Characterization of an unknown exudate gum from Iran: Persian gum

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Abstract— ***Persian gum (PG) is a type of exudate gum which naturally secretes from the barks of mountain almond trees (Amygdalus scoparia Spach).The gums are collected from two provinces (Fars and Eastern Azerbaijan) and after that they are categorized at 4 levels based on color, then pulverized and some of their properties investigated. Our findings show that PG is an acidic gum (pH=4.4±0.02), with moderate moisture (8.8±0.30% w/w), low protein (0.20±0.006% w/w) and fat (0.35±0.18% w/w) contents. Its specific rotation is levorotatory and the water absorption capacity and cold water insoluble gel are 12.65±0.38 g/g and 71.28±0.26 % w/w, respectively.***

Keywords- Persian gum, Amygdalus scoparia Spach, Physicochemical properties, Almond.

I. 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. It should be noted that gum secretion may also occur due to climate adaptation of some trees that is called physiological gummosis [2]. All in all, exudate gums are the oldest types (since 3000 BC) which are usually used as thickener, stabilizer, rheology modifier as well as dietary fiber or fat replacers [3–5]. Over the past few decades, scientists have constantly tried to find new sources and varieties of water-soluble polysaccharides [6]. Moreover, the annual turn-over of food hydrocolloid industries is over 3 billion US dollars of which the share of natural and plant based hydrocolloids is reasonably high [7].

Rosaceae family, *Prunus* genus, consists of peach, plum, apricot, cherry, and almond trees which all can produce exudate gums. Mountain or wild almond (*Amygdalus scoparia* Spach) which is a shrub or tree from this family spreads and grows in Irano-Turanian and Zagrosi regions in Iran. The gum which exudes from the bark or branches of this tree is locally called Persian gum (PG), Shirazi or Zedu gum. Persian gum (Fig. I) can be found in different shapes, sizes, and colors (white, light yellow, amber, red, and/or brown). Each square meter of canopy of mountain almond tree can produce some 20–50 grams of PG whereas its annual production exceeds more than 400 metric tons in Iran. Persian gum can potentially be used in foods, pharmaceuticals, and other industries and nowadays, it is being used as a suspending or emulsifying agent in combination with Arabic gum and gum tragacanth in pharmacy, edible gels and pastilles, stabilization of milk–orange juice mixture, colors, clothing (for stiffness of clothes), and isolating the surface of boats [8–10].

Although, over the past few years, some reports have been published regarding the exudate gums of peach and nectarine [2, 6, 11–12] but with the best of our knowledge, no report or scientific research has been reported on the physicochemical properties of Persian gum. Therefore, in the present study we aim to characterize some properties of PG, collected from two regions in Iran. Understanding these properties can show its applicability as a natural gum in order to be used possibly as a potential replace for microbial based gums.

II. EXPERIMENTAL

a) Collecting the gums

The exudated gums from the bark of mountain almond trees have been gathered between August to September (2010) in Fars (Larestan and Jahrom plains) and eastern Azerbaijan (Arasbaran forests) provinces, packed in nylon bags and kept at fridge prior to analysis (Fig. I).

b) Grading and milling

The collected Persian gums are divided to 4 groups which coded according to Table I. Then, they are powdered in two stages using Falling number AB (Box 5101 model, Sweden) and Agromatic AG (AQC 109 model, Germany) mills. The powders pass through sieve nest (Damavand, Iran) and the particles smaller than 250 microns (mesh No. 60) are collected and used for further analyses.

Figure. I. Natural size, color, and shape of Persian gum particles

TABLE I. Categorizing the Persian gums on the basis of color and collecting geographical regions

	Province	
Color	Fars	Eastern Azarbayjan
White	F1	A1
Light yellow	F2	A2
Amber	F3	A3
Brownish red	F4	A4

c) Determination of some physicochemical properties of PG

The pH of aqueous dispersion (5% w/v, hydrated over night in double distilled water) is measured using pH meter (Metrohm, 827 model, Switzerland) at 20˚C [13]. In accordance with Horwitz (2002) for measuring the moisture, some 2 g of PG powder is weighed and kept at 105 °C for 5 h in an electric oven (Memert, Germany) until constant weight is reached. The dry matter content is also calculated by subtracting the moisture content from 100. For ashing purposes, 2 g of PG powder is burnt directly by flame then kept at 550°C for 5 h (Herasus electric funnel, Germany) till white ash is acquired [14].

