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RESEARCH ARTICLE

HEATING GUM ARABIC ABOVE 60 ^{0}C

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A B S T R A C T

Gum arabic is prepared from the species senegal and seyal of the Acacia trees. This study aims to analyze the effect of heating *Acacia senegal* and *Acacia seyal*above 60ºC. The samples were incubated using incubator at 63ºC for 6hrs, 24hrsand48hrs respectively. Heating effect was investigated using gel permeation chromatography coupled to muli-angle laser light scattering (GPC-MALLS) to determine the average molecular weight (Mw). The results showed the effect of temperature (above 60ºC) on gum arabic molecular weight distribution.The results for *Acacia senegal* at 63ºC showed that the weight average molecular weight slightly decreased by 8.5%, 16% and 22% after 6hrs, 24hrs and 48hrs of incubation respectively. For *Acacia seyal*, the weight average molecular weight decreased by 14%, 39% and 48% after 6hrs, 24hrs and 48hrs respectively. The study concluded that molecular weight of *Acacia seyal* sample affected more than *Acacia senegal* samples.

INTRODUCTION

Gum arabic (GA) is a natural polysaccharide that exudates from two species *Acacia senegal* and *Acacia seyal* trees [1]. It commonly used as one of the food hydrocolloids. It is used as efficient emulsifier beside long term stabilizer in food and cosmetic products [2-5] containing oil-water interfaces.Different studies in the past have focused on the functional characteristics and structural aspects of gum arabic. They investigated its utility in the devel opment of low viscosity concentrated solutions and its potential for stabilizing the emulsions [6]. There have been numerous publications concerned with determining the average molecular weight of the gum. Fenyo and Vendevelde [7] obtained values ranging from $2.5x10^5$ to $1.0x10^6$. Anderson and Stoddart [8] had previously shown that the protein component was associated with high molecular weight fraction and that the remaining lower molecular mass fractions were virtually and exclusively polysaccharide. Anderson and Stoddart [8] determined the structure of gum arabic by subjecting it to a series of Smith Degradation (SD) using periodate. They obtained seven distinct degradation products. Anderson and Mc Dougal [9] carried out a series of Smith Degradation on *Acacia senegal*. They reported that the molar ratio of polysaccharideto protein in the whole gum (31:1) decreased to 18:1 in the first SD product but remained constant at 11:1 in the second, third and fourthproducts. Furthermore, Anderson and Yin [10] carried out a series of Smith Degradation on *Acacia seyal* and reported that the molar ratio ofpolysaccharide to proteinin the whole gum (113:1) decreased to 58:1, 27:1, 5.5:1 and 4:1 in the first, second, third and fourth SD products respectively. Thus, it is evident that comparatively few of amino acids in *Acacia seyal* gum are attached to periodate-vulnerable sugars in peripheral positions and that the majority of the amino acids are located at deep-seated locations within the complex gum macromolecules.

The presence of gum arabic is observed as a mixed salt having polysaccharidic acid. Its pharmacological usefulness has been reported as an anti-oxidant and the protector of renal, hepatic, and cardiac toxicities. It has also reported adverse effects including hypersensitivity, effects on vitamin D and electrolyte balance [11]. The study of Mocak et al. [12] found that it is possible to classify the gums using chemometric methods. The gums can be classified into adulterants in food usage and those conforming to food additives specification. Despite the extensive research concerning chemical structure of gum arabic, it is seen that processing of gum arabiccould not answer the question,in which fractions (AG,AG and Gp), breaking of protein occurred. Hence, the effects of processing by heating above 60^0C on weight average molecular weight and structure of gum arabic was investigated.

Experimental

Materials

Table 1 gives detail of samples (variety, origin and characterization) used in the current study.

Table 1 Detail of the samples of this study

Sample code	sample variety	Date of collection	Place of collection	Sample Nature	Soil type	Size of the sample
AS-1	A. senegal var. senegal	2004	Sennar	Authentic	Clay	Medium to big pieces
AS-2	A. senegal var.senegal	2004	Abujebeha	Authentic	Sand	Medium to big pieces and few small tears
AS-3	A. senegal var.senegal	2004	Gum arabic company	Commercial		Small to medium sized pieces
Sy-1	A. seyal Var. syal	2004	Damazeein	Authentic	Clay	Medium to big pieces yellow

Sample code	sample variety	Date of collection	Place of collection	Sample Nature	Soil type	Size of the sample
						to brown colour

Preparation of the samples for the analysis of the crude gum

The gum was finely ground using a mortar and pestle, and sieved through a mesh No. 16. To prepare gum solutions, three grams of ground gum (based on dry weight) were dissolved in 100ml distilled water or phosphate buffer (using a roller mixer for 3h and centrifuged for 25min at 25^0C, at speed of 2500rpm to remove insoluble matter) to give a 3% aqueous gum solution.

