Thickening capacity of Cordia lutea Lam mucilage gum in a liquid soap formulation

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Capacidad espesante de la goma de mucílago Cordia lutea Lam en una formulación de jabón líquido

Capacitat espessidora de la goma de mucílag Cordia lutea Lam en una formulació de sabó líquid

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ABSTRACT

The study refers to the use of *Cordia lutea* Lam gum as a natural thickener in a liquid soap formulation. The aim was to determine the phytochemical components and the thickening capacity of mucilage gum in a liquid soap formula. The color of the fruit and the mucilage gum were determined by CIELab methodology, the phytochemical screening of the mucilage gum extracted by manual pressure, by rapid chemical reactions. The hydrocarbons were determined by gas chromatography and the viscosity using a rotational viscometer. Liquid soap was made according to a commercial formula using a DCA 3^2 design along with the factors amount of mucilage and Texapon at two levels (low and high) and viscosity and foam formation that were used as response variables. The thickening effect of the mucilage gum in the soap was evidenced through the viscosity (mPa.s) and foaming capacity by the test tube method; those variables were tabulated using the statistical software statgraphics plus. Phytochemical results showed the presence of saponins, quinones, carotenoids and coumarins; and hydrocarbon compounds: tetratriacontane (34,28%), n-hexadecanoic acid (28,74%) and 9-12-15-Octadecatrienoic acid (18,19%). The viscosity of the mucilage gum was greater than 14000 mPa.s and that of the liquid soap that ranged from 1931 to 2822 mPa.s. The pH was 6,5 to 6,8 and the foaming was comparatively higher than commercial products. The mucilage gum obtained constitutes a natural thickener with an important projection of immediate application in the pharmaceutical and cosmetic industries.

***Keywords: Cordia lutea*, composition, mucilage gum, thickener, soap**

RESUMEN

El estudio se refiere al uso de la goma Cordia lutea Lam como espesante natural en una formulación de jabón líquido. El objetivo fue determinar los componentes fitoquímicos y la capacidad espesante de la goma de mucílago en una fórmula de jabón líquido. El color del fruto y de la goma de mucílago se determinó mediante la metodología CIELab, el tamizaje fitoquímico de la goma de mucílago extraída por presión manual, mediante reacciones químicas rápidas. Los hidrocarburos se determinaron por cromatografía de gases y la viscosidad utilizando un viscosímetro rotacional. El jabón líquido se elaboró según una fórmula comercial utilizando un diseño DCA 3^2 junto con los factores cantidad de mucílago y Texapon a dos niveles (bajo y alto) y viscosidad y formación de espuma que se utili-

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zaron como variables de respuesta. El efecto espesante de la goma de mucílago en el jabón se evidenció a través de la viscosidad (mPa.s) y capacidad espumante por el método de probeta; dichas variables fueron tabuladas mediante el software estadístico Statgraphics plus. Los resultados fitoquímicos mostraron la presencia de saponinas, quinonas, carotenoides y cumarinas; y compuestos hidrocarbonados: tetratriacontano (34,28%), ácido n-hexadecanoico (28,74%) y ácido 9-12-15-octadecatrienoico (18,19%). La viscosidad de la goma de mucílago fue mayor a 14000 mPa.sy la del jabón líquido que varió de 1931 a 2822 mPa.s. El pH fue de 6,5 a 6,8 y la formación de espuma fue comparativamente más alta que los productos comerciales. La goma de mucílago obtenida constituye un espesante natural con una importante proyección de aplicación inmediata en la industria farmacéutica y cosmética.

Palabras clave: Cordia lutea, composición, goma de mucílago, espesante, jabón.

