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PLANT-BASED SURFACTANTS: A PROMISING SAVIOR FROM COSMETIC RELATED COMPLICATIONS

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ABSTRACT

There is various drawback associated with synthetic surfactants specially used in dermatological preparations. Surfactants are the most often recognized to be a possible skin irritant. Synthetic surfactants cause skin problems such as dryness, itching, post-wash tightness, stratum corneum layer damage, dermatitis, and so on. Replacement of synthetic surfactants with mild synthetic and/or natural surfactants has far wider implications for organizations that produce natural surfactants and ensure that their replacement will lead to better application while eliminating skin-related concerns. It investigated how the sourcing, modification, and formulation of cellulose, starch, protein, and lignin-based polymers and particles might affect safety and efficacy due to their readily available and promising performance. We have discussed how these plant-based polymers are utilized to overcome the challenges of synthetic surfactants and polymers. Various green surfactants not only have surface properties but can be also utilized for their other benefits like emulsion stabilizers, antibacterial, antioxidant, and emollient activities in formulations. Various green surfactants can reduce the complications associated with synthetic surfactants. plant-based surfactants offer a potential solution to the toxicity concerns associated with synthetic surfactants. They have a wide range of applications in the food, cosmetics, and pharmaceutical industries. Proteins and polysaccharides derived from plants have shown promising results in stabilizing emulsions and overcoming the challenges posed by synthetic surfactants. Further research and development in this field can lead to safer and more effective surfactant formulations. Green surfactants, including glycolipids, lipopeptides, phospholipids, surface-active

antibiotics, fatty acids/neutral lipids, polymeric surfactants, and particle surfactants, are being explored as alternatives to synthetic surfactants. This review focuses on recent developments in the use of plant-based polymers and particles in cosmo-pharmaceutical applications.

KEYWORDS: Plant Based surfactants, green surfactant, Biosurfactant, Amphiphiles, Biobased surfactants

INTRODUCTION

Plant-based surfactants are amphiphiles obtained from plants either by isolation method or any chemical modification. They are natural, and vegan in nature so can be widely used in food, cosmetics as well as in pharmaceuticals. Nowadays due to the extensive toxicity of synthetic surfactants, green surfactants especially plant-based surfactants are utilized extensively.[1] All proteins and some polysaccharides can adsorb at the globule surface, reducing the interfacial tension as well as interfacial elasticity gets modified. Proteins and polysaccharides may also communicate with other molecules through covalent bonding or electrostatic interactions, and oppositely charged biopolymers can be organised as bilayers. These systems work together to provide electrostatic and steric stability, allowing for thermal stability in the face of external stimuli. However, toxicity concerns are also important for these excipients which include anaphylactic hypersensitivity, axonal demyelination, and acute toxicity of the heart and thymocytes. They are also utilized as drug delivery carriers. Maximum proteins and few polysaccharides can adsorb on the surface of a globule, lowering the interfacial tension and increasing interfacial elasticity thus can be promising compounds for vegan, toxicity-free surfactants. Polysaccharides stabilize emulsions by increasing the continuous phase's viscosity. Several cytotoxicity tests reveal that nonionic is the least hazardous, with cationic > anionic > amphoteric > nonionic being the order of toxicity. The major problems resulting from surfactants are dermatitis, aphthous ulcers, and skin irritation however they are limited but statistical data have shown the fact that these pollutants are found in concentrations higher than their predicted no effect concentrations and up to this level they are very harmful and surfactants in formulations add-on the toxicity. The surfactant toxicity related to detergents is widely assessed but there are no scientific data available related to the surfactant toxicity of foods, cosmetics, and pharmaceuticals. In some pharmaceutical preparations, a high concentration of surfactants is utilized like SNEDDs, niosomes, and other surfactant-based formulations. They considerably influenced the study of surfactant toxicity related to pharmaceuticals and methods to asses as well as eliminate these

problems. Plant-based surfactants are one of the approaches to overcome these toxicity concerns. Plant-based surfactants include proteins like whey proteins, caseins, pea proteins, etc, and polysaccharides like xanthan gum, alginates, carrageenan, hyaluronan, chitosan, gum arabic, HPMC, galactomanose, etc.

