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Study on the effects of sucrose and lactose on the rheological properties of *Alyssum homolocarpum* seed gum in dilute solutions

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Abstract

Nowadays, demands for hydrocolloids which improve the rheological properties of foods as well as retain their properties under the influence of food additives have increased. In this study, dilute solution properties were employed to understand the molecular and conformational properties of *Alyssum homolocarpum* seed gum (AHSG), in presence of sucrose and lactose. The model of Tanglertpaibul & Rao was selected as the best model for the estimation of the intrinsic viscosity. It was shown that except for water, the solutions of sucrose and lactose are poor solvents for AHSG as indicated by a decrease in intrinsic viscosity, swollen specific volume, shape function, and coil dimensions. As the sucrose and lactose concentrations increased, the coil radius decreased. The reduction in the shape and swollen volume parameters in the presence of sucrose and lactose as compared to the sugar-free solution indicated the negative effect of the opted sugars on the molecular volume of the gum. Evaluations of the dilute solution properties of the gum in sucrose and lactose solutions revealed that the existence of a conformation tending to ellipsoidal shape and the probability of the conformation of random coil with no molecular entanglements in AHSG solutions.

Keywords: *Alyssum homolocarpum*, intrinsic viscosity, lactose, sucrose.

Introduction

In recent years, application of hydrocolloids has dramatically increased in the food industry. Owing to their safety, availability and low processing costs, herbal seeds have a proper potential for the extraction of hydrocolloids. Most of these seeds have starch as food supply for their embryos. Yet, some others have non-starch polysaccharides with functionalities similar to those of gums and could be used as commercial gums (Bostan, Razavi, Farhoosh, 2010). Some of these plants grow in different regions of Iran and contain some polysaccharides known as hydrocolloids (Razavi, Farhoosh, Bostan, 2007).

Qodume Shirazi (*Alyssum homolocarpum*) is a member of Cruciferae family which has many traditional applications (Koocheki, Mortazavi, Shahidi, *et al.*, 2009). Qodume is native to some Middle East countries including Egypt, Iraq, Iran and Pakistan (Amin, 2005). Its mucilage is pharmaceutically applicable and has recently been examined as a novel source of hydrocolloid (Koocheki *et al.*, 2009b, Koocheki, Kadkhodaee, Mortazavi, *et al.*, 2009a; Koocheki, Shahidi, Mortazavi, *et al.*, 2011). Due to the food fibers of hydrocolloids, they can be utilized in the formulations of food and pharmaceutical products, inspection of the characteristics of novel sources of herbal gums with appropriate properties. Optimization of AHSG extraction conditions has been carried out through the response surface methodology (Koocheki, Mortazavi, Shahidi, *et al.*, 2010). The rheological properties of the gum was studied in the stable conditions under the impact of concentration (1.5-4%), temperature (5-65°C), pH (3-9), the salts of $CaCl_2$, $MgCl_2$, NaCl and KCl and sucrose (0-40%) (Koocheki *et al.*, 2009b). The viscoelastic behavior of AHSG has been recently

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investigated in the linear viscoelastic region (LVE) as a function of temperature and concentration (Hesarinejad, Koocheki, Razavi, 2015a). The obtained mechanical spectrum demonstrated that this gum, like many commercial gums, acts as a weak gel in the studied concentration range (1.5-3%). In addition, some of the physico chemical and functional properties of this gum have been determined. These properties include thickening, gelling, stabilizing and fat replacing which represent its potential as an alternative for commercial gums in food and pharmaceutical formulations (Koocheki *et al.*, 2009b; Koocheki *et al.*, 2010; Koocheki & Kadkhodaee, 2011; Koocheki *et al.*, 2009a; Koocheki & Razavi, 2009; Koocheki, *et al.*, 2011).

