Fractionation, physicochemical properties and mineral content of gum Arabic and its fractions
I.A.Bashir¹ and M.E.Osman²,

1-Faculty of Pharmacy, El Neelain University, P.O.Box 12702, Khartoum.
2- Faculty of Science, Sudan University, P.O.Box 407 Khartoum.

Corresponding author: I.A.Bashir, E.mail: intisar94@hotmail.com

ABSTRACT

Gum Arabic from Acacia senegal (Wild) has been fractionated by a foaming method into two fractions, high protein fraction (HPF) that represents 30% of the gum and a low protein fraction (LPF) which represents 70% of the gum. A comparative study between the crude gum and the two fractions carried out in the scope of their physio-chemical properties.

A proximate analysis of the crude gum and the two fractions(HPF and LPF respectively) revealed that, the moisture content(10.11,10.04 and 10.05) and specific rotation( -31,-30 and -30) were insignificantly different whereas ash%(3.7,3.33 and 3.03), acid insoluble ash%(0.3,0.135 and 0.145), acid insoluble matter% (0.18, 0.55 and 0.58) and pH (4.49, 4.47 and 4.25) were significantly different . The nitrogen (0.28, 1.51 and 0.007) and protein content (1.85, 10.01 and 0.05) and the intrinsic viscosity (17, 44.5 and 6 cm$^{-3}$/g) were, highly, significantly different.

Mineral composition of crude gum, fractions HPF and LPF revealed that LPF had the highest content of calcium (17590) whereas HPF had the highest potassium and magnesium composition(4417 and 1717 respectively). Crude gum had the highest sodium content (151.7).

INTRODUCTION

Gum Arabic is a polysaccharide. Polysaccharides are natural macromolecules of universal occurrence in living organisms and plants, where they perform a variety of functions, many of which are not fully understood(Aspinall, 1970). However it is recognized that they act as skeletal substances in the cell wall of higher plant and seaweeds, provide reserve food supplies in animal
and plant and function as protective substances in plants e.g. in the form of exudates gums, sealing off sites of injury. The polysaccharides derived from the plant kingdom (Aspinall, 1970) have proved to be of economic importance with a variety of functions which include food, pharmaceutical and other technical applications.

Acacia gums are Arabinogalactan-protein (AGP) which are higher plants secretions. They are a group of macromolecules characterized by a high proportion of carbohydrate in which galactose and arabinose are the predominant monosaccharide sub-units. In some situations arabinogalactans are isolated as free polysaccharides, in others they occur in covalent association with protein either as proteoglycans, in which the protein component carries a polysaccharide constituent (Gottschalk, 1972; Reid and Clamp, 1978), or as glycoprotein, in which the protein component is covalently linked to one or more oligosaccharide residues (Spiro, 1966; Marshall, 1972; Kornfeld and Kornfeld, 1976). The protein content of arabinogalactan-proteins varies between 2 to 10% of the total composition (Fincher et al., 1983). However values as high as 60% have been reported (Anderson and Farquhar, 1979).

Further studies of the polysaccharide gum from Acacia senegal using $^{13}$Cnmr (Defaye and Wrong, 1986) have suggested that the gum Arabic does not have strictly regular repeating units. However, a branched hexasaccharide has been proposed as being representative of the main subunit of the highly branched polysaccharide of the gum.

Size exclusion chromatography studies (Vandevelde and Fienyo, 1985) have shown that gum Arabic consists of two main components, a protein deficient (major) component (70% of the total) and protein-rich (minor) component (30% of the total) emphasizing the polydispersity of the gum and confirming the view that the gum is an arabinogalactan-protein complex. Gum Arabic has also been fractionated (Randall et al., 1989) using hydrophobic interaction chromatography into three fractions namely, a protein deficient arabinogalactan, a protein-rich arabinogalactan protein complex fraction and a glycoprotein fraction representing 89, 10 and 1 of the total respectively. However these fractions where shown to contain a range of different molecular weight components revealing further the complexity of the gum (Osman et al, 1994).
Characterization of the fractions obtained by hplc using $^1$H, $^{13}$Cnmr and methylation analysis(William et al., 1990a) has shown that all three fractions are composed of sugar residues of similar structure i.e. composed of a galactan core of $\beta$ 1, 6-linked galactopyranose with the other sugar residues occupying peripheral positions.

The objective of this study is to fractionate the gum Arabic into two fractions by simple physical method and to determine the physiochemical properties of the crude gum and its fractions.

**MATERIAL AND METHODS:**

**Materials:**

Crude gum Arabic samples were donated by Gum Arabic company, Khartoum, Sudan.

**Methods:**

Physicochemical properties of gum Arabic and the fractions include moisture content , total ash, acid insoluble ash, acid insoluble matter, nitrogen %, protein%, specific optical rotation, pH, viscosity and mineral composition (calcium, potassium, sodium, magnesium, iron and copper) are measured using standard methods.

**Fractionation of gum Arabic:**

30%(w/v) crude gum solution was heated in water bath at temperature 50-60° C, air was passed through the solution using an aerating pump to form a foam which was collected in Petri-dishes then left to dry as HPF fraction. 4 volume (400 ml) of absolute ethanolic alcohol were added to the remaining solution and few drops of dilute hydrochloric acid was added, a precipitate was formed, filtered and dried from alcohol by air to form LPF fraction.(Karamallah,1998.).
Characterization:

Standard methods were used to characterize crude gum and the fraction, parameters of characterization include moisture content, total ash, acid insoluble ash, acid insoluble matter, specific optical rotation, pH, viscosity, Nitrogen%, protein%, and cationic composition.

RESULTS AND DISCUSSION

Table 3-1: Physiochemical properties of crude gum and fractions:

<table>
<thead>
<tr>
<th>Sample / Parameters</th>
<th>Crude gum</th>
<th>HPF</th>
<th>LPF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture %</td>
<td>10.11</td>
<td>10.04</td>
<td>10.05</td>
</tr>
<tr>
<td>Ash %</td>
<td>3.7 %</td>
<td>3.33 %</td>
<td>3.08 %</td>
</tr>
<tr>
<td>Acid insoluble ash</td>
<td>0.3 %</td>
<td>0.135%</td>
<td>0.145%</td>
</tr>
<tr>
<td>Acid insoluble matter</td>
<td>0.18 %</td>
<td>0.55 %</td>
<td>0.58 %</td>
</tr>
<tr>
<td>Specific rotation</td>
<td>-31°</td>
<td>-30°</td>
<td>-30°</td>
</tr>
<tr>
<td>pH</td>
<td>4.47</td>
<td>4.49</td>
<td>4.25</td>
</tr>
<tr>
<td>Intrinsic viscosity in cm³/g</td>
<td>17</td>
<td>44.5</td>
<td>6</td>
</tr>
<tr>
<td>Nitrogen %</td>
<td>0.28 %</td>
<td>1.51 %</td>
<td>0.007%</td>
</tr>
<tr>
<td>Protein %</td>
<td>1.85 %</td>
<td>10.01%</td>
<td>0.05%</td>
</tr>
<tr>
<td>Molecular weight</td>
<td>5.97 x 10³</td>
<td>13.5 x 10³</td>
<td>3.7 x 10³</td>
</tr>
</tbody>
</table>
Table 3-2: Mineral composition (ppm) of crude gum, HPF and LPF

<table>
<thead>
<tr>
<th>Element/sample</th>
<th>Ca</th>
<th>K</th>
<th>Na</th>
<th>Mg</th>
<th>Zn</th>
<th>Cu</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude gum</td>
<td>7509.96</td>
<td>4244.9</td>
<td>151.7</td>
<td>1620.27</td>
<td>13.24</td>
<td>2.74</td>
<td>80.9</td>
</tr>
<tr>
<td>HPF</td>
<td>1587.56</td>
<td>4417.7</td>
<td>95.05</td>
<td>1717.05</td>
<td>52.71</td>
<td>7.22</td>
<td>455</td>
</tr>
<tr>
<td>LPF</td>
<td>17590.57</td>
<td>2829.75</td>
<td>36.1</td>
<td>1616.52</td>
<td>18.28</td>
<td>5.23</td>
<td>92.6</td>
</tr>
</tbody>
</table>

**DISCUSSION**

From table 3-1 which show the physiochemical characteristics of crude gum and the fractions: moisture content of the gum indicates the hardness of the gum, good quality gum should have a moisture% not more than 15%(JECFA, 1999), in this study the moisture content for the crude gum is 10.11% and for HPF it was 10.04 and 10.05 for LPF. There is neglctable variation between the crude gum and the two fractions moisture content. The crude gum values fall within JECFA (1999) range (10 – 15%) which is in agreement with previous study carried out by Anderson et al.(1978, 1979) and Karamallah(1965).

Ash% content indicates the presence of inorganic elements, Anderson and Dea(1968). Siddig(1996) showed that the type of the soil affects the ash content significantly. Gum Arabic from heavy soil(Eastern Sudan) gives ash content of 3.5% while that from sand soil(Western Sudan) gives 3.3%. Also Awad Elkarim(1994) reported that the value of ash content increase as proportion of inert matter increase because purified gum has a lower ash content than unpurified gum and she reported a wide range for ash from 3.33% to 10%. Aging was found to increase ash content(Ali, 1996). In the present study the ash content was 3.7%, 3.33% and 3.08 for crude...
gum, HPF and LPF respectively. The crude gum ash content complies with requirement of JECFA specification(1999) in which the ash% for crude gum arabic is less than 4%.

The pH value were 4.47, 4.49 and 4.25 for which crude gum, HPF and LPF respectively. pH of crude gum Arabic of 4.6 is more or less in agreement with present result, it has been reported as 4.46 (Karamallah et al., 1998 and Awad Elkarim, 1994) and 4.47(Osman, 1998) and 4.82(Behairy, 2003).

The optical activity of organic molecule is related to their chemical structure, so it is considered as the most important criterion of purity and identity of any type of gum. Vulgares series is laevorotary, the commiferae series is dextrorotary.

The specific rotation for crude gum powder, HPF and LPF were -31°, -30° and -31° respectively. These findings for crude gum comply the requirement of JECFA (1990), which range between -26° and -34°.

Viscosity is a factor involving the size and the shape of the macromolecule. In the present study the intrinsic viscosity of crude gum was found to be 17cm⁻³/g which is in sequence with previous studies: Duvallets, et al., (1993) reported a range of 14 – 60cm⁻³/g with a mean viscosity changes with the age of the crop, season and samples picked from one tree. Vandeveldt et al. (1995) found that the intrinsic viscosity of samples obtained from Acacia senegal gum originated from Sudan was in the range of 15.5 to 40ml⁻³/g⁻¹.

The presence of portien affect viscosity(Andero et al., 1968) and emulsifying activity(Dickinson and Stainby, 1988). The nitrogen% for crude gum, HPF and LPF were 0.28, 1.51 and 0.007% respectively giving protein% of 1.85, 10.01 and 0.05 (NCF is 6.6, Anderson, 1986) respectively.

Calcium content of crude gum was found to be 7509.96 ppm which is in agree with Siddig(2003) who reported a range of 5700 – 7500 ppm for calcium content of crude gum Arabic, but the calcium content for crude gum was slightly high when compared with Buffo et al., 2001 finding who reported a range of 5387 – 6314 ppm for calcium content of gum Arabic.
The calcium content of fraction LPF was 17590.57 ppm, which was very high as compared with crude gum or fraction H that contain very low calcium(1587 ppm) when compared with crude gum or fraction LPF.

Potassium content of crude gum Arabic powder was 4244.9 ppm which is low as compared with Siddig(2003) and Buffo et al. (2001) who reported a range of 7500 – 7800 ppm and 6664 – 7735 ppm respectively. Sodium content of crude gum was 151.7 ppm, wide range for Acacia senegal gum sodium content had been reported by previous investigators: Siddig (2003) reported sodium content range of 7.092 – 27.70 ppm, Buffo et al., (2001) reported a range of 3.84 – 11.99 ppm, Anderson et al., (1990b) reported a value of 22010 µg/g and Anderson and Weiping(1992) reported a range of 56 – 1304 µg/g for sodium content of gum Arabic. The sodium content of fraction L and H (36.1 and 94.05 ppm respectively) was low when compared with crude but fraction L had the lowest content of sodium.

Magnesium content of crude gum was 1620.27ppm which is in agree with Buffo et al.(2001) who reported a range of 1345 – 1987 ppm for Magnesium content of crude gum Arabic but the present result is in disagree with Siddig (2003) who reported a range of 22.386 – 25.54 ppm for magnesium content of gum Arabic. Magnesium content of fraction L(1616.52 was similar to Magnesium content of crude gum where as Magnesium content of fraction HPF (1717.05) was slightly higher than Magnesium content of the crude gum.

Potassium, Sodium and Magnesium content of fraction LPF was less than fraction HPF and crude gum content. Zinc, Copper and Iron content of fraction LPF was less than fraction HPF content. So fraction LPF had lower mineral content when compared with crude gum or fraction HPF mineral content except for Calcium content which was higher than crude gum and fraction HPF calcium content, this may be due to less ash content of fraction LPF when compared with fraction HPF and crude gum ash content.
Conclusion:

The benefit of this study is that it succeed in fractionating the gum liquid into two fractions (high protein and low protein content) using aeration. The physical and chemical properties of the crude gum is within JECFA range.

Fraction L has the higher content of calcium and fraction H has the higher content of Potassium and Magnesium whereas crude gum has the higher content of Sodium.

REFERENCES


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