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Natural Foaming Agents: A Review

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*Abstract:*In the cosmetics and pharmaceutical industry surfactants have played a very important role since their discovery. They've been used in preparations such as shampoo, detergents, face washes and many more formulations make use of these surfactants. But they are also produced from non-renewable sources of energy such as petroleum which causes not only the exhaustion of these natural resources but also their byproducts are toxic to the humans and to the nature as well as their biodegradability is very low. They have a low production cost and can be produced on a large scale. Traditionally used foaming agents in ayurveda have been there for thousands of years along with other natural agents that can create foam are looked at as alternatives to reduce the harmful effects of chemical surfactants. Biosurfactants are the agents which are produced by microbes and other biological sources which are also excellent foaming agents which can be great alternatives for synthetic petroleum-based surfactants. This review article herein discusses such few green foaming agents which are completely natural in origin and can be used as an alternative for chemical surfactants and lead the prospects of our formulations in the future.

Keywords:
Herbal shampoo, Natural foaming agent, pH modifier, viscosity modifier, antibacterial agents.

I. INTRODUCTION

Shampoos serve the purpose of cleansing the hair and scalp and are among the most popular cosmetics. These goods are made up of a mixture of surfactants (tensioactive agents) to remove dirt and sebum from the hair as well as other ingredients for conditioning, smoothness, anti-dandruff activity, and medicated properties [1]. The primary substances in shampoos, known as surfactants, are amphipathic molecules made up of a hydrophilic and a hydrophobic section. As a result, they can lower surface tension as well as interfacial tension between fluids with various polarities. While the hydrophilic component may be made up of an ester group, hydroxyl, phosphate, carboxyl, or sugar, the hydrophobic portion is often made up of a hydrocarbon chain containing one or more saturated, unsaturated, hydroxylated, or branched fatty acids [2]. Most surfactants are non-biodegradable and are hazardous to both humans and the planet because they are made from petroleum wastes. Also, there are instances of hair damage from shampoos' use of synthetic surfactants such as SLS, SLES which include hair loss, follicle drying, and scalp irritation. The human scalp is very sensitive as it also covers the cranial region, it is important to take good care of the scalp health. As an extension of the hair follicle in the scalp, if overall health of scalp is not maintained over a period hair may become coarse and dry. As a result, natural substitutes for these drying chemical surfactants are required. surfactants that are natural in origin, have benefits over synthetic alternatives such biodegradability and low toxicity [3]. The possible unwanted and harmful effects of these chemical surfactants containing shampoo can be completely avoided by using natural in origin or herbal foaming agents which can replace the surfactants for good. Sustainable and eco-friendly alternatives will not only reduce toxic waste from production but are also better for overall health of the scalp. These substitutes can range from traditionally used ayurvedic materials to newly discovered natural in origin substances which can be used as alternatives to chemically synthesized foaming agents.

1.2 WHAT ARE SYNTHETIC/CHEMICAL SURFACTANTS

Surfactants are surface active agents that help reduce the tension between two surfaces to provide stability. Emulsions and foaming agents widely use surfactants for stability in their structure. They have amphiphilic nature, and both have a hydrophobic and hydrophilic region that act accordingly. Depending on the charge of the hydrophilic head of the molecule, surfactants can be divided into four groups: anionic (negative charge), cationic (positive charge), amphoteric (both negative and positive ions), and non-ionic (no charge). Their character typically specifies which applications are suitable for them. Examples of anionics in detergents are sodium dodecyl sulphate (SDS) and linear alkylbenzene sulfonate (LAS), which are used in laundry detergents, household cleaning goods, and personal care items. Although they are not as effective as anionics for detergents, cationic surfactants are nonetheless employed in detergents, fabric softeners, and hair conditioner [4]. Initially, only renewable resources like plant or animal oils were used to make surfactants. The bulk of surfactants currently

in use are toxicologically problematic and only partially or slowly biodegrade, causing environmental harm [5]. Petroleum based synthetic surfactants make use of non-renewable resources which are limited in nature. Wide use of these sources is implied because it is much cheaper to produce as well as produced in large quantities. The secondary byproducts of these are also toxic in nature. Irritation, dryness, patchy skin and redness are one of the few symptoms which are caused by harsh surfactants like SLS, SLES in cosmetic products like shampoo and face washes. Using alternatives such as natural foaming agents and biosurfactants is the need currently.

II. TRADITIONALLY USED NATURAL FOAMING AGENTS

Foaming agents which are traditionally used for herbal shampoo preparation. Since ancient times these foaming agents have been utilized for cleansing hair. These agents are most used in herbal shampoo formulation, commercially as well as traditional homemade shampoo.

