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Physical, functional and chemical properties of *Grewia venusta* (ururu) mucilage extract

*Alobo, A. P. and Arueya, G. L.

Department of Food Technology, University of Ibadan, Nigeria

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Abstract

Food stabilizers and bulking agents required by food industries in developing countries are largely obtained by importation and usually at high cost. Attempts made to get other local substitutes have met with hydration, viscosity and syneresis problems. *Grewia venusta* (ururu) mucilage may be a possible substitute but it has not been explored. The objective of this study was to characterize this mucilage in terms of physical, functional and chemical properties. Grewia venusta stem bark obtained from Ajaokuta, Nigeria was subjected to aqueous extraction at tropical ambient temperature, oven-dried (thin layer, 50±3°C) and milled into powder. Its physical, functional and chemical properties were determined. Both the wet and dry mucilage (yield = 18%) were reddish brown in colour (L^*=37.33, a^*=9.38, b^*=10.43). The dispersability and hygroscopicity were 93.00% and 14.00%, respectively. The apparent viscosity decreased from 7.68 to 6.23 Ns/m^2 after drying. The mucilage exhibited higher shear stress values (3.84-5.90 Ns/m^2) at 10°C compared to those (1.65-2.51 Ns/m^2) at 80°C. The emulsion stability of the wet and dry mucilage was 17.72% and 16.40%, respectively. Foam capacity was low (8.00-10.39%) while foam stability was high (97.60- 97.78%). The mucilage contained 0.07% tannins, 0.21% saponins, 0.04% glycosides, 1.46% alkaloids, 0.06% flavonoids, 12.65% pectin, 0.92 mg/100 g oxalates, 0.10% hydrocyanic acid, 0.30% phytates and 0.88% oligosaccharides. These findings suggest that *Grewia venusta* mucilage has good potential use as a food additive.

Introduction

Mucilages and gums obtained from plants have been used as alternatives to hydrocolloids produced by biosynthetic or fermentative processes (Wang and Wang, 2013). Although mucilages and gums obtained from linseed, quince seed and guar legume seed as well as gum arabic, gum tragacanth, gum karaya, gum ghatti and carrageenan gum have considerable potential uses in foods (Prasad *et al*., 2012), they are not widely distributed. Gums produced by certain plants like cashew (*Anacardium occidentale* L.) and Cyamopsis tetragonalobus possess evidence of some drawbacks such as uncontrolled rate of hydration, pH dependency, thermal decomposition, biodegradation, low shear stress resistance and syneresis, which limit their use (Prasad *et al*., 2012; Olusola *et al*., 2014). In order to solve this problem, it would be useful to search for suitable, cheap and locally available substitutes.

The suitability of hydrocolloids for use in specific foods as additives and other applications can be predicated on the diverse study and characterization of the hydrocolloids. Because of the wide application and suitability of hydrocolloids for particular food systems, there is need to pay attention to hydrocolloids from lesser known sources such as *Grewia venusta* (ururu). *Grewia venusta*, is a small tree or shrub that grows wild in the savannah region of Nigeria. It is wide spread in tropical Africa, Asia and Australia. The relative dominance and density of G. venusta among 29 different tree species in Kogo forest reserve in North-Western Nigeria were reported as 0.46 and 1.25, respectively (Bello *et al.*, 2013). Previous studies on *Grewia* mucilage were largely focused on its use in pharmaceutical manufacture (Emeje *et al*., 2008; Nep and Conway, 2010; Ogaji and Okafor, 2011; Ogaji and Hoang, 2011). One such study (Nenonene *et al.*, 2009) indicated the presence of some phytochemicals, which were however not quantified. These chemicals play important roles in plants and humans when the plants are used as food. The objective of this study was to extract and dry mucilage from *Grewia venusta* stem bark and determine its physical, functional and chemical properties. The assumption is that the mucilage may be suitable for use in human food.

