Foaming properties of plants gum

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Abstract- Hydrocolloids, often called gums that generally contain many hydroxyl groups and may be polyelectrolytes .Foams are colloidal systems in which tiny air bubbles are dispersed in an aqueous continuous phase. Many processed foods consumed daily are liquid or solid foams, such as the head of soft drinks and beer, whipped cream, mousses, meringue, bread and ice cream. The utilization of these gums depends on their uniquefunctional properties such as viscosity, emulsion, gelling and foaming properties .Foaming ability and stability has proven to be beneficially affected by the addition of gums, which stabilizes the interfacial film (air–water).In the current stud i investigated that Arabic gum, locust bean gum (0.1% and 0.25% w/v), xanthan gum and a xanthan/locust bean gum mixture (0.1% w/v) had a positive effect on foam creation. Freezing provoked collapse of the foam structure, but samples containing l-carrageenan at concentration greater than 0.085% showed a well preserved firmness, as deduced from the small changes observed in their viscoelastic parameters.The effects of drying methods on the foaming capacity of flaxseedgum. we have reported here the foam forming capacity and its stability for the seed meal karaya gum. The effect of xanthan gum, guar gum, gum Arabic , karaya gum and LBG on the foaming properties of the NaCn hydrolysates and controls (1% (w/v) protein) was determined,in duplicate.Reserchers isolated an albumin fraction with high foaming ability and foam stabilizing ability from guar meal, and designated guar foaming albumin (GFA).

Keywordscomponent;gum, foaming properties, foam structure,stability, viscoelastic

Introduction

The term ‘hydrocolloids’ refers to a range of polysaccharides and proteins that are nowadays widely used in a variety of industrial sectors to perform a number of functions including thickening and gelling aqueous solutions, stabilising foams, emulsions and dispersions, inhibiting ice and sugar crystal formation and the controlled release of flavours, etc[1].

Plant gums are adhesive substances that are carbohydrates in nature and are usually produced as exudates from the bark of trees or shrubs. Some plant gums, such as gum arabic are soluble in water, dissolving to give clear solutions. Others including gum tragacanth produce mucilages by absorbtion of large quantities of water. Gums are water-soluble polysaccharides of high molecular weight derived from a variety of sources such as bacteria and plants. Differences in gum composition, structure and molecular weight confers each with unique properties suitable for different food applications. The choice of gum for a particular processed food depends on its ability to interact with other food components [2]. Plant gums originating from many countries have been an important item in international trade for centuries in food, pharmaceutical, paper textile and other industries. Depending upon their major use, plant gums may be broadly classified as 'food' and 'non-food' or 'technological grade' gums. The former can be used as food additives in various kinds of confectioneries, foods and beverages and include gum arable, gum tragacanth, gum karaya and gum carob. The latter category finds its major use in non-food industrial applications and include 'gum ghatti', 'gum talha' and a variety of other gums[7].

I. Plants gum

- *Carrageenan*

For many centuries, red seaweeds have been used for foods in the Far East and Europe. Different species of *Rhodophycae* contain naturally occurring polysaccharides which fill the voids within the cellulose structure of the plant. The main species of *Rhodophycae* used in the commercial production of carrageenan include *Euchema cottonii* and *E. spinosum*. Carrageenan extracted from this species comprises both kappa and lambda types although it has been shown that these do not occur within the same plant but in individual plants which grow together (McCandless *et al*., 1973). Carrageenan is a high molecular weight linear polysaccharide comprising repeating galactose units and 3,6-anhydrogalactose (3,6 AG), both sulfated and non-sulfated, joined by alternating α-(1,3) and β-(1,4) glycosidic links[3]. An almost continuous spectrum of carrageenans exist but the work of Rees and co-workers (Rees, 1963; Anderson, Dolan and Rees, 1965) was able to distinguish and attribute definite chemical structures to a small number of idealised polysaccharides. The main carrageenan types, lambda, kappa and iota, can be prepared in pure form by selective extraction techniques. The thickening and gelling properties of the different types of carrageenan are quite different[1].

