Formulation and evaluation of a shampoo made from Saqta root for the reduction of chemical surfactants in gray water

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***Abstract*– The use of cleaning and hygiene products composed of chemical surfactants generates alterations in the aquatic environment causing environmental problems. Thus, the objective of this research was to obtain a shampoo from Saqta root as an alternative to reduce chemical surfactants in gray water. For this purpose, the afrosimetric index and foam density of Saqta root were determined, and surface tension measurements were performed. The results showed that the Saqta root dose of 11 mg/mL was optimal for making shampoo, and its physical and chemical characteristics showed a viscosity of 16560 cP, foam index 0.08 and a pH of 6.5. Analyses of domestic wastewater showed a decrease in the concentration of chemical surfactants from 6.004 mg/L to <0.050 mg/L. Finally, it is concluded that the use of Saqta shampoo influences the decrease of chemical surfactants in gray water and is a sustainable alternative.**

***Keywords*—shampoo, saqta root, natural surfactant, gray water.**

I. Introduction

During the second half of the twentieth century, alternatives emerged to develop cleaning and cleaning products from natural resources that generate less impact on water bodies [1] because chemical surfactants cause environmental problems such as eutrophication in the aquatic environment, causing oxygen depletion and consequently causing the death of flora and fauna. Therefore, many research centers have found it necessary to develop biodegradable and environmentally sustainable products to reduce pollution in water bodies.

Most cleaning products such as detergents, soaps and shampoos contain substances called surfactants such as sodium lauryl ether sulfate, olioxyethylene and ioleoylamidoamine [2]. These substances when in contact with water generate gray water, which in turn when discharged into surface water causes contamination [3]. Shampoos are used in esthetic centers because it removes hair impurities such as grease, dirt, dandruff, among others [4]. In addition, this product is used to control hair loss, shine and silkiness [5].

Literature review has shown that natural resources have surfactant capacity due to the presence of saponins in their composition, and these could act as a favorable alternative to chemical surfactants [6]–[9]. Among the natural species we have *Sapindus mukurossi* which was used for the manufacture of an ecological shampoo [10], as well as *Fenugreek, Acacia Concinna*, *Azadirachta Indica*, *Sanctu Ocimum* [11]. Likewise, the shampoo based on the alcoholic extract of Urtica urens L. leaves with a pH of 5.7 performs hair loss control qualities and does not cause dermal irritation [5]. Similarly, shampoo from *Rosmarinus officinalis* combats hair dandruff [12]. With this, a shampoo from herbs with properties of a natural foaming agent, have conditioning, antioxidant and antimicrobial effect [8]. Also, *Acacia Concinna*, is a medicinal plant known for the ability to biodegrade and act as a natural surfactant [13].

Several works have used natural resources to produce various cleaning products, but saqta root, which is found at 3762 m.a.s.l. in the city of Cusco, Peru, has not yet been used. Therefore, this research determined the influence of the use of Saqta shampoo in the reduction of chemical surfactants in gray water. Likewise, the Saqta-based shampoo benefits the population and the environment because it will be a sustainable product that has a positive effect on the water, unlike synthetic shampoos that are composed of chemical surfactants.

II. Materials and Methods

A. Obtaining Saqta

The Saqta (*Colignonia sp.*) (Figure 1) was obtained from the city of Chinchero, Cusco, which is located at 3762 m.a.s.l. For the characterization of the plant anatomy of *Colignonia sp.* several cuts were made using a microtome as an instrument. The root sections were placed on different glass slides to be pretreated with lugol reagent, and then analyzed by scanning electron microscope (SEM) to see their plant anatomy.

B. Physical and chemical characterization of saqta root

In the physical characterization of Saqta, humidity and apparent density were determined, and to evaluate the persistence of the foam, an afrosimetric test was carried out in 3 time intervals of 5 - 20 min (+), 20 - 25 min (++) and > to 30 min (+++). The afrosimetric index was also evaluated to determine the ideal concentration to reach the adequate foam height.

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In the chemical characterization, foam density was evaluated by means of surface tension tests carried out in a CSC SCIENTIFIC Tensiometer.

