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Comparative Study of Physico-Chemical Properties of Babool (*Acacia nilotica*) and Karaya (*Sterculia urens* Roxb.) Gums

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ABSTRACT

Study of the physico-chemical properties of natural gums is a prerequisite to understanding the nutritional, culinary and commercial value and their utilization. The main objective of the present piece of work was to determine some important physico-chemical properties of babool (*Acacia nilotica*) and karaya (*Sterculia urens* Roxb.) gum. The physico-chemical properties of babool and karaya gums were determined by using standard methods and the data obtained was analyzed for comparison of both the gums. The investigation revealed that there were significant differences in the percentage of swelling index, water holding capacity, solubility, moisture content, porosity, ash content, pH and protein. Although there were no significant differences obtained in the values of true density, bulk density, angle of repose, refractive index, coefficient of friction, and fat between the two test samples. The protein and nitrogen content of babool gum were superior to those of karaya gum. Water holding and oil holding capacity were superior in karaya gum to babool gum. The viscosity of babool gum was decreased with the decrease in shear rate, whereas the viscosity of karaya gum increased with the decrease in shear rate. Data generated from the study confirms that there are a number of similarities in some properties and differences in other properties of both the test gum exudates.

Keywords *Acacia nilotica*, Karaya gum, Natural gums, Physico-chemical properties, Viscosity.

INTRODUCTION

Botanically, gum is an adhering substance of vegetable origin, mostly acquired as exudate from the bark of trees or shrubs belonging to the family Fabaceae (Leguminosae). Gums are a group of plant products, established primarily due to the disintegration of plant cellulose, also known as gummosis. Gums are bio-polymeric materials composed of complex hetero polysaccharides and proteinaceous materials (Phillips and Williams 2000). Gums are essentially divided into grade-I of karaya and grade-II of babool, dhawada

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(*Anogeissus latifolia*) and khair (*Acacia catechu*) in the Chhattisgarh state. *Acacia nilotica/*acacia gum/ gum arabic is a gummy dried exudate that gathers from the surfaces of the branches and the stems of the acacia trees. Karaya gum is the chief hydrocolloid from India and this gum is an exudate from the *Sterculia urens* tree.

Acacia nilotica (Indian gum arabic) belongs to the family Leguminosae and sub family Mimosaceae. It is indigenously known as Babool or Kikar. It releases from the wounds in bark. It is normally released between the months of March and May. *Acacia nilotica* has been acknowledged worldwide as a multipurpose tree (Raj *et al.* 2015). The physical and chemical properties of acacia gum make it unique from other natural gums, and that is why it has very important uses in the food industry. The gum contains L-arabinose, L-rhamnose, galactose and four aldobionic acids. Acacia gum is also used in non-food industries for instance in modern pharmacy where it is commonly employed as a binder, demulcent, emulsifier or for film-forming. Acacia gum is a complex composition of glycoproteins and polysaccharides predominantly consisting of arabinose and galactose. Acacia gum is a lead ingredient in traditional lithography and is used in glue, paint production, cosmetics, printing and numerous industrial applications (Chikamai *et al.* 2009).

Gum karaya also known as Indian tragacanth secured from *Sterculia urens* Roxburgh (Family –Sterculiaceae). The indigenous names of karaya gum are gulu, kadaya, katera, kullo, and tapsi. The major part of commercial karaya gum is procured from *S. urens*. All parts of the karaya tree discharge a soft gum when wounded. It contains approximately 8% of acetyl groups and 40% uronic acid residues. Gum karaya is well suited for maintaining low pH emulsions, such as dressings and sauces. It is mainly utilized as an ingredient in the preparation of denture fixative powders, bulk laxatives, emulsions, lotions, as a pulp binder in the formation of thin paper-sand suspension properties (Setia *et al.* 2010).

There has been increasing attention to the use of hydrocolloids, particularly for the gums. Natural gums have many advantages over synthetic polymer, such as biocompatibility, low cost and low toxicity (eco-friendliness). Looking at the above properties and their utilization in a vast era, the objective of the present study was to extend the knowledge concerning the physico-chemical properties of babool gum and karaya gum. To attain this objective, the determination and comparison of physico-chemical properties of both the test gums were performed.

MATERIALS AND METHODS

Collection of plant exudates

The exudates of babool (*Acacia nilotica*) and karaya (*Sterculia urens* Roxb.) gum samples were procured from the Network Project on Harvesting, Processing, and Value Addition of Natural Resin and Gums operational at IGKV, Raipur, Chhattisgarh.

Preparation of sample

Gum samples were cleaned and dried properly under sun drying (Figs. 1-2) and then pulverized with the help of a laboratory crusher to convert the samples into uniform grit sizes. The powder obtained was then passed through a sieve (mesh size – BSS 22). A gum sample was stored in an airtight plastic bag until further use.

Experimental site

The work was carried out in the Department of Agricultural Processing and Food Engineering, Swami Vivekanand College of Agricultural Engineering and Technology and Research Station, Faculty of Agricultural Engineering, Department of Plant Physiology, Agricultural Bio-Chemistry, Medicinal and Aromatic Plants, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh).

Determination of physico-chemical properties

Moisture content (dry basis) was calculated using method described in AOAC (2010). The true density of the babool and karaya gum powder samples was determined by using the toluene displacement method (Mohsenin 1980). Bulk density of the test gums was found out using method narrated in WHO (2012). The tap density was acquired by softly tapping a graduated

Fig. 1

Fig. 2

Fig. 1. Babool gum. **Fig. 2.** Karaya gum.

measuring cylinder containing the sample of gum powder (Reddy *et al*. 2015). Porosity is explained as the percentage of void space in the bulk material not occupied by the material (Singhal and Samuel 2003). Bulkiness is the reciprocal of bulk density (Yadav *et al.* 2015). The Hausner's ratio was calculated using the formula given by Yadav *et al.* (2015). Carr's compressibility index was determined using the values of apparent density and tap density with the help of the relationship as stated by Reddy *et al*. (2015).

The swelling index of babool and karaya gum granules was determined by the method described by Gauthami and Bhat (1992) and the formula given below (Kumar *et al.* 2011).

$$SI = \left(\frac{X_o - X_t}{X_o}\right) \times 100 \qquad (1)$$

Where, SI = Swelling index (%), X_o = Initial volume of gum (ml), X_t = Volume occupied by swollen gum powder after 24 h (ml).

The angle of repose was determined using the standard procedure and calculation was carried out using following equation (Sahu *et al.* 2019).

$$\theta = \tan^{-1}\left(\frac{h}{r}\right) \qquad (2)$$

Where, θ = Angle of repose in degree, h = Height of the gum heap formed on circular plate in cm, r = Radius of the circular plate in cm.

The static coefficient of friction 'μ' was determined for three different structural materials, viz., glass, metal, and rubber by using a tilting table method. The gum powder was filled in the sample box and placed parallel to the direction of motion and then tilt the table slightly. The coefficient of friction (μ) was calculated as the tangent of angle using the relationship given below (Alonge and Udofot 2012).

$$\mu = \tan\theta \qquad (3)$$

The viscosity of test gums was determined and calculated for the 1% and 3% aqueous solutions at a temperature range of 10 to 60ºC at an interval of 10ºC temperature and at rotational speed (0.5 to 100 rpm) of spindle no. 61 through the Brookfield DV-E Viscometer (Sinha 2017). In order to maintain the desired temperature, a hot and cold water bath attached to the instrument was used. The ash content was estimated by the method described in AOAC (2010). The pH of gums was determined using a pH analyzer (ELICO LI614). It was determined with a 1.0% aqueous solution of gums under room temperature (Ameh 2012). The refractive index of gum samples was measured in filtered 1% aqueous solution using an automatic refractometer (DG-NXT) as described by Dib *et al.* (2008). The solubility index is expressed as the percentage solubility of gum in the solvents (Mohsenin 1980).

$$\text{Solubility index (\%)} = \frac{W_{ds}}{W_s} \times 100 \quad (4)$$

Where, W_{ds}= Weight of dissolve gum sample in solution (g), W_s= Weight of gum sample (g).

Water holding and oil holding capacities were determined using the REMI R-8C BL centrifuge as per the method described by Sarkar *et al*. (2018).

$$WHC = (SSW\text{-}SW)/SW \quad (5)$$
$$OHC = (OSW\text{-}SW)/SW \quad (6)$$

Where, SSW = Weight of swollen sample, SW = Weight of sample, OSW = Weight of oil absorbed sample.

Crude protein was determined by the Micro-Kjeldahl method (AOAC 2010). According to AOAC (2010), fat content of babool and karaya gum was determined by the soxhlet plus solvent/ fat extraction method.

RESULTS AND DISCUSSION

The findings of the different physico-chemical properties of babool and karaya gums are depicted in Table 1. In order to minimize the experimental error, the mean values along with the standard deviation (SD) were taken.

Moisture content

The moisture content of babool and karaya gums was recorded to be 14.31 and 16.54% (db), respectively (Table 1). Makki *et al.* (2018) reported that the moisture content of babool gum in different parts of Sudan ranges from 11.86 to 18.89%. The values of moisture content of babool gum were observed to be close to the values (15.91±0.42% (wb)) reported by Sinha (2017). The moisture content on a dry basis of the karaya gum was lower than the value (17.47±0.44%, wb) reported by Sahu *et al.* (2019). The dry matter

Table 1. Physico-chemical properties of babool and karaya gums.

Sl. No.	Physico-chemical properties	Babool gum		Karaya gum	
		Mean	SD	Mean	SD
1	Moisture content (%, db)	14.31	0.83	16.54	0.33
2	Average dry matter (%)	85.69	0.61	83.46	0.19
3	True density (g/cm^3)	1.26	0.07	1.38	0.17
4	Bulk density (g/cm^3)	0.72	0.01	0.68	0.01
5	Tap density (g/cm^3)	0.78	0.01	0.73	0.01
6	Porosity (%)	42.90	2.53	50.70	5.51
7	Bulkiness (ml/g)	1.38	0.01	1.47	0.01
8	Hausner's ratio	1.08	0.01	1.07	0.01
9	Carr's compressibility index (%)	7.69	0.31	6.85	0.11
10	Swelling index (%)	31.81	6.43	125.5	4.94
11	Angle of repose (°)	44.33	1.15	44.98	1.14
12	Coefficient of friction (N)				
	Glass	0.39	0.01	0.38	0.02
	Mild steel	0.45	0.02	0.45	0.01
	Rubber	0.47	0.01	0.49	0.01
13	Ash content (%)	3.53	0.04	6.02	0.04
14	pH	4.58	0.10	5.47	0.08
15	Refractive index (%)	1.333	0.00	1.334	0.21
16	Solubility (%, per 100 ml)				
	Hot water	56	1.41	28	1.41
	Cold water	32.50	0.71	4.35	0.21
	Acetone	0	-	0	-
	Chloroform	0	-	0	-
	Ethanol	0	-	0	-
17	Water holding capacity (%, per 100 ml)	8.05	0.21	90.80	1.55
18	Oil holding capacity (%, per 100 ml)	12.35	4.17	16.40	0.29
19	Protein content (%)	2.48	0.07	0.74	0.05
20	Nitrogen content (%)	0.37	0.01	0.11	0.01
21	Fat (%)	0.60	0.14	0.48	0.12

was determined as 85.69% for babool and 83.46% for karaya gum.

True density

The values of true density for babool and karaya gum powder/granules were obtained as 1.26 g/cm^3 and 1.38 g/cm^3, respectively (Table 1). It indicates that the true density values for both the gum samples are nearly equal. The values were in close agreement with the values reported by Sarkar *et al.* (2018) for these gums.

Bulk density

The bulk density of babool and karaya gum powder/granules was determined to be 0.72 and 0.68 g/cm^3, respectively. The bulk density values obtained for both the gums are close to the values reported by Sinha (2017) and Sahu *et al.* (2019) for these gums.

Tap density

The tap density for babool and karaya gum powder/granules resulted from these experiments was 0.78 and 0.73 g/cm^3, respectively. Bhushette and Annapure (2017) has studied the tap density of *Acacia nilotica* and commercially available acacia gum and reported a value of 0.88 and 0.52 g/cm^3, respectively. It is worth mentioning here that the value of tap density is very much dependent on the granule or powder characteristics of the gums.

Porosity

The average porosity value of babool and karaya gum granules was determined to be 42.90 and 50.70%, respectively. Higher porosity of karaya gum may result in rapid loss of internal temperature during storage or processing with ease in heat and mass transfer during drying, whereas lower porosity may result in slower loss of internal temperature. Sinha (2017) mentioned that the porosity of babool gum was 54.82%, which is higher than the values obtained in this analysis. Sahu *et al.* (2019) investigated that the porosity of karaya gum (46.76%), which is slightly lower than the present result. This may be because granule size affects the porosity values of gum granules.

Bulkiness

The value of bulkiness of babool gum granules was found to be 1.38 ml/g, whereas for karaya gum it was 1.47 ml/g. This result indicated that the powder is lighter in nature. The babool gum is less bulky than the karaya gum, but there is no appreciable difference between them. The bulkiness for karaya gum reported by Sahu *et al.* (2019) is slightly less than the value obtained in this study.

Hausner's ratio (H)

The Hausner's ratio is an indirect indicator of powder flow. The Hausner's ratio of babool and karaya gum powder was noted to be dependent on tap and bulk density, and the value obtained in this study was 1.08 and 1.07 for babool gum and karaya gum, respectively (Table 1). Hausner's index of *Acacia nilotica* and commercially available acacia gum investigated by Bhushette and Annapure (2017) was found to be 1.324 and 1.287, respectively. The Hausner's ratio for both the gums indicates good flow property. Hausner's ratio of less than 1.25 is considered to have better flow properties (Reddy *et al.* 2015).

Compressibility (Carr's) index

The bulk density and tap density of any free-flowing powder influence the carr's compressibility index. It can be seen (Table 1) that the carr's compressibility index for both the test gums babool and karaya was found to be 7.69 and 6.85%, respectively. Carr's index value up to 15 usually describes the excellent flow properties of the materials (Reddy *et al.* 2015). The compressibility (Carr's) index of babool and karaya gum granules/powder are similar and have fair flow properties.

Swelling index

Swelling capacity is the measure of the starch's ability to absorb water and swell, as well as reflect the extent of associative forces in the starch granules. It is an indication of the non-covalent bond between the molecules of starch granules. The swelling index of babool and karaya gums was found to be 31.81 and 125.5%, respectively (Table 1). The swelling index of karaya gum is higher than that of babool gum, which indicates more water absorption compared to babool gum. The swelling index of karaya gum was resulted in the range of 22.33 to 69 ml/min for different grades of sample (Poosarla and Muralikrishna 2017). The swelling index of these gums is much lower than the value reported for Charota (*Cassia tora*) gum (Sonwani *et al.* 2018).

Angle of repose

Angle of repose for any free-flowing material is important as it is effectively used in many design considerations and process operations. The angle of repose of babool and karaya gum granules was determined to be 44.33° and 44.98°, respectively (Table 1). The angle of repose values for both the babool and karaya gums were reported to be 39.05° and 38.73° by Sarkar *et al.* (2018) while analyzing the physico-chemical and functional properties of some natural Indian gums. In another study for karaya gum has, the reported value was 47.27 ± 2.91°, by Sahu *et al.* (2019) which is close to the value obtained in the present research.

Coefficient of friction

The coefficient of friction of babool and karaya gum was measured for three frictional surfaces, namely glass, mild steel, and rubber, and the results are presented in Table 1. It can be seen (Table 1) that the values of the coefficient of friction of both the gums are at par on the different surfaces used under study. The highest value was obtained for the rubber surface and the lowest for the glass surface for both the gums. Similar type of finding has been reported by earlier researcher (Sarkar *et al.* 2018).

Ash content

The ash content in both the test gums was obtained as 3.53 and 6.02%, respectively. The result indicates that the content of foreign matters or minerals is higher in karaya compared to babool gum. The higher mineral content increases the wider application of gum in pharmaceutical uses. The ash content (2-4%) of gum arabic (babool gum) was investigated by Lelon *et al.* (2010), which is similar to the present findings. Karaya gum has an ash content of 4.62%, according to Sahu *et al.* (2019).

pH value

The pH values of the babool and karaya gum samples were determined to be 4.58 and 5.47, respectively (Table 1), which indicates both the gums are acidic in nature. The pH range of 4.5-5.5 for babool gum has been reported by Azanu *et al.* (2019) and found to be close to the present findings. Sahu *et al.* (2019) reported 4.26 for karaya gum, and Poosarla and Muralikrishna (2017) gives a pH range of 6.7-7.2 for dark brown colored karaya gum.

Refractive index

The value of the refractive index for babool and karaya was observed to be 1.333 and 1.334, respectively. Sahu *et al.* (2019) have reported a closer value of the refractive index for karaya gum samples. Yousif *et al.* (2017) also estimated the refractive index to be 1.34-1.35 of guar gum.

Fat

It can be seen from Table 1 that the babool gum has a little higher content of fat (0.60%) as compared to karaya gum (0.48%). However, there is no appreciable difference in the fat content of both the gums. Bhushette and Annapure (2017) investigated whether the fat content in *Acacia nilotica* (Babool gum) was 0%. Yadav *et al.* (2015) reported similar types of findings in the mucilage of karaya gum. There is a negligible amount of fat present in both the gums.

Solubility

The solubility of babool and karaya gum was determined by using various solvents such as hot water, cold water, ethanol, acetone, and chloroform. Solubility is the most reliable criteria to evaluate the behavior of a powder in an aqueous solution. The solubility of babool and karaya gums was 56 and 28% in hot water and 32.5 and 4.35% in cold water, indicating superior solubility of babool gum than karaya gum (Table 1). The samples of both the gums were observed to be insoluble in the case of other organic solvents, namely, ethanol, acetone, and chloroform, which confirm the findings obtained by Yadav *et al.* (2015) and Eddy *et al.* (2012).

Water holding (WHC) and oil holding (OHC) capacity

The hydrophilic properties of both the gums have been indicated in terms of water holding capacity or hydration capacity. It can be seen (Table 1) that the value of the water holding capacity of babool and karaya gums was obtained to be 8.05% per 100 ml and 90.8% per 100 ml, respectively. This indicates that the water holding capacity of karaya gum is excellent and much higher than babool gum, which shows more hydrophilic constituents such as polysaccharides in karaya gum. An increase in WHC has always been associated with an increase in amylose leaching and solubility as well as loss of starch crystalline structure. The oil holding capacity (OHC) of babool and karaya gum were found to be 12.35% per 100 ml and 16.40% per 100 ml, respectively. This indicates the superiority of karaya gum in comparison to babool gum.

Nitrogen and protein

The nitrogen and protein contents in babool gum were found to be 0.37 and 2.48%, respectively (Table 1). The values of nitrogen and protein in acacia seyal obtained by Ibrahim *et al.* (2013) are slightly lower than in this investigation. The nitrogen and protein content of *Acacia senegal* (babool gum) was analyzed by Makki *et al.* (2018) and reported the values of gums ranging between 0.28-0.38% (nitrogen) and 1.85-2.51% (protein), which is almost close to the mentioned result. The nitrogen and protein content of karaya gum were determined to be 0.11 and 0.74%, respectively. These values are slightly lower than the values reported by Sahu *et al.* (2019) for karaya gum. Both the values for babool gum are comparatively higher than the values for karaya gum.

Viscosity

It can be depicted in Fig. 3 that the viscosity of babool gum decreased with the decrease in shear rate at 1% and 3% concentrations at a temperature of 30°C. This was potentially due to babool gum tending to dissolve in water with respect to time, so its viscosity decreases. The result of the viscosity of karaya gum is shown in Fig. 4. It can be seen that the viscosity was reversed in trend to that of babool gum. In karaya gum, the viscosity increases with the decrease in shear rate, i.e., the decrease in rotational speed at 1% and 3% gum concentration. This may be because of karaya gum swell-up in water with respect to time. It can be seen that with the increase in shear rate, the viscosity decreased for both the concentrations at room temperature (30°C). However, these findings need to be validated with different samples. On the determination of the viscosity of gums, not much work has been reported. Efforts have been made to understand the effect of temperature on the viscosity of both the test gums for the temperature range of 10 to 60°C under a shear rate of 0.5 to 100 s^{-1}. The results of the experiments have been shown in Figs. 5-6. It is clear from Fig. 5 that as the temperature increased along with the decrease in shear rate, the viscosity of babool gum decreased. As the temperature increases from 10 to 60°C in babool gum, viscosity drops to

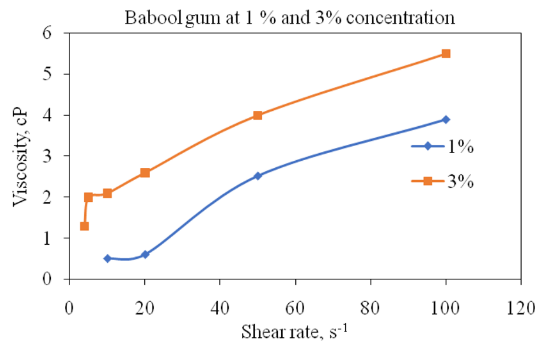

Fig. 3. Effect of shear rate on viscosity of babool gum at room temperature (30 °C).

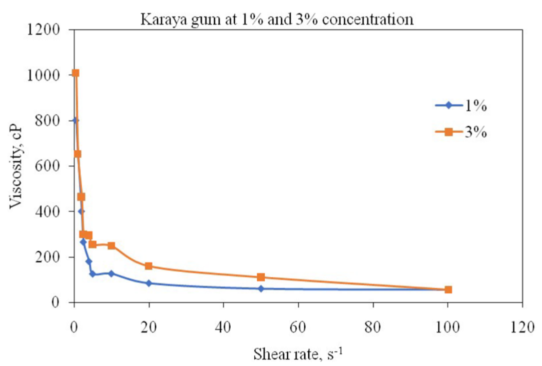

Fig. 4. Effect of shear rate on viscosity of karaya gum at room temperature (30 °C).

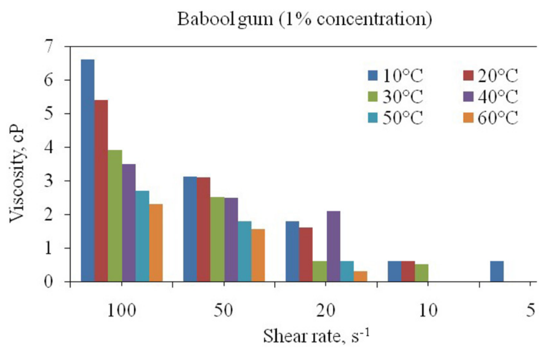

Fig. 5. Variation in viscosity with different temperature and rotational speed for babool gum.

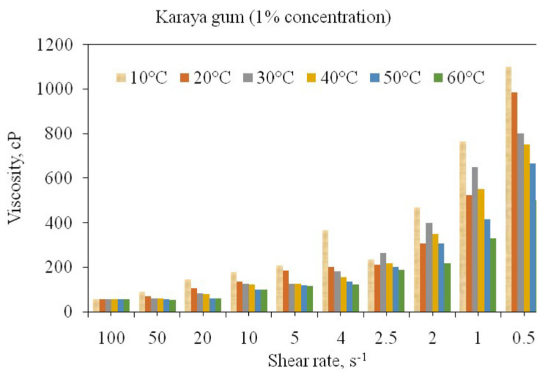

Fig. 6. Variation in viscosity with different temperature and rotational speed of karaya gum.

65.15%, i.e., from 6.6 to 2.3 cP at 100 s^{-1}. It can be seen that both the spindle rpm and temperature of the solution had a visible effect on viscosity. In the case of babool gum solution, the viscosity reading could not be observed below the shear rate of 5 s^{-1}, which indicates no resistance to the solution. According to Phillips and Williams (2000), the viscosity of a 1% aqueous solution of high-grade gum decreased upon heating. In babool gum, no result is noticed at lower rotational speed (shear rate). An increase in temperature from 10 to 60ºC (0.5 s^{-1}) will be accompanied by 54.36% drop in viscosity, from 1100 to 502 cP in karaya gum. Poosarla and Muralikrishna (2017) studied the viscosity of karaya gum and found that it is 1830 cps/min for freshly procured gum at 25ºC (20 rpm).

CONCLUSION

The physico-chemical properties of the babool and karaya gums revealed that they possessed similarities in some of the properties and dissimilarities in some of the properties. The protein and nitrogen content of babool gum are superior to karayam gum. Karaya gum's water and oil-holding capacity is superior to babool gum. The viscosity of babool gum was decreased with the decrease in shear rate, whereas the viscosity of karaya gum increased with the decrease in shear rate. The results of this study support the suitability of gum for medications, culinary, nutritional, detoxifying, and therapeutic industries. The physico-chemical properties of babool and karaya gum are suitable for thickening, adhesive, binding, and stabilizing in food applications.

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