The fat content of dried PG powder is extracted (Foss automatic suxlete, 2050 Soxtec, Sweden) by using normal hexane and reported on dry basis. In order to measure the protein content, one catalyst tablet of Foss, Kjeltabs Cu/1.5 [containing 0.15 g of $Cu(SO_4)\times 5H_2O$ and 1.5 g of $K_2(SO_4)$] is mixed with 0.3 g of dried PG power, and 7 ml of concentrated sulfuric acid (Merck Chemicals Co., Darmstadt, Germany). This mixture is transferred to Microkjeldal (Foss, Tecator^{TM}, Digestor Auto, Sweden) and digestion is completed (400˚C, 2 h). Afterward, the protein content is calculated (nitrogen content times 6.25) [14].

For tannin, the completely hydrated aqueous dispersion (1% w/v) of PG is centrifuged at 5000 *g* for 15 min. Then, the aqueous solution (9% w/v) of $FeCl_3$ (Merck Chemicals Co., Darmstadt, Germany) is added (0.1 ml for any 10 ml of supernatant) and the UV absorbance (430 nm) is measured (Sinco spectrophotometer UVS-2100, Seoul, South Korea). The calibration curve is made by standard solutions. Each 10 ml of these solutions contained 0, 25, 50, 100, and 200 ppm of tannic acid (Merck Chemicals Co., Darmstadt Germany) and 0.1 ml of $FeCl_3$ solution [15].

The fully hydrated dispersion of PG (1% w/v) is centrifuged at 6000 *g* for 15 min. Then, the rotation angles (α) of supernatants are measured using a polarimeter [Perkin-Elmer, 241, USA, equipped with sodium lamp (D= 589 nm), cell width 0.2001 dm], at room temperature (25 °C). The measurements are repeated 3 times and the specific rotation [α] is calculated according to equation 1 [16]:

$$[\propto]_{D}^{T=25^{\circ}C} = \frac{\propto}{C\cdot L} \quad (1)$$

Where α, C, and L belong to rotation angle, concentration of samples (g/mL), and cell width (dm), respectively.

The *L**, *a**, and *b** indices of PG dispersions are directly measured using colorimeter (HunterLab, Color Flex, USA) whereas the *C** (chroma index) and *H** (hue angle) indices are calculated using the following equations [17]:

$$C^* = [(a^*)^2 + (b^*)^2]^{1/2} \quad (2)$$

$$H^* = \tan^{-1}\left({b^*}/{a^*}\right) \quad (3)$$

The content of some minerals (Zn, Ca, and Mg) is measured by atomic absorption spectrophotometer (Shimadzu, AA-670, Japan) using acetylene–air mixture. For doing so, the PG powders are digested and the calibration curves of the abovementioned minerals are plotted. Then, the digested samples are gradually injected to the AAS and their mineral contents are measured. Furthermore, the Na and K contents are determined by flame emission spectrophotometer (Jenway, PFP 7, England) [14].

The PG dispersion (0.5 g PG powder in 40 ml of distilled water, after complete hydration) is centrifuged at 1600 *g* for 10 min. Then, the supernatant is discarded and the swollen insoluble gel is weighed and the water absorption capacity (WAC) (g/g) calculated using equation 4 [18]:

$$WAC = \frac{(\text{swollen gel } weight - initial\ sample\ weight)}{initial\ sample\ weight} \quad (4)$$

In order to measure the minimum gelation concentration of PG, different concentrations of PG dispersions (1–15% w/v) are prepared and heated in water bath (93±2 °C) for 1 h. Then, they are immediately cooled down and kept at refrigerator (4 °C) for 1 h. At this stage, the glass tubes, containing samples, are kept upside down to judge in which concentration they will be gelled. Therefore, the least gelation concentration of PG is determined by visual observation [19].

