Effect of Geographical Location on some Physicochemical Properties and Emulsion Stability of A.seyal Gum

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Abstract:

The objectives of present study were to investigate the effect of geographical locations on physicochemical properties and emulsion stability of gum from *A.seyal*. Gum samples were collected from areas of *Heglieg, Abeyei*, *Nama* and *Elfula* West Kordofan State, Sudan during (2018-2019). The samples were carefully, cleaned, milled then packed and stored in polyethylene bags. Spectrophotometer, ICPE-9000 Spectrometer methods used. Different gum parameters such as: solubility, moisture, protein, minerals, pH, tannin, M.wt, viscosities and emulsions stability were measured. Emulsion stability of *Acacia seyal* gum tested with oil types (groundnut, sesame and sunflower) under effect of temperature, stirring time, concentration and gum grade. Data were analyzed using SPSS. The results found that Gum from *Elfula* contained highest emulsion stability (1.53), *Nama* (1.15) compared to gum from *Heglieg* and *Abeyei* locations. The statistical analysis showed that no significant differences ($P \leq 0.05$) between four different locations sources of the solubility, moisture, ash, nitrogen, protein contents, pH, optical rotation and intrinsic viscosity, while there were significant differences ($P \leq 0.05$) found between above locations in absolute viscosity, reduced viscosity, molecular weight and Emulsion stability. *Elfula* contain higher N (0.69%), protein (4.53%), *Nama* (0.59%) N, (3.86%) protein compared to gum from

Heglieg and *Abeyei* location. In addition *A. seyal* gum shows +ve results for tannin tested for all samples, intrinsic viscosity (15.09, 11.87, 13.49 and 15.06 mL/g) for gum from *Heglieg*, *Abeyei*, *Nama* and *Elfula* location, respectively. Mineral contents, gum samples had higher values of S (200, 160, 120 and 110 ppm) followed by Mg (180, 130, 110 and 80 ppm), Ca (160, 150, 130 and 110 ppm). Sesame oil showed most stable emulsion, while groundnuts of *Abeyei* (0.50), *Elfula* (0.97) and sunflower *Abeyei* (0.39) and *Nama* (0.85) showed the lowest emulsion stability. In concluded remarks emulsion stability was significantly influenced by the type of oil, stirring time, concentration, gum grade and temperature.

Keywords: Physicochemical, Emulsion, Stability, Acacia Seyal, Gum Arabic.

تأثير الموقع الجغرافي علي بعض الخواص الفيزيوكيميائية وثبات المستحلب لصمغ الأكاشيا سيال

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المستخلص:

هدفت هذه الدراسة للكشف عن تأثير الموقع الجغرافي علي الخواص الفيزيوكيميائية وثبات المستحلب لصمغ الأكاشيا سيال. جُمعت العينات من مناطق هجيليج، أبيي، ناما والفولة بولاية جنوب كردفان، السودان خلال العام 2018-2019م. نظفت العينات وسُحنت وحُفظت في أكياس البولي إثين. أُستخدمت طرق الأسبكتروفوتوميتر وأيون البلازما المزدوج في التحليل. قيست عدة عوامل مثل: الذوبانية، الرطوبة، البروتين، المعادن، الرقم الهيدروجيني، التانينات، الوزن الجزيئي، اللزوجة وثبات المستحلب. تم إختبار ثبات المستحلب لصمغ الأكاشيا سيال بذوبانه في عدة زيوت مثل (الفول السوداني، السمسم وزهرة الشمس) تحت تأثير كل من درجة الحرارة، زمن الإثارة ودرجة تركيز الصمغ. جُللت البيانات باستخدم الجزم الإجصائية للنظم الإجتماعية SPSS. وُجد أن صمغ منطقة الفولة يحتوي علي نسبة إستقرار عالية بلغت (1.53)، ناما (1.13) مقارنة بضموغ منطقتي هجيليج وأبيي. أظهر التحليل الإحصائي بأنه لا توجد فروق معنوية عند (P≤0.05) بين مناطق الدراسة المختلفة لكل من: الذوبانية، الرطوبة، الرماد، النيتروجين، البروتين، الرقم الهيدروجيني، الدوران الضزئي واللزوجة الأصيلة. وهناك فروق معنوية ذات دلالة إحصائية بقيمة (P≤0.05) بين المناطق الاربعة المذكورة آنفاً في اللزوجة المطلقة، اللزوجة المنخفضة، الوزن الجزيئي واستقرار المستحلب. منطقة الفولة تحتوي علي نسبة نيتروجين عالية (0.69)،

بروتين (4.53)، ناما (0.59) نيتروجين و (3.86) بروتين مقارنة بمنطقتي هجيليج وأبيي. بالإضافة لذلك أظهرت نتائج صمغ الأكاشيا سيال نتائج إيجابية لإختبار التانين لكل العينات. قيم اللزوجة المنخفضة (15.09، 11.87، 13.49 و 15.06 ملجرام/جرام) لصمغ مناطق هجيليج، أبيي، ناما والفولة علي التوالي. قيم محتويات المعادن لعينات الصموغ كانت عالية لكل من الكبريت (200، 160، 120 و110 جزء من مليون جزء)، الماغنسيوم (180، 130، 110 و80 جزء من مليون جزء)، ثم الكالسيوم (160، 150، 130 و110 جزء من مليون جزء). أظهر زيت السمسم استقرار مستحلب عالي بينما زيت الفول السوداني لمنطقة أبيي 0.50، الفولة 0.97 وزيت زهرة الشمس لأبيي كانت 0.39، ناما 0.85 تُظهر قيم مستحلب منخفضة. خلُصت الدراسة أن مؤشرات استقرار المستحلب تتأثر معنوياً بنوع التربة، زمن الإثارة، التركيز، درجة الصمغ ودرجة الحرارة.

الكلمات المفتاحية: الخواص الفيزيوكيميائية، المستحلب، الاستقرارية، الأكاشيا سيال و الصمغ العربي.

