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Investigation Of The Effect Of Stevia Sweetenter And Adding Quince Seed Gum On The Rheological Properties Of Jelly

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ABSTRACT

Although application of sweeteners and thickeners substituting sugar in food products is effective in reducing the calorie intake, but it is usually accompanied by changing the product texture. Reducing sugar in the formulation of jelly powder using stevia as a strong sweetener composition and quince seed gum with respect to the qualitative properties of the product was analyzed in this study to investigate the possibility of substituting stevia with sugar. Different percentages of stevia (with 0, 25, 50, 75, and 100% sugar) were prepared along with quince seed gum, and the jelly samples were evaluated with regards to the rheological properties by using the strain sweep test measurement at constant frequency of 1 Hz, frequency sweep at the strain of 0.1% and frequency range of 0.1 to 10, as well as the creep test and the power-low equation. The results obtained from adding stevia and quince seed gum to the jelly powder sample showed that increasing the rate of stevia reduced the storage module, while the existence of sugar and quince seed in the jelly powder formula increased the storage module. The Newton viscosity of the samples increased by increasing the rate of stevia, while the immediate and delayed disintegration modulus decreased by increasing the rate of stevia. The results indicated that in addition to reducing the rate of calorie intake, substituting a part of sugar with stevia in the jelly powder can cause main changes in the rheological features of the jelly powder, reduce the elasticity module and increase the viscosity module, and by adjusting the rate of sugar substitution with stevia, it can be used as a commercial replacement in the industry.

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1. Introduction

In recent years, the consumption of ultra-beneficial products with less sugar and calories has attracted public attention[1]. The increase in the prevalence of obesity in the Middle East countries, including Iran, is due to rapid changes in lifestyle, more inactivity, reduced physical activity, and increased consumption of foods rich in saturated fat and sugars.[2]. One of the most important ways to control diabetes is to use a low-calorie and sugar-free diet. Non-nutritive sweeteners such as stevia are a suitable choice for diabetic patients so that their sugar intake does not exceed the allowed amount[3]. Sucrose is one of the main components of the formulation of sweet products, which, in addition to creating flavor, plays a role as a water inhibitor in forming the texture of products, including jelly.[4].

Jelly is a semi-solid and transparent product that is prepared during a special process using sugar or fruit juice or other permitted sugary substances as a sweetener and pectin or gelatin as a gel forming factor, and it may be a flavoring and coloring agent. Add hydrocolloids to it[5]. Jelly is one of the products with a semi-solid consistency, and therefore, the role of sugar as a volume and texture creator in this product is not as high as that of solid sweet products such as cake, despite the presence of gelling agents, so achieving the appropriate texture of jelly by increasing the amount of strong sweetener Stevia and reducing the amount of volumizer seems possible[6 and 7].Hydrocolloids are widely used in food with the purpose of creating gel, texture modification and stabilization. Due to their linear, large and flexible structure, polysaccharides can increase viscosity even in low concentrations.[8]. Hydrocolloids, including gum to grain, are widely used in food with the purpose of creating gel, modifying texture and stabilizing. Mucilage is hydrolyzed into a composite grain of cellulose and polysaccharides[9]. The gum contains compounds such as cellulose and arabinose[10 and 11].Nowadays, the use of stevia sweetener, which is a natural compound, has gained serious acceptance in many countries. This composition is not caloric and can be a good substitute for artificial sweeteners such as aspartame, saccharin and cyclamate, without the effects of abuse of these sweeteners.[13 and 12]. This sweetener is used in the production of low-calorie products that are also suitable for diabetics, such as jams, fruit milk drinks and chocolate milk, juice, soft drinks and ice cream.[14-16]. stevia*Stevia rebaudiana* It is a herbaceous and cold-sensitive plant. Four main steviol glucosides have been identified in stevia, which are the main factor in creating a very sweet taste, more sweetness than sucrose, less calories and 200 to 300 times sweeter than sucrose.[17 and 18].The most abundant species of this plant are: Redbayana, Pilosa, Avator, Palmerau sali, Signoria serrata. Diterpene glycosides are compounds that are known to be the main cause of creating a very sweet taste in stevia plant extracts.[19].