*Corresponding author.
Email: *apalobo@yahoo.com*

Materials and Methods

Plant material and preparation of mucilage powder *Grewia venusta* stems were cut from trees at Ajaokuta, Nigeria and used for the study. Mucilage from the stems was extracted using the procedure described by Ogori and Gana (2012) with modifications. The stems were thoroughly cleaned by scrapping off the brownish powdery bark with knife and then washed in clean water. The washed stem barks were cut into short pieces of about 20 cm long and reduced to thin strips and weighed to about 700 g. The pieces were mixed with 1.5 liter of clean water and squeezed thereafter to release the mucilage, which was then filtered through a double-folded muslin cloth to separate it from the pieces of strips. The mucilage was dried (thin layer) in an air oven (Gallenkamp BS 200, England) at 50±3^{o}C for 24 h, milled and sieved using a laboratory sieve of 80 mesh. Mucilage yield was determined by taking the ratio of the weight of the dry sample to the weight of the stem bark strips and multiplying by 100.

Decolorisation of Grewia *mucilage*

Grewia mucilage (2.0 g) was dispersed in 20 mL of distilled water in four different separating funnels into which 50 mL of each of solvents including ethanol, methanol, hexane and acetone were added. The mixtures were shaken every 30 min for 2 h and the mucilage was dried at 40^{o}C for 48 h in an air oven after desolventization.

Physical properties

The dispersibility of the sample was determined using the method described by Kulkarni *et al*. (1991). Ten grams of sample was weighed and mixed with 50 mL distilled water in a 100 mL measuring cylinder. Total solid content was determined according to AOAC (2005) method. The hygroscopicity of the dry mucilage was determined following the procedure of Ogori *et al*. (2013). Viscosity was measured using the method of Park *et al.* (2014) with modifications. A 100 mL sample of wet mucilage was transferred to each of five 100 mL beakers and viscosity measurements were made using a Brookfield DV-E viscometer (Brookfield Engineering Labs, USA) with spindle number 4 at five variable speeds of 20, 40, 60, 80 and 100 rpm. Viscosity readings were taken at temperatures of 10 to 80^{o}C. Constant temperature was maintained by placing the beakers on ice blocks or a thermostatic water bath (Gallengkamp, England). The dry *Grewia* mucilage was rehydrated to 20% (w/v) and used for viscosity determination. The colour of the mucilage was measured using a colorimeter (Processor, DP-400, Japan). Hunter Lab colour values for L* (lightness), a* (redness/greenness) and b* (yellowness/blueness) were measured directly using the colorimeter according to the method of Chaikham *et al.* (2014). The gel clarity of the dried mucilage samples treated with solvents to decolorize (as above) were assessed using the method of Builders *et al.* (2012) with slight modifications. The transmittance of a 0.5% dispersion of decolorized mucilage in distilled water at ambient temperature (30±2^{o}C) was measured at 580 nm using a spectrophotometer (Jenway V6300, England). The result was expressed as a percentage.

Functional properties

Foam capacity and foam stability were determined as described previously (Onwuka *et al.*, 2010). Emulsion activity and stability were determined using the methods of Eltayeb *et al*. (2011) with slight modifications. The emulsion (2 gram sample, 25 mL each of distilled water and refined soy bean oil) was prepared in a calibrated centrifuge tube. The emulsion was centrifuged (Hettich Universal II, Germany) at 2000 rpm for 5 mins. The ratio of the height of the emulsion layer to the total height of the mixture was calculated as the emulsion activity expressed in percentage. The emulsion stability was estimated after heating the emulsion contained in a graduated centrifuge tube at 80^{o}C for 30 min in a water bath, cooling for 15 mins under running tap water and centrifuging (Hettich Universal II, Germany) at 2000 rpm for 5 mins. The emulsion stability, expressed as a percentage, was calculated as the ratio of the height of the emulsified layer to the total height of the mixture. Bulk density was determined according to the method described by Arueya and Iloghalu (2013). The swelling index and least gelation concentration were determined using the method described by Iwuoha (2004). Water absorption capacity was determined using the modified method of Onimawo *et al.* (1998). Oil absorption capacity was determined using the method of Chandra and Samsher (2013). One gram of sample was mixed with 10 mL refined vegetable oil (Sp. gravity, 0.9092) and allowed to stand at ambient temperature (30 ± 2°C) for 30 mins.