One of the important properties of biopolymers is their effectiveness in developing high viscosity in aqueous solutions, even at low concentrations. Since the coils of polysaccharides are separated from each other in the dilute solutions and move independently and freely, determination of intrinsic viscosity in dilute solutions provide good knowledge concerning the fundamental properties of macromolecules in solution (Pamies, Schmidt, Martinez, & Torr, 2010). The attraction-repulsion interactions among the chain segments affect the hydration of the polysaccharide and its hydrodynamic molecular volume. Molecular volume is associated with the chain conformation of polysaccharide molecules in the respective solution. These interactions could vary either with the properties of different solvents or with the electrostatic repulsion between the chain parts via addition of some cosolutes like sugars (development of new solvents). Therefore, the change in the hydrodynamic molecular volume, conformation and macromolecular aggregations could be evaluated through the change in the intrinsic viscosity (Van Aken, 2006). The effect of some additives, such as different sugars, on the intrinsic viscosity of a wide range of hydrocolloids have been extensively studied (Richardson, Willmer & Foster, 1998; Samavati, Razavi, Rezaei & Aminifar, 2007; Mohammad Amini & Razavi, 2012; Behrouzian, Razavi & Karazhyian, 2014; Mirabolhassani *et al.*, 2017).

In our previous research, the monosaccharide composition, ζ-potential, particle size distribution, specific volume and molecular parameters of AHSG were verified at different temperatures (Hesarinejad, Razavi, Koocheki, 2015b). It is necessary to study the effects of different conditions on the rheological behavior of this hydrocolloid for more investigations on the molecular behavior of this gum. The actual formulation of foods may contain different ingredients. It is also essential because of the complexities of food media caused by different concentrations of ingredients such as sugars. Among sugars, the most abundant ones in food products is sucrose, afterwards the lactose is also the most important constituents present in dairy systems, which along with sucrose play a vital role in taste and texture of various food products; hence, the main objective of this study was to investigate the effects of sucrose and lactose on the rheological properties of AHSG in a dilute domain (e.g. intrinsic viscosity; molecular conformation; shape and hydration parameters; coil radius and volume) in order to understand its behavior in real systems.

2. Materials and Methods

AHSG was extracted under the optimal conditions (36.3 ± 1°C, pH=4 and water to seed ration of 40:1 for 1 h), purified by ethanol (Koocheki *et al.*, 2010) and then freeze-dried. Initially, the AHSG was dissolved in deionized water in the presence or absence of cosolutes (sucrose, lactose) under constant mixing (1000 rpm) using a magnetic stirrer for 30 min at room temperature. After that, the stock solutions (0.1 $g.dl^{-1}$) were left at ambient temperature overnight for complete hydration. Sucrose and lactose (Merck, Germany) were used for the preparation of sugar solutions.

Measurement of the solution's viscosities

The viscosity of samples was measured using a Cannon-Ubbelohde capillary viscometer (Size 75, Cannon Instruments Co., Germany; viscometer constant, k = 0.01875 mm^2/s^2) immersed in a thermostatic water bath under precise temperature control (25±0.1°C). In this experiment, the passage time of the solvent and samples from one mark to another was measured using a chronometer and the relative viscosity of the samples (η_{rel}) was calculated through the division of the sample passage time (t) by that of the solvent (t_s) (Eqn. 1). Next, the specific viscosity was computed by Eqn. (2):

$$\eta_{rel} = \frac{\eta}{\eta_s} = \frac{t}{t_s} \tag{1}$$

$$\eta_{sp} = \frac{\eta - \eta_s}{\eta_s} = \eta_{rel} - 1 \tag{2}$$

Intrinsic viscosity ($[\eta]$) was determined by fitting the obtained data from the dilute region measurement to the models of Huggins (1942) (Eqn.3), Kraemer (1938) (Eqn.4), Tanglertpaibul and Rao (1987) (Eqn.5) and Higiro et al (2006) (Eqns. 6 and 7):

$$\frac{\eta_{sp}}{C} = [\eta] + K'[\eta]^2 C \tag{3}$$

$$\frac{ln\eta_{rel}}{C} = [\eta] + K''[\eta]^2 C \tag{4}$$

$$\eta_{rel} = 1 + [\eta]C \tag{5}$$

$$\eta_{rel} = e^{C[\eta]} \tag{6}$$

$$\eta_{rel} = \frac{1}{1 - C[\eta]} \tag{7}$$

where k′ and k″ are constants of the Huggins and Kraemer models, respectively. Intrinsic viscosity is equal to the slope of the plot of $\ln \eta_{rel}$ against C according to equation 6 and the slope of the plot of $1 - \frac{1}{\eta_{rel}}$ against concentration (C) based on equation 7.