2.1 Sapindus Mukorossi (REETHA)

It is a member of the Sapindaceae family and is frequently referred to as Reetha. The fruit is sometimes known as a soapberry or a washnut. Many local households still wash their hair with soapnut (reetha), which is still popular. The fruits have saponin, which are organic surfactants that can be used to wash clothes, skin, and hair. These saponins can also be used as pesticides to get rid of lice on the scalp, for as an example [6].10–11% of the fruit's saponins are found in the pericarp. Saponins, triterpenoids, fatty acids, and flavonoids are the fruits' main chemical components. Other species have compounds that are astringent. The antibacterial, fungicidal, and anti-inflammatory properties of these substances are well established and will be beneficial for hair products. Mukurozi saponins have been found to have solubilizing properties. pericarps were used to isolate monodesmoides and bisdesmoides [7]. Since reetha is thought to be helpful for the health of hair, it is frequently used as the main ingredient in shampoos and soaps for cleaning hair. It is included as a common herb in the Ayurvedic list of herbs and minerals and is a crucial component of cleansers and shampoos. Additionally, eczema, psoriasis, and freckle removal are all treated with it. Considering that it possesses mild insecticidal qualities, it is also used to get rid of lice from the scalp. The plant is renowned for having antibacterial qualities that are helpful for scalp wounds [6]. d

2.2 Saponaria Officinalis (SOAPWORT)

A typical perennial plant belonging to the Caryophyllaceae family, Saponaria officinalis. Common names for this plant include soapwort, bouncing-bet, crow soap, wild sweet William, and soap weed. There are roughly 20 different varieties of soapwort [8]. Six unique triterpenoid saponins—sophorabioside's C–H—and two significant triterpenoid saponins—sophorabioside's A and B—were identified from the entire Saponaria officinalis plant [9]. Saponins from soapwort are a rich supply and combine with water to create a lot of foam. Cleaning hair without compromising its structure is beneficial. It includes silicon, which will assist to prevent hair from falling out, and can be used with horsetail (Equisetum arvense).

1.3 Yucca angustifolia (YUCCA)

The genus Yucca includes perennial shrubs and trees and is part of the subfamily Agavoideae of the Asparagaceae family. It is also referred to as "ghosts in the graveyard" because it is frequently found growing in rural cemeteries. Indigenous people have used yucca plants for generations for a variety of purposes, including the production of fiber for rope, sandals, and clothing, as well as soap from the roots. Yucca has more recently been utilized in food supplements, shampoos, and soaps. Saponins from yuccas produce a protracted foaming effect [6]. The yucca's roots and blossoms are abundant in steroidal saponins, which include the aglycones Sarasapogenin and tigogenin. Additionally prevalent in yucca species are phenolic chemicals, such as new yuccaols and gloryosaols. [10] This Native American cure for hair loss is effective. The roots have been shown to be incredibly effective and may be found in several shampoos that are suggested for people who are experiencing hair loss or thinning hair. The extract contains saponins, a cleaner that also works to lessen itching and irritation. The saponins may also be useful in reducing dandruff, which some people may believe to be a contributing factor to hair loss. Although yucca does not treat baldness or hair loss, its root extracts can enhance the condition of the hair that is still present and stop additional hair loss.

1.4 Chlorogalum pomeridianum (AMOLY LILLY)

The Chlorogalum genus is referred to by the common names Soap Plant, Soap Root, and Amole. They are primarily found in California and are endemic to western North America, from Oregon to Baja California. Depending on the species, soap plants are perennial plants with extended bulbs. The bulbs, which might be white or brown, typically have a fibrous coating [10]. They are abundant in saponins. This can be used as a hair cleanser because it has a rich source of saponins, which are foaming agents.

1.5 Quillaja saponaria (SOAP BARK)

The Quillaja saponaria, also known as the soap bark tree or soapbark, is an evergreen tree that is indigenous to central Chile and grows in warm, temperate climates. Due to the presence of a glucoside saponin, sometimes referred to as quillaia saponin, the inner bark of Quillaja saponaria can be ground into a powder and used as a soap alternative [11]. More than 100 triterpenoid saponins are present in quillaja extract, the majority of which are quillaic acid glycosides. Other important ingredients include tannins and polyphenols. Triterpenoidal saponins from quillaja are non-ionic surfactants that are remarkably durable in acidic pH conditions and resistant to heat and salt.External application of Quillaja saponaria is thought to relieve itchiness and irritation of the scalp. As a gentle cleanser and foaming agent, it is also used to treat skin ulcers and dandruff.

1.6 Glycyrrhiza glabra (LIQUORICE)

G.glabra is often referred to as sweet liquorice, jesthamadha has numerous commercial applications in the pharmaceutical and cosmetic industries. This species belongs to the leguminosae family, the functional edible section of plant is root, which is generally dried and powdered for the application purpose other plant elements from which liquorice powder is obtained from underground peeled roots, unpeeled stolons, and underground steams [12]. Glycyrrhizin is the primary chemical component of liquorice root and is 50 times sweeter than sucrose. It is a white, crystalline powder comprised of the calcium and potassium salts of glycyrrhizic acid, which when hydrolyzed produces glycyrrhetic or glycyrrhetinic acid. A triterpenoid saponin with a -amyrine structure is glycyrrhizin acid. Moreover, it contains triterpenoid glycosides (saponins), isoflavonoids, and flavonoids, all of which are extremely valuable in the cosmetics sector [13]. Although it functions as a foaming agent as well as an antibacterial and an antifungal, it is particularly helpful for hair cleansing and hair development purposes.