C. *Elaboration of the saqta shampoo*

For the preparation of the shampoo, the Saqta was first washed with distilled water to avoid impurities and was then dehydrated in an oven in order to pulverise it and obtain the natural surfactant. Next, distilled water was added for each gram of Saqta root powder in the proportion of 1:3, and the mixture was brought to boil. Subsequently, the mixture was filtered to obtain the natural surfactant which was combined with the thickener (Xanthan Gum) in a ratio of 2 g of thickener per 100 mL of natural surfactant. Finally, the following ingredients were added: 28 mL of the natural preservative Procide CG Ecocert, 28 mL of almond vegetable oil, 8 mL of vegetable glycerin and 3 drops of castor oil, and mixed vigorously until complete homogenization.

D. *Saqta shampoo application and characterization*

After the Saqta shampoo was prepared, it was applied in the esthetic centers and samples were taken, evaluating pH, foam index, viscosity and surfactant concentration.

Fig. 1 Saqta: a) Saqta plant, b) Root of Saqta and c) Powdered Saqta.

III. Results and Discussion

A. *Plant anatomy of Saqta*

It is important to observe the plant anatomy of the plant because it determines the morphology, structure, family and class to which the Saqta belongs. The characterization of Saqta or Sachaparacay showed that it is a tuberous root of reservoir nature due to the formation of successive vascular cambium rings. In addition, tissues such as the suber, phellogen and phellodermis have radial arrangement [14]. Figure 2 shows the plant anatomy of Saqta root. One of the bundles of the vascular ring with phloem, vascular cambium and xylem is observed, the latter surrounded by its xylem fibers with six woody vessels, as shown in Figure 2-a. Figure 2-b shows the starch grains in the parenchyma associated with the xylem (A) and its fibers (B).Two concentric rings of vascular bundles are also observed, separated by the fundamental parenchyma (see Figure 3-c), and the central region of the root, with two vascular bundles, radial cells and part of the fundamental parenchyma is shown in Figure 2-d.