Processing by heating

0.045gm of gum arabic dissolved in 4.5ml of 0.2M NaCL.ThepH was adjusted to 7.0. The solution incubated at 63^0Cin Stoppard test tubes for 6, 24 and 48 hrs. 2ml of the incubated sample was diluted to 4mg/ml dry weight using 0.2M NaCL and used for evaluation by the GPC-MALLS method and compared with the control.

Multi angle laser light scattering systems (MALLS) [13]

The GPC system comprised of a high precision pump (waters, USA), an injector (rheodyne 7125 valve rheodyne, UK), Hemabio linear column (600x8mmpacked with 10um)and hydrophilic modified hema gel (hydroxyethyl methacrylate copolymer). The column effluent was monitored byDAWN DSP laser light scattering photometer (Wyatt Technology Corporation, USA).

UV detector (Pye Unicam, UK) and the software (Astra 4.5 for windows, Wyatt Technology, USA) were arranged.The system was switched on two hours to equilibrate before carrying out any analysis. Gum samples were accurately weighed 0.02gm in small vials to which 5ml of 1M NaCL were then added. The vials were Stoppard and kept on a roller shaker for two hours. 100uL solution were injected into the GPC system via 0.45m Millipore (waters UK), keeping the flow rate at 0.5ml/min at ambient temperature. The data generated were analysed using the Astra 4.5 software.

RESULTS AND DISCUSSION

Effect of heating on the molecular weight distribution and parameter

The weight average molecular weight of the samples used in study was determined using GPC-MALLS and the results are tabulated in Table 2, Table 3, and Table 4.

Table2 The effect of heating at 63^0C on molecular weight (Mw) parameters of *A. senegal from Sennar*

Sample	5 Mwx10	%mass recovered	Polydispersity Mw/Mn	Mw 5 3peakx10	%mass recovered	Polydispersity Mw/Mn
				34.5	2.3	1.4
AS-1 control	**4.7**	113	2.2	4.4	81.6	1.3
				0.99	16.1	1.0
6hrs at 0 63 C				58.3	1.2	1.6
	4.3	111	2.2	4.3	78.3	1.5
				1.1	17.6	1.2
24hrs				43.7	1.2	1.5
0	**4.0**	111	2.2	3.8	80.7	1.5
at 63 C				1.5	18.3	2.1
48hrs				61.8	0.8	1.6
0	**3.8**	111	2.0	3.7	81.2	1.5
at 63 C				1.4	18.3	1.6

Table 3 The effect of heating at 63^0C on molecular weight (Mw) parameters of

A. senegal from Company

Sample	5 Mwx10	%mass recovered	Polydispersity Mw/Mn	Mw 5 3peakx10	%mass recovered	Polydispersity Mw/Mn
AS-3 control	**6.1**	118	2.2	39.0 5.4 1.3	4.0 80.6 16.0	1.3 1.5 1.1
6hrs at 0 63 C	**5.0**	113	2.0	37.6 4.7 1.2	2.3 85.5 12.3	1.3 1.5 1.6
24hrs at 0 63 C	**4.5**	113	2.0	42.1 4.3 1.2	1.4 80.2 18.5	1.3 1.5 1.6
48hrs at 0 63 C	**4.7**	104	2.0	53.4 9.9 0.95	0.65 79.6 19.9	1.3 1.5 1.3

***Table* 4** The effect of heating at 63^0C on molecular weight (Mw) parameters of *A. senegal from Abujebeha*

Sample	5 Mwx10	%mass recovered	Polydispersity Mw/Mn	Mw 5 3peakx10	%mass recovered	Polydispersity Mw/Mn
AS-2 control	**4.6**	114	2.2	35.9 4.3 1.2	1.2 80.2 18.5	1.3 1.5 1.6
6hrs at 0 63 C	**4.0**	108	2.2	50.7 4.1 0.8	1.2 81.7 17.6	1.4 1.5 1.2
24hrs at 0 63 C	**4.0**	111	2.1	43.7 3.9 1.5	1.2 80.7 18.3	1.5 1.5 1.2
48hrs at 0 63 C	**3.8**	113	2.0	56.5 4.1 0.79	0.80 80.4 19.4	1.4 1.5 1.1

From Table 2, it is observed that weight average molecular weight Mw x 10^5 was initially at 4.7 for AS-1 control (senegal). It reduced to 4.3 in 6 hrs, 4.0 in 24 hrs, and 3.8 in 48 hrs at 63°C. Overall, there was a reduction of 0.9 in the duration of 48 hrs for peak three.