RESUM:

L'estudi fa referència a l'ús de la goma Cordia lutea Lam com a espessidor natural en una formulació de sabó líquid. L'objectiu era determinar els components fitoquímics i la capacitat d'espessiment de la goma de mucílag en una fórmula de sabó líquid. El color del fruit i la goma de mucílag es va determinar mitjançant la metodologia CIELab, el cribratge fitoquímic de la goma de mucílag extreta per pressió manual, per reaccions químiques ràpides. Els hidrocarburs es van determinar per cromatografia de gasos i la viscositat mitjançant un viscosímetre rotatiu. El sabó líquid es va fer segons una fórmula comercial utilitzant un disseny DCA 3^2 juntament amb els factors quantitat de mucílag i Texapon a dos nivells (baix i alt) i viscositat i formació d'escuma que es van utilitzar com a variables de resposta. L'efecte espessidor de la goma de mucílag al sabó es va evidenciar a través de la viscositat (mPa.s) i la capacitat d'escuma pel mètode del tub d'assaig; aquestes variables es van tabular mitjançant el programari estadístic Statgraphics plus. Els resultats fitoquímics van mostrar la presència de saponines, quinones, carotenoides i cumarines; i compostos hidrocarburs: tetratriacontà (34,28%), àcid n-hexadecanoic (28,74%) i àcid 9-12-15-octadecatrienoic (18,19%). La viscositat de la goma de mucílag era superior a 14000 mPa.s i la del sabó líquid que oscil·lava entre 1931 i 2822 mPa.s. El pH era de 6,5 a 6,8 i l'escuma era comparativament més alta que els productes comercials. La goma de mucílag obtinguda constitueix un espessidor natural amb una important projecció d'aplicació immediata en la indústria farmacèutica i cosmètica.

Paraules clau: Cordia lutea, composició, goma de mucílag, espessidor, sabó

INTRODUCTION

The genus *Cordia* reaches more than 300 species distributed in Africa, America and Asia[1]. In Peru, there are 30 species, including *Cordia lutea* with medicinal importance[2]. In Ecuador the presence is significant, but there are no reports of different types of species. The fruit contains reducing sugars, saponins, phenols, tannins, amino acids[3]. Its structure combines a polar group (sugar) and a non-polar group (steroid), necessary to form natural detergent. It is also used as a stabilizer and emulsifier in cleaning products and cosmetics[4] and the resin of the fruit as a glue[5].

Mucilage is a network of polysaccharides that behaves as a pseudoplastic liquid (non-Newtonian fluid) with adhesive properties and a rheological modifier for food and biomedical materials[6]. It is gelatinous, imitates vegetable gum and is made up of protein and polysaccharide[7], carbohydrates with branched structures consisting of monomeric units of L-arabinose, D-xylose, D-galactose, L-rhamnose and galacturonic acid[8], it forms viscous masses with the capacity to absorb water. It is insoluble in alcohol and has colloidal properties. The mucilage of *C. lutea* is sticky to the touch and behaves more like rubber than a mucilage.

Gums are pathological products formed by damage to the plant, exposure to unfavorable conditions or rupture of cell walls (extracellular formation: gummosis) and mucilages are normal products of metabolism, formed inside the cell[9]. It has several forms of exposure: mucilage gums, seed gums, and exudate gums[10].

Mucilages and gums (polysaccharide macromolecules) of high molecular weight[11] and biodegradable[12] produce gels when combined with appropriate solvents[13,14]. Its distinctive physicochemical and structural diversity benefit health[15], the plant ingredients are used for application in the pharmaceutical and cosmetic industries[16]. They are hydrocolloids that produce a mixture of sugars and uronic acids by hydrolysis[17], a reason for the application of mucilage gum from *C.* lutea as a natural thickener in a liquid soap formula. Therefore, the aim was to determine the phytochemical components and the thickening capacity of the mucilage gum of *Cordia Lutea* Lam, in a liquid soap formula.

MATERIALS AND METHODS

In Ecuador, *C. lutea* is found in hot and dry climates in the provinces of Loja, Azuay, El Oro, Guayas, Santa Elena and Manabí. The mature sample of *C. lutea* was collected in its natural ecosystem in Jipijapa canton, Manabí province.

Physical characteristics such as color were determined using the CIE Lab chromatic model (Capsure Palette X-rite color capture equipment with built-in software), pH by the potentiometric method and for soluble solids, the ATAGO digital equipment was used from scale 0 to 93 °. The extraction of the product that is called mucilage gum was carried out using a manual extractor (figure 1).