1.7 Centella asiatica (BRAHMI)

Brahmi, commonly known as Indian Pennywort and Mangosteen, is an umbelliferae plant. mostly found in marshlands in Madagascar, Sri Lanka, and India. This herb is very valuable in ayurveda.Triterpenoid saponin glycosides,indocen telloside, brahmoside, brahminoside, asiaticosides, thankuni side, and isothankuniside make up most of this herb's chemical makeup. Through hydrolysis, terpene acid can be synthesized. Indocentoic, Brahmic, Asiatic, Thankunic and isothankunic acids are glycosides [13]. This herb aids in hair development and boosts the immune system. It is also known as a brain tonic. Moreover, it enhances blood circulation, enhances hair health and development, and encourages hair thickness by accelerating the keratinization process. It can function as a foaming agent. It is broadly used in the pharmaceutical and cosmetic industries.

2.8 Hibiscus sabdariffa Linn. (ROSSELLE)

Edible flower belongs to the malvaceae family, commonly called as roselle, most used in Indonesia and in India this flower has great nutritional value, for that reason it is widely used in food, pharmaceutical as well as cosmetic industries. Due to the exceptional nutritional value of this flower, there is wide scope for research. The consumable flower, which is a member of the malvaceae family, and which is also identified as roselle, is utilized most frequently in India and Indonesia. Due to its high nutritional potential, it is also widely employed in the culinary, pharmaceutical, and cosmetic sectors. There is a lot of room for investigation because this flower has remarkable nutritional value. This variety can be utilised as a foaming agent because its key ingredients are flavonoids and saponins. Roselle has several advantages for the growth and health of the hair. It promotes hair growth, aids in hair thickening and blackening, and plays a key role in conditioning the hair and minimizing split ends. Can be used as a foaming agent. Therefore, this plant has lot of benefits and has several uses in hair care industries [14].

2.9 Azadirachta Indica Linn (NEEM)

Neem, a member of the meliaceae family, is widely distributed over parts of India, Pakistan, Bangladesh, Sri Lanka, Thialand, Malaysia, and eastern South African nations. The most prominent names for this species are Magrgosa, Azadirachta, and Melia azadirachta. Virtually every component of the plant is employed for a variety of therapeutic purposes. The dried portions of the plant, including the stem, roots, leaves, fruits, and gum, are crucial to its morphological integrity. These plants are mostly known for their antibacterial properties and ability to naturally ward off pests [10]. Tetranorterpenoids like azadirachtin, nimbin, and salanin, which are primarily responsible for the antibacterial activity, are among the most complex types of compounds found in neem tree leaves. It also contains flavonoids like quercetin, nimatone, and kaempferol. Moreover, it includes reducing sugar, glycosides, and carbs. Moreover, it exhibits successful outcomes in saponification tests, improves It has extraordinarily powerful antibacterial action. It has also been demonstrated to be crucial for the growth and development of hair. It minimizes hair loss and strengthens existing hair. Moreover, it improves hair quality by lowering dandruff. It maintains the scalp microbial composition. And also has excellent antifungal potential. It has the capability of functioning as a foam enhancer and stabilize foam created by other foaming agents [15].

2.10 Aloe (ALOE VERA)

Most typically known as Aloe, Musabbar, and Kumari. Aloe, a member of the Liliaceae family, includes several species based on the structure of its leaves, including Aloe ferox Miller, Aloe vera Linn, and Aloe barbadensis Mil, which may be found in Barbados and Socotra, respectively. Africa is the geographical location to several aloe plants, including the cape aloe type that is farmed there. Aloe gel has medicinal properties; dried gel or juice is harvested by cutting a cut at the base of the leaves. Aloe is widely known for both its medicinal and beauty properties. As a result, many different industries employ it extensively [16]. Among the many compounds found in aloe are anthraquinones, which include aloin, anthracene, risistannol, ethereal oil, and aloetic acid, as well as vitamins, lignin, enzymes, saponins, minerals, carbohydrates, fatty acids, and amino acids. Aloe gel is a rich source of minerals including zinc, iron, potassium, and magnesium as well as vitamins like E, A, and C. Aloe has several applications for hair, although it is most consistently used to condition the scalp. It improves hair regeneration in addition to encouraging hair growth. It also has antibacterial properties. It has been demonstrated that using aloe to treat hair improves hair quality. Moreover, it gives hair shine. It has the potential to be utilized as a foaming agent in many formulations because of its high foaming capability [17].

Acacia Concinna (SHIKAKAI)

The ayurvedic herb shikakai has traditionally been used to treat dandruff and prevent hair loss. From ancient times, shampoo has almost always contained shikakai. As a foaming agent, dried acacia concinna fruit is utilised. India is where it's most common found. Moreover, it finds extensive use in the pharmaceutical and cosmetic sectors. Alpha and hemicelluloses are the primary chemical constituents of dried fruit. Moreover, the test for carbohydrates is positive. It has a significant amount of saponin, which gives it a strong foaming ability and makes it popular as a detergent or cleaning agent [18]. Shikakai is widely used as a foaming and cleansing agent and is well suited for shampoo and conditioner. Shikakai effectively eliminates excess oil as well as debris from the scalp. Moreover, it possesses both antibacterial and antifungal properties. It can stop hair from maturing [19].

2.12 Ocimum Sanctum (TULSHI)

One of the laminaceae family's members, Ocimum sanctum, is primarily found in India and the as its important constituents, it has a mixture of alkaloids, tannins, saponins, and flavonoids [20]. southern and eastern regions of the Asian continent. Tulsi is a versatile medicinal herb that contains antibacterial, antifungal, analgesic, and decongestant properties. It has a tremendous amount of potential and offers a few health advantages. This plant is mentioned in various therapeutic formulations in Traditional ayurvedic literature. This plant extract can heal several ailments; mostly leaves are used for extraction. It also encourages hair growth, reduces dandruff, and treats many bacterial and fungal infections. It also enhances the circulation of blood to the brain. It also serves as a foaming agent. It has a wide range of uses in the herbal and nutraceutical industries and is potentially incorporated in many diverse pharmaceutical formulations.

2.13rigonella foenum-gracum (FENUGREEK)

Foenum-gracum Trigonella is a leguminous bean and a member of the Fabaceae family. It is eaten all over the world and has several medical benefits including analgesic, anti-inflammatory, wound healing, mucolytic action, increasing blood circulation and boosting the growth of new hair, and it also has antibacterial and antifungal activity. It can be employed in both pharmaceutical and nutraceutical industries. It has various advantages that are described in Chinese and Ayurvedic literature. Alkaloids, Flavonoids, Carbohydrate, Glycosides, Steroids, Protein, Amino Acids, Phenolic Compounds and Tannins, Terpenoids, and Saponins are the chief natural compounds in fenugreek seeds. Being an antioxidant and a foaming agent, it has several benefits It is a well-known component in several formulations [21].

2.14Cocos nucifera (COCONUT)

The Arecaceae family comprises coconuts. This plant, also known as coco dabahia or beach coconut, is widely available in Southeast Asian nations including Indonesia, Thailand, Malaysia, and the Philippines. Coconut has a variety of therapeutic uses, including as a conditioner, foaming agent, anti-lice agent, antibacterial agent, and antifungal agent. It contains several nutritional features, including a richness of important minerals and vitamins. [21] Its primary chemical constituents comprise of flavonoids, carbohydrates, reducing sugar, tannins, saponins, alkaloids, glycosides, phytosterols, phenols, and terpenoids. It has several beneficial properties in the medical, food, and pharmaceutical industries. It is widely used as an anti-lice ingredient in shampoo and soap formulations, enhances hair structure, and gives hair luster [22].

III. NOVEL FOAMING AGENTS

Apart from the traditionally used foaming agents, there are some unusual substances which have impressive foaming ability which if coupled with foam stabilizers can create a stable and good foam which can be an alternative to SLS like surfactants. A few of these agents are discussed herein.

3.1 spent coffee grounds (SCG)

Traditionally coffee is a favored beverage in everyday life. This caffeine containing product has an array of different applications. Amongst many brewing methods for coffee is a pour over method where boiling water is passed through coffee powder sitting inside a filter, which results in the extraction of the filtered concoction of concentrated liquid coffee leaving the coffee powder as a residue. This used coffee powder residue can now be used as a good foaming agent. Spent coffee grounds (SCG) give rise to a good foam structure. SCG has a great emulsification capacity as well as stability. compounds with surface active components impart foaming ability to it. Protein molecules with a high molecular weight are responsible for the production of foam while the foam stability is a result of melanoidins present within the coffee [23]. The foam height of the spent coffee ground was good enough to be used for its foaming ability.A study in its conclusion has established that SCG can be of use as a foaming agent. The synthetic surfactants currently employed could be effectively replaced with foaming agents based on SCG. A variant of coffee known as Robusta when used as SCG gives a very stable foam after defatting. In this way SCG has implications for its use in the cosmetics industry. This will be an upcycled option which will minimize the waste created by using coffee which is reused in a more innovative way.

3.2 Wine lees derived yeast

Yeast is naturally used for the fermentation process and as a result produces alcohol. In the traditional alcohol preparation yeast is widely used. In the making of wine yeast is used and over a period as the wine ages, this yeast deposits at the bottom of the wine container. This same yeast is an amalgam of dead and alive matter which has sludge like consistency. Mannoproteins along with amphipathic polysaccharides form a protein like chain which contributes to its foam stability and emulsifying properties [24]. As a source for this yeast red and white wine lees were used. Mannoproteins are then extracted and an oil in water emulsion was formed with a good stability [25]. A foam stability study showed excellent foam prepared and stabilized over a period of several hours using yeast.

3.3 Fermented Extracts Of Cyclea Peltata.

A good foaming activity was produced by the production of plant extracts and the fermentation of Cyclea peltata leaf extract with Lactobacillus plantarum. An herbal shampoo was made with the help of this extract. According to earlier research by a group, the leaf extract contains alkaloids, flavonoids, tannins, phenolic acid, saponins, and proteins [26]. Lactic acid, which protects hair from sunlight and enhances the texture and strength of hair fibers, was found in the fermented product, which was advantageous for shampoo bases. Cyclea peltata was used as the primary component in herbal shampoo formulations, along with other herbal ingredients. The formulated shampoo was evaluated for its various organoleptic (Color, Oduor) and physicochemical (pH, solid content, wettability, emulsification, and foam stability) properties to determine the best formulation. After it was finished, the shampoo formulation was tested for various physicochemical qualities to determine the ideal formulation. The benefits of the shampoo and how it might be improved are made clear by testing for physicochemical qualities. Based on these characteristics, the several formulations were also contrasted [26]. Cyclea peltata leaf extract that has undergone fermentation can be used as a key ingredient in shampoo formulations to produce high-quality foam. Since only the natural surfactant soap nut is utilised, the harsh surfactants or preservatives of chemical origin contained in synthetic shampoos can cause dryness and irritation of the scalp. This fermented extract of Cyclea peltata has good foam stability and antidandruff characteristics, just like many other herbal origin formulations.

3.4 Egg White

Foam is typically described as a two-phase colloidal structure with a continuous phase (typically water) and a gas phase (typically air) suspended in it as bubbles or gas cells. The two main criteria for assessing the quality of foamed products are foamability and foam stability. After being hydrolyzed by lipase and phospholipase A2, the foaming and structural characteristics of egg white protein with or without yolk or yolk fractions (plasma and granules) were examined [27]. In a recent study, it was discovered that the hydrolyzed forms of egg white protein's foaming capabilities, which are regulated by yolk fractions, are stable. Egg white dispersions with yolk and plasma displayed an apparently significant loss in foam capability (FC) and foam stability (FS) when compared to EW alone, indicating that yolk and plasma might compete with egg white at the air-water interface. Granules, a different portion of the yolk, did not impair the ability of the proteins in egg whites to foam, though. The offered foam stability was implied to be helpful. This may represent a breakthrough in the application of egg white foam in the cosmetic and culinary industries. The fact that it is harmless by nature makes it advantageous for use in food preparations, and the foam stability has positive implications for application in the cosmetics industry [28].

3.5 Protein Nanofibrils From Mung Bean

Mung bean (*Vigna radiate* (*Linn.*)) is a leguminous plant which has been cultivated for more than 2000 years in China. Given its rich history and being used for its rich antioxidant properties in daily consumption it is a rich source of protein. Although proteins are a well-known source of amino acids which constitute them, there are several other characteristics that proteins might have. These properties, which primarily include emulsification, the combination of water and oil, and foam formation, are influenced by the physicochemical properties of proteins, such as their molecular size and structure, as well as by the method used to separate proteins, ionic strength, pH, and other ingredients during the food processing system. These properties make an interesting prospect that might be able to utilize the mung beans protein for a good foaming capacity. Nanofibrils make a novel drug delivery system but alternatively can act as a stabilizing and carrier system. Protein nanofibrils of isolated protein from mung bean were found to have a stable foam, A study has shown [29]. This might be a great stabilizer for natural foams with a good foaming capacity but a non-stable foam.

IV. BIOSURFACTANTS:

Microorganisms can produce biosurfactants with various molecular structures and surface activities using a range of substrates as carbon sources, including carbohydrates, hydrocarbons, lipids, and oils. These microorganisms include filamentous fungi, yeasts, and bacteria. The chemical surfactants used in the cosmetics industry for their good foaming capacity are usually derived from a petroleum base [30]. These give a great yield at a much smaller fraction of the cost and are hence preferred to produce cosmetic goods. Although their foaming capability is good, these chemical surfactants also pose a significant threat to the human skin when used over a period such as dryness, over stripping the skin from its natural sebum production. Synthetic surfactants are used in many products such as soaps, shampoo, toothpastes, face wash for their various abilities like foaming, emulsification, wettability [31]. Chemical surfactants are also non-biodegradable and they're by products are toxic. This is where biosurfactants come into picture. Biosurfactants are biodegradable and are hence environmentally friendly, not only that but they're non-toxic as well. They are sourced from biological sources such as microbes, animals and plants and are safe to use [32].

