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Evaluation of emulsion functionality of some Sudanese gums and their blends using He-Ne laser light scattering process

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Abstract
This study aimed to harness laser light scattering process for evaluation of the emulsifying qualities of some Sudanese gums and their blends. Three *Acacia* gums namely *A. senegal*, *A. seyal* and *A. polyacantha* were used. He-Ne laser light and specially designed sample's holder cell were configured in an experimental setup to allow for estimating the scattered laser light from the emulsions prepared from these gums and their blends. The study revealed that the emulsifying power (EP) of the studied gums can be arranged in the following order: *A. polyacantha* > *A. seyal* > *A. senegal*, hence their relative emulsifying power, taking *A. senegal* as reference, in the order 1.4: 1.3: 1.
The study established that *A. polyacantha* gum forms the most stable emulsions, while *A. seyal* forms the least among them. Emulsions prepared from blending of these gums show that a blend of 30% *A. polyacantha* and 70% *A. seyal* has the best emulsifying power and the highest emulsifying stability compared to emulsions prepared from the two pure gums alone.

Keywords: *A. senegal*, *A. seyal*, *A. polyacantha*, Laser**,** Emulsifying power**,** Emulsions stability

1. Introduction
Many species of the genus *Acacia*, particularly those of the subfamily *Mimosoideae* and family *leguminosae* are known to produce gummy exudates from their stems and branches when injured accidentally or deliberately [1]. The most important of these gum exudates is the ancient ingredient Gum Arabic, which has been in use since 4000 BC. It is the oldest and best known of all the natural gums [2].
Gum Arabic is produced from the tree of *Acacia senegal*. Another natural gum exudates that follows in importance is Gum Talha produced from *Acacia seyal* trees [3]. Chemically gum exudates are complex polysaccharides, neutral or slightly acidic salts containing calcium, magnesium and potassium cations [4-5]. Gum Arabic and many other gum exudates have been used as emulsifier, stabilizer, clarifier or viscosity modifiers. Gum arabic is used to emulsify and stabilize many flavors used in soft drinks, such as fruit flavors, cola, and root beer. The function of emulsifier or stabilizer is essentially to increase the viscosity of the aqueous phase by thickening it so that it approximates or slightly exceeds that of the oil. In this way the tendency of the dispersed phase to slip or coalesce is minimized, and the emulsion is, so to speak, stabilized [2]. A relatively new natural gum exudate is Kakamout gum produced from the trees of *Acacia polyacantha*. It is gradually gaining ground in the international gum market and ranked in the third position in Sudanese gums export following Gum Arabic and Gum Talha [6].
Light scattering techniques, especially laser light scattering, have become a very convenient technique for studying colloidal systems, emulsions and solutions involving macromolecules.
This work aims to harness laser light scattering as a tool of evaluation of the functional qualities of some Sudanese natural gum emulsifiers and their blends, in comparison to *Acacia senegal* which is regarded as bench mark standard, to its qualities all other gum emulsifiers are referred.

2. Materials and Methods
Experimental setup
The scattered laser light from emulsion studied in this work was measured using a specially tailored system that satisfies the required experimental conditions. The setup is schematically illustrated in Figure (1).

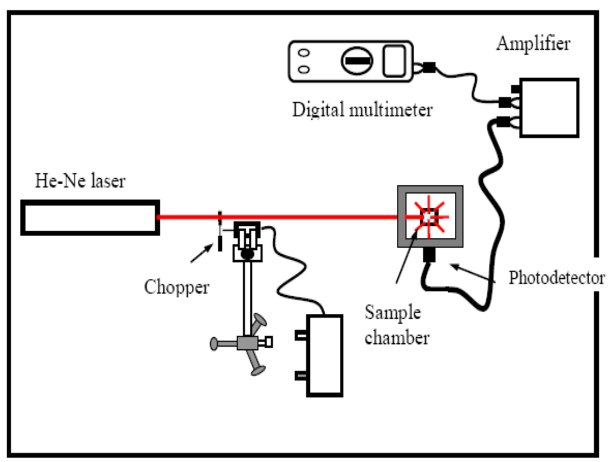

Fig 1: Schematic diagram of the experiment setup

Experimental procedure
Preparation of emulsions
For each gum (*A. senegal*, *A.seyal*, and *A. polyacantha*.) 25% (w/v) solution was prepared by accurately weighing 25gm of the gum (on dry weight base) and dissolved in exactly 100ml of distilled water. From this stock solution, 10 ml were taken in hard glass test tube (20x2cm). Exactly 2.8 ml of olive oil was then added to the test tube such that gum to oil ratio was 1:1. The mixture was homogenized using Ultra Turrax homogenizer fitted with dispersion tool, for 4 minutes at 24000 rpm speed. The resultant emulsion was allowed to stand for 15 minutes to exclude any air bubbles. Then 0.1 ml of the

emulsion was withdrawn using micropipette and introduced into 100ml volumetric flask, and completed with distilled water up to the mark. This constitutes a 1000 fold diluted working solution of the original emulsion which was immediately used for subsequent measurements [7].