Estimation of the molecular conformation

The biopolymer conformation could be calculated by the *b* parameter form Eqn. 8 which is the slope of the logarithmic plot of log η_{sp} versus concentration (Lai, Tung & Lin, 2000).

$$\eta_{sp} = aC^b \tag{8}$$

Shape and swollen volume parameters determination

Voluminosity or swollen specific volume (υ_s) which gives us some information about the polymer conformation under different conditions of the solvent is applied to determine the volume of the solvated polymer molecules.

For determining υs, the Y equation -which is characterized as follows- can be plotted against concentration under different conditions, so that the υ_s would be measured at C=0 (the intercept) (Joseph et al., 1991).

$$Y = \frac{\eta_{rel}^{0.5} - 1}{C(1.35\eta_{rel}^{0.5} - 0.1)} \tag{9}$$

Subsequently, the shape of polymer's molecules in a solution could be estimated through υ factor (Eqn 10). According to this equation, swollen specific volume and intrinsic viscosity are associated with each other in which υ is referred to as the shape factor and the extent of the viscosity increment which is concerned with the shapes of polymer's particles in the solution (Antoniou *et al.*, 2010).

$$[\eta] = \upsilon.\upsilon_s \tag{10}$$

If υ=2.5, the particles shapes will be spherical and if υ>2.5, the particles shapes in the solution will tend to oval.

Coil radius and volume estimation

Based on Einstein`s viscosity equation, the hydrodynamic coil radius (R_{coil}) is obtained as follows (Antoniou *et al.*, 2010):

$$R_{coil} = \left[\frac{3[\eta].M_w}{10\pi.N_A}\right]^{\frac{1}{3}} \tag{11}$$

Where M_w is the molecular mass, N_A represents the Avogadro's number and $[\eta]$

denotes the intrinsic viscosity. If the assumption of the coil spherical shape is correct, the helix volume (V_{coil}) will be determined as follows:

$$V_{coil} = \frac{4}{3}\pi R_{coil}^{3} \quad (12)$$

Results and Discussion

Intrinsic viscosity

The difference in the rheological behavior of various hydrocolloids solutions is the result of the difference between their individual macromolecular conformations in the solution. The conformation of each macromolecule has an impact on its hydrodynamic volume. Intrinsic viscosity is applied to specify the hydrodynamic volume occupied by macromolecule (Bohdanecky and Kovar, 1982). It is also influenced by hydrodynamic properties which include a measure of the permeability of the polymer coil to solvent and chain anisotropy (Samavati, Razavi, Rezaei, and Aminifar, 2007).

The typical twin Huggins-Kraemer and triple Tanglertpaibul & Rao, Higiro 1 & Higiro 2 plots for AHSG's intrinsic viscosity calculation are represented in Figs. 1 and 2, respectively.

The intrinsic viscosity [η] of AHSG calculated by five models (Eqns. 3-7) at different concentrations of sucrose and lactose is listed in Table 1. It can be seen that AHSG did not follow the Huggins and Kramer's equations, whereas slope based relations (Tanglertpaibul & Rao, Higiro 1 & Higiro 2) indicated high efficiency to determine the intrinsic viscosity of AHSG, because they showed better linear fit with higher correlation coefficient (R^2) and lower root mean square error (RMSE) values. Therefore, the estimation of the intrinsic viscosity of AHSG from the slope of the dilute region seemed to provide more reliable results

McMilan (1974) stated that the plot-slope-based determination methods of the intrinsic viscosity have higher determination coefficients and lower standard errors as compared to those which are based on intercept (extrapolation).

