The Pharma Innovation Journal 2023; 12(5): 08-16

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(5): 08-16

www.thepharmajournal.com
Received: 14-02-2023
Accepted: 17-03-2023

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Plant-based emulsifiers: Sources, extraction, properties and applications

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DOI: https://doi.org/10.22271/tpi.2023.v12.i5a.20043

Abstract
The plant-based emulsifiers are derived from plant sources as an alternative to synthetic emulsifiers used in food for the stability and the thickness. In this review an overview of emulsifiers, sources, extraction, physicochemical characteristics and applications of the different plant-based emulsifiers are highlighted. The emulsion properties and the molecular properties of the different plant-based emulsifiers from different sources have been studied. Under the class of the lecithin as an emulsifier, has different sources with wide range of functions. The challenges of the plant-based emulsifier been clearly discussed, the main challenges comparing to synthetic emulsifiers is that the plant-based emulsifiers are very costly, its required in large amount for maintaining the emulsion, comparing to synthetic emulsifiers the plant-based emulsifiers very difficult to extract. But compared to the synthetic emulsifiers the plant-based emulsifiers provide good nutritious to the body. The main objective of this review article to highlight the importance, extraction, types and sources of plant-based emulsifiers their applications in food industry.

Keywords: Emulsifier, extraction, lecithin, gum Arabic, guar gum, applications

1. Introduction
Under the chemical class of surfactants, the emulsifiers falls and emulsifiers are the surface-active substances, more specifically the emulsifiers are water-soluble surface-active substances. Emulsifiers will reduce the surface tension and also reduce the enlargement of the molecule. Emulsifiers can be divided into ionic and non-ionic. In ionic surfactant mostly includes soaps and in the non-ionic mainly ethoxylates (Miller, 2015) [25]. In the soluble oils and the water emulsion the oils are emulsified rapidly and form the stable emulsion. Emulsifiers mainly used to keep residues from precipitation the solution or the components. Keeping the precipitation is by giving the hydrophobic groups into the hydrophobic areas. Emulsifiers used in the food industry enable to obtain better food quality which, due to the different composition, may have problems with consistency. Maintaining the consistency is the important function of the emulsion and also to made emulsion in the solution as such as possible (Bergenståhl, 2008) [5]. The plant-based emulsifiers include the guar gum, gum Arabic, lecithin, natural powders and the faba bean protein. The guar-gum a versatile polymer obtained from the z tetragonolobus. And it belongs to the Leguminosae family, the guar gum has high viscosities to aqueous solution at low concentration. The lecithin provides a dozen function includes as an emulsifier, wetting agent, viscosity reducer, and as a release agent. The application of the lecithin is been included in many foods like margarine, shortenings, baked goods, chocolate, candy and macaroni. The lecithin is been introduced into the fats and oils as a crystal inhibitor and the antioxidant (ADM, 2014) [1]. The gum Arabic extracts from the tree acacia Senegal and the acacia seyal. The gum Arabic contains the high amount of the carbohydrate and the low protein content. The gum Arabic mainly produce in the African countries like Senegal and the Sudan. Traditionally the gum Arabic is used for the chronic renal failure and the stomach discomfort. The gum production from the tree mainly because of the injury, climatic variation etc (Ahmed, 2018) [2]. The faba bean protein is a promising emulsifier but the usage of this emulsifier is less in food industry. The faba bean protein isolates depend upon the various characteristics includes the solubility, surface charge, and the interfacial activity (C. Liu *et al*., 2022) [21]. The interfacial activity will affect the droplet size distribution. The Maillard reaction and the acetylation would increase the interfacial activity of the faba bean protein. The natural powders provide the various function to the body it acts as anti-inflammatory, anti-viral and the anti-bacterial property to the body (Nushtaeva, 2016) [29].

2. Food emulsifiers

The emulsifiers are the substance that makes the oil and the water mix. According to some people, emulsifiers are needed only for the forming water and oil emulsion only. The broad application of the emulsifiers includes aeration improvement, texture improvement, preventing the chocolate bloom, making the ice cream creamier, more resistant to melting, increase in the shelf life, and reducing the fat content of a variety of foods (Cassiday, 2016) [7]. The emulsifiers are the amphophilic molecules that stabilize and form the emulsion. The emulsifiers have a broad range of applications in food such as texture improvement, appearance, and increase in shelf-life time. The basics of the emulsifiers include the emulsion consisting of the oil droplets dispersed in the aqueous phase (o/w). The emulsion can be formed by the mixing or the shaking of the two immiscible liquids but the emulsion formed by this is thermodynamically unstable. Without the emulsifiers, the emulsion typically breaks down in minutes and a distinct layer of the oil and the water phase. The emulsifier is the amphiphilic molecules that contain both hydrophilic and hydrophobic regions. The hydrophilic region is the polar and the water-loving region and the hydrophobic region is the non-polar and water-hating region. In the oil in, water emulsion the non-polar part interacts with the oil droplet, and the polar component faces the surrounding aqueous solution. In the water in oil emulsion the polar group interact with water droplet and non-polar region subjected to the oily solution. The surface tension gets reduced by these interaction, in the two immiscible liquids (Cassiday, 2016) [7] (McClements & Gumus, 2016) [24]. The measure of an emulsifiers oil and water solubility is determined by the HLB balance. The range of the HLB scale is from 0-10. And HLB measure of 10 an emulsifier is equally interaction of oil and water. HLB value greater 10 indicates the hydrophilic emulsifiers and HLB value less than 10 indicates the hydrophobic emulsifiers, the hydrophilic emulsifiers having greater stabilizing for oil in water emulsion and the hydrophobic emulsifiers having the greater stabilizing in water in oil emulsion (Miller, 2015) [25].

