Development of a Solid Organic Shampoo Formulation

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Abstract: The present work is focused on the development of a solid organic shampoo in order to respond to the current demands of consumers, offering an innovative product within the organic cosmetics market. In this context, three lines of shampoo were developed: a line for oily hair, another for normal hair and a third one for dry and damaged hair. The experimental conditions and ingredients required to develop a product able to wash and moisturize, and at the same time remain solid before and after washes, were tested. Secondly, the developed laboratory-scale process was scaled up to commercial scale, highlighting the differences between the two. Among the product quality tests, microbiological analysis and dry weigh determinations were performed to calculate the amount of water and volatiles present in the shampoo and whether microbial contamination was present. A preservative was not added to the shampoo, since the contents of water and volatiles were low. The microbiological tests confirmed that it was not necessary to add a preservative, since the shampoo medium was not propitious for bacterial and fungal growth. Under these conditions, the product was legally approved according to the EU regulation 1223/2009. A sustainable, sulphate-free, silicone-free, plastic-free solid shampoo was obtained with abundant and creamy foam, allowing a quick and improved washing. Finally, packaging design was also part of the project: a method for hanging the bar shampoo using cork materials was created and recycled paper was used for packaging.

Keywords: Solid bar shampoo, organic cosmetics, sulphate free shampoo, silicones free shampoo, plastic free shampoo, vegan shampoo, sustainable shampoo.

Introduction

In a society where the environmental awareness of the damages caused by the daily use of chemicals in skin and hair care influences the consumer's attitude towards buying organic products, it is important to provide consumers with a wider range of these products. This would lead to a significant impact on human health and would promote a more sustainable economy.

In the case of cosmetics and in regards to hair, consumers buy all sorts of products that may dry out, damage or lead to a continued degraded state of the hair. These products often contain harmful ingredients for humans and environment, for example petroleum-based polymers, silicones, plastics and synthetic and harsh chemicals, such as sulphates, which can be aggressive to the scalp and may strip hair of its natural oils. Therefore organic hair products reduce the level of daily exposure to damaging chemicals, have sustainably sourced organic and biodegradable ingredients, protect biodiversity and some are packed with recycled content. They also contain herbal infusions, mild surfactants, butters, oils and pure essential oils that provide a clean, hydrated, and, above all, healthy hair.

Shampooing is by far the most frequent form of cosmetic hair treatment. In the beginning, shampoos were made from soap or mixtures of soaps, this was not accepted or used for several reasons. Therefore, new shampoo products were formulated, more precisely, in the form of clear or opaque liquids, lotions, pastes, gels, foam aerosols or dry absorbent powder products (Tibbetts, 1990), however, bar shampoos are still not as well known in the market as the other shampoos mentioned above, highlighting this product as quite innovative.

Thus, the aim of this work was to develop three lines of solid organic shampoos, for oily, normal and dry/damaged hair, that lasted longer than a traditional liquid shampoo, were eco-friendly and did not contain any sulphates, plastics, silicones or other additives that would strip extensively the natural moisture of the hair and scalp. To formulate a solid shampoo bar able to clean the scalp and hair and at the same time moisturize it without causing dryness is a complex task. Therefore, the aim was to formulate a mixture of mild surfactants (solid and liquid) to clean the hair, butters and oils to nourish it, active ingredients to repair and moisturize it, hardeners and powders to give the desired texture and toughness and finally the aroma.

Materials and Methods

Laboratory-Scale

Surfactants and Liquid Phase

The liquid surfactants (cocamidopropyl betaine and coco glucoside) and the water-soluble ingredients with the exception of hydrolyzed wheat protein (phase A) were weighted and placed into a glass heatproof container. The heatproof container with phase A was placed into a hot water bath at 80ºC. Afterwards, this phase was used to melt and incorporate the solid surfactant phase (phase B). Phase B, which was previously weighted into a glass heatproof beaker, was slowly added to phase A which was placed in the glass heatproof container inside hot water (80ºC), and stirred until it was completely melted and a thick mixture was formed.

The heating step was performed by two different approaches. The first was a more traditional method, using a double boiler and a heating plate, and the second (more accurate method) in a thermostatic bath. In both methods, the water that was placed either in the bath or in the double boiler had to be at the same level as the mixture inside the glass heatproof container, to ensure that it remained at the desired temperature. The glass heatproof container was always kept inside of the bath until the end of the protocol. The glass heatproof container was always kept inside of the bath until the end of the protocol.

