ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

Biophysical investigation of plant exudate of *Acacia senegal* (L) Willd. from Sudan-savannah ecological zone of Nigeria

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Manuscript Info

Manuscript History:

Received: 13 May 2013
Final Accepted: 26 May 2013
Published Online: May 2013

Key words:
Exudate, *Acacia senegal*, Savannah, Gum Arabic, Biophysical

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Abstract

Plant gum exudate harvested from *Acacia senegal* (Acacia gum/gum Arabic) is the most widely used plant gum especially in food and pharmaceutical industries due to its non toxicity and excellent properties as emulsifiers and stabilizers in emulsions. It consists of complex polysaccharides and glycoprotein, and its qualities are defined by the biophysical properties of the gum. Analyses of some biophysical properties using range of techniques were carried out for harvested, untreated gum Arabic from Sudan-savannah ecological zone of Nigeria. The results revealed that it has some qualities which were in agreement with the international standard specified for gum Arabic. The soil type of the study area was found to be clayey-sandy in nature.

Introduction

Plant exudation is cause as a result of wound response by plant cells at the site of injury in which it gives out a sticky viscous fluid which oozes out to cover or seal the opening and eventually becoming a glossy, translucent hard mass as in *Acacia* plants. According to Izydorczyk, *et al*., (2005), plant exudates are produced by plants so as to seal-off infected sections of the plant and prevent loss of moisture due to physical injury or fungal attack. Rana, *et al*., (2011), reported that plant gum exudates are produced by several plants as a result of the protection, mechanism against mechanical or microbial injury.

Gum Arabic is an exudation from certain *Acacia* trees that occurs in a wide belt of semi-arid lands stretching across sub-Saharan Africa (Islam *et al*., 1997). *Acacia senegal* produce plant exudate known as *Acacia* gum or gum arabic, which is described as a plant gum exudate obtained from stems and branches of natural stains of *Acacia senegal* or closely related species such as *Acacia seyal*.) Al-Assaf *et al*., (2007) define *Acacia* gum as a dried exudation obtained from the stems and branches of natural strains of *Acacia senegal* (L) Wildenow or closely related species of *Acacia* (Family *Leguminosae*).

The gum is made up of complex polysaccharides whose quality is defined by its biophysical parameters which can be influenced by genetic and environmental factors; the understanding of these factors will bring about improvement in of *Acacia senegal* strains and the gum they produced within a geographical location. Studies of gum arabic from trees of different age and location by Idris, *et al*., (1998) indicated significant variation in gum properties among *Acacia Senegal* trees. Karamalla, *et al*., (1998), identified country variation in gum resources as one of the sources of natural variation limits that warrant the need for characterization of quality indices of gum Arabic with particular emphasis on the internationally acceptable quality specification of the gums which includes its physicochemical/biophysical properties among others.

The biophysical composition of plant gum significantly influences their application. These properties affects the processing and end result and therefore makes this nature of studies necessary so as to determine the predictability of the end product and

consequently quality of the output. Considering the numerous commercial application of gum arabic especially in the food industry, investigation of its biophysical properties is of great importance. Williams and Philips, (2003) observed that, the rapid increase in the consumption of ready-made meals and the consumers growing awareness of the need to increase the amount of fiber in the diet, has led to steady rise in the use of gums in different food products.

Apart from the numerous applications of gum Arabic obtained from *Acacia senegal* trees in the food and other commercial industries, other local uses of *Acacia senegal* includes, environmental control such as soil stabilization by serving as wind breaks and improving soil fertility through soil nitrogen fixation, provision of fodder for animal feeds and fuel wood among others. All these are additions to provision of gum Arabic for medicinal, domestic use and also as an item of great commercial value to the local populace, thus making the quality of gum as an important criterion for choice of *Acacia* seedlings to be used for agro forestry systems. The aim of this work therefore, is to investigate some biophysical properties of gum Arabic from *Acacia senegal* grown under savannah ecological condition of Nigeria so as to authenticate the species and also to see if it has quality parameters that meet the international specification of gum Arabic.

Methodology

Gum Arabic samples were collected from the field located within latitude $11^0 24''$ and longitude $11^0 59''$ with an altitude of 456, in the Sudan-savannah ecological type in north eastern Nigeria. During collection only clean nodules, exude under natural environmental influence were handpicked directly from the trees (and assumed to be grade one). They were all free from contamination by plant bark and other physical substances. The nodules were mechanically kibbled for the purpose of this investigation. The biophysical parameters determined and their various methods are reported below.

Determination of pH and Refractive Index

Natural pH of the gum Arabic samples collected was measured using **Jenway 3020** pH meter. To do this, different concentrations (w/v) of the gum Arabic aqueous solution was prepared and the pH measured using the electrode of the pH meter. The refractive index of 1% (w/v) aqueous solution of the gum Arabic sample was measured using the **Bellingham and Stanley, London** Abbe refractometer.

Moisture content

This was obtained by heating 5 grams of accurately weighed gum arabic sample at 105^0C until a constant weight is obtained and the moisture content then calculated as percentage weight loss to total weight of sample.

Nitrogen and Protein content

The percentage nitrogen and protein contents of the gum Arabic samples were determined based on the technique called Kjeldahl analysis method using **NA 2100** nitrogen and protein analyzer and applying the standard nitrogen conversion factor (NCF) 6.6 as proposed by Anderson, (1986) to convert nitrogen to protein.

Ash and soluble fibre content

Ash content was determined from the dried sample after determining the moisture content. The dried sample was ignited at 550^0C in a desiccator and weighed. Ash content was then recorded as percentage loss in weight after ignition to that of original sample. The amount of total soluble fibre was obtained by the subtraction of the total contents of Ash, Water and Protein from 100.

Specific/optical rotation

Specific/optical rotation was determined for 1.0% (w/v) gum Arabic solution. The sample was dissolve and measurement was done using the **Jusco P-1020** automatic polarimeter.

Relative Viscosity

The Relative viscosity of the gum Arabic samples was measured at 25^0C by the use of viscometer, according to (AOAC, 1990). The viscosity was calculated thus

Viscosity (25^0C) = $T–T_o/T_o$

Where T= Flow time of 1% solution and T_o = Flow time of distilled water. (All times are measured in seconds).

Data were recorded in replicates for all parameters and analysed using Statistical Analysis System (SAS) software according to (Snedecor and Chochran, 1987).

Result and Discussion

The freshly harvested (raw) gum Arabic nodules are as shown in figure 1 below, consisting of selected nodules free from contamination by plant bark, visible objects and other substances.

Figure 1. Macrograph of gum nodules after harvest

The international specification of gum Arabic quality parameters is presented in Table 1 to serve as bases for comparison with the gum samples used in this study. The soil in the study area was found to be clayey sand with pH 5.93 as presented in Table 2. The nitrogen content and available phosphorus were found to be 0.04g/kg and 0.022ppm respectively, and organic carbon of 0.36g/kg, while the exchangeable potassium was 1.111cmol/kg. The study of the physicochemical properties of the study area (Table 2) was necessitated due to the understanding that soil affects the properties of plant exudate. Similarly, NGARA, (2005), reported that the emulsifying properties of gum Arabic could be directly influenced by the botanical type, soil and climate.

The result of biophysical analysis of *Acacia* gum (gum Arabic sample) consisting of 9 different parameters is presented in table 3.

pH and Refractive index

The pH of the gum samples obtained in aqueous solution ranges between 4.3–5.3 with a mean value of 4.7 obtained from three readings. It was also observed that the pH of the gum samples changes with change in concentration of the aqueous solution. This is similar to observation made by Mahendra *et al*., (2008) in which a mean pH of 4.5–5.5 was reported with difference in concentration. A value of 1.351 was obtained for refractive index which is similar to value of 1.35 reported for gum arabic in the Damazin region of Sudan (Sabah El-Kheir, *et al*., 2008).

Moisture content

The percentage moisture content recorded for the experiment was 13.91% and occurs within the international acceptable limit of 13–15% and in agreement with the value reported by (FAO, 1998). Similar result was obtained for gum arabic from *Acacia senegal* var s*enegal* in solit and Kakpkun in Kenya in which a mean percentage moisture content of 15.0 and 14.9 respectively (Lelon, 2010).

Nitrogen and Protein content

The mean nitrogen content of the gum was found to be relatively high 0.45% Table 3 compared to the international standard of 0.26–0.39 (Table2) with corresponding high protein content of 2.81% using the 6.24 standard nitrogen conversion factor (NCF). This is an encouraging result considering the significance of nitrogen in the application properties of gum arabic. It is important to study the nitrogen content of gum because it forms an important component which absorb unto the surface of oil droplet for the purpose of emulsion stability. Dickinson, (1992) reported that the protein moiety of gum arabic affect its emulsification ability and that the best emulsion stability is found in gums with highest amount of nitrogen.

Ash and soluble fibre

The ash and soluble fibre content of the sample were found to be 3.01 and 82.05% respectively. The ash content is in agreement with the FAO, (1995) standard. Williams and Phillips, (2003) observed that the presence of soluble fibre in gum Arabic and the growing awareness of the need to increase it amount in human diet has contributed to the sturdy use in food products.

Optical rotation

The Optical rotation for the gum Arabic samples analysed was found to -28 ^{0}. This is similar to earlier results reported by Idris, *et al*., (1998) and is within the range of the international standards of the FAO, (1995) for *Acacia* gums.

Relative Viscosity

The result of this study indicated that, the relative viscosity of the gum investigated at 25^{0}C was found to be 13.94. This is very close to the value of 14.29 obtained for Kordofan (Sudan) gum by Sabah El-Kheir, *et al*., (2008), although Karamalla, *et al*., (1998), observed in an earlier study with 94 authenticated gum arabic samples that viscosity have very wide variation among the different samples studied and added that, it varies with factors such as gum concentration, temperature difference, storage period and preparation method of the gum solution.

Table 1. International specification of gum Arabic quality parameters

Property		Range	
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	(550^0c)	
Copper (ppm)	Iron (ppm)	Manganese (ppm)	Zinc (ppm)
52-66	730-2490	69-117	45-111

Source: (FAO, 1995)

Table 2. Physicochemical properties of soil of study area

Property	Value
PH	5.93
Organic Carbon (g/kg)	0.36
Total Nitrogen (g/kg)	0.04
Available P (ppm)	0.022
Exchangeable k (cmol/kg)	1.111
Sand	46.7
Silt	20.2
Clay	33.1

Table 3.General biophysical properties of *Acacia senegal* natural gum

Property	Value
pH	4.70±0.20
Moisture (%)	13.91±0.53
Ash content (%)	3.01±0.20
Soluble fibre (%)	82.05±0.50
Nitrogen (%)	0.45±0.10
Protein (%)	2.81±0.10
Optical rotation (degrees)	-28±1.00
Refractive Index	1.351±0.01
Relative viscosity (cps)	13.94±0.01

Conclusion

This gum have met most of the standards set up in the FAO, (1995) quality specification and can therefore be considered to be truly gum from *Acacia senegal* which could be considered as a potential source of good gum Arabic from Nigeria that can be exploited for commercial purpose in the market due to its qualities, based on the biophysical properties analysed. However, it can be subjected to broader analysis in terms of molecular characterisation and emulsification properties for the purposes of quality control.

Acknowledgement

The authors gratefully appreciate the financial support from The Federal Polytechnic Damaturu, Nigeria and Education Trust Fund (ETF), Nigeria for this research.

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