3. Emulsifier characteristics

Characteristics of emulsifier is used to be in food industry and in the other industries as well. The physicochemical property of the emulsifier is the important characteristic of emulsifier in the food industry. Ability to rapidly adsorb to the surfaces of the droplets created during homogenization, ability to reduce the interfacial tension by an appreciable amount so as to facilitate further droplet disruption and the ability to form a protective coating around the droplets that prevents their aggregation by generating strong repulsive forces, such as steric or electrostatic repulsion these are the three characteristics of the emulsifier mainly used in food and other industries (McClements & Gumus, 2016) [24]. To compare the effectiveness of the different types of natural or synthetic emulsifier mainly by the surface pressure at saturation, surface activity and the surface load these are the different parameters to checking the effectiveness of the emulsifier The phospholipids present in the cell membranes of plants, animals and microorganisms these phospholipids are the amphiphilic molecules and naturally present used as emulsifier (McClements & Gumus, 2016) [24].

4. Physicochemical characteristic of emulsifier

There are various physicochemical properties of emulsifiers that strongly influence the functionality. Among that surface activity is one of the main characteristics of an emulsifier. Ability to form an interface on the surface is called the surface activity. Reduce the surface tension. The lifetimes of bubbles are increased. (Only very pure water displays a very short lifetime, a few seconds, of bubbles created by shaking. Normal standard “pure water,” double distilled, usually displays a bubble lifetime of about 20–30 s.), The emulsify ability of oils in water is enhanced. Smaller drops with a longer lifetime are formed with less stirring, The aggregation rate of dispersed particles is changed. Surface-active additives may induce or prevent flocculation of dispersions, The sediment volume of settling particles is influenced. Surface additives inducing adhesive may create a loose or compact sediment, Crystallization properties are changed. This may include crystallization rate and crystal shape (Bergenståhl, 2008) [5]. The interfacial tension is a crucial characteristic in all three dimensionless numbers but is challenging to measure at the time scales involved in emulsification processes. The interfacial tension is a crucial characteristic in all three dimensionless numbers but is challenging to measure at the time scales involved in emulsification process. The value of dimensionless number is influenced by the emulsifiers used, interface to mass transfer, binding to the interface, and main important influence by formation of visco-elastic films. To know the apparent interfacial tension, utilizing the surface area of the droplets created during emulsification in Y-junctions along with the continuous phase's known velocity and viscosity (Güell *et al*., 2017) [12].

4.1 Physicochemical characteristics of phospholipids

Two fatty acids consist in phospholipid polar and non-polar the two fatty acids been attached to the polar head and the phosphoric acid moiety attached to a glycerol backbone non polar head. Phospholipid form a single layer around the oil and the fatty acids protrude or penetrate into the oil droplet. Type of structure formed depends on phospholipid type and concentration, and impacts emulsion formation and stability. Phospholipids based emulsifier used in food industry mainly based on lecithin’s and these lecithin’s mainly extracted from different sources such as the soyabeans, eggs, canola seeds, cotton seed and sunflower. The food lecithin consist of different mixtures of phospholipids with different heads and tails groups different types of lipids were included in the phospholipids. Common phospholipids in the food grade lecithin are phospho phatidylcholine (PC), phospho tidyletanolamine (PE), phosphatidylinositol (PI), and phosphatidic acid (PA). In nature non polar tail consist of different types carbon atoms and double bonds (McClements *et al*., 2017) [23].

4.2 Emulsion formation by lecithin

HLB (Hydrophilic lipophilic balance) number of the lecithin depends upon the number of the head and tail group. Mainly for the natural emulsifiers the HLB number is seven. The HLB number seven means they can disperse both in the oil and water phase. The functionality and the effectiveness of the lecithin mainly depend whether they dispersed in oil phase or in the water phase. The which phase gives better effectiveness is not yet known. The HLB of lecithin is less compared to the lyolecithin. Due to the higher HLB number of the lyolecithin it is dispersed in the water phase than the oil phase prior to homogenisation. Effectiveness of lecithin’s at forming oil-in-water emulsions is highly system dependent. Higher shear produces the large oil droplets and less shear in emulsion produces the small oil droplets mainly 500nm. With increase in the emulsifier concentration the size of the droplets decreases during the homogenisation. The type of the lecithin depend upon the droplet size and the emulsion structure (McClements *et al*., 2017) [23]. Picture 1 is the HLB scale given by (ADM, 2014) [1]

4.3 Different types of plant-based emulsifiers

A group of natural emulsifiers are called as plant base emulsifiers. In daily life there are many plant- based and vegan type emulsifiers are used in daily life and in recipes. The source of different based emulsifiers and the properties of the emulsifiers been recorded in the Table 1 by (McClements *et al*., 2017) [23]