To monitor both the water bath and mixture temperatures, a laser thermometer was used. At this stage, the water bath was kept at 80ºC and the mixture reached around 60ºC. In early procedures, other bath temperatures were used, up to 95-100ºC.

Phase B was incorporated under stirring and that procedure was also carried out in two different ways, more specifically: (1) manually or (2) by using a stirrer (between approximately 50 and 250 rpm) with different types of impellers Perfurated Square-Blade Impeller and Straight-Blade Impeller) according to the size of the sample and the corresponding stirring requirements.

Oil Phase

The oils, oil-soluble ingredients and hydrolyzed wheat protein (phase C) were previously weighted and placed together in a glass heatproof beaker. Thereafter, the beaker was placed inside a water bath at 90ºC, until all components had been dissolved. For this step, there was no need of special stirring, since they mixed easily only with the help of a stirring rod. In this case, the water was also at the same level as the oil phase inside the container, providing a faster melting.

Incorporation of phase C with A and B

When melted, phase C was added to the mixture of phase A and B (glass heatproof container in hot water bath at 90ºC) under stirring. Before the phase C was added, the hot water bath was increased to 90ºC. The stirring speed was dependent on the size of the sample and on the type of impeller. The mixture was stirred until a low viscosity and homogeneous mixture were obtained.

Powdered active ingredients phase

The steps mentioned above are common to all three formulations. However, in the case of the oily hair shampoo, there is an additional step which corresponds to the powdered active ingredients phase (phase E). After phase C has been incorporated, the powder phase (phase E), which was previously weighted into a glass beaker, was added to the glass heatproof container, at the same bath water temperature (90ºC), with the contents reaching around 75ºC. Also, this phase was added all at once, under low stirring speed (approximately 50 rpm), preventing powder from escaping and cause losses.

Essential Oils

The next part of the protocol was the addition of the essential oils (phase D) which provided the desired perfume and aromas. After the essential oils have been weighted into a glass beaker, these were immediately covered, avoiding their evaporation and loss. Right before the mixture was poured into the moulds, essential oils were added to the glass heatproof container under stirring.

Moulding and Curing

With the mixture in the glass heatproof container at a temperature of at least 75ºC, it was spooned into the moulds, with the mixture under stirring. The shampoos were kept inside the moulds during 48 hours inside the warehouse at a temperature and humidity corresponding to the atmospheric conditions. These parameters were monitored with an external thermometer. After 48 hours inside the moulds the shampoos were removed from the moulds and placed in trays inside the warehouse at room temperature.

Scale-Up

In the scale-up process, the procedure was similar with the exception of the materials and equipment.

Regarding the heatproof container, three different types of vessels were used: (1) a 2-L glass heatproof container suitable for intermediate size samples, (2) a 5-L plastic heatproof container for large size samples and (3) a 5-L glass heatproof container also for large size samples.

Considering the heating step of phase A and B, it was only performed in the thermostatic bath, excluding the heating plate and double boiler method. In relation to the agitation, it was only accomplished by using impeller 3 (between approximately 150 and 500 rpm), throughout the protocol.

Concerning the materials used at both scales, the last difference corresponds to the moulds. For the laboratory scale, two types of moulds were used: one containing 25-30 grams of shampoo and the other 45-50 grams. For the scale-up process, the moulds were larger, had a cylindrical shape and contained between 75 and 85 grams of product.

A final step was added in the scale-up process. Seven days after removing the shampoos from the moulds, they were ready to be punched with a 1 mm needle, in order to insert a corked wire. Two corked wires (35mmx1mm) were used to provide a line to hang the shampoo, with the aid of a recycled cork piece previously cut and used as a stopper.

pH measurement

In order to control the pH of the solid shampoos, a 1:3 dilution was performed in hot water to obtain a solution with the dissolved shampoo. Thus, the pH of the achieved solution was measured using a pH meter.

Water Content Determination

Dry weight tests were performed on some samples, to determine their content in water and volatiles. The drying was made to 3 replicates of different formulations. First, the sample was cut into strips, and each strip was weighted in an analytical balance before drying. A dry weight measurement balance was used and the sample dried at a temperature of approximately 106°C until constant weight. The drying was done inside a fume hood to prevent the release of toxic compounds, such as sodium cocoyl isethionate. After drying, the strip sample was cooled in a desiccator for about 20 minutes in order to prevent water absorption and also allowing the sample cooling. Afterwards, the sample strip was reweighed in the analytical balance, and the content of volatiles that had been evaporated was determined by weight difference.

The sample mass was obtained by the difference between the total and the plate mass (equation 1):

$$Sample\ Mass = Total\ Mass - Plate\ Mass \ (1)$$

The total weight lost (TWL) was calculated by dividing the volatiles mass by the sample initial mass (equation 2):

$$\text{TWL} = \frac{\text{Lost volatiles mass}}{\text{Sample mass before drying}} \ (2)$$

Microbiological Analysis

In order to execute the microbiological control of the product, quick microbiological test kits were used. The mikrocount® duo dipslides are

plastic nutrient media slides coated on both sides with a agar media, namely one for detection of general microbial growth (universal medium) and another for detection of fungal growth (antibiotic media).
The application of the mikrocount® dipslides procedure was performed in a laminar flow chamber to avoid any contamination and the used method was the contact inoculation, which is suitable for surfaces and solid samples. First, the shampoo samples were cut along the smallest centre axis with a disinfected x-acto knife and then both sides of the nutrient media carrier were presses manually onto the sample surfaces and held for about 10 seconds. Thereafter, the mikrocount® dipslides were incubated during 14 days in an incubator at 30 ºC and regularly inspected for the appearance of colonies.

Results and Discussion

Oily Hair Shampoo

The first shampoo to be formulated was the oily hair shampoo. After 40 tests of different formulations and experimental conditions, a shampoo with the desired characteristics was obtained, with the following formulation (Table 1). It should be noted that in all the Tables presented in the results the quantities of used ingredients result from a normalization of their base ranges given in appendix A. Also, the formulations are identified according to the type of shampoo: O for oily hair, D for dry and damaged hair and N for normal hair.
The sodium cocoyl isethionate (SCI) was previously dissolved with the liquid surfactants (cocamidopropyl betaine and coco glucoside). The stearic acid, cetearyl alcohol and carnauba wax were mainly used as hardeners and contribute to the consistency and texture of the shampoo. The activated charcoal and the grey clay were specially chosen for the oily hair shampoo due to their adsorbent properties, grabbing the oil particles present in dirty oily hair. Finally, the other ingredients, namely, shea butter, hydrolyzed wheat protein, panthenol, olive oil and glyceryl oleate were responsible for the moisture and hydration that the shampoo provides to the hair strands.

Table 1: Formulation O40 of oily hair shampoo.

Phases	Components	Quantity (% of the base range)
A	Cocamidopropyl Betaine	40.80
	Coco Glucoside	45.27
B	Sodium Cocoyl Isethionate	36.10
C	Stearic Acid	57.00
	Cetearyl Alcohol	21.43
	Organic Coconut Oil	17.40
	Organic Shea Butter	15.31
	Glyceryl Oleate	11.11
	Olive Oil	0
	Hydrolyzed Wheat Protein	1.000
	Panthenol	11.11
	Carnauba Wax	19.80
E	Grey Clay	21.29
	Activated Charcoal	12.50
D	Organic Rosemary Essential Oil	22.10

Regarding the 40 formulations, some of the corresponding shampoos were quantitatively evaluated between each formulation in different parameters such as visual characteristics, texture, application to wet hair and effects on dry hair. On a scale of 1 to 5, several features were evaluated (Figure 1 and 2).

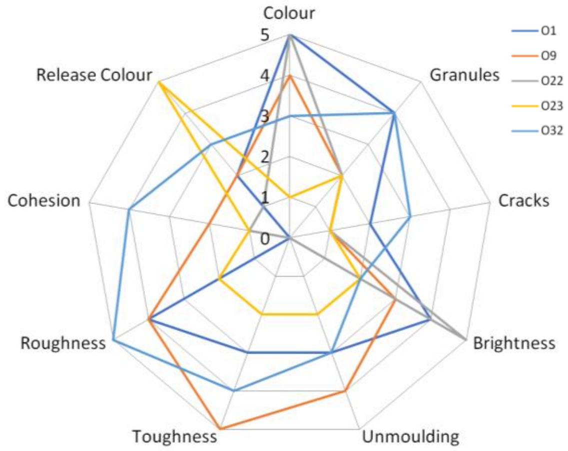

Figure 1: Quantitative evaluation (visual characteristics and texture) of oily hair shampoos corresponding to formulations O1, O9, O22, O23 and O32.

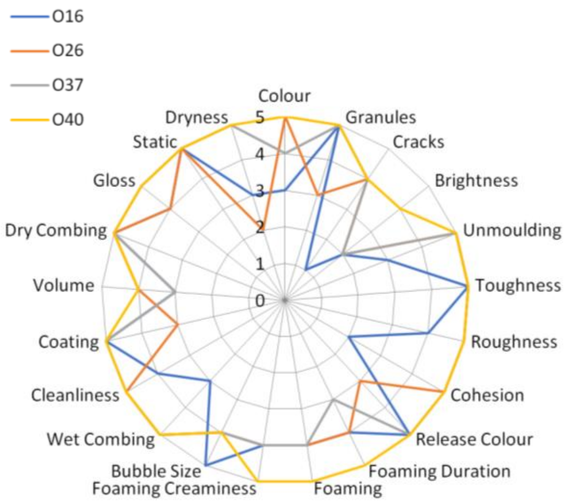

Figure 2: Quantitative evaluation (visual characteristics, texture and hair tests) of oily hair shampoos corresponding to formulations O16, O26, O37 and O40.

Dry and Damaged Hair Shampoo

Based on the shampoo formulation for oily hair (formulation O40), a shampoo for dry and damaged hair was created. For that purpose, 8 tests were performed to formulate the shampoo and to achieve the outlined goals for its features (Table 2).

Table 2: Formulation D8 of dry and damaged hair shampoo.

Phases	Components	Quantity (% of the base range)
A	Cocamidopropyl Betaine	50.00
	Coco Glucoside	80.00
	Panthenol	16.67
	Vegetable Glycerin	11.11
B	Sodium Cocoyl Isethionate	50.00
C	Stearic Acid	60.00
	Cetearyl Alcohol	20.00
	Organic Coconut oil	30.00
	Organic Shea Butter	14.29
	Glyceryl Oleate	0
	Olive Oil	0
	Hydrolyzed Wheat Protein	0
	Carnauba Wax	27.77
	Organic Açai Oil	12.50
D	Organic Geranium Essential Oil	44.44

Considering the oily hair shampoo, the first change was to remove the grey clay and the activated charcoal, since these ingredients are specific for the adsorption of hair oil particles, which are not suitable in this case. It is therefore proposed to replace these two ingredients with others that meet the needs of dry hair, promoting its hydration and repairing. One of new ingredients was vegetable glycerin which has highly humectant properties, is responsible for the transepidermal water loss reduction and for maintaining the adequate level of moisture in the *stratum corneum*, allowing hair flexibility. In order to give a touch of excellence to the hair fibers, since these are dry and damaged, the açai oil was used in order to restore hair strands and provide them shine and softness. Some of the dry and damaged hair shampoos were also quantitatively evaluated similarly to the oily hair shampoo (Figure 3).

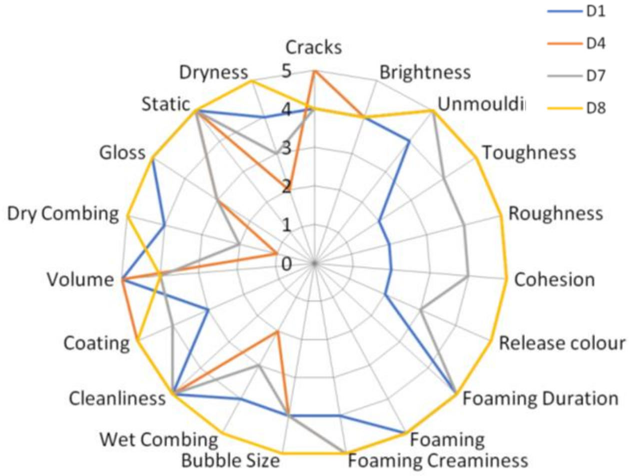

Figure 3: Quantitative evaluation (visual characteristics, texture and hair tests) of dry/damaged hair shampoos corresponding to formulations D1, D4, D7 and D8.

Normal Hair Shampoo

Finally, a test was performed in order to produce a shampoo that was the intermediate between the oily and dry/damaged hair shampoo- a shampoo for normal hair.

Considering the previous oily hair formulations, the first dissimilarity to notice was the removal of the grey clay and the activated charcoal, since these ingredients are specific for the adsorption of hair oil particles, which are not necessary for normal hair. Regarding the dry/damaged hair formulations, the açai oil was not present in the formulation for normal hair, since this oil is extremely repairing for hair strands, and is not essential for hair strands which are not damaged.

The remaining part of the percentage corresponding to the açai oil in dry hair formulation 8 was transferred to olive oil in order to provide a hydration component, although lower than the required for dry hair.
In conclusion, a shampoo suitable for hair without special needs such as oil removal or extra moisturization was obtained, guaranteeing hair cleaning and hydration at the same time (Table 3).

Table 3: Formulation 1 of normal hair shampoo.

Phases	Components	Quantity (% of the base range)
A	Cocamidopropyl Betaine	50.00
	Coco Glucoside	90.00
	Vegetable Glycerin	11.11
	Panthenol	16.67
B	Sodium Cocoyl Isethionate (Needles)	52.50
C	Stearic Acid	60.00
	Cetearyl Alcohol	20.00
	Organic Coconut oil	30.00
	Organic Shea Butter	14.29
	Carnauba Wax	27.77
	Glyceryl Oleate	0
	Olive Oil	12.50
	Hydrolyzed Wheat Protein	0
D	Organic Lemongrass Essential Oil	44.44

The normal hair shampoo was also evaluated according to the same parameters and since the goals for normal hair shampoo were achieved in the first formulation, only one evaluation was performed (Figure 4):

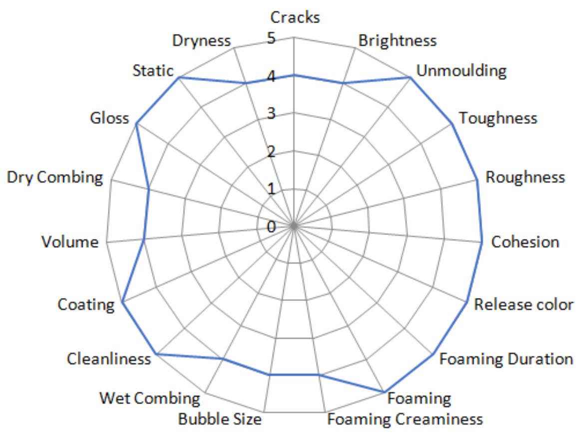

Figure 4: Quantitative evaluation (visual characteristics, texture and hair tests) of normal hair shampoo corresponding to formulation N1.

Water Content Determination

In order to decide whether it would be necessary to introduce a preservative in the formulation, the amount of water and volatiles in the shampoo was determined. For that purpose, two oily hair formulations were chosen, namely, formulation O33 (with water) and O37 (without water).
First, with the technical data sheet and the purity of each ingredient given by the suppliers, it was possible to estimate the maximum amount of water present in each formulation. Note that the mass of water was obtained by multiplying the water content in each ingredient by the mass of each ingredient in the formulation. The results obtained were 12,62 g and 11,49 g for formulation 33 and 37, respectively.
Then, to obtain otherwise the content of water and volatiles present in the sample, drying tests were performed and the obtained results are presented in Tables 4 and 5.

Table 4: Results obtained from drying - formulation O33.

Sample 1	Drying Time	16,04 min
	Lost Volatiles Mass	0,1324 g
	TWL	0,0375
Sample 2	Drying Time	17,12 min
	Lost Volatiles Mass	0,1562 g
	TWL	0,048
Sample 3	Drying Time	12,21 min
	Lost Volatiles Mass	0,0971 g
	TWL	0,0350

Table 5 Results obtained from drying - formulation O37.

Sample 1	Drying Time	15,07 min
	Lost Volatiles Mass	0,0619 g
	TWL	0,0350
Sample 2	Drying Time	54,22 min
	Lost Volatiles Mass	0,3254 g
	TWL	0,1106
Sample 3	Drying Time	11,58 min
	Lost Volatiles Mass	0,1248 g
	TWL	0,049

Taking into account the results, it can be verified that the values that were obtained in the drying are very different from the values obtained by estimation, according to the data of the suppliers. An explanation for this difference may be related to some water evaporation during the shampoo manufacturing process since it is performed at high temperatures. Another possible explanation is related to the drying time of the sample, as it can be seen in sample 2 of formulation O37. In this sample, the drying time was much higher compared to all the other samples from the 2 formulations. This was due to a difference in the protocol: during the drying of this sample, the door of the hood was closed (which did not happen in the other drying procedures), and its ventilation caused instability in the dish of the balance, resembling a change of weight. Thus, the drying did not stop until the door of the hood was opened, stopping the ventilation which in turn stopped affecting the weight on the scale. Supposedly, if this had not happened, the drying time would have been between 10 to 20 minutes, and the TWL would be much smaller (between 0.03 and 0.05 g/g), as found in the other samples. It would also be expected that, regardless of how long the sample remained on the scale at 105 °C after the drying time has ended, the mass of lost volatiles remained the same. However, this did not happen and the mass of volatiles lost continued to increase, leading to the conclusion that if the door did not open and the sample continued to dry, the mass lost would increase and possibly reached the estimated mass of water calculated before. Presenting these values to Oxford Biosciences, an accredited company that offers cosmetic product safety reports, it was concluded that it would not be necessary to add preservative for the shampoos. The Oxford Biosciences also legally approved the shampoo according to regulation EU 1223/2009.

Microbiological Analysis

In order to evaluate the quality of the product at a microbiological level, and to confirm the adequacy of the non-addition of preservative to the shampoo, the microbiological analysis was performed.

Microbiological Analysis 1- July 20th

The first analysis was performed on July 20th, and the microbiological tests were executed on 6 samples of different productions of the 3 lines of shampoo. In addition, a replica of each of the samples was performed, leading to a total of 12 kits (Table 6).

Table 6: Microbiological analysis samples.

Shampoo type	Production
Oily Hair Shampoo (formulation O40)	July 18th- production 1
	July 18th- production 2
Normal Hair Shampoo (formulation N1)	July 2nd
	July 18th
Dry/Damaged Hair Shampoo (formulation D8)	July 9th
	July 18th

The production of July 18th of dry/damaged hair shampoo was performed after the previous disinfection of the moulds and of all the material and equipment used during the process, which did not happen with the other samples.

Seven days after the start of the incubation of the kits at 30ºC (July 27th), what looked like a fungus and a bacterium were visible on the July 18th sample of normal hair shampoo (Figure 5) and an apparent bacterium colony on the July 9th sample of dry/damaged hair shampoo, replica 2 (Figure 6).

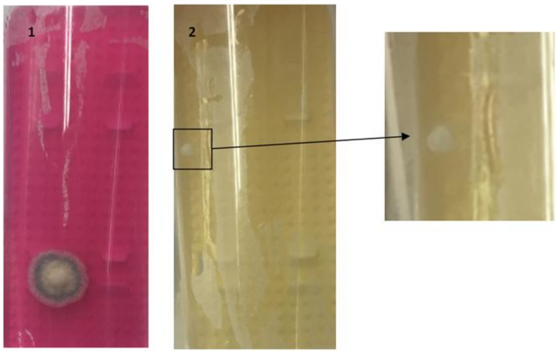

Figure 5: Fungus (1) and bacterium (2) in the sample July 18th of normal hair shampoo.

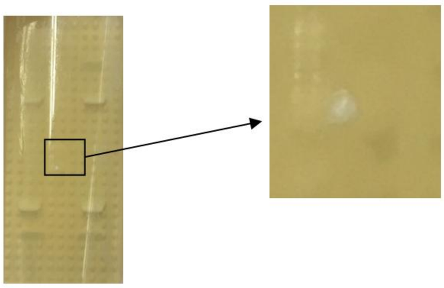

Figure 6: Bacterium in the sample July 9th of dry/damaged hair shampoo replica 2.

Microbiological Analysis 1- September 20th

The samples used in the first analysis were kept in a confined space without light at room temperature. On September 20th the microbiological analysis was repeated to the same samples as before, in order to evaluate the consistency of the results and to verify how long the shampoo samples would be good for consumption from a microbiological point of view.

After 13 days of incubation, there was no evidence of bacteria or fungi growth on the culture kits from all the samples, which leads to the conclusion that the shampoo medium is not propitious to the growth of fungi and bacteria. As a conclusion, the bacteria and fungi previously detected in the first analysis were there still in viable form due to the short time after the production (2 days and 11 days respectively). The unfavourable growth conditions of the shampoo (such as the low content of water in the formulations) lead to the fungus and bacteria death after the considerable storage time following the production (2 months).

Other Process Parameters

Sodium Cocoyl Isethionate Dissolution

The time required for complete dissolution of SCI in the liquid surfactants of different productions of dry and damaged hair shampoo was analyzed as function of (1) the bath temperature at which each process occurred in samples with similar masses (Figure 7) and (2) mass and agitation level in samples with different masses (Figure 8).

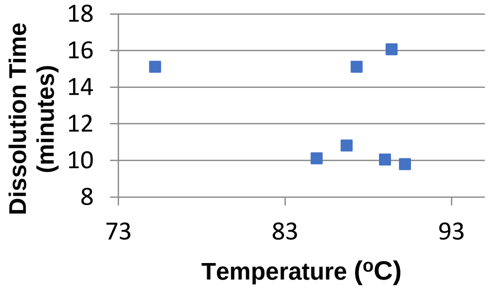

Figure 7: Dissolution time of SCI as a function of the bath temperature.

Through the analysis of Figure 7, it was concluded that the dissolution time does not have a tendency to decrease or increase with the increase in the bath temperature, as long as it is above 70-75 °C. That is, as long as the process is occurring at a high temperature, the SCI can dissolve easily in the liquid surfactants and the time of this process does not depend on the temperature from the above-mentioned value.

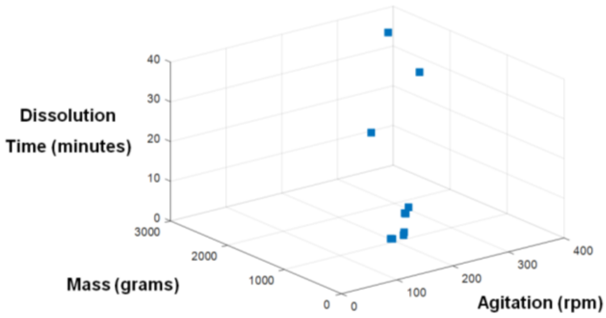

Figure 8: Dissolution time of SCI as a function of mass and agitation.

Regarding the dissolution time as a function of the mass of the sample in Figure 8, it was confirmed that the time increases with the increase of the sample mass. This is due to the greater difficulty in transferring heat from the thermostatic bath water to the mass inside the container. That is, since the mass of SCI is larger, the contact area with the walls of the container, in relation to the working volume, becomes smaller and consequently, the heat transfer is slower, leading to an increase in the dissolution time.

In order to try to overcome the increase of the dissolution time with the increase in mass, it was attempted to increase the stirring power applied to the mixture favouring the contact with the walls of the container, and improving heat transfer. However, this strategy was not sufficient to overcome the increase in mass factor, that is, the dissolution time increased even as the stirring rate increased.

Other Product Parameters

Final Shampoos pH

The pH of the 3 shampoos was also determined to confirm if they were suitable for the hair. The scalp pH is 5.5, and the hair shaft pH is 3.67 (Dias & Almeida, 2014) and hair care products with a pH in this range of values are beneficial for hair health.

For the dry and damaged hair shampoo, the pH was measured in 3 different samples of this shampoo and the results were 6.31, 6.32 and 6.30. In the case of oily and normal hair shampoos, only one sample of each was used to determine the pH and the obtained results were 6.86 and 6.49, respectively.

Comparing the obtained results with the values mentioned above, it is confirmed that the pH of the shampoos is slightly higher the recommended range. The formulations which have an alkaline pH may increase the negative electrical net charge of the hair fiber surface and consequently increase the friction between the fibers, causing frizz (Dias & Almeida, 2014).

On the other hand, comparing the obtained pH of the shampoos with the pH of a regular soap (which is used by some people to wash the hair), it is confirmed that is significantly lower since the pH of most of the soaps is approximately 10. Thus, the importance of washing the hair with the shampoo instead of soap is emphasized for several reasons:

- The pH of the shampoo is closer to the optimum pH for the hair. Since the hair has no ability to readjust the pH as the skin has, as a long-term effect the continuous use of soaps will damage the hair and the scalp.
- The possibility to add the active ingredients to the formulations without destroying them as would happen in the soap formulations. This is also due to the high pH of the soap.
- The shampoo foam characteristics are not dependent on the hardness of the water as it is with soap. Hard water has a high content of calcium and magnesium cations which react with the anions of the soap and precipitate as scum. This reduces cleaning efficiency and also lays down an insoluble layer of these precipitates on the hair scalp, damaging it (Kirk-Othmer, 2013).

Comparison with a Control Shampoo

Taking into account the characteristics obtained in the final shampoos, it was decided to compare these features with those of another shampoo of the same type (organic solid shampoo). This shampoo is produced by a French company named Lamazuna. The Lamazuna shampoo was used as a control to evaluate the different parameters of the produced shampoo in this work.

The characteristics were evaluated in both shampoos, reaching the following results (Figure 9).

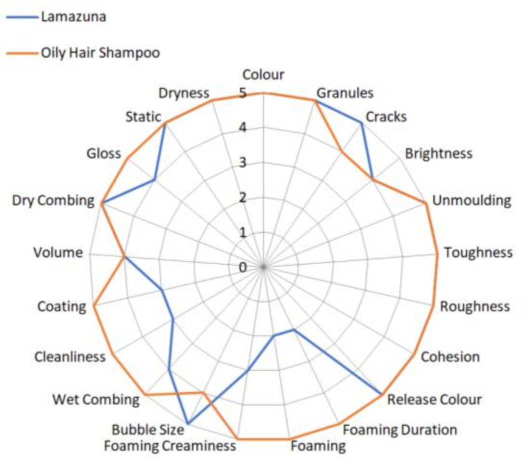

Figure 9: Evaluation of Oily Hair Shampoo produced in the present work and Oily Hair Shampoo from Lamazuna.

Analyzing the previous graph, it is confirmed the two shampoos have different characteristics, namely:

- The produced oily hair shampoo was evaluated with a stronger ability to wash and clean the hair in comparison with the Lamazuna shampoo.
- The Lamazuna shampoo has smaller cracks than the produced shampoo.
- The foam of both shampoos is extremely different since the Lamazuna shampoo has poor foam with small bubbles, making difficult the washing of the hair from its root to the tips. On the other hand, the produced shampoo is characterized by rich and creamy foam which appears immediately after its contact with water, allowing an easy and quick wash.

Despite the fact that the evaluations were more perceptible when tested in real hair (mainly in relation to the cleaning and coating), some of them (such as foaming quantity and creaminess) were also visible in the lab test hair (Figure 10).

Figure 10: Foaming test in lab test hair of Oily Hair Shampoo and Lamazuna Oily Hair Shampoo.

Legal Approval and Price

The solid shampoos produced in this work were legally approved by Oxford Biosciences according to regulation EU 1223/2009, which sets obligatory requirements for cosmetic products that have been made available on the market within the European Union.
After the production of several shampoos these were put up for sale for 7,90€ in different physical stores such as Organii (Baixa-Chiado, Príncipe-Real, Lx Factory, Saldanha and Porto) and in Maria Granel (Alvalade).

Conclusions and Future Improvements

Regarding the development and production of the three lines of shampoo, it was possible to conclude that after the oily hair shampoo production, the other two shampoos were easily reproducible, by adding to the formulation the specific ingredients for each type of hair. In fact, from the moment the manufacturing process was defined and the desired characteristics were reached, it was only necessary to manipulate the active ingredients according to the needs of the hair.
In a nutshell, three products were obtained in accordance with the previously delineated expectations.
When determining the quantity of water and volatiles present in different formulations samples, it was concluded that it was not significant, and for this reason, it was not required a preservative. This was confirmed through the microbiological analysis of the final formulations since the shampoo medium was not propitious for bacteria and fungi growth.
The pH of different samples for the three shampoo lines was determined, and the results obtained (between 6.31 and 6.86) were above what was desired for the healthiness of the hair (between 3.7 and 5.5, approximately).
When comparing the features of the obtained shampoo with the control shampoo (Lamazuna shampoo), the shampoo produced in this work proved to be better in the foam quantity and creaminess which allowed a quick and improved washing of the hair.
Finally, a hanging system with cork was created, as well as the shampoo packaging with recycled paper.
In order to improve the work done, the pH of the shampoo should be adjusted with citric acid in a way that this pH is closer to the hair pH. This will provide a less aggressive washing of the hair, and the increasing of the electrical charge of the hair cuticle will be avoided.
To achieve the absence of the microorganisms after the production, the moulds and the material should be previously disinfected with an alcoholic solution.
An automatic or semi-automatic filling machine with heating and mixing devices should be necessary if increased the scale of production. However, the heating fluid should not be water, in order to ensure the mixture fluidity.
In conclusion, the goals set at the beginning of this work were accomplished. However, the above-mentioned changes can be implemented to improve not only the quality of the shampoos, but also the manufacturing process.

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