RATIONALE BEHIND APPLICATION OF PLANT SURFACTANTS

Glycolipids, lipopeptides, phospholipids, surface-active antibiotics, fatty acids/neutral lipids, polymeric surfactants, and particle surfactants are examples of green surfactants.[5] From synthesis to disposal, the synthetic surfactants have environmental as well as physiological concerns which make them unsuitable for future requirements. To overcome it different approaches are practiced which target to reduce the dependency on synthetic surfactants. Surfactants have an antibacterial or germicidal impact on microorganisms. Surfactant toxicity might potentially be attributed to cell surface responses such as depolarization. As a result, less important nutrients are absorbed and less oxygen is used. Another impact might be a delay in hazardous metabolic products being released from the body. Both of these consequences eventually lead to the demise of the cell organism. Saccharomyces cerevisiae treated with SDS and LAS microarray analysis. These detergents induced membrane damage and changes in the cells, according to the results oxidative stress and carbon metabolism.[4] Up to acceptable limits, it may be considered significantly non-hazardous but over prolonged use and concurrent use of different surfactants, they are toxic to humans also. Environmental regulations and government restrictions on the use of potentially hazardous surfactants in products have also encouraged the research and application of biomaterials as viable alternatives for artificial surfactants. Microbially derived biosurfactants have been used to improve feed digestibility in agricultural applications, seed protection and fertility, plant-pathogen control, antimicrobial activity, antibiofilm activity, wound healing and dermatological care, improved oral cavity care, drug delivery systems, and anticancer treatments. The potential of biosurfactants has been constrained by the wide range of research approaches used, the emphasis on pathogens as source species, and the high cost of large-scale manufacture. Non-ionic surfactants have been proven to anesthetize the eyeball, therefore combining them with anionics would make many shampoos pleasant on the eyes. At 24 hours after exposure, cultured bovine lens cells treated with 0.1–0.025 percent SDS showed a loss of eye lens transparency, as well as a substantial increase in lens wet weight and axial length. According to recent research, the worldwide market supports new efforts

and is seeking biological alternatives to synthetic surfactants, which accounted for $ 1.74 billion in sales in 2011.

CURRENTLY USED PLANT-BASED SURFACTANTS

One of the most common chemicals in cosmetics and personal care products is surfactant. These compounds are crucial to formulations because they produce emulsions, foams, wetting capacity, cleaning dispersants, and even exhibit antioxidant and antibacterial activity[6]. The roots, stems, seeds, fruit, and leaves of a plant, as well as other parts of the plant, can all consist of surfactants that are derived from plants. Phospholipids, proteins or protein hydrolysates, and saponins are examples of compounds with amphiphilic properties that may be both hydrophobic and hydrophilic. Pharmaceutical emulsions may benefit from the usage of natural emulsifiers/stabilizers such as proteins and polysaccharides, which are utilised in the food industry. The pharmaceutical industry already employs these natural polymers for things like the production of capsules (gelatin), tablet binder (chitosan, gum Arabic, and Hypromellose), suspending agent (chitosan), mucoadhesive formulations (chitosan), extended-release tablet matrix (Hypromellose).[2] Several proteins can act as emulsifiers due to their tendency for adsorption at the oil-water interface to maintain emulsion stability. The majority of polysaccharides stabilise emulsions by creating a dense network in the continuous phase, which grows extremely viscous and may even gel. Only a few analogues of polysaccharides exhibit surface properties that enable oil-water interface adsorption. It may be possible to enhance emulsion stability by combining the benefits of proteins and polysaccharides under the proper circumstances (concentration, protein-to-polysaccharide ratio, pH, ionic strength, and temperature).[3,7] The currently used plant-based surfactants and their rationale of application is enlisted in Table-1.

Table 1: Surfactants and their Application.