Table 1: Types of plant-based emulsifiers and their properties

Emulsifier	Sources	Molecular property	Emulsion property	Reference
Lecithin (Phospholipid)	Soyabean, cotton seed, sunflower, canola seed	Consisting of the polar and non-polar on the same molecule	Form small droplets at low levels via high-energy emulsification methods. Unstable under acidic conditions (pH < 3) and high ionic strength (>100-mM NaCl). Less sensitive to high temperatures.	(Klang & Valenta, 2011) [17]
Lyolecithin (phospholipid)	Modification of the raw lecithin by the enzymatic and the chemical modification	Consisting of the polar and the non-polar on the same molecule.	forms small droplets at low levels via high-energy emulsification methods.	(Cabezas *et al*., 2012) [6]
Saponins (bio emulsifier)	Isolate from the bark of the Quillaja Saponaria tree	Hydrophilic and the hydrophobic parts on the same molecule.	Fairly small droplets at low levels via high-energy emulsification methods.	(Mitra & Dungan, 1997) [26]
Soy protein	Soybeans	Mixture of globular proteins with wide range of molecular weights.	Small droplets at low concentration.	(Bellesi *et al*., 2016) [3]
Pea protein	Pea	Mixture of globular proteins with wide range of molecular weights	Small droplets at higher concentration	(Benjamin *et al*., 2014) [4]
Lupin protein	Lupin beans	Globulin 70% and albumin 20%	Small droplets at low concentration	(Benjamin *et al*., 2014) [4]
Gum arabic	Extract from Acacia Senegal tree	Consisting of hydrophobic protein part and hydrophilic polysaccharide parts on the same molecule.	Form micron or submicron droplets at high surfactant-to-oil ratio via high-energy emulsification methods.	(Ozturk *et al*., 2014) [30]
Beet pectin	Extracted from sugar	Consisting of branched anionic hydrophilic polysaccharide.	Via high energy emulsifier methods form micron or sub-micron surfactant at high oil ratio.	(Phatak *et al*., 1988) [31], (Funami *et al*., 2011) [10]
Citrus pectin	Extracted from citrus fruit	Consisting of branched anionic hydrophilic polysaccharide.	Form micron or submicron droplets at high surfactant-to-oil ratio.	(Leroux *et al*., 2003) [19]

4.4 Guar gum

Guar gum obtain from the seeds of the Leguminosae family and it is a polygalactomannan that's the guar gum. Cyamopsis tetragonolobus the family of the guar gum. Guar gum is a water-soluble polysaccharide and it provide high viscosity to aqueous solution even at low concentration. Manufacturing process of guar gum done according to (Gupta & Variyar, 2018) [13]. Characteristics of the guar gum include the pods of the guar are green, each pod is 5-8 cm long, and these pods contains the eight to nine seeds, the seeds are 2-4 mm long and 35mg weight. Seed coat is 14-17% of the guar plant and the endosperm is rich in the galactomannan (Gupta & Variyar, 2018) [13].

strong hydrogen bonds formed by dissolving in the polar solvents such as the liquid ammonia, hydrazine, formamide and in water. And it gets swells when guar gum dissolve in water and polar solvents. The non-polar solvents form the weak hydrogen bonds like hydrocarbons, ketones and alcohol (Gupta & Variyar, 2018) [13]. With the increase in temperature, decrease in particle size and decrease in Ph the solubility of the guar gum will increase (Gupta & Variyar, 2018) [13].

4.1.1 Rheology

Providing the high viscosity to aqueous solution even at low concentration. Most important functional property of the guar gum is rheology. Viscosity of the guar gum solution increases with the increase in the concentration of the guar gum. Increase in concentration leads to the increase in the entanglements and thus that leads to the increase in the viscosity. Increase in the temperature leads to increase in the hydration of the guar solution (Gupta & Variyar, 2018) [13].

4.1.2 Applications of guar gum in food industry

Unique property of the guar gum includes water retention capacity, decrease the evaporation rate, modification in freezing rate, modification in the ice crystal formation. The guar gum is safe by the UN drug administration. There is a permissible limit in the usage of the guar gum in the food by the regulation section 184.1339 the limit is 2% for the fats and oils and in the processed vegetables, and in fruit juices. The maximum limit in the usage of the guar gum in the baked goods is the 0.35% (Gupta & Variyar, 2018) [13]. Uses of guar gum in different food industry been tabulated in Table no 2 by (Gupta & Variyar, 2018) [13]

Table 2: Applications of guar gum as emulsifiers in food industry

Sr. No.	Type of foods	Uses	References
1.	Meat industry	• Thickeners • Fat replacer	
2.	Dairy industry	• Improving mouthfeel • Stabilizing the foam • Viscosity maintains • Preventing the separation of the serum	(Gupta & Variyar, 2018) [13]
3.	Beverage industry	• Thickener • Stabilizer	

4.2 Lecithin

Gums from the treatment of crude oils (soybean, canola, sunflower) contain about 70% phospholipids and 30% oil and water. The lecithin is recovered by drying. Fluid, oil-free, and modified lecithin's can be classified. Gums from the treatment of crude oils (soybean, canola, sunflower) contain about 70% phospholipids and 30% oil and water. By the addition of free fatty acids, metal salts, and/or oil Fluidization is accomplished. Indicate a minimum of 62% acetone insoluble specifications for fluid lecithin usually. Addition of hydrogen peroxide and benzoyl peroxide to the degumming step colour is important, lecithin may be bleached. Is obtained by treating the gums with acetone Oil-free lecithin is obtained, resulting in 95–97% phospholipids. Hydrophobic lipophilic balance (HLB) values Commercial lecithin cover a wide range, to the emulsification required for various applications which serves as a guide, depending whether oil-in-water (O/W) or water-in-oil (W/O) are needed. To reduce surface tension at the oil–water interface and facilitates disruption of bulk phases into small droplets lecithin is been added. For the type of emulsion required by the HLB value. For example, W/O emulsions require HLB values from 3–6 W/O, from 8–18 O/W, and 6-8 both types fall in the range (List, 2015) [20]. Application of lecithin in food industry been given in Table no 3 by (Szuhaj *et al*., n.d.) [33]

