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Physicochemical Characteristics of Some *Acacia* Gums

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ABSTRACT

Some *Acacia* gums (*A. senegal*, *A. seyal*, *A. polyacantha* and *A. laeta*) were subjected to physicochemical characteristics evaluation in order to illustrate some information required for identification and differentiation between *A. senegal* gum and the three most important *Acacia* gums produced in Sudan. The results showed that the four types of *Acacia* gums have similar pH-values but there were some wide variations between them in other physical characters. For chemical characters *Acacia. senegal* show the highest value for moisture and ash content and *Acacia seyal* has the lowest value for nitrogen percentage, the other two types of gum were almost similar. The four types of gums show variations in mineral composition. Amino acids profile showed that *Acacia laeta* gum has the highest total amino acids content. Aspartic acid and serine were the most dominant amino acids in four types of *Acacia* gums tested.

Key words: Gum Arabic, amino acids, mineral composition

INTRODUCTION

Gum Arabic is the oldest and best known tree gum exudates and has been used as article of commerce for over 5000 years (Whistler, 1993). It is the exudation from certain *Acacia* trees, which occurs in a wide belt of semi-arid land stretching across sub-Saharan Africa (Islam *et al*., 1997). There are more than 120 species of *Acacia*, which are classified into three major groups, subgenus *Acacia* (Gummiferae) containing 120-130 species; sub-genus *Aculeiferum* (vulgares) with 180-190 species and subgenus *Phyllodinae* with more than 900 species.

Commercial gum is not collected from a single botanical species. *Acacia senegal*, *Acacia seyal* and *Acacia polyacantha* have the widest distribution in the gum belt. Even these species are found in more than one variety. Other gum-yielding *Acacia* species have limited distribution and supply e.g., *Acacia laeta* and *Acacia mellifera*. Of all these species, only *A. senegal* is systematically planted and the remainder come from natural stands (Islam *et al*., 1997). Taxonomically, only *A. laeta*, *A. mellifera* and *A. polyacantha* are admissible as related species of *A. senegal* (Ross, 1979).

In Sudan more than thirty distinct *Acacia* species are found. Among them twenty species are gums producing sources. All regulatory definition of gum Arabic recognizes that the gum Arabic of commerce originates from more than one species of *A. senegal* (L.) and related species of *Acacia*. It consists mainly of high molecular mass polysaccharides and their calcium, magnesium and potassium salts which on hydrolysis yield arabinose galactose, rhamnose and glucuronic acid. Toxicological monographs were prepared in 1978, 1982, 1986 and 1990 and an ADI not specified

was granted in 1982 and confirmed 1990. In the most recent review the limits of specific rotations and the nitrogen content were deleted from the specifications and the definition refers to *A. Senegal* and *A. seyal*. Other *Acacia* species were not included (FAO, 1997).

The objectives of this study are to illustrate the physical and chemical characteristics of some types of *Acacia* gums.

MATERIALS AND METHODS

Samples collection: Place of collection of samples and characteristic of the soils from which the samples have been collected were described in Table 1.

Samples preparations: Gum nodules were dried at room temperature, cleaned by hand, ground using mortar and pestle, sieved through sieve No. 4 and kept in a labeled plastic sachets for analysis.

METHODS

Moisture content: The moisture content was calculated according to FAO (1990) paper No. 49. Accurately weighed two grams of the ground gum were heated in an oven (Heraeus) at 105°C to a constant weight. Then, the moisture content was determined as percentage of the lost weight to the total weight.

Ash and nitrogen%: Ash and total nitrogen were determined according to AOAC (1984) method.

Apparent equivalent weight: The apparent equivalent weight was estimated according to the Encyclopaedia of Chemical Technology (Stander, 1966). The aqueous gum solution was treated with amberlite resin and titrated against 0.02 N sodium hydroxide using phenolphthalein as indicator. The equivalent weight was calculated as follows:

$$\text{Eq. wt.} = \frac{50.000 \times 0.3}{M}$$

Where:

Eq. wt. = Equivalent weight
M = Milliliters of 0.02 N sodium hydroxide neutralized 10 mL of formulation solution
0.3 = Grams of gum per 10 mL of the 3 solution

Table 1: Description of the samples used in the study

Samples	Place of collection	Soil type
Acacia senegal 1	Obied	Sand
Acacia Senegal 2	Obied	Sand
Acacia senegal 3	Gum Arabic Co.	Sand
Acacia seyal	Obied	Sand
Acacia polyacantha 1	Damazine	Clay
Acacia polyacantha 2	Damazine	Clay
Acacia polyacantha 3	Gum Arabic Co.	Clay
Acacia laeta 1	Ocay	Clay
Acacia laeta 2	Rahad	Clay
Acacia laeta 3	Gum Arabic Co.	Clay

All samples are authenticated samples

Uronic acid: Uronic acid percentage was determined by multiplying the molecular weight of uronic acid (194) by 100 and dividing by the apparent equivalent weight of the sample.

pH: pH values were measured directly in a homogenate prepared with 10% (w/v) gum powder in distilled water, using a glass rod electrode pH meter.

Specific optical rotation: The specific rotation was measured for 10% solution (on a dry basis) using an Optical Activity Bellingham and Stanley Ltd. polar meter fitted with a sodium lamp and with a cell of path length of 20 cm.

Viscosity: Absolute viscosity was measured using Brookfield viscometer.

Intrinsic viscosity: The viscosity was assessed using a Cannon-Ubbelohde (MI30) semi micro-dilution viscometer size 75. Intrinsic viscosity was determined according to the following equations:

$$\eta \text{ rel} = \frac{\eta}{\eta_o} = \frac{t}{t_o} \quad (1)$$

$$\eta \text{ sp} = \eta\text{rel}-1 \quad (2)$$

$$\eta \text{ red} = \frac{\eta\text{sp}}{c}$$

$$[\eta] = \text{Lim} \left(\frac{\eta \text{ sp}}{c}\right) \quad (3)$$

$$c \to 0$$

Where:

t = Flow time in seconds for sample
t_o = Flow time in seconds for solvent
c = Concentration
η = Viscosity of sample
η_o = Viscosity of pure solvent
ηrel = Relative viscosity
η sp = Specific viscosity
$[\eta]$ = Intrinsic viscosity

Mineral composition: The mineral content was determined using the technique of x-ray fluorescence. Sodium and magnesium was determined using GBC 932 plus Atomic Absorption spectrometer.

Amino acids composition: Amino acids profiles were determined using newly developed Carbohydrate Removal Kit (CRK). The CRK facilitates chromatographic analysis and Pulsed Amperometric Detection (PAD) of trace levels of free amino acids in the presence of large quantities

of carbohydrates without the needs of any pre or post-column derivatization. This technique was applied to the study of the amino acids profiles of the Residual protein present in the polysaccharide sample by controlled acid hydrolysis, removal of released monosaccharide using the CRK and subsequent quantitation of the released acids.

Detailed time study (over the period 0-24 h) was performed on selection of replicate gum samples (150 mg) which were accurately weighed into small vials. The samples were dissolved in small quantity of water (2.5 mL) for 2 h (approx.), subjected to 5 mL of 6 M methanesulphonic acid (MSA, 4 M) and hydrolyzed at 90 °C for 20 h in water bath. The hydrolysates were neutralized using 7.5 mL sodium hydroxide (4 M) and subjected to CRK/amino acid analysis using a gold electrode and silver chloride reference electrode, Dionex Amino Pac PA 10 analytical, using demonized water, sodium hydroxide (2.5 M) and sodium acetate (1.0) as eluents at a flow rate of 0.25 mL min^{-1}. All of the provided whole gum samples and fractions were subsequently hydrolyzed under the same conditions (4 M MSA, 90°C, 20 h).

Asn and Gln are completely converted to Asp and Glu, respectively, during acid hydrolysis. Trp suffers complete loss during acid hydrolysis.

RESULTS AND DISCUSSION

Physical characteristics

pH: Table 2 shows the pH for *A. senegal*, *A. polyacantha* and *A. laeta* ranges between 4.35-4.64, 4.36-4.85 and 4.30-4.31, respectively. For the single sample *A. seyal* the pH obtained is 4.22. All those results are in agreement with the figures obtained by Karamalla (1965), Anderson *et al.* (1968, 1990), Anderson (1978) and Osman *et al.* (1993) and higher than the values obtained by Sabah El-Kheir *et al.* (2008).

Viscosity: Absolute viscosity was measured using Brookfield viscometer, the results were shown in Table 2, the viscosity for *A. senegal*, *A. polyacantha* and *A. laeta* ranges between 86.0-109 CPS, 57.0-172.0 CPS 63.7-127.0 CPS, respectively. It can be seen that there was a variation in viscosity among samples from the same species for all gum types. For *A. seyal* sample the viscosity is 167.0 CPS. These results confirmed the fact that there was an inherited variation in the molecular weight of natural gum.

The intrinsic viscosity for *A. senegal*, *A. polyacantha* and *A. laeta* ranges between. 12.3-14.0 mL g^{-1}, 12.7-12.9 and 15.3-17.8 mL g^{-1}, respectively. *A. seyal* show an intrinsic viscosity

Table 2: Physical characteristics of some acacia gum

Samples	pH	Intrinsic viscosity (mL g^{-1})	Viscosity (CPS)	Specific rotation (degree)
Acacia senegal 1	4.38	14.00	109.0	-32.5
Acacia senegal 2	4.50	16.40	90.0	-31.0
Acacia senegal 3	4.35	12.30	86.0	-31.0
Acacia seyal	4.22	15.95	167.0	+50.0
Acacia polyacantha 1	4.42	12.80	119.0	-7.0
Acacia polyacantha 2	4.85	12.70	172.0	-7.0
Acacia polyacantha 3	4.36	12.90	57.0	-12.0
Acacia laeta 1	4.30	17.80	63.7	nd
Acacia laeta 2	4.31	16.70	127.0	-27.0
Acacia laeta 3	nd	15.30	nd	nd

nd: Not determined

of 15.9 mL g^{-1}. These results for *A. Senegal* were found to be in good agreement with the values reported by Anderson and Stoddart (1966) Anderson *et al.* (1983), Idris (1989) and Anderson (1991) and lower than the result founded by Sabah El-Kheir *et al.* (2008). And the result obtained for *A. seyal* falls within the range reported by Anderson and Weiping (1991). *A. polyacantha* and *A. laeta* were found to be in good agreement with and Karamalla (1965) and Anderson (1978).

Specific optical rotation: Table 2 shows the specific rotation values for the gum samples. *A. senegal*, *A. polyacantha* and *A. laeta* ranges between -31-32.5, -7-12 and -27-37 degree, respectively. *A. Senegal* has a value of+50°. The result obtained for *A. Senegal* in this study agree with the values reported by Anderson (1991, 1978) and FAO (1990) and disagree with the values mentioned by Sabah El-Kheir *et al.* (2008) and for *A. senegal*, *A. polyacantha* and *A. laeta* were in agreement with the values reported by Anderson and Weiping (1991).

Chemical characteristic

Moisture: The moisture content of *A. Senegal* was found to fall within the range of 10.00-16.15%, *A. seyal* 10.4%, *A. polyacantha* 9.4-11.6%, *A. laeta* 9.50-12.78% (Table 3). The results obtained are within the range reported by Sabah El-Kheir *et al.* (2008) for *A. senegal*.

The ash content as shown in Table 3 of *A. Senegal* was found to be within the range of 3.00-5.34%, *A. polyacantha* 2.5-3.8%, *A. laeta* 3.5-.8% and *A. seyal* 3.5%. The results obtained are higher than the result obtained by Anderson (1978) and Anderson and Farquhar (1979) for *A. seyal* and *polyacantha* and lower for *senegal* and in agreement with Anderson *et al.* (1991) for *A. seyal* and Sabah El-Kheir *et al.* (2008) for *A. senegal*.

The nitrogen content of *A. senegal* found to be in the range of 0.32-0.35% and the value of 0.21% was reported for *A. seyal*, for *A. polyacantha* the nitrogen content was determined as 0.33-0.36% and that for *A. laeta* were reported as 0.31-0.32% (Table 3). All these values are higher than the values obtained by Anderson (1978) and Anderson and Farquhar (1979) except for *A. polyacantha* the values are almost similar and the values are within the range obtained by Sabah El-Kheir *et al.* (2008) for *A. senegal*. For *A. senegal* the values obtained for equivalent weight were found to be in the range of 1363-1500, whereas the values obtained for uronic acid contents for the same sample were 12.93-14.23%. All those values for equivalent weight and uronic acid contents obtained for *A. senegal* are in full agreements with the values obtained by Karamalla

Table 3: Chemical compositions of some *Acacia* gums

Sample	Moisture (%)	Ash (%)	Nitrogen (%)	Equivalent weight (g)	Uronic acid (%)
Acacia senegal 1	12.57	5.34	0.34	1363	
Acacia senegal 2	16.15	3.00	0.32	1500	14.28
Acacia senegal 3	10.00	5.00	0.35	nd	nd
Acacia seyal	10.40	3.50	0.21	nd	nd
Acacia polyacantha 1	11.38	2.50	033	1500	12.93
Acacia polyacantha 2	11.60	3.16	0.36	1666	11.64
Acacia polyacantha 3	9.40	3.80	0.33	nd	nd
Acacia laeta 1	12.78	3.80	0.32	1250	15.52
Acacia laeta 2	11.85	3.50	0.31	1153	16.18
Acacia laeta 3	9.50	nd	nd	nd	nd

nd: Not determined

Table 4: The mineral composition of some *Acacia* gums

	Sample											
Element (ppm)	Na	K	Ca	Mg	Mn	Fe	Cu	Zn	Br	Rb	Sr	Zr
A. senegal 1	7.092	7500	5700	25.54	570	530	123	39	2.8	5.8	36	10
A. senegal 2	27.702	7800	7500	22.386	640	540	130	46	4.0	9.8	39	10
A. seyal 3	5.491	7900	11200	11.744	750	nd	130	620	2.9	15	40	10
A. polyacantha 1	6.141	9200	7900	13.095	6660	570	160	48	3.1	12	37	12
A. polyacantha 2	5.907	8700	5700	17.976	650	580	140	45	3.2	16	73	14
A. laeta 1	5.590	8400	11200	18.247	640	580	140	48	4.2	2.2	55	12
A. laeta 2	33.110	9800	7300	20.457	640	510	130	46	3.0	32	59	12

nd: Not determined

(1965), Anderson *et al.* (1991) and Siddig (1996). For *A. polyacantha* the value of equivalent weight were 1500 and 1666, whereas the values obtained for uronic acid content for the same samples were 11.64-12.93%. The values of equivalent weight for *A. laeta* were found to be 1153-2150. On the other hand, the values of 15.52-16.8% uronic acid were found for the same sample. All results obtained for *A. polyacantha* and *A. laeta* were in good agreements with the values reported by Anderson and Weiping (1991).

Mineral composition: The mineral compositions of *Acacia* gums are shown in Table 4. Comparing the values reported for *A. Senegal* with the values reported by Buffo *et al.* (2001), we could observe that the value of K was the same value, the value reported for Mg was low and the values reported for Ca, Mn, Fe, Cu and Zn were higher. For *A. seyal* the values for Na and Ca were more or less the same values, lower for K and Mg and very high for Mn, Fe, Cu and Z. Buffo *et al.* (2001) reported no values for Br, Rb, Sr, or Zr.

Comparing the four gum types with each others, the values for Na were found to be, more or less, the same in all gum types except for *Acacia polyacantha* which had a low Na value. The values of K were higher in *Acacia seyal*, *Acacia polyacantha* and *Acacia laeta* and *Acacia seyal* had the highest values. Mg, Mn, Br and Zn had more or less the same values in all gum types. Fe, Cu and Zn more or less the same values except for *A. seyal* which had a wider range compared with other three types. *Acacia laeta* had a wider range of Rb and *Acacia polyacantha* had a wider range of Sr.

The results totally disagreed with the values reported by Anderson and Weiping (1992) except for Zn, where the values reported were more or less the same this maybe due to the differences in techniques used or growing conditions.

Amino acid: Table 5 shows the amino acid profile of *Acacia* Gums. The results show that *Acacia laeta* gum has the highest total amino acid content followed by *Acacia senegal* gum then *Acacia polyacantha* gum and lastly *Acacia seyal* gum. Serine (0.26%) and aspartic acids (0.22%) were the two dominant amino acid present in *Acacia senegal* gum. Serine (0.22), aspartic acid (0.14%) and glumatic acid (0.13) were the dominant amino acids present in *Acacia seyal* gum. Aspartic acid (0.44%) and serine were the dominant amino acid present in *Acacia seyal*, Aspartic acid (0.24%) and serine (0.21%) were the dominant amino acids in *Acacia polyacantha* gum and serine (0.43%) and hydroxyproline (0.31%) were the dominant amino acids present in *Acacia laeta*. These results were not consistent with the data obtained by

Table 5: The amino acids composition of some *Acacia* gums

Samples (% w/w)	*A. senegal* 3	*A. seyal*	*A. polyacantha* 3	*A. laeta* 3
Alamine	0.11	0.06	0.09	0.14
Arginine	0.04	0.02	0.03	0.05
Aspartic acid	0.22	0.14	0.24	0.14
Cystine	0.02	0.02	0.02	0.03
Glutamic acid	0.11	0.13	0.17	0.27
Glycine	0.10	0.03	0.06	0.10
Histidine	0.12	0.05	0.08	0.14
Hydroxyproline	0.19	0.11	0.17	0.31
Isoleucine	0.04	0.01	0.04	0.08
Leucine	0.16	0.09	0.13	0.21
Lysine	0.09	0.02	0.09	0.10
Methionine	0.01	0.01	0.01	0.01
Phenylalanine	0.12	0.04	0.15	0.14
Proline	0.12	0.07	0.13	0.18
Serine	0.26	0.22	0.21	0.43
Threonine	0.10	0.04	0.08	0.13
Tyrosine	0.04	0.04	0.06	0.13
Valine	0.05	0.02	0.06	0.06
Total	1.90	1.10	1.80	2.60

Anderson *et al.* (1990) for *Acacia senegal* and *Acacia seyal* where hydroxy proline was the dominant amino acids. This may be due to the differences in techniques.

CONCLUSION

It would appear that, the characterization of four types of gum trees showed differences in chemical composition. Concerning amino acid patterns, serine and aspartic acids were dominant in all gum trees.

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