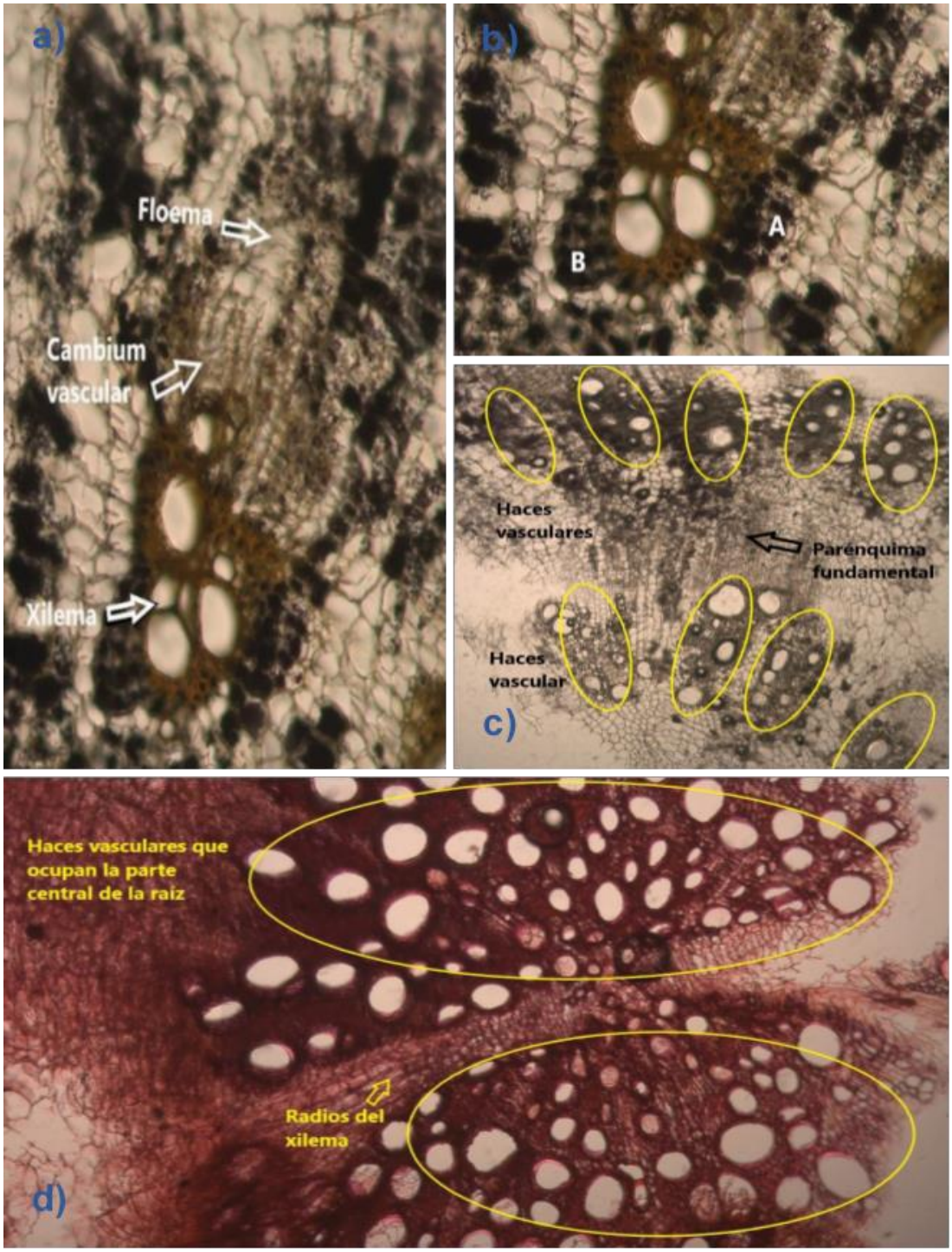

Fig. 2 Saqta root plant anatomy.

B. Physical and chemical analysis of Saqta

Table 1 details the physical and chemical characteristics of Saqta, showing that Saqta root has a humidity of 70.98%, apparent density of 0.6250 g/mL and a pH of 6.53. The afrosimetric test showed a stable foam greater than 30 minutes, valued with (+++). The afrosimetric index showed that the ideal concentration to reach the adequate foam height of 1 cm was 0.0125 g/10 mL, as shown in Figure 3. It was also observed that the foam density in alkaline medium is consistent while in acid medium it is minimal

.

TABLE I
PHYSICAL AND CHEMICAL ANALYSIS OF SAQTA ROOT

Parameter	Unit	Value
Humidity	%	70.98
Apparent density	g/mL	0.6250
pH	-	6.53
Afrosimetric test	min	> 30
Afrosimetric index	g/10mL	0.0125

Fig. 3 Afrosimetric index.

On the other hand, the surface tension tests as a function of Saqta concentration and pH are shown in Figure 4. In Figure 4-a it is observed that the surface tension of the liquid decreases as the Saqta concentration increases, reaching the critical micellar concentration value at a concentration of approximately 11 mg/mL (0.011 g/mL). The surface tension increases slightly as the solution becomes more alkaline, as observed in Figure 4-b.

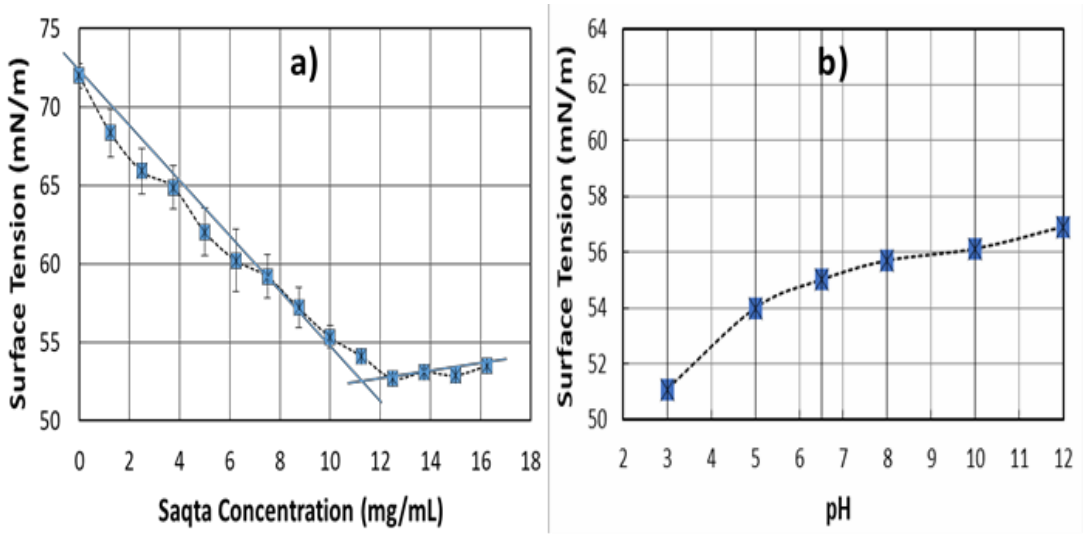

Fig. 4 a) Surface tension as a function of Saqta concentration: pH = 6.5 and b) Surface tension as a function of pH: Saqta concentration = 11 mg/mL.