Table 3: Applications of the lecithin in food industry

Foods	Purpose	References
Margarine	Anti sapatter	
Chocolates and caramel	Controls viscosity, reduce sticking and controls crystallization.	
Instant foods	Act as both emulsifier and wetting agent.	(Szuhaj *et al*., n.d.) [33]
Bakery products	Act as the emulsifier and the wetting agent	
Dairy products	Act as the emulsifier, wetting, releasing and the anti sapetter	
Salad products	Emulsifier and control crystallization	

4.2.1 Dry de-oiled lecithin

The dry oiled lecithin served in the food industry as the release agent, oil in water emulsifier, viscosity modifier or increaser and also act as the release agent. This is used in the food products when the food is needed in the dried form or when the food needs the low flavour is required. The dry de-oiled lecithin is packed in the 44 1-lb packages, 18 boxes/pallet, 794 lbs. This lecithin can be stored in the non-moisture container for two years that means the unopened containers (List, 2015) [20]

4.2.2 Rapeseed lecithin

Rapeseed lecithin has a phosphatide profile similar to the soyabean. 38–46% PC, 27–43% PE, and 18–33% PI by the rapeseed contains and the soyabean contains 43% PC, 16% PE, and 41% PI. The total phospholipid content depends upon the type of the extraction of the oil that is solvent extraction or the expellers are used. In the solvent extraction the oil contains the phospholipid of 1-5.3% and the expellers oil contains 0.6-2.4%. Difference in the use of the solvents in the extraction yields the phospholipid content. Hexane yields the low crude oil with the low phospholipid content. Alcohol yields high phospholipid content than the hexane. The pressed oil has the less phospholipid content than the solvent extracted oil. The rapeseed lecithin having the less flavour, taste, colour and the appearance. The usage of the rapeseed been used in the chocolate and the margarine in the European countries. Seven rapeseed lecithin manufacturing companies been begun India (List, 2015) [20].

4.2.3 Sunflower lecithin

Sunflower the major source of the lecithin grown. In the countries like the Argentina, France, Hungry and the Uruguay where the sunflower grown mostly. The sunflower composition is similar to the soyabean. Only the phosphatidylcholine is higher in the sunflower compared to the soyabean. Alcohol fractionation and the enzymatic modification been used in the extraction of the sunflower lecithin. The alcohol fractionation where the phosphatidylcholine increased by the 41% to the 65%. The sunflower lecithin been difficult to handle since it is very pasty compared to the soyabean lecithin. The sunflower manufacturing company first opened in the Hungry and the its been expanded in the Europe, Africa, middle east and in the Japan (List, 2015) [20].

4.2.4 Organic lecithin

Generally produced from the non-genetically modified soyabean, sunflower oil, and the canola. The hexane solvent is not used in the extraction of the organic lecithin. The seeds been pressed to give the crude oil. The crude oil filtration, water hydration, centrifugation drying and the fluidization process to yield and produce the organic lecithin. Oil free lecithin is not available. Application of the organic lecithin in the ice cream, chocolate, infant formula, dietary foods etc. (List, 2015) [20].

4.2.5 Hydroxylated lecithin

The hydroxylation of the lecithin occurs in the presence of the hydrogen peroxide, and the lactic acid. The hydroxylation occurs at the double bond of the fatty acids. Hydroxylation of lecithin by the reaction produces dihydroxy stearic acid and increases the acetyl values, indicating that double bonds are hydroxylated. The hydroxylation reaction is very slow (List, 2015) [20].

4.3 Faba bean protein

Faba bean protein a storage protein. The faba bean had a promising emulsifying property. The faba beans consist of the globulin, glutenin and the polyamines. The intermediary subunits consist of the alpha and beta sub units. The alpha sub units are hydrophilic and beta sub units are hydrophobic the alpha sub units been found on the surface but the beta sub units been found in the core. The faba bean has the more rigid structure due to the interaction between the alpha and beta sub units been connected with the electrostatic and the hydrophobic reaction (C. Liu *et al*., 2022) [21]. The production of the faba bean protein by the isoelectric precipitation (Karaca *et al*., 2011) [16]. In connection with the heating, acidification and the enzyme added cross linking the emulsifying property of the faba bean protein been studied (Nivala *et al*., 2021) [28]. The application of the faba bean protein in the food industry is not good and not been much more used for the emulsifying property in food industry (C. Liu *et al*., 2022) [21].

