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Research Article

Rheological properties of wild sage seed gum solution: Effects of different concentrations of ascorbic acid, citric acid, malic acid and tartaric acid

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Abstract

In this study, the effect of edible organic acids at two different concentrations on the viscosity and rheological behavior of Wild Sage Seed Gum (WSSG) solution was investigated. The apparent viscosity values of the WSSG solution in the organic acids model system (0.5% concentration) were measured as 10.31, 4.48, 7.00, and 5.49 mPa·s for ascorbic, citric, malic, and tartaric acids, respectively, at a shear rate of 49 s^{-1} and 20°C. The apparent viscosity of the WSSG solution decreased as the concentration of organic acids increased from 0.5% to 1%. The most significant reduction in viscosity was observed with 1% tartaric and citric acids, while the smallest reduction occurred with 0.5% ascorbic acid. The Herschel-Bulkley equation was found to be the most suitable model for describing the behavior of the WSSG solution containing edible organic acids. This model demonstrated excellent performance, with a maximum correlation coefficient greater than 0.9956 and minimal error values. For both the Power Law and Herschel-Bulkley (HB) models, the consistency coefficient values of the samples decreased as the acid concentration increased. The sample with 1% tartaric acid exhibited the lowest consistency coefficient, while the sample with 0.5% ascorbic acid had the highest consistency coefficient. Additionally, the flow behavior index of the samples increased with higher acid concentrations.

Keywords: Consistency coefficient; Flow behavior index; Herschel-Bulkley; Wild sage.

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1. Introduction

Gums (hydrocolloids) interact strongly with water and serve as thickeners, influencing the viscosity, consistency, and textural properties of food products [1]. Various types of gums, including Wild Sage Seed Gum (WSSG), Basil Seed Gum, Balangu Seed Gum, xanthan, guar, pectin, karaya, carrageenan, locust bean, acacia, carboxymethyl cellulose (CMC), Arabic gum, and alginate, are used in a wide range of food products. These include beverages, sauces, dairy products, instant foods, ready-to-use dessert soups, bakery items, and confectioneries [2-6]. Wild Sage Seed Gum (WSSG) is a hydrocolloid extracted from the seeds of *Salvia macrosiphon* L. It is effective in thickening and stabilizing food products, making it a strong candidate for various applications in the food industry. Compared to some commercially available food-grade gums, WSSG performs exceptionally well. Its aqueous dispersions exhibit high viscosity and shear-thinning behavior [7]. Wild Sage Seed Gum (WSSG) has a high carbohydrate content of 69.01% (on a dry basis) and a low protein content of 2.08% (on a dry basis). The average moisture content is 11.24% (wet basis), while the ash content is 9.20% (dry basis). The gum contains approximately 30.2% uronic acids. WSSG is classified as a galactomannan with a mannose-to-galactose ratio of 1.78–1.93:1 and has a weight-average molecular weight of approximately 4×10^5 Da [8].

Organic acids are organic compounds with acidic properties, classified according to the number of carboxylic groups they contain [9]. Ascorbic acid, a cost-effective food additive, is commonly used for food preservation and to prevent browning [10]. Alpha-hydroxy acids are a class of organic acids characterized by a carboxylic acid group with a hydroxyl group attached to the adjacent carbon. Lactic, citric, and malic acids are examples of alpha-hydroxy acids, which are commonly used in food, beverages, and animal nutrition [11]. Tartaric acid is commonly used as an acidulant. As a hydroxy acid, it is the most water-soluble among solid acidulants and imparts a strong tart flavor, enhancing grape-like tastes, particularly in grape and lime flavors. It naturally occurs in fruits such as grapes and pineapples [9].

For certain hydrocolloids, factors such as ion presence, temperature changes, pH variations, or the addition of other solutes can lead to dominant interactions between polymer segments. These interactions may induce gelation by forming ordered molecular structures, such as junction zones [12]. pH is a crucial parameter influencing the rheological properties of hydrocolloid solutions. The addition of acid to an aqueous xanthan gum solution, as well as changes in pH, can significantly impact its viscosity [5]. Hayta et al. [5] investigated the effect of pH on dispersions of galactomannan-xanthan gum mixtures. They observed a clear enhancement in apparent viscosity for sample solutions within the pH range of 2 to 6. However, the consistency coefficient values gradually decreased at pH 2. Medina-Torres et al. [13] reported that the viscosity of Opuntia ficus indica gum stabilizes at a constant value in the basic pH range but decreases sharply as the pH drops from 7 to 2. Brenelli et al. [14] studied the in vitro viscosity of guar gum, pectin, and carboxymethyl cellulose (CMC). Their results show that acidification, alkalinization, and exposure to intestinal ions cause various viscosity changes in gums with similar initial viscosities, demonstrating a direct correlation with the slight decrease in viscosity observed in vitro. In the study by Ozgur et al. [1], the flow properties of a ternary gum system (xanthan, CMC, and pectin) were examined using a model system containing an organic acid (citric or tartaric acid) and sucrose. Their results showed that CMC had the highest consistency coefficient among the gums, compared to xanthan gum and pectin, in both the citric acid–sucrose and tartaric acid–sucrose model systems. Salehi et al. [15] examined the effect of organic acids on the viscosity and rheological behavior of guar gum solutions. The results showed that the sample containing 1% tartaric acid had the lowest consistency coefficient, while the sample with 0.5% ascorbic acid had the highest consistency coefficient. Additionally, the flow behavior index of the guar gum solution increased with higher acid concentrations.