Surfactant	Composition	MOA	Formulation	REF.
Whey proteins	α-lactalbumin, β-lactoglobulin, Lactoferrin, BSA	droplets disruption, electrostatic repulsion between droplets.	protein supplements, nutrition products, weight management products, mood control products.	[3,8]
Caseins	αs1, αs2, β, κ caseins	a combination of electrostatic and steric repulsions	Nutritional supplementation, foods, cosmetics	[9]
Pea proteins	vicilin, legumin albumins (21%, 4–53 kDa),	A combination of polar amino acids/peptides (hydrophilic moiety) and non-polar chain	carriers for encapsulation, controlled release, targeted delivery protection of essential	[3,10]

	globulins (66%, 150–400 kDa), glutelins (12%)	compounds (hydrophobic moiety) produces an amphiphilic structure with high surface activity	oils, phenolic compounds, and vitamins	
Xanthan gum	1,4-linked β-D-glucose residues, having a trisaccharide side chain attached to alternate D-glucosyl residues, side chains are β-D-mannose-1,4 β-D-glucuronic acid1,2- α -D-mannose	thickening properties, yield stress, and shear-thinning, thixotropic behaviors, prevent flocculation and creaming in emulsions	a suspending and stabilizing agent in oral and topical formulations, the production of sustained-release matrix tablets, Synthesis of environment-friendly Biocomposite	[11]
Alginates	α-(1-4)-l-guluronic acid, α-(1-4)-d-mannuronic acid	colloidal properties, Divalent ions (such as Ca2+) form ionic bridges with glucuronic acid units belonging to different chains, forming a physical gel	alginate emulsion-based edible films to protect microencapsulated aroma compounds	[3,4,12]
Carrageenans	α -d-galactose β-d-galactose	Helix–helix aggregation promoted by cations (such as K+ or Ca2+) gives rise to thermal hysteresis between sol-gel, and gel–sol transitions	Oral extended-release tablets, Microcapsules, Microspheres, As a stabilizer of micro/nanoparticles	[13] [14,15]
Hyaluronic acid	D-glucuronic acid, N-acetyl-D-glucosamine	stiffened random coil structure, shear thinning behavior	cosmetic filler, facial contours, Ophthalmic lubricant treatment of pain in patients with osteoarthritis of the knee	[14,16]
Gum arabic	Arabinogalactan, Glycoprotein, Arabinogalactan-Protein.	Adsorption, steric hindrance, above pH 2, negative charge allows electrostatic stabilization	insulin-loaded nanoparticles based on ionic gelation, encapsulate and control the release of endoglucanase,	[17]
Galactomannans	β-(1-4)-d-mannose, α- (1-6)-D-galactose.	Lowering interfacial tension precipitation of a gum film onto the oil droplets.	Tablet matrix, sustained-release formulations	[3]
HPMC	partly O-methylated and O- (2-hydroxypropylated) cellulose	accumulate at the oil-water interface	Matrix tablets, controlled release formulations, Liquisolid tablets, HPMC capsules, Floating Drug delivery systems like micro balloons, floating tablets, and granules.	[3]

Lecithin	Phosphatidylcholine Phosphatidylethanolamine Phosphatidylinositol Phosphatidic acid	choline moiety containing Negatively Charged phosphate group along with Positively charged trimethyl-amino group electrostatic amphiphilic structure with high surface activity	Creams lotions, foundations and cleansing creams, sunscreens, soaps, bath oils, shampoos, and Hair conditioners	[18]

PROTEINS AS A SOURCE OF PLANT-BASED SURFACTANT

Proteins are a good source of food stabilizers; emulsion stabilizers act as carriers of micronutrients (minerals and vitamins) and fatty acids, edible films, coatings, encapsulation, and nanocarriers. They effectively stabilize the emulsions in 1-3% w/w conc. At saturation monolayer coverage, most proteins reduce the oil-water tension by around 15–20 mN/m, compared to 30–40 mN/m for tiny synthetic surfactants. Proteins, on the other hand, produce more thermodynamically and kinetically stable emulsions due to their surface adsorption properties. They either work by a combination of electrostatic and steric repulsions, lower interfacial tension, and shield newly generated tiny droplets from flocculation and coalescence or adsorb at the contact, decreasing the interfacial tension and facilitating droplet breakup, droplets repel each other electrostatically. An amphiphilic structure with high surface activity is created by combining polar amino acids/peptides (hydrophilic moiety) with non-polar chain compounds (hydrophobic moiety). An amphiphilic structure with high surface activity is created by combining polar amino acids/peptides (hydrophilic moiety) with non-polar chain compounds (hydrophobic moiety).[2,3] Some of them are-