Niuckerson *et al* (2004) declared as the polymer concentrations are prepared by sequential dilutions, the error of the term ηsp/C increases and attempts for fitting the data to the Huggins model will encounter problems.

Table1. Comparison between the intrinsic viscosity values of AHSG calculated by different models as a function of sugar type and concentration (at 25°C)

	Huggins			Kraemer			Tang. & Rao			Higiro 1			Higiro 2		
Treatment	[η]	R^2	RMSE	[η]	R^2	RMSE	[η]	R^2	RMSE	[η]	R^2	RMSE	[η]	R^2	RMSE
Control	18.38±0.08	0.97	0.14	18.29±0.12	0.95	0.09	23.11±0.19	0.99	0.00	15.83±0.19	0.99	0.01	10.75±0.11	0.99	0.02
Sucrose (%)															
10	11.48±0.12	0.84	0.22	11.39±0.21	0.91	0.14	13.68±0.09	0.99	0.01	9.54±0.11	0.99	0.01	6.73±0.06	0.95	0.04
20	11.15±0.07	0.94	0.09	11.00±0.17	0.98	0.05	12.79±0.12	0.99	0.00	8.79±0.21	0.99	0.01	6.45±0.11	0.94	0.04
30	10.75±0.11	0.89	0.19	10.66±0.14	0.83	0.14	13.79±0.02	0.97	0.00	8.35±0.19	0.99	0.01	6.24±0.10	0.94	0.04
40	7.18±0.16	0.78	0.13	7.00±0.21	0.97	0.08	6.56±0.08	0.99	0.00	5.14±0.17	0.97	0.01	5.14±0.10	0.92	0.03
Lactose (%)															
2.5	15.89±0.13	0.74	0.15	15.51±0.14	0.94	0.10	17.17±0.13	0.99	0.00	11.63±0.14	0.98	0.01	8.11±0.12	0.85	0.04
5	11.00±0.10	0.95	0.41	11.78±0.12	0.75	0.25	20.71±0.10	0.99	0.01	14.09±0.14	0.99	0.01	9.56±0.09	0.97	0.03
10	11.86±0.16	0.85	0.39	12.16±0.22	0.61	0.18	16.82±0.11	0.99	0.01	11.43±0.08	0.99	0.01	7.81±0.14	0.97	0.03
15	9.92±0.09	0.95	0.35	9.76±0.17	0.83	0.21	15.85±0.09	0.99	0.00	10.86±0.13	0.99	0.01	7.55±0.11	0.98	0.02