The fully hydrated aqueous dispersions of PG (4% w/v) are centrifuged (20379 *g* for 15 min). The supernatant is discarded and the insoluble fraction is mixed and washed with distilled water and centrifuged at least 4 times to ensure that all soluble fractions are discarded. Then, the insoluble fraction are dried (105 °C, 12 h), weighted and reported as cold water insoluble gel content of PG. In terms of hot water insoluble gel content, the procedures are similar except the first step in which the aqueous dispersions of PG (4% w/v) are heated (93±3 °C, 2 h) then centrifuged [15].

d) Statistical analysis

For statistical analysis, the SPSS 16.0 software and one-way ANOVA are used. In case of significant difference between samples (*p<0.05*), Duncan test is applied. All the curves are plotted using Excel 2007.

III. RESULT AND DISCAUION

Based on our visual observations, Persian gum is a transparent to semi-opaque exudate gum which can be found in different shapes, sizes, and colors (Fig. I). It has no special flavor but smells like confectioneries (sweet smell). It normally can be broken to fine angular particles using a very light milling process.

Resembling most exudate gums, the natural pH of aqueous dispersions of Persian gum is acidic (4.30–4.62) and their geographical growing regions show no significant effects on this property (Table II). However, a significant difference between the natural pH of various color groups is perceived where lighter the color, higher the pH and this behavior can be possibly related to the natural pH of pigments at various concentrations. Generally speaking, pH depends on the hydration of solutes, physicochemical characteristics, as well as the thermodynamic properties of the system [19]. In line with our observations, the natural pH of Arabic gum (*Acacia senegal* subspecies of *senegal*) was reported over the range 4.37–4.95 [20] whereas for the one which was collected from Central Rift valley in Ethiopia was about 4.04 [13].

In terms of the moisture content, different groups of Persian gums contain some 8.41–9.07% water where the effects of color and growing region is somehow significant more likely due to different climates in which they are cultivated. It is noteworthy that the moisture content and a_w have profound effects on shelf life, physicochemical characteristics, chemical changes (such as none-enzymatic browning), microbial spoilage and enzymatic changes in foods and ingredients [19]. The mean moisture of Arabic gums (*Acacia senegal*) which is collected from Central Rift valley in Ethiopia, is equal to 15% [13].

The ash content of different color groups of PG collected from Fars province is almost similar whereas those from eastern Azerbaijan were somehow different, likely due to the composition of the soil of two regions. It has been reported that the ash content of Arabic, guar, and xanthan gums were 1.2%, 11.9%, and 1.5%, respectively [21]. However, due to abovementioned reasons, in another report the ash content of Arabic gum (*Acacia senegal* species) was 3.8% [22]. Similar to the other plant gums, the fat content of Persian gum was very low and negligible.