Whey proteins

Milk Whey proteins are Composed of α-lactalbumin, β-lactoglobulin, Lactoferrin, BSA, and immunoglobulins. β-lactoglobulin proteins bear a net negative charge and induce relatively strong electrostatic repulsion between droplets. They adsorb at the interface and facilitate droplet disruption by lowering the interfacial tension and electrostatic repulsion between droplets. However, the emulsion formulated is heat sensitive and has proteolytic resistance. It is widely used in the field of specialized enteral and clinical protein supplements, sports nutrition products, and products specific to weight management and mood control.it is also used as a carrier of micronutrients (minerals and vitamins) and fatty acids, Edible films, and coatings. Whey protein-based emulsions are heat-sensitive.[8]

Caseins

Using a mix of electrostatic and steric repulsions, lower interfacial tension, and shielding newly generated tiny droplets from flocculation and coalescence, casein is regarded as a good emulsion stabilizer, emulsifying agent, and Nutritional supplement. Casein's ability to alter drug dissolution from compacts has been documented. They are extensively used in Nutritional supplementation formulations, foods, cosmetics, and formulation of casein nanoparticles as carriers for the oral delivery of biologically active compounds. Up to the date, no serious toxic effects are observed in any studies. Because of its emulsifying and bubble-forming capabilities, casein floating beads were designed to extend the gastric retention time of drugs.[9] Casein-based protein emulsions are highly sensitive to destabilization by acidification and calcium ions.

Pea Proteins

Pea Proteins act by the combination of polar amino acids/peptides (hydrophilic moiety) and non-polar chain compounds (hydrophobic moiety) producing an amphiphilic structure with high surface activity. They are mainly composed of vicilin, legumin albumins (21%, 4–53 kDa), globulins (66%, 150–400 kDa), and glutelins (12%). Ducel et al., studied that Pea proteins can reduce the oil-water interfacial tension and contribute to the stability of emulsions by forming a stiff barrier at the interface. Pea Protein can be used as a carrier for encapsulation systems and could be applicable for controlled release, targeted delivery, and protection of food bioactive such as essential oils, phenolic compounds, and vitamins.it is also used as an Anti-aggregation agent, body weight control, obesity treatment, and Essential oil encapsulation to protect from oxidation. It may cause enteritis at higher doses however no such conc. required as surfactant.[10]

POLYSACCHARIDES AS A SOURCE OF PLANT-BASED SURFACTANT

Xanthan gum

Thickening properties, along with yield stress and shear-thinning and thixotropic behavior, Xanthan gum prevents flocculation and creaming in emulsions thus stabilizing the emulsions. It contains 1,4-linked β-D-glucose residues, having a trisaccharide side chain attached to alternate D-glucosyl residues, side chains are β-D-mannose- 1,4 β-D-glucuronic acid and 1,2-α -D-mannose. It is a suspending and stabilizing agent in oral and topical formulations or the production of sustained-release matrix tablets, thickeners, and stabilizers in personal care products like creams, and eye contour gels and Synthesis of environment-friendly

Biocomposite. Amico et.al. investigated the antioxidant effect at 0.2% conc. in human corneal epithelial cells. It is also useful in the removal of lead and chromium ions from vest water. Useful in the multimetal west treatment and dye removal, chemically modified xanthan used in west water treatment.[11]