Studying the rheological properties of polysaccharide gums is crucial when they are used as food additives, particularly in applications that require specific rheological characteristics, such as stabilization and thickening [16, 17]. Studying the stability of gum solutions in acidic environments is crucial for understanding their functional properties in food processing and, more recently, for examining the physiological effects of dietary fiber [18]. In this study, we investigated how the addition of edible organic acids (ascorbic acid, citric acid, malic acid, and tartaric acid) to Wild Sage Seed Gum (WSSG) dispersions affects their viscosity and rheological properties.

2. Materials and methods

2.1. Production of acid solutions containing gum

For the current study, wild sage seeds (*Salvia macrosiphon* L.) were cleaned to remove any dirt or unwanted materials. The seeds were then soaked in water at 25°C for 20 minutes, using a ratio of 1 part seeds to 20 parts water [7]. The Wild Sage Seed Gum (WSSG) was extracted from the seeds using an extractor (FJ-479, Tulips, Iran), which employs a rotating disc to scrape the gum from the seed surfaces. The resulting dispersion was then dehydrated in an oven (Shimaz, Iran) with air circulation at 60°C. After dehydration, the gum was ground into powder, packaged, and stored in a cool, dry place.

Organic acids, including ascorbic acid, citric acid, malic acid, and tartaric acid, were purchased in powder form (China) and dissolved in distilled water. Two concentrations of each acid were prepared: 0.5% and 1%. A sample of distilled water served as the control (0% acid). The Wild Sage Seed Gum (WSSG) solutions were prepared by dissolving the gum powder (0.20%, w/v) in distilled water [19], and different concentrations of the organic acid solutions were mixed using a magnetic stirrer.

2.2. Apparent viscosity

The apparent viscosity of Wild Sage Seed Gum (WSSG) dispersions was measured using a viscometer (Brookfield DV2T, RV, USA) at 20°C. An example of the process for preparing the acid solutions containing WSSG and measuring the apparent viscosity and flow behavior index of the dispersion is illustrated in Fig 1. The apparent viscosity and shear stress (SS) of the WSSG dispersion were measured at various shear rates (12.2–171.2 s^{-1}) using an UL Adapter Kit.

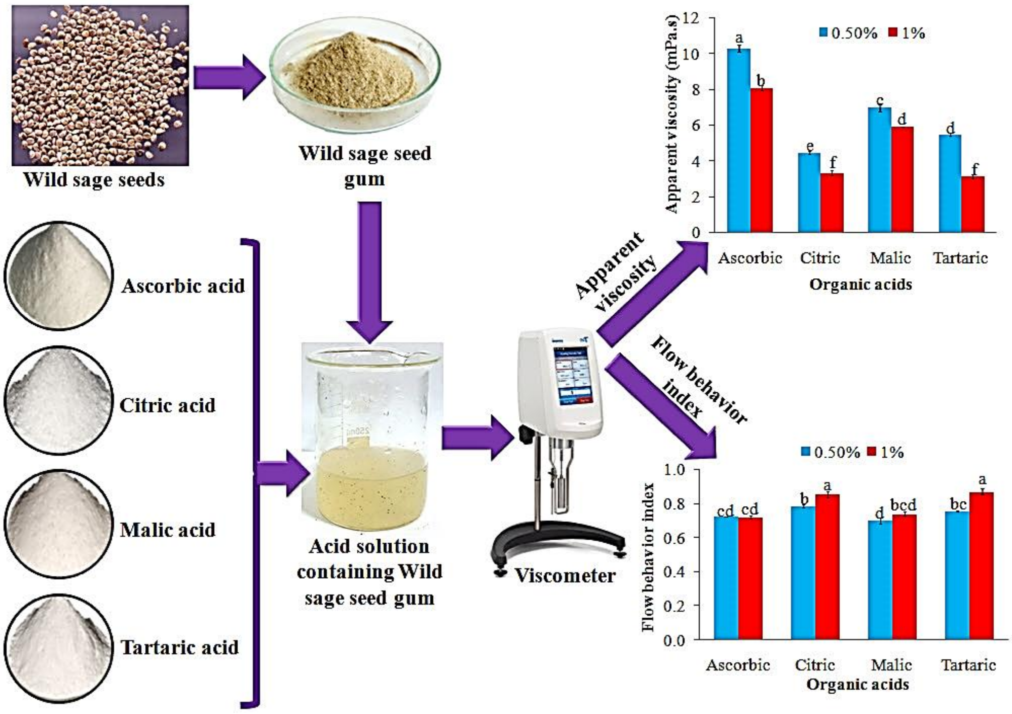


Fig. 1. Schematic of the process for preparing acid solution containing Wild sage seed gum and measuring the apparent viscosity and flow behavior index of the dispersion.

2.3. Mathematical modeling

Power Law, Bingham, Herschel-Bulkley (HB), and Casson models are commonly applied to represent the behavior of various gum dispersions [7]. In this study, these models were used to fit the shear stress (SS) and shear rate (SR) data of Wild Sage Seed Gum (WSSG) dispersions containing edible organic acids. The experimental results were analyzed for ease of use in rheological studies and to maintain appropriate accuracy using the Curve Fitting Tool (cftool) in MATLAB software (version R2012a).

2.4. Statistical analysis

The analysis was conducted in triplicate, and the results are presented as the mean with standard deviation (SD). Differences between means were assessed using Duncan's multiple range test with SPSS (version 21) for Windows. Mean differences were considered significant at the $p < 0.05$ level.

