FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 3 No. 3, September, 2019, pp 594 –601

PHYSICOCHEMICAL ANALYSIS OF PLANT GUM EXUDATES OF SOME SELECTED PLANT SPECIES IN KANO STATE NIGERIA

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ABSTRACT

The present investigation was carried out to study the Physicochemical properties of gum exudates from *Azadirachta indica*, *Boswellia dalzieli. Anogeissuss leiocarpus* and *Sterculia setigera*. Physicochemical properties of these gum exudates were investigated to assess the economic value and utilization in pharmaceutical, Ethno-medicine and food industries as substitute to gum Arabic. From the results it was observed that, *Sterculia setigera* have significantly ($P \leq 0.05$) recorded the highest values in all the physicochemical parameters which is followed by *Boswellia dalzielli* in protein nitrogen content and viscosity, while *A. indica* in nitrogen, swelling index and viscosity respectively. From the result, *Anogeissus leiocarpus* significantly recorded the lowest values in all the physicochemical parameters. Atomic absorption spectrometer was used to determine the mineral content of the gum exudates. Results indicated that, all the gum exudates were found to contain Magnesium (Mg), Calcium (Ca) Iron (Fe), Sodium (Na) and Potassium (K). Heavy metals such as Cadmium (Cd), chromium (Cr) were not detected in all the gum samples. While Lead (Pb) and Zinc (Zn) were detected in a very minute quantity. Results indicates that, the gum exudates possess a good physicochemical properties similar to gum Arabic, which indicated the possibility of using these exudates as substitutes to many other gums. Due to the remarkable similarity in the physicochemical properties of gum exudates of gum Arabic and the gum of the plants in this study more investigations are needed to study the functional and rheological properties so as to be considered as the main substitute of other gums.

Keywords: Gum, Exudates, Physicochemical, *Azadirachta*, Minerals, *Boswellia*.

INTRODUCTION

Gum exudates are typically products of broadleaved trees and shrubs which are produced either naturally from exudation from crack in the bark or damage to the bark by insects or animals. they are tears or flakes of dried sap (exudates) of many trees and shrubs. These gum exudates are complex polysaccharide derivative of natural origin (Goyal and Kaushik 2015). They are hydrophilic carbohydrate polymers of higher molecular weight generally composed of monosaccharide units joined by glucocidic bonds (Sunil, and Sunali 2014). Many plants from different Families produce gum, notable among them include, Family Meliaceae, e.g *Azadirachta indica*, Family Sterculaceae e.g *Sterculia setigera* Combrataceae e.g *Anogeissuss leiocarpus*, Bursaraceae *Boswellia dalzielli*, Family legumenoceae, e.g Gum Arabic, Anacardiaceae e.g *Anacardium occidentale* (Sunil, and Sunali 2014). *Azadirachta indica* commonly known as Neem, is a tree in the Family Meliaceae, it is one of two species in the genus *Azadirachta* and native to the indian subcontinent i.e India, Nepal, Pakistan. Bangaladesh and Sri lanka. It is typically grown in tropical and semi tropical regions. It's fruit and seed contain neem oil. It is one of the medicinal plant, its products have been used in traditional medicine as antihelmintic, antifungal, antidiabetic, antibacterial, contraceptive, antiviral and sedative (GRIN 2017). The plant produce gum exudate a mixture of protein and polysugars (Brindha and Mallika 2015). *Sterculia setigera* is a deciduous tree with a large, open spreading crown, it generally grows up to 16 meters tall. It grows in Sudan and Guinea zones of Africa. The tree has a long range of local uses being harvested from the wild for food, medicine and to supply a variety of commodities (Ken 2019). The plant produces gum which is partially acylated polysaccharide made up of galactouronic acid, beta D. galactose, glucuronic and L- Rhamnose (Bhoj *et al.*, 2015). *A leiocarpus* commonly known as axle wood tree. It is a tall evergreen tree native to Savanna of tropical Africa (Margerate 1998). It is the sole west African species distributed from tropical, central and East Africa through the Tropical South East Asia. The axle wood tree has many

