

Research Article

Morphological and Physicochemical Characterization of Ipin Gum (*Ficus elastica*)

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Abstract: Ipin gum (*Ficus elastica* exudate gum) is exudate gum from a plant growing naturally in the forest of Nigeria. The gum is yet to be commercially exploited as the physicochemical properties of this gum are yet to be characterized. Various physicochemical methods, scanning electron microscopy (SEM), X-ray diffraction spectrometry (XRD) and Fourier transform infrared spectroscopy (FTIR) were employed to characterize this gum in the present study. SEM analysis suggested that the native gum has irregular particle size. The XRD pattern of the native gum indicates a completely amorphous structure. Elemental analysis of the gum shows potassium, 600.0±1.52mg/g, sodium 300.23±0.2mg/g, manganese 0.31±0.00mg/g, magnesium 410.33±1.0mg/g, Iron 8.7±0.00mg/g and zinc 61.1±0.22mg/g. Physicochemical parameters shows moisture content to be 7.68±0.15%, Ash content 2.70±0.30%, Protein content 2.08±0.02%, pH 5.5±0.10, Viscosity 22.10±0.50, Refractive index 1.34±0.01, Water holding capacity 84.90±4.25%, specific rotation -25.4±0.4 degree, swelling index 9.50±1.10% and Emulsifying capacity 17.29±0.20cm⁻¹. These results compared favourably with acacia senegal gum (gum arabic) and makes ficus elastica exudate gum highly recommendable for use in food and pharmaceutical industries. The major functional groups identified from FTIR spectrum include 3641cm⁻¹ (OH), 1731cm⁻¹ (CH₃CO), 1632cm⁻¹ (-COO-), 1429cm⁻¹ (-COO-) and 1249cm⁻¹ (-CH₃CO).

Keywords: Ipin gum, ficus elastica, SEM, physicochemical, FT-IR, Food, Pharmaceutical.

INTRODUCTION

Gums are heteropolysaccharide complex carbohydrate with high molecular weight; they are sticky substances which exudate from certain plant either as a result of microbial infection or as a result of mechanical injury [1, 2, 27]. According to [3], exudate gums are formed as a result of microbial infection on the plants and the plants in turn synthesize the liquid substances as a defense mechanism to seal off the wound and prevent further invasion of the tissue. Due to excellent properties of exudate gum such as solubility, viscosity, binding, stabilizing, thickening and emulsifying, they are utilize in an overwhelming number of applications ranging from adhesive industry to beverages, confectionaries, cosmetic, paint, paper, pharmaceutical and food industry [4]. These products serve as basic raw material in several multibillion-dollar industries around the world [4-6].

Evidently, there are no sufficient studies that confirm the physicochemical, morphological and structural characterization of this gum. Hence this research aims at investigating the physicochemical, morphological, structural and elemental analysis of the gum in order to evaluate its potential industrial

applications, mostly in food and pharmaceutical. The results of this research is likely to highlight the physicochemical properties, the arrangement of gum particles, purity levels, percentage of crystallinity and amorphousity, the type of functional groups present and the concentration of mineral elements in order to amplify the possibility of the gum applications in food and pharmaceutical as an emulsifier in food processing, effective binder and suspending agent in drug formulation.

MATERIALS AND METHODS

Collection and preparation of gum

Gum was collected from the bark of ficus elastic tree in Owena Forestry, Ondo State, Nigeria between November 2009 and February 2010. The plant was identified and authenticated at the herbarium of the Department of Plant Science Technology, University of Jos. Gum was tapped from the bark of the tree. The crude samples of gum consist of a mixture of large and small nodules mixed with bark and organic debris. These were hand sorted to remove fragments of bark and other visible impurities and then were spread out in the sun to dry for one weeks. The dried cleaned gum samples were milled with a kenwood blender (UK) and

later sieved using a bin (mesh size-250microns) so as to obtain a fine and uniform sample, kept in labeled plastic container for subsequent analysis.

Purification of gum sample

Dried crude gum (10g) was stirred in cold distilled water (250ml) for 2 hours at room temperature. The supernatant was obtained by centrifugation and made up to 500ml and ethanol solution was added (1: 4 v/v) to precipitate all the carbohydrate. The precipitated material was washed again with ethanol, followed by distilled water and dried at room temperature milled with kenwood blender (UK) and later sieved using a bin (mesh size-250microns) kept in labeled plastic container for subsequent analysis.

Physicochemical analysis of ficus elastica gum

The moisture content was determined by drying to constant weight at 1050c (in a muffle furnace) [7]. Nitrogen content of the gum was determined by kjeldah method [7] using Gerhad kjeldotherm and vapodest system (Germany). Crude protein was calculated from the nitrogen content using the conversion factor of 6.25. pH, relative viscosity, water holding capacity, emulsifying capacity, specific rotation and swelling index were measured accordingly to [7].

Elemental analysis of ficus elastica gum

Elemental contents of native ipin gum were analyzed using atomic absorption spectrophotometer (AAS), A- analyst model 400 (England) for the presence and concentration calcium, magnesium, manganese, zinc and iron and flame photometer Hitachi 482 (Germany) for the presence and the concentration of potassium, and sodium

Microstructure studies by SEM

Morphological features of the gum were studied with a JSM – 5600LV scanning electron microscope of JOEL (Tokyo, Japan). The dried sample was mounted on a metal stub and sputtered with gold in order to make the sample conductive, and the images were taken at an accelerating voltage of 10KV and at 500x magnification[7].

X –ray powder Diffraction (XRD).

X-ray diffraction patterns of the gum were analysed using a siemens D5000 X-ray diffractometer (Siemens, Munich, Germany). Powder sample, packed in rectangular aluminum cells, was illuminated using Cuk & radiation ($\lambda = 1.54056 \text{ \AA}$) at 45KV and 40mA. Samples were scanned between diffraction angles of 5° to 40° 2θ , scan steps of 0.1 were used and the dwell time was 15.0 sec. A nickel filter was used to reduce the K α contribution to the X-ray signal. Triplicate measurements were made at ambient temperature.[7]

Fourier Transform Infrared (FT-IR)

The FT-IR spectrum of the sample was recorded in an IR spectrometer (Nicolet Magna 4R 560. MN USA), using potassium bromide (KBr) discs prepared from powdered samples mixed with dry KBr.

RESULTS

The results for the physicochemical analysis and elemental analysis are presented in Table 1 and 2

Table 1: Physicochemical characteristics of ipin (ficus elastica) gum.

Moisture content (%)	7.68±0.15
Ash content (%)	2.70±0.30
Protein content (%)	2.08±0.02
pH	5.50±0.10
Relative Viscosity	22.10±0.50
Refractive index	1.34±0.01
Water holding capacity (%)	84.90±4.25
Specific rotation (°)	-25.46±0.40
Swelling index (%)	9.50±1.10
Emulsifying capacity (cm ⁻¹)	17.29±0.20

Table 2: Mineral element composition of Ficus elastica gum

Element	mg/100g
Calcium	55.31±0.01
Magnesium	26.60±0.10
Sodium	23.63±0.40
potassium	20.9±50.12
Manganese	8.54±0.31
Cobalt	4.77±0.10
Iron	4.47±0.20
Zinc	40.28±0.14

Mean± S.D, n=3



Fig 1: Crude *Ficus elastica* exudates gum



Fig 2: Purified *Ficus elastica* exudate gum

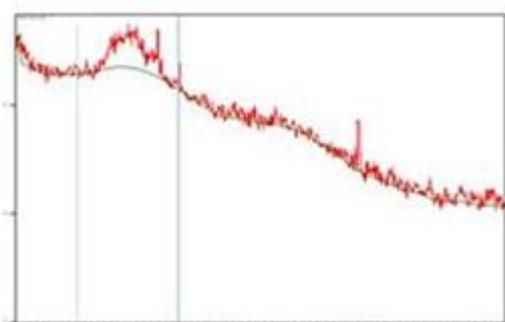


Fig 3: X-ray diffraction pattern of *Ficus elastica* Gum

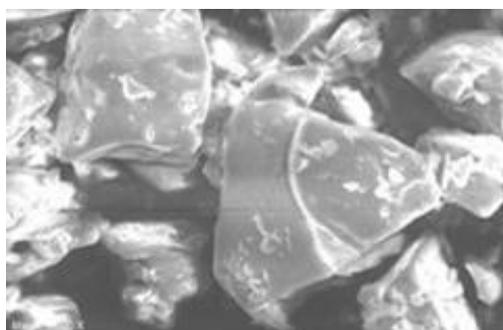


Fig 4: Scanning electron microscopy (SEM) of *Ficus elastica* Gum

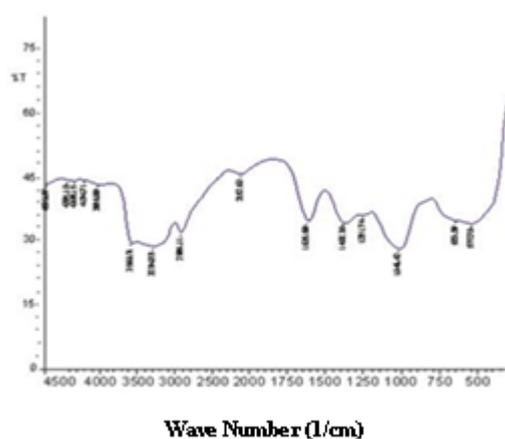


Fig. 5: FTIR of *Ficus elastica* gum

DISCUSSION

Table 1 shows the physicochemical parameters. The swelling capacity in water expressed in percent was 9.50% (Table 1). The result shows that the gum has a high swelling index compared to a standard gum arabic with swelling index of 8.5% [8]. The gum may perform well as binder and matrix agent. The relatively high swelling index at pH = 5.5 implies that the gum may be useful as a matrix former in controlled drug-release. Swelling is a primary mechanism in diffusion controlled release dosage form [9].

The pH measurement shows that the gum solution was slightly acidic. The pH value of 5.5 (Table 1) is in good agreement with reported pH values for gum arabic and anarcadium occidentale .L (Cashew gum) by several authors [6, 25, 26]. The acidity of the plant gum is not unexpected since many of them are known to contain salts (Ca, Mg, K, Na and Fe) of acidic polysaccharides, the activity of which is due to uronic acids in their structure [10]. The pH of an exudate gum is an important parameter in determining its suitability in formulations since the stability and physiological activity of most preparations depend on pH [11, 29, 30]. Moisture content of the gum was 7.68% (Table 1) and compares favourably with the minimum standards (< 15%) for good quality gum according to European specification [8]. This suggests its suitability in formulations containing moisture sensitive drugs. Given suitable temperature moisture will lead to activation of enzymes and the proliferation of microorganisms, thereby affecting its shelf life. It is important to investigate the importance of an exudate gum, for industrial application lies not only on the cheap and easy availability of the material but the optimization of production processes such as drying, packaging and storing [13]. The total ashes value of the gum was found to be 2.70% (w/w) (Table 1) this falls within the acceptable level of less than 4% for gum arabic reported by [14] for food and pharmaceuticals. Ash content is an important property considered as a purity parameter in gums. The very low values of ash show that ficus elastica exudates gum has a good quality of mineral content with low level of contamination [14]. Relative viscosity of gum solution at (30oC) was found to depend on gum concentration [2]. The relative viscosity of the gum was found to be 22.10 (Table 1). Molecular association in fluids greatly influences their rheological behaviors. Increase in viscosity with concentration is probably due to increase in the molecular weight of the gum [15, 29].

The value for protein content obtained 2.08% (Table 1) fairly agrees with that of acacia gum (0.5 – 2.7%) [12]. The moderate protein content in the gum sample is noteworthy. This is because protein content is known to have effects on the emulsifying behaviour of gum with the best emulsion capacity and stability found in gums with higher nitrogen content [16, 8].

The specific rotation of the aqueous gum was found to be optically active (-25.460) (Table 1). This shows that the sugar present is laevorotatory. Emulsifying capacity was determined in form of Turbidity. The emulsifying capacity was found to be 17.29 cm⁻¹ (Table 1). A higher turbidity is an indication of a better emulsion capacity. In addition to protein content of gum, the typical molecular structure and high molecular weight are responsible for good emulsifying properties [17]. A similar correlation between molecular weight and emulsion stability of gum arabic was reported by Underwood EJ [8].

Refractive index of the gum sample was found to be 1.34 (Table 1). This may prove to be a qualifying index for this gum. Adeyanju [6]. Reported that refractive index for acacia senegal gum was 1.338 and Seyal gum was 1.337. Water holding capacity of the gum was found to be 84.90%. The water holding capacity of gum is the ability to hold water and does not only depend on the functional group of carbohydrate that are hydrophilic but also on the protein present in the gum, since they also contain functional groups that are able to bind with water molecule. Thus addition of other substance can be accommodated and this may improve the texture of the overall product [18, 19, 28].

Scanning electron microphotographs (SEM) of the gum sample is depicted in Fig 4 at 500x magnification and 50 μm scale. It exhibit fibrous long non-distinct shaped large fibres. These properties could be of importance when considering applications based on surface characteristics. It is clear from plate that the gum has irregular particle size. It has been reported that particle size and specific surface area influence the hydration behaviour of gums, which in turn influence their intrinsic viscosity and molecular mass [15, 20]. Earlier studies carried out on guar gum – a galactomannan rich tree gum, established that particle size influenced the hydration kinetics and its molecular mass [2, 15]. Scanning electron microscopic studies (SEM) are used to examine the characteristic distinct crystalline morphology of some commercial gums at magnification from (x100) to (x6000). Values above this magnification lead to decaying of sugar particles. The observation recorded has revealed that SEM studies of various polysaccharides could be used to

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find out the purity of substance e.g. in food and medicinal applications.

The x-ray diffractogram of the gum shows presence of numerous halves (Fig 3) with weak peaks, confirming its almost complete amorphous nature. The result of (XRD) confirms that the gum exhibits only an amorphous portion.

The IR spectrum is shown in Figure 5. The finger print region of the spectrum consists of two characteristic peaks between 700 and 1316 cm⁻¹, attributed to the C-O bond stretching [5]. The band at 1604 cm⁻¹ was assigned to the O-H bending of water [18]. Contribution from carbonyl stretches in the 1700 cm⁻¹ region indicate the presence of ester linkages. The broad band at 3286 cm⁻¹ is due to hydrogen-bonded hydroxyl groups that contributes to the complex vibration stretches associated with free inter and intra-molecular bound hydroxyl groups which make up the gross structure of carbohydrate [18]. These are all consistent with a polysaccharide structure that is neither starch nor cellulose, but has some peptide cross-links and some amino sugars [5].

The result of elemental analysis of gum showed that *Ficus elastica* is rich in sodium, calcium, magnesium, iron, potassium, manganese and cobalt. Mineral elements compositions are reported based on the dry matter (DM) (Table 2)

CONCLUSION

The results of this study clearly show that *Ficus elastica* gum have good physicochemical properties and good concentration of essential elements which compared favourably with standard gum Arabic and WHO/FAO requirement. Thus *Ficus elastica* gum can be utilized in gum based industries, most importantly in food and pharmaceuticals as emulsifier in food processing and effective binder in drug formulations.

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