3. Results and discussion

3.1. Apparent viscosity

As functional ingredients, hydrocolloids or gums are utilized to control the rheology and textural properties of foods and serve as fat and sugar replacers due to their high fiber content [20]. Fig 2 illustrates how the viscosity of WSSG dispersion changes with varying shear rates. The apparent viscosity of WSSG dispersion decreases with increasing stirring speed, demonstrating shear-thinning behavior. In this study, the apparent viscosity of the sample containing 0.5% ascorbic acid decreased from 17.1 mPa·s to 7.1 mPa·s as the shear rate increased from 12.2 s^{-1} to 171.2 s^{-1}.

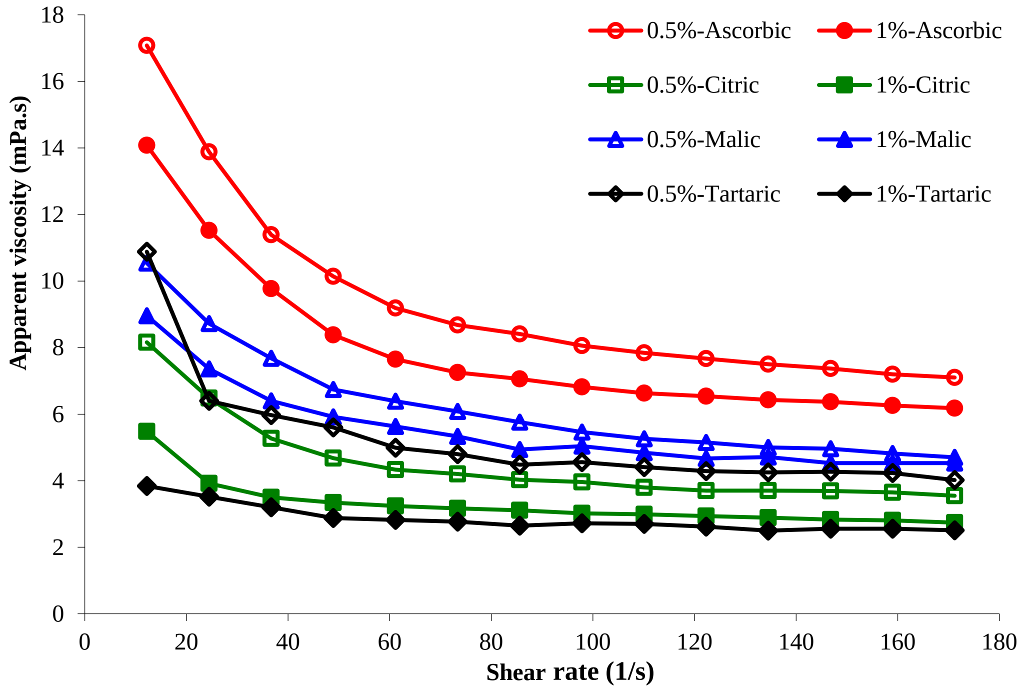


Fig. 2. Impact of shear rate on the apparent viscosity of Wild sage seed gum dispersion containing edible organic acids.

Organic acids are essential components in food that significantly influence flavor. The type and concentration of these acids can substantially affect the taste and aroma of food [21]. In this study, the apparent viscosity of the control sample (0% acid) was measured at 32.29 ± 0.42 mPa·s at a shear rate of 49 s^{-1} and 20°C (Fig 3). The apparent viscosity of WSSG dispersions prepared with a 0.5% concentration of various organic acids was measured at 49 s^{-1} and 20°C. The values were 10.31 mPa·s for ascorbic acid, 4.48 mPa·s for citric acid, 7.00 mPa·s for malic acid, and 5.49 mPa·s for tartaric acid. The apparent viscosity of the WSSG dispersions decreased as the concentration of organic acids increased from 0.5% to 1%. This behavior was observed for all organic acids. The most significant decrease in viscosity was noted with 1% tartaric acid or citric acid, while the smallest decrease was observed with 0.5% ascorbic acid. Specifically, when the concentration of ascorbic acid increased from 0.5% to 1%, the apparent viscosity of the WSSG dispersion decreased from 10.31 mPa·s to 8.07 mPa·s at a shear rate of 49 s^{-1}. These findings are consistent with existing data, which indicate that the viscosity of fully hydrated guar gum solutions is slightly lower at acidic pH compared to neutral pH, even in the absence of degradation [18].

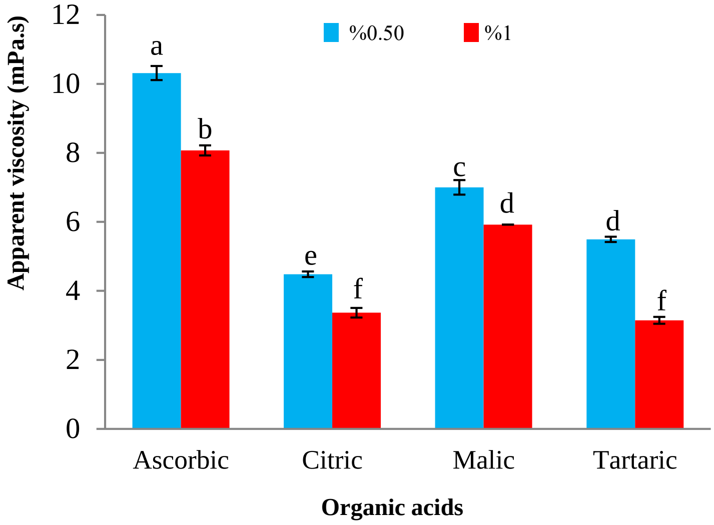


Fig. 3. Impact of organic acids on the apparent viscosity of Wild sage seed gum dispersion (shear rate=49).