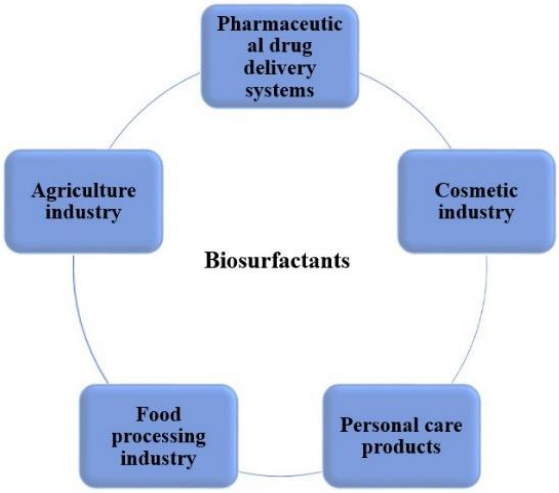

Figure 1. Applications of Biosurfactants in various industries

4.1 ADVANTAGES OVER SYNTHETIC OR CHEMICAL SURFACTANTS

The easy availability, low production costs, longer shelf lives, and enhanced performance at low temperatures of petroleum-based surfactants explain their widespread use. Because of their branched, irregular, and even hydrocarbon chains, they provide formula versatility. Due to their sources being non-renewable in nature and toxic byproducts harmful for the environment as well as humans has led to search for better alternatives [33].

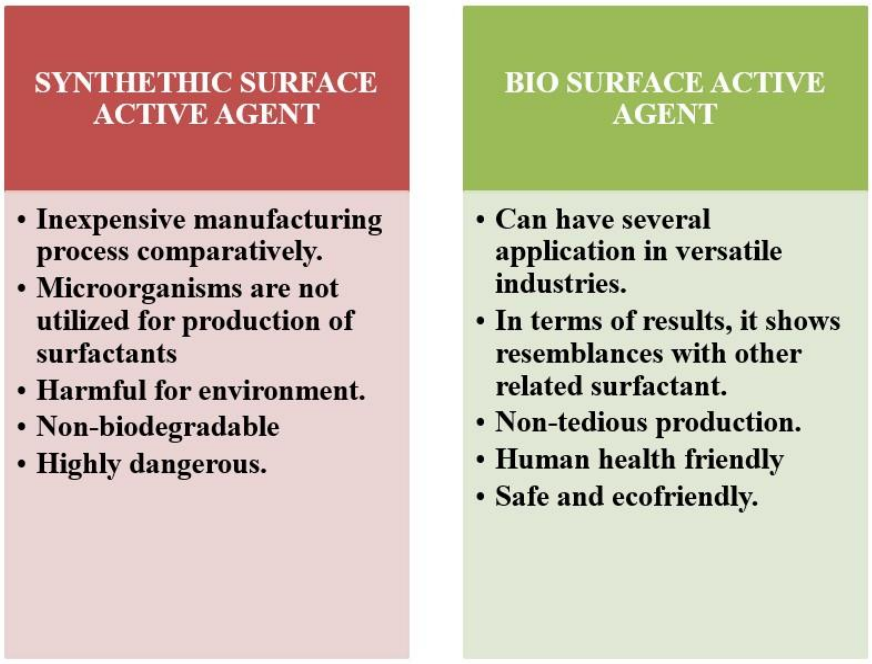

Figure 2. Comparison of synthetic surfactants vs Biosurfactants

4.3 Applications Of Biosurfactants In Various Industries

Due to their widespread uses and advantages such as very good biodegradability, low toxicity while giving very stable foam make biosurfactant a good option as a substitute for chemical surfactants.

Table 1. Roles and applications of biosurfactants as used by various industries.

Industries	Biosurfactant Types	Role Of Biosurfactants	Application	References
Medicine	Rhamnolipids,sophorolipids and lipopeptides	Anti-adhesive agents, antifungal agents, antibacterial agents, antiviral agents, vaccines, gene therapy, immunomodulatory molecules.	Microbiological, Pharmaceuticals and therapeutics	[34], [35]
Cosmetics	Sophorolipids, mannosylerythritol lipids, rhamnolipids and lipopeptides	Emulsification, foaming agents, solubilization, wetting agents, cleansers, antimicrobial agents, mediators of enzyme action, antioxidant, moisturizing, healing, and skin toning properties.	Health and beauty products	[32],[36]
Agriculture	Rhamnolipids,sophorolipids and lipopeptides	pesticides and fertilizer's, emulsification of pesticide solutions, facilitation of biocontrol mechanisms of microbes, plant pathogen elimination	Biocontrol Fertilizer's, Plant protection	[34],[37]
Food	Glycolipids, lipeptides and polymeric surfactants	Solubilization of flavored oils, control of consistency, emulsification, wetting agent, spreading, detergency, foaming, thickener.	Emulsification, Functional ingredient	[38],[39]
Nanotechnology	Rhamnolipids and lipopeptides	emulsification in finishing formulations, softening. Synthesis of nanoparticles Emulsification, stabilization.	Synthesis of nanoparticles	[40],[41]

5. GREEN FOAMING AGENTS

A tabular representation of all the natural foaming agents discussed within the article along with their properties is given below.