Alginates

Alginates are hydrophilic colloidal carbohydrates found in brown seaweeds (Phaeophyceae), especially Laminaria hyperborean, Macrocystis pyrifera, and Ascophyllum nodosum. It is composed of α-(1-4)-l-guluronic acid, α-(1-4)-d-mannuronic acid subunits which have colloidal properties, along with Divalent ions (such as Ca2+) form ionic bridges with glucuronic acid units belonging to different chains, forming a physical gel. Alginates are thickening and stabilize ointments, creams, face packs, detergents, hair gels, and fixatives. Alginate emulsion-based edible films are used to protect microencapsulated aroma compounds. The daily permissible dose is 0– 50 mg/kg of human body weight, thus GRAS By USFDA. Thickening, stabilizing, suspending, film-forming, gel-producing, and emulsion stabilizing are some of its distinctive colloidal features.[3]

Carrageenans

Carrageenan originates from the cell walls and intracellular matrix of a variety of seaweed species (Eucheuma, Chondrus, and Gigartina). Carrageenans are divided into three categories: kappa (κ), iota (ι), and lambda (λ). Their main structure is made up of disaccharide repeating sequences of α -d-galactose connected at position 3 and β-d-galactose linked at position 4. carrageenans in the continuous phase of microemulsions increased sodium fluorescein penetration in porcine skin by enhancing the required consistency for better application over wide skin patches. It acts by Helix–helix aggregation promoted by cations (such as K+ or Ca2+) and gives rise to thermal hysteresis between sol-gel, and gel–sol transitions. Carrageenan concentrations of 0.1–0.5 w/v % can produce stable emulsions. Nonparenteral formulations prepared by carrageenans are suspensions, emulsions, gels, lotions, eye drops, suppositories, tablets, and capsules. Food-grade Carrageenan has an acute oral LD50 of more than 5000 mg/kg in rats. Nanoparticles composed of Carrageenan /chitosan combination (0.1–3 mg/ml) were shown to be non-toxic in cytotoxicity experiments using in vitro grown cell lines. Another investigation found that when greater polymeric concentrations (3.5 percent) were utilized, the cytotoxicity of the Carrageenan /alginate hydrogels was exceptionally low. The maximum cytotoxicity is caused by the addition of

sulfate groups to G-6. Carrageenan anticoagulant action is related to the number of sulfate groups, comparable to heparin/heparan sulfate. As a result, when manufacturing carrageenan into blood-contact biomaterials such as parental drug delivery vehicles or tissue regeneration scaffolds, more caution is essential. Carrageenan can adversely affect human intestinal epithelial cells. After being exposed to carrageenan (1–10 mg/l) for 1–8 days, cell death was seen in human colonic epithelial cells–both primary cells and a cell line.[2,13,15,19]

Hyaluronic Acid

Hyaluronic acid is an anionic linear biopolymer composed of alternating disaccharide units of d-glucuronic acid and N-acetyl-d-glucosamine with β (1-3) and β (1-4) linkages. Biodegradability, biocompatibility, non-toxicity, non-immunogenicity, specific viscoelasticity, hydration, and lubrification are only a few of its physicochemical and biological features. It has a molecular weight of 1 103 to 1 107 g/mol (Oh et al., 2010). It acts by stiffened random coil structure, and shear-thinning behavior. Hyaluronic acid is used in osteoarthritis (via intra-articular injections, known as viscosupplementation), ocular surgery (as a vitreous replacement), plastic surgery (as a matrix injected to treat facial wrinkles and folds, and to enhance the appearance of the lips), tissue engineering (for tissue regeneration, restoration, and repair, primarily due to its high biocompatibility), and other applications. It is also used as modeling the breast in women, thorax in men, and buttocks as well as cosmetic filler, facial contours. Ophthalmic lubricant treatment of pain in patients with osteoarthritis of the knee. Targeted specific and long-acting delivery of various biopharmaceutics such as protein, peptide, and nucleotide therapeutics are being studied recently.[20,21] Lajavardi et al. (2009) developed a hyaluronic acid gel that contained vasoactive intestinal peptide-loaded liposomes. The gel's viscosity and flexibility were improved via interactions between hyaluronic acid chains and liposomes. The vasoactive intestinal peptide for uveitis therapy was delayed as a result of this.[22]