Error bars represent the SD of the mean of three replicates. Different letters above column indicate significant differences between dispersions ($p<0.05$).

3.2. Power law model

Studying rheological properties is crucial for designing various processes, including fluid flow, pumping, extraction, filtration, purification, pasteurization, evaporation, and drying [16]. Given the importance of rheological characterization and modeling in food formulations, the number of scientific studies on this topic has increased significantly in recent years [22]. In the current study, experimental data on shear stress versus shear rate were fitted to the Power law, Bingham, Herschel–Bulkley, and Casson models [23]. The Power law model demonstrated the best performance, with a high r-value (> 0.9946), and low sum of squared errors (SSE) (< 0.0062) and root mean square errors (RMSE) (< 0.0227) for all dispersions containing edible organic acids (see Table 1). In this study, the k and n values for the control sample were 0.174 ± 0.003 Pa·s^n and 0.568 ± 0.006, respectively. It was observed that the addition of organic acids significantly influenced the rheological parameters of the solutions. The effect of organic acids on the consistency coefficient of the WSSG dispersion is illustrated in Fig 4. The consistency coefficient of the samples decreased with increasing acid concentration. The sample with 1% tartaric acid or citric acid exhibited the lowest consistency coefficient, while the sample with 0.5% ascorbic acid had the highest consistency coefficient. The results indicate that increasing the malic acid concentration from 0.5% to 1% reduced the consistency coefficient of the WSSG dispersion from 0.023 Pa·s^n to 0.014 Pa·s^n ($p < 0.05$). Wang et al. [18] investigated the stability of guar gum in aqueous systems under acidic conditions at temperatures of 25°C, 37°C, and 50°C. Their results indicate that guar gum remains relatively stable under mild acidic conditions. However, increased temperatures and lower pH values reduce the stability of guar gum in solution.

Table 1. Values of statistical parameters of the Power law model for estimating shear stress data

Organic acid	Acid concentration	Sum of squared error (SSE)	Correlation coefficient (r)	Root mean square error (RMSE)
Control	0%	0.0048	0.9997	0.0198
Ascorbic	0.5%	0.0057	0.9981	0.0218
Citric		0.0015	0.9985	0.0110
Malic		0.0009	0.9993	0.0083
Tartaric		0.0028	0.9969	0.0153
Ascorbic	1%	0.0037	0.9979	0.0173
Citric		0.0006	0.9989	0.0071
Malic		0.0016	0.9984	0.0112
Tartaric		0.0013	0.9968	0.0099

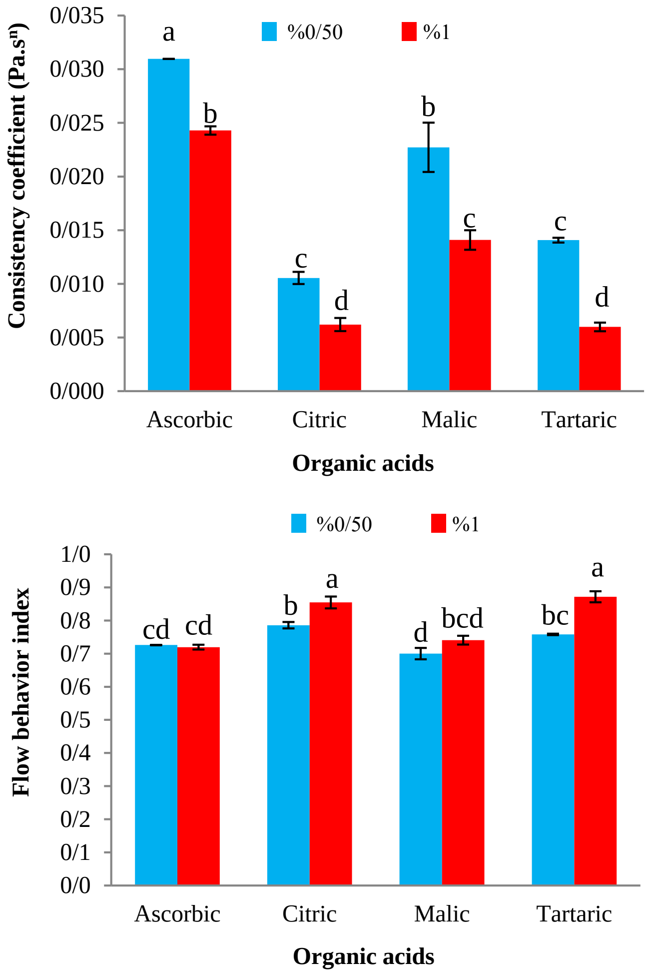


Fig. 4. Impact of organic acids on the consistency coefficient and flow behavior index of Wild sage seed gum dispersion (Power law model).

Error bars represent the SD of the mean of three replicates. Different letters above column indicate significant differences between dispersions ($p<0.05$).

Tartaric acid and its derivatives are utilized for various purposes, including flavor enhancement, preservation, pH regulation, chelating, as well as serving as humectants, firming agents, baking additives, and emulsifiers [24]. According to the Power law equation, a fluid exhibiting shear-thinning behavior has a flow behavior index (n) of less than 1 [25]. The effect of organic acids on the flow behavior index of WSSG dispersion is illustrated in Fig 4. The flow behavior index of the samples increased with higher acid concentrations, indicating a reduction in shear-thinning behavior. The sample containing 1% tartaric acid exhibited the highest flow behavior index, while the sample with 0.5% malic acid had the lowest. The results show that increasing the citric acid concentration from 0.5% to 1% significantly enhanced the flow behavior index of the WSSG dispersion, from 0.786 to 0.855 ($p < 0.05$). These changes in the consistency coefficient and flow behavior index of the WSSG dispersion may be attributed to structural modifications of the gum induced by the presence of different acids.