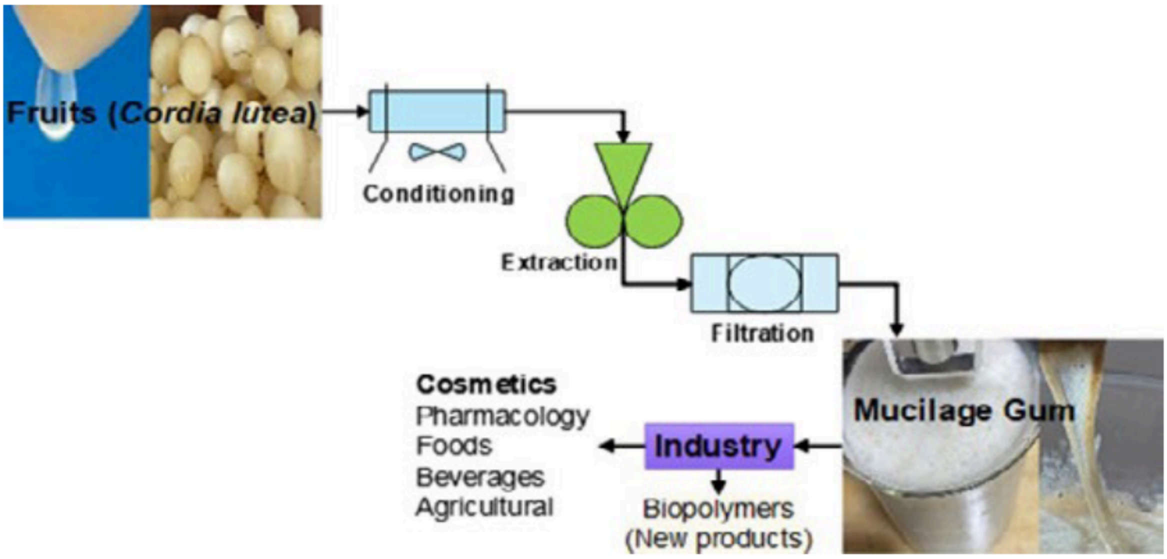


Figure 1. *Process diagram for obtaining mucilage gum*

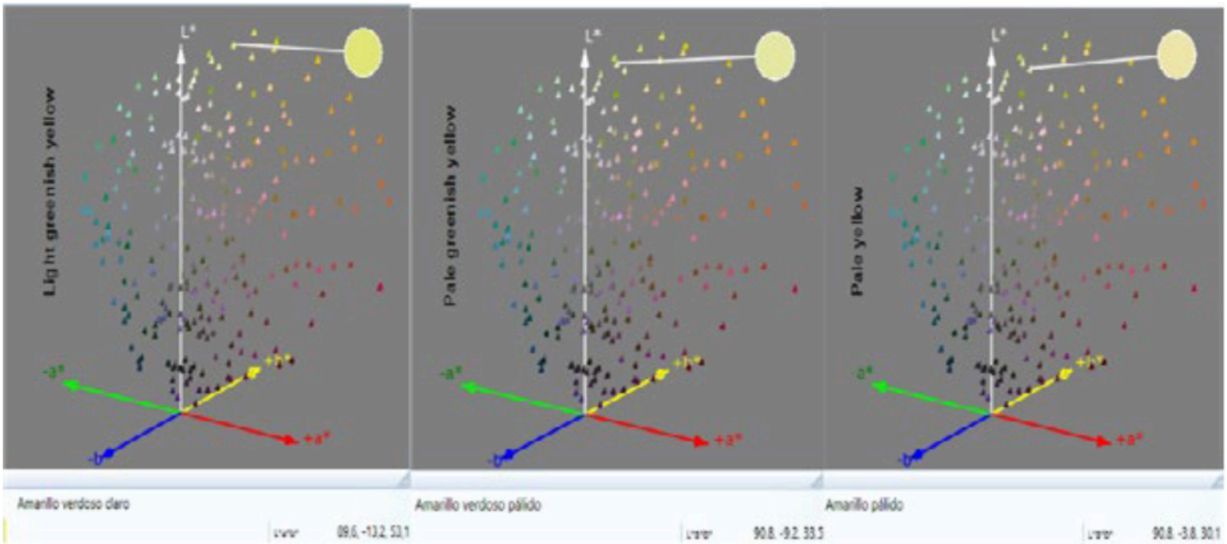


Figure 2. *Fruit color and mucilage gum by CIElab color model*

Phytochemical screening for secondary metabolites was performed by chemical reactions with appropriate solvents and for hydrocarbon compounds by gas chromatography/mass spectrometer (GC/MS). Viscosity was determined using a CGOLDENWALL NDJ-5S rotational viscometer.

