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Studies on Tanzanian *Acacia* gums. Part 3. Some properties of gum exudates from the series Vulgares and Gummiferae

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Some properties of gum exudates from Tanzanian *Acacia senegal* var. *leiorhachis, A. polyacantha* ssp. *campylacantha* and *A. tortilis* ssp. *spirocarpa* are presented, and compared with Sudanese commercial *Acacia* gums. Some properties of the gum exudates from *A. senegal* var. *leiorhachis* and *A. polyacantha* ssp. *campylacantha* show significant differences from Sudanese *Acacia* gums by having a higher proportion of insoluble gel fraction, lower magnesium content and higher viscosity. Furthermore, the methoxyl content of *A. polyacantha* spp. *campylacantha* gum is higher than previously reported. The viscosity of *A. tortilis* ssp. *spirocarpa* gum, on the other hand, is similar to that of Sudanese *Acacia* gums at the same concentration. However, the nitrogen content is higher, whereas its alkaline earth metal content is lower.

INTRODUCTION

Acacia gum (gum arabic) is a natural polysaccharide which is a permitted food additive. The Joint FAO/WHO Expert Committee for Food Additives (JECFA) (FAO, 1990) defines gum arabic as the dried exudation obtained from the stems and branches of *Acacia senegal* (L) Willdenow or 'closely' related species of *Acacia* (family Leguminosae). It also specifies that the specific rotation should be −26° to −34° and nitrogen content between 0·27 and 0·39% (w/w).

Over 1000 species of *Acacia* have been identified botanically and the interpretation of the words 'closely' related has received comment recently (Jurasek *et al.*, 1993). We also note that subspecies and/or variations for example *A. senegal* var. *leiorhachis* exist, and as we are going to show in this paper some of the solution properties of their gums may differ significantly from those obtained from the main species. *Acacia polyacantha* ssp. *campylacantha* (syn. *A. campylacantha*) belongs to the series (Bentham, 1875) Vulgares whilst *A. tortilis* ssp. *spirocarpa*, like *A. seyal* (the source of commercial gum tahl), belongs to the series Gummiferae. The properties of *Acacia* gum exudates vary depending on the species, geographical location, age of plant, etc. (Anderson, 1976).

In an effort to evaluate the commercial potentiality of gum exudates from some Tanzanian *Acacia* species, we have examined some properties of gum exudates from *A. senegal* var. *leiorhachis, A. polyacantha* ssp. *campylacantha* and *A. tortilis* ssp. *spirocarpa*. Some of the results we are presenting show substantial differences from those reported previously.

MATERIALS AND METHODS

Origin of samples

The gum samples were collected from central Tanzania in the following locations:

(a) *Acacia senegal* var. *leiorhachis* gum was collected from a single tree, 37 km from Morogoro on the Morogoro to Dodoma road.
(b) *Acacia polyacantha* ssp. *campylacantha* gum was collected 162 km from Dar es Salaam on the Dar es Salaam to Morogoro road.
(c) *Acacia tortilis* ssp. *spirocarpa* gum was collected 139 km from Morogoro on the Morogoro to Dodoma road.

Botanical vouchers from each of these species were also collected and deposited in the Herbarium, Botany Department, University of Dar es Salaam and confirmation of the species obtained from the Royal Botanical Gardens (Kew, UK).

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Table 1. Some physicochemical properties of Tanzanian and Sudanese *Acacia* gums

	A. senegal var. *leiorhachis*	*A. polyacantha* ssp. *campylacantha*	*A. tortilis* ssp. *spirocarpa*	Sudanese gum arabic[a]
Moisture (%, w/w)	13·8	14·0	14·5	13·8
Ash (%, w/w)	4·2	3·5	1·9	3·7
Acid insoluble matter (%, w/w)	0·3	1·1	0·7	—
CWIG (%, w/w)	8·9	36·7	13·3	0·2
HWIG (%, w/w)	2·1	10·9	11·6	0·1
Ca (g/100 g)[b]	0·75	0·72	0·62	0·75
Mg (g/100 g)[b]	0·17	0·15	0·07	0·25
Optical density	0·19	0·18	0·22	0·06
Tannin (%, w/w)	0·37	0·58	0·50	—
Methoxyl[b] (%, w/w)	0·30	0·40	0·65	0·25[c]
Nitrogen[b] (%, w/w)	0·44	0·44	2·54	0·29[c]
Protein (N × 6·60)[d]	2·90	2·90	16·76	1·91
Specific rotation, $[\alpha]_D$ in H_2O (degrees)	−24·6	−12·2	+73·2	−30[c]
Viscosity				
100 g/litre	33·68	35·63	6·99	7·30
150 g/litre	64·18	—	16·83	14·62

[a]Mhinzi & Mosha (1995).
[b]Corrected for moisture content.
[c]Anderson, 1977.
[d]Anderson, 1986.