application in Nigeria. It is used medicinally for the treatment of Ascaris, Gonorrhoea, general body pain, Asthma and cough (Mann *et al.,* 2008). It produces gum known as gum ghatti which is a natural exudation but yield can be increased by making artificial incision. The gum is calcium and magnesium salt of an acidic polysaccharides composed of L- arabinose, D- galactose, D-rhamnose and D- glucose. These polymer (gums) are useful as tablet binders, disintegrants, emulsifiers, suspending agents, gelling agents, stabilizing agents, thickeninig agents and coating agents in microcapsules. Gums are also used in cosmetics (Acacia gum and tragacanth), adhesive, paints and paper manufacturing (Jani *et al.,* 2009). Local medicinal uses have been claimed to serve as smoothening and softening agents, taken internally for cough, diarrhoea, dysentery, sore throat, hemorrhage, and externally in the treatment of local imflammation and nodular leprosy (Gindaba and Nigatu, 2007). Many gums are known to alleviate infection like diarrhoea, dysentery, sore throat, kidney wound and gum infection (Bhoj *et al.,* 2015). In Africa gum Arabic plays significant role both in the rural life and economic activities of the people (Mokwunya and Aghughu 2010). Nigeria is the leading producer of gum in west Africa also second largest world producer/exporter of gum after Sudan (Tunde 2018). *Acacia seyel* and *Acacia Senegal* are two most commercially important sources of gum Arabic. Gum Arabic is harvested majorly in Africa, which means countries in Europe, the Americans, Asia and others rely solely on imports (Akerodulu 2017). Robbins (1988) has stated that in spite of the problems which beset the gums market in recent years, the fact remain that, in many cases, the gum provide a valuable sources of income for many people. This remain true today, Thousands of people worldwide living in regions ranging from semi - arid and desert depend on the collection of gums, in order to provide them with an income. Equally many millions of people and the world make use of these product in their every-day life (Jani *at al.,* 2009).

MATERIALS AND METHODS

Collection and identification of plant materials

The gum exudate samples were collected from different plants yielding gum and different locations within the study area. The plants under study were, *Anogeissus leiorcarpus* (Family Combrataceae), *Boswellia dalzielli,* (Family Burseraceae), *Azadirachta indica* (Family Meliaceae) and *Sterculia setigera* (Family Sterculiaceae). *Boswellia* and *Sterculia* were collected at Gomo village of Sumaila local government area of Kano State. While *Azadirachta* and *Anogeissus* were collected at Gwarabjawa village of Dambatta and Gajida village of Tofa local government area of Kano State. Plant samples were identified and authenticated in the Department of Plant Biology Herbarium, Bayero University, Kano. The samples were relatively pure and were collected locally by hand using knife and simple tapping method, this was done by slashing the bark using axe (Vincent, 2009). After the superficial injury tears of gum formed on the exposed wounded surface and were left to dry and hardened for two weeks, this is for *Boswellia dalzielli* and *Sterculia setigera,* the tears were picked by hand from the stem where they have been formed and placed in a container. For *Azadirachta indica,* and *Anogeiossus leiocarpus,* the gum exudes naturally from the cracks of the cortex/bark as hard nodules or beads, then collected by hand using a knife. Impurities such as bark pieces and sand particles were carefully removed by hand and samples were dried at room temperature and reduced to a fine powder and kept in a polythene bag for further use (Issa *et al.,* 2014).

Physicochemical analysis

Physicochemical analysis of the samples under study was carried out in the soil laboratory of Faculty of Agriculture, (BUK), Multi-user lab Ahmadu Bello University, Zaria (ABU) and Plant Biology lab Bayero University, Kano. The physico-chemical properties of the gum investigated include pH , moisture content, ash content, viscosity, nitrogen content, protein content and swelling index and minerals content.

Determination of moisture content

Moisture content was determined using oven drying method. 2g of grounded gum sample were weighed in clean and dry crucible and oven dried at 105^{O}C for 5hours until a constant weight was obtained. Then the crucible was allowed to cool for about 30 minutes before reweighing. Moisture content was expressed as a percentage of the weight from the original weight (Dagnew and Fikremaria, 2017).

$$\% \text{ Moisture} = \frac{W_1 - W_2}{\text{Wt of sample}} \times 100$$

Where:

W1 = Initial weight of the crucible and the sample before loss of moisture

W2 = Final weight of crucible and the sample after loss of moisture

Determination of ash content:

2g of the grounded gum samples were weighed in dry crucible and heated in a furnace at 550^{0}C after three hours

it was allowed to cooled in a desiccator and weighed (Degnew *et al.,* (2009). The total ash content was determine using the following expression:

$$\frac{W3 - W2 \times 100}{W1}$$

Where :
W3 = Weight of the sample and crucible after heating
W2 = Weight of empty crucible
W1 = weight of the sample before heating