Gum Arabic

Gum arabic is a polysaccharide with both protein and polysaccharide components. The arabinogalactan (AG) (80–90 wt. percent of the total gum), the glycoprotein (GP) (2–4 wt. percent of the total gum), and the arabinogalactan-protein (AGP) (10–20 wt percent of the total gum) fractions are separated by the relative protein-to-polysaccharides content. Depending on its origin and tree age, the molar mass of the whole gum can range from 3.0 105 to 5.8 105 g/mol. The association of polysaccharides blocks along the peptidic chain

provides the macromolecule a "wat-tle blossom"-like structure and makes it amphiphilic, allowing it to adsorb at the air-water and oil-water interfaces. It is usually utilized as an emulsifying agent, 10–30 w/w percent, 10–30 w/w percent as a pastille base, 5–10 w/w percent as a suspending agent, and 1–5w/w percent as a tablet binder, the ideal concentrations of gum arabic are 10–20 w/w percent. It is used in insulin-loaded nanoparticles, encapsulates, and controls the release of endoglucanase, osmotic, suspending, and expanding agents in an osmotic tablet system.[4,17]

Galactomannans

They are rigid hydrophilic biopolymers with a polymannose backbone (β-(1-4)-d-mannose) and grafted α- (1-6)-D-galactose units. Generally, they are used as thickening, water-holding, and stabilizing agents. The rheological behavior of these solutions is usually non-Newtonian. Tablet matrix from guar and locust bean gums was prepared by Coviello et. al. (2007) and studied the release of model molecules. They showed that it was possible to modulate the release of the molecules from this galactomannan matrix.[23]

Hydroxypropyl methylcellulose (HPMC)

Hypromellose is partly O-methylated and O- (2-hydroxypropylated) cellulose having various applications in pharmaceutical and food industries for controlled drug release, control of texture, and rheological properties of dispersions, emulsification, etc. They act by accumulating at the oil-water interface. The structural characteristics of cellulose derivatives may be associated with their emulsion stabilizing capabilities. Moreover, the hydrophobic (rich in methoxy groups) and hydrophilic (rich in hydroxypropyl groups) areas dispersed throughout the cellulose backbone provide these macromolecules their surface activity, allowing them to adsorb at fluid interfaces and reduce interfacial tension (Camino et al., 2009) Pharmaceutical use of HPMC (0.45–1 w/w %) has been reported in vehicles for eye drops and artificial tear solutions. HPMC is an alternative to gelatin in the manufacturing of hard capsules. Hypermallose is extensively used for Controlled drug releases, control of texture and rheological properties of dispersions, emulsification, Matrix tablets, controlled release formulations, Liquisolid tablets, HPMC capsules, Floating Drug delivery systems like micro balloons, floating tablets, and granules.[24]

Lecithin

It is composed of phosphatidylcholine, phosphatidylethanolamine, phosphatidylinositol, and phosphatidic acid. soya lecithin contains 15% phosphatidylcholine (PC), 10%

phosphatidylinositol (PI), 11% phosphatidylethanolamine (PE), and 4% phosphatidic acid (PA). The PL found in lecithin can self-associate with water or oil to reduce the system's free energy. Hydrophobicity, or the tendency for a system to decrease thermodynamically unfavourable contact between non-polar groups and water, is the primary driving factor for the creation of various sorts of colloidal systems. The mechanisms include micelle formation and in phosphatidylcholine, choline moiety containing negatively charged phosphate group along with positively charged trimethyl-amino group facilitates electrostatic amphiphilic structure with high surface activity.[25] Soya lecithin liposomes containing ethanol as a penetration enhancer are effective in the transdermal delivery of herbal drugs with antimicrobial properties drugs used for the topical treatment of alopecia. In emulsions, lecithin reduces the surface tension by orientating at the interface, with the fatty acid tails protruding into the oil droplets and the hydrophilic head orientating toward the water.[14] Lecithin is largely used in oil-in-water emulsions to encapsulate and deliver polyunsaturated oils and bioactive compounds (e.g., carotenoids) in food. It is widely used in creams, lotions, foundations and cleansing creams, skin softening in cosmetics sunscreens, soaps, bath oils, shampoos, and hair conditioners.[18,28]