- *Galactomannans*

Galactomannans as reserve carbohydrates are found as cell wall storage polysaccharides
of various albuminous or endospermic seeds. The galactomannans from these three sources are composed entirely of linear (1-4)-β-D-mannan chains with varying amounts of single D-galactose substituents linked to the main backbone by (1-6)-α -glycosidic bonds. These polydisperse galactomannans can be easily distinguished from each other by their overall mannose galactose ratios between 1.6:1 and ca. 3.5:1[1].

A. Carob bean gum

The evergreen carob tree can be planted in semi-arid or subtropical zones and grows in calcareous soils . The main chain of carob, tara and guar galactomannans is structurally similar to that of cellulose. Cellulose is composed of β-D-glucopyranosyl groups polymerised by 1–4 linkages[1].

B. Guar gum

Guar gum is a seed endosperm portion obtained from guar plant known as Cluster Bean. Guar seed was industrially processed into guar gum in 1940s and 1950s in United States. It is globally used as stabilizing and thickening agent in various industries such as food, pharmaceuticals, cosmetics, textile and oil recovery (Mudgil, Barak, & Khatkar, 2011b). In food industry, guar gum is utilized for its viscosity property in various food products such as sauces, soups, dairy products and baked food products .This high viscosity of guar gum is attributed to high molecular weight ranges between 0.1 and 2.8 Million. The basic structure of galactomannans is already mentioned in the introduction. These polycondensates consist of linear chains of mannose units linked by 1⟶4-α-D-glycosidic bonds at which the hydrogen atom of several primary hydroxyl groups on C6 are substituted by single β-D-galactose units by 1⟶6 linkages. The galactose content of carob bean gum is 17–26% wt.; tara gum ca. 25% wt.; guar gum 33–40% wt[6].

- *Gum Arabic*

Gum arabic or gum *Acacia* is a tree gum exudate and has been an important article of commerce since ancient times. It was used by the Egyptians for embalming mummies and also for paints for hieroglyphic inscriptions. The gums from *Acacia senegal* and *Acacia seyal* are complex polysaccharides and both contain a small amount of nitrogenous material that cannot be removed by purification. Their chemical compositions vary slightly with source, climate, season, age of the tree, etc., Gum arabic readily dissolves in water to give clear solutions ranging in colour from very pale yellow to orange-brown and with a pH of ~4.5[2]. The highly branched structure of *Acacia senegal* gum gives rise to compact molecules with a relatively small hydrodynamic volume and as a consequence gum solutions become viscous only at high concentrations. The major application of gum arabic is in the confectionery industry where it is used in a variety of products including gums, pastilles, marshmallows and toffees. In marshmallows the gum is used as a foam stabilizer while in toffees it is used to emulsify the fats present[1].

- *Kraya*

Gum karaya (Sterculia urens) is one of the commercial and industrial important trees of India. It belongs to the family of Sterculiaceae, and usually grows in dry and rocky forests regions. The roasted and cooked seeds are eaten by economically weaker sections of population. The seeds consist of 56% kernels, which contain 35% protein, 26% oil and 28% carbohydrates[4].

II. Foam

Food foams, such as beaten egg white, are similar to emulsions except that instead of containing two liquids, they contain a gas (usually air or carbon dioxide) dispersed within a liquid. Foams are colloidal systems in which tiny air bubbles are dispersed in an aqueous continuous phase*[2]. Foams* make a vital contribution to the volume and texture of many common food products. They give volume and a distinctive mouth feel to products such as whipped cream and ice cream and they give a light, airy texture to baked goods. Improperly formed or unstable foams result in dense products with a low volume, which are unacceptable to consumers. Foams are inherently unstable and it is imperative that food scientists increase their knowledge of the factors affecting foam stability, in order to enhance the quality and shelf life of these products. A foam contains gas bubbles dispersed in a liquid continuous phase. The liquid phase may be a simple dispersion, as in egg white, which is a dilute protein dispersion, or it may be complex, containing emulsified fat droplets, ice crystals, and/or solid matter. Examples of complex food foams include ice cream, angel food cake, marshmallows, and yeast-leavened breads. Foams such as meringue and baked goods are heat set, which denatures the protein and converts the liquid phase to a solid phase. This gives permanence to the foam structure. Foams are similar, but the dispersed phase consists of large gas bubbles surrounded by a very thin, continuous, liquid film. The nature of the emulsifier or foaming agent is crucial in determining stability. It must adsorb at the interface, reduce surface tension, and form a stable, viscoelastic interfacial layer that resists rupture, so that coalescence of liquid droplets or loss of gas bubbles is avoided. Additional factors are important in foam stability; it is important that the liquid film between the gas bubbles is very viscous, so that drainage due to gravity is minimized. Evaporation of the liquid also must be prevented during normal storage and handling conditions[5].