3.3. Bingham model

The experimental values of shear stress (SS) versus shear rate (SR) for WSSG dispersions containing edible organic acids were fitted to the Bingham model, and the constant coefficients of this model were calculated. The mean values for the sum of squared errors (SSE), correlation coefficient (r), and root mean square error (RMSE) for the WSSG dispersions ranged between 0.0003 and 0.1295, 0.9920 and 0.9995, and 0.0049 and 0.1039, respectively (see Table 2).

Table 2. Values of statistical parameters of the Bingham model for estimating shear stress data

Organic acid	Acid concentration	Sum of squared error (SSE)	Correlation coefficient (r)	Root mean square error (RMSE)
Control	0%	0.1212	0.9923	0.1005
Ascorbic	0.5%	0.0053	0.9983	0.0209
Citric		0.0008	0.9989	0.0078
Malic		0.0051	0.9959	0.0194
Tartaric		0.0012	0.9986	0.0101
Ascorbic	1%	0.0036	0.9979	0.0170
Citric		0.0003	0.9993	0.0054
Malic		0.0025	0.9975	0.0142
Tartaric		0.0012	0.9970	0.0097

The current study indicates that the Bingham yield stress (τ_0^B) and Bingham plastic viscosity (η^B) of the control sample were 0.781 ± 0.007 Pa and 0.015 ± 0.0002 Pa·s, respectively. The effect of organic acids on the Bingham yield stress of WSSG dispersion is shown in Fig 5. The results reveal that the Bingham yield stress of the samples decreased as the acid concentration increased. The dispersion containing 1% tartaric acid exhibited the lowest yield stress (0.034 Pa), while the sample with 0.5% ascorbic acid showed the highest yield stress (0.180 Pa). The results indicate that increasing the citric acid concentration from 0.5% to 1% significantly reduced the Bingham yield stress of the WSSG dispersion, from 0.064 Pa to 0.035 Pa ($p < 0.05$).

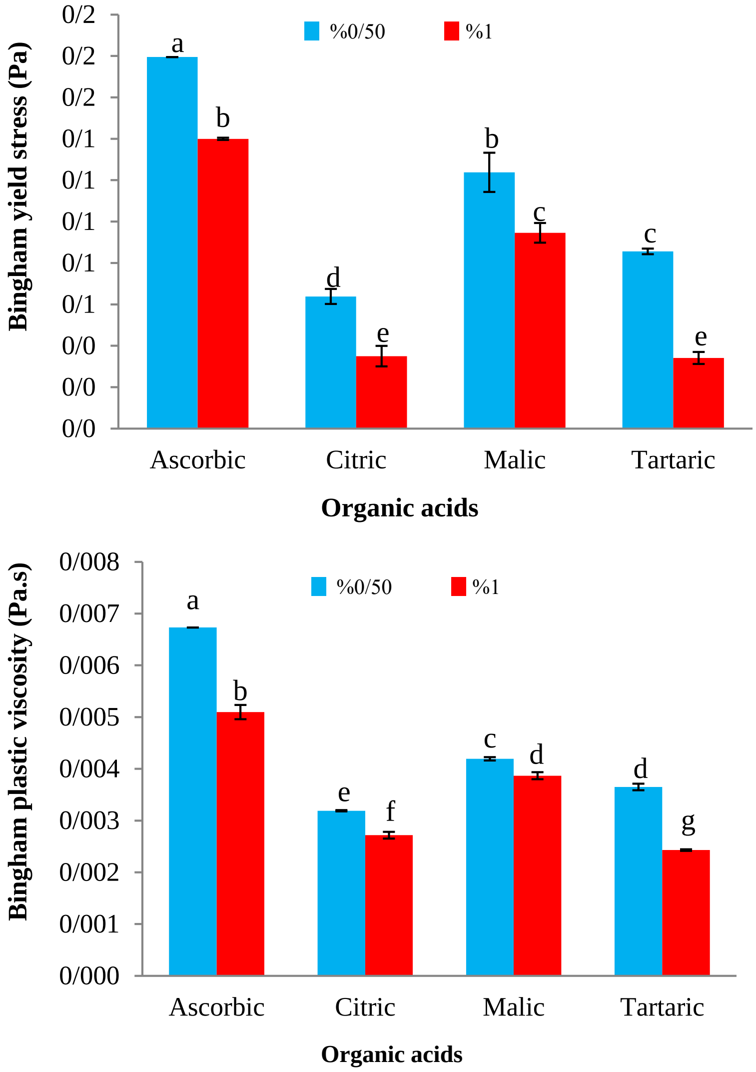


Fig. 5. Impact of organic acids on the Bingham yield stress and Bingham plastic viscosity parameters of Wild sage seed gum dispersion (Bingham model).

Error bars represent the SD of the mean of three replicates. Different letters above column indicate significant differences between dispersions ($p<0.05$).

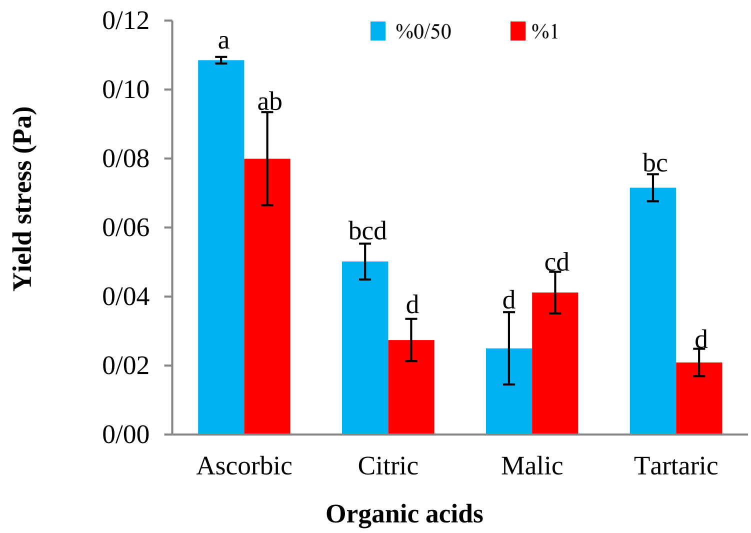
Fig 5 illustrates the effect of organic acids on the Bingham plastic viscosity of WSSG dispersions. The plastic viscosity of the samples decreased with increasing acid concentration. The dispersion containing 1% tartaric acid had the lowest plastic viscosity (0.0024 Pa·s), while the sample with 0.5% ascorbic acid had the highest plastic viscosity (0.0067 Pa·s). The results show that increasing the ascorbic acid concentration from 0.5% to 1% significantly reduced the Bingham plastic viscosity of the WSSG dispersion, from 0.0067 Pa·s to 0.0051 Pa·s ($p < 0.05$).

3.4. Herschel-Bulkley (HB) model

Over the past three decades, hydrocolloids have become increasingly prevalent in food formulations for two main reasons. The first is their physical functionality, which involves their capacity to alter the chemical conformation and structure of polymers within a solution or system, thereby achieving desired rheological properties and food structure [12]. The experimental values of shear stress (SS) versus shear rate (SR) for the WSSG dispersion were fitted to the Herschel-Bulkley (HB) model, and the constant coefficients of this model were determined. The mean values for the sum of squared errors (SSE), correlation coefficient (r), and root mean square error (RMSE) for the WSSG dispersion ranged from 0.0002 to 0.0055, 0.9956 to 0.9998, and 0.0039 to 0.0223, respectively (see Table 3). Based on the Herschel-Bulkley (HB) model, all WSSG dispersions exhibited shear-thinning behavior, characterized by a flow behavior index (n_h) less than 0.998 (see Fig 6). The HB model results indicated that the yield stress values ranged from 2.30×10^{-6} Pa to 1.27×10^{-1} Pa.

Table 3. Values of statistical parameters of the Herschel-Bulkley model for estimating shear stress data

Organic acid	Acid concentration	Sum of squared error (SSE)	Correlation coefficient (r)	Root mean square error (RMSE)
Control	0%	0.0036	0.9998	0.0177
Ascorbic	0.5%	0.0022	0.9993	0.0139
Citric		0.0007	0.9991	0.0075
Malic		0.0006	0.9995	0.0072
Tartaric		0.0011	0.9988	0.0100
Ascorbic	1%	0.0017	0.9990	0.0125
Citric		0.0003	0.9995	0.0049
Malic		0.0012	0.9988	0.0098
Tartaric		0.0011	0.9972	0.0095



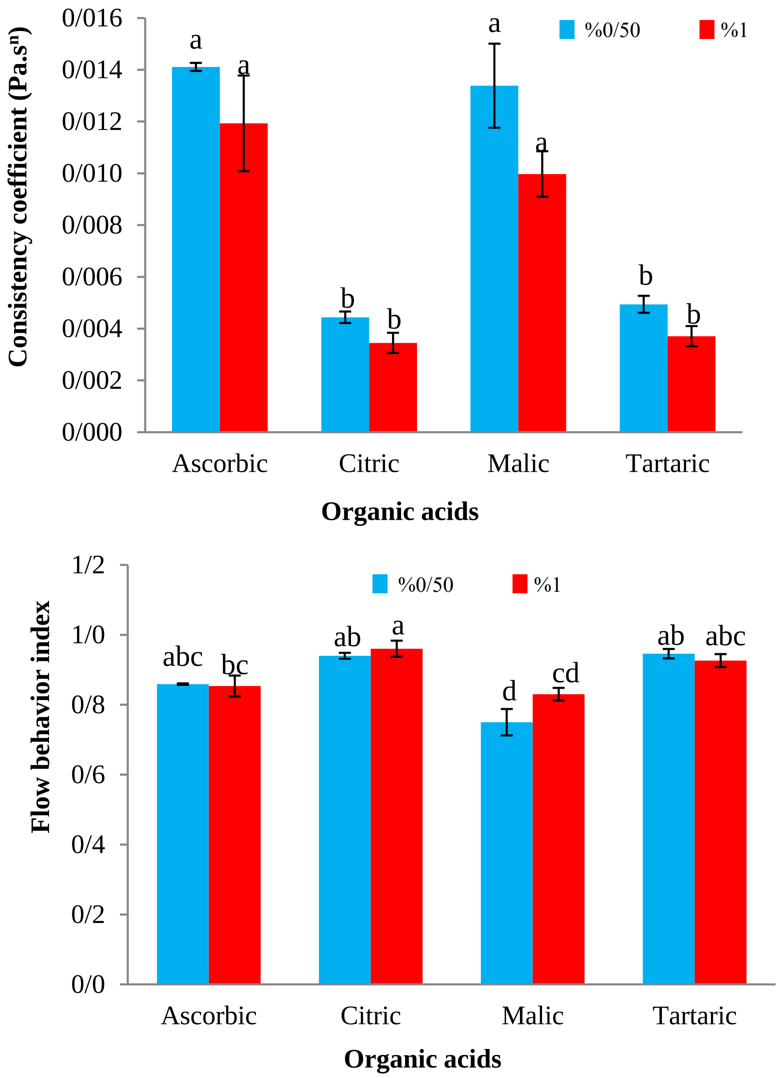


Fig. 6. Impact of organic acids on the yield stress, consistency coefficient, and flow behavior index parameters of Wild sage seed gum dispersion (Herschel-Bulkley model).

