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Physico-chemical analysis of gum kondagogu (*Cochlospermum gossypium*): a potential food additive

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The physico-chemical characteristics of gum kondagogu (*Cochlospermum gossypium*) were examined for the first time. The gum was compared with conventionally used food grade gum karaya (*Sterculia* sp.). Chemical analyses revealed that gum kondagogu had higher soluble fibre, protein, tannin, calcium and potassium contents than karaya gum. Gum kondagogu also differs from gum karaya in terms of its intrinsic viscosity, water binding capacity and pH. The basic constituent sugars were similar to that of gum karaya but the proportions of the individual sugars varied. Gum kondagogu had a higher uronic acid (glucuronic and galacturonic acid, 63%) content than neutral sugars (arabinose, rhamnose and galactose, 37%), which could lead to significant differences in the utility and functionality of the gum.

INTRODUCTION

Natural gums are incorporated into diverse food formulations to impart a wide variety of characteristics to the finished product. In particular they are employed to confer resistance to undesired physical processes such as crystallisation, gravitational sedimentation and mechanical desegregation (Walker, 1983). The selection of a hydrocolloid for a processed food often depends on the unique properties of the gum, as suitability is related to underlying physico-chemical properties of the gums, their interaction with water and other food ingredients. Among the naturally occurring gums, gum Karaya (*Sterculia* sp.) is one of the most profusely used gums at present and ranks second only to gum arabic (*Acacia* sp.) in commercial importance as a food additive (Gautami and Bhat, 1992). There are minor differences in the accepted botanical sources of gum karaya listed in the international pharmacopoeia and regulatory agencies (Anderson *et al*., 1982). The Food and Drug Administration of the USA (FDA, 1974) lists 18 acceptable contributing *Sterculia* sp., though it is generally accepted that gum karaya is the dried exudate from *Sterculia urens* Roxb, *Sterculia villosa* (India) *Sterculia setigera* (Sudan and Senegal). However, according to the Food and Agriculture Organisation (FAO, 1991) the gum from *Cochlospermum gossypium* A.P. De Condolle or other species of *Cochlospermum* (Fam. *Bixaceae*) are also included under karaya gum. The bulk of the world's supply of gum karaya is obtained from India and the state of Andhra Pradesh is one of the major producing centres in India (Gautami and Bhat, 1992). Another important forest product collected from the state of Andhra Pradesh is gum kondagogu (*C. gossypium*). Commercially, gum kondagogu is cheaper than gum karaya. This gum does not have a separate identity in the market and is usually mixed with gum karaya and marketed.

Natural gums are classified into different groups depending on the basal chain structure and structural units (Aspinall *et al*., 1967); gum karaya and gum kondagogu are thus classified in the same group. Considerable work has been done since the mid 1930s on the chemistry, uses and applications of gum karaya (Gautami and Bhat, 1992). However, there have been no previous attempts to characterise gum kondagogu (*C. gossypium*) in terms of its physico-chemical properties, nor its uses for food applications, though it has equal potential as a food additive.

The present communication relates investigations carried out on gum kondagogu with respect to its chemical composition and physico-chemical properties, as the functionality of the gum is related to these underlying properties.

MATERIALS AND METHODS

Gum samples were collected from Girijan Co-operative Corporation, a Government of Andhra Pradesh

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Undertaking, Hyderabad, India. Gum kondagogu (KG) was available in three grades, Grade I (KG I), Grade II (KG II), Grade III (KG III). The grading was based on colour and presence of bark and foreign matter. Grade I gum karaya was also procured from the same agency. The gum samples (in intact lump form) had been stored carefully since their receipt, in air-tight polypropylene jars under darkness. Small quantities of the gum were reduced to a fine powder immediately before analysis, using a high speed mechanical blender (Sumeet, India). For GLC analysis, the reference standards and the derivatising reagents were procured from Sigma Chemical Company, St Louis, USA. All other solvents and reagents used were of analytical grade.

METHODOLOGY

Identification tests listed for gum karaya (FAO, 1991) were applied for both gum kondagogu and gum karaya. The Association of Analytical Chemists (AOAC) methods for detection of gums in foods and drugs by spot test identification were also applied (AOAC, 1984). Moisture contents were determined by drying to constant weight at 105°C. Total ash contents were established by ashing at 550°C (in a muffle furnace) to constant weight (AOAC, 1984). The ash obtained was dissolved in dilute hydrochloric acid and the mineral content was analyzed by atomic absorption spectrophotometry (Perkin Elmer model 238, USA). Calcium, potassium and sodium were estimated by flame photometry (Digison model DIF-777, India). Nitrogen contents of the gums were determined by Kjeldahl method (AOAC, 1984) using Gerhadt Kjeldotherm and Vapodest (Germany). Protein content was calculated using the conversion factor 6.25. Volatile acidity was measured according to the AOAC method (AOAC, 1984). Tannins (polyphenols) were extracted in 1% hydrochloric acid in methanol and estimated by the Folin-Denis method (AOAC, 1984). Fibre content was estimated by AOAC method (1984) with a modification, i.e. centrifugation was used to separate soluble and insoluble fibre fractions. Specific rotations were determined in 0.2 M ammonium hydroxide using an automatic digital polarimeter (model AA-10 Optical Activity Ltd, England) with Sodium D line lamp. For the evaluation of intrinsic viscosity, samples were prepared according to the methodology established by Anderson *et al.* (1982). Briefly, 25 ml of 0.2 M ammonia was added to 30 mg gum (moistened with two drops of ethanol) and left overnight. Later, 25 ml of 2 M sodium chloride solution was added to obtain a final solution with an ionic strength of 0.1 M with respect to ammonia and 1 M with respect to sodium chloride. The viscosity measurements were made using a Haake Rotaviscometer (Germany), spindle number NVST 500, at 25°C and the calculations were based on the Huggins and Kraemer equation (Morris, 1983),

$$(nsp/c)_{c\to O} = [n] \quad (1)$$

$$(nsp/c) = [n] + k[n]^2 c \quad (2)$$

where, nsp = specific viscosity; n = intrinsic viscosity; c = concentration of the gum; k = Huggins constant

The water-binding capacity was determined by standard American Association of Cereal Chemists (AACC) method (AACC, 1983).

Gas chromatographic analysis was done on a Perkin Elmer, GC model Sigma 300 (USA), using a stainless steel column of length 2½ m (3% SE-52 on 80/100 Chromosorb W HP, Chromatopak, India). A flame ionization detector (FID) or hot wire detector (HWD) was used along with a Perkin Elmer LC 1-100 Laboratory computing integrator for analysis. Injector port and detector temperatures were 230 and 250°C, respectively. Linear programming was used from 150–200°C with an increase of 1°C per minute with no holding time and nitrogen flow rate being 30 ml min^{-1}. Trimethylsilylation was used for carbohydrate analysis after methanolysis, according to the procedure of Ha and Thomas (1988). Inositol was used as an internal standard.

RESULTS AND DISCUSSION

Gum samples of karaya and kondagogu were subjected to identification tests developed specifically for gum karaya as listed in the FAO compendium on food additives (FAO, 1991). The gum kondagogu did not confirm to the above specifications at least for three identification tests, the basic difference stemming from the test with hydrochloric acid, sodium hydroxide and 65% ethanol as shown in Table 1. When the AOAC (AOAC, 1984)

Table 1. Identification tests as recommended by FAO (1991)

Test	Kondagogu	Karaya
(A) Solubility	Positive	Positive
(B) Swelling by ethanol solution	Negative	Positive
(C) Colour reaction with conc. HCl	Negative (yellow)	Positive (pink)
(D) Colour reaction with 5N NaOH	Negative (yellow)	Positive (brown)
(E) Precipitate formation	na	na
(F) Gum constituents	Positive	Positive

na = not analysed.

test for identification of gums was applied, the results (Table 2) indicated that the gums belonged to the same group; however, the gum kondagogu did not give positive results for the chemical confirmatory tests. These preliminary screening tests show that there are certain basic differences between gum kondagogu and karaya.

The results of the chemical analysis indicate that the moisture, ash and volatile acidity contents of gum kondagogu correspond with those reported for commercial gum karaya and gum exudates of *S. setigera, S. urens* and *S. villosa* (Anderson *et al.*, 1982) (Table 3). The cationic profile of gum karaya has been analysed for the first time along with kondagogu (Table 4). The cationic profile of gum kondagogu was comparable to that of gum karaya except for the minerals calcium and potassium which were found to be present in higher concentrations in the kondagogu.

The protein content in gum kondagogu was in the range of 6.3–5.0%. It significantly varied from that of gum karaya wherein the protein content was reported to be 0–1.4% (Anderson *et al.*, 1982). It has long been established that one of the variable analytical parameters for gum exudates is their nitrogenous content, since the nitrogenous component is exclusively associated with proteinaceous material (Anderson *et al.*, 1985). The higher protein content of gum kondagogu may be a

Table 2. Spot identification tests for food hydrocolloids (AOAC, 1984)

Reagent	Kondagogu	Karaya
(a) Alcoholic precipitate	Flocculant mass on centrifugation	Flocculant mass on centrifugation
(b) Gp I reagent	Negative	Negative
(c) Gp II Reagent	Negative	Negative
(d) Gp III Reagent	Positive, swells strongly stained pink granular mass	Positive, swells strongly stained pink granular mass
Chemical confirmatory tests:		
(a) HCl test	Yellow colour	Pink colour
(b) Aqueous methylene blue stain	Lightly stained	Strongly stained, characteristic blue colour, swells
(c) Gp IV reagent	Negative	Negative

Group(Gp) I reagent—iodine-potassium iodide in zinc chloride solution.
Group(Gp) II reagent—alcoholic iodine solution.
Group(Gp) III reagent—ruthenium red solution.
Group(Gp) IV reagent—sulphuric acid.

Table 3. Proximate analysis of gum kondagogu and gum karaya

	Kondagogu grade			
Parameter (%)	KG I	KG II	KG III	Karaya grade I
Moisture	15.25 (±1.178)	16.97 (±0.216)	15.88 (±0.098)	16.52 (±1.147)
Ash[a]	7.3 (±0.33)	9.4 (±0.60)	7.3 (±0.22)	5.2 (±0.34)
Nitrogen	1.00	0.8	0.90	0.20
Protein[b]	6.3 (±1.11)	5.0 (±1.08)	5.6 (±1.30)	1.2 (±0.59)
Volatile acidity[b]	15.9 (±0.35)	16.5 (±0.47)	16.0 (±0.66)	14.7 (±0.33)
Tannin[b]	0.073 (±0.0079)	0.103 (±0.0170)	0.150 (±0.0150)	0.027 (±0.0053)
Total fibre[b]	80.0 (±20.50)	na	na	87.4 (±5.68)
Insoluble fibre[b]	77.5 (±13.99)	na	na	86.3 (±8.17)
Soluble fibre[b]	22.5 (±8.00)	na	na	13.7 (±3.4)

$n = 6$
na = Not analyzed.
[a]Corrected for moisture content.
[b]Corrected for moisture and ash content.

Table 4. Cationic profile of the gum kondagogu and karaya

Mineral[a] (μg g^{-1} gum)	Kondagogu grades			Karaya grade I
	KG I	KG II	KG III	
Aluminium	22.0 (±9.83)	77.5 (±21.00)	55.4 (±5.97)	29.1 (±4.38)
Calcium[b]	20093 (±1964)	17580 (±1002)	21095 (±3013)	11615 (±1938)
Cadmium	nd	nd	nd	nd
Cobalt	1.7 (±0.530)	1.8 (±0.126)	1.6 (±0.350)	1.5 (±0.386)
Copper	11.0 (±4.86)	8.4 (±0.37)	11.4 (±0.14)	7.2 (±0.33)
Chromium	2.6 (±0.17)	1.8 (±0.33)	1.5 (±0.32)	1.3 (±0.69)
Iron	25.0 (±4.89)	71.6 (±9.35)	35.6 (±3.78)	41.4 (±4.35)
Potassium[b]	13739 (±1394)	17086 (±1606)	11768 (±765)	6353 (±1319)
Lead	nd	nd	nd	nd
Mercury	nd	nd	nd	nd
Manganese	78.6 (±6.80)	146 (±5.18)	77.0 (±6.90)	138 (±6.52)
Magnesium	150 (±41.97)	127 (±46.07)	177 (±28.95)	131 (±39.03)
Nickel	4.0 (±1.35)	3.0 (±0.26)	3.7 (±0.38)	2.7 (±1.35)
Sodium[b]	2896 (±360)	3377 (±402)	2481 (±307)	2055 (±84)
Zinc	2.8 (±0.43)	3.1 (±1.16)	3.2 (±1.73)	9.1 (±3.29)

$n = 6$;
[a]Corrected for moisture content.
[b]Estimated by Flame Photometry;
nd = Not detected.

significant differing factor between the two gums. Previously, it has been emphasised that the proteinaceous components remain central to the understanding of gum properties, tertiary structure and biosynthesis of complex gum molecules (Anderson *et al*., 1985). Present investigations suggest that protein content could be one of the analytical parameters which could be used to differentiate between *Sterculia* and *Cochlospermum* sp. gums.

The tannin content of gum karaya has been analysed for the first time (Table 3). It was observed that the tannin content of gum karaya (0.027%) is less than that of gum kondagogu (0.073%). Further, the tannin content also varied with the grades of gum kondagogu, Grades II and III contain more tannin than Grade I, possibly indicating the gum quality. The tannin content can be used as one of the biochemical parameters to check the quality of the gum kondagogu for grading and also to differentiate it from gum karaya.

Further, these gums also differ in composition in terms of type and quantity of fibre (Table 3). The total fibre contents of karaya and kondagogu were found to be 87 and 80%, respectively. The soluble and insolble fibre contents of karaya were found to be 13.7 and 86.3%, while those of kondagogu were 22.5 and 77.5%. This difference gives an indication of the underlying structural differences between the two gums.

The specific rotations of the gums were observed to be in a similar range (Table 5). No difference in specific rotation was observed within the various grades of gum kondagogu. The intrinsic viscosity values of the two gums were found to be different, i.e. 728 ml g^{-1} for gum kondagogu and 960 ml g^{-1} for gum karaya, respectively. Previously, Anderson *et al*. (1982) have reported that the intrinsic viscosity values were in the range of 720–1160 ml g^{-1}, for gum karaya, which exceeds the value (550 ml g^{-1}) reported by Kubal and Gralen (1948). This difference in intrinsic viscosities could lead to considerable change between the properties and functionality of the gums, as intrinsic viscosity gives an indication of the differences in the molecular weight and space occupied in solution and therefore has implications for molecular shape. The water-binding capacity of gum kondagogu was higher than that of gum karaya (Table 5). Water-binding capacities of KG II and III were found to be higher than to KG I. This variation may be attributed to the differences in the composition of the gums, epecially the protein content. The pH of gum kondagogu ranged from 4.9–5.0 and karaya from 4.7–5.4. The present investigations show that the physico-chemical properties of gum karaya and kondagogu differ considerably with respect to intrinsic viscosity, water-binding capacity

Table 5. Physico-chemical properties of gum kondagogu and karaya

Parameter	Kondagogu grades			Karaya grade I
	KG I	KG II	KG III	
Specific rotation				
$[\alpha]_D$	+ 53.5	+ 53.5	+ 53.5	+ 58
(b,c)	(±7.37)	(±8.30)	(±8.10)	(±6.90)
Intrinsic viscosity				
[*n*]	729	na	na	968
(b,d)	(±30.19)			(±210)
pH	4.9 – 5.0	na	na	4.7 – 5.4
Water-binding capacity ml g^{-1} gum				
	35.1	48.7	47.3	29.6
	(±1.96)	(± +2.81)	(±1.36)	(±2.03)

(b) corrected for ash and moisture.
(c) in 0.2 M Ammonium hydroxide.
(d) in 0.1 M Ammonium hydroxide + 1.0 M Sodium chloride.
n = 6.
na = not analysed.

and pH, thereby influencing the utility of the gums for food applications.

The TLC analysis which is one of the identification tests for gum constituents, recommended by FAO (FAO, 1991) revealed the presence of galactose, rhamnose, and uronic acid. Aspinall *et al.* (1965) reported that gum kondagogu and karaya, on partial acid hydrolysis, yielded similar profiles of oligosaccharides, although the individual components of the mixtures were not separated. The presence of galactose, rhamnose, galacturonic acid and glucuronic acid residues was also established, and showed that the gums probably differ with respect to the proportions of the constituent sugars. In the present study, the gas chromatographic analysis of gum kondagogu revealed the basic constituents of the polysaccharide to be arabinose, galactose, rhamnose, galacturonic acid and glucuronic acid (Table 6) as reported earlier (Aspinall *et al.*, 1962). Though the basic sugar components were similar in both the gums, the proportions of the constituent sugars were found to be different. In gum kondagogu, the uronic acid content was 63% while the neutral sugars content was 37%. However, in gum karaya the major constituents were neutral sugars (69%), the uronic acid content being 31% (Anderson *et al.* 1982). The significant difference was the presence of 36% glucuronic acid in gum kondagogu which was found to be very high as compared to karaya gum (3–12%) (Anderson *et al.*, 1982). The galacturonic acid content of gum kondagogu was found to be 27%, while that of karaya ranged from 15–28% (Anderson *et al.*, 1982). The neutral sugar composition of gum kondagogu included rhamnose (19%), galactose (16%) and traces of arabinose (0.5%), while the contents of rhamnose and galactose in karaya were higher and ranged 30–36% and 33–42%, respectively (Anderson *et al.*, 1982). The present investigation clearly illuminates the important difference between gums kondagogu and karaya, with respect to the content of uronic acids, especially the glucuronic acid. Possibly the variation in the glucuronic acid content of gum kondagogu may influence its functional behaviour and properties as compared to karaya gum. Thus, the potential of gum kondagogu as a food additive needs to be explored.

With regard to identity and quality considerations, gum kondagogu can be differentiated from gum karaya, by the analytical characteristics. Our present study reveals that differences do exist between these gums with respect to uronic acid content, protein, fibre and tannin content and also intrinsic viscosity, pH, water-binding capacity. These parameters could be important in establishing an independent identity for the gum kondagogu.

Table 6. Percent sugar composition of gum kondagogu

Gum (lot)	Percent				
	Arabinose	Rhamnose	Galactose	Galacturonic acid	Glucuronic acid
1	0.74	19.3	1.20	23.9	44.8
2	0.35	20.8	11.9	24.3	42.6
3	0.91	22.5	17.6	29.0	30.0
4	0.016	20.2	18.0	28.4	33.4
5	0.95	18.9	19.8	26.4	34.0
6	0.041	16.1	20.4	28.9	34.2
Mean ± SD	0.5	19.6	16.5	26.8	36.5
	(±0.42)	(±2.12)	(±3.96)	(±2.31)	(± +5.82)

Though the use of gum from *Cochlospermum gossypium* has been permitted under the international regulatory system, toxicological safety evaluation has not yet been reported for its food applications.

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