Determination of pH

pH of the gum samples were determine by shaking 1% W/V dispersion of the sample in water for Five minutes and P^H was determine using P^H meter (Hanna – 209-209 R). (Degnew *et al.,* 2009)

Relative viscosity

The relative viscosity of the gum sample was determine using a capillary viscometer at room temperature about 25^{O}C (Dagnew and Fikremaria, 2017). In determining the relative viscosity the time of efflux of solution and solvent was measured in the same viscometer taking the density of both solution and the solvent as equal. It is calculated as follows:

$$RV = \frac{T - T_0}{T_0}$$

Where:
T = Flow of gum solution in seconds
T_0 = Flow of solvent (Sodium chloride 4%)

Determination of Nitrogen content

Nitrogen content was determined by semi micro kjeldahl Method (Yusif 2001). In determining the nitrogen content of gum samples 1gram of each sample was weighed and transferred to kjeldahl digestion tube and potassium Sulphate was used as catalyst. Then 10ml of concentrated Sulfuric acid (H_2sO_4) was added and heated at 240 ^{O}C until a clear pale yellowish green color was observed indicating the completion of digestion. The tubes were then allowed to cool at room temperature. Their content was transferred to distillation apparatus followed by addition of distilled water and 30% (W/V) sodium hydroxide. Steam distillation was carried out and the release of ammonia was absorbed in 25ml of 2% boric acid. Back titration of the generated borate was then carried out against 0.1N hydrochloric acid, using methyl red as an indicator. Blank titration was carried out the same way. Nitrogen content (N) was then calculated (Degnew and Fikremariam 2017).

$$\text{Nitrogen \%} = \frac{0.014 \times (\text{volume of titrant-volume of Blank}) \times 100}{\text{Weight of sample (grams).}}$$

Protein content:
Protein content was calculated using Nitrogen conversion factor (NCF) of 6.6 as follows
Protein % = N × 6.6

Determination of mineral content
Dry ashing method was used in the sample preparation, 1g of the sample was placed in cold furnace and heated to 550 ^{O}C for four hours and allowed to cool. Then 10ml of hydrochloric acid was added to the sample and heated gently for 10min, then cooled and filtered into 100ml volumetric flask and diluted with distilled water. Atomic absorption spectrometer was used to determine the mineral content.

Determination of swelling index

Swelling index was determine using the method of (Aparanji and Muralikrishna 2015). One gram of powdered gum was accurately weighed and was transferred to a 100ml measuring cylinder. The final volume occupied by the powder was noted and the volume was made up to 100ml with distilled water. The cylinder was stoppered, shaken gently and set aside for 24 hours. The volume occupied by the gum sediment was noted after 24 hours. The swelling index (SI) was calculated by the following formula.

$$SI (\%) = \frac{Vt - V_0}{V_0} \times 100$$

Where V_0 is the initial volume of the powder in a graduated cylinder and Vt denotes the volume occupied by the swollen gum after 24 hours

STATISTICAL ANALYSIS

Each analysis was repeated three times and value reported in respect of all the gum samples are actually the average of three replications. Experimental results were analysed by analysis of variance (ANOVA) using Genstat 64-bit release 17.1 software 17th edition.

RESULTS

The physicochemical analysis of the gum samples was carried out in all the gum samples and the results were presented in table form (Table 1 and 2). From the results it was observed that, *Sterculia setigera* have significantly ($P \leq 0.05$) recorded the highest values in almost all the physicochemical parameters which is followed by *Boswellia dalzielli* in protein nitrogen content and viscosity, while *A. indica* in nitrogen swelling index and viscosity respectively. From the result, *Anogeissus leiocarpus* significantly recorded the lowest values in all the quality

parameters. However, the pH of all the gum exudate samples were not significantly different (P≤0.05).

The results of elemental analysis of the gum exudates is presented in Table 2. Results indicated that, all the gum exudates were found to contain magnesium (Mg), Calcium (Ca) Iron (Fe), Sodium (Na) and Potassium (K). However, some elements such as Lead (Pb) and Zinc (Zn) were found to be detected in minute quantity, heavy element like Cadmium (Cd), and Chromium (Cr) were not detected completely. From the results it was observed that, *Sterculia setigera, Anogeissus leiocarpus* and *A. indica* contains the elements in the following order K > Na >Mg > Ca. whereas in *Boswellia dalzielli* Sodium (Na) was found to be the highest followed by the remaining elements in the following order Na > K > Ca > Mg. *Boswellia dalzielli* significantly (P≤0.05) recorded the highest amount of sodium (Na), calcium (Ca), Iron (Fe), Zinc (Zn) and Cupper (Cu) followed by *Anogeissuss. leiocarpus.* While *Sterculia setigera* significantly (P≤0.05) recorded the highest amount of potassium (K) and Magnesium (Mg). From the results *Azadirachta indica* significantly (P≤0.05) recorded the least amount of all the elements. Analysis of variance showed significant differences (P≤0.05) in Mg, Ca, Fe, Zn, Cu, Mn Na and K.

TABLE 1: Result of physicochemical analysis of different gum exudates from different plant species.

	Physicochemical parameters						
Gum exudates	Protein(%)	Nitrogen(%)	S.I (%)	Ash(%)	Moisture(%)	P^H	Viscosity
A. indica	2.37^{c}	0.36^{d}	35.23^{b}	8.23^{b}	7.12^{bc}	5.10	20.30^{b}
A. leiocarpus	2.70^{bc}	0.42^{c}	26.31^{c}	4.70^{c}	6.43^{d}	5.16	22.60^{ab}
B. dalzielli	3.10^{b}	0.47^{b}	10.52^{d}	5.41^{c}	7.22^{b}	5.11	$20.10b^{b}$
S. setigera	3.30^{a}	0.50^{a}	50.00^{a}	12.63^{a}	8.03^{a}	5.14	24.60^{a}
LSD	0.008	0.005	1.511	1.320	1.389	0.923	2.793

Note: Means sharing the same are not significantly different ($P \leq 0.05$

Table 2: Results of elemental analysis of the gum exudates samples from different plants (ppm)

	Minerals										
Plant samples	Mg	Ca	Fe	Zn	Cu	Mn	Cd	Pb	Cr	Na	K
S. setigera	22.608^{a}	2.326^{d}	0.580^{d}	0.051^{bc}	0.000^{c}	0.052^{a}	0.000	0.320^{c}	0.000	762.85^{c}	2784.81^{a}
A. leiocarpus	22.067^{b}	5.209^{b}	0.928^{c}	0.098^{b}	0.022^{b}	0.030^{b}	0.000	0.438^{a}	0.000	845.77^{b}	1434.60^{c}
B. dalzielli	8.715^{d}	24.052^{a}	3.030^{a}	3.785^{a}	1.177^{a}	0.000^{c}	0.000	0.378^{b}	0.000	1409.63^{a}	843.88^{d}
A. indica	9.241^{c}	2.657^{c}	1.590^{b}	0.000^{c}	0.000^{c}	0.000^{c}	0.000	0.350^{bc}	0.000	663.35^{d}	2194.09^{b}
S.E ±	0.045	0.017	0.617	0.018	0.004	0.014	0.000	0.019	0.000	0.101	1.929

Note: Means sharing the same letter are not significantly different ($P \leq 0.05$).

DISCUSSION

The gum extracts of *Anogeissus leiocarpus, Azadirachta indica, Boswellia dalzielli,* and *Sterculia setigera* were investigated for their physicochemical properties. The pH of an exudate gum is an important parameter in determining it's suitability in various applications, in pharmaceutical industries pH is used in determining its suitability in pharmaceutical formulations since the ability and physiological activity of most preparation depend on pH (Adeyanju *et al*,. 2016). From the result it shows that all the gum samples were found to be acidic. This really corresponds with the finding of Yusif (2011), where he reported the pH value of 5.0 in gum Arabic (*Acacia sieberiana*). The pH value obtained in this research is in good agreement with the reported pH values for gum Arabic and other Acacia gum by several authors (Rabbeea *et al.,* 2018). The acidity of plant exudates under study is not unexpected since the exudates were found to contain salts such as Ca, Na, Mg, Fe, K of acidic polysaccharides, the acidity of which is due to uronic acid in their structure (Abu-baker *et al.,* 2007). In *Anogeissus leiocarpus* the pH value contradicts the findings of Semia *et al.,* (2009), where he reported the pH value of 4.2 in *Anogeissus leiocarpus*. Similarly in *Sterculia setigera* the pH value of 4.8 to 4.7 was reported by Wadood And Elfatih 2010 which also contradicts the present findings. However, despite this conflicting findings the values recorded in this research fell within the accepted limit in Gum Arabic which ranges from 3.19 to 5.61 (Semia *et al.,* 2009). From the present findings, the nitrogen content of the gum exudates was found to be within the accepted limit as reported by Siddiqi (1996), where he reported the specified limit for gum Arabic (0.19% – 0.62%). Protein content was found to be in the range of 3.30%, 3.10%, 2.37%, 2.77% respectively. Values obtained from *Azadirachta indica* and *Anogeissus leiocarpus* fairly correspond with other findings in other acacia species *A. nilotica* (2.71) *A. seiberiana* (2.51) and *A. Senegal* 2.71 (Yusif, 2011). Similarly, the results also is in agreement with the results reported in Albizia and Amara gum (2.55% and 2.39) (Isssa *et al.,* 2014). However, the results for all the gum samples fell within the specified limit for gum Arabic 1.25- 4.09% as reported by Siddiqi (1996). The values of ash content obtained in this studies indicates that *Sterculia setigera* and *Boswellia dalzielli* were found to be above the international specification of quality parameters which states 4% as the ash content for gum Arabic (Joseph *et al.,* 2010). However, in *Anogeissus leiocarpus* the ash content fell within the said specification 4%. Moreover, the results also contradicts the finding of Yusif (2011) where he reported the ash value of ash in other acacia species 3.54%, 3.42%, and 3.30% respectively. The total ash is used to determine the critical level of foreign matter, acid insoluble matter, salt of calcium, potassium and magnesium (Joseph *et al.,* 2010). Moisture content facilitates the solubility of hydrophilic carbohydrates and hydrophorbic protein in gum Arabic (Elmquist 2003). In *Azadirachta indica* higher value of 10.6% was reported by Eiman and Hageltayeb (2017) which contradicts the value for this study. Similarly in *Sterculia setigera* the values in this study contradicts the finding of Wadood and Elfatih (2010) where he reported 12.5 % as the moisture content for *Sterculia setigera*. In addition Semia *et al.* (2009) reported the moisture content of *Anogeissus leiocarpus* as 8.2% which also contradict the present findings. However, despite the lower values recorded in all the samples compared to other findings reported, the values are still within the international specification of quality parameters $\leq$ 15% (Joseph *et al.,* 2010). Viscosity of the gum was considered as one of the most important analytical and commercial parameters, since its factors involve the size and the shape of the macromolecules. The viscosity measures the thickness of gums which is one of the parameters used for the determination of quality gum (Okojie *et al.,* 2010). Viscosity and swelling index of gum decides the quality of gum in industrial application. Result of the present study, correspond with the findings of Yusif (2011) in different acacia species, *Acacia senegal* (22.60), *Acacia sieberiana* (20.18), *Acacia nilotica* (24.80) respectively.

Characterization of the gums by mineral content showed that all the gum samples contained high amount of Pottassium (K), Sodium (Na), Calcium (Ca), Magnesium (Mg), and Iron (Fe). This corresponds with the work of Yusif (2011) where he also reported the presence of these element in higher quantity in different species of Acacia (Gum Arabic). Similarly, Emejie *et al.,* (2009) reported that, gum consist of calcium, Magnesium, sodium and potacium salt of a complex substance known as polyuronides. Other heavy metals such as Lead (Pb) and Zinc (Zn) Copper (Cu) appeared in a very minute quantity and this is in agreement with other findings where these element appeared in minute quantity in Gum Arabic (Degnew, 2009).

CONCLUSION

In conclusion, physicochemical properties of gum exudates of the plants understudy have been investigated. The study shows that, the gum exudates possessed a good physicochemical properties and high level of Pottassium (K), Sodium (Na), Calcium (Ca), Magnesium (Mg), and Iron (Fe) which makes it suitable as meal replacer, nutritional beverages in pharmaceutical formulations. The physicochemical properties for the gum exudates as revealed by this study compare very well with that of internationally specified qualities for gum Arabic. Hence, the results of this study support the gums suitability for industrial application. In addition, the results of the investigation indicates the possibility of using all the gum exudates from

these plants as good substitute to many other gums used in pharmaceuticals, food and non - food industries.

RECOMMENDATIONS

Due to the remarkable similarity in the physicochemical properties of gum exudates of gum Arabic and the gum of the plants in this study more investigations are really needed to study the functional and rheological properties of these gums so as to be considered as the main substitute of other gums. It is recommended that, the plants from which these gum are derived can also be cultivated and their biodiversity be conserved.

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