V. GREEN FOAMING AGENTS

A tabular representation of all the natural foaming agents discussed within the article along with their properties is given below.

Table 2 Traditional foaming agents

SR.NO	FOAMING AGENT	BIOLOGICAL NAME	BIOLOGICAL SOURCE	CHEMICAL CONSTITUTENT	APPLICATION	REFRENCES
1.	Reetha	*Sapindus Mukorossi*	Himalaya, Maharashtra, Karnataka and Goa	Saponins, triterpenoids, fatty acids, and flavonoids	Cleansing agent and shows antibacterial, fungicidal, and anti-inflammatory properties	[6],[7]
2.	Soapwort	*Saponaria Officinalis*	Asia and Europe	triterpenoid saponins—sophorabioside's, sophorabioside's A and B	Cleansing property helps to restore hair structure.	[8],[9]
3	Yucca	*Yucca angustifolia*	Southern part of America, Texas, Maxico	saponins	Cleansing agent, promotes conditioning, anti-dandruff property.	[10]
4.	Amoly Lilly	*Chlorogalum pomeridianum*	California and are endemic to western North America, from Oregon to Baja California.	saponins	Cleansing agent, detergent	[10]
5.	Soap Bark	*Quillaja saponaria*	Central Chile	Triterpenoids saponin, glucoside saponin, tannins, polyphenols	Foaming agent, cleansing agent, treat ulcer and dandruff	[11]
6.	Liquorice	*Glycyrrhiza glabra*	Western Asia, North Africa And Southern Europe.	triterpenoid saponin with a -amyrine structure is glycyrrhizinic acid	Foaming agent, antibacterial and antifungal properties are shown.	[12]
7.	Brahmi	*Centella asiatica*	Madagascar, Sri Lanka, and India	Triterpenoid saponin glycosides,indocentelloside, brahmoside, brahminoside, asiaticosides, thankuni side	It promotes new hair generation, foaming agent, inhaces blood circulation etc.	[13]

8.	Rosselle	*Hibiscus Sabdariffa Linn*	India, Indonesia, Malaysia	flavonoids and saponins.	promotes hair growth, aids in hair thickening and blackening, reduces split ends, conditions hair and foaming agent	[13]
9.	Neem	*Azadirachta Indica Linn*	India, Pakistan, Bangladesh, Sri Lanka, Thailand, Malaysia, and eastern South African nations	Tetranorterpenoids, flavonoids like quercetin, nimatone, saponins, reducing sugar and carbohydrates.	Antimicrobial, antidandruff agent, foaming agent, antifungal activity.	[15]
10.	Aleo Vera	*Aloe*	Africa, Barbados and Socotra	anthraquinones, aloin, anthracene, risistannol, ethereal vitamins A, and E, lignin, enzymes, saponins, minerals, carbohydrates, fatty acids, and amino acids.	Conditioning the scalp, improves hair regeneration, antibacterial properties, foaming agent, improving the structure of hair	[16],[17]
11.	Shikakai	*Acacia Concinna*	Tropical rainforest of southern Asia	Alpha and hemicelluloses, mostly saponins	Cleansing agent, foaming agent (detergent)	[18],[19]
12.	Tulshi	*Ocimum Sanctum*	India and the southeastern regions of the Asian continent	alkaloids, tannins, saponins, and flavonoids	antibacterial, antifungal, analgesic, and decongestant properties, foaming agent and hair growth, reduces dandruff.	[20]
13.	Fenugreek	*Trigonella foenum-gracum*	Trigonella foenum-graecum Linn. Dried seeds	Alkaloids, Flavonoids, Carbohydrate, Glycosides, Steroids, Protein, Amino Acids, Phenolic Compounds and Tannins, Terpenoids, and Saponins	analgesic, anti-inflammatory, wound healing, mucolytic action, antibacterial, antifungal activity, promotes hair growth and foaming capacity.	[13]
14.	Coconut	*Cocos nucifera*	Southeast Asian nations including Indonesia, Thailand, Malaysia, and the Philippines	flavonoids, carbohydrates, reducing sugar, tannins, saponins, alkaloids, glycosides, phytosterols, phenols, and terpenoids	Anti lice activity, foaming agent, conditioning agent, improves hair structure, and give shine to hair	[21],[22]