- *Foaming Agents*

Foam stabilisers are ingredients that decrease this instability in that they contribute to the uniformity or consistency of a product when subjected to an array of conditions encountered during production, storage and use. Typical foam stabilisers are thickening or gelling agents such as gums, starches, pectins and gelatin. These agents act by either increasing the viscosity of the continuous phase or by forming a three-dimensional network that retards the movement of components within the foam[2]. Other ways to increase viscosity of the continuous phase include addition of gums and other thickening agents[5].

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- *Guar Foaming Albumin*

Protein stabilized foam is important to the structure and texture of many food products, including various cakes, confections, meringues, etc. Recently we isolated an albumin fraction with high foaming ability and foam stabilizing ability from guar meal, and designated guar foaming albumin (GFA) .The foaming activity of GFA was 10 times higher than that of egg white at low protein concentrations. GFA mainly composed of a simple protein with the molecular mass of 13 kDa. As a plant protein, GFA has a rather high nutritional value, and would be best suited to allergic patients against animal proteins. These features of GFA make it a promising candidate as a foaming agent in lieu of egg white. Guar meal is a byproduct during extraction of a guar gum, a galactomannnan gum, widely used as stabilizer in various processed food. The specific volumes of GFA were 1.2-1.9 times higher than those of egg white when compared at the same protein concentrations. The foaming ability as well as stability were assessed at much higher protein concentrations. Interestingly, the foam volumes of the 1:1 mixture of GFA:EW were close to those of EW at lower than 20 mg/ml, but they became close to those of GFA as the protein concentration increased[7]. isoelectric points (pI) between the acidic and basic proteins must be sufficiently large so that at intermediate pHs, interactions are strong enough to yield good foaming properties. GFA is prepared by the acid precipitation at its pI of 4 and most proteins of egg white have their pIs at the acidic region. Therefore, the synergistic effect observed here may not be explained merely by a simple electrostatic interaction between oppositely charged proteins. It is also interesting to mention that mixtures of two dissimilar proteins exhibit thermodynamic incompatibility upon mixing resulting in phase separation at the air-water interface.. Bubble size distribution. Since the foam produced by GFA seemed much smoother in appearance than that by EW (5-7), GFA can produce smaller and more uniform bubbles than EW; the average bubble size of GFA is half of that of EW with a much narrower size distribution. According to the Laplace principle, the internal pressure of a bubble is greater than the external pressure, and the pressure difference is inversely proportional to radius of the foam bubble (1-7). Therefore, smaller foam bubbles can withstand heavier load than larger bubbles; the smaller the bubble sizes, the stiffer and stronger the foams become[7].

- *Foamin properties LBG gum*

Locust bean gum (LBG) is produced from seeds of the Ceratonia silliquia plant. The gum is mainly composed of galactomannan but the structure differs to that of guar gum. LBG is usually used in combination with other gums in food products. As with guar gum, LBG is mainly used in dairy products such as frozen desserts[2]. however, it also provides excellent spread-ability and stability to cheese-spreads, sour cream, cream dips and yoghurt. In ice-cream LBG provides heat shock resistance, desirable texture and chewiness[2].

