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Comparison of Some Physicochemical and Functional Properties of Farsi Gum and Other Rosaceae Plant Gum Exudates

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Abstract

New plant gums obtained from different sources have attracted the attention of researchers for a wide range of applications, especially in the food industry. These molecules were used for a variety of purposes since they are chemically inert, biodegradable, less expensive, non-toxic and widely available. They represent one of the most abundant raw materials used not only in commercial food products, but also in cosmetic and pharmaceutical products. Among these gums, the ones produced by Rosaceae family have been taking special attention. Rosaceae family consists of peach, plum, apricot, cherry, and almond trees which all can produce exudate gums. Mountain or wild almond (*Amygdalus scoparia Spach*) is a tree or a shrub from this family that a transparent type of gum is exuded from the trunk and branches of this tree namely Farsi gum (also called Zedo gum). Thus, the aim of this review is to report the recent advances in Farsi gum and other rosaceae plant gum exudates. An emphasis is given for their chemical composition, structures and functional properties.

Keywords: Farsi Gum, Rosaceae Gums, Physicochemical Properties, Functional Properties.

1. Introduction

From the technical and industrial point of view, gums are herbal or microbial polysaccharides and their derivatives which can disperse in cold or hot water, produce viscose suspensions or solutions [1]. Herbal exudate gums normally secrete from bark, branch, and fruit of trees due to their protection impacts against mechanical damages or microbial attacks. The exudate gums are amongst the oldest and most traditional thickening and stabilizing agents used in food. Despite competition from other gums, several of these natural exudates continue to be used in large quantities [2].

Gum production yields could be further enhanced by making incisions in the bark or stripping it from the trees or shrubs. Gums have a protective function in limiting the spread of fungal and bacterial pathogens by isolating the infected tissues. This phenomenon prevents microorganisms to reach the internal tissues of the plant, as they are unable to pass through the gum barrier, which allows covering the infection, and the affected plants may recover [3].

Plant gums are hydrophilic carbohydrates of high molecular weights, generally composed of monosaccharide units linked by glucosidic bonds. They have numerous features including nontoxicity, non-irritancy, availability at low cost, sustainability, biodegradability, biocompatibility, and ecofriendly, which make them more preferred than synthetic and semi-synthetic polymers [4]. Exudate gums have been used for decades in a variety of fields and have retained their importance despite the appearance of alternative gums with similar properties. Gum production yields could be further enhanced by making incisions in the bark or stripping it from the trees or shrubs. Gums have a protective function in limiting the spread of fungal and bacterial pathogens by isolating the infected tissues [5]. This phenomenon prevents microorganisms to reach the internal tissues of the plant, as they are unable to pass through the gum barrier, which allows covering the infection, and the affected plants may recover. If for any reason, gum formation is retarded or prevented, microorganisms are able to spread, and extensive damage may occur [6].

A wide range of families such as Leguminosae, Sterculiaceae, Anacardiaceae, Combretaceae, Meliaceae, Rutaceae, and Rosaceae, produce gums. Production of copious quantities of gum by stone-fruit trees belonging to Rosaceae family is a well-known phenomenon that has attracted the attention of botanists and horticulturalists for over 100 years. The most studied Rosaceae plants for their gums (including those produced by stone-fruits, fruits, and trees) are: Cherries, plums, apricots, peaches and almonds [6].

Based on their solubility in water, gums are classified as soluble, insoluble, or partially soluble gums. Partially soluble gums form initially a swollen jelly by dispersing in water, and then become a solution when adding more water. Rosaceae gums are generally insoluble in oils or organic solvents (i.e. hydrocarbons, ether, or alcohols), whereas they are either water-soluble or absorb water (swell up or disperse in cold water to give a viscous solution or jelly) [5].