Oakenfull et al. (1986) investigated the stabilization of gelatin gels by sugars and polyols, including sucrose, glucose, fructose, sorbitol, glycerol, and ethylene glycol, in concentrations ranging from 0-500 grams per kilogram. The results of the research of these researchers showed that with the exception of ethylene glycol, the effects of other sugars and polyols were almost the same, so that by adding 400 grams per kilogram of gelatin, the shear modulus and gelation speed increased and while the amount of this Characteristics for ethylene glycol were negligible[20 and 21].

Jelly is one of the types of desserts and suitable snacks that have been researched in different countries for its low-calorie varieties. Francisca et al. (2010) used polyols in the preparation of gelled low-calorie confectionery products. These researchers used different percentages of isomalt (zero, 20, 30, 50, 75 and 100%) along with sucralose and evaluated the jelly samples in terms of texture and physical, chemical, microbial and sensory-taste properties. The results showed that the complete replacement of sugar with at least 50% by weight of sugar alcohol isomalt along with 0.13% sucralose caused tissue strength, and with the reduction of isomalt, the strength of the gel decreased.[22].

Peng et al. (2007) compared gelatin desserts made from sucrose and different types of gelatin, such as pig gelatin and fish skin, in terms of texture, and found that desserts made from gelatin mixtures containing agar were more resistant to degradation due to deformation. Big is from tilapia fish gelatin and pork gelatin (23). Also, Khouryieh et al. (2006) and Acosta et al. (2008)

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examined jelly desserts made from alternative sweeteners, pectin and various gums. The results of their research showed that the combination of xanthan gum and carob seed gum significantly reduces water loss compared to each of the gums used separately. Also, the findings of these researchers showed that a combination of xanthan gum and carob seed gum causes higher strength and flexibility than using xanthan gum or carob seed gum alone (24 and 25).

2- Materials and methods

2-1 - Materials

The raw materials of this research include sugar from Qazvin Sugar Factory, stevia in the form of rhabdioside A with 99% purity from Astra Company in China, gelatin from Halal Tos Mashhad Company, water and 96% ethanol from Kimia Alkal Zanjan Company.

2-2- Methods

2-2-1- Aqueous extraction of grain mucilage to

The mucilage extraction of 50 grams of seeds was done using double distilled water at a ratio of 20:1 at a temperature of 25 degrees Celsius and a duration of 60 minutes. Before adding the seeds, the water was heated to 60 degrees Celsius and then during the extraction period, the mixture of water and seeds was mixed using a stirrer (Shimi Fan, Iran) at a speed of 700 rpm. Then, the seeds were separated from the hydrocolloid solution with the help of a Buchner funnel connected to a vacuum pump, and by adding 96% ethanol (3 times the volume), the mucilage was precipitated. In the continuation of the obtained mucilage, it was dried in an oven at a temperature of 50 degrees Celsius for 24 hours.[26].

The measurement of extraction efficiency was calculated based on the initial weight of the seed. Mucilage prepared under optimal conditions was considered as a control sample[27].

2-2-2-preparation of jelly

The base formulation of jelly was adjusted using the ingredients of edible gelatin (9 grams), gum to grain (0.1 grams) per 100 grams of sucrose.

Different ratios of 0, 25, 50, 75 and 100 based on the weight-weight percentage of stevia were substituted for sucrose (Table 1) and to achieve the same sweetness as sucrose. The sweetness of stevia was considered to be 300 times that of sucrose.

To prepare the samples, the amount of gelatin powder, sugar and gum per grain were mixed according to Table 1. Then 80 cc of boiling water was added to this mixture. In order to close the obtained solution, it was transferred to the refrigerator. The prepared sample was kept at this temperature until the tests were performed.

Table 1 The Percentage composition of Ingredients used to make jelly powder(gr)

INGREDIENTS	CONTROL	TREATMENT 1	TREATMENT 2	TREATMENT 3	TREATMENT 4
Water	80	80	80	80	80
Gelatin	1.8	1.8	1.8	1.8	1.8
Quince seed gum	0	0.1	0.1	0.1	0
Sucks	20	13.33	6.68	0	0
Stevia	0	0.022	0.044	0.066	0.066
Sugar replacement(%)	0	25	50	75	100

2-2-3-Measurement of rheological characteristics

In order to investigate the rheological behavior of the jellies prepared from MCR300 Physica rotary rheometer, manufactured by Anton Paar, Austria, to measure the strain scan at a fixed frequency of 1 Hz, the frequency scan was used to determine the linear viscoelastic region at a strain of 0.1% and a frequency range of 1/1 0 to 10 using PP25 spindle and blank space[1] 0.2 mm was done. Also, in order to check and compare the viscous and elastic behavior of production samples, creep test was used[29 and 30].