SAPONINS AS SURFACTANT

The acetate mevalonate pathway is used to synthesise a class of tensioactive chemicals known as saponins. Saponins are utilised mainly due to their foaming and cleansing activities. These molecules cause a large decrease in surface tension and a lot of foaming. The naturally occurring amphiphilic glycosides known as saponins have nonpolar aglycone structure moieties (sometimes referred to as sapogenins) separated from polar glycone structure moieties (sugars). According to their aglycone counterparts, saponins are divided into two groups: triterpenoid saponins and steroidal saponins. The steroidal saponins have 27 C-atoms, whereas the triterpenoid saponins have 30 C-atoms, making this the distinction between the two groups.[26] The more than 100 families of vascular plants, as well as certain marine sources, include a variety of secondary metabolites known as saponins. Triterpenoid saponins are mostly produced by dicotyledonous plants (families like Fabaceae, Araliaceae, and Caryophyllaceae), whereas steroidal saponins are primarily produced by monocotyledonous plants (families like Liliaceae, Dioscoreaceae, and Agavaceae).[26]

CONCLUSION

The use of synthetic surfactants in dermatological preparations has several drawbacks, including skin irritations and other skin problems. As a result, there has been a shift towards using mild synthetic and natural surfactants to eliminate these concerns. Cellulose, starch, protein, and lignin-based polymers and particles have been explored for their safety and efficacy in overcoming the challenges associated with synthetic surfactants. They can also interact with other molecules through covalent bonding or electrostatic interactions, allowing for thermal stability. However, it is important to consider the toxicity concerns associated with these plant-based surfactants, including anaphylactic hypersensitivity and acute toxicity. Despite these concerns, plant-based surfactants offer potential as drug delivery carriers. Green surfactants provide several benefits over chemically generated surfactants, including high biodegradability and low ecotoxicity, as well as the ability to be easily created using renewable energy sources. Surface-active compounds produced from microbes are often employed in the pharmaceutical, food, cosmetic, textile, oil, and agricultural sectors. Haque et al.,[27] employed them as antifungal and antibiofilm agents. Biosurfactants generated by bacteria and their antibacterial, antifungal, and antiviral characteristics are of great interest in the microbiological world. However microbial surfactant production is quite costly as compared to plant-derived surfactants. Consumer demand for environmentally friendly goods is an element that is rapidly influencing the cleaning products industry. The search for natural or derived biodegradable raw materials with fewer preservatives and petrochemicals has resulted from this need. Green surfactants and plant-based chemicals are two promising materials that are gaining attraction in efforts to produce or alter goods that are more eco-sustainable as well as beneficial for human skin. Plant based surfactants are promising candidate in place of hazardous synthetic surfactants. Plant-based surfactants are derived from plants through isolation or chemical modification methods. They are natural and vegan, making them suitable for use in food, cosmetics, and pharmaceuticals. Proteins and polysaccharides obtained from plants can adsorb at the globule surface, reducing interfacial tension and providing stability to emulsions. Surfactants can have antibacterial or germicidal effects on microorganisms, but their toxicity can be harmful to humans as well. Plant-based surfactants, such as proteins like whey proteins, caseins, and pea proteins, as well as polysaccharides like xanthan gum, alginates, and carrageenans, offer promising solutions to overcome the toxicity concerns associated with synthetic surfactants. Various plant-based surfactants have been identified for different applications. For example, whey proteins,

including α-lactalbumin, β-lactoglobulin, lactoferrin, and BSA, disrupt droplets and induce electrostatic repulsion between them.

CONFLICT OF INTEREST

The authors have no conflicts of interest regarding this investigation**.**

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NA.

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