- *Foaming properties Gum karaya*

Foaming capacity (FC%) and foam stability (FS%) were determined according to the method of by dispersing 2 g of seed meal in 100 mL distilled water in a 250 mL beaker. Since foaming is an important characteristic feature of most of the protein rich meal, we have reported here the foam forming capacity and its stability for the seed meal. The(Dehulled–defatted seed meal)DDSM showed a considerable amount of foam forming capacity (32%) when compared with the WSM. DDSM was found to exhibit very good foam stability even after 45 min (93%) and 90 min (75%). This could be due to the presence of more number of secondary and tertiary groups of carbohydrate chains with protein to form layers around air droplets. Similar kind of foam stability data were observed earlier by in other seed meals like defatted sunflower meal[4].

- *Stability of whipped dairy creams containing locust bean gum/l-carrageenan mixtures*

Freezing provoked collapse of the foam structure, but samples containing l-carrageenan at concentration greater than 0.085% showed a well preserved firmness, as deduced from the small changes observed in their viscoelastic parameters. Whipped cream has a complex emulsion-foam structure where the properties of each component greatly contribute to the colloidal stability [3]. In whipped dairy creams, air cells are surrounded by a film of partially aggregated fat globules which greatly contributes to foam stability crystallization degree is adequate [3]. The freezing and frozen storage implied a decrease of

the overrun depending on the gum mixture. The greater the hydrocolloids content the lower the overrun decrease during freezing and frozen storage. Therefore, although hydrocolloids limit the air incorporation capacity of cream, after frozen storage the residual overrun is similar to that retained in whipped creams without stabilizers. A previous study reported the influence of LBG/l-carrageenan mixtures on chilling stability of whipped creams on the basis of changes in the same parameters. The influence on whipping and mechanical properties of whipped dairy creams were also analysed . In the studied concentration range (the same as in the present work) hydrocolloids conferred a greater foaming resistance to dairy cream (increasing the whipping time and reducing the overrun) while they decreased the elastic character and consistency of them whipped product as compared with the gum-free sample[3].

- *properties of flaxseed gum powders*

The effects of drying methods on the foaming capacity of flaxseed gum. The Duncan test showed that the drying methods had significant effect on the foaming capacity ($p < 0.05$ .the untreated sample and 105 °C oven dried sample have the highest foaming capacity (above 40%). The spray dried and freeze dried samples have the lowest foaming capacity (about 10%), while the remaining three drying methods have medium foaming capacity (between 20% and 30%). Except 105 °C oven dried sample, all the other drying processes reduced the foaming capacity of flaxseed gum solutions. The foaming capacity of 0.5% xanthan and guar gum solutions was reported to be 15% and 27% when tested using similar method. When the difference in the concentration is considered, it appears that the foaming capacity of flaxseed gum resembles that of xanthan gum and guar gum. It was previously reported that the foaming capacity of flaxseed gum solution (1%, w/v) to be 75% that of ovalbumin . Polysaccharide gums impart positive effects in foaming properties in food system because of their high Viscosity . Hence flaxseed gum has potential to be used in food systems to improve foaming properties because of its moderate foaming capacity and relatively high viscosity (Wang et al., 2009).

- *The effects of drying methods on foam stability of flaxseed gum*

solutions were tested. It appears that the flaxseed gum solutions have weak foam stability. Only the 105 _C oven dried sample has high foam stability (approximately 47 min, highest among all the samples). Because of its best foam stability and foaming capacity, the 105 _C oven dried sample can be considered having best foaming properties among all the samples. Ethanol precipitated and spray dried samples also have higher foam stability than untreated one ($p < 0.05$)[8].

- *Effect viscosite of foaming*

Arabic gum, locust bean gum (0.1% and 0.25% w/v), xanthan gum and a xanthan/locust bean gum mixture (0.1% w/v) had a positive effect on foam creation. All polysaccharides increased foam stability, probably due to the viscosity increase and to the creation of a network, which prevents the air droplets from coalescence. Foaming ability and stability has proven to be beneficially affected by the addition of polysaccharides . This positive effect is effect firstly attributed to the increase of viscosity of the aqueous phase and secondly to the creation of a network, which stabilizes the interfacial film (air–water).the differences between the polysaccharides studied are mainly due to their different contribution to the viscosity increase.

It has been shown that these polysaccharides produce viscous solutions in the following order GA < LBG < XG .Furthermore, XG-LBG mixtures are known to exhibit a synergistic behaviour, resulting in highly viscous solutions, which probably explains the increase in relative overrun. However, the addition of 0.25% w/v XG or XG-LBG does not seem to help in the creation of foam. It seems that the greatly increased viscosity of the aqueous phase does not allow air to enter the system and create an acceptable foam. The stability of foams and the drainage were also affected in the same way. Due to the increased viscosity of the aqueous phase, the coalescence of the air bubbles was prevented and the liquid drainage was reduced[9]

- *Protein/polysaccharide complexes*

Protein/polysaccharide complexes mostly originate from electrostatic interactions between oppositely charged macromolecules. To reduce further the free energy of the system, these soluble complexes further aggregate until their size and surface properties lead to insolubilization.. in the case of β-lactoglobulin complex formation with acacia gum, Schmitt et al. confirmed the very fast coarsening (within an hour) of the β lactoglobulin and acacia gum mixture at pH 4.2, ratio 2:1 and 1 wt.% total biopolymer concentration by following the composition of the dilute phase after mixing. between β-lactoglobulin and acacia gum at pH 4.2 for a ratio of 2:1 induced a change in the secondary structure of the protein. As for βlactoglobulin/acacia gum complexes, napin/pectin complexes were more surface-active than the pure protein. Interfacial films with a thickness of 315 Å were formed in the foam, leading a reduced drainage rate and improved foam volume stability compared to pure napin foams[10].

- *Effects of soy protein hydrolysis and polysaccharides addition on foaming Properties*

The effect of polysaccharides addition on foaming properties depended in a complicated way on the degree of hydrolysis of protein, surface-activity of polysaccharide, concentration of both macromolecules, contribution of polysaccharide consistency to bulk viscosity and interfacial interactions between biopolymers. However, through cluster analysis the best combination of protein/polysaccharide to obtain defined foaming properties could be determined for an eventual industrial application.[11]

Abbreviations Used: EW, egg white (thin albumen); GFA, guar forming albumin; pI, isoelectric point

[1] Handbook of hydrocolloids Edited by G. O. Phillips and P. A. Williams
[2] Stabilization of sodium caseinate hydrolysate foams Daniel J. Walsh, Kathrina Russell, Richard J. FitzGerald Department of Life Sciences, University of Limerick, Limerick, Ireland Received 11 July 2007; accepted 9 September 2007.
[3] Stability of whipped dairy creams containing locust beangum/l-carrageenan mixtures during freezing–thawing processes M.M. Camacho, N. Martı´nez-Navarrete, A. Chiralt
[4] Chemical and functional characterization of Gum karaya (Sterculia urens L.) seed meal Narsing Rao Galla, Govardhana Rao Dubasi
[5] Food Emulsions and Foams
[6] Guar Gum Derivatives. II. Foaming Properties ofHydroxyalkyl Derivatives H. Prabhanjan, M. M. Gharia & H. C. Srivastava Ahmedabad Textile Industry's Research Association (ATIRA), Ahmedabad-380015, India

[7] Guar Foaming Albumin – A Foam StabilizerAmi Shimoyama and Yukio Doi Department of Food and Nutrition, Kyoto Women’s University, Higashiyama-ku, Kyoto,Japan
[8] Effects of drying methods on the functional properties of flaxseed gum powders Yong Wanga, Dong Li a, Li-Jun Wangb, Shu-Jun Li c, Benu Adhikari
[9] Surface tension of Phaseolus vulgaris and coccineus proteins and effect of polysaccharides on their foaming properties
Eleousa A. Makri, Georgios I. Doxastakis
[10] Protein/polysaccharide complexes and coacervates in food systems Christophe Schmitt, Sylvie L. Turgeon
[11] Effects of soy protein hydrolysis and polysaccharides addition on foaming properties studied by cluster analysis Karina D. Martínez, María E. Farías, Ana M.R. Pilosof ,