Preparation of emulsions of gum blends

Using 25% (w/v) solutions of *A. senegal* and *A. polyacantha* a 1:1 blend of gums were prepared. Also blends of *A. polyacantha* and *A. seyal* of varying concentrations 10%, 30%, 50%, 70%, 90% with respect to *A. polyacantha* were prepared. These solutions were mixed with the appropriate amount of the oil phase and homogenized to produce emulsions following exactly the same procedure detailed above. The emulsifying power and stability of the different gum blends' emulsions were followed by measuring the scattered laser light for each of them at a different time intervals.

Irradiation procedure

A diluted emulsion (1:1000) was introduced into the quartz cuvette in the sample chamber and irradiated by He-Ne laser of 632nm wavelength and 1mW output power. The intensity of the scattered laser light was detected by a photodiode placed at an angle of 90° to the path of the incident laser light and displayed on a digital multimeter. The readings were taken at the same time every day for ten consecutive days. Nine samples with different concentrations were studied following this procedure [7].

3. Results and discussion

Laser light scattering of pure gums

The obvious advantages of measuring the scattered laser light from oil-in-water emulsion's droplets are: firstly, provides a measure for emulsifying power of the emulsifying agent, the more powerful the emulsifying agent is, the smaller the oil droplets size shall be. Secondly, the growth of the oil droplets with emulsion aging indicates the rate of coalescence of oil droplets hence reflects the stability of the emulsion system [8]. The variation of the scattered laser intensity with time reflects the growth of the oil droplets with emulsion's aging. The faster the rate of oil's droplets growth the lower the emulsion's stability [9]. Figure (2) shows the intensity of scattered laser light, measured for the three emulsions, prepared using pure gums, as a function of the age of emulsion. Using *Acacia senegal* gum as standard well established emulsifier enables comparative evaluation of the emulsification functionality of the other two gums.
It is clear that the oil droplets of the emulsions, prepared from the gums under study, vary in sizes in the order: *A. polyacantha* < *A. seyal* < *A. senegal*. While the emulsifying power of the three gums follows the order: *A.polyacantha* > *A. seyal* > *A. senegal*.

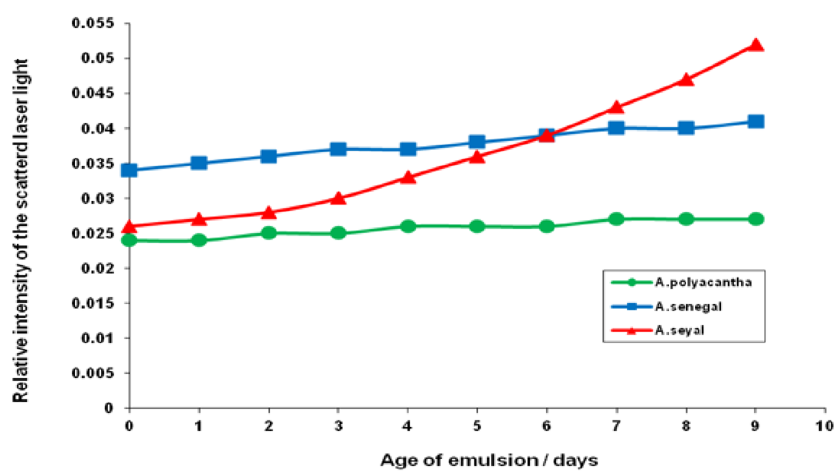

Fig 2: Relative intensity of the scattered light at different pure gum emulsions ages

This result agrees with Hassan (2000) study which was done using absolute measurements of oil droplets size of emulsions and established that *A.seyal* formed initially smaller oils' droplets in its emulsions compared to *A. senegal* [7].
Interestingly, *A. polyacantha* possesses the highest emulsifying power among the three gums studied as shown in Figure (2). The ratio of emulsifying power of *A. polyacantha*: *A. seyal*: *A. senegal* was found to be 1.4: 1.3: 1 respectively.
Comparison of the curves obtained for the three gums' emulsion, shown in Figure (2) indicated that *A. seyal* forms the least stable emulsion, while *A. senegal* and *A. polyacantha* are of comparable stability. If the curves in that figure are approximated to straight lines, their slopes constitute an indicator to approximately quantify the relative stabilities of the emulsions. Hence the relative stability of *A. polyacantha*: *A. seyal*: *A. senegal* is: 1: 1/7: 1/2 i.e. (1: 0.14: 0.5).
This result supports the findings of Hassan [7] and Satti [10], that *A. senegal* forms far stable emulsions compared to *A. seyal*.