Introduction

Gum Arabic (GA) or Acacia gum is an edible biopolymer obtained as exudates of mature trees of *Acacia senegal* and *Acacia seyal* which grow principally in the African region of Sahel in Sudan. The exudate is a non-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 (**1**). GA is a product of the genus Acacia; namely *Acacia senegal* and *Acacia seyal* locally known in Sudan as *Hashab* and *Talha* respectively. The two acacias are found in Sub-Saharan Africa in a belt widely known as the gum belt. Sudan is the world's largest producer of GA, followed by Chad and Nigeria (**2**). The composition of GA is effected mainly by the location, tree age, season of exudation, storage type and the genetic factor (**3, 4**). GA or *Acacia* gum is a soluble dietary fiber obtained from the stems and branches of the *Acacia senegal* and *Acacia seyal* plants, which grow mainly in the African region of Sahe in Sudan (**5**). *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 (**6**). However, the composition of GA may change depending on the source, climate, and soil (**7**). Because of the physical properties of GA, it has been widely used in various industries including cosmetics, textiles, ceramics, pharmaceuticals and foods (**2**), and food production as an emulsifier, a stabilizer, and a thickener due to its non-digestibility, low-solution viscosity, and safety (**8**). The physical properties of *Acacia* Gum, established as quality parameters include solubility, moisture, viscosity, optical rotation, pH, total ash, acid soluble in ash. 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**).

Materials and Method

Study areas:

Dried gum samples were collected from *Acacia seyal trees* in areas of *Heglieg* (longitudes 27° 52' 59.99" E, and latitudes 11° 58' 59.99" N), *Abeyei* (longitudes 28° 26' 9.60" E and latitudes 9° 35' 42" N), *Nama* (longitudes 31° 2' 0" E and latitudes 12° 35' 41" N), *El Fula* (longitudes 28° 20' 46" E and latitudes 11° 42' 43" N) in West Kordofan State during the season of 2018- 2019. The areas had a varying climate, ranging from desert and semi-desert in the north, to rich savanna in the south. Arid and semi-arid zones cover the largest part of this region. The soil in the region ranges from sandy in the north to heavy cracking clay in the south. In between, there are the so-called "gardud" soils, the sandy soils cover about 60%of the cultivated land, with organic matter, N and P comprising less than 1%, the clay soils were dark, cracking vertisols, low in N and P and *gardud* soils were compacted soils found on the high ridges of undulating plains, developed in- situ from the local igneous and metamorphic rocks, (**9**).

Gum sampling and perpetration:

The gum samples used in this work were collected and cleaned by hand to be sure it were free from sand, dust and bark impurities, and then were milled in Agriculture Research Station (El Obeid) mill, then kept in labeled (polyethylene) bags.

Sample A Heglieg Area	Sample B Abeyei Area	Sample C Nama Area	Sample D El fula Area

Figure (3.1) Hands pick raw gum samples from four areas;

Solubility

Solubility was obtained by dissolving 1g of formulation (W) in 100 ml of each of the following solvents, distilled water and ethanol in 250ml conical flask, then stirred for 30 minutes by magnetic stirrer and the solution filtered through filter paper No.42, which was weighted before filtration (W_1). The filter paper and contents were then dried at 105°C for 30 minutes, cooled and weighted (W2W2), (**10**).The solubility was calculated as percent according to the following equation:

$$S\,\% = \frac{W - (W2 - W1)}{W}$$

S = Solubility

WW =Weight of formulation

W1W1 =Weight of empty filter paper

W2W2 = Weight of filter paper + insoluble formulation.

Moisture content

The determination was conducted on accurately weighted, 2 g of previously will mixed gum powder. An empty crucible was dried in an oven at 105°C for 30 minutes, cooled in a desiccators and weighted (W1W1), about 2 g of formulation were placed in the crucible weighted accurately (W2W2) and heated for 5 hours at 105°C, cooled in a desiccators and weighted again (W3)W3), (**10**). The loss on drying was calculated as follows:

$$\text{Moisture content \%} = \frac{(W2 - W3)}{(W2 - W1)} \times 100$$

W1W1 = Weight of the empty crucible

W2W2 = Weight of the crucible + formulation

W3W3 = Weight of the crucible + formulation after drying.

Nitrogen and protein contents

Nitrogen and crude protein were determined using a semi-micro *Kejeldal* digestion and distillation method, 1g of the formulation was weighed into 100 ml *Kejeldal* flask, 2 tablets of catalyst mixture (potassium sulfate + copper sulfate) and 12.5 ml concentrated sulfuric acid were added. The flask containing all these mixtures was heated on an electric heater for digestion for two hours, then was cooled and placed in the distillation unit. The ammonia evolved was received in 25 ml of boric acid solution containing 3 drops of mixed indicator (bromocresol, green and methyl red) (**11**). The trapped ammonia was titrated against 0.1N HCl; hence the protein percentage was determined according to (**12**), by multiplying nitrogen percentage N% by the factor 6.6.

$$N\% = \frac{V \times N \times 14 \times 100}{S}$$

V = Volume of HCl

14 = Atomic mass of nitrogen

N = Normality of HCl (mol /$dm^3 dm^3$)

S = Weight of sample.

Protein % = N% × 6.6 Where: 6.6 = the nitrogen factor for gum Arabic (**12**).

Total ash contents

The ash percentage was determined as an empty crucible was heated at 105°C for 30 minutes, cooled in a desiccators and weighted (W_1), about 2g of formulation were accurately weighted in a crucible (W_2), and ignited in an electronic muffle furnace at 550°C until free from carbon, cooled in a desiccators and weighted

(W_3), then the total ash percentage was calculated as follows (**10**).

$$\text{Total ash content \%} = \frac{W2 - W1}{W2 - W3} \times 100$$

W1 = Weight of the empty crucible

W2 = Weight of the crucible + the formulation

W3 = Weight of the crucible + ash

Specific optical rotation:

The specific optical rotation was determined for 1.0 % aqueous solution on dry weight basis using an optical activity Bellingham and Stanley ltd. AD 220 polar meter fitted with sodium lamp and with a cell path length of 20 decimeter at room temperature (25°C) after filtration of the gum solution through filter paper No. 42.Readings were taken three times and averaged. The specific optical rotation was calculated according to using the following equation:

$$\propto = \frac{Z \times 100}{C \times L}$$

∝∝ = Specific optical rotation

Z Z = observed optical rotation

CC = concentration of solution

L L = Length of polar meter cell in decimeter

pH value

pH was determined in 10% aqueous solution using two standard buffer solutions of pH 4.00 and 7.00 were used for the calibration of the pH meter. The temperature was kept at 25°C and the pH was left to stabilize for one minute and then the pH of gum formulations was read directly.

