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Physicochemical Characterization of Gum Exuded From Prosopis Cineraria and Prosopis Glandulosa Species of Thar Desert Pakistan

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Abstract: *Prosopis cineraria and prosopis glandulosa torryana wildly growing trees in Thar Desert Pakistan exude gum in appreciable quantities. The climatic conditions of desert catalyze gum exudation from trees and may affect their quality characteristics. No research work has been carried out to characterize these valuable gums and evaluate their potential for commercial exploitation. In the present study 135 samples (16kg) of P.glandulosa gum and 87 samples (9kg) of P.cineraria gum were collected and studied for their physicochemical properties. P. cineraria gum was sorted in three classes as amber, light yellow having dull luster and transparent golden yellow shades. P.glandulosa gum samples were sorted as dark brown and light brown samples. Among the physicochemical characteristics studied, moisture content of all classes of gums varied between 8-14%, ash 3-9%, protein 10 -21%, insoluble matter 0.8 - 1.9%, and the tannin content of transparent golden yellow samples of p.cineraria gum as 0.3-0.6%. The tannin content p. glandulosa was found to be fairly high making it unsuitable substitute of gum for food applications. All the samples were found to be dextrorotary and showed lower pH values. The intrinsic viscosity of gum samples ranged between 10.6-13.6 ml/g and the values were used to calculate viscosity average molecular weight of gum samples. All the samples were found to be rich in amino acid content having Hydroxyproline between 300-380, tyrosine 270-326, aspartic acid 170-210, and serine 170-195 residues per 10000 residues. Cationic composition of ash of gum samples revealed calcium magnesium sodium and potassium as major cations whereas no presence of toxic metals lead cadmium and mercury was detected. Comparative assessment of data indicated that P.cineraria gum was of better quality as compared to that of P. glandulosa and that the application of classification procedure has marked effect on gum quality and potential to make p. cineraria gum as suitable substitute of gum arabic.*

Key words: *Chemical characterization, Prosopis gum, prosopis glandulosa, prosopis cineraria.*

I. Introduction

Several species of Acacia fabaceae, Astragallus fabaceae, Stercula malvaceau, and Prospis fabaceae exude gums respectively known as gum Arabic, gum tragacanth, gum karaya, and mesquite gum having wide variety of applications in food, adhesives, medical, cosmetic, and biotechnological industries. A number of other plants also exude gums which because of their poor quality or availability in lesser amounts have not attained level of industrial importance [1, 2]. Among the naturally exuded gums, the gum Arabic is probably the most studied gum having widest range of applications than gum tragacanth gum karaya gum talha and mesquite gum [3]. Due to lack of dependable supplies in world market and continuous price hike increasing emphasis is being placed on research and development of substitutes of gum Arabic [4]. The leguminous prospis species such as p.glandulosa, p.valutina, p.juliflora ,p. cineraria and others exude gum from their main trunk and branches in the way similar to acacia species, and their gum is popularly known as mesquite. Although majority of prosopis species are known to be natives of Americas but the plants have now been spread to one third part of earth's surface in view of their enhanced adaptability, low water requirements, potential to combat deforestation, and land degradation. The mesquite gum has been known since ancient times and has remained integral part of latin American and parts of united states cultures [5]. It is water soluble gum and shares several functional properties with gum Arabic. Chemically it is arabinogalactan protein having capability to form compact globular structure in solution and acting as emulsifier and stabilizer like gum Arabic [6]. The mesquite gum is not recommended as food additive due to its higher tannin content [7]. Though it has received scant attention in the past but recent reports indicate that it is better emulsifier than gum Arabic and it has prospects for use as food additive if processed for removal of tannins [8].

Thar desert is part of great Indian tropical desert with an approximate area of 14000 square miles It is located between 240 and 27, north latitude and 690 and 72, east longitudes occupying south east corner of

Pakistan. The climate of desert is generally dry and very hot during summer months (max temp 510C) and receives annual monsoon rainfall 120mm to 206 mm. The precipitation pattern is characterized by cyclic fluctuations resulting in recurrence of longer spells of drought prevailing for two to four years. The desert witnesses extensive vegetation during the monsoon season in addition of being habitat of number of plants like cactus, prosopis cinerararia, azadirachta indica, tocomella undulate, salvadora oleoides ,albezia labbeck, acacia Senegal, ziziphus mauritiani. A large number of shrubs also grow which local inhabitants use for variety of purposes. p.glandulosa Torreyana, is a native of Americas [9] and exotic to Pakistan. It is widely distributed throughout the desert in the form of dense healthy plants of sizes up to three meters. Prosopis cineraria is a native of tropical Indian desert and grows wildly attaining heights up to eight meters. Both of these prosopis species are very well adopted to hot and dry climate of Thar Desert exuding gum in fairly good quantities in addition to serving as source of fodder, fuel, timber and vegetables for local people [10].

