16):

- Octyldodecanol: oily component used in emulsions, deodorants, and antiperspirants, having good spreadability.

Table I
Sample Composition

	Samples								
Component (%)	A1	A2	A3	B1	B2	B3	C1	C2	C3
Sodium stearate	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Propylenglycol	68.5	67.0	65.5	68.5	67.0	65.5	68.5	67.0	65.5
Deionized water	23.0	22.5	22.0	23.0	22.5	22.0	23.0	22.5	22.0
Octyldodecanol	2.0	4.0	6.0						
PPG-5-ceteth-20				2.0	4.0	6.0			
PPG-15-stearyl ether							2.0	4.0	6.0

- PPG-5-ceteth-20: tensoactive, water-soluble, having emollient and moisturizing properties.
- PPG-15-stearyl ether: easily spreadable emollient, lubricating skin without excessive oiliness.

Propyleneglycol and the conditioning agent were heated in a water bath to 80°C. Sodium stearate was then added, and the solution was stirred until total dispersion was reached. Finally, water heated to 80°C was added, and the formulation was stirred until it was homogeneous and then molded at 60°C (17,18).

The Ethics Committee of the Universidad de la República Oriental del Uruguay concluded that all samples were adequate for testing on humans.

SENSORY ANALYSIS–FREE-CHOICE PROFILE (FCP)

Selection of descriptors. A panel of eight assessors from the Faculty of Chemistry trained in the descriptive analysis of food products, but with no previous experience in evaluating cosmetics, participated. Vocabulary development consisted in presenting to assessors two pairs of samples in three sessions. Each pair had the lowest (2%) and the highest (6%) concentration of two different conditioning agents (see Table I):

Session 1: A1-B3 and C1-A3
Session 2: B1-A3 and C1-B3
Session 3: A1-C3 and B1-C3

Assessors were asked to describe differences perceived between the samples of each pair in:

- Sample surface by observing the lateral surface of the stick portion extracted.
- Sensations experienced when the stick was applied twice on their inner forearm.
- Sensations perceived on skin when touching with the fingers, right after the stick was applied.
- Skin characteristics five minutes after application, by touching with the fingers.

Later on, individual interviews were held, in which assessors selected the terms they wished to use for evaluation in their individual score sheets. A training session was carried out afterwards using these personal score sheets, providing assessors the chance to modify or clarify descriptors. Finally, individual score sheets with non-structured 10-cm scales were obtained to describe attribute intensity.

Sample evaluation. A balanced complete block experimental design was carried out for duplicate evaluation of the nine samples during nine sessions (two samples per session). The samples were evaluated at room temperature and labeled with three-digit code numbers. Non-structured 10-cm scales were used to describe attribute intensity. Sensory testing was performed in a sensory laboratory that was designed in accordance with the ISO (1988) standard (19).

STATISTICAL ANALYSIS

FCP sensory data were analyzed by generalized procrustes analysis (GPA) using Senstools for Windows, version 2.2.21 software (Oliemans, Punter and Partners BV and Talcott BV, Utrecht, The Netherlands).

In sensory profiling an assessor scores N samples for V attributes or descriptive terms, providing an $N \times V$ matrix. These data may be considered as representing a configuration of N points and V dimensions. Procrustes analysis originated as a method for matching two such configurations when two assessors scored the same set of samples. In practice, M assessors are involved and each produces a configuration. In generalized procrustes analysis (GPA) the configurations are compared simultaneously. These configurations are iteratively matched to a common consensus configuration. This consensus configuration is the mean of the transformed configurations, and replaces the panel mean of the untransformed configurations. Transformation steps include translation, rotation/reflection, and scaling (8).

In this case, replicate assessment of samples by each assessor was included as data, providing individual matrices with 18 rows (nine samples × two replicates) and V columns (according to the number of descriptors used by each assessor). An average consensus map of the samples was obtained and the three dimensions were interpreted, considering correlation coefficients $\geq |0.5|$ for each assessor (9).