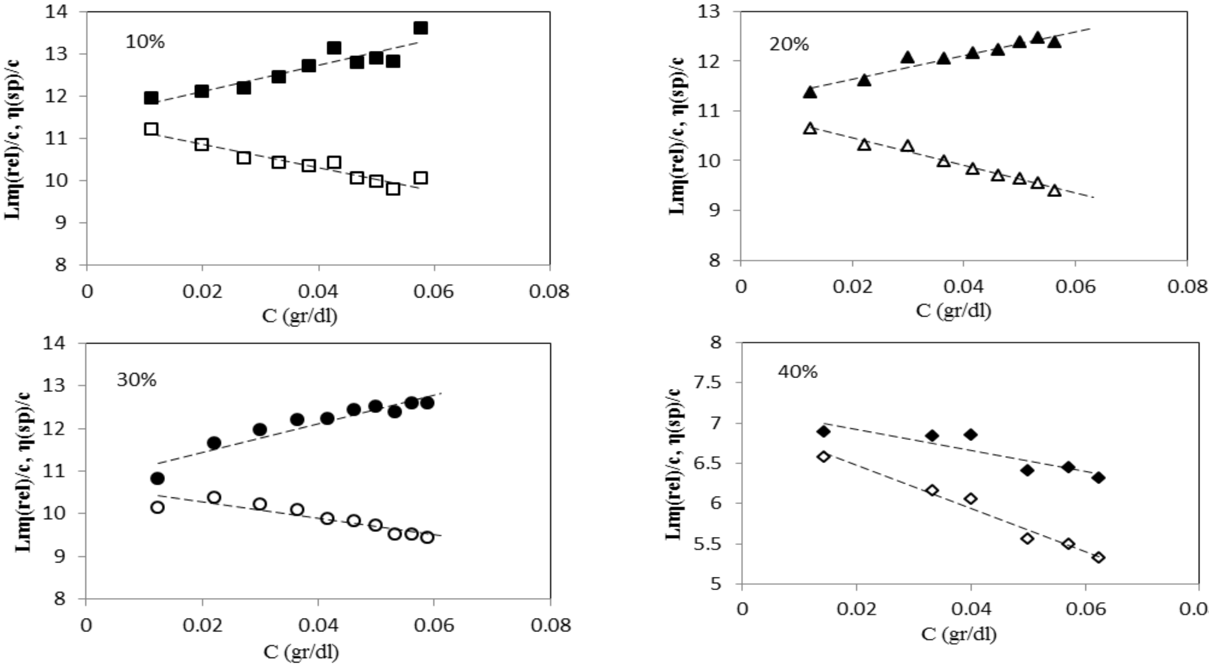

Fig 1. The plots resulted from fitting the Huggins (solid) and Kraemer (hollow) models to the data of the dilute region viscometry test of AHSG in different concentrations of sucrose (25°C).

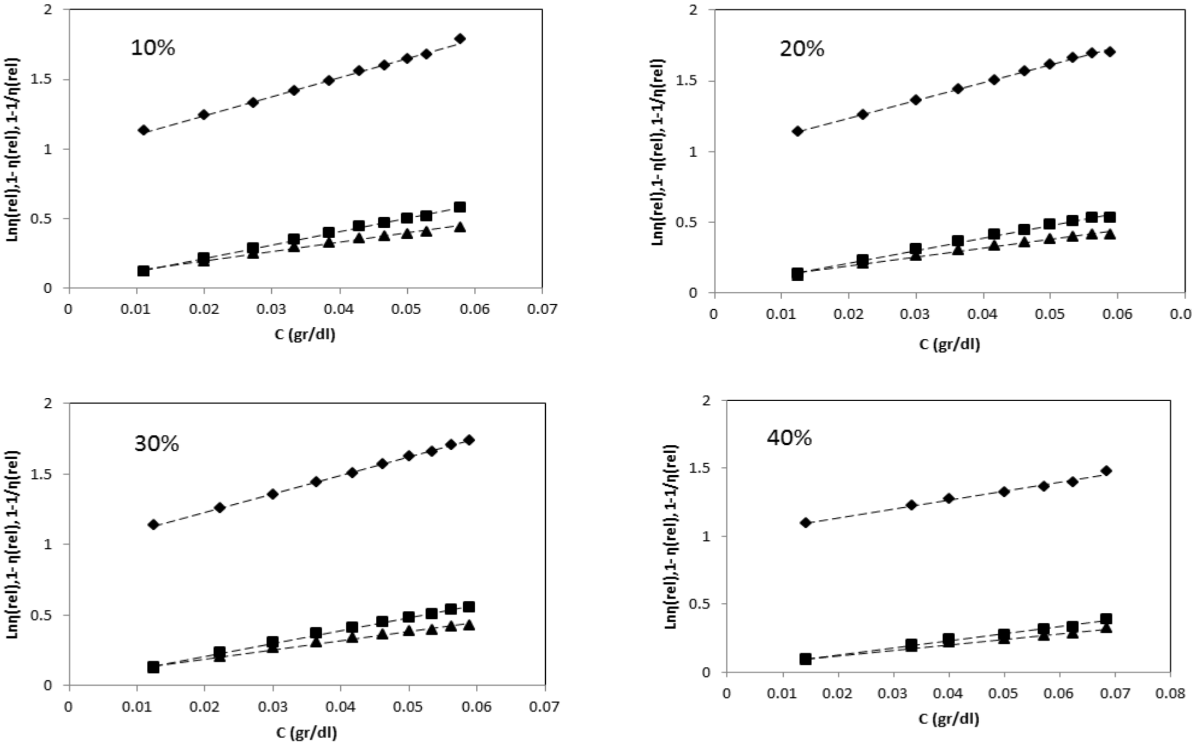

Fig 2. The curves obtained from fitting the models of Tanglertpaibul & Rao (◆), Higiro 1 (■), Higiro 2 (▲) to the dilute-region viscosity data of AHSG in different concentrations of sucrose (25°C).

Launay *et al* (1986) mentioned that the Huggins equation is valid only when $\eta_{sp} < 0.7$. The specific viscosity ranged from 0.2 to 1 in the present study. Lai *et al* (2000) and Higiro *et al* (2007) applied the models which calculate the intrinsic viscosity based on the plot slope, because the data of the two gums of *hsian-tsao* leaf gum and xanthan against concentration could not be fitted to the linear regression model.

After comparison of the R^2 and RMSE values of the three slope-based models of Tanglertpaibul & Rao, Higiro1 and Higiro2 and verification of their capability in showing the difference between intrinsic viscosities in various concentrations of sucrose and lactose, the model of Tanglertpaibul & Rao was chosen as the superlative model with the highest R^2 and the lowest RMSE (Table 1). Adding the lactose, the intrinsic viscosity of the AHSG solution decreased from 23.11 dl/g in the lactose-free sample to 15.85 dl/g in the 15% lactose solution. This reduction can be attributed to the impact of lactose on the reduction of the molecular associations. Slight decrease in the intrinsic viscosity of AHSG at different concentrations of lactose could be probably due to the decrease in the solvent quality.

Similar finding was also reported by Mirabolhassani *et al*, (2016) for Basil seed gum (BSG). They indicated that the intrinsic viscosity of BSG was decreased when the lactose concentration increased from 5 to 15% (w/v). Elfak *et al* (1977) observed that the intrinsic viscosities of the two hydrocolloids of guar and locust bean gum were reduced to 60% after the addition of 40% sucrose. Nonetheless, this decreasing trend was different at the concentration of 30% w/w and the rise in the solution intrinsic viscosity was observed in this concentration. The phenomenon can be explained as follows: sucrose is probably able to break down the intramolecular hydrogen bonds as a hydrogen-bond-forming agent and may cause the unfolding of the polymeric chain which in turn may lead to the viscosity increase. Similar results were reported for the cress seed gum (Behrouzian *et al*., 2013) and balangu seed gum (Mohammad Amini and Razavi, 2012) in the presence of lactose.

The same decreasing trend was also observed with the addition of sucrose as the intrinsic viscosity of the AHSG solution with reduction from 23.11 dl/g in the sucrose-free sample to 6.56 dl/g in the 40% sucrose sample. Similar results were reported by Michel *et al* (1984). They indicated that with the addition of sucrose to the high-methoxyl pectin hydrocolloid solution, the intrinsic viscosity decreased due to the reduction of the solvent quality. A similar phenomenon was also observed by Richardson *et al* (1998) investigating the effect of sucrose on the hydrodynamic volume of two commercial hydrocolloids (guar and locust bean gum). The reduction in the intrinsic viscosity of hydrocolloids has been reported as a function of various concentrations of β-glucan in maltose (Grimm *et al*., 1995). On the other hand, Chen and Joslyn (1967) observed a dramatic increase in viscosity after investigating the effect of the sucrose solution on the intrinsic viscosity of the pectin solution in the dilute solution. They stated the equilibrium electrical conductivity of the polyelectrolytes solution was reduced as the sucrose concentration increased. They ascribed this viscosity increment to the fact that when the dielectric constant decreases, the electrostatic forces become stronger and the pure charge of the solution is reduced due to the increase in the number of the linked ions. Since, the carboxyl groups of pectin have been dissociated to a lesser extent, the electrostatic repulsion between these groups have decreased and the hydrogen bonds between these hydroxyl groups and the ones of the adjacent molecules lead to aggregation (Chen & Joslyn 1967; Elfak, Pass, Phillips, & Morley, 1977; Mohammad Amini & Razavi, 2012; Richardson *et al*., 1998).