2.7. Molecular weight

The molecular weight was calculated using Mark-Houwink equation.

$$\eta i = K \times Mw^{t}$$

MwtMwt= Molecular weight
ηi = Intrinsic viscosity
K and a = Mark -Houwink constants

Based on (Anderson and Rahman, 1967), the values of K and a, were determined for *Acacia seyal* gum as follows: $K = 1.3 \times 10^{-2}$ $K = 1.3 \times 10^{-2}$, $a = 0.54 a = 0.54$

Tannin contents

0.1 ml Ferric chloride was added to 10 ml 1% aqueous gum solution. Presence of blackish coloration or precipitate indicates the presence of tannin (**13**).

Determination of Mineral contents

Mineral content were determined using Shimadzu's ICPE-9000 multi type spectrometer. One gram of dried gum was weighted and placed in a porcelain crucible, then placed in a cool muffle furnace and ashed at 550°c overnight. The ash was cooled and 0.1ml of it was dissolved in 5 ml of 20% hydrochloric acid. The solution was warmed in a sand bath, to dissolve the ash, and then filtered through an acid washed filter paper. The filter paper was washed and the solution was diluted with 10ml distilled water and well mixed, then put in the Spectrometer cell to determine the absorption of the element and the observed reading was taken.

Absolute viscosity

A digital Brookfield viscometer was used for this study. It measured the torque required to rotate an immersed spindle in a fluid. The gum mucilage sample of concentration (25% w/v) was prepared in a 250 ml beaker. Appropriate enough to immerse the spindle groove in the fluid. Then, the viscosity was determined using the instrument with spindle No. 2 speed of rotation 60 rpm and then for each sample triplicate measurements were made.

Intrinsic viscosity (η)

The intrinsic viscosity was obtained by extrapolation of reduced viscosity against concentrations back to zero concentration.

The interception on Y – axis gives (η).

Measurement of stability of emulsions

Three types of refined oil (sesame, groundnut and sunflower) and 20% aqueous gum solution were used to prepare stock emulsions. Emulsions were prepared by blending a measured amount of the gum solution (20%) and the oil (2:1 v/v) for one minute at 1800 rpm using homogenizer (triplicate preparations were made for each study). Aliquot 1 ml of the stock emulsion was diluted in distilled water to give final dilution of 1ppm. The absorbance was then read at 520 nm in spectrophotometer (CECIL, CE 2041). Another reading of absorbance was recorded after an hour following the same procedure as before (**14**).

$$\text{Emulsion stability (E. S)} = \frac{\text{First reading}}{\text{Reading after 1 hour}}$$

Tests for stability of emulsion under influence of some factors:

These tests were done with the objective of studying effect of emulsification factors of stirring time, temperature, concentration, gum grade and quality, on emulsion stability. The tests for stability were performed in emulsions prepared by mixing the sesame oil (Selected as giving the highest emulsion stability) with 20% aqueous gum solution, (**14**).

Stirring time: This test was done to study effect of the length of stirring on emulsion stability. One ml of the stock emulsion was diluted with distilled water to a concentration of 1ppm and then stirred for different times (1 and 2 minutes) using magnetic stirrer. Emulsion stability was determined following the previous procedure (**14**).

Concentration: Distilled water diluted concentrations of stock emulsion solution of 1ppm and 2ppm were prepared and examined for emulsion stability under a fixed stirring time of one minute at room temperature. Emulsion stability was measured as before (**14**).

Temperature regime: Emulsions of 1ppm concentration were subjected to four temperature regimes; 30, 50 and 70°C°C; for 30 minutes and then emulsion stability was measured as before (**14**).

Gum grade: Emulsions were prepared by blending 20% aqueous gum solutions and sesame oil in a ratio of 2:1 Determination of emulsion stability was done following the method described by (**14**).

Statistical analysis:

Each sample was analyzed chemically in triplicate then averaged. Data was assessed by analysis: SPSS+ Excel using ANOVA. (Analysis of variance), the mean difference is significant at the 0.05 level.

Results and Discussion

General physicochemical properties of GA

Results of analytical data of *A .seyal* gums collected from four locations namely *Heglieg*, *Abeyei*, *Elfula* and *Nama* from west Kordofan State, Sudan. There were no significant differences (P≤0.05) between the four locations in an average of solubility table (1), moisture content, ash content, tannin, pH, optical rotation, intrinsic viscosity, molecular weight and significant differences (P≤0.05) between the four locations for nitrogen content, protein content, absolute viscosity, reduced viscosity and Emulsion stability. Tables (3) and table (4) showed physicochemical properties of the four samples, analysis of the samples was carried out in triplicate and then an average.

3.1 Solubility

Table (1) showed an average of solubility of *Acacia seyal* gum in distilled water were (98.83, 99.83, 99.17 and 99.83%) from *Heglieg*, *Abeyei*, *Elfula* and *Nama* respectively, thus insoluble percentage were within the range 0.2 - 1.6% for *A. senegal* gum determined (**15**). But it was insoluble in ethanol thus agree with (**16**).