RESULTS AND DISCUSSION

Assessors selected a number of descriptors ranging from 11 to 19, grouped into four categories:

- Stick aspect (ASP)
- Sensations during application (SDUR)
- Sensations after application (SAFT)
- Sensations five minutes after application (S5MIN)

There were many common terms across the group of assessors such as opacity or transparency in ASP category, spreadability in SDUR, and absorption rate in SAFT, used by all assessors.

In order to evaluate an assessor's performance (reproducibility, discriminating ability, and panel agreement), assessors' configurations and residual variances, and sample configurations for each assessor, were considered. The consensus space showed that the assessors perceived the samples in the same way and had a low residual variance in the first dimension.

The total amount of variance explained by the first dimension of the average configuration consensus map of the samples with their repetitions was 80.9% for ASP, 50.9% for SDUR, 64.3% for SAFT, and 58.8% for S5MIN. The second dimension explained 9.2% of the variation of ASP, 20.2% of SDUR, 12.9% of SAFT, and 13.0% of S5MIN.

Sample consensus configurations with their duplicates for all assessors is shown in Figures 1–4 for each category of descriptors. As seen in the figures, the samples were considerably distanced, indicating that they differ markedly in their sensory attributes. In order to define the main attributes that differentiate samples, correlation coefficients between the attributes and the first dimension in the sample space were calculated. Sensory descriptors from each assessor showing high correlation ($|r| \geq 0.5$) with the first dimension are given in Table II.

For the stick-aspect set, roughness, exudation, and opacity (correlation coefficient greater than 0.88) showed a positive correlation with the first dimension, while uniformity and

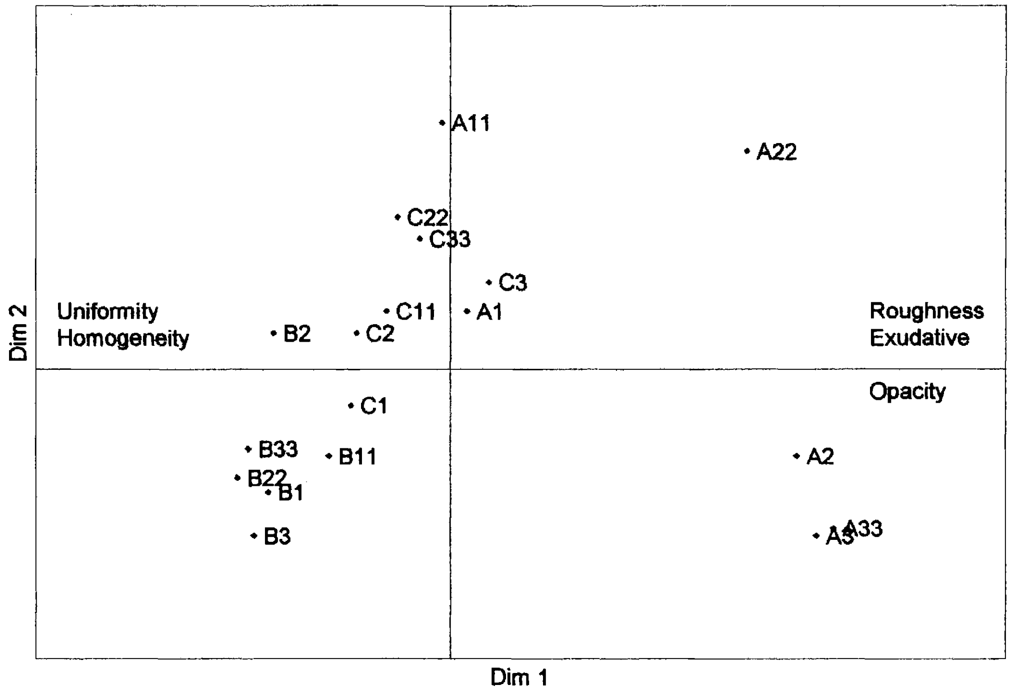

Figure 1. Aspect consensus plot of the samples, including repetitions: first two dimensions.