The differences in the intrinsic viscosity of AHSG at all concentrations of sucrose and lactose were significant ($p<0.05$). Since, AHSG intrinsic viscosity was the highest in the two solutions of 30% sucrose and 5%

lactose, it can be concluded that these two solutions are probably the best solvents for AHSG among the sugar-containing solvents. However their qualities are lower than that of the pure water (the blank sample).

Molecular parameters

Using the power-law equation (Eqn. 8) and the estimation of *b* from the slope of the log-log plot of η_{sp} against concentration in the dilute region, we could reach to an attitude about the conformation of polysaccharides (Lai *et al*, 2000). This parameter ranged from 0.96 to 1.30 for AHSG in the presence of sucrose and lactose within the entire range of the examined concentrations. Researchers associate the slope values >1 in the dilute region with either the conformation of the random coil (Irani, et al., 2016; Lapasin and Pricl, 1995) or entanglement (Morris *et al*, 1981). They also related the slope values <1 to the rod-like conformation (Lai and Chiang, 2002; Razmkhah *et al*., 2016; 2017).

As observed in Table 2, the value of the dimensionless concentration or the Berry number (C[η]) lay within the range of 0.09-0.81 and 0.21-0.88 after the addition of sucrose and lactose to AHSG solution, respectively. Considering these data and since the *b* parameter of the power-law equation was more than 1, the conformation of the randomized coil without entanglement could be predicted in AHSG solutions.

Table 2. The molecular parameters of AHSG in the dilute region as a function of the sugar type and concentration (25°C)

Treatment	*b*	C[η]	υ (-)	υ_s (dl g^{-1})	R_{coil} (nm)	V_{coil} (nm^3)
Control	1.10±0.01	0.25-0.90	2.55	7.21	11.10	5732.50
Sucrose (%)						
10	1.06±0.00	0.15-0.79	3.10	4.40	9.26	3325.72
20	1.05±0.01	0.15-0.75	2.98	4.29	9.05	3109.35
30	1.11±0.01	0.17-0.81	3.25	4.21	9.26	3320.86
40	0.96±0.01	0.09-0.37	2.35	2.78	7.24	1594.79
Lactose (%)						
2.5	1.00±0.00	0.25-0.73	2.85	6.01	9.99	4174.17
5	1.30±0.01	0.34-0.88	4.31	4.80	10.06	5034.77
10	1.15±0.01	0.28-0.84	3.53	4.76	9.92	4089.08
15	1.21±0.01	0.21-0.67	3.66	4.32	9.72	3853.27

Standard deviation was less than 2% for the three replicates of all samples.

With the addition of sucrose to 20%, the *b* parameter decreased as compared to the aqueous solution and increased at the concentration of 30% and decreased again dramatically at the concentration of 40%. In the case of the lactose-containing solutions, it decreased till 2.5% and was maximized at 5% and decreased again at 10% and increased at 15%. Through the verification of the Berry number and referring to the observations of Kasaai, Charlet, & Arul (2000) and Behrouzian *et al* (2013), it could be found out all AHSG samples are within the dilute region in the presence of sucrose and lactose solutions and it demonstrates that no entanglement and coil-overlapping has taken place (Table 2). It seems that the two competing factors: a reduction in polymer/polymer association resulting in a decrease in the intrinsic viscosity (normally a consequence of a better solvent) and good solvents increasing the intrinsic viscosity through coil expansion were present throughout the sucrose concentration range studied (Richardson et al., 1998).

Table 2 shows the voluminosity (υ_s) and the shape factor (υ) of AHSG solution in the presence of sucrose and lactose. The υ_s of AHSG decreased with the rise in sucrose and lactose concentration, which reveals the negative effect of the selected sugars on the volume of AHSG molecules signifying the reduction in the interactions between AHSG and water which may lead to the gum intramolecular interactions

The amount of υ in the sugar-free solution (deionized water) was less than 2.5 exhibiting the spherical shape of the molecule. However, it was more than 2.5 in sucrose and lactose solutions, indicating that the molecules tended to be ellipsoidal shape. Yet, it decreased to approximately 2.35 in the sucrose concentration of 40%, showing the molecule shape tended to be spherical.

The results of the coil radius (R_{coil}) and volume (V_{coil}) of AHSG in the presence of various concentrations of sucrose and lactose are summarized in Table 2. As sucrose and lactose concentrations increased, the coil radius of AHSG decreased. The V_{coil} of AHSG decreased with the rise in the sugar concentration as well. The variations were more pronounced in the presence of sucrose rather than lactose. A similar phenomenon was observed in the case of Balangu seed gum in the presence of sucrose and lactose (Mohammad Amini and Razavi, 2014; Mirabolhassani *et al.*, 2016). An opposite trend as the increase in the coil radius and volume was observed in sucrose concentration of 30% and lactose concentration of 5%.

Conclusion

In this study, the effects of sucrose and lactose in various concentrations were investigated in dilute solution properties of AHSG. After fitting different models, the Tanglertpaibul & Rao model was selected as the superlative model for the determination of the intrinsic viscosity of AHSG in the dilute solution with the highest R2 and the lowest RMSE. The intrinsic nature of the two solutions of 30% sucrose and 5% lactose were the best solvents for AHSG. Addition of sucrose and lactose decreased the intrinsic viscosity of the hydrocolloid solution via the influence on the reduction of molecule associations and reducing the solvent quality. The reduction in voluminosity and shape factor in the presence of sucrose and lactose rather than the sugar-free solution implied the negative effect of the chosen sugars on the volume of AHSG molecules. Comparing to the sugar-free solution, the rise in the shape factor value to more than 2.5 suggests the tendency of the spherical shape of the AHSG molecules to the ellipsoidal shape. As the concentrations of sucrose and lactose increased, the coil radius decreased. In general, it could be concluded that the solvent quality decreased significantly as the concentration of sucrose and lactose increased in the AHSG solution

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مطالعه اثر ساکارز و لاکتوز بر ویژگی‌های رئولوژیکی صمغ دانه قدومه شیرازی در ناحیه رقیق

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چکیده

امروزه تقاضا برای هیدروکلوئیدها نه تنها به‌منظور بهبود خواص رئولوژیکی مواد غذایی، بلکه جهت حفظ ویژگی‌های آن‌ها تحت تاثیر افزودنی‌های غذایی افزایش یافته است. در این مطالعه ویژگی‌های ناحیه رقیق صمغ دانه قدومه شیرازی برای درک خواص مولکولی و ساختمانی آن در حضور ساکارز و لاکتوز مورد بررسی قرار گرفته است. مدل تانگ و رائو به‌عنوان بهترین مدل برای تخمین ویسکوزیته ذاتی انتخاب شد. نتایج این پژوهش نشان داد که به جز آب، محلول‌های ساکارز و لاکتوز به دلیل کاهش ویسکوزیته ذاتی، حجم مخصوص متورم، تابع شکل، و ابعاد مارپیچ، حلال های ضعیفی برای صمغ دانه قدومه شیرازی هستند. با افزایش غلظت ساکارز و لاکتوز، شعاع مارپیچ کاهش می یابد. کاهش پارامترهای شکل و حجم متورم در حضور ساکارز و لاکتوز در مقایسه با محلول بدون قند نشان دهنده اثر منفی قندها بر حجم مولکولی صمغ است. ارزیابی ویژگی‌های ناحیه رقیق این صمغ در محلول های ساکارز و لاکتوز وجود کنفورماسیون بیضی شکل و احتمالا حلقه تصادفی بدون درگیری مولکولی را در صمغ دانه قدومه شیرازی نشان داد.

واژه‌های کلیدی: صمغ دانه قدومه شیرازی، ویسکوزیته ذاتی، لاکتوز، ساکارز

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