Farsi gum, as a biopolymer, is transparent to semi cloudy exudate of the wild or mountain almond tree (*Amygdalus scoparia Spach*) with no special flavor and smells. Wild almond trees can be found in central Asia and Irano- Turanian and Zagrosi regions of Iran particularly in mountainous areas, forests or where they have been planted either to reduce soil erosion or as a gum source. The main Persian gum producer is Iran with over 400 t of annual export. This country exports a large amount of this gum for use in food, medicinal, and industrial applications [7]. Few studies have been devoted to investigating Farsi gum. Thus, some physicochemical and functional properties of the Iranian native gum are unknown. A quick search on the Internet demonstrates that Farsi gum is mistakenly referred to as gum arabic in some texts and papers. Due to unfamiliarity with this gum together with small number of studies implemented on it, it is called arabic gum in commercial context in a wrong way due to the apparent similarity between them. While arabic gum is taken from acacia tree, gum exported from iran by the name of arabian type is taken from mountain almond tree [8].

2. Rosaceae gum chemical composition

Exudate gums are composed of different substances, mainly polysaccharides with diverse structures. The composition of gum polysaccharides varies from species to species and from cultivar to cultivar. Generally, exudate gums are reported to contain various metal ions as neutralized cations [9-10], the nature and amount of these constituents depend on the composition of soil upon the trees grew [11], the age, and the species of the tree [12].

In recent study, it has been demonstrated that the main constituent of Farsi gum exudates is carbohydrates (93.1%). The remaining components include slight amounts of proteins and large amounts of minerals, with high abundance of calcium (6900 ppm), potassium (1670 ppm), and magnesium (720 ppm). Calcium, which is known to be responsible for gel formation in some plant gum exudates was the main cation in the Farsi gums [8].

In another study, it has been demonstrated that the main constituents of almond gum exudates are carbohydrates (74.2 %) and proteins (3.46 %) [13]. Some minerals have been also detected as well as relatively low lipid content. Almond trunk gum exudates presented large amounts of minerals, with the main constituents being calcium (6317 ppm), magnesium (752.2 ppm) and potassium (274.7 ppm) [14]. Previous works demonstrated that Cherry gum is composed of 2.33 % proteins, 2.55 % ash, 9.25 % moisture, and 73.72 % total Sugars [15]. Similar study showed that the lyophilized water extractable fraction of peach gum was composed of 3.80 % moisture, 85.67 % total sugar, and 1.74 % ash contents [16].

Table 1. Physicochemical properties of some Rosaceae gums

Rosaceae gum	Moisture (%)	Carbohydrate (%Dw)	Protein (%Dw)	Fat (%Dw)	Ash (%)
Farsi gum	11.28	93.1	0.207	not determined	1.58
Almond gum	7.33 ± 0.20	87 ± 2.65	0.478 ± 0.03	0.33 ± 0.08	0.95 ± 0.02
Cherry gum	9.25 ± 0.54	73.72 ± 2.4	2.33 ± 1.25	not determined	2.55 ± 0.6
Peach gum	3.80 ± 0.19	85.67 ± 0.37	not determined	not determined	1.74 ±0.04

Table 2. minerals composition of some Rosaceae gums.

Rosaceae gum	Ca (ppm)	Na (ppm)	K (ppm)	Mg (ppm)	Zn (ppm)	Fe (ppm)
Farsi gum	6900	9.7	1670	720	1.5	9.3
Cherry gum	40.06	4.10	9.80	2.39	0.376	2.62
Almond gum	6317	11.9	274.7	752.2	49.7	7

3. Rosaceae gum structures

The exudate gums of Rosaceae family are mainly composed of galactose, arabinose and glucuronic acid with other sugars present in small or trace quantities [17-18]. In 2013, monosaccharide composition analysis of Farsi gum was performed by combined gas chromatography/mass spectrometry (GC/MS) of the per-O-trimethylsilyl (TMS) derivatives of the monosaccharide methyl glycosides produced from the sample by acidic methanolysis. The results showed, that Farsi gum polysaccharide have a molecular weight of 4.74×10^6 Da. All the samples mainly consisted of galactose and arabinose, an indication of arabinogalactan polysaccharide. Fucose (Fuc), glucose (Glc), N-acetyl galactosamine (GalNAc) and N-acetylglucosamine (GlcNAc) were not detected in Farsi gum. Although gum arabic and Farsi gum are both classified as arabinogalactan polysaccharides, Farsi gum contained more arabinose (more than two times), less galactose and very little rhamnose and galacturonic acid. It should be noted that the presence of xylose (6.8–9.2 mol%) and mannose (0.3–0.4 mol%) in Farsi gums can be used to distinguish these gums from arabic one [8].