The quality and yield of exudate gums is known to be function of age of trees, place of exudation, tapping intensity, variety of species, and their origin. Moreover the soil characteristics and weather systems in which plants sustain their life have also effect on gum characteristics [11-13]. The gum characteristics of prosopis species particularly that of p.glandulosa Torreyana growing in sandy soil of Thar desert and thriving in hot and dry weather were observed to be different from those growing in alluvial plains. Similarly gum yielded by p. cineraria was observed to be sold in market in three grades and used in several food preparations. To the best of our knowledge no previous studies have been reported on the gum samples of prosopis species from this area therefore an investigation was carried out to study the quality these gums. In this paper we report the physicochemical properties of gums of p. cineraria, and p. glandulosa Torreyana and their comparisons, dependence of physicochemical properties on the different grades of gums exuded by prosopis cineraria, and a comparative study of the properties of gum samples exuded by p.glandulosa growing in sandy soils of Thar desert and those growing elsewhere in alluvial plains of sindh province Pakistan.

II. Materials And Methods

Sampling

Desert area was surveyed extensively for p.glandulosa and 135 samples of naturally exuded gums were collected from well grown healthy plants. For comparison purposes equal number of samples was also collected from plants growing in alluvial plains of sindh province. The gum samples of p. cineraria were collected from trunk and branches of healthy trees and samples sorted visually according to color at the time of collection.

Classification

p. cineraria, gum samples were classified according to visual identification of different shades of yellow colors at the time of sampling. The exuded gums in three shades namely, golden yellow (A), light yellow having dull luster (B) and Amber (C) were identified and samples sorted accordingly. p.glandulosa brown gum from desert plants was found to be of lighter intensity than that of the plants of river water fed alluvial soils. All samples were stored separately in glass containers after removal of pieces of bark and other visible impurities. The samples were then grinded using high speed grinder to obtain powders of approximately uniform size.

III. Physicochemical Analysis

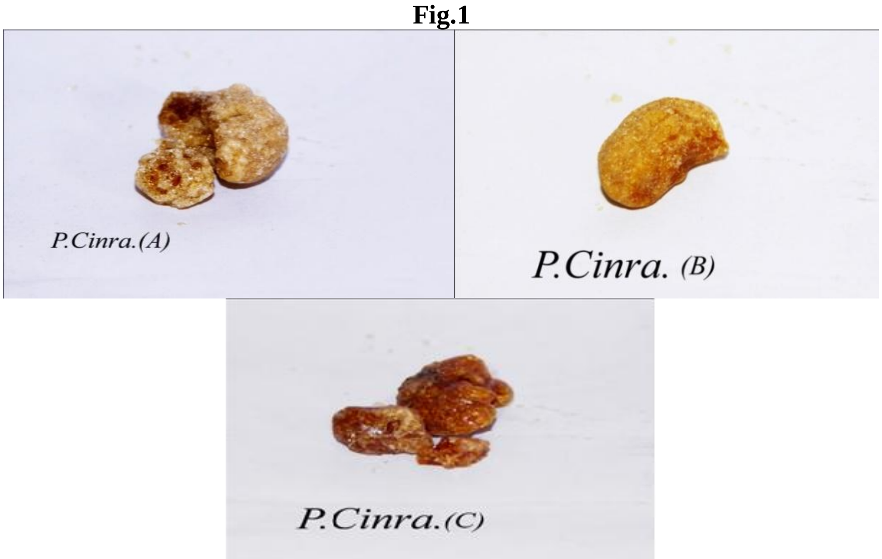
Moisture content of samples was determined by weighing 10 g of samples in pre weighed porcelain dishes and left to dry in oven for five hours, cooled and reweighed. The samples were again heated for an hour at the same temperature and any changes in weight noted. The moisture content was calculated using relationship based on ratio of the weight of sample to that of the weight difference calculated before and after heating of the sample. The ash content was calculated by heating the sample in muffle furnace to dull redness at 8500C in crucibles. The ash content was calculated from the ratio of net weight of residue and weight of the sample. Insoluble matter was determined by preparing 10 % (w/w) gum solutions and filtering them using whatman no 45 filter papers. Pre weighed filter papers were then dried in the oven and reweighed. The differences in weights were then used to calculate the % content of insoluble matter. Viscosity measurements were carried out using Ubbelohde viscometer on 2% gum solutions prepared in 0.1 N NaCl. Viscosity average molecular weight of gum samples was calculated from intrinsic viscosity by Mark-Houwinkk-Sakurada equation using value of constant $K = 1.47X10^{-2}$ and $\alpha = 0.50$ as reported in the literature for mesquite gum [5, 14]. Total nitrogen was determined by Kjeldahl method (Grimshaw et al 1989 and protein content calculated from total nitrogen using conversion factor 6.53. The tannin content was studied using method recommended by Box [15]. The method is based on the formation of tannic acid from the reaction between tannin extracted from gum the sample and Dennis Folin reagent. (50 gm sodium tungstate + 10 g of phosphomolybdic acid + 25 ml of orthophosphoric acid). The amount of tannic acid produced from the reaction is directly read from calibration curve of suitable tannic acid standards at 760 nm using UV-Visible spectrophotometer. Amino acid analysis was carried out on Hittachi, amino acid analyzer equipped with chromatointegrator 2500 as per procedure recommended by manufacturers. The cationic composition of gum samples was studied by atomic absorption spectrometry using standard methods recommended for the analysis of respective metallic elements. PH was measured on Orion PH meter using 10% (w/w) gum solutions. The specific Optical rotation of all the gum samples was measured using 10% (w/w) gum solutions in Optica Pol-1 Polarimeter using cells of 10 cm length and the glucouronic acid content determined by carbazole method [16].

IV. Results And Discussion

Hot and dry weather scant rainfall and sandy soil offers ideal conditions for gum exuding plants to thrive and enhance their gum production capabilities. P.cineraria a native species of Thar desert and p. glandulosa torryana an exotic of Americas have adopted very well to these weather conditions and exude gums in appreciable quantities. It is also known that both the quality and quantity of gums depend on number of factors including botanical origin, nature of climate, type of soil and characteristics of trees [14, 17, 18], therefore it is reasonable to expect the gums of these prospis species to have unique characteristics.

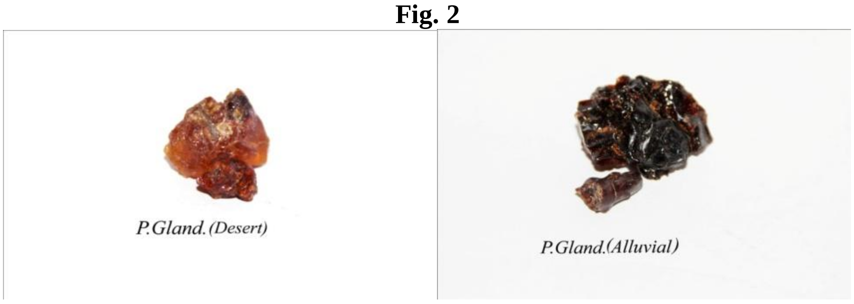
In the present study the naturally exuded gum samples collected from p.cineraria in three grades followed the definite pattern of quality and yields. Among the samples graded according to shades of yellow color the amber gum exuded along the main trunk of trees up to the height of 8 to 10 feet. It exuded in the form of striations characterized by presence of small warts. The other two grades identified as golden yellow (A), and light yellow having dull luster (B) exuded on the branches of trees in the form of distinct nodules of sizes equal to or greater than 2.5 cm. generally a tree of age more than 20 years was found to yield less than 250 grams of gum A, 200-400 grams of gum B and 350-660 grams of gum C as shown in Fig. 1

Fig.1



in the months of May and June of the year. The yield of light brown gum exuded by p.glandulosa growing in sandy soil of Thar desert varied between 500-700 grams but the same species growing in alluvial plains exuded dark brown gum in the yield between 100-250 grams as shown in Fig. 2.

Fig. 2



This finding is in agreement with the earlier reports where by yield and quality of acacia gums were found to depend on types of soil [12,18]. Quantitatively these yields are also in fair agreement with the amounts of unsorted gums exuded by south American prosopis species [19].

The results of physicochemical studies of gum samples are listed in table 1. It may be seen that among the three classes of p.cineraria gum, class A and B were found to have lower ash content than the class C samples. This might probably be due to place of exudation of gum on trees. The class C samples exuded along main trunk of trees, being close to surface of soil (5-7 ft high) where rough winds carrying dust and fine particulate matter might come in contact of exuding gum and deposits invariably. The similar effects could also be responsible for high ash values of p.glandulosa gums whose place of exudation on trees was as high as three to four feet above the ground level. The content of insoluble matter also followed similar pattern resulting in very small values for P. cineraria gums A and B and relatively higher values for rest of the gum samples. The samples of insoluble matter when examined under microscope revealed presence of bark pieces as main components followed by sand particles and tiny insects. However it is possible to reduce the content of insoluble matter if gum samples are subjected to classification. Thus the moisture content of all the samples and insoluble residue contents of P