The thickening capacity was tested by making liquid soap using a DCA 3^2 design according to factors: amount of mucilage gum and Texapon at three levels (low, medium and high), adding 0.4% benzalkonium chloride (antibacterial), cosmetic preservative and water to complete one liter of product, estimated by the response variables viscosity and foam formation (table 1). The results were tabulated using the statistical software statgraphics plus.

Table 1. *Factors, levels and response variables for liquid soap*

Factors	Units	Levels			Response Variables
		Low	Medium	High	
Mucilage gum (X1)	g	200	300	400	Viscosity (mPa.s) Amount of foam (ml)
Texapone-Sodium Lauryl Ether Sulfate (X2)	g	120	160	200	

RESULTS AND DISCUSSION

Characteristics of the fruit and mucilage gum of *C. lutea*

The fruit of *C. lutea* is fleshy and when squeezed, a transparent and sticky liquid sprouts. It is used by the community members as glue in school activities and hair fixative. Soluble solids in semi-ripe fruits are 9º±1Bx and in mature fruits 15± 1oBx. The pH is moderately acidic (6,5), typical of the acid mucilage group of plants[18], an important variable for the formulation of cosmetic products. The color of the fruit (semi-ripe) varies from light greenish yellow to yellow, pale greenish (ripe fruit) and the mucilage gum of the ripe fruit acquires a paleyellow color stimulated by the oxidation of the product in the extraction process (figure 2).

Color as a measure variable of acceptance or rejection of a product is based on attributes of luminosity, tonality and purity, where the value (a) of CIEL*a*b* of the attribute of tonality or sensation was negative very close to quadrant (-a) green color in the uptake and was more diffuse as the fruit reached maturity and oxidation of the mucilage gum; aspect that deserves further investigation.

The extraction yield was 37±2%, a variable that should be the subject of future research with an equipment designed for this purpose; since very few reports have been published on the use of mucilages in industrial applications[19].

CHEMICAL ANALYSIS

The photochemical screening of mucilage gum (table 2) shows the presence of tannins, "antimicrobial components associated with their antioxidant capacity"[20], quinones in basic medium, hydrolyzed α, β quinones and naphthoquinones "widely used in biological activity in the cosmetology and pharmaceutical industries as antibacterial, antifungal, antimalarial and anticancer"[21], carotenoids and coumarins with "antioxidant" effect[22], also with bactericidal, fungicidal and/or fungistatic properties and efficient activity as insecticides due to their toxicity[23]. As non-specific metabolites that deserve further study, there are triterpenes "with 30 carbon atoms with antioxidant, anticancer, antiseptic and anti-inflammatory, antimicrobial, antiviral, and antiparasitic properties"[24,25].

Table 2. *Phytochemical components*

Secondary metabolites		Result
Alkaloids		(-)
Tanins		(+)
Saponins*		(+)
Flavonoids		(-)
Triterpenes		(-+)
Steroids		(-)
Quinones	Acid	(-)
	Base	(+)
Quinones α, β hydrolyzed		(+)
Carotenoids		(+)
Coumarins		(+)
Naphthaquinones		(+)