In a recent study, monosaccharide composition of almond gum (molecular weight $=11.22\times10^6$ Da) was evaluated by HPLC-RI system. The results showed, that arabinose and galactose are the main monosaccharides present in almond gum. This suggests that almond gum can be considered to belong to the arabinogalactan polysaccharides with small amounts of xylose, rhamnose, glucose, and mannose. The amounts of arabinose and galactose in both the whole gum and the soluble fraction were higher than that in the insoluble fraction. However, other sugars exhibited relatively identical amounts of polysaccharides in all the samples tested [14]. Studies have shown that almond gum is composed of 92.36% of polysaccharides (dry weight basis), with the main monosaccharide being arabinose (46.83%), galactose (35.49%), and uronic acid (5.97%) together with a small amount of protein (2.45%) [19]. The sugar composition in almond gum is similar to that in Farsi gum [14], possibly indicating their common origin. However, the almond gum is the exudate from sweet almond trees while the Farsi one is usually obtained from bitter mountainous almond trees (Amygdalus scoparia from Rosaceae family).

Other findings showed that, gum exudate polysaccharide from nectarine trunk (molecular weight $= 3.93\times10^6$ g/mol) is composed of arabinose, xylose, mannose, galactose, and uronic acids, with respective molar ratios of 37:13:2:42:6 [20].

Moreover, apricot gum polysaccharide, with a molecular weight of 1.92×10^5 Da is composed of 4-O-methyl-D-glucuronic acid, D-glucuronic acid, D-xylose, L-arabinose, and D-galactose in a respective molar ratios of 0.6:1:0.3:3.2:3.2, as well as traces of D-mannose [21].

In other study chemical analysis of peach gum polysaccharides showed that these polysaccharides are acidic arabinogalactans, having a molecular weight of 5.61×10^6 Da, and are composed of arabinose, xylose, mannose, galactose, and uronic acids in the respective molar ratios of 36:7:2:42:13 [20].

In a recent study, monosaccharide composition of cherry gum exudates was evaluated by HPLC-RI system after acidic hydrolysis [15]. Results showed the presence of arabinose, galactose, glucose, rhamnose and xylose. The molecular weight of the gum was estimated to 5.55×10^5 Da.

Other findings showed that plum gum polysaccharide had a molecular weight of 1.9×10^5 Da. This polysaccharide was composed of D-glucuronic acid, 4-O-methyl-D-glucuronic acid, D-galactose, D-mannose, L-arabinose, and D-xylose, with traces of L-rhamnose [21].

Table 3. Molecular weight of some Rosaceae gums

	Farsi gum	Peach gum	Apricot gum	Nectarine gum	Plum gum	Almond gum	Cherry gum
Molecular weight	4.74×10^6 Da	5.61×10^6 g/mol	1.92×10^5 Da	3.93×10^6 g/mol	1.9×10^5 Da	11.22×10^6 Da	5.55×10^5 Da

Table 4. Monosaccharide composition of some Rosaceae gums

Farsi gum	Peach gum	Apricot gum	Nectarine gum	Plum gum	Almond gum	Cherry gum
Ara=61.1 Gal=28.4 Rha=1.1 Gal. A=0.6 Man=0.3 Xyl=6.8 4-0-Methyl-GlcA=1.7	Ara=36 Xyl=7 Man=2 Gal=42 Uro. A=13 Rha= traces	Ara=3.2 Gal =3.2 Xyl=1 Man= trace Glc. A=0.3 4-0-methyl-D-GlcA=0.6	Ara=37 Xyl=13 Man=2 Gal=42 Uro. A=6 Rha= traces	Ara=34 Gal =32 Xyl=10 Man=10 GlcA=4 4-0-Methyl-D-GlcA=6 Rha= trace	Ara=46.5 Gal=32.9 Xyl=6 Gluc=0.15 Man=0.35 Rha=0.85	Ara=60.99 Gal=5.44 Gluc=3.53 Rha=1.37 Xyl=1.16