Table 3 Novel foaming agents

SR. NO	FOAMING AGENT	SOURCE	APPLICATION	REFERENCES
1.	spent coffee grounds (SCG)	Arabica coffee beans	- Used as a foaming agent	[23]
2.	Wine lees derived yeast	Yeast sedemented over a year in red/white wine	- Foaming agent - Conditioning properties - biological surfactant	[24],[25]
3.	FERMENTED EXTRACT OF *CYCLEAPELTATA*	Extract from leaves of *cycleapeltata*	- High quality stable foam - P.H modifier	[26]
4.	Egg white	Eggs	- Surface active agent - Emulsifier - Foaming agent	[27],[28]
5.	Protein nanofibril from mung bean	Mung beans	- Foam stabilizer - Antioxidants	[29]

VI. FUTURE OF GREEN SURFACTANTS

Surfactants are the most important and widely used excipients. Out Of many sources, petrochemicals are the widely used source in the production of this agent which has a lot of disadvantages in terms of pollution and public health. To bypass these issues natural alternatives are becoming the next important option for industries as they are produced from different natural sources which are eco-friendly [42]. These amphiphilic compounds are mainly used in detergents and soaps. Low toxicity, biodegradable property, high foaming, and being environment-friendly makes natural surfactants a better alternative to synthetic surfactants. As we have discussed, the future for these natural surfactants is quite assured of holding a great potential for growth. Pharmaceutical and cosmetic industries have a lot of demand for biosurfactants as surfactants are the important constituents of many pharmaceutical and cosmeceutical preparations [43]. Chemically based surfactants create damage to the skin like allergy and irritation and hence they are a suitable alternative for this industry also to eliminate those issues. According to many upcoming trends and shifts of brands to give consumers an eco-friendly alternative. The current trends in the market show a possible twice as much profit and market value for biosurfactants.

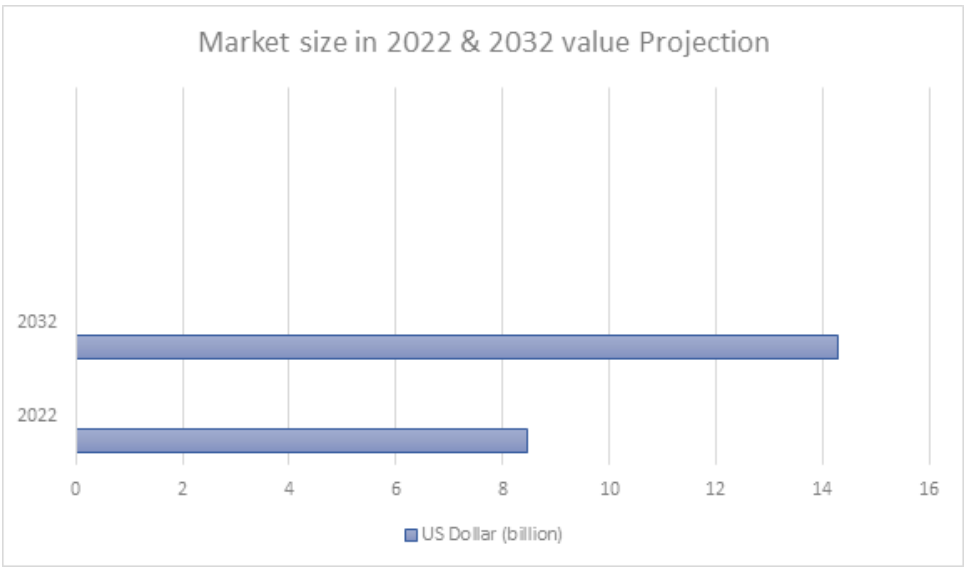

Figure 3.According to Global market insights Biosurfactants Market Report Coverage market size in 2022 and projection of market size in 2032 [44]

As seen above the potential growth in the market for biosurfactants is expected to grow in exponential numbers. The development of cosmetic, personal care, and pharmaceutical formulations using biological surfactants instead of synthetic surfactants is anticipated to make a shift in the paradigm of how consumers will likely shift their preferences [45].

VII. CONCLUDING REMARKS

The need for replacing chemical surfactants is established throughout our discussion in this review. The harm these bring to the environment, human skin or hair is long lasting and may be permanent. Due to their low toxicity, remarkable physicochemical properties (including surface/interfacial activity), bioavailability, and origin from renewable resources, natural origin/ green surfactants are ideal substitutes for their chemical equivalents. These characteristics make biobased surface-active agents very appealing to the primary sectors connected to human health, including pharmaceuticals, food and cosmetics, and environmental protection; as mentioned in this article, many of them have already found extensive use. The prospects for these seem very promising with only a few limitations. Larger production costs and limited output are the two main concerns regarding the use of biosurfactants instead of their chemical counterparts. If these concerns are considered for further research studies, a new industrial approach for economically and ecologically better products which are safe and non-hazardous to health will be a boon for all the sectors involved with the use of synthetic foaming agents.

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