Sample preparation

The gum samples were milled to pass a 2 mm sieve, spread out in trays and allowed to equilibrate with atmospheric moisture for 7 days and then stored in air-tight containers.

Experimental procedures

Nitrogen was determined by the Kjeldahl method, specific rotation by a Model AA-10 automatic polarimeter and methoxyl content by the recommended method (JECFA, 1983). The detailed experimental procedures for all the other parameters except tannin content have been described previously (Mhinzi & Mosha, 1995).

Tannin content

All the three samples gave a positive test in the officially recommended qualitative method for the detection of tannin. Tannic acid was used as the reference standard and the tannin contents in the gum solutions were determined as follows. The absorbance of a 2% (w/w) gum solution was determined at 430 nm using a Griffin Model 40 colorimeter. This was used as a reference point from which the absorption, after addition of 0·1 cm^3 ferric chloride solution (9 g ferric chloride hexahydrate made up to 100 cm^3 using distilled water) was measured. The absorbance of a ferric chloride solution (0·1 cm^3 added to 10 cm^3 of distilled water) was used as a blank.

The colorimeter was calibrated as follows. Standard solutions of tannic acid in the range 5×10^{-4}–2×10^{-2} (w/v) were prepared. To 10 cm^3 of each standard, 0·1 cm^3 of the ferric chloride solution were added and the absorbance at 430 nm determined. A plot of these absorbances against the corresponding concentrations of tannic acid gave a straight line plot which was used as the calibration curve for the tannin content determination of the gum solutions.

RESULTS AND DISCUSSION

The physicochemical data for the samples studied are summarised in Table 1. The cold and hot water insoluble gel (CWIG and HWIG) contents for all the three samples are higher compared to Sudanese commercial gum arabic (presumably derived from *A. senegal*). The insoluble gel content is a good measure of the quality of *Acacia* gums, and good quality gum arabic should be almost completely soluble in water. Gum tahl is considered (Anderson & Bell, 1974) inferior in quality to *A. senegal* gum because it possesses a higher proportion of insoluble gel. Previous work (Anderson & Karamalla, 1966) has shown that the gum exudate from *A. polyacantha* ssp. *campylacantha* (syn. *A. campylacantha*) from Sudan has an insoluble fraction (CWIG + insoluble matter) of 0·7% (w/w), whereas an insoluble fraction of 6·5% (w/w) has also been reported (Phillips *et al.*, 1980) for the gum exudate from this species. The CWIG content in the gum from *A. polyacantha* ssp. *campylacantha* (36·7%, w/w) found in this work is comparable to that of gum ghatti (34%, w/w) (Jefferies *et al.*, 1977). The gum exudate from *Albizia zygia* has been shown to contain an insoluble fraction of 20% (w/w) (Ashton *et al.*, 1975). A substantial fraction of the insoluble gel in *A. polyacantha* ssp. *campylacantha* dissolves on boiling, and the HWIG content (10·9%, w/w) is far less than that found in gum ghatti (28·6% w/w). The insoluble gel of the gum exudate from *A. tortilis* ssp. *spirocarpa* does not dissolve on boiling (Table 1).

In all the three samples studied a higher proportion of calcium compared to magnesium is observed. A higher proportion of calcium than magnesium has also been observed in other tree exudate gums, for example gum ghatti and gum karaya (Reymond *et al.*, 1981) and *Khaya grandifoliola* gum (Aslam *et al.*, 1978). The calcium content in the gum exudate from *A. senegal* var. *leiorhachis* is equivalent to that of Sudanese commercial gum arabic whereas the magnesium content is lower. The gum exudate from *A. tortilis* ssp. *spirocarpa* shows a very low magnesium content.

Previous work (Anderson, 1977) shows *A. senegal* gum to possess nitrogen, 0·29% (w/w), methoxyl, 0·25% (w/w), specific rotation, -30° and acid equivalent weight, 1100. The results for *A. senegal* var. *leiorhachis* (Table 1) show a slightly higher proportion of nitrogen (0·36%, w/w) and specific rotation of −24·6°. The methoxyl content of the gum from *A. senegal* var. *leiorhachis* (0·30%, w/w) is significantly higher than that previously reported (Anderson & Wieping, 1990) for a sample of gum arabic from Tanzania, assumed to be from *A. senegal*. Our recent work (Mhinzi & Mosha, 1993) gives a value of 1583 for the acid equivalent weight of *A. senegal* var. *leiorhachis*. For *A. polyacantha* ssp. *campylacantha* gum, the values obtained in this work for methoxyl content (0·40%, w/w) and specific rotation (−12·2°) also differ significantly from those reported previously (Anderson & Karamalla, 1966). The methoxyl content (0·65%, w/w) and specific rotation (+73·2°) of *A. tortilis* ssp. *spirocarpa* gum found in this work are similar to the published values (Anderson & Bell, 1974) for the gum from this species obtained from Sudan. However, the nitrogen content (2·54%, w/w) is significantly higher, and it is interesting to note that the higher protein content has not contributed significantly to the value of the optical rotation.

The viscosities of the gums from *A. senegal* var *leiorhachis* and *A. polyacantha* ssp. *campylacantha* are much higher (about four and a half times) than that of gum arabic from Sudan at the same concentration (Table 1). The viscosity of *A. tortilis* ssp. *spirocarpa* gum, on the other hand, is comparable to that of gum arabic from Sudan at the same concentration. The results in Table 1 show that, although the viscosities of the gums from *A. senegal* var. *leiorhachis* and *A. polyacantha* ssp. *camplylacantha* are similar at the same concentration, the insoluble gel fraction of the latter is considerably higher than the former. Likewise although the CWIG content of *A. tortilis* ssp. *spirocarpa* is comparable to that of *A. senegal* var. *leiorhachis*, its viscosity is significantly lower. This behaviour is different from that observed in gum ghatti (Jefferies *et al.*, 1977). It has previously been shown (Jefferies *et al.*, 1977, 1978) that commercial gum ghatti consists of a soluble fraction and an insoluble gel fraction which ranges from 8 to 23% (w/w) and the viscosity of the whole gum depends on the proportion of the insoluble gel fraction. This means that there is a wide variation of viscosity from batch to batch, rendering gum ghatti a gum of unstable quality.

Acacia polyacantha ssp. *campylacantha* (syn. *A. campylacantha*) is regarded (Anderson *et al.*, 1983) as a close botanical relative of *A. senegal* and as such it can legitimately be sold under the name gum arabic for use as a food additive. In order to evaluate the commercial potential of authentic tree exudate gums it is necessary to compare their properties with those of established commercial gums. It has been suggested (Phillips *et al.*, 1980) that the metal composition and pretreatment of natural gums may become a major factor in their subsequent solution behaviour, especially in controlling their properties as thickening and gelling agents. The high proportion of insoluble gel in the gum from the three species (Table 1) means that their usefulness as sources of commercial gum arabic is somewhat limited. The high viscosities at low concentrations of gums from *A. polyacantha* ssp. *campylacantha* and *A. senegal* var. *leiorhachis* means also that their effectiveness as stabilising and/or emulsifying agents when incorporated with large amounts of insoluble materials will be limited. The reason for the formation of varying amounts of insoluble gel by *Acacia* gums is not entirely clear, although the gel fraction is known to have a higher molecular weight than the soluble fraction (Anderson & Dea, 1968). Thus, for example, although the calcium and magnesium contents in *A. senegal* var. *leiorhachis* and *A. polyacantha* ssp. *campylacantha* are similar to Sudanese gum arabic, their insoluble gel contents are significantly higher. The only tree exudate gum reported to be gelled by calcium ions is that from *Khaya grandifoliola* (Aslam *et al.*, 1978). The gel fraction of gum ghatti contains a higher proportion of calcium ions than the soluble fraction (Jefferies *et al.*, 1982). However, this is not the cause of gel formation because the solubility of the gel is not appreciably altered by changing the calcium ion content.

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