As evidenced in Figure 4-a, the surfactant concentration was 0.011 g/ml, resulting in a higher concentration compared to that used in the preparation of *Pyagi Phool* shampoo, which was 6.40x10-4 g/ml [7]. Likewise, Ref. [13] replaced the synthetic surfactant with *Acacia Concinna* which has properties of a natural surfactant, with the optimum dosage for shampoo making being 4.4x10-4 g/mL.

C. Physical and chemical characteristics of Saqta shampoo

Table 2 shows the physical and chemical characteristics of Saqta shampoo.

TABLE II
PHYSICAL AND CHEMICAL CHARACTERISTICS OF SAQTA SHAMPOO

Parameter	Unit	Value
pH	-	6.5
Foam Index	-	0.08
Viscosity	Pc	16560
Surfactant Concentration	mg/L	< 0.05

From Table 2 it was observed that the foam index resulted to be lower (0.08) compared to the synthetic shampoos that are found in an average of 0.46 [15], demonstrating that the natural shampoo presents lower foam due to the absence of chemical surfactants. Similarly, the pH of synthetic shampoos has a value between 5-7 [16], while Saqta shampoo had a pH value of 6.5. Other herbal shampoos of *Fenugreek* (Methi), *Azadirachta indica* (neem), *Concinna Acacia* (shikakai), *Sapindus mukorossi* (reetha) and *Sanctu Ocimum* (tulsi) had a value of 5.46, indicating that shampoos from natural resources have similar characteristics to synthetic products.

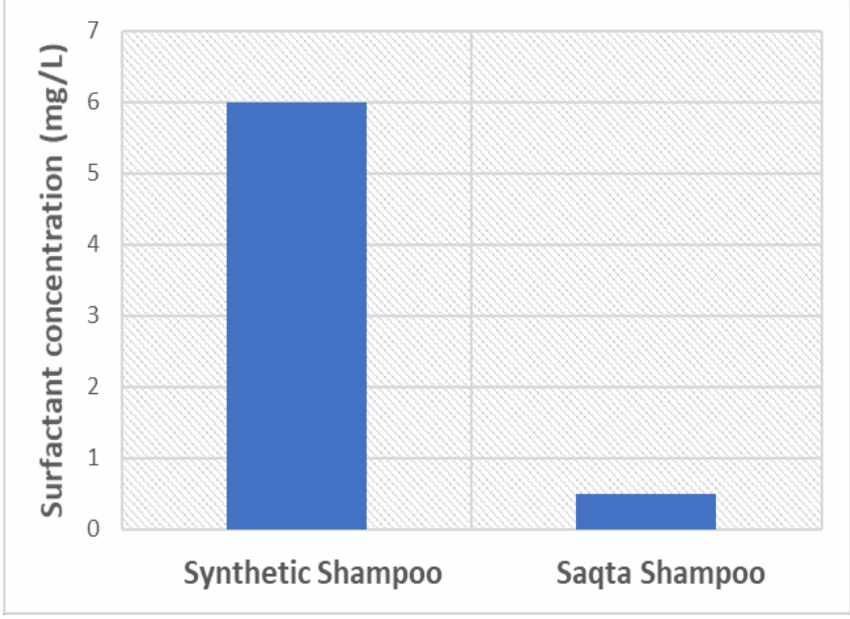

Fig. 5 *Surfactant concentration in gray water*.

As shown in Figure 5, the surfactant concentration for synthetic shampoo in gray water was 6.004 mg/mL, exceeding the limits established by the ECA for waters in category 1 for detergents. Whereas, Saqta's shampoo showed a surfactant concentration <0.05 mg/L, complying with the current regulations of Supreme Decree N° 004-2017-MINAM [17].

IV. CONCLUSIONS

The use of Saqta shampoo influences the reduction of 99.17% of chemical surfactants in gray water, and it is a sustainable alternative because it was made from natural products free of chemical surfactants. The optimum concentration to obtain a Saqta shampoo was 0.011 g/mL (for 500 mL of shampoo it was necessary to use 5.5 g of Saqta). In addition, the physical and chemical characteristics of the shampoo were pH of 6.5, viscosity of 16560 cP, foam index of 0.08 and a surfactant concentration of <0.05 mg/L.

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