Proximate composition

The protein (macro Kjeldahl, N x 6.25), fat (Soxhlet extraction, using petroleum ether), moisture, fibre and ash contents were determined using AOAC (2005) methods. Carbohydrate was estimated by difference, where carbohydrate = 100% – (fat + protein + ash+ moisture + crude fiber). The pH of sample (10% w/v) was determined at room

temperature (30±2°C) using a digital pH meter (Mettler Delta, 350, Germany). The pH meter was first standardized with buffer solutions (pH 4.0 and 9.0).

Mineral analysis

Mucilage sample (1 gram) was digested with 20 ml of acid mixture (650 ml concentrated HNO_3; 80 mL perchloric acid; 20 mL concentrated H_2SO_4) according to the method of Young and Tarawou (2014). The clear digest was diluted to 200 mL with distilled water and aliquots were used for atomic absorption spectrophotometry (AAS, Analyst 200, Perkin Elmer, UK) using filters that matched Ca, Mg, Fe, Mn, and Cu. Na and K were estimated using a flame photometer (Jenway PFP7, UK). Phosphorus content was determined according to AOAC (2005) method using spectrophotometer (Jenway V6300, England). Two grams of sample was used for the determination.

Phytochemical analysis

Tannin and pectin were determined as outlined by AOAC (2005). Tannic acid standards within the range of 0-1 ppm were treated as with the sample. Saponins, glycosides alkaloids and flavonoids were determined as described by Harborne (1998).

Determination of anti-nutrients and total oligosaccharides

Oxalate, phytate, hydrogen cyanide and total oligosaccharide contents were determined according to the methods of Soetan (2012). Triplicate samples (unless specified otherwise) were used in all the determinations and means ± standard deviation (SD) were computed.

Results and Discussion

Physical and functional properties

Mucilage was successfully extracted from *Grewia venusta* stem bark using water. The mucilage was slimy and easily detached from the drying surface at the end of the drying process and after cooling. The dehydration of gums and mucilages is not an easy task due to their stickiness and hygroscopicity that lead to problems in controlling the drying time, adhesion to the dryer wall, caking and subsequent handling of the product. Wall stickiness and thermo plasticity are some of the main considerations during the drying of gums and mucilages. The yield of the mucilage after drying of the wet extract was 18.00% (Table 1). The yield is comparable to that obtained by Nenonene *et al.* (2009) who achieved 20% mucilage extraction yield from boiled powdered *G. venusta* stem bark. Such thermal extraction process may however, affect the properties (particularly the viscosity) of the mucilage. The higher extraction attained by these researchers may be attributed to the heat treatment, which probably resulted in improved hydration and dissolution of the mucilage. Most hydrocolloids usually degrade slowly and lose emulsification efficiency and viscosity as a result of the precipitation of complex polymers due to heat (Randall *et al*., 1989). The extracted and dried mucilage was reddish brown (L^*=37.33, a^*=9.38, b^*=10.43) in colour. The colour of mucilage and gums is mainly due to the presence of pigments and other substances derived from the source of mucilage. It has been noted that plants under stress conditions synthesize flavonoids, some of which impart colour naturally such as anthocyanins and those that become brown after oxidation like flavonols (Petrussa *et al*., 2014). Okafor *et al*. (2001) indicated that *Grewia* polysaccharide gum consists of glucose and rhamnose as the main monosaccharide components and galacturonic acid as the main sugar acid. A reaction between aldehydic sugars such as glucose and protein leading to the formation of Schiff bases may contribute to the colour of the extracted gum. One of the essential quality attributes of food is colour, which may however not be favoured in some foods. According to Bixler (1994), highly clear gels are favored in many foods. Decolorization of the *Grewia* mucilage may therefore enhance its range of utilization in foods. Attempts made to decolorize the mucilage using alcohol, hexane, petroleum ether and acetone were only partially successful as

Table 1. Selected physical properties of *G. venusta* mucilage

Parameter	Wet mucilage	Dry mucilage
Mucilage yield (%)	ND*	18.00
Solubility (%): (30±2°C)	ND	17.59±0.62
Dispersibility (%)	ND	93.00±0.22
Total solids (%)	56.84±0.32	ND
Hygroscopicity (%)	ND	14.00±0.13
Viscosity (Ns/m²)	7.68±0.08	6.23±0.16
Colour	ND	L*=37.33, a*=9.38, b*=10.43

Values are means±standard deviation of triplicate determinations. *ND, Not determined.

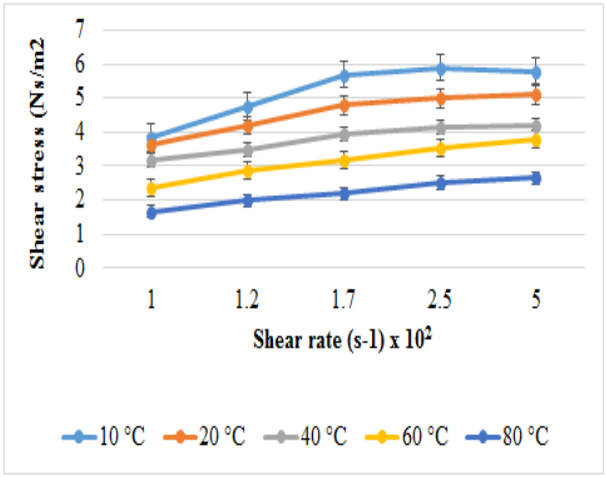

Figure 1. Relationship between shear stress and shear rate of *Grewia venusta* gum as influenced by temperature

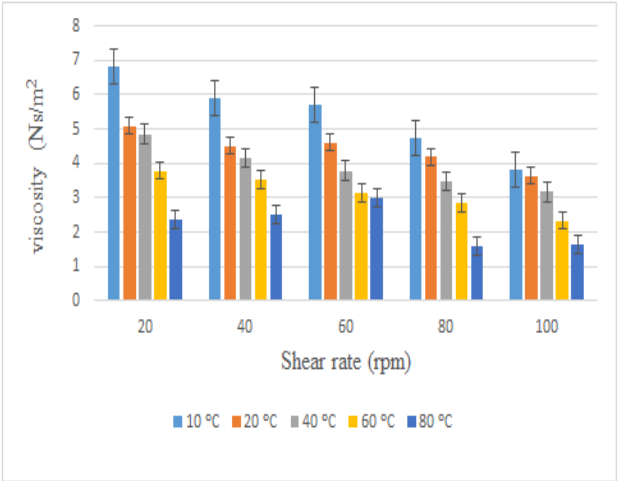

Figure 2. Effect of shear rate and temperature on the viscosity of *Grewia venusta* mucilage

the reddish brown coloration was still noticeable in the decolorised samples. For example, the gel clarity of the mucilage extracted with ethanol (Table not presented) was 29.8% and was significantly higher than that of the control (11.3%) and those extracted with methanol (16.6%), hexane (20.2%) and acetone (20.5%). The variations in the gel clarity of the mucilage may be partly attributable to the extent of extraction of pigments from the gum and polymer dispersion in water after solvent extraction. The dried *Grewia* mucilage was soluble in water (solubility = 17.59%). It was insoluble in ethanol, methanol, acetone and hexane. Cold water solubility of gums obtained from Trichilia rika, Newbouldia baevis, Ficus sycomorus and Fagara zanthoxyloides by Ja'o (2014) were 9.2%, 7.8%, 8.4% and 9.4% w/v, respectively. The gums were also reported to be insoluble in ethanol, chloroform and acetone. The solubility of the gums indicate that they are ionic (Ja'o, 2014). Choudhary and Pawar (2014) indicated that some gums, such as gum arabic readily dissolve in water, whereas, mucilages form slimy masses. Many hydrocolloids such as alginates, carrageenan, gum arabic, xanthan and pectin are polyelectrolytes that possess charged groups. The groups ensure strong hydration, particularly on a per-molecule basis (Chaplin, 2016). The presence of counter ions and co-ions or ions with the same charge as the polyelectrolyte will introduce complex behavior that are ion specific and depend on the concentration of the ions. Generally neutral hydrocolloids are less soluble whereas polyelectrolytes are more soluble but hydration kinetics depend on many factors. According to Chaplin (2016), Xanthan, guar gum and carboxymethyl cellulose are soluble in cold water but carrageenan, locust bean and many alginates require hot water for complete hydration and dissolution. Such water may be held specifically through direct hydrogen bonding. Interactions between hydrocolloids and water depend on hydrogen bonding and therefore on temperature. Nep and Conway (2010) indicated that *Grewia* polysaccharide gum slowly hydrates and swells in water and has aqueous solubility of about 0.2 mg/ml or 20%. The low solubility of the mucilage was attributed to insoluble cell-wall materials making up a larger proportion of the dry mucilage. However, the presence of acetyl groups has been reported to account for the insolubility of certain gums in water (Ogaji, 2011). The dispersability of the dry *Grewia* mucilage was 93%. This property exhibited by other hydrocolliods has been exploited in the food, cosmetic and some pharmaceutical industries and used in the stabilization and suspending of foods, drinks, cosmetics and in liquid or solid dosage forms (Ja'o, 2014). A high thermal stability of the Grewia gum indicated by the high oxidation onset of 267±6.2°C as reported by Nep and Conway (2010) suggests that the gum can be used under conditions of high thermal stress.

Absorption of moisture by a sample exposed to the atmosphere implies hygroscopicity. The hygroscopicity of the dried *Grewia* mucilage reflected by moisture content after exposure was 14%. Hygroscopicity of a product may be affected by the moisture concentration gradient between the product and the atmosphere as well as the presence of hydrophilic groups in the product (Fenandes *et al*., 2013). Absorption of moisture is an important factor for powder reconstitution since it can lead to caking and reduce dispersibility. The knowledge of hygroscopicity of a product is helpful in the consideration of the type of packaging material that is suitable for the product. The viscosity of the liquid mucilage extract was 7.68 Ns/m^2 compared to that of the rehydrated dry mucilage, which was 6.25 Ns/m^2. This difference is due to the high solid content of the

Table 2. Functional properties *Grewia venusta* mucilage

Property	Liquid mucilage	Dry
mucilage		
Foaming capacity (%)	10.39±0.24	8.00±0.42
Foaming stability (%)	97.78±0.17	97.60±0.22
Emulsion activity (%)	29.39±0.30	25.80±0.15
Emulsion stability (%	17.72±0.21	16.40±0.28
Bulk density (g/ml)	ND*	0.68±0.37
Swelling index	ND	1.74±0.06
Water absorption capacity (%)	ND	216.50±0.15
Oil absorption capacity (%)	ND	152.50±0.21
Least gelation concentration (%)	ND	20.00±0.27

Values are means ± standard deviation of triplicate determinations.
*ND, Not determined.

liquid extract, which was 56.84% (Table 1). The shear stress of the mucilage increased with increasing shear rate. The rate of increase in shear stress reduced as from shear rate of 60 rpm. The curves obtained at 10-40°C are typical of fluids that exhibit pseudoplastic flow as reported earlier (Rao, 1999). These findings suggest that *Grewia venusta* mucilage requires more stress to flow at low temperatures. The implication of this is that high energy pumps may be required to pump the mucilage at low temperatures. The shear stress of the mucilage increased linearly with the rate of shear at temperatures of 60°C and 80°C, respectively. The viscosity of the *Grewia* mucilage decreased with increasing shear rate and temperature (Figure 2). The highest viscosity value of 6.80 Ns/m2 was at shear rate of 20 rpm and temperature of 10oC, while the lowest viscosity value was at 100 rpm and 80°C. Regardless of spindle rotation, viscosity was rather low at 80°C compared to those at lower temperatures. The mucilage possessed pseudoplastic shear thinning behavior exhibited by the decreasing viscosity with increased shear rate. Manjunatha and Raju (2015) showed that Newtonian viscosity increased significantly with increase in total solid content, whereas it decreased significantly with increase in spray dried beet root (*Beta vulgaris* L.) juice powder. According to Qi and Cui (2005) structural change in gum molecules due to shearing and temperature could occur, resulting in viscosity reduction. The mucilage probably oriented itself more parallel to the surface, which decreased its resistance to spindle rotation. At high shear rates, a decrease in viscosity can be attributed to a decreasing number of chain entanglements (Qi and Cui, 2005). In addition molecule formation could be destroyed at faster spindle speed, which could result in less of the molecules sliding together and could result to low viscosity (Brookfield, 2009). Knowledge of rheological properties of a material is important for the design of pumping and transport facilities and as a tool in process control during handling.

The *Grewia* mucilage had a low foam capacity and a relatively high foam stability value (Table 2). Foam formation and stability are a function of type of protein, pH, viscosity and surface tension of a material (Eltayeb *et al.,* 2011). Foams are used to improve texture, consistency and appearance of foods. Food ingredients with good foaming properties are required in bakery products as well as whipped toppings and desserts that require a high percentage of porosity (Onwuka *et al.*, 2010). The emulsion activity and stability of the liquid *Grewia* mucilage were 29.39% and 17.72%, respectively compared to the 20% activity for flax seed mucilage as reported by Al-Sayed *et al.* (2012). Emulsion characteristics of flours containing proteins often contribute to their functionality in foods. Globular and soluble proteins are surface active and they promote oil-in-water emulsions. Emulsion stabilization by hydrocolloids is related to decreased precipitation of dispersed solid particles, decreased creaming rates of oil droplets and foams, prevention of aggregation of dispersed particles, prevention of syneresis of gelled systems containing oil and retardation of coalescence of oil droplets (Milani and Maleki, 2012). Such levels of emulsion could be useful in food systems such as mayonnaise and salad dressings (Eltayeb *et al*., 2011). The bulk density of the mucilage (0.68 g/mL) was moderate and comparable to that of guar gum (0.55 g/mL) reported by Builders *et al.* (2012). Bulk density of a food sample could be used to determine its packaging requirements as this relates to the load the food exerts if allowed to rest directly on one another. The pH values of 5.17-5.80 suggest that the mucilage

Table 3. Chemical properties of liquid and dry *Grewia venusta* mucilage

Proximate composition and mineral profile*			Phytochemicals, anti-nutrients and flatulence factors**		
Parameter	Liquid	Dry	Parameter	Liquid	Dry
Moisture (%)	43.00±0.3	8.00±0.42	Saponins (%)	0.21	0.20
Fat (%)	1.80±0.14	2.50±0.13	Glycosides (%)	0.01	0.04
Ash (%)	2.50±0.07	2.50±0.12	Flavonoids	0.01	0.06
Protein (%)	4.60±0.40	5.80±0.35	Pectin (%)	3.86	12.65
Fiber (%)	4.20±0.23	7.40±0.19	Alkaloids (%)	1.04	1.46
CHO$^{\phi}$ (%)	41.90±0.31	73.80±0.36	Tannins (%)	0.01	0.07
pH	5.17±0.04	5.80±0.12	Oxalates (mg/g)	ND^{+}	0.92
Ca (mg/100 g)	ND^{++}	0.87±0.01	Phytates (%)	ND	0.30
Mg (mg/100 g)	ND	3.33±0.01	Hydrogen cyanide (mg/100 g)	ND	0.10
P (mg/100 g)	ND	0.36±0.18	Total oligosaccharides (%)	ND	0.88
Cu (mg/100 g)	ND	1.22±0.01			
Fe (mg/100 g)	ND	1.68±0.03			
Mn (mg/100 g)	ND	0.29±0.05			
K (mg/100 g)	ND	108.50±0.30			
Na (mg/100 g)	ND	53.60±0.02			

* Values are means ± SD of triplicate determinations.
**Values are means of duplicate determinations. CHO$^{\phi}$=Carbohydrates; ND++ not determined

is acidic. The pH value of the mucilage fell within the pH range for carrageenan and guar gum (4.0-7.0) as well as gum arabic and pectin (2.0-7.0) reported by Brenntag Food and Nutrition Europe (BFNE) (2010). Hematyar *et al.* (2012) reported that gum tragacanth with pH range of 5.0-6.0 had good acid stability compared to most hydrocolloids. Bello-Perez *et al*. (1999) associated rapid swelling to breakage of inter molecular hydrogen bonds in amorphous areas of starch that allows irreversible and progressive water absorption. Swelling power is related to the associative binding within the hydrocolloid network. The mucilage had a high oil absorption capacity. It may be useful in food systems such as baked products and meat, where oil absorption is desirable, particularly for flavour retention and improved palatability. The least gelation concentration of the mucilage at room temperature was 20%. Hydrocolloids retain their extended structures upon hydration and this may give rise to mixed entanglement, which may give rise to gels at low concentrations. Milani and Maleki (2012) indicated that swollen particulate forms of gelled hydrocolloids are particularly useful as they combine macroscopic structure formation with an ability to flow and often have an attractive soft solid texture, which is especially sought in food applications. The gelation of the mucilage in cold water provides potential opportunity for the mucilage to replace chemically cross-linked starches and additives such as carboxylmethyl cellulose that are based on chemical treatment.

Chemical properties of Grewia venusta mucilage

The proximate and mineral compositions of the Grewia mucilage are in Table 3. The protein content (4.60%) is comparable to the 4.00% for gum arabic reported by Iwe and Attah (1993). The values are low when compared to the protein content of seed mucilages like linseed, basil, dragon head and quince seeds (Fekri, 2008). Drying resulted in an increased concentration of the protein (4.60-5.80%), fat (1.80-2.50%), fibre (4.2-7.40%), and carbohydrate (41.90-73.80%) of the mucilage. The increases were probably due to a concentration effect attributed to the reduction in moisture content. The mucilage contained reasonable amount of fibre comparable to those of gum arabic and *Cissus* mucilage reported by Iwe *et al*. (2003). The high fibre content of the Grewia venusta mucilage may make it suitable as a bulking agent in bakery food products. Bulking agents are substances that add to the bulk of food. They provide dietary fibre that usually contain low calories and pass through the intestine undigested (Milani and Maleki, 2012). Common bulking agents are soluble fibre like guar gum, pectin and glycerine. Bulking agents are widely used in low caloric foods, meal replacement, pastries, breads, cereals and most processed foods. The fat and mineral contents, particularly Ca (0.87 mg/100 g) and P (0.36 mg/100 g) were low. The low mineral content of the mucilage may be attributed to extraction of the mucilage in which case some of the minerals may remain unextracted in the stem bark. Burkill (2000) reported Ca and P values of 45.30 mg/100 g and 79.00 mg/100 g, respectively for whole *Grewia* mollis stem bark. Generally, the concentration of ash in the mucilage studied is relatively comparable to those reported for some plant gums (Lelon *et al*., 2010; Vinod and Sashidhar, 2010). The tannins, glycosides, alkaloids, flavonoids and pectin of the Grewia mucilage (Table 2) increased as a result of drying. The mucilage contained a high amount of pectin, which may make it suitable as an ingredient for jam and jelly preparation from low pectin fruits. Many of these phytochemicals have been shown to possess bioactive properties which are pharmacological and anti-microbial (Mboto *et*

al., 2009). The phytochemicals are known to possess potential chemical applications and are deliberately added as supplements against cancer, cardiovascular and coronary heart diseases in man (Onyeka *et al.*, 2012). It has been suggested that flavonoids may contribute to the maintenance of mental and visual functions (International Food Information Council (IFIC), 2004). In particular, tannins and flavonoids found in pigmented plant materials are known to play a role against cardiovascular diseases, and saponins present in legumes and some vegetables slow down DNA replication in cancer cells (Arogba, 2008). A number of phytochemicals are phenolic compounds such as tannins and flavonoids, which function as antioxidants (Zielinski and Kozlwska, 2000). Antioxidants play important role in lipid and emulsion systems by preventing undesirable flavour change and oxidative damage to the living cells and tissues of plants, animals and man (Ologundudu *et al*., 2009). Free radicals produced by oxidative reactions within living cells, which are injurious to the cells can be reduced through consumption of antioxidant-rich foods. This dietary approach may slow down, prevent, or even reverse certain diseases by keeping in shape or boosting the immune system, and even slow down the natural aging process. This is the basis for the free-radical theory of aging (Anonymous, 2006), and it has been demonstrated that the total life span of mice could actually be extended by therapeutic manipulation of reactive oxygen species metabolism (Arogba, 2008). The anti-nutrients and oligosaccharide contents of the mucilage appeared to be low, and there are no references regarding mucilages in the literature to compare the values with.

Conclusion

Grewia venusta stem bark mucilage was successfully dried and milled into powder, which was reddish brown in color. Although the foaming capacity of the mucilage was low, the foam was stable. The mucilage could be useful as a functional ingredient on account of its physical/functional properties and phytochemical composition.

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