(Ara = arabinose, Gal = galactose, Rha = rhamnose, Gal. A = galacturonic acid, Man = mannose, Xyl = xylose, GlcA = glucuronic acid, Uro. A = uronic acids, Gluc = glucose)

4. functional properties

Gums exhibit diverse physiochemical properties making them widely used for a variety of applications. The functional and rheological properties of these polysaccharides often depend on their monosaccharide composition, physicochemical properties and interaction with water [22-23]. Polysaccharides and proteins are usually included in food formulation as ingredients. Proteins have an essential role as emulsifying and stabilizing agents, whereas polysaccharides are mainly used for thickening and emulsifying. The overall stability and texture of food colloids depend on the functional properties of their ingredients, with the nature and strength of the protein–polysaccharide interactions [24].
In recent studies, the viscosity of Farsi gum solution was evaluated at different shear rates. The solutions of Farsi gum showed a shear thinning behavior at different concentrations which means the apparent viscosity decreases by increasing the shear rate. It was also observed that increasing gum concentration led to increased viscosity [25]. In another study, the viscosity of almond gum solutions at different concentrations were determined. The solutions of almond gum showed a Newtonian behavior at 0.5 and 1% w/w and above these concentrations, the solutions presented a shear thinning behavior [14]. In a similar study, the viscosity of peach gum solution was determined. The results showed, apparent viscosity for peach gum solution was dependent on concentration and all tested solutions had a shear-thinning behavior [20].

In recent study, the emulsion capacity and stability of Farsi gum solution was evaluated. Emulsions were prepared by mixing 20 ml of sunflower oil with 80 ml of Farsi gum aqueous solution (0.5, 1, 1.5, 2 and 3% w/w). The results showed emulsion ability and emulsion stability of Farsi gum solution increased by increasing farsi gum concentration, also emulsion ability and emulsion stability arrived to maximum level (100%) at 1.5% and 2% gum concentration, respectively [25]. The increase of the emulsifying capacity and emulsion stability, observed when increasing the gum concentration, may also be ascribed to the increase of the viscosity of the continuous phase, which contributes to improving the kinetic stability of the emulsions [26], due to the reduction of the separation velocity of the emulsion droplets [27].

In another study, Farsi gum showed better emulsion capacity and stability than gum arabic, which could be used in food industry to completely or partially replace gum arabic as potential surfactant. The protein was low in Farsi gum, therefore, the emulsification properties of Farsi gum was not associated with protein or protein/polysaccharide complexes. It is assumed that high molecular weight of Farsi gum polysaccharide could be the main factor contributing to its emulsification properties [28].

In 2012 the emulsification properties of almond gum solutions were determined. The results showed gum concentrations <5% w/w induced creaming phenomena after only 3 h from the preparation of the samples, suggesting a high degree of instability. Higher gum concentrations caused the emulsions to become more homogeneous and more stable, according to the visual observations and emulsion stability measurements. The results also showed that for a 20% w/w olive oil, an almond gum concentration of 7% w/w in the aqueous phase was the minimum required to increase the emulsion stability index to>80%, thus suggesting that this almond gum concentration is sufficient to cover the oil‑water interface of the oil droplets [19].

In another study, the emulsifying properties of peach gum were investigated in comparison with gum arabic. peach gum exudates showed better emulsion capacity and stability than gum arabic. Proteins were not detected in peach gum polysaccharide fractions, therefore, the emulsification properties of peach gum polysaccharides were not associated with protein or protein/polysaccharide complexes. It is assumed that high molecular weight and high branched substitution of peach gum polysaccharide could be the main factors contributing to its emulsification properties [16].

Foaming capacity and foam stability of gums depend on such different factors as protein content, molecular weight, gum structure, and the presence of other compounds in the gum [19]. In recent study, foaming capacity of Farsi gum solution were studied in 1, 2, 3, 4 and 5 percent concentrations. Results showed that Farsi gum solution is not able to forming foam in concentrations below 3%. It produces foam in concentrations 4 and 5 percent in which such little amount was quickly gone and it couldn't be measured. Inability of Farsi gum in forming foam can be attributed to the structural properties of this gum and small amount of protein found in the gum [25].

In 2016 the ability of the 4% w/v solution of almond gum and its fractions to produce a stable foam was studied. The values for the foaming capacity of the whole gum as well as its soluble and insoluble fractions were 30%, 35%, and 15%, respectively [14]. While polysaccharides are not generally considered as surface active agents, they can improve the foaming capacity of foaming systems by increasing its viscosity which, in turn, leads to the creation of a network that prevents the coalescence of air-bubbles [29].

5. Conclusions

Nowadays, Rosaceae gums represent a potential feedstock for both food and nonfood applications. Their potential to preserve and enhance the food quality, to remove waste materials from aqueous solutions, to be used in formulations for pharmaceutical purposes, and in other recent industrial applications, make them a promising natural source for a wide range of applications. This potential is related to their low cost, availability, nontoxicity, biodegradability, biocompatibility, and ability to promote chemical modifications. However, despite of all of these interesting properties of Rosaceae gum exudates, deep economic studies have to be performed to estimate the global cost for harvesting and using Rosaceae gums in numerous applications at industrial scale.

6. References

[1]. Sciarini, L. S., et al. Chemical composition and functional properties of Gleditsia triacanthos gum. *Food Hydrocolloids* 23.2 (2009): 306-313.

[2]. Wareing, M. V. "Exudate gums." *Thickening and gelling agents for food*. Springer US, 1997. 86-118.

[3]. F.T. Brooks, Disease resistance in plants, New Phytol. 27 (1928) 85–97.

[4]. N.S. Bhunvara, M.L. Khorana, Studies on suspending properties of *Hyprophila spinosa*, Indian Drugs. 22 (1985) 500–502.

[5] G.T. Kulkarni, K. Gowthamarajan, R.R. Dhobe, F. Yohanan, B. Suresh, Development of controlled release spheroids using natural polysaccharide as release modifier, Drug Deliv.12 (2005) 201–206.

[6]. Bouaziz, Fatma, et al. "Recent advances in Rosaceae gum exudates: From synthesis to food and non-food applications." *International journal of biological macromolecules* 86 (2016): 535-545.

[7]. Abbasi, Soleiman, and Soudabeh Mohammadi. "Stabilization of milk–orange juice mixture using Persian gum: Efficiency and mechanism." *Food Bioscience* 2 (2013): 53-60.

[8]. G. Fadavi, M.A. Mohammadifar, A. Zargarran, A.M. Mortazavian, R. Komeili, Composition and physicochemical properties of Zedo gum exudates from *Amygdalus scoparia*, Carbohydr. Polym. 101 (2014) 1074–1080.

[9]. G.S. Mhinzi, Intra-species variation of the properties of gum exudates from *Acacia Senegal* var. Senegal and *Acacia seyal* var. fistula from Tanzania, Bull. Chem. Soc. Ethiop. 17 (2003).

[10]. L. Pachuau, H. Lalhlenmawia, B. Mazumder, Characteristics and composition of *Albizia procera* (Roxb.) Benth gum, Ind. Crops Prod. 40 (2012) 90–95.

[11]. R.C.M. de Paula, S.A. Santana, J.F. Rodrigues, Composition and rheological properties of *Albizia lebbeck* gum exudate, Carbohydr. Polym. 44 (2001) 133–139.

[12]. J.-W. Li, L.-P. Fan, S.-D. Ding, X.-L. Ding, Nutritional composition of five cultivars of chinese jujube, Food Chem. 103 (2007) 454–460.

[13]. F. Bouaziz, C.B. Helbert, M.B. Romdhane, M. Koubaa, F. Bhiri, F. Kallel, et al., Structural data and biological properties of almond gum oligosaccharide: Application to beef meat preservation, Int. J. Biol. Macromol. 72 (2015) 472–479.

[14]. Rezaei, Atefe, Ali Nasirpour, and Hossein Tavanai. "Fractionation and some physicochemical properties of almond gum (Amygdalus communis L.) exudates." *Food Hydrocolloids* 60 (2016): 461-469.

[15]. C. Malsawmtluangi, K. Thanzami, H. Lalhlenmawia, V. Selvan, S. Palanisamy, R. Kandasamy, et al., Physicochemical characteristics and antioxidant activity of *Prunus cerasoides* D. Don gum exudates, Int. J. Biol. Macromol. 69 (2014) 192–199.

[16]. H.F. Qian, S.W. Cui, Q. Wang, C. Wang, H.M. Zhou, Fractionation and physicochemical characterization of peach gum polysaccharides, Food Hydrocoll. 25 (2011) 1285–1290.

[17]. G.O. Aspinall, The exudate gums and their structural relationship to other groups of plant polysaccharides, Pure Appl. Chem. Chim. Pure Appliquée. 14 (1967) 43–55.

[18]. G.O. Aspinall, Gums and mucilages, Adv. Carbohydr. Chem. Biochem. 24 (1969) 333–379.

[19]. Mahfoudhi, N., et al. "Chemical composition and functional properties of gum exudates from the trunk of the almond tree (Prunus dulcis)." *Revista de Agaroquimica y Tecnologia de Alimentos* 18.3 (2012): 241-250.

[20]. F.F. Simas-Tosin, R. Wagner, E.M.R. Santos, G.L. Sassaki, P.A.J. Gorin, M. Iacomini, Polysaccharide of nectarine gum exudate: Comparison with that of peach gum, Carbohydr. Polym. 76 (2009) 485–487.

[21]. J. Rosik, Structural features of the polysaccharide of apricot gum in dependence on the infection with fungi, application of a synthetic material and vegetative period, Acta Hortic. 11 (1968) 523–528.

[22]. S.W. Cui, Y. Brummer, Understanding carbohydrate analysis, in: S.W. Cui (Ed.), Food Carbohydr. Chem. Phys. Prop. Appl., CRC Press, Boca Raton, FL, 2005: pp. 67–104.

[23]. B. Janaki, R.B. Sashidhar, Physico-chemical analysis of gum kondagogu (*Cochlospermum gossypium*): a potential food additive, Food Chem. 61 (1998) 231–236.

[24]. A. Corsi, A. Milchev, V.G. Rostiashvili, T.A. Vilgis, Interface stability and copolymers: Application to food systems, Food Hydrocoll. 21 (2007) 870–878.

[25]. Amini, J., Nasirpour, A. and Keramat, J., 2016, Effect of Drying Temperature and Heating Treatment on Functional Properties of Farsi Gum, Novel Findings in Food industries & Healthty Nutrition.

[26]. Benichou A, Aserin A and Garti N. (2004). Protein polysaccharide interactions for stabilization of food emulsions. Journal of Dispersion Science and Technology 25(2): 239–239.

[27]. Damodaran S. (2005). Protein stabilization of emulsions and

foams. Journal of Food Science 70(3): R54–R66.

[28]. Golkar, A., Nikbakht, M., Amiri, S. And Nasirpour, A., 2013, Comparison of Emulsifying properties of Farsi gum and Arabic gum, Twenty First National Congress of Food Science and Technology.

[29]. Makri, E. A., & Doxastakis, G. I. (2007). Surface tension of Phaseolus vulgaris and coccineus proteins and effect of polysaccharides on their foaming properties. Food Chemistry, 101, 37e48.