TABLE II. Chemical, physical, and physicochemical properties of Persian gum

Collecting region / Parameter	Fars				Eastern Azarbayjan			
	F1	F2	F3	F4	A1	A2	A3	A4
pH	4.62 ± 0.01 ^{d}	4.44 ± 0.01 ^{c}	4.37 ± 0.00 ^{b}	4.36 ± 0.01 ^{b}	4.61 ± 0.06 ^{d}	4.42 ± 0.02 ^{c}	4.36 ± 0.01 ^{b}	4.30 ± 0.02 ^{a}
Moisture (%)	8.89 ± 0.30 ^{ab}	8.85 ± 0.24 ^{ab}	9.07 ± 0.05 ^{b}	8.64 ± 0.15 ^{ab}	8.89 ± 0.70 ^{ab}	8.87 ± 0.50 ^{ab}	8.70 ± 0.18 ^{ab}	8.41 ± 0.29 ^{a}
Dry matter (%)	91.11 ± 0.03 ^{ab}	91.14 ± 0.24 ^{ab}	90.93 ± 0.05 ^{a}	91.35 ± 0.15 ^{ab}	91.10 ± 0.07 ^{ab}	91.13 ± 0.50 ^{ab}	91.30 ± 0.18 ^{ab}	91.59 ± 0.29 ^{b}
Total ash (%)	2.48 ± 0.26 ^{a}	2.30 ± 0.23 ^{a}	2.19 ± 0.24 ^{a}	2.34 ± 0.27 ^{a}	2.87 ± 0.25 ^{ab}	3.00 ± 0.35 ^{ab}	2.83 ± 0.22 ^{ab}	3.58 ± 0.60 ^{b}
Fat (%)	0.19 ± 0.15 ^{a}	0.38 ± 0.16 ^{ab}	0.68 ± 0.04 ^{b}	0.39 ± 0.30 ^{ab}	0.28 ± 0.15 ^{ab}	0.30 ± 0.28 ^{ab}	0.11 ± 0.82 ^{a}	0.52 ± 0.40 ^{ab}
N (%)	0.033 ± 0.001 ^{a}	0.032 ± 0.001 ^{a}	0.032 ± 0.001 ^{a}	0.032 ± 0.001 ^{a}	0.032 ± 0.001 ^{a}	0.032 ± 0.001 ^{a}	0.031 ± 0.001 ^{a}	0.032 ± 0.001 ^{a}
Protein (%)	0.209 ± 0.004 ^{a}	0.203 ± 0.004 ^{a}	0.203 ± 0.004 ^{a}	0.200 ± 0.009 ^{a}	0.200 ± 0.009 ^{a}	0.203 ± 0.004 ^{a}	0.197 ± 0.004 ^{a}	0.200 ± 0.009 ^{a}
Tannin (%)	0.58 ± 0.05 ^{a}	0.65 ± 0.02 ^{a}	0.72 ± 0.05 ^{ab}	0.88 ± 0.02 ^{b}	0.56 ± 0.09 ^{a}	0.64 ± 0.04 ^{a}	0.82 ± 0.05 ^{b}	1.42 ± 0.13 ^{c}
Specific rotation (degree)	-5.99 ± 0.50 ^{d}	-5.49 ± 0.00 ^{d}	-6.16 ± 0.29 ^{d}	-5.99 ± 0.00 ^{d}	-12.33 ± 0.29 ^{a}	-7.83 ± 0.76 ^{c}	-10.83 ± 0.76 ^{b}	-7.66 ± 0.57 ^{c}
Zn (mg/100 g)	17.98 ± 0.03 ^{a}	19.18 ± 0.11 ^{a}	13.16 ± 0.17 ^{a}	16.40 ± 0.13 ^{a}	18.35 ± 0.44 ^{a}	20.06 ± 0.32 ^{a}	16.31 ± 0.29 ^{a}	23.35 ± 0.82 ^{a}
Mg (mg/100 g)	6.35 ± 0.23 ^{a}	6.16 ± 0.28 ^{a}	4.90 ± 0.62 ^{a}	5.96 ± 0.13 ^{a}	5.62 ± 0.19 ^{a}	6.22 ± 0.27 ^{a}	6.38 ± 0.22 ^{a}	6.57 ± 0.21 ^{a}
Ca (mg/100 g)	3.49 ± 0.50 ^{a}	4.55 ± 0.24 ^{a}	4.11 ± 0.58 ^{a}	2.58 ± 0.37 ^{a}	3.49 ± 0.50 ^{a}	5.74 ± 0.03 ^{a}	3.69 ± 0.52 ^{a}	3.58 ± 0.51 ^{a}
Na (mg/100 g)	2.28 ± 0.05 ^{a}	3.10 ± 0.17 ^{ab}	4.74 ± 0.06 ^{b}	2.69 ± 0.00 ^{a}	3.10 ± 0.05 ^{ab}	2.69± 0.00 ^{a}	3.10 ± 0.06 ^{ab}	2.28 ± 0.06 ^{a}
K (mg/100 g)	7.59 ± 0.06 ^{a}	8.80 ± 0.00 ^{b}	9.21 ± 0.05 ^{c}	7.18 ± 0.00 ^{a}	10.43 ± 0.00 ^{d}	10.83 ± 0.03 ^{d}	9.61 ± 0.00 ^{c}	9.61 ± 0.00 ^{c}
a*	1.06 ± 0.01 ^{a}	2.13 ± 0.01 ^{b}	3.61 ± 0.01 ^{c}	5.60 ± 0.00 ^{d}	1.05 ± 0.01 ^{a}	2.15 ± 0.02 ^{b}	3.62 ± 0.02 ^{c}	5.60 ± 0.1 ^{d}
b*	7.33 ± 0.02 ^{a}	11.13 ± 0.02 ^{b}	14.97 ± 0.04 ^{c}	18.68 ± 0.00 ^{d}	7.35 ± 0.01 ^{a}	11.15 ± 0.01 ^{b}	14.99 ± 0.01 ^{c}	18.67 ± 0.01 ^{d}
L*	91.51 ± 0.01 ^{d}	88.60 ± 0.00 ^{c}	85.09 ± 0.00 ^{b}	80.23 ± 0.01 ^{a}	91.51 ± 0.01 ^{d}	88.61 ± 0.01 ^{c}	85.08 ± 0.02 ^{b}	80.24 ± 0.01 ^{a}
C*	7.41 ± 0.02 ^{a}	11.34 ± 0.17 ^{b}	15.40 ± 0.04 ^{c}	19.51 ± 0.01 ^{d}	7.43 ± 0.01 ^{a}	11.36 ± 0.01 ^{b}	15.42 ± 0.01 ^{c}	19.49 ± 0.03 ^{d}
***H**(degree)**	81.75 ± 0.09 ^{d}	79.14 ± 0.09 ^{c}	76.43 ± 0. 06 ^{b}	73.32 ± 0.00 ^{a}	81.87 ± 0.06 ^{d}	79.05 ± 0.09 ^{c}	76.42 ± 0.09 ^{b}	73.31 ± 0.2 ^{a}

Different small letters at each row show significant differences *($p<0.05$)*.

The mean content of nitrogen (N) in examined Persian gums is 0.032±0.001% on the dry basis. The nitrogen and amino acid content of plant gums is suggested as suitable manner for authentication of various species. In fact, JECFA/FAO (1990) justified the nitrogen content of Arabic gum (0.26–0.39%) as an indication for recognizing this gum from the others as well as ensuring its purity and conformity [23]. In addition, it has been shown that the nitrogen content of *Acacia senegal* subspecies *senegal* can be over the range 0.25–1.42% (w/w) [20] which is almost the highest amongst the exudate gums. Equal to the N content, the average protein content of Persian gums is quite low (0.200±0.006% w/w) and no significant difference is seen regarding the growing region and color. Moreover, it was reported that Arabic gum contains some 2.31% protein [13] and protein–arabinogalactane were reported as the main ingredients of this gum [24] Therefore, due to the negligible content of fat, protein and ash, one can obviously conclude that the major fraction of the Persian gum should be polysaccharides.

Based on our observations (Table II), the tannin, as natural polyphenolic component, content of colored groups of PG was much higher than the lighter ones where the A4 contained the maximum amount of tannins (1.42± 0.13% w/w). In addition, a significant difference was seen between the tannin content, color and the origin of PG.

However, some researchers believe that there is not a dominant relationship between tannin content and color intensity of gum solution [15]. Moreover, Whistler (1993) described that the tannins which come into the exudate gums after secretion are due to its contact with the bark which can be considered as an indication of age and purity regarding the influence of origin [25]. It was also reported that the tannin content of *Acacia polyacantha* subspecies of *campylacantha* collected from Tanzania was about 0.58% [23], whereas in *Acacia senegal* subspecies *senegal* it was variable between 0.28% to 0.58% [20].

In general, the specific rotation of examined gums is negative or levorotatory (Table II). Even though, the ones from Fars province have lower specific rotations against ones which gathered from eastern Azerbaijan. In addition, the latter ones have high specific rotations (maximum at -12.33°±0.29 in A1) and there is a significant difference between gums based on their color groups. The specific rotation of the gums can be related to the variety of tree. In line with these observations, Duvallet and coworkers (1993) showed that the specific rotation of 75 specimens of *Acacia senegal* gums was variable over the range -25° to -62° [23].

The quantities of measured minerals are as follows: Zn> K> Mg> Ca> Na where the color or the growing region has no effects on Zn, Mg and Ca whereas the K and Na contents of various gums are significantly different. The metallic ion content of gum is an indication of the soil in which the plant was grown [26]. The alkaline minerals in the *Acacia senegal* gums from Central Rift valley in Ethiopia are: K> Ca >Mg > Na [18]. In terms of color indices, our findings showed that higher the visual color of gums were, higher a^* (redness), b^* (yellowness) and C^* (chroma) and lower H^* (hue angle) and L^* (lightness), values.

The data analysis of more than 800 Arabic gum samples which had been collected from 12 regions demonstrated that some parameters like soil, annual rain fall, temperature (gathering season), age, secretion site, and gathering multiplicity, have very low effects or insignificant effects on the quality of gum. Furthermore, based on a long term survey (1960–1999) they reported that the moisture, ash, nitrogen, tannin, specific rotation, and pH of *Acacia senegal* gums were 10.75%, 3.7%, 3.3%, 0.00%, , -31.3°, and 4.66, respectively [27]. It is noteworthy that the findings of other researches on *Acacia senegal* and *Acacia glomerosa* were somehow different [28].

Based on our observations (Table III), the water absorption capacity of examined Persian gums were over the range 11.07–14.26 which means that each gram of PG can absorb on average some 12 grams of water. This is why that exudate gums like PG have found extensive industrial applications [2]. It is recognized that the water absorption capacity of macromolecules depends on the hydrophilic–hydrophobic balance, as well as the cationic, anionic or non–ionic patches which can absorb different amount of water [19]. Due to such properties, psyllium gum has recently been used as a natural binder in landscape [29] which means that Persian gum has also such capabilities to be used at these applications as well.

Experiments on various concentrations of Persian gum (Table III) demonstrated that PG can produce a true gel only at higher concentrations (11– 12% w/v), whereas at lower findings, it was reported that Cissus gum cannot produce a true gel but a putty-like mass probably owing to its molecular structure and chemical composition. Meanwhile, Glicksman (1982) illustrated that while all the gums have viscosity increase and thickening properties but relatively a small number of them are able to gel [19].

Regarding the cold and hot water insoluble gels of Persian gum, a significant difference is seen based on the color and collecting region (Table III) .As it can be seen and is expected the hot water insoluble gel content is reasonably lower than cold water one more likely due to the solubilizing effect of heating on some polysaccharides. Insoluble gel content is usually considered as an indication of quality which is commonly variable among exudate gums, for instance *Acacia malacocephala* (CWIG, 5.88; HWIG, 3.92% w/w), *Acacia polyacantha* (CWIG, 36.70; HWIG, 10.90% w/w) and *Acacia tortilis* subspecies *spirocarpa* (CWIG, 13.30; HWIG, 11.60% w/w) [15, 20].

IV. CONCLUSION

Persian gum can be introduced as a natural plant gum which mostly consists of polysaccharides. This gum showed high water absorption capacity, capable to gel, which potentially can be used as an economic rheology modifier, stabilizer, gelling agent, and thickener at a wide range of pH in food systems in place of microbial based hydrocolloids.

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TABLE III. Properties of Persian gum dispersion

Collecting region / Parameter	Fars				Eeastern Azarbayjan			
	F1	F2	F3	F4	A1	A2	A3	A4
Water absorption capacity (g/g)	13.96 ± 0.41 b	13.10 ± 0.13 b	11.07 ± 0.18 a	11.74 ± 0.33 a	13.04 ± 0.58 b	14.26 ± 0.68 c	12.78 ± 0.43 b	11.28 ± 0.34 a
Least gelation concentration (% w/v)	11	11	12	12	11	12	12	12
Cold water insoluble gel (% w/w)	71.68 ± 0.05 cd	71.24 ± 0.06 bc	70.59 ± 0.27 ab	71.16 ± 0.42 bc	71.82 ± 0.43 cd	72.41 ± 0.29 d	71.20 ± 0.03 bc	70.18 ± 0.52 a
Hot water insoluble gel (% w/w)	46.68 ± 0.37 bc	46.79 ± 0.14 bc	46.46 ± 0.54 bc	45.49 ± 0.42 ab	45.04 ± 1.00 a	45.83 ± 0.58 ab	46.04 ± 0.46 ab	47.70 ± 0.20 c

Different small letters at each row show significant differences *($p<0.05$)*.

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