The variation in emulsifying power and emulsion stability of the three gums studies may be understood considering the molecular structure models proposed for *Acacia* gums. The three gums studied are complex polysaccharides composed of six carbohydrate moieties, galactopyranose, arabinopyranose, arabinofuranose, rhamnopyranose, glucropyranosyl uronic acid and 4-o methyl glucropyranosyl uronic acid, and also contain small amount of protein as an integral part of the structure. [4-5].
Fractionation studies had shown that these gums can be fractionated into a number of arabinogalactane-protein fractions having varying sugar and protein ratios. There are high molecular weight protein-associated fractions that approximate a wattle blossom model structure. The high molecular mass fraction is the one responsible for the emulsifying functionality of *Acacia* gums [11-12].
A. seyal possess the highest molecular mass and the least amount of protein among the three gums. It has smaller molecular radius of gyration compared to *A. senegal*. This

indicates highly compacted and highly branched structure. On the other hand *A. senegal* gum molecule is comparatively less branched. This makes it more capable of unfolding its polypeptide chain and better anchored to the oil droplets surface [1]. The distribution of the molecular fractions affect the long term stability of the emulsion as the smaller fractions diffuse faster than the larger, high molecular mass fractions, to the oil droplets surface [13].

Laser light scattering of gum blends emulsions

The effect of blending on the emulsifying functionality of gums was investigated. The relative scattered laser intensity was measured at different time intervals for emulsions prepared using gums' blends of varying ratios.

During preparation of the different blends the economic factors were given considerable weight. Hence blending of *A. senegal* with *A. polyacantha* was given least consideration as *A. senegal* is the most expensive of all the gums.

Blends composition of the three gums are shown in Table (1).

Table 1: Blends composition of three gums

Type of Gum	Gum Blend Composition					
	Blend A	**Blend B**	**Blend C**	**Blend D**	**Blend E**	**Blend F**
A.senegal%	50	-	-	-	-	-
A. seyal%	-	50	90	70	30	10
A. polyacantha%	50	50	10	30	70	90

Figure (3) reflects the emulsifying power and stabilizing ability of 1:1 ratio blends *of A. senegal* and *A. polyacantha.* Curves for emulsions of pure gums were shown for comparison. Although the emulsion obtained using the blend was of comparable stability to both pure parent gums, its oil droplets size was bigger than that of pure *polyacantha*.

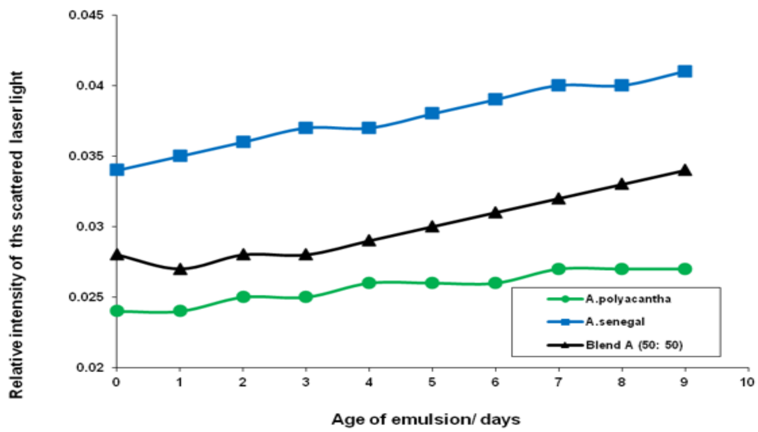

Fig 3: Variation of relative intensity of scattered light with age of emulsions, pure gums and blend A

Figure (4) shows the relative scattered laser light intensity variation with age of emulsion of *A. seyal* and *A. polyacantha* blend (1:1 ratio), and emulsions of pure parent gums. The initial oil droplet's size of blend's emulsion was reduced by ~25% compared to the oil droplet's size of pure *A. polyacantha* emulsion.

Although the stability of the blend's emulsion was improved, the droplet size rate of growth was faster in the blends compared to the emulsion prepared using pure *A. polyacantha*.

