Physicochemical Properties
of Gums of *Acacia Senegal* L. and *Acacia Seyal* L. from
*Hegleeg* and *Gebaish* Areas, Sudan

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Date: October/2014
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Date of Examination: 23/10/2014
Dedication

To My Family

To My Friends
Acknowledgements

All thanks to almighty Allah the sustainer of the universe. I would like to express my gratitude to my supervisor, Dr. Mubarak Elsiddig Elamin for standing beside me during this study and providing me with scientific support to conduct this work.

My gratitude is to lab staff of Tabuc Pharmaceutical Company for moral support and to the Faculty of Science, Sudan University of Science and Technology, for their help and technical support. Special thanks are due to Dr. Omer EL-Taieb for his unlimited support.

I am ever so grateful to my dearest parents, Widad Mostafa and Faisal for everything. I have been blessed to have parents who have supported, encouraged and inspired me endlessly throughout my life.
Physicochemical Properties of Gums of *Acacia Senegal* L. and *Acacia Seyal* L. from Hegleeg and Gebaish Areas, Sudan

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**Abstract**

Gum Arabic or *Acacia* gum is a biopolymer obtained as exudates of mature trees of *A. senegal* and *A. seyal* - the main sources of *Acacia* gum – which grow principally in tropical Africa. *Acacia* gum is being used in a wide range of industrial sectors. The aim of this research was to study and compare some physicochemical properties of two *Acacia* gum species; Hashab gum (*Senegal* gum) and Talha gum (*Seyal* gum) with the international European specifications for pharmaceutical and food industry requirements. The samples of *A. seyal* were collected from Hegleeg area while that of *A. senegal* were collected from Gebaish area in December 2013. The samples were cleaned and crushed then characterization studies such as determination of solubility, moisture content, viscosity, color, specific optical rotation, pH, total ash content, acid insoluble ash and Tannin were made. The outcomes indicated that the solubility, moisture content, pH value, total ash content and acid insoluble ash content for Hashab gum and Talha gum were found to be (50.35%, 49.22%), (6.38%, 5.2%), (4.6, 4.3), (4.3%, 3.2%), (0.20%, 0.13%) respectively. The results showed a large differences in optical rotation and viscosity for the Hashab gum (-28.67°, 80.2 cP) and the Talha gum (49.16°, 115.0 cP). In addition Talha gum showed positive result for Tannin content test while Hashab gum showed a negative result. These values conform well to the international standards in all aspects. Indeed, it is possible to utilize the gum arabic of the Higleeg Gebeish areas for commercial and/or industrial purposes. This study concluded that some properties of *A. seyal* gum such as color and Tannins content may limit it is uses. It was recommended to remove the color and Tannins from *A. seyal* gum to upgrade its quality.
الخصائص الفيزيائية والكيميائية لصمغ الهشاب وصمغ الطلح من منطقتي هجليج وغيش، السودان

أحمد فيصل أحمد إبراهيم

ملخص الدراسة

الصمغ العربي او صمغ الأكاسيا عبارة عن بوليمر حيوي يتم الحصول عليه كإفرازات من الأشجار الناضجة.

صمغ الطلح وصمغ الهشاب هو الموارد الرئيسية للصمغ العربي والتي تنمو بصورة أساسية في المناطق الاستوائية في أفريقيا. يستخدم صمغ الأكسيا في قطاعات صناعية واسعة. يهدف هذا البحث لدراسة ومقارنة الخواص الفيزيائية والكيميائية لنواعين من الصمغ العربي هما صمغ الهشاب وصمغ الطلح بالمواصفات الأوروبية العالمية للصناعات الدوائية والغذائية. تم جمع عينات صمغ الطلح من منطقة هجليج وعينات صمغ الهشاب من منطقة غبيش في شهر ديسمبر 2013. تم نظافة العينات وطحنها ثم تم دراسة الخواص مثل الصلابة، محتوى الرطوبة، الزروحة، اللون، الدوران الضوئي النوعي، الإس الهيدروجيني، الرماد الكلي، الرماد غير الذائب في الحمض، النتائج المتحصل عليها أوضحت أن الدوائية، محتوى الرطوبة، الإس الهيدروجيني، محتوى الرماد الكلي ومحتمي الرماد غير الذائب في الحامض لصمغ الظهر وصمغ الطلح هي (50.35%, 50.22%, 49.22%, 6.38%, 3.4%), (0.2%)(0.13%) على الترتيب. أظهرت النتائج أن هناك اختلافات كبيرة في الدوران الضوئي النوعي والزروحة لصمغ الظهر (80.2°) وصمغ الطلح (69.16°). بالإضافة لذلك فإن صمغ الطلح أعطى نتيجة إيجابية لاختبار التانين بينما أعطى صمغ الظهر نتيجة سلبية. هذه القيم تطابق المواصفات العالمية من جميع الأوجه. بعدها لذلك فإن استخدام الصمغ العربي من مناطق غبيش وهجليج تجارية أو صناعياً. خلصت الدراسة إلى أن بعض خواص صمغ الطلح مثل اللون ومحتمي الرماد قد تحسن من استخداماته.