The dependence of elastic modulus (Equation No. 1) and viscous modulus (Equation No. 2) with angular frequency was investigated with the power equation.

Equation number 1:

$$G' = K' \times \omega^{n'}$$

Equation number 2:

[1].Gap

$G'' = K'' \times \omega^{n''}$

In this equation, G' is the storage modulus (Pa), G" is the loss modulus (Pa), ω is the angular frequency (rad/s), K', K", n' and n" are constant values.

MCR300 rheometer was used to perform the creep test. Creep data were fitted using the Kelvin model according to equation 3. The Kelvin model is used in food industries to provide information about the internal structure of the product due to its simplicity and providing acceptable results. Therefore, in this research, gelatin system was used in the creep analysis

Equation number 3:

$$(t) = j_o + j_r \left[\left[1 - exp\left[-\frac{t}{\lambda ret} \right] \right] \right] + \frac{t}{\mu_N}$$

That J_O, immediate commitment module[2] ، J_r , delayed yield modulus[3]; l_{right}, Delay time[4] and m_N, Newtonian viscosity[5] Is.

2-2-4- Statistical analysis

Statistical analysis of rheological data and determination of coefficients was done with Rheouplus software and graphs were drawn with Microsoft Office Excel 2013 software. Data related to creep resistance test using Matlab2016 software with Berger model[6] Matched.

3. Results and Discussion

3-1- Strain scan test

Relative size of the storage module[7] (G') and loss modulus[8] (G") The different doors of jelly powder at 1 Hz frequency are shown in Figures 1 and 2. In this figure, the effect of the amount of sugar, stevia and gum per grain on the storage and loss modulus can be seen.

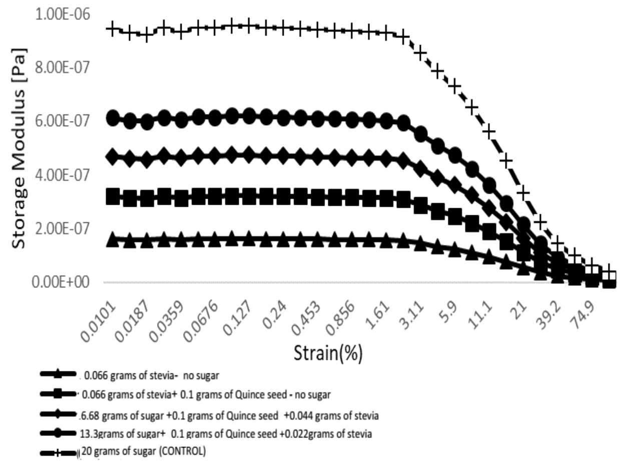

Fig 1 Storage modulus of jelly powder samples as a function of strain at 25˚C and at a constant frequency of 1 Hz.

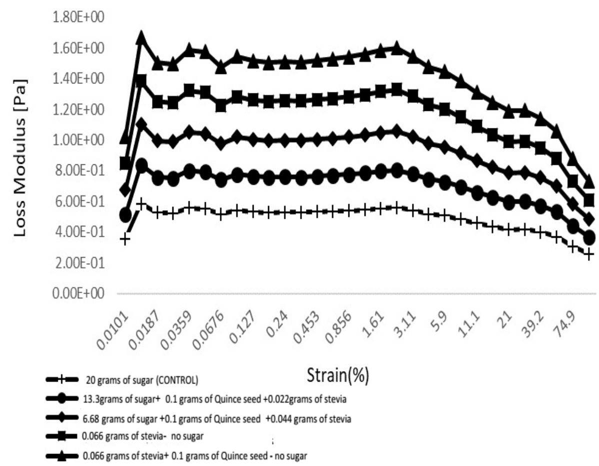

Fig 2 Loss modulus of jelly powder samples as a function of strain at 25˚C and at a constant frequency of 1 Hz.

The results showed that with increasing amount of stevia, the storage modulus decreased, so that the control sample without stevia had the highest storage modulus and the sample without sugar, with stevia and without gum to seed had the lowest storage modulus.

The linear viscoelastic range indicates the strength or weakness of the gel. The higher the value, the stronger the gel structure. If the elastic component is larger than the viscous component,

2. Instantaneous creep compliance
3. Retarded elastic compliance
4. Retardation time
5. Newtonian viscosity
6. Burger model
7. Elastic modulus
8. Viscous modulus

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it indicates a gel-like structure, and if the viscous component is larger, the material in this area shows liquid properties. In general, all the samples show viscous behavior because the drop modulus in all samples is greater than the storage modulus. is bigger and with the increase of strain, both the loss and storage modulus decrease.

The domain scan test provided data related to the linear viscoelastic behavior of materials through the determination of storage and loss moduli. Applied strain amplitude for linear viscoelastic region measurements[9] was limited to obtain a linear response regime[32 and 33]. The linear viscoelastic region was considered from 0.01 to 1% strain, where the moduli are independent of strain. Critical strain[10] It was observed in the range of about 1%.

3-2- Frequency scanning test

Storage and loss modules of jelly powder samples as a function of frequency at constant strain of 1% and temperature of 4°C are shown in Figures 3 and 4. The results showed that up to about 3% strain, the reaction of the samples is independent of the deformation range and the structure of the samples is preserved, while at concentrations higher than this value, with the increase in the frequency, the values of the moduli are somewhat reduced, and in total, the modulus of the drop has Higher values than the storage modulus.

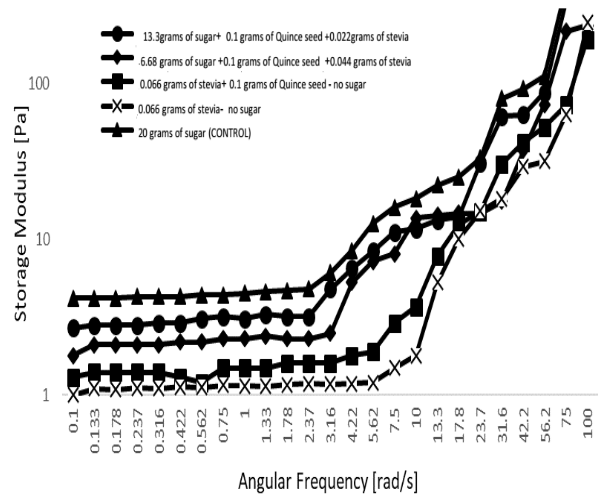

Fig 3 Storage modulus of jelly powder samples as a function of frequency at 25˚C and 1% constant strain

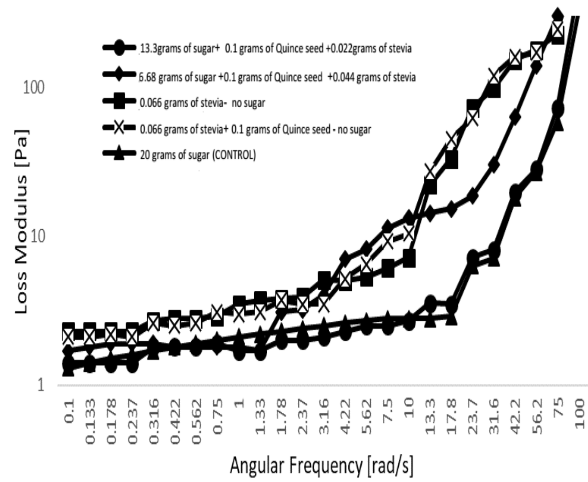

Fig 4 Loss modulus of jelly powder samples as a function of frequency at 25˚C and 1% constant strain

3-3- Tangent drop

Figure 5 shows tanθ as a function of frequency in different jelly powder samples. The ratio of G" to G' is the loss factor[11]They say that they represent with tan θ. In other words, storage modulus represents elastic properties, dissipation modulus represents viscous properties, and tangent theta represents a measure of behavior ratio, so that figures with tan θ slope less than 45 degrees have

[9]. Linear viscoelastic region

[10]. Critical strain

[11]. Loss factor

elastic properties and samples with tanθ greater than 45 degrees have more viscous properties. are displayed.

Elastic modulus not only indicates the ability to recover elastic deformation, but also indicates the amount of elastic potential energy. Loss factor or loss tangent (G"/G') is a factor that shows the ratio between the amount of energy lost during the test period to the amount of energy stored in the same test period.

According to the figure, the amount of drop tangent in the samples containing sugar was equal to or less than 1, considering that the drop factor in the case of real gels is about 0.01, so the treatments containing sugar investigated in this research can be classified in the pseudo-gel category. According to the figure below, the highest amount of drop factor is related to sugar-free treatments, which have higher viscous modulus than other treatments.

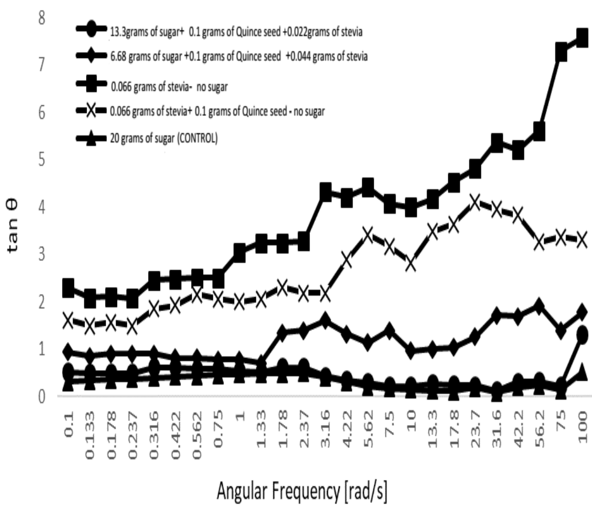

Fig 5 tanθ jelly powder samples as a function of frequency at 25˚C

3-4-power model

Both elastic modulus and loss can be considered as a function of frequency. Dependence of modules with frequency can be done using the power law[12]justified In foods that have a strong texture at low frequencies, G" may not follow the frequency. The power law relationship is only true at high frequencies.

For a real gel, the value of n′ is equal to zero, while for a physical gel, the value of n′ is higher than zero. A lower value of n′ indicates elastic gels, while values close to 1 for this parameter correspond to systems with viscous behavior. According to the results of Table 2, the parameter n′ was lower than n″ in all starch gel samples, and both parameters decreased with the increase of stevia. The lowest value of the parameter n′ was related to the control gel sample, which showed that this gel has characteristics close to a real gel and has the lowest frequency dependence. The values of n′ greater than 1 obtained for all samples indicated that all samples have viscous behavior.[34].

According to Table 2, K" values indicate that the viscous property of the samples is more subject to frequency than the elastic ability of the samples, so it is a sign of subjectivity. The high n index of the elastic modulus indicates more drastic changes in the behavior structure of the samples compared to the frequency, which is quite evident according to Figure 2 that at higher angular frequencies, the growth of the G" curve is more intense than the growth of the G" curve.[35].

Table 2 Changes in storage modulus (G ') loss modulus (G ") versus angular frequency changes for jelly samples based on sugar replacement percentage with Stevia

Sample based on sucrose replacement percentage	k´(Pa)	n´	R^2	k″ (Pa)	n″	R^2
Control	0.0282	1.1006	0.9722	0.1129	0.9988	0.9988

[12]. power law

25% Sucrose	0.0725	1.3381	0.8969	0.1104	1.068	0.9969
50% Sucrose	0.0358	1.4135	0.8786	0.1160	1.0969	0.9985
75% Sucrose	0.0295	1.7742	0.9944	0.1885	1.0236	0.9959
100% Sucrose	0.0434	1.9476	0.8909	0.1293	1.1707	0.9943

3-5-Creep

Although the Kelvin model shows the delayed elastic behavior well, it is not enough to describe the creep behavior of many biological materials. By combining the Kelvin model with the Maxwell model, the fourth Berger element model is obtained as a series, which describes the creep behavior better. The reason of having an independent spring can show the initial elastic behavior during the creep test. Also, due to having an independent spring, this model is able to show the Newtonian behavior after a long period of time.

The results according to Table 3 and Figure 6 show that the lowest amount of immediate and delayed yield modulus of the witness sample is consistent with the results obtained from the frequency sweep test, because in the said test, the highest amount of reserve modulus is also It was related to control samples. Also the results of λ_{right} It shows that the samples in which sucrose is replaced with a high percentage of stevia (75 and 100%) will have the longest time required to reach the initial strain and the highest Newtonian viscosity, which is due to Their viscous modulus was higher in the frequency sweep test, which seems reasonable.

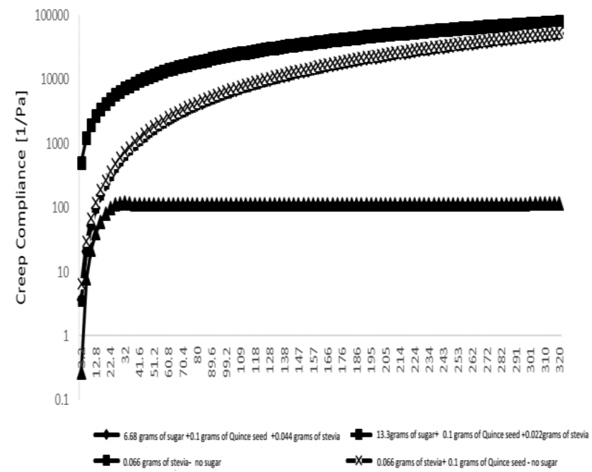

Fig 6 Comparison of burger model with laboratory data obtained from creep test for control and different samples of jelly

In general, it can be concluded that the addition of stevia has caused the strength of the produced gel to decrease and the viscous behavior will prevail over the elastic one, and sucrose and gum to the grain have increased the strength and the elastic behavior will prevail over the viscose one.

Table 3 Berger Model Factors for Jelly Samples Based on Sugar Replacement Percentage Stevia

Sample	J_O	J_r	l_{right}	m_N	R^2	RMSE
Control	0.74	0.59	0.013	381.7	0.99	0.02
25% Sucrose	0.66	0.33	0.014	211.3	0.98	0.1
50% Sucrose	0.59	0.32	0.014	281.9	0.96	0.12
75% Sucrose	0.41	0.31	0.015	414.3	0.96	0.07
100% Sucrose	0.37	0.20	0.200	415.2	0.97	0.13

4 - Conclusion

The results of adding stevia and gum to the jelly powder sample showed that increasing the percentage of stevia decreased the storage modulus, so that the control sample had the highest storage modulus and the highest elastic behavior, and the sugar-free samples had the most viscous behavior as well. The addition of gum to the grain also increased the elastic behavior, but the increase in the behavior was less than that of sugar. The Newtonian viscosity increased with the increase of stevia content, while the immediate and delayed elastic modulus decreased with the increase of stevia content. In general, it can be said that jelly powder containing stevia can be introduced as a low-calorie food item in such a way that only part of the sugar is replaced by stevia, with rheological characteristics similar to the control sample in people's diet.

5-Resources

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مقاله علمی-پژوهشی

بررسی تاثیر جایگزینی شیرین کننده استویا و افزودن صمغ به دانه بر خواص رئولوژیکی ژله

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چکیده

کاربرد عوامل شیرین کننده و قوام دهنده جایگزین شکر در محصولات غذایی اگرچه در کاهش کالری موثر است ولی معمولا با تغییر بافت محصول همراه است. در این تحقیق کاهش شکر در فرمولاسیون پودر ژله با استفاده از استویا به عنوان یک ترکیب شیرین کننده قوی و صمغ به دانه بر ویژگیهای کیفی محصولبه منظور بررسی امکان جایگزینی استویا با شکر مورد بررسی قرارگرفت. درصدهای مختلف استویا(۰، ۲۵، ۵۰، ۷۵ و ۱۰۰ درصد شکر) همراه با صمغ به دانه تهیه شد و نمونه های ژله از نظر ویژگی های رئولوژیکی با استفاده از اندازه گیری آزمون روبش کرنش در فرکانس ثابت ۱ هرتز، روبش فرکانس در کـرنش ۰/۱ درصد و دامنه فرکانس ۰/۱ تا ۱۰ ، آزمون خزش و معادله توان مورد ارزیابی قرار گرفتند. نتایج حاصل از افزودن استویا و صمغ به دانه به نمونه پودر ژله نشان داد که افزایش درصد استویا باعث کاهش مدول ذخیره گردیده است در حالی که وجود شکر و به دانه در فرمولاسیون پودر ژله سبب افزایش مدول ذخیره ای شد. ویسکوزیته نیوتنی نمونه ها با افزایش میزان استویا افزایش در حالی که مدول وادادگی فوری و تاخیری با افزایش میزان استویا، کاهش یافتند. نتایج نشان داد که جایگزین نمودن قسمتی از شکر با استویا در پودر ژله می تواند علاوه بر کاهش میزان کالری آن می تواند سبب تغییرات عمده ای در ویژگی های رئولوژیکی پودر ژله و کاهش مدول الاستیک و افزایش مدول ویسکوز آن شده که با تنظیم مقدار جایگزینی شکر با استویا می توان از آن به عنوان جایگزین تجاری آن در صنعت استفاده نمود.