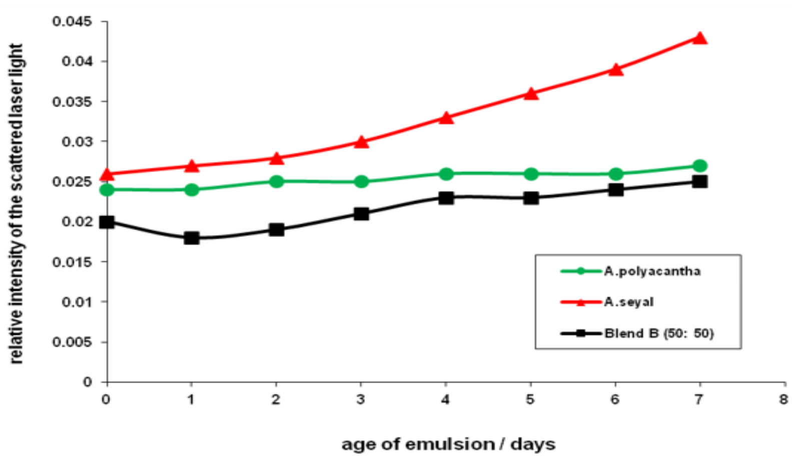

Fig 4: Variation of relative intensity of the scattered light with age of *A. polyacantha*, *A. seyal* and blend B emulsions

Figure (5) shows the variation of the relative intensity of the scattered laser light with the age of emulsions prepared using blends of varying proportions of *A. seyal* and *A. polyacantha*.

The emulsion of the blend containing 10% *A. polyacantha* approaches the behavior of pure *A. seyal* and shows the smallest initial droplet size but the least emulsion stability. Unexpectedly the emulsion obtained using a blend of 90% *A. polyacantha* did not approximate the behavior of emulsion obtained from pure *A. polyacantha*. The oil droplet's size of the emulsion fluctuates during the first six days and then remained constant at the end of the observation period.

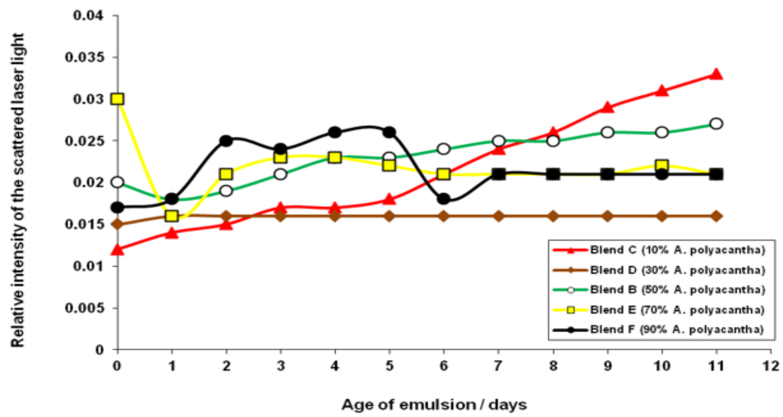

Fig 5: Variation of relative intensity of the scattered light with age of blend C, D, E and F emulsions

Interestingly the emulsion obtained using a blend of 30% *A.polyacantha*-70% *A. seyal* was found to be the most stable in which the oil droplet's size remained almost constant during all the observation period, indicating exceptional stability. The initial oil droplet size also was quite small compared to that produced when either of the pure parent gums was used, as shown in Figure (6).

According to Dickinson [8, 14], two main molecular factors would be expected to influence the rate of lowering the interfacial tension and consequently promote an efficient emulsification process: the molecular weight of the Arabinogalactane-protein complex and the accessibility of the polypeptide component within the macromolecular complex.

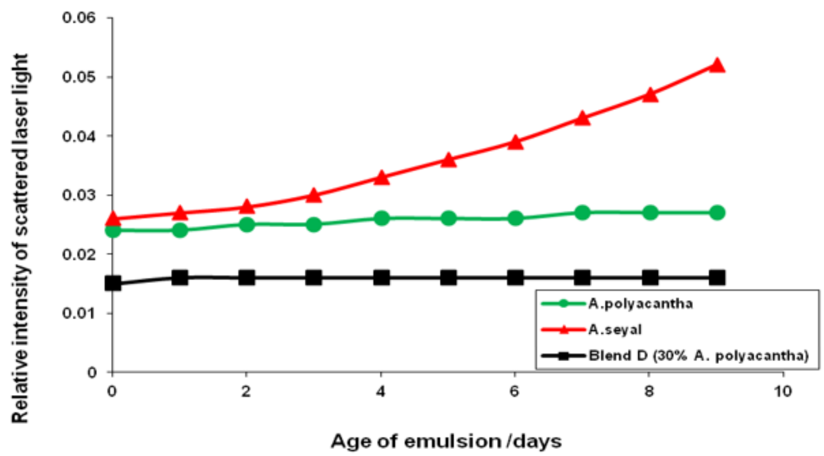

Fig 6: Variation of relative intensity of the scattered light with age of pure *A. polyacantha*, *A. seyal* and blend D emulsions

Low molecular weight fractions diffuse faster to the o/w interface, hence resulting in reduction of interfacial tension, while high molecular weight fractions diffuse slowly and affect the interfacial tension slowly [15].

4. Conclusions

1. The study proposed and tested a simple yet, highly effective and fairly accurate laser light scattering system for evaluation of emulsion's functionality of emulsifying agents and their blends.
2. The study revealed that the emulsifying powers (EP) of the gums studied can be arranged in the order: *A. polyacantha* > *A. seyal* > *A. senegal*, consequently the relative emulsifying power, taking *A. senegal* as reference, has the ratios of 1.4: 1.3: 1 in the same order.
3. The study established that *A. polyacantha* gum forms the most stable emulsion, while *A. seyal* forms the least stable one among the three gums.
4. Blending of the emulsifying gums shows that a superior emulsifier can results from a blend of *A. polyacantha* and *A. seyal* in proportion of 30% to 70%.

5. Acknowledgement

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6. References

1. Hassan EA, Assaf Al-S, Phillips GO, Williams PA. Studies on Acacia gums: Part III molecular weight characteristics of *Acacia seyal* var. *seyal* and *Acacia seyal* var. *fistula*. Food Hydrocolloids. 2005; 19:669-677.
2. Madhav P, Yadav J, Manuel Igartuburu, Youchun Yan, Eugene A. Nothnagel. Chemical investigation of the structural basis of the emulsifying activity of gum Arabic. Food Hydrocolloids. 2007; 21:297-308.
3. FAO. A Review of production, markets and quality control of gum arabic in Africa. Project No. TCP/RAF/4557, FAO, Rome, 1996.
4. Osman ME, Menzies AR, Martin BA, Williams PA, Phillips GO, Baldwin TC. Characterization of gum arabic fractions obtained by anion-exchange chromatography. Phytochemistry. 1995; 38:409-417.

5. Islam AM, Phillips GO, Sljivo A, Snowden MJ, Williams PA. A review of recent developments on the regulatory, structural and functional aspects of gum arabic. Food Hydrocolloids. 1997; 11:493-505.
6. Omer EA, Alomari AA, Osman ME, El-Henawy AA. Preparative Fractionation Analysis of *Acacia polyacantha* Gum Using Acetone as a solvent. American Chemical Science Journal. 2015; 6:164-171.
7. Hassan EA, Characterization, Fractionation of *Acacia seyal* Gum. Ph.D. Thesis, University of Khartoum. Sudan, 2000.
8. Dickinson E, Galazka VB, Anderson DMW. Emulsifying behaviour of gum arabic. Carbohydrate Polymers. 1991; 14:373-392.
9. Dickinson E. Hydrocolloids as Emulsifiers and Emulsion Stabilizers. Food Hydrocolloids. 2009; 23:1473-1482.
10. Satti AAE. Characterization, Toxicological Study of *Acacia nilotica* var. *nilotica* Gum from Sudan PhD. Thesis, Sudan University of Science and Technology. Sudan, 2011.
11. Fincher GP, Stones BA, Clarke AE. Arabinogalactan proteins: structure, biosynthesis and function. Annual Review of Plant Physiology. 1983; 34:47-70.
12. Osman ME, Menzies AR, Williams PA, Phillips GO, Baldwin TC. The molecular characterization of the polysaccharide gum from *Acacia senegal*. Carbohydrate Research. 1993; 246:303-318.
13. Dickinson E. Hydrocolloids at interfaces and the influence on the properties of dispersed systems. Food Hydrocolloids. 2003; 17:25-39.
14. Dickinson E, Murray BS, Stainsby G, Anderson DMW. Surface activity and emulsifying behaviour of some *Acacia* gums. Carbohydrate Polymer. 1988; 2:477-490.
15. Randall RC, Phillips GO, Williams PA. The role of the proteinaceous component on the emulsifying properties of gum arabic. Food Hydrocolloids. 1988; 2:131-140.