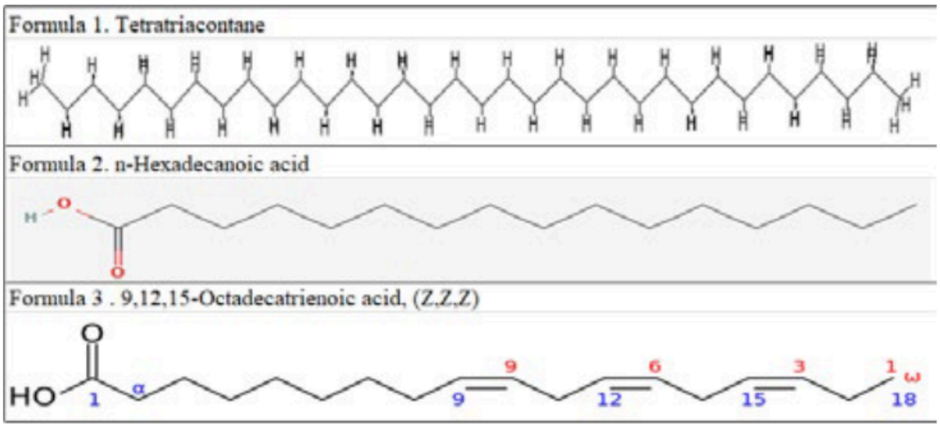
(+): positive, (-) negative. (*) abundant, (-+) Non specific

The large amount of saponins is notorious, an important component in foam formation, with "antifungal, anti-inflammatory, antimicrobial, antioxidant"[26] properties that are substantial for study. Research on *C. lutea* flowers show the presence of brass compounds, naphthaquinones and anthraquinones, steroids, alkaloids, phenolics, flavonoids, leukoanthocyanins and anthocyanidins, reducing sugars, amino acids and resins, especially[27]. In addition, the presence of hydrocarbons in the mucilage gum is reported, assessed by gas chromatography/mass spectrometer (table 3).

The hydrocarbons found in the highest proportion are tetratriacontane (34.28%), followed by n-Hexadecanoic acid (28.74%) and 9,12,15-Octadecatrienoic acid (18.19%). Tetratriacontane is a natural product[28], with a linear molecular structure typical of a higher alkane[29], with anti-asthmatic properties; also used as a drug for disorders of the urinary system[30] (Formula 1). The n-Hexadecanoic acid acts as an anti-inflammatory[31], with antimicrobial activity[32], known as palmitic acid with a molecular structure. Found naturally in palm oil and palm kernel oil[33], it is an inhibitor of prostaglandin-E2 9-reductase[34] (formula 2). The 9,12,15-Octadecatrienoic acid, (9Z,12Z,15Z), known as α-Linolenic Acid, is an

Table 3. *Hydrocarbon components in mucilage gum*

No.	Peak Name	Retention Time	Relative Area	CAS Number	Chemical Formula
		min	%		
TIC	TIC	TIC	TIC	TIC	TIC
1	(E)-Hexadec-9-enoic acid	27,550	3,25	10030-73-6	$C_{16}H_{30}O_2$
2	n-Hexadecanoic acid	27,965	28,74	57-10-3	$C_{16}H_{32}O_2$
3	(Z)-18-Octadec-9-enolide	31,202	0,54	80060-76-0	$C_{18}H_{32}O_2$
4	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-	31,338	18,19	463-40-1	$C_{18}H_{30}O_2$
5	Cyclopropaneoctanoic acid, 2-[[2-[(2-ethylcyclopropyl)methyl]cyclopropyl]methyl]-, methyl ester	31,543	0,05	10152-71-3	$C_{22}H_{38}O_2$
6	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-	31,685	0,52	463-40-1	$C_{18}H_{30}O_2$
7	Pentacosane	40,076	14,44	629-99-2	$C_{25}H_{52}$
8	Tetratriacontane	42,909	34,28	14167-59-0	$C_{34}H_{70}$
Total			**100,00**		



Formula 1. Tetratriacontane

Formula 2. n-Hexadecanoic acid

Formula 3 . 9,12,15-Octadecatrienoic acid, (Z,Z,Z)

essential fatty acid[35]; belonging to the group of omega-3 fatty acids of vegetable oils and has been reported to

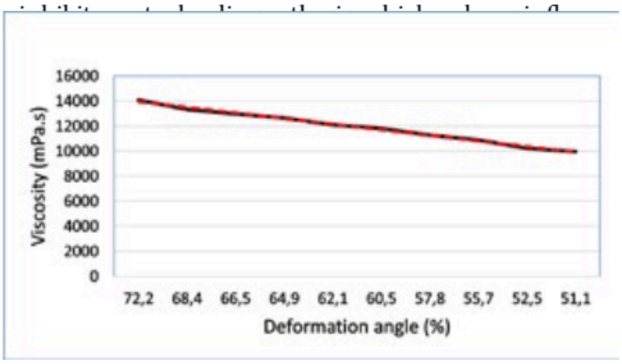


Figure 3. *Behavior of the Viscosity with respect to the % of deformation*

The viscosity (Figure 3) was 14080 mPa.s (spindle 3 and deformation angle at two digits and 6 rpm), with temperature control between 23.9 and 24.6ºC. Different viscosity measurements of the mucilage gum show a non-linear behavior due to the effect of the relationship between the shear stress and the rate of deformation. The heterogeneous behavior gives the product characteristics that correspond to a non-Newtonian fluid, in which "the movement of the fluid itself affects the viscosity, adopting changing values as speed and shear force do."[37]. Mucilage gum behaves as a non-Newtonian fluid is characterized by the fact that the tangential stresses depend only on the rate of deformation[38]. When the temperature increased from 5 to 85°C the apparent viscosity of other polysaccharides decreased from 3.01 to 0.13 Pa.s (3000 to 130 mPa.s)[39], a value lower than that obtained in mucilage gum from *C. lutea* .

Mucilage gum is physically a non-Newtonian fluid with characteristics of a pseudoplastic fluid, where the apparent viscosity decreases with increasing rate of deformation and does not depend on the time variable. However, it is necessary to address new rheological studies to characterize the type of fluid.

Thickening capacity of mucilage gum in liquid soap formula

Table 4 shows the results of viscosity and amount of foam generated by the soap obtained at two factors: amount of mucilage gum and Texapone at three levels: lower, medium and higher.

Table 4. *Factors, levels and response variables in the soap formula*

BLOQUE	Mucilage gum (X_1)	Texapone (X_2)	Viscosity	Amount of foam
	g	g	mPa.s	ml
1	-1	-1	1206	130
1	1	-1	1931	151
1	-1	1	1397	136
1	1	0	2598	172
1	0	0	2305	163
1	0	1	2463	167
1	-1	0	1292	138
1	0	-1	2084	145
1	1	1	2822	178

Viscosity values of 2822 mPa.s at a higher level are evident, generated by the thickening effect of the mucilage gum, a characteristic that allows substituting sodium chloride (traditional thickener) in a soap formula. The viscosity of these products varies between 1070 to 4626 cP[40].

The viscosity of the soap using mucilage gum from *C. lutea* as a natural thickener in substitution of sodium chloride for all treatments ranges from 1206 to 2822 mPa.s, values that adjust to "commercial products that are between 1000 to 9000 mPa.s and the minimum viscosity (so that it does not flow to the eye) has a value of 1250 Cp[41,42], from 850 to 1250[43]. Generally, the effect of the electrolyte (salt) on the viscosity of the soap depends on the components of the soap formula, as well as the type of salt used, that at 0.5% the viscosity exceeds values of 200 Cp and when used at 1% it could reach values higher than 10,000 Cp[44], an effect that is also achieved with the incorporation of mucilage gum.

For liquid soap according to the regression coefficient reached a constant in viscosity (dependent variable) of 2338,1 for an R-squared (adjusted by g.l.= 97.62%). The independent variable is the amount of mucilage gum incorporated with the greatest significant effect, and not so with the variable texapon. Consequently, the variables must be carefully controlled and evaluated in the production process, where the optimum viscosity

value established by the statistical program is 3006[45] mPa.s. Figure 4 shows the level of significance of the viscosity of liquid soap in its order: mucilage gum at its two levels, Texapon at a high level and its interaction at a higher level.
Consequently, the statistical result is significant.

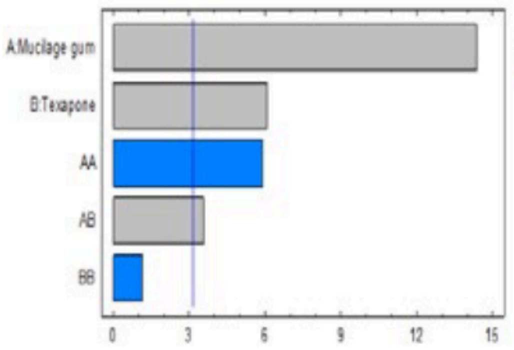


Figure 4. *Pareto diagram for Visosity*

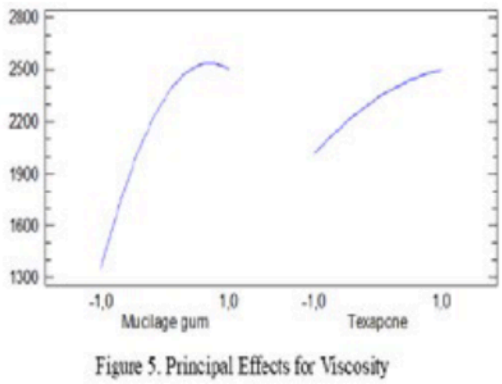


Figure 5. *Principal Effects for Viscosity*

Figure 5, shows the effect of mucilage gum on the viscosity of the processed product, evidencing its thickening capacity. Figure 6, the interactions between mucilage gum and texapon for liquid soap viscosity shows the thickening effect of these two products; so that, at an industrial level, these two variables must be operated with special attention to optimize the thickening capacity of the material under study.

Figure 7, illustrates the behavior of incorporated texapon and mucilage gum, where the viscosity of the liquid soap increases as the amount of mucilage gum increases. Therefore, for liquid soap production, the amount of mucilage gum as a thickener and Texapon as a cleaning product must be assessed, and their complementary ingredients to be incorporated must be the subject of further investigation. Consequently, the viscosity increases proportionally to the mucilage gum concentration and texapon in the product.

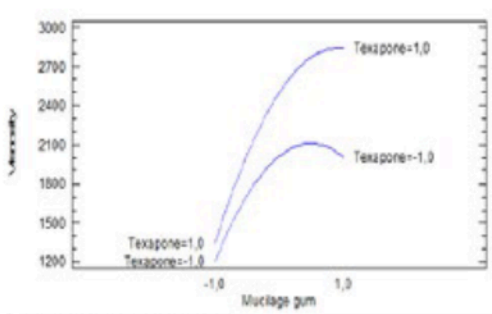


Figure 6. *Interaction for viscosity*

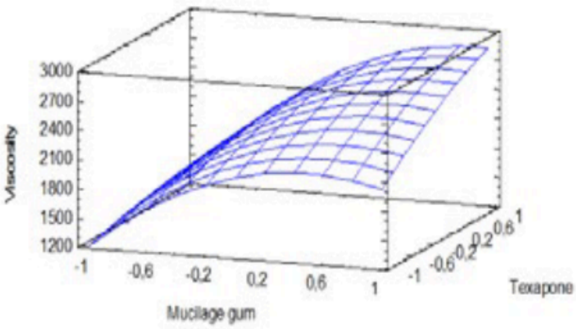


Figure 7. *Response surface for viscosity*

The amount of foam generated by the mucilage gum and texapone reached 216 ml, controlled in a 1000 ml capacity cylinder using a 2% soap solution in tap water; foaming capacity provided by mucilages[24], important for hygiene products. This value is considered higher than those analyzed in commercial liquid soaps (120 to 175 ml) and similar to "204 to 210 ml"[46]. The mucilage gum of *C. lutea* (muyuyo) shows its thickening capacity and the formation of a large amount of foam, which suggests further research to evaluate its properties as a raw material for other cosmetic products. The pH of soap varies from 6.5 to 7.2, pH values in soaps that are within 3.5 to 9.0[23] ; Tested products have an acceptable pH range for hair from 5.0 to 7.0, which is close to the pH of skin[47]. Other peculiarities such as color (characteristic of mucilage gum) and good wetting, give the obtained product great possibilities of technological application and acceptance.

CONCLUSIONS

The thickening capacity of the mucilage gum from the fruit of *Cordia lutea* Lam, its physical properties, and components makes it a novel raw material with a wide field of application in the cosmetic, pharmacological, food, agricultural, and biopolymer industries. It deserves more attention from the scientific community as an alternative study to obtain sustainable products necessary in the industry as substitutes for synthetic raw materials, with immediate application and social benefits.

AUTHORS CONTRIBUTION:

All authors have contributed to the development of the work.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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