Table (1): Solubility of *Acacia seyal* gum in distilled water and ethanol (at room Temperature)

Locations	Solvent	Average of solubility%
Locations	water ethanol	98.83 00.00
Hegleig	water ethanol	99.83 00.00
Abeyei	water ethanol	99.17 00.00
Elfula	water ethanol	99.83 00.00
Nama	water ethanol	98.83 00.00

Moisture content

An average of moisture content of *Heglieg*, *Abeyei*, *Elfula* and *Nama* samples were found to be (10.82, 12.15, 10.48 and 11.32%) respectively table (2). Results of *Nama* and *Abeyei* were within the range from 11% to 16.1% of *A. seyal var. seyal* gum but *Heglieg* and *Elfula* results less than these values (**16**) reported for *A. seyal var. seyal* gum. Also results for the four samples were higher than the range from 7.4% to 8.3% for moisture content of *A. seyal var. seyal* gum which Hassan *et al*., (2005) reported and less than the value of 12.6% for the moisture content of *A. seyal var. seyal* gum (**17**). Results table (2) were conforming to the Sudanese Standards moisture content (not more than 15%) (**18**).

Table (2): Chemical properties of *Acacia seyal* gum from deferent locations in West Kordofan State. Protein% = nitrogen $\% \times 6.6 \% \times 6.6$. Anderson (1986).

Locations	moisture%	nitrogen%	protein %	Total ash %	pH	$Mw \times 10^5 g/mol$
Heglieg	10.82	0.26	1.72	2.50	4.20	6.37
Abeyei	12.15	0.29	1.91	2.87	3.98	4.06
El Fula	10.48	0.69	4.55	2.79	4.10	6.1
Nama	11.32	0.59	3.89	2.96	4.20	4.96

Ash content

For ash content the results showed in table (2) were agree with the range from 1.94% to 3.55% for A. *seyal* var. *seyal* gum (**18**), and it were less than 3.1% (**19**), 3.9% (**20**) and less than that values for samples on heavy soil 3.5% and 3.3% Anderson *et al*. (1968) found for *A.senegal* gum. Findings in table (2) within the range of standard specification (2 - 4%) (**10**). the maximum limit of total ash for food and pharmaceutical quality of Gum Arabic is 4% w/w (**18, 15**).

Nitrogen and Protein content

Table (2) showed (0.26, 0.29, 0.69, and 0.59%) values of nitrogen content and (1.72, 1.91, 4.55, 3.89%) values of protein content using the 6.6 standard Nitrogen Conversion Factor NCF (**21**) for *A.seyal* gum from *Heglieg*, *Abeyei*, *Elfula* and *Nama* respectively. Values of nitrogen content table (2) for *Heglieg* (0.26%) and *Abeyei* (0.29%) were within the range compared to the international standard of (0.26-0.39%) table (3) and nitrogen content of *Elfula* (0.69%) and *Nama* (0.59%) relatively were found to be higher than that value in table (3), with corresponding this was an encouraging result considering the significance of nitrogen in the application properties of Gum Arabic. It was important to study the nitrogen content of gum because it forms an important component which absorb onto the surface of oil droplet for the purpose of emulsion stability, (**22**) reported that the protein moiety of Gum Arabic affect its emulsification ability and that the best emulsion stability was found in gums with highest amount of nitrogen.

Table (3): International specifications of quality parameters of Gum Arabic (10).

Parameter	*Acacia senegal*
Moisture content (%)	13–15
Ash content (%)	2–4
Internal energy (%)	30–39
Volatile matter (%)	51–65
Optical rotation (degrees)	-26 – -34
Nitrogen content (%)	0.26–0.39
Cationic composition of total ash at 550 °C	
Copper (ppm)	52–66
Iron (ppm)	730–2490
Manganese (ppm)	69–117
Zinc (ppm)	111–45

pH values

Table (2) illustrated pH of samples for *Heglieg*, *Abeyei*, *Elfula* and *Nama* (4.20, 3.98, 4.10 and 4.20) respectively, these values were less than the value of 4.30 for pH of *Acacia senegal* gum recorded and 4.66 pH values for *Acacia senegal* reported, but similar to 4.20 for *Acacia seyal* gum reported by (**15**). The Gum Arabic of the four samples was slightly acidic, and these values were in agreement with standard international specification of quality parameter of Gum Arabic (**10**). This acidity was due to major component and cations of Gum Arabic.

Molecular weight

As illustrated in table (2), the molecular weights for *Heglieg*, *Abeyei*, *Elfula* and *Nama* were found to be (6.37, 4.06, 6.1 and 4.96$\times 10^5 \times 10^5$) g/mol g/mol respectively, analysis of variance revealed significant differences (P≤0.05) between the four locations. The present findings tables (2) were higher than 3.0×10^3, and lower than $1.0\times10^6 10^6$ (23), also lower than 4.0×10^6 4.0×10^6 - $2.2 \times 10^6 2.2 \times 10^6$, (**24, 25**), found to be 5.4×10^5 5.4×10^5 *A. senegal* gum. Molecular weight variation in values maybe due to gum heterogeneity as well as variation in techniques used to separate.

Specific optical rotation

Aqueous solutions of the four samples were found to be optically active (dextrogyrate). An average of specific rotation of *Heglieg*, *Abeyei*, *Elfula* and *Nama* samples were: (+47.03°, +48.47°, +57.43° and +50.53°) respectively table (4), these findings were within the range +39º to +63.9º for *A. seyal* gum **(23)**. Analysis of variance showed no significant differences ($P\leq0.05$) between the samples within each location. Relevant to specific rotation, the four locations proved to be insignificantly ($P\leq0.05$) different.

Tannin content

Test for Tannins with $FeCl_3$ showed a dark blue color of the *Acacia seyal* gum, a positive test table (4). The presence of Tannins in *A. seyal* gum does not make it suitable for use in the food and pharmaceutical industries.

Viscosity

The increase in viscosity of the gum is a result of raising the pH and the reduction in viscosity is due to increasing temperature. In addition, it can be clearly noticed from Table (4) that each study reported a different value for pH of studied gum solution (range: 3.9-5.54). Absolute viscosity were measured using Brookfield viscometer, concentration of gum 25% showed in table (4) , the viscosity for *A. seyal* gum, from *Helieg*, *Abeyei*, *Elfula* and *Nama* which were found to be (52.65, 43.00, 53.61 and 48.35) cps/s respectively, there were significant deference ($P\leq0.05$) between the four location. Variation in viscosity among samples from deferent locations confirmed the fact that there was an inherited variation in the molecular weight of natural gum.

Table (4): Physical properties of *Acacia seyal* gum from different locations from west Kordofan State

Locations	Specific rotation	Intrinsic viscosity (ml/g)	Absolute viscosity cp/s	tannin%
Heglieg	+47.03°	15.09	52.65	**+ve**
Abeyei	+48.47°	11.87	43.00	**+ve**
El Fula	+57.43°	15.06	53.61	**+ve**
Nama	+50.53°	13.49	48.35	**+ve**

Intrinsic viscosity

Table (4) report the results of the four samples (15.09 ,11.87 ,15.06 and 13.49 ml/g) for *Heglieg*, *Abeyei*, *Elfula* and *Nama* respectively of *Acacia seyal* gum there were no significant differences (P≤0.05) between them, results were within the range 10.4 -19.8$cm^3 g^{-1}$ of *A. senegal var. senegal*, **(26)** studied. Results obtain from *A .seyal* gum table (4) were less than that value 16.6 $cm^3 g^{-1}$ for *A.senegal var.senegal*, and higher than 11.0 $cm^3 g^{-1}$ for *A. seyal var. seyal*. Results in table (4) agree with **(27, 28),** whom reported an intrinsic viscosity of *A. seyal var. seyal* in the ranges between 11.9-17.6 $cm^3 g^{-1}$and 11.6 - 17.7 $cm^3 g^{-1}$ respectively.

Reduced viscosity

As illustrated in Figure (1), (2) reduced viscosity inversely decreased with an increase of concentration; may be due to cleavage of molecular bonds which leads to molecular break down and low viscosity. Solutions containing less than 10% of Gum Arabic have a low viscosity and respond to Newtonian behavior **(29).**

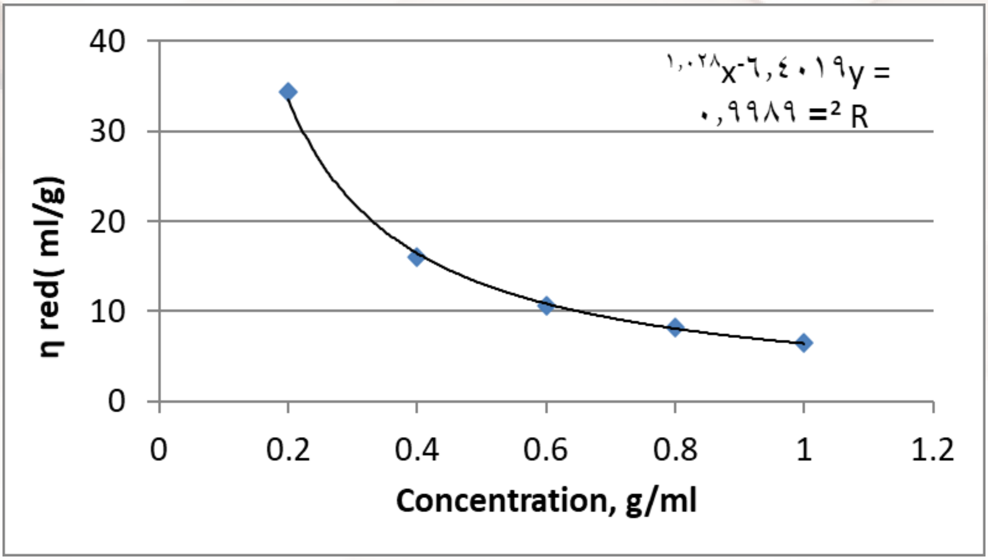

Figure (1): Relations between reduced viscosity and concentration (g/ml) for *Heglieg* location.

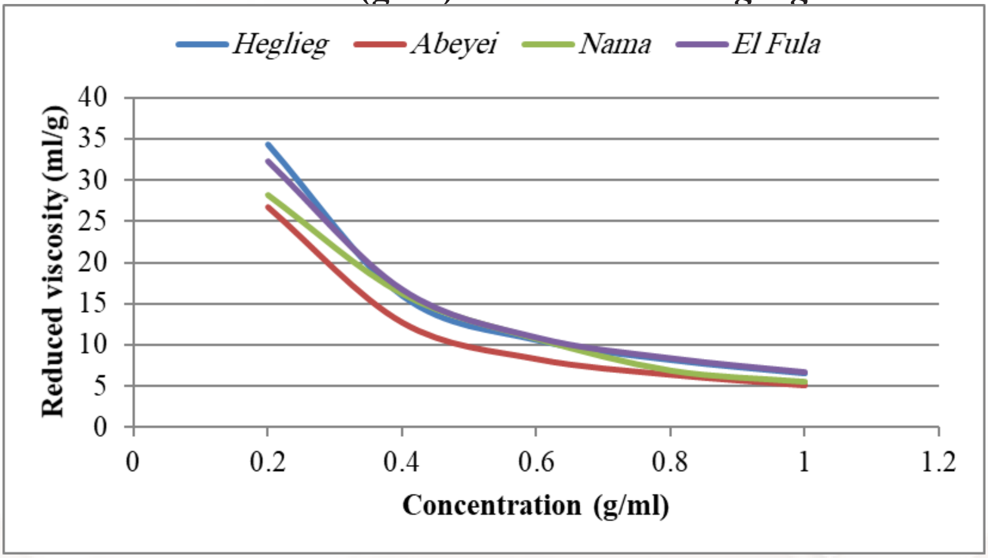

Figure (2): Relation between reduced viscosity and concentration (g/ml) for *Heglieg*, *Abeyei*, *Nama* and *Elfula* locations.

Cations composition

Cationic composition studied using ICP Emission Spectroscopy-9000 technique. Table (5) show that Sulphur had the major values (200,160 ,120 and 110ppm) among the cations study for *Heglieg*, *Abeyei*, *Nama* and *Elfula* locations respectively, followed by Mg, Ca, K, I, P, Na, Cu and the lowest was Ho, for *Heglieg* location. For *Abeyei* location Sulphur followed by Ca, Mg, Pt, P, I, Na, K and the lowest was Si. Nama location the highest Sulphur followed by Ca, Mg, P, I, K and the lowest was Ho. But for Elfula location the highest Sulphur followed by Ca, Mg, I, Na, Cu, K and the lowest one were Si and Ba. From observation table (5) *Elfula Seyal* gum had the lowest value of S and minerals than the others samples and that is may be due to rain fall and types of soil.

Table (5): The cationic composition of *acacia seyal* gum from *Heglieg*, *Abeyei*, *Elfula* and *Nama* locations.

Heglieg	ppm	*Abeyei*	ppm	*Elfula*	ppm	*Nama*	ppm
S	200	S	160	S	110	S	120
Mg	180	Mg	130	Mg	80	Mg	110
Ca	160	Ca	150	Ca	110	Ca	130
K	33	K	13	K	7.3	K	13
I	30	I	16	I	12	I	15
P	29	P	19	P	-	P	15
Na	17	Na	14	Na	10	Na	9.8
Cu	10	Cu	9.9	Cu	8.5	Cu	8.8
Ba	4.4	Ba	3.0	Ba	2.5	Ba	2.8
Ta	4	Th	9.7	Si	2.5	Bi	4.8
Mo	3.8	Pt	23	Fe	3.5	Si	2.3
Fe	2.2	Fe	2.1	-	-	Fe	2.8
Si	1.7	Si	1.5	Zn	0.26	Ho	1.1
Sr	1.5	Sr	2.7	Sc	0.22	Sr	0.90
Ho	1.2	Zn	0.66	Mn	0.17	Zn	0.39
Cd	0.58	Sc	0.35	Li	0.04	Sc	0.26
Sc	0.40	Lu	0.18	-	-	-	-
Zn	0.34	Li	0.03	-	-	-	-
Mn	0.19	-	-	-	-	-	-

Effect of emulsification factors on stability of emulsion

Effect of types of oils, temperature, stirring time, concentration and gum grade on emulsion stability were present in table (6) to (10) and figure (3) to figure (7). Oil types: table (6) Figure (3) show that emulsions prepared by mixing pure oils (groundnut, sesame and sunflower), with aqueous solutions of gums had varies stabilities (1.25, 1.08, 1.07), (0.50, 1.13, 0.39), (0.97, 1.53, 1.16) and (1.09, 1.15, 0.85) for *Hegleig*, *Abeyei*, *Elfula* and *Nama* respectively. Table (6) figure (3) indicated that using different types of oil results significant ($p \leq 0.05$) differences in emulsion stability (E.S) for the four samples of gum. Emulsion stability (E.S) when using sunflower oil was the lowest for *Abeyei* and *Nama* gums (0.39 and 0.85) respectively), also groundnut oil was the lowest for *Abeyei* and *Elfula* gums (0.50 and 0.97) respectively. While that the sesame oil was more stable (1.08, 1.13, 1.53 and 1.15) for *Heglieg*, *Abeyei*, *Elfula* and *Nama* respectively and *Elfula* gum gave the highest emulsion stability (E.S) in sesame oil compared to *Hegleig*, *Abeyei* and *Nama* gums. Differences in emulsion stability (E.S) may be ascribed to difference in protein content (Table 2). Protein was the fraction that provides the functionality of the Gum Arabic as emulsion stabilizer, therefore, the best emulsion capacity and emulsion stability in regard to coalescence and flocculation were records in gum with highest nitrogen content **(30).**

Table (6): Emulsions Stability of *Heglieg*, *Abeyei*, *Elfula* and *Nama Seyal* gum as affected by different oil types. (At room Temperature)

locations	oil	Average of E.S
Heglieg	Groundnut	1.25
	Sesame	1.08
	Sunflower	1.07
Abeyei	Groundnut	0.50
	Sesame	1.13
	Sunflower	0.39
El Fula	Groundnut	0.97
	Sesame	1.53
	Sunflower	1.16
Nama	Groundnut	1.09
	Sesame	1.15
	Sunflower	0.85

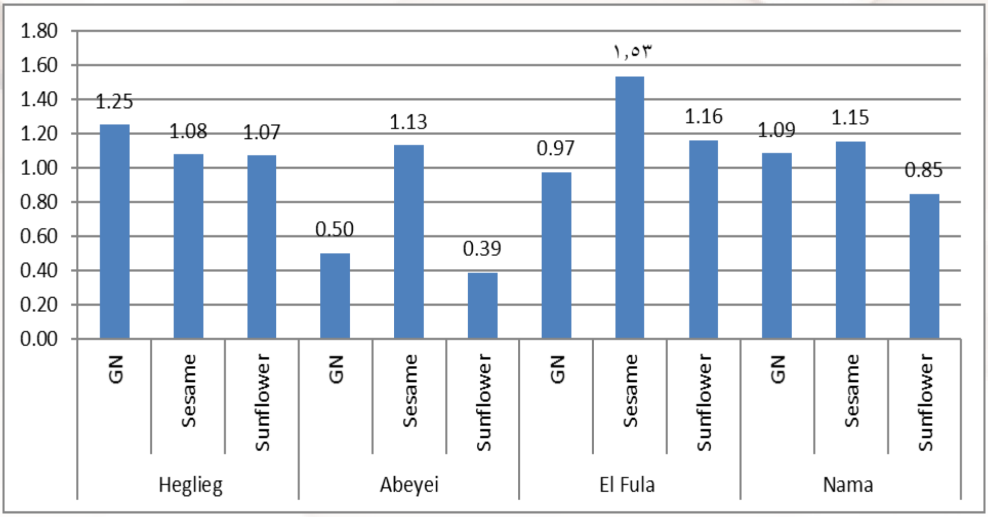

Figure (3): Emulsions Stability of *Heglieg*, *Abeyei*, *Elfula* and *Nama Seyal* gum as affected by different oil types.

Effect of Stirring of time (minutes)

Table (7) Figure. (4) Illustrates the variation of emulsifying stability for *A. seyal* gum, the emulsifying stability for *Abeyei* and *Nama* increased with an increasing time of stirring, when the *Heglieg* and *Elfula* decreased with an increasing times of stirring. This decreasing in emulsifying stability may be due to the formation of homogenous emulsion, which shows an incomplete adsorption for protein at the surface of the oil.

Table (7): Emulsions Stability of *Heglieg*, *Abeyei*, *Elfula* and *Nama seyal* gum under different stirring times (minute). (At room Temperature)

location	stirring (minute)	Average of E.S
Heglieg	1 m	0.77
	2 m	0.57
Abeyei	1 m	0.86
	2 m	1.10
El Fula	1 m	1.47
	2 m	0.96
Nama	1 m	1.04
	2 m	1.45

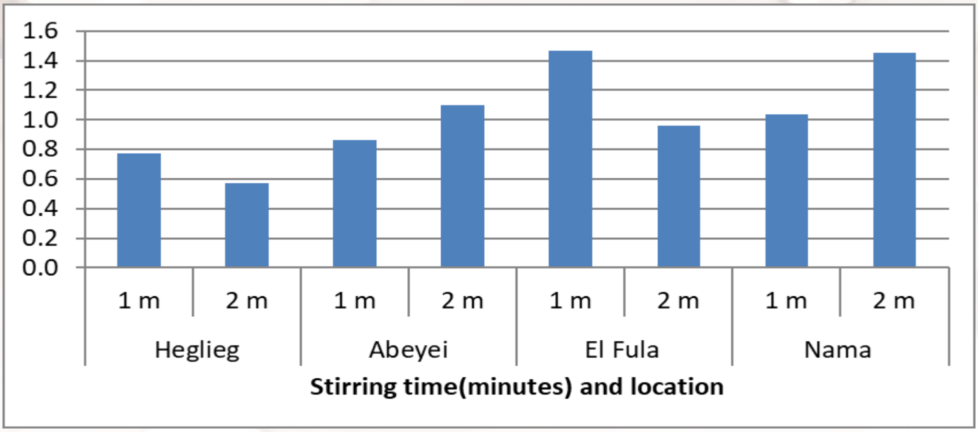

Figure (4): Emulsions Stability of *Heglieg*, *Abeyei*, *Elfula* and *Nama seyal* gum under different stirring times (minutes).

Effect of Concentration

Table (7) Figure (5), illustrates stability of emulsions with concentrations of 1ppm and 2ppm for *Acacia seyal* gum samples. *Heglieg* and *Abeyei* gums reveals an increased with an increasing of concentration, but for *Elfula* and *Nama* (highest protein) gums stability of emulsions were decreased with an increase of concentration ,this may be due to cleavage of molecular bonds which leads to molecular break down and decreased on stability of emulsions.

Table (8): Effect of varied concentrations (ppm) on measurement of emulsions stability of *Heglieg*, *Abeyei*, *Elfula* and *Nama seyal* gum. (At room Temperature)

locations	concentration (ppm)	Average of E.S
Heglieg	1ppm	1.1449
	2ppm	1.1525
Abeyei	1ppm	0.8655
	2ppm	1.2977
El Fula	1ppm	1.4421
	2ppm	0.9682
Nama	1ppm	1.2447
	2ppm	1.0487

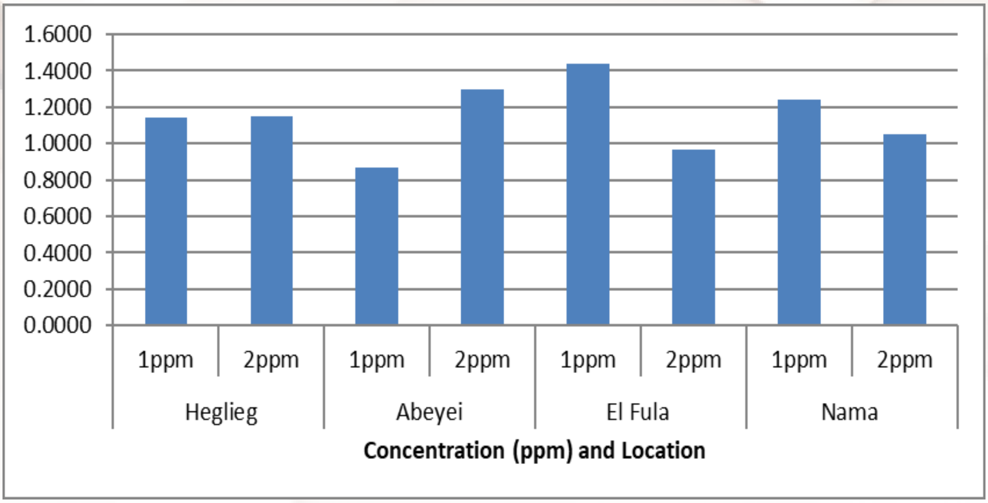

Figure (5): Effect of varied concentrations (ppm) on measurement of emulsions stability of Effect of Temperature regime (°C)

Table (9) Figure (6), illustrated stability of emulsions for *A.seyal* gum from *Heglieg*, *Abeyei*, *Elfula* and *Nama* at 30°C, 50°C and 70°C, respectively. Emulsions stability increased for *Heglieg*, *Abeyei* and *Nama* with an increase of temperature, those findings agree with those reported by **(31),** but for *Elfula* gum it was an adverse effect on the emulsifying stability; because the emulsifying stability depends on the protein in the gum, which may be affected by temperature, and may leads to denaturalize of the component of protein.

Table (9): Emulsions Stability for *Heglieg*, *Abeyei*, *Elfula* and *Nama seyal* gum under different heating of temperature (°C)

locations	temperature (°C)	Average of E.S
Heglieg	30	0.962
	50	1.096
	70	1.137
Abeyei	30	0.976
	50	1.106
	70	1.229

locations	temperature (°C)	Average of E.S
El Fula	30	1.117
	50	1.080
	70	0.942
Nama	30	0.897
	50	0.981
	70	1.340

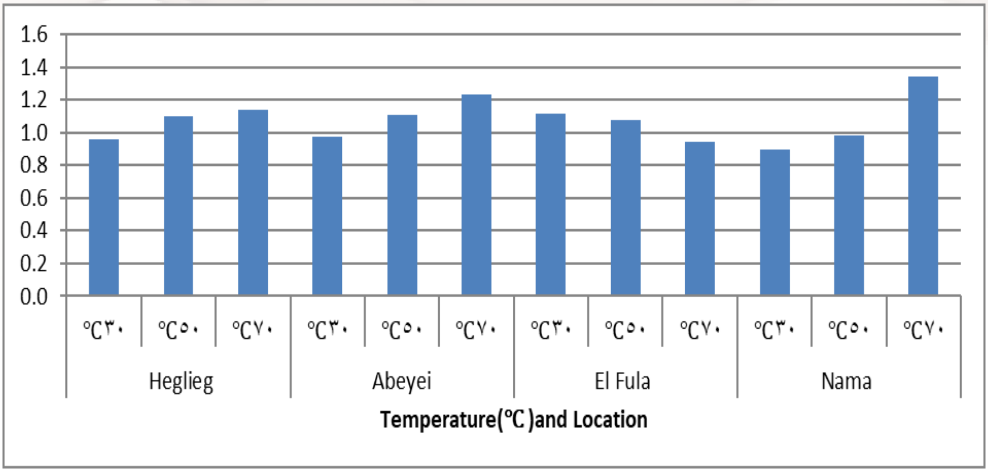

Figure (6): Emulsions Stability of *Heglieg*, *Abeyei*, *El fula* and *Nama seyal* gum under different heating of temperature (°C).

Gum grade:

Table (10) Figure (7) study effect of Stability of sesame oil-in-water emulsion of *Acacia seyal* gums, for *Elfula* was significantly ($p \leq 0.05$) higher than stability of emulsions from *Heglieg*, *Abeyei*, and *Nama*. There for *Elfula* gum was the best one than the others locations; due to higher nitrogen and protein content.

Table (10): Effect of gum grade on Emulsions stability of *Heglieg*, *Abeyei*, *Elfula* and *Nama seyal* gum.

locations	Average of Emulsions stability
Heglieg	1.078
Abeyei	1.132
El Fula	1.534
Nama	1.155

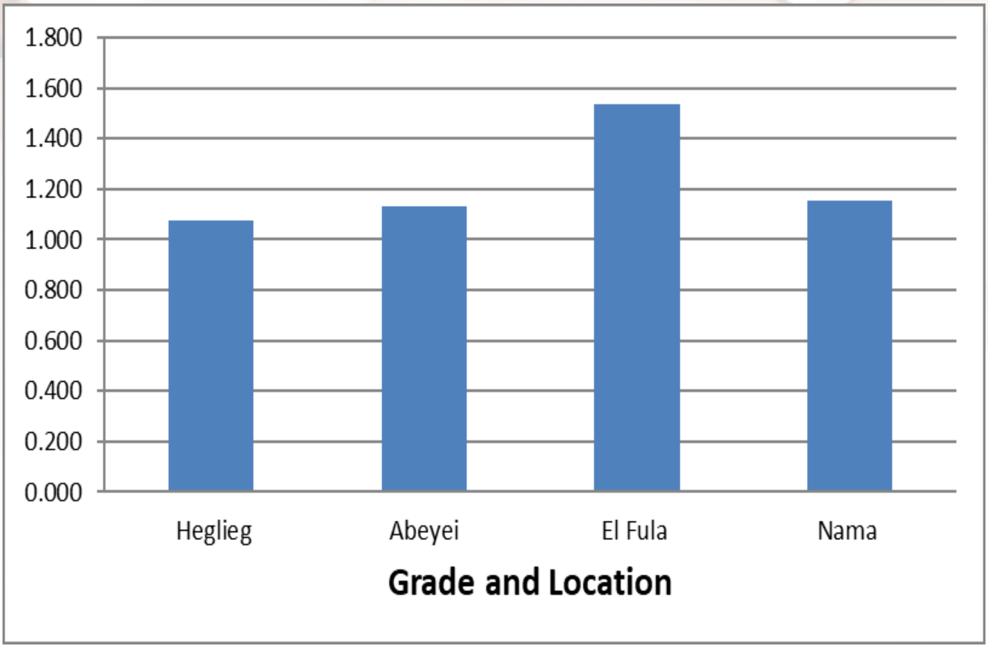

Figure (7): Effect of gum grade on Emulsions stability of *Heglieg*, *Abeyei*, *Elfula* and *Nama seyal* gum.

Conclusion:

From this study it can be concluded that Gum Arabic (*Acacia seyal*) samples from the study areas were within the range of the specifications given by the 'Joint Expert Committee, FAO for Food Additives for Gum Arabic. There was significant difference in physicochemical characteristics analyzed for the Gum Arabic samples brought from *Heglieg*, *Abeyei*, *Elfula* and *Nama* locations. Reduced viscosity measurements at different concentrations indicate that the reduced viscosity decreased with an increasing concentration of the samples. Locations and factors as such oil type, stirring time, concentration and temperature could influence the quality and emulsion stability of gum produced which in turn reflected in emulsification properties of the Gum Arabic. This study concludes that *A. seyal* gum containing tannins which limits it used in food and nonfood industry applications.

Recommendations

Study recommends to removing the Tannins and color from *A. seyal* gum so as to upgrade its quality and to be used in food and nonfood industry applications further study was needs to determine the factors influencing the emulsion stability and the soil characteristics for *Acacia seyal* and different *Acacia*s of Gum Arabic in *Heglieg*, *Abeyei*, *Nama* and *Elfula* locations.

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