4.4 Gum Arabic

The gum arabic also known as the acacia gum, arabic gum, acacia, Senegal gum, and the Indian gum. The gum arabic generally extracted from the tree species known as the acacia species called acacia Senegal and the acacia seyal. Acacia comes under the family Fabaceae. The gum Arabic generally a dietary fibre generally rich in the carbohydrate and less in the protein content. The sugar arabinose and the ribose been extracted from the gum arabic. The original source of the gum arabic. The gum arabic been extracted mainly been seen in the countries like the region of the Africa like Sudan, Senegal, and the Nigeria. In the food industry the gum arabic been mainly used in the confectionaries (Jaafar, 2019) [14]. Application of gum arabic in food industry been given in Table no 4 by (Szuhaj *et al*., n.d.) [33]

Table 4: Applications of gum arabic in food industry

Product	Approximate use level (%)	Function	References
Dairy products	1.5-2.0	Texture, crystallization, stabilization	
Meat products	0.13-1.0	Softness, fat replacer, cooking, viscosity	(Mudgil *et al*., 2014) [27]
Bread and baked goods	0.1-1.0	Loaf volume, dough machinability	
Pasta	0.2-1.5	Texture, stabilizer, dough resiliency	
Spreads (ketchup, cheese)	0.1-1.0	Consistency, spread ability	
Shakes	0.1-0.6	Bodying, stabilize overrun	

4.4.1 Application of gum arabic in food industry

The Acacia gum been used in the sucrose or in the high free sugar systems, and in the dried form and it provides better texture to the confectionary products. The acacia gum generally used in the candies, chewy products, jujubes, and in the sucrose or polyols. For the moulded candies the gum arabic application is according to the texture needed. For the hard texture the acacia gum is extracted from the A. Senegal at higher concentration. For the soft texture the acacia gum is used with other gelling agents like gelatine (2006, Al Shaarani & Al Wazi) [35].

4.4.2 Mustard, ginger, cinnamon powder as emulsifiers

The yellow mustard mucilage is been extracted from the white or the dried layer, and it's been dried in the room temperature. The emulsifying property of the water-soluble yellow mustard mucilage is high compared to the gum arabic and the citrus pectin. The yellow mustard mucilage contains the 84% pectic polysaccharide and the 16% non pectic polysaccharide. This water-soluble mucilage also been interacted with the galactomannans (Wu *et al*., 2015) [34]. The natural food powders like the mustard, cinnamon, ginger been used as the solid emulsifiers. The oil in water emulsion been formed from the aqueous dispersion of the food powders except the olive oil. To prevent the coalescence the concentration of the mustard powder requires at least 0.3% (mass). To prevent the sedimentation the concentration of the mustard powder requires 15%. For the cinnamon the concentration of the cinnamon requires 15% to prevent the sedimentation. In the all powders the cinnamon the best compared to the other products since it has high emulsifying capacity and also it has high antioxidant and the antimicrobial properties (Nushtaeva, 2016) [29].

4.4.3 Emulsion stabilizing by the natural powders

The natural food powders are insoluble. In the natural food powders the milk powder been also used as the emulsifier. The all-food powders forms oil in water emulsion except the talc the talc forms the water in oil emulsion. The emulsion forms easily by the mixing and also by the simple shaking of the oil and the aqueous phase (Nushtaeva, 2016) [29]. The volume of the emulsion formed by the natural powders increased linearly with the increase in the powder concentration in the aqueous phase from 1-10%. The emulsion remained stable for the one month there may be no change in the concentration of the emulsion. The natural emulsifiers are classified according to the increasing hydrophobicity Starch < milk powder < ginger < mustard and cinnamon < talc. The nutmeg powder is not considered as a powerful emulsifier because of the toxicity. The best protection against the coalescence and the sedimentation by the mustard and the cinnamon. The type of the oil influence the emulsion stabilization by the natural powders (Nushtaeva, 2016) [29].

5. Extraction of plant-based emulsifiers

Plant based emulsifiers can be extracted from different sources like pectin from abelmoschus esculentus, orange peel and the sugar beet.

5.1 Extraction of pectin from Abelmoschus esculentus

Polysaccharide present it that confers it a thick and slimy nature by Abelmoschus esculentus or okra has a substantial content. Investigated for their composition and structure okra polysaccharide extracted. Emulsifier was characterized for protein content, zeta potential and subjected to high pressure size exclusion chromatography. Mixing equal volumes of stock emulsion (A) and an okra extract solution (B) of either hot buffer soluble solids (HBSS) or chelating agent soluble solids (CHSS) or diluted alkali soluble solids (DASS) Emulsions were prepared by mixing these. HBSS extract exhibited extensive flocculation, strong shear-thinning rheology and fast creaming at low concentration by that It was founded. Creaming greatly reduces at a high concentration (1.25% - 2.5%). On the other creaming even at a concentration of 2.5% CHSS exhibiting almost the same behaviour did not reduce. Of more than 1.65% delayed creaming DASS exhibited intermediate behaviour and a concentration (Dasgupta & Das, 2015) [8].

Okra pods in model acidic emulsions of hexadecane in water at Ph 3.0 was investigated. The emulsifying efficiency and capacity of gum extracted. At a Ph of 4.0 Isolation of pectin, a heteropolysaccharide, was carried out, Okra Extract4 (OE4) and 6.0(OE6). Droplet size distribution and average droplet size after 30 days of storage whereas OE6 proved to be more stable OE4 exhibited Ostwald's ripening (Dasgupta & Das, 2015) [8].

5.2 Extraction of pectin from orange peel

Rich source of pectin is orange peel. Natural food-additive used extensively in food industries as a thickener, a texturizer, a stabilizer and other applications include fat replacer in spreads, salad dressing, ice cream etc are used by the pectin. Also, according to for pectin is an excess of 30000 tons annually and growing by 4-5% per annum the world market demanded for Therefore, it is necessary to establish in a shorter time and in better quality a method by which the pectin is manufactured (Dasgupta & Das, 2015) [8]. Using microwave extraction of pectin from orange peel is described. Shorter time, less solvent, higher extraction, better products with lower cost these are the advantages. The steps associated with this extraction of pectin from orange peel been done by the (Kanmani, 2014) [15]. Extraction of pectin by conventional extraction done by (Su *et al*., 2019) [32] is given in figure 1.

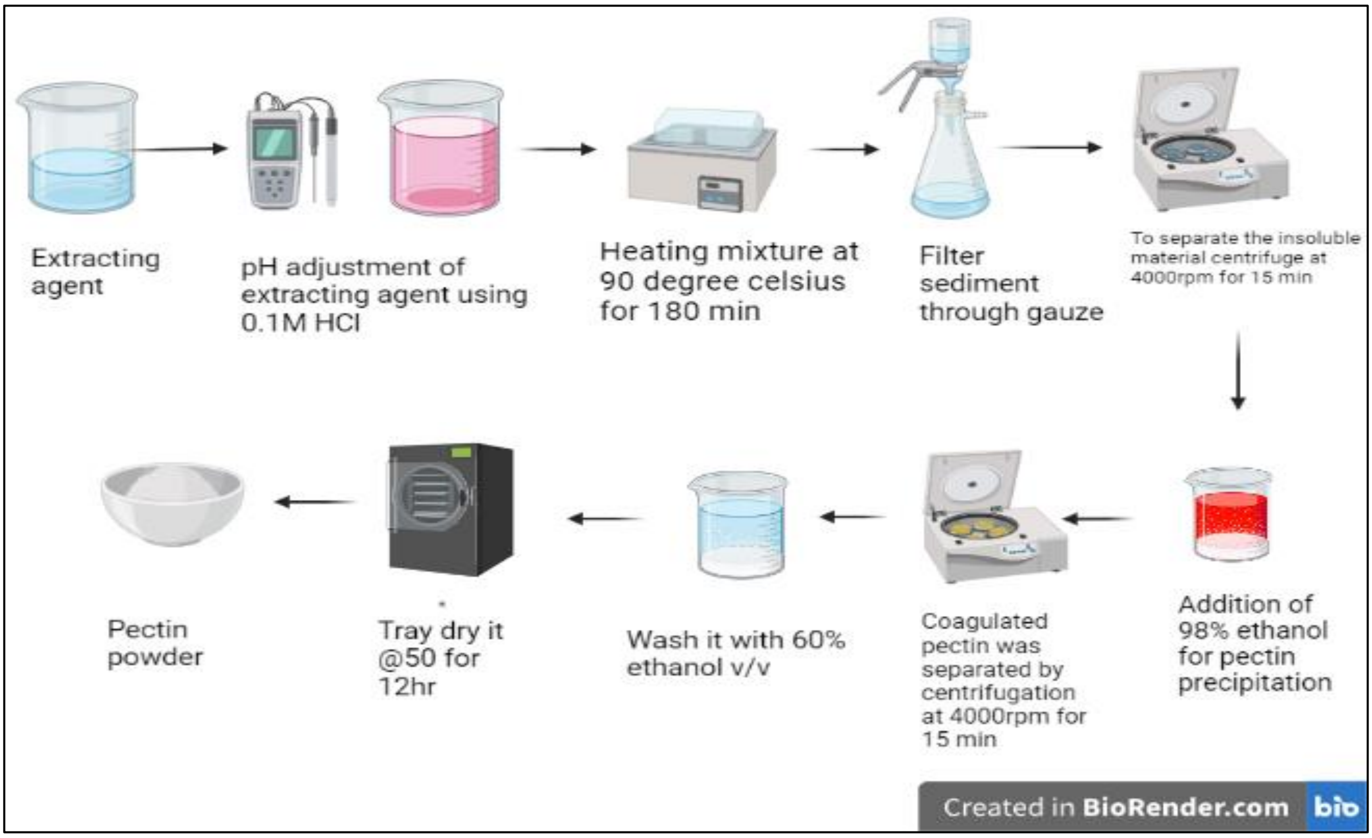

Fig 1: Extraction of pectin from orange peel through conventional extraction (Su *et al*., 2019) [32]

5.3 Extraction of the pectin from sugar beet

The extraction of the pectin from the sugar beet is done by the various solvent extraction procedures. The sugar beet pulp is the waste or the residue left after the sugar extraction. By the three methods the pectin extraction done from the sugar beet pulp. 1st method is HCL method 2nd method is the EDTA extraction and third method is the ammonium oxalate extraction by (Phatak *et al*., 1988) [31].

6. Performance of plant-based emulsifiers

Consisting of water droplets trapped within oil droplets that are dispersed in an aqueous continuous phase Water-in-oil-in-water (W/O/W) emulsions are complex colloidal dispersions. There are numerous potential applications of this kind of double emulsion in the food industry. For instance, they can be used to develop reduced-calorie products by replacing some of the oil present inside the oil droplets with water droplets, including dressings, sauces, and beverages. Water-soluble and oil-soluble bioactive components, including probiotics, vitamins, nutraceuticals, and antioxidants Double emulsions can also be utilized for the encapsulation and protection for that use. The application of double emulsions within commercial food applications is often limited because they have a tendency to breakdown due to droplet creaming, aggregation, Ostwald ripening, and expulsion/leakage of encapsulated substances Theses are the application of double emulsions within commercial food applications. Many of these instability mechanisms can be inhibited or prevented by careful selection of emulsifiers Many of these instabilities of the emulsifiers to stabilize the oil/water and water/oil interfaces of the emulsifiers (J. Liu *et al*., 2021) [22].

6.1 Impact of emulsifier properties on particle size of W/O/W emulsions

Characteristics of the W/O/W emulsions was investigated by the impact of the type and amount of emulsifier used on the particle size characteristics. By the aqueous phase was too viscous to homogenize We could not prepare emulsions using more than 2%. The protein concentration was insufficient to form stable W/O droplets in addition, emulsions could not be formed with less than 1% WPI or SPI, presumably. With increasing emulsifier concentration for pectin and gum Arabic there was the expected reduction in mean droplet diameter. The W/O droplet surfaces and/or to thicken the aqueous phase since there would have been more amphiphilic polysaccharide molecules available to adsorb that. With increasing WPI and SPI concentration Surprisingly, however, there was actually an increase in d32 diameter. With increasing protein concentration in O/W emulsions This effect was unexpected, as the droplet size typically decreases (J. Liu *et al*., 2021) [22].

W/O/W emulsions fabricated using the four emulsifiers were also measured by the particle size distributions (psds). For gum arabic and pectin, even at the lowest concentrations used Monomodal psds were obtained. For the gum arabic-double emulsions was not significantly affected by emulsifier concentration of the PSD, which suggests that 0.5% gum arabic was enough for fabricating double emulsions. With increasing pectin concentration Conversely, the peak in the psds of the pectin stabilized double emulsions moved downward. So, more is required to stabilize the droplets This may have been because pectin is a less surface-active molecule than gum arabic and so more is required to stabilize the droplets. In addition, aqueous phase pectin increases the viscosity. After homogenization by slowing droplet movement which may promote droplet disruption during homogenization by increasing the shear forces generated or inhibit droplet coalescence (J. Liu *et al*., 2021) [22].

For the WPI and SPI-double emulsions for bimodal distribution were observed. In the case of WPI, the population of large particles increased, as the protein concentration was increased while the population of small particles decreased. Indicating the presence of larger particles in the case of SPI, the peaks moved upward with increasing protein concentration. This result indicates that higher protein concentrations led to larger droplets in the emulsions (J. Liu *et al*., 2021) [22].

6.2 Influence of emulsifier properties on zeta-potential of W/O/W emulsions

Of the W/O droplets in double emulsions prepared using different emulsifier types and concentrations an electrophoretic instrument was used to determine the zeta potential. Similar Zeta-potential – emulsifier concentration profiles, the double emulsions formed from the two polysaccharide emulsifiers had similar as did the ones formed from the two protein emulsifiers. Had relatively high negative zeta-potentials (− 31 to − 37 mv) the gum Arabic- and pectin-coated W/O droplets, with the absolute value decreasing with increasing polysaccharide concentration. This effect can be attributed to the presence of ionized carboxylic acid groups (-COO-) on these biopolymers. (− 58 to − 48 mv the WPI- and SPI coated W/O droplets had higher negative zeta-potentials), whose absolute value decreased with increasing protein concentration. To screen the electrostatic interactions the reduction in the magnitude of the ζ-potential as the emulsifier concentration increased may have been due to the ability of non-adsorbed charged emulsifiers (and their counter-ions) (J. Liu *et al*., 2021) [22].

7. Health benefit of plant-based emulsifiers

7.2 Lecithin

The choline is the important part of the vitamin B complex. The soy lecithin contains some of the other phospholipids including the phosphatidylethanolamine and the phosphatidylinositol. The choline is required for the human cells if the choline is absent the humans will die due to the apoptosis. The choline is produced by the body itself it must be needed by the metabolism itself. The deficiency in the choline may result in the liver damage (Lecithin and Choline Health Benefits. Pdf, n.d.).

7.3 Guar gum

Guar gum decreases the cholesterol level and the glucose level because of the gel foaming property of the guar gum. The guar gum decreases the appetite and hunger. Decreasing the cholesterol level by guar gum is due to the increase in the bile acid production in faeces and decrease in enterohepatic bile acid which may enhances the production of bile acids from cholesterol and thus hepatic free cholesterol concentration is reduced. Guar gum helps in maintaining the bowl relativity (Mudgil *et al*., 2014) [27]. The maintaining the dosage of the guar gum in daily life helps in the preventing mutagenic activity. The dosage of the guar gum is 2500mg/day. The main health benefit of the guar gum includes the decreasing the LDL cholesterol, controlling the diabetes, and the prevention of the digestive problems (Mudgil *et al*., 2014) [27].

7.4 Gum arabic

The important health benefit of the gum arabic is the fat metabolism. The high intake of the dietary fibre helps in the satiation and satiety, change glycaemic index, influence gastric emptying, and aid in gut hormone secretion, and therefore, this may result in maintaining the body weight. The major health benefit of the gum arabic includes the anti-obesity effects, hypoglycaemic effect, hyperlipidaemic effect, probiotic effect, antidiabetic effect, antioxidant effect and the protection and good function for cardiac (Ahmed, 2018) [2].