From Table 3, it is observed that weight average molecular weight Mw x 10^5 was initially at 6.1 for AS-3 control (senegal). It reduced to 5.0 in 6 hrs, 4.5 in 24 hrs, and increased to 4.7 in 48 hrs at 63°C. Overall, there was a reduction of 1.4 in the duration of 48 hrs for peak three. The reduction is greater than AS-1 control; however, there is not continuous decrease in the fraction. After decreasing to 4.5 in 24 hrs, the fraction again increased to 4.7 in 48 hrs.

From Table 4, it is observed that weight average molecular weight Mw x 10^5 was initially at 4.6 for AS-2 control (senegal). It reduced to 4.0 in 6 hrs, remained at 4.0 in 24 hrs, and reduced to 3.8 in 48 hrs at 63°C. Overall, there was a reduction of 0.8 in the duration of 48 hrs for peak three. The reduction is less than AS-1 and AS-3 controls. After initial decrease, it remained constant and reduced only 0.2 from 24 hrs to 48 hrs.

Fig. 1 shows that there is a sharp increase/decrease in LS, AUX for the volume 11 mL to 16 ML.

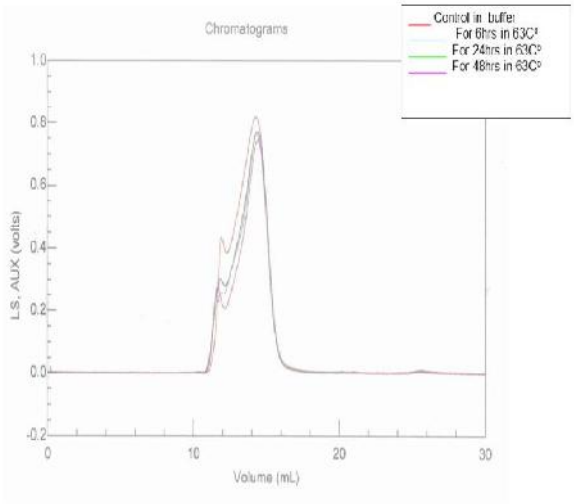

***Figure* 1** GPC- LS Chromatograph of *A. senegal* gum (1) control at 63ºC ±1

Fig. 2 shows LS, AUX reaches zero level when the volume is 6 mL for 6 hrs. The peak volume is reached when LS, AUX is 0.15 volts. At 22 mL, greater volts are observed for 6 hrs.

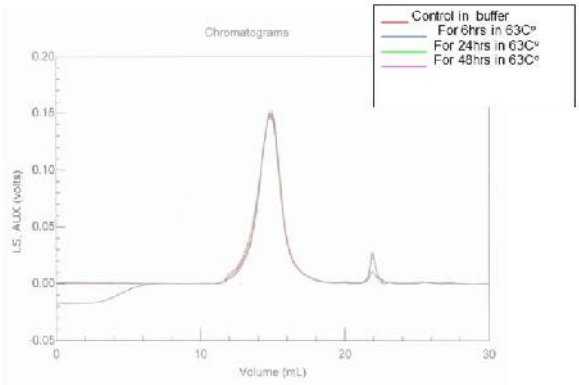

Figure 2 GPC- RI Chromatograph of *A. senegal* gum (1) control at 63ºC ±1

Fig. 3 shows that there is a sharp increase/decrease in LS, AUX for the volume 11 mL to 18 ML.

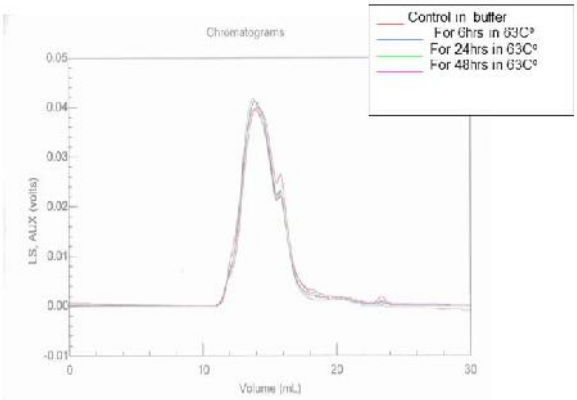

Figure 3 GPC- UV Chromatograph of *A. senegal* gum (1) control at 63ºC ±1

Fig. 4 shows that there is a sharp increase/decrease in LS, AUX for the volume 11 mL to 16 ML. However, there are significant variations based on different hours.

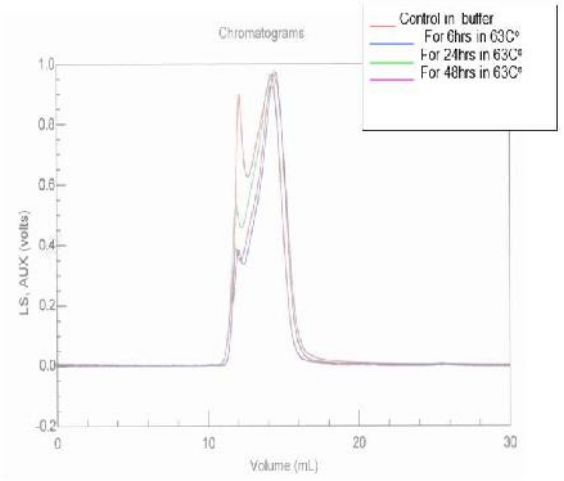

Figure 4 GPC- LS Chromatograph of *A. senegal* gum (3) control at 63^0C±1

Fig. 5 shows that there is a sharp increase/decrease in LS, AUX for the volume 11 mL to 15 ML. In this case, normal curve is not observed and there is a sudden decrease in value.

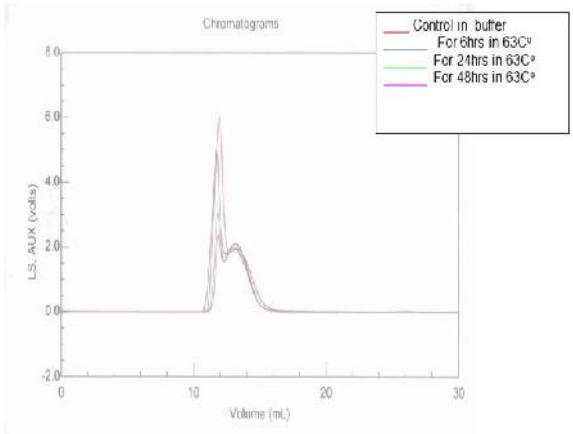

***Figure* 5**GPC- LS Chromatograph of *A. seyal* gum control at 63^0C±1

Fig. 6 shows that there is a sharp increase/decrease in LS, AUX for the volume 11 mL to 17 ML. Increments are also observed from 20 to 22 mL.

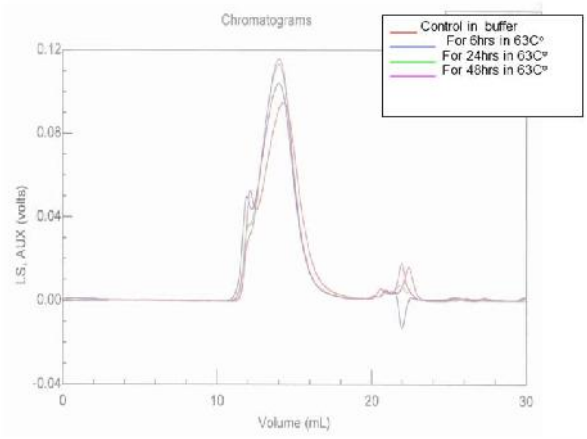

Figure 6 GPC- RI Chromatograph of *A. seyal* gum control and 63^0C±1

Fig. 7 shows that there is a sharp increase/decrease in LS, AUX for the volume 11 mL to 19 ML.

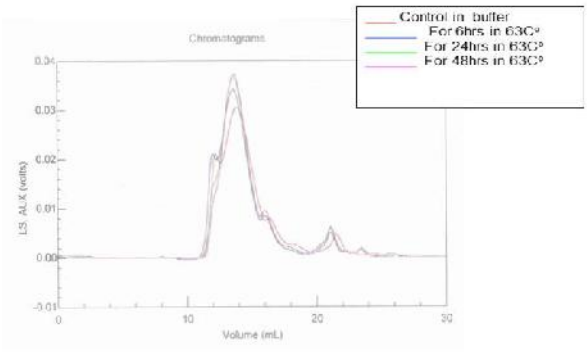

Figure 7 GPC-UV Chromatograph of *A. seyal* gum control at 63^0C±1

CONCLUSIONS

The molecular weight of *A. seyal* samples affected more than those of *A. senegal*. Heating gum arabic solutions above 60^OC affect the molecular weight significantlywhere the average molecular weight remained fairly constant (M_n= 19000-18000). It indicates no major structural modification

and this is in agreement with Fincher etal. [14]. The usefulness of gum arabic can be enhanced by introducing its processing at a temperature above 60^{o}C. In that case, seyal samples have responded significantly higher than senegal samples.

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