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VISCOSITY OF SOME ACACIAS GUM AND RELATIONSHIP TO POTASSIUM CHLORIDE AND CALCIUM CHLORIDE

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ABSTRACT

Background Gum arabic is a complex polysaccharide that has food, pharmaceutical and technical applications; its known uses go back about 5,000 years. The development of the processing industry over the last three years has resulted in increased domestic competition for raw gum, and in turn better prices paid to farmers as well as more value added captured in Sudan. This positive development comes at a propitious time as increased consumption of soft drinks and confectionary products, as well as rapid development of health and dietetic products is boosting the world demand for gum arabic.

Methodology Brookfield viscometer was used to investigate the viscosity of gum solutions *Acacia senegal*, *Acacia seyal* and *Acacia polycantha* with potassium chloride (KCl) and calcium chloride ($CaCl_2$) at different gum concentrations i.e. 10, 15, 20, 25, 30 and 35%, respectively.

Results Interaction was found between salts and gum solutions for three species. As the gum concentration increased, a significant increase in viscosity values was observed for all gum mixtures. The addition of KCl and $CaCl_2$ increased the viscosity of gum arabic solution.

Conclusion Gum viscosity could be increased significantly by adding salt, particularly KCl.

INTRODUCTION

Gum arabic (*Acacia* species) is the exudate obtained from the various species of the genus *Acacia* (Kaddam et al. 2020). There are about 1100 species distributed over tropical and sub-tropical areas of Africa, India, Australia and America. International specification identifies gum arabic as a dried exudate obtained from the stems and branches of *Acacia senegal* (L.) Willd. or *Acacia seyal* (Khaliq et al. 2015). The quality of gum arabic is affected by botanical origin, individual tree differences, environmental factors such as climatic and soil conditions, and harvest and post-harvest handlings. It is obvious that gums from different species (*A. senegal* and *A. seyal*) exhibited the characteristics that are intrinsically different. Even within the same species, different varieties and individuals of different provenances produce gum with different characteristics. Recognizing these differences in the species, varieties and environment is important in producing gum arabic for a desired end use (Lemenih 2005; Khan et al. 2016). Gums have been used in diverse ways in the food industry as stabilizing and texture enhancing agents while improving the organoleptic quality of food. These properties of gums have been the main focus of research over the years. Gums are classified according to their source of extraction, chemical structure and physical characteristics. Due to the presence of the hydroxyl group and their hydrophilic nature, gums are able to impact viscosity or gelling properties to their media (da Silva et al. 2020). The present study was planned with the objective to investigate the effect of potassium chloride (KCl) and calcium chloride ($CaCl_2$) on gum arabic (*Acacia* species).

MATERIALS AND METHODS

The experiment was carried out at the laboratory of Forestry and Gum Arabic Research Centre, Agriculture Research Corporation, Soba, Khartoum, Sudan. Sample of gum nodules were collected from Kordoufan state in Sudan during the dry seasons from three varieties of *Acacia* trees *A. senegal, A. seyal* and

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A. polycatha. The samples were air dried at room temperature, and ground using a blender and kept in plastic containers to be ready for preparation of gum solutions. Gum solutions of different concentrations viz 10, 15, 20, 25, 30 and 35% were prepared. Two grams of KCl salt and $CaCl_2$ salt were added to the different concentrations of gum solutions, each on an individual basis. Viscosity and pH of the different gum solutions were measured using Brookfield viscometer (MYR viscometer-version L spindle 3, speed 200 rpm) and pH-meter. The data were analyzed using the Microsoft Excel 2007 computer software.

RESULTS AND DISCUSSION

Viscosity is the thickness and adhesiveness of a solution. It can range from high viscosity (thick gel) to a low viscosity (slightly gelled). Solutions are easily prepared containing up to 37% gum arabic at 25°C, and this solubility is responsible for its excellent stabilizing and emulsifying properties when it is combined with large amounts of insoluble material (BeMiller and Whistler 2012).

The concentration trend on the solution viscosity of gum is presented in Figure 1, 2 and 3. Results revealed a clear effect of adding KCl and $CaCl_2$ on viscosity and acidity of the gum solution for all gum types used in the experiment. The viscosity of gum increased significantly with a decrease in the acidity of the solution. Data presented in Table 1 depicted that adding the two types of salt to the *Acacia senegal* gum solutions resulted in significantly higher viscosity of the solution with increasing the concentration of gum

Table 1 Effect of KCl and $CaCl_2$ on viscosity and pH of *Acacia senegal* gum

Treatments	Concentration	Viscosity	pH
Control (Pure gum)	10	50	4.95
Gum with KCl	10	90	3.9
	15	110	3.8
	20	120	3.95
	25	150	3.85
	30	170	3.77
	35	190	3.73
Gum with CaCl2	10	80	3.87
	15	120	3.71
	20	130	3.66
	25	140	3.63
	30	160	3.58
	35	240	3.55

Table 2 Relationship between the salt, concentration of gum arabic solution and viscosity of *Acacia senegal* gum

Treatments	Equation	R^2
Pure gum	Viscosity = 21.14 x + 12.67	0.98
Gum with KCl	Viscosity = 20.29 x + 67.33	0.98
Gum with $CaCl_2$	Viscosity = 26.57 x + 52	0.86

Table 3 Effect of KCl and $CaCl_2$ on viscosity and pH of *Acacia seyal* gum

Treatments	Concentration	Viscosity	pH
Pure gum	10	40	5.23
Gum with KCl	10	70	4.37
	15	90	4.21
	20	100	4.13
	25	130	4.8
	30	200	3.98
	35	350	3.97
Gum with $CaCl_2$	10	70	4.03
	15	80	3.97
	20	90	3.98
	25	110	3.94
	30	190	3.91
	35	270	3.91

compared to the viscosity of the gum solutions without adding the salt. In spite of increasing the viscosity of the gum after the addition of KCl it had same trend as the increasing in viscosity of the gum without the addition of salt with increasing concentration. The trend of increasing in gum viscosity when adding calcium chloride had different pattern, and these results were reflected by the linear relationship and equations (Table 2). The viscosity of gum arabic solution is affected by pH, addition of salts or other electrolytes (Addisalem et al. 2016a). BeMiller and Whistler (2012) reported that the addition of calcium chloride lowered the viscosity of gum arabic solutions, but as the calcium chloride concentration increased the viscosity started to increase.

Data presented in Table 3 showed the higher effect of the KCl on the viscosity of *Acacia seyal* gum solution compared to the gum solution after the addition of $CaCl_2$, especially when the gum concentration was increased in the solution. A linear relationship between viscosity and concentration of gum solution for concentrations of 10% up to 35% in *Acacia seyal* gum solution was found (Table 4). The addition of KCl and $CaCl_2$ to *Acacia polycantha* gum solution resulted in a slight increase in viscosity of the gums (Table 5). However, the increase in gum viscosity was higher when the gum concentration increased in solution (30%) after adding salt. There was a linear relationship between viscosity and concentration of gum solution for concentrations of 10% up to 35% with very good fit (Table 6). These result were in agreement with Coppen (2005) and Addisalem et al. (2016b) who claimed that gum arabic solutions exhibited Newtonian behavior that could be expressed by a linear relationship between viscosity and concentration of up to 35%. It was explained by the fact that the latter were linear molecules and intermolecular entanglements could readily occur while this was not the case for the highly compact, branched gum arabic molecules.

The pH ranged from 4.95 to 4.61, 5.23 to 4.91 and 4.20 to 3.9 for pure gum solutions of *Acacia senegal*, *Acacia seyal and Acacia polycantha*, respectively. After addition of salt to gum solutions, pH decreased with increasing of gum concentration and the range of pH become with the addition KCl 3.9 to 3.73, 4.37 to 3.97, 4.3 to 3.93 for *Acacia senegal*, *Acacia seyal and Acacia polycantha*, respectively. The range of pH in the presence of $CaCl_2$ was 3.87 to 3.55, 4.03 to 3.91, 4.17 to 3.84 for *Acacia senegal*, *Acacia seyal and Acacia polycantha*, respectively (Table 1, 3 and 5). Similar results were reported by BeMiller and

Table 4 The relationship between salt, concentration of gum arabic solution and viscosity of *Acacia seyal* gum

Treatments	**Equation**	R^2
Pure gum	Viscosity = 38.28 x + 27.33	0.82
Gum with KCl	Viscosity = 50.28 x + 19.33	0.80
Gum with $CaCl_2$	Viscosity = 38.57 x	0.83

Table 5 Effect of KCl and $CaCl_2$ on viscosity and pH of *Acacia polycantha* gum

Treatments	**Concentration**	**Viscosity**	**pH**
Pure gum	10	100	4.20
Gum with KCl	10	100	4.3
	15	120	4.18
	20	130	4.04
	25	150	3.96
	30	210	3.96
	35	420	3.96
Gum with $CaCl_2$	10	120	4.17
	15	130	4.10
	20	140	3.98
	25	150	3.94
	30	230	3.89
	35	530	3.84

Table 6 The relationship between salt, concentration of gum arabic solution and viscosity of *Acacia polycantha* gum

Treatments	**Equation**	R^2
Pure gum	Viscosity = 46.57 x + 8.67	0.67
Gum with KCl	Viscosity = 53.71 x + 2	0.71
Gum with $CaCl_2$	Viscosity = 67.42 x + 19.33	0.63

Whistler (2012) and Siddiqui et al. (2016).

CONCLUSIONS

The results reflected a linear relationship between viscosity and concentration of gum solution with salt for concentrations of 10 to 35% with very good fit. It was explained by the fact that the latter were the linear molecules and intermolecular entanglements could readily occur while this was not the case for the highly compact, branched gum arabic molecules. The addition of KCl and $CaCl_2$e increased the viscosity of gum arabic solutions.

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