7.5 Natural powders

Cinnamon had good medicinal value in food and it has also good antiviral properties that is high effective against the HIV 1 and HIV 2. And it has good antioxidant property and antitumor properties (Gruenwald *et al*., 2010) [11]. Mustard powder contains high amount of the phytonutrients mainly, glucosinolates. And the mustard contains the variety of the minerals including the iron, magnesium, calcium, zinc and phosphorus. The mustard seed powder is a good source of the omega 3 fatty acid. The mustard provides the anti-inflammatory action by the minerals selenium and the magnesium (Divakaran & Babu, 2015) [9]. Health benefits of plant-based emulsifier is given in the figure 2.

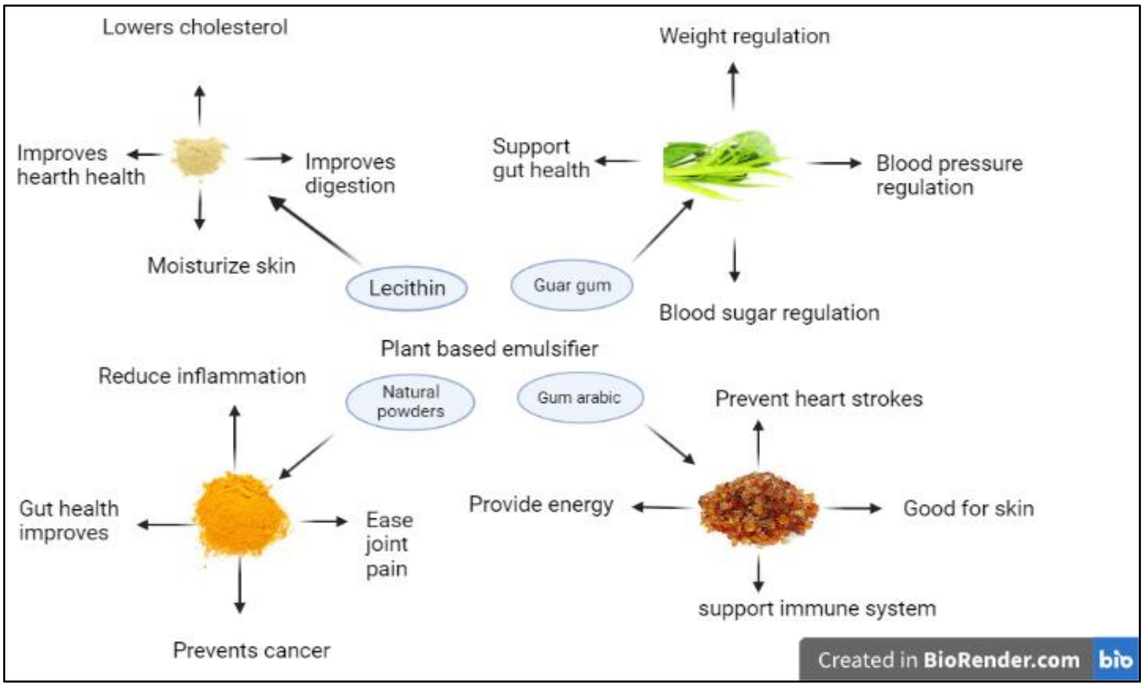

Fig 2: Health benefits of different plant-based emulsifiers

8. Future Challenges of the plant-based emulsifiers / natural emulsifiers

Physicochemical qualities of natural emulsifiers, but there are also a number of additional elements that could prevent their widespread use in food. Finding a financially sound supplier for the natural emulsifier is crucial first. This could be a naturally occurring resource that is being underutilised and sustainable, or it could be a by-product of another food processing operation. Second, it's critical to find suitable isolation techniques that can be applied to the emulsifier to extract and purify it so that it can be utilised as a food component. These techniques will be heavily influenced by the natural emulsifier's characteristics and the substance from which it is separate, and which could involve operations like disruption (physical, chemical, or Enzymatic), solvent extraction, filtering, centrifugation, and selective precipitation (Nushtaeva, 2016) [29].

Many natural substances have a wide range of molecular and functional characteristics, depending on things like the species they came from, the climate and soil, the season they were separated, the extraction techniques used, etc. Lastly, it is It's crucial that the emulsifier may be consistently acquired in adequate levels and at a dependable price. Some natural emulsifiers come from places around the world where there are abundant resources. Political unrest that could endanger the availability of ingredients and cause significant changes in ingredient prices Fifth, for the substance to be effective, it must be widely regarded as safe (GRAS) can be included in meals (Nushtaeva, 2016) [29].

9. Conclusion

To meet the customer needs of food contains the nutritious, natural food ingredients, the plant-based emulsifier is a good replacer for the synthetic emulsifiers in the food. The plant-based emulsifiers provide a good nutritious to the food, and easily available in nature so that easily extract it if it available in large amount. The disease prevention capacity of the plant-based emulsifiers is good than the synthetic emulsifiers. The different plant-based emulsifiers having the different function in the body and also different property in usage in the foods. The performance of the plant-based emulsifier in the food is good than the synthetic emulsifiers. But there are negative impacts of usage of the plant-based emulsifiers in food. Since plant-based emulsifiers are high costly and also not easily to extract and the extraction process may lead to high cost.

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