Error bars represent the SD of the mean of three replicates. Different letters above column indicate significant differences between dispersions ($p<0.05$).

The flow behavior and thickening properties of gums in solution can be significantly affected by variables such as shear rate, time, compound concentration, temperature, and pH. Analyzing the individual and combined effects of these factors is crucial, particularly when gums are used for modifying food texture, as well as in process design, evaluation, and modeling [16]. Several studies have examined the rheological characteristics of hydrocolloids, both individually and as components of food formulations [7, 15-17, 19]. In this research, the yield stress, consistency coefficient, and flow behavior index (based on the Herschel-Bulkley model) for the control sample were 0.109 ± 0.019 Pa, 0.141 ± 0.003 Pa·s^n, and 0.603 ± 0.003, respectively. The effect of organic acids on the consistency coefficient of WSSG dispersion is illustrated in Fig 6. The consistency coefficient of the samples decreased with increasing acid concentration. Specifically, ascorbic acid concentration increased from 0.5% to 1%, resulting in a reduction of the consistency coefficient of the WSSG dispersion from 0.014 Pa·s^n to 0.012 Pa·s^n ($p > 0.05$). The sample with 1% citric acid exhibited the lowest consistency coefficient, while the sample with 0.5% ascorbic acid showed the highest consistency coefficient.

The impact of organic acids on the flow behavior index (based on the Herschel-Bulkley model) of WSSG dispersion is shown in Fig 6. The flow behavior index of the samples increased with higher concentrations of citric and malic acids, indicating a reduction in shear-thinning behavior. The sample containing 0.5% malic acid had the lowest flow behavior index (0.750), while the sample with 1% citric acid had the highest (0.960). Specifically, when the malic acid concentration increased from 0.5% to 1%, the flow behavior index of the WSSG dispersion increased from 0.750 to 0.830 ($p > 0.05$), reflecting a decrease in shear-thinning behavior.

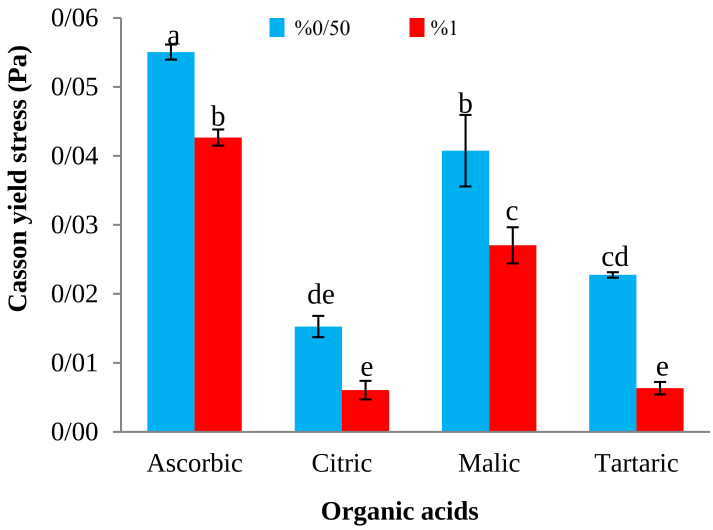
3.5. Casson model

The experimental values of shear stress (SS) versus shear rate (SR) for WSSG dispersions containing edible organic acids were fitted to the Casson model, and the constant coefficients of this model were determined. The relationship between shear stress and shear rate was well described by Casson's equation. The mean values of the sum of squared errors (SSE), correlation coefficient (r), and root mean square error (RMSE) for the WSSG dispersion ranged from 0.0002 to 0.0325, 0.9954 to 0.9996, and 0.0041 to 0.0520, respectively (see Table 4).

Table 4. Values of statistical parameters of the Casson model for estimating shear stress data

Organic acid	Acid concentration	Sum of squared error (SSE)	Correlation coefficient (r)	Root mean square error (RMSE)
Control	0%	0.0275	0.9982	0.0478
Ascorbic	0.5%	0.0019	0.9993	0.0123
Citric		0.0008	0.9989	0.0080
Malic		0.0016	0.9987	0.0105
Tartaric		0.0014	0.9984	0.0109
Ascorbic	1%	0.0019	0.9989	0.0126
Citric		0.0004	0.9992	0.0056
Malic		0.0012	0.9988	0.0097
Tartaric		0.0012	0.9972	0.0092

Casson yield stress represents the minimum stress required for a fluid to begin flowing [26]. In the current study, the Casson yield stress ($\tau_0 c$) and Casson plastic viscosity (ηc) for the control sample were 0.354 ± 0.007 Pa and 0.093 ± 0.001 Pa·s, respectively. The effect of organic acids on the Casson yield stress of WSSG dispersion is illustrated in Fig 7. The results show that the Casson yield stress of the samples decreased as the concentration of acids increased. The dispersion containing 1% citric acid had the lowest Casson yield stress (0.006 Pa), while the sample with 0.5% ascorbic acid had the highest yield stress (0.055 Pa). The results indicate that increasing the malic acid concentration from 0.5% to 1% significantly reduced the Casson yield stress of the WSSG dispersion, from 0.041 Pa to 0.027 Pa ($p < 0.05$).



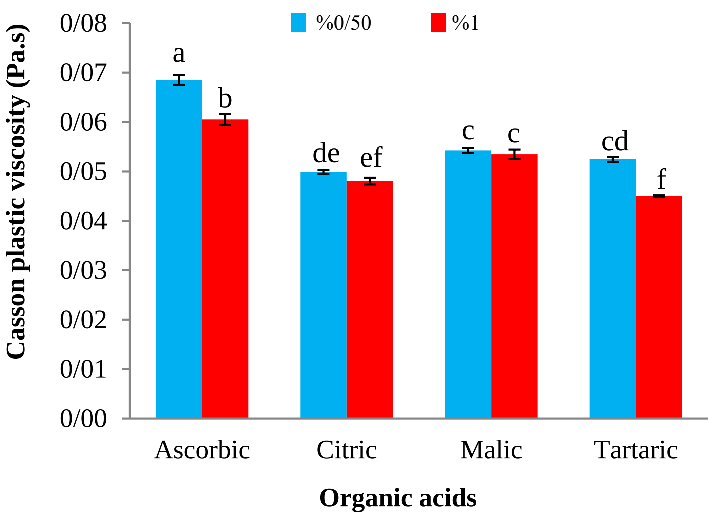


Fig. 7. Impact of organic acids on the Casson yield stress and Casson plastic viscosity parameters of Wild sage seed gum dispersion (Casson model).

Error bars represent the SD of the mean of three replicates. Different letters above column indicate significant differences between dispersions (p<0.05).

Additionally, Fig 7 illustrates the effect of organic acids on the Casson plastic viscosity of WSSG dispersion. The plastic viscosity of the samples decreased with increasing acid concentration. The dispersion with 1% tartaric acid exhibited the lowest plastic viscosity (0.045 Pa·s), whereas the sample with 0.5% ascorbic acid had the highest plastic viscosity (0.068 Pa·s). The results show that increasing the tartaric acid concentration from 0.5% to 1% significantly reduced the Casson plastic viscosity of the WSSG dispersion, from 0.052 Pa·s to 0.045 Pa·s ($p < 0.05$).

4. Conclusions

Different types of gums are used in a variety of food products, including beverages, sauces, dairy products, instant foods, ready-to-use dessert soups, bakery items, and confectioneries. Edible organic acids such as malic, citric, ascorbic, and tartaric acids are commonly added to these products for pH control. In the present study, the effects of edible organic acids (ascorbic, citric, malic, and tartaric) at two concentrations (0.5% and 1%) on the viscosity and rheological parameters of WSSG dispersion were investigated. The findings revealed that the apparent viscosity of WSSG dispersions decreased as the shear rate increased, demonstrating shear-thinning behavior. As the concentration of selected organic acids increased, the viscosity of the solutions decreased, with the greatest reductions observed for tartaric and citric acids. Based on the correlation coefficients (r) and error metrics (SSE and RMSE) of the estimated parameters, the Herschel-Bulkley (HB) model was selected as the best fit for the experimental data of WSSG dispersions. The consistency coefficients (from the Power Law and Herschel-Bulkley models) of the samples decreased with increasing acid concentration. However, the flow behavior index (from the Power Law model) increased with higher concentrations of the selected organic acids. Based on these findings, it is not recommended to use WSSG in food products containing high concentrations of tartaric and citric acids.

5. Funding

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مقاله پژوهشی

ویژگی‌های رئولوژیکی محلول صمغ دانه مرو: تأثیر غلظت‌های مختلف اسید آسکوربیک، اسید سیتریک، اسید مالیک و اسید تارتاریک

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چکیده

در این مطالعه تأثیر اسیدهای آلی خوراکی در دو غلظت بر ویسکوزیته و رفتار رئولوژیکی محلول صمغ دانه مرو بررسی شد. مقادیر ویسکوزیته ظاهری محلول صمغ دانه مرو تهیه‌شده در سیستم مدل اسیدهای آلی (۰/۵٪) برای اسیدهای آسکوربیک، سیتریک، مالیک و تارتاریک در سرعت برشی برابر ۴۹ بر ثانیه و در ۲۰ درجه سلسیوس به ترتیب برابر ۱۰/۳۱، ۴/۴۸، ۷/۰۰ و ۵/۴۹ میلی پاسکال ثانیه تعیین شد. ویسکوزیته ظاهری محلول صمغ دانه مرو با افزایش غلظت اسیدهای آلی از ۰/۵ به ۱ درصد کاهش یافت. بیشترین کاهش ویسکوزیته مربوط به اسیدهای تارتاریک و سیتریک ۱ درصد و کمترین آن مربوط به اسید آسکوربیک ۰/۵ درصد بود. معادله هرشل بالکلی بهترین مدل برای توصیف رفتار محلول صمغ دانه مرو حاوی اسیدهای آلی خوراکی بود. این مدل با حداکثر ضریب تبیین (<۰/۹۹۵۶) و حداقل مقادیر خطا عملکرد خوبی از خود نشان داد. مقادیر ضریب قوام نمونه‌ها (مدل‌های قانون توان و هرشل بالکلی) با افزایش درصد اسید کاهش یافت. نمونه حاوی ۱٪ اسید تارتاریک کمترین مقدار ضریب قوام و نمونه حاوی ۰/۵٪ اسید آسکوربیک دارای بیشترین مقدار ضریب قوام بود. با افزایش غلظت اسید، شاخص رفتار جریان نمونه‌ها افزایش یافت.

کلمات کلیدی: دانه مرو، شاخص رفتار جریان، ضریب قوام، هرشل بالکلی.

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