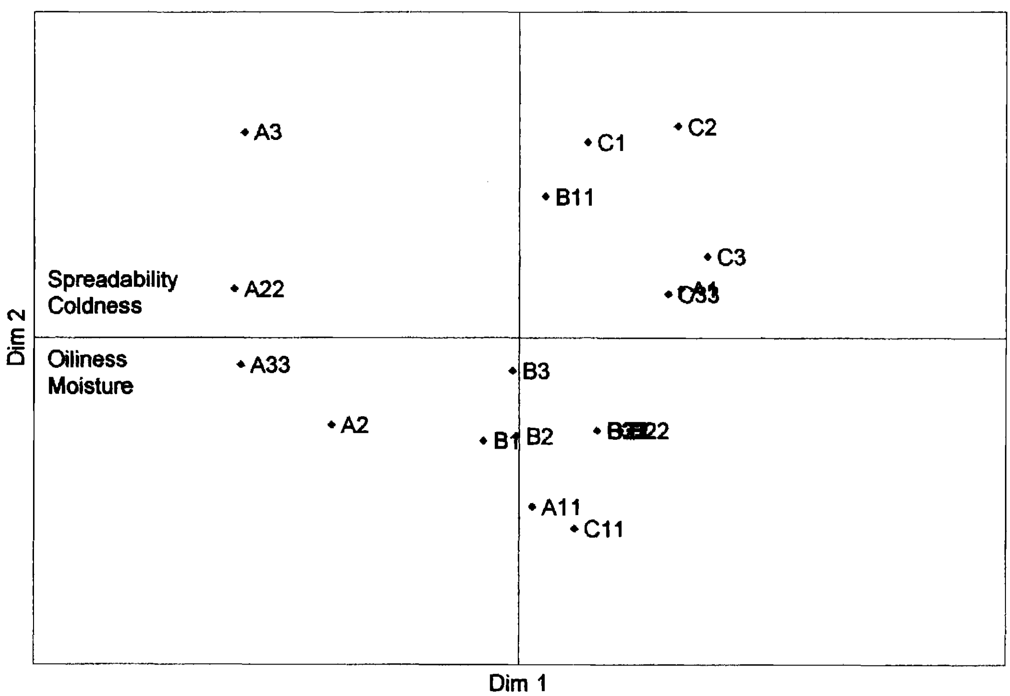

Figure 2. Sensations-during-application consensus plot of the samples, including repetitions: first two dimensions.

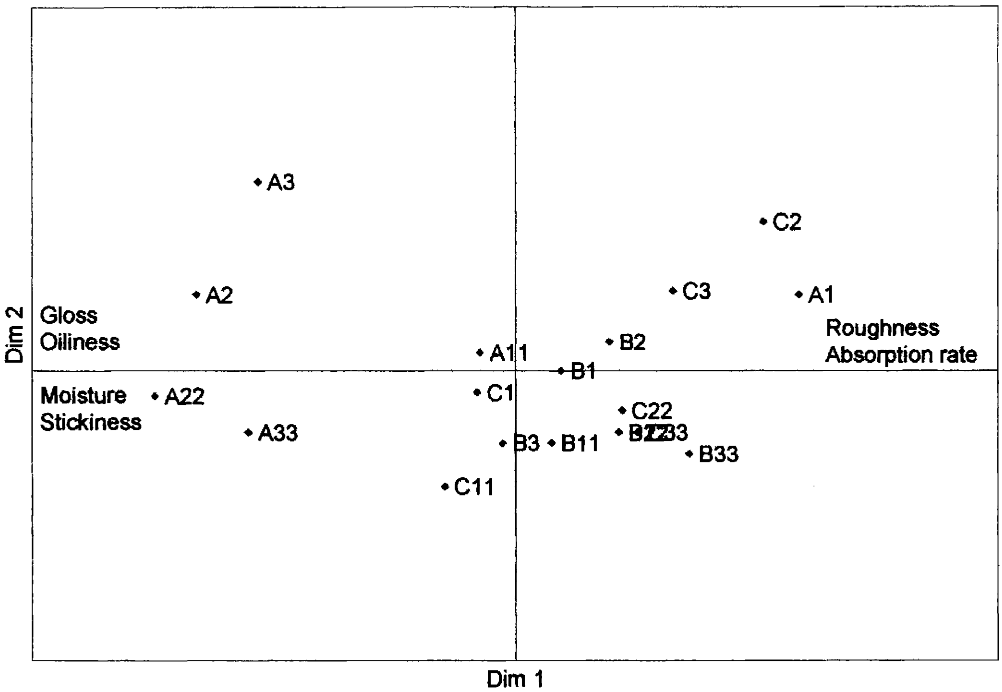

Figure 3. Sensations-after-application consensus plot of the samples, including repetitions: first two dimensions.

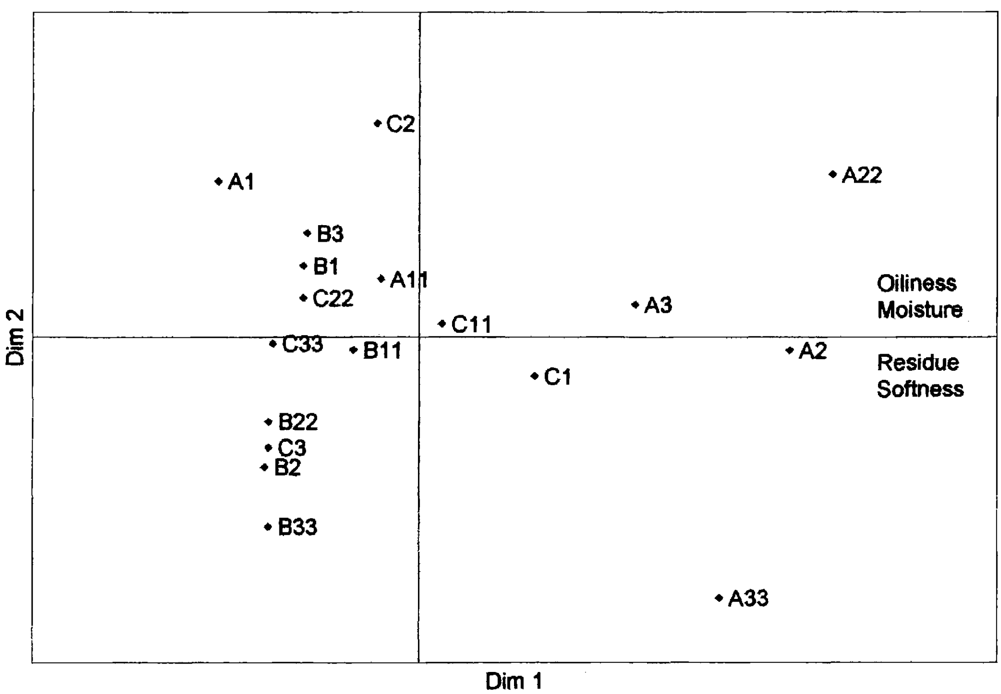

Figure 4. Sensations-five-minutes-after-application consensus plot of the samples, including repetitions: first two dimensions.

Table II
Descriptors Most Highly Correlated with the First Dimension (r ≥ |0.5|)

Assessor	ASP	SDUR	SAFT	S5MIN
1	Gray color (−0.65) Exudation (0.95) Opacity (0.91) Uniformity (−0.94)	Stickiness (0.89 Spreadability (−0.75) Coldness (−0.67) Oiliness (−0.71)	Gloss (−0.61) Oiliness (−0.84) Residue (−0.79) Softness (−0.49) Absortion rate (0.85)	Oiliness (0.77) Residue (0.66) Softness (0.65)
2	Exudation (0.96) Opacity (0.91) Roughness (0.70)	Spreadability (−0.76)	Roughness (0.66) Gloss (−0.75) Oiliness (−0.73) Absorption rate (0.88)	Roughness (−0.66) Oiliness (0.86) Residue (0.95)
3	Roughness (0.93) Exudation (0.89) Opacity (0.88)	Spreadability (−0.58) Hardness (0.50) Oiliness (−0.50)		Oiliness (0.54) Moistness (0.51)
4	Exudation (0.93) Transparency (−0.98)	Spreadability (−0.63)	Absorption rate (0.63) Oilness (−0.58)	
5	Exudation (0.93) Heterogeneity (0.90) Opacity (0.90)	Spreadability (−0.69) Coldness (−0.72) Moistness (−0.83)	Oiliness (−0.66) Moistness (−0.83) Tautness (0.65) Absorption rate (0.64)	Oiliness (0.70) Moistness (0.58) Residue (0.51)
6	Smoothness (−0.80) Opacity (0.95)	Oiliness (−0.83)	Oiliness (−0.91) Absorption rate (0.63)	Oiliness (0.90)
7	Gloss (−0.75) Gray color (−0.54) Uniformity (−0.83) Moistness (0.78) Opacity (0.89)	Gloss (−0.73) Spreadability (−0.50)	Roughness (0.61) Gloss (−0.73) Oiliness (−0.50) Moistness (−0.87) Stickiness (−0.49) Absorption rate (0.56)	Gloss (0.50), Elasticity (0.75)
8	Roughness (0.76) Exudation (0.95) Opacity (0.92)	Moistness (−0.86)	Moistness (−0.70) Absorption rate (0.64)	Oiliness (0.58) Moistness (0.69) Residue (0.59) Absorption rate (−0.63)

homogeneity correlated negatively. Samples A2 and A3 (4% and 6% octyldecanol) were far apart from the rest, being associated with negative characteristics such as being rough and exudative and lacking uniformity. Samples B1, B2, and B3 (PPG-5-ceth-20) were located on the other side of the first dimension, associated with desirable sensory characteristics. Samples C1, C2, and C3 (PPG-15-stearyl ether) along with sample A1 (2% octyldodecanol) showed an intermediate behavior.

For the sensations-during-application set, spreadability, coldness, oiliness, and moisture correlated negatively with the first dimension, spreadability being the most frequently cited descriptor. Samples A2 and A3 were again apart from the rest, perceived as easily spreadable but greasy. Samples B, C, and A1 did not differ clearly from the rest, being less spreadable and lacking undesired attributes.

For the sensations-after-application set, roughness and the rate of absorption showed a positive correlation with the first dimension, while gloss, oiliness, moisture, and stickiness correlated negatively. The rate of absorption and oiliness were the descriptors most frequently cited. Samples A2 and A3 again differed from the rest, showing greater oiliness and a slower absorption rate. Even though the group of samples B, C, and A1 did not differ clearly from the rest, sample C1 (2% PPG-15- stearyl ether) moved slightly towards the left quadrant.

Regarding the sensations-five-minutes-after-application data set, oiliness, moisture, residue, and softness correlated positively, oiliness and residue being the most frequently mentioned. Samples A3, A2, and C1 differed from the rest, having greater oiliness and residue.

CONCLUSIONS

- Formulations containing 4% and 6% octyldodecanol (A2, A22 and A3, A33) and 2% PPG-15-stearyl ether (C1, C11) were considered inadequate, since they showed unwanted qualities such as exudation, a slow absorption rate, high oiliness, and residue.
- Formulations containing 2% octyldodecanol; 2, 4 and 6% PPG-5-ceteth-20; and 4 and 6% PPG-15-stearyl ether presented different characteristics regarding the four categories of descriptors evaluated, all of them being acceptable considering the properties sought.
- FCP provided relatively quick and useful information about the samples, being an efficient tool to gather reliable data for the kind of problem approached, in a relatively short period of time.

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