تمت التوصية بإزالهة اللون والثاني من صمغ الطلح لتحسين جودته.
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Chapter (I)

Introduction and Literature Review
1.1 Introduction :-

Gum Arabic or Acacia gum is a biopolymer obtained as exudates of mature trees of A. senegal and A. seyal - the main sources of Acacia gum – which grow principally in Tropical Africa[1].

The exudate is a viscous liquid, rich in soluble fibers, and its emanation from the stems and branches usually occurs under stress conditions such as drought, poor soil fertility, and injury. Production is stimulated by ‘tapping’, which involves removing sections of the bark with an axe taking care not to damage the tree[2].

Chemically, Acacia gum is a complex mixture of macromolecules of different size and composition (mainly carbohydrates and proteins). Today, the properties and features of Acacia gum have been widely explored and developed and it is being used in a wide range of industrial sectors such as textiles, ceramics, lithography, cosmetics and pharmaceuticals, encapsulation, food, etc. Regarding food industry, it is used as a stabilizer, a thickener and/or an emulsifier agent (e.g., soft drinks, syrups, carbonated beverages, gummy candies and creams) [3].

In lithography Acacia gum is used widely in plating and etching, it is used as sensitizer for lithographic plates element in the light, sensitive composition and ingredient for the fountain solution which is used to moisten the plate during printing.

Acacia gum is used extensively in the textile industry as sizing and finishing agent and in printing formulation for imparting designs or decoration to fabrics. It finds limited use in finished silk and rayon; it gives body to the fabric without interfering with its transparency[4].

In the pharmaceutical industry Acacia gum is used as a carrier of drugs since it is considered a physiologically harmless substance. Additionally, recent studies have highlighted Acacia gum antioxidant properties, its role in the metabolism of lipids, its
positive results when used in treatments for several degenerative diseases such as kidney failure, cardiovascular and gastrointestinal disorders [1].
1.2 *A. senegal* Classification :-

**Family:** *Leguminosae*.

**Vernacular names:** Hashab gum tree, White gum tree, Gum Arabic tree.

1.3 *A. senegal* descriptions :-

*A. senegal* is a prickly shrub or tree of small to medium size measuring up to 15m in height. The bark may be yellowish brown to crimson black in color, rough or smooth, have a papyrus consistency and may be peeled apart in strips or heavily cracked and black in older trees. The tree top may be slightly rounded, flat and somewhat spread out or even spindly and frayed with branches of irregular sizes. The tree may have small, smooth branches or be ‘hairy’ in texture.

1.4 *A. senegal* gum :-

A pale white to orange-brown solid, which breaks with a glassy fracture. The best grades are in the form of whole, spheroidal tears of varying size with a matt surface texture. When ground, the pieces are paler and have a glassy appearance [3].

1.5 *A. seyal* Classification :-

**Family:** *Leguminosae*.

**Vernacular names:** Talha.

1.6 *A. seyal* descriptions :-

*A. seyal* is a small to medium tree (up to 17m high and 60cm in diameter) with a distinct sunshade shape for the treetop in adult trees.

The branches are bright red in color and secrete a yellowish gum, as do cracks and slits in the bark resulting from dryness. The small branches also have numerous reddish small glands and auxiliary thorns organized in pairs. The latter
are 7cm long, slender, straight, pointy and light gray in color. The tree has a thin red-brown bark.

1.7 A. seyal gum:

It’s more brittle than the hard tears of A. senegal [5].

1.8 Chemical composition of Acacia senegal and Acacia seyal gums:

Acacia gum generally consists of a group of macromolecules characterized by a high proportion of carbohydrates, which are predominantly composed of D-galactose and L-arabinose units and a low proportion of proteins, these compositions may vary slightly depending on its origin, climate, harvest season and tree age. Therefore, there are some differences between the chemical composition of the Acacia gum taken from A. senegal and A. seyal [1].

- A. senegal gum contains the simple sugars: rhamnose (~12%), galactose (~34%), arabinose (~25%), besides glucuronic acid (~16%) and 4-O-methyl glucuronic (~1.5%), and a protein component (~2%) [6].

- A. seyal gum contains the simple sugars: rhamnose (~3%), galactose (~32%), arabinose (~41%), and glucuronic acid (~6.5%) and 4-O-methyl glucuronic (~5.5%), and a protein component (~0.97%) [3].

1.9 Physical Properties of Acacia senegal and Acacia seyal:

The physical properties of Acacia gum, established as quality parameters include solubility, moisture, viscosity, color, optical rotation, pH, total ash, acid insoluble ash. Acacia Gum is a natural complex mixture of hydrophilic carbohydrate and hydrophobic protein component emulsifier which adsorbs onto surface of oil droplets while the hydrophilic carbohydrate component inhibits flocculation and coalescence of molecules through electrostatic and steric repulsions in food additives. Acacia gum can get dissolved in water in a concentration of 50% w/v, forming a fluid solution.
with acidic properties (pH ~4.5). Moisture content facilitates the solubility of hydrophilic carbohydrates and hydrophobic proteins in Acacia gum.

Viscosity is a measure of the resistance of a fluid to flow. Relative viscosity of gum solution has been found to depend on gum concentration. Viscosity of gum solution increases with increase in gum concentration. Increase in viscosity with concentration is due to increasing number of high molecular weight polymeric chains of the gums per unit volume[1].

The ability of A .Senegal gum to form highly concentrated solutions is responsible for the excellent ability and emulsifying properties of A .Senegal gum when incorporated with large amount of insoluble materials compared to a. seyal gum [6].

Total ash content is used to determine the critical levels of foreign matter, acid insoluble matter, salts of calcium, potassium and magnesium. The cationic compositions of ash content are used to determine the specific levels of heavy metals in Acacia gum [3].

Optical rotation is used to determine the nature of Acacia gum sugars as well as to identify the source of production [7].
1.10 Aim of the study:-

The aim of the present study was to compare some physicochemical properties (Solubility, Moisture, Viscosity, Color, Specific optical rotation, pH, total ash, acid insoluble ash, Tannin) of two Acacia gum species; Hashab gum (Senegal gum) and Talha gum (Seyal gum) with International European Specifications for Pharmaceutical and Food Industry Requirements.
Chapter (2)

Materials and Methods
2.1 Materials :-

2.1.1 Gum samples:-

The *A. seyal* samples were taken from a harvest collected from Higleeg in southern Kordofan State for Henelie Gum Factory in December 2013.

The *A. senegal* samples were taken from a harvest brought from Gebeish forest in Western Kordofan state in December 2013.

The samples were cleaned from foreign particles and crushed to be ready for testing.

2.1.2 chemicals:-

Hydrochloric acid (2M).

Ferric chloride hexahydrate (10.5%).

2.1.3 Equipment:-

Beakers(100, 500)ml, graduated cylinder, test tubes, thermometer, Silica crucibles, Desiccator over silica gel crystals.

2.1.4 Instruments :-

2.2 Methods:-

2.2.1 Solubility:-

Procedure:-

50.35gm of A. senegal gum sample was added To 100 ml purified water. 49.22gm of A. seyal gum sample was added to another 100 ml purified water. The crushed samples was added slowly while mixing until appearance of small lumps then the percentage of solubility was determined.

Accepted criteria:-

Acacia gum is soluble in about twice its mass of distilled water.

2.2.2 Moisture:-

Procedure:-

5.0012g of each Acacia gum sample placed in(MA 150 Sartorius) Moisture Analyzer , after 20 minutes the result displayed as %.

Accepted criteria:-

The percent of loss on drying should not be more than 15.0 % [8].

2.2.3 Viscosity:-

Procedure:-

The viscosity of 1% gum solutions (1gm of each Acacia gum sample in 100ml of purified water) was measured at 20°C using (NDJ-8S) Digital Viscometer.

Accepted criteria:-

Viscosity should be between 80 - 150.0 CPS.[9]
2.2.4 Color:-

Procedure

30gm of each *Acacia* gum sample dissolved in 100 ml purified water and the color of *Acacia* gum samples solutions was determined using Lovibond comparator colorimeter.

2.2.5 Specific Optical Rotation:-

Procedure:-

2gm of each *Acacia* gum sample dissolved in 100 ml purified water and the specific optical rotation of gum solutions was measured at 20°C using EQUIP-TRONICS (EQ-80) Digital Polarimeter.

Accepted criteria:-

Specific optical rotation should be between -26.00° and -34.00° for *A. Senegal* [10].

2.2.6 pH

Procedure:-

25gm of each *Acacia* gum sample dissolved in 100 ml purified water and the pH of gum solutions was measured using HANNA-HI-2211 pH/ORP meter.

Accepted criteria:-

pH should be between 4.00 and 4.8 [10].

2.2.7 Total Ash:-

Procedure :-
A cleaned Silica crucibles was ignited at 600 ± 50° for 30 minutes, then allowed to cool in a desiccator over silica gel and their weight was recorded 1.1013 g of Acacia senegal gum and 1.0123g of Acacia seyal gum was placed in a crucible and Ignited at 600° ± 50° until the residue was completely incinerated. the crucible was cooled in a desiccator over silica gel .then the weight was recorded, and the total ash percentage was calculated as follows:

\[
\text{Total Ash} = \frac{\text{weight of sample after ignition}}{\text{weight of sample before ignition}} \times 100\%
\]

\[
A. \text{senegal Total Ash}\% = \frac{0.0374}{1.1013} \times 100\% = 3.4\%
\]

\[
A. \text{seyal Total Ash}\% = \frac{0.0324}{1.0123} \times 100\% = 3.2\%
\]

**Accepted criteria:**

Total Ash content should be not more than 4.0% [8].

**2.2.8 Acid in soluble ash:**

**Procedure:**

The ash content of the test 2.2.7 was boiled for 5 minutes with 25ml of 2M hydrochloric acid, the insoluble matter was collected in an ash less filter paper and washed with hot purified water, then it was ignited, and the weight was recorded. Acid in soluble ash percentage was calculated as follows:

\[
\text{Acid insoluble ash} = \frac{\text{weight of sample after ignition}}{\text{weight of sample before ignition}} \times 100\%
\]

\[
A. \text{senegal acid in soluble ash}\% = \frac{0.0022}{1.1013} \times 100\% = 0.20\%
\]

\[
A. \text{seyal acid in soluble ash}\% = \frac{0.0013}{1.0123} \times 100\% = 0.13\%
\]
Accepted criteria:- Acid in soluble ash should be not more than 0.50 %.

2.2.9 Test for Tannins:-

Procedure:-

10gm of each *Acacia* gum sample dissolved in 100 ml purified water, to 10 ml of *Acacia* gum solutions 0.1 ml of 10% ferric chloride solution (28.96gm of ferric chloride dissolved in 100 ml purified water ) was added.

Tannins are a complex group of polyphenolic compounds. phenol groups form a blue color upon addition of aqueous ferric chloride.

Equation:

\[ 3ArOH + FeCl_3 \rightarrow Fe(OAr)_3 + 3HCl \]

Where:

Ar : Aromatic.

Accepted criteria:-

Neither the precipitate nor the liquid should show a dark blue color with *A. Senegal*.

*A. Seyal* gum gives a dark blue color indicating the presence of Tannin [8].
Chapter (3)

Results and discussions
### 3.1 Results:

The results of the physicochemical characteristics of *Acacia* gum samples are shown in Table 1.

**Table 1: Comparison of the results of physicochemical characteristics of *A. senegal* and *A. seyal*.

<table>
<thead>
<tr>
<th>No.</th>
<th>Test</th>
<th><em>A. senegal</em></th>
<th>Specifications*</th>
<th><em>A. seyal</em></th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Solubility</td>
<td>50.35%</td>
<td>soluble in twice its mass of distilled water</td>
<td>49.22%</td>
<td>soluble in twice its mass of distilled water</td>
</tr>
<tr>
<td>2.</td>
<td>Moisture</td>
<td>6.8%</td>
<td>not more than 10.0%</td>
<td>5.6%</td>
<td>—</td>
</tr>
<tr>
<td>3.</td>
<td>Viscosity</td>
<td>82.5cps</td>
<td>80.0 - 150.0 cps</td>
<td>115.0cps</td>
<td>—</td>
</tr>
<tr>
<td>4.</td>
<td>Color</td>
<td>0.90</td>
<td>—</td>
<td>4.3</td>
<td>—</td>
</tr>
<tr>
<td>5.</td>
<td>Specific Optical Rotation</td>
<td>-28.67°</td>
<td>(-26.00°) - (-34.00°)</td>
<td>+49.16°</td>
<td>—</td>
</tr>
<tr>
<td>6.</td>
<td>pH</td>
<td>4.6</td>
<td>4.00 - 4.80</td>
<td>4.3</td>
<td>—</td>
</tr>
<tr>
<td>7.</td>
<td>Total Ash</td>
<td>3.4%</td>
<td>not more than 4.0%</td>
<td>3.2%</td>
<td>not more than 4.0%</td>
</tr>
<tr>
<td>8.</td>
<td>Acid Insoluble Ash</td>
<td>0.20%</td>
<td>not more than 0.50%</td>
<td>0.13%</td>
<td>not more than 0.50%</td>
</tr>
</tbody>
</table>
3.2 Discussions :-

3.2.1 Solubility :-

The test showed a slight difference in solubility of *A. Senegal* gum (50.35%) and *A. Seyal* gum (49.22 %). The gums of both varieties have high water solubility. This result is in agreement with that reported in literature[1].

3.2.2 Moisture:-

The moisture content in Hashab gum (6.8%) was higher than that of Talha gum moisture content(5.6%), The moisture content in both varieties was found to lie within the range specified in specifications.

3.2.3 Viscosity:-

The viscosities of 30 % aqueous solutions *A. senegal* and *A. seyal* gum samples at 20°C were 82.5 and 115.0 cps, respectively. Both results were found to lie within the range specified in specifications (80 – 150cps).

The relatively low viscosity of *A. senegal* gum solutions compared to its high solubility in water besides the fact that it is recognized as safe food additive is an advantage when used as an emulsifier in food industries.

3.2.4 Color :-

The color values of 10% aqueous solutions of *A.senegal* and *A. seyal* gums were 0.90 and 4.3 , respectively , on Lovibond comparator scale
The fact that the color of aqueous *A. senegal* gum is very low or negligible is another advantage because it does not change the color of the food product to which it is added.

The higher color value (4.3) of *A. Seyal* gum is a disadvantage because this imparts color to the food product.

### 3.2.5 Specific Optical Rotation :-

The specific optical rotation of 2% aqueous solutions of *A. senegal* and *A. seyal* were -28.67° and +49.16°, respectively, these values are in conformity with specifications. This striking difference in optical rotation is used as a crucial characteristic to determine the type of gum product.

*A. senegal* Gum in aqueous solutions is levorotatory probably due to the higher percentage of L-arabinose compare to D-galactose in *A. senegal* Gum composition.

*A. seyal* Gum aqueous solutions is dextrorotatory, probably due to the higher percentage of D-galactose compare to L-arabinose in *A. seyal* Gum composition.

### 3.2.6 pH :-

The higher acidity (low pH) of *A. Senegal* could be due to the presence of the higher content of Glucoronic acid in *A. Senegal* (~16%) compared to that of *A. Seyal* (~6.5%) [3,6].

### 3.2.7 Total Ash:-

Total ash content of *A. Senegal* Gum was slightly higher (3.4%) than that of *A. Seyal* Gum (3.2%).

### 3.2.8 Acid insoluble ash:-
Acid insoluble ash content was higher in *A. Senegal* gum (0.20%) than that in *A. Seyal* gum (0.13%).

### 3.1.9 Tannins:-

The test for Tannins with FeCl₃ showed a dark blue color with *A. Seyal* gum i.e a positive test for Tannins, while *A. Senegal* gum gave a negative test for Tannins. The absence of Tannins in *A. senegal* is an advantage as for use in food industries because the Tannins have a bitter taste which affects the taste of food products. The presence of Tannins in *A. seyal* gum does not make it suitable for use in the food industries.
Chapter (4)

Conclusion and Recommendation
(4.1) Conclusion :

The physicochemical characteristics of the sample A. senegal gum processed at Heneli factory lie within the limits specified in the international European specifications. However, the specification combines A. senegal with A. seyal.

The high solubility and low viscosity of A. senegal gum, besides the absence of Tannins make A. senegal gum suitable for use in the food and pharmaceutical industries as an emulsifier because it does not change the color or taste of the products. However, the presence of Tannins and color in A. seyal gum makes it not suitable for use in the food industries.
(4.2) **Recommendation:-**

It is recommended that both types of acacia gum should be given a separate specification. It is also recommended that trials be made to remove the color and Tannins from *A. seyal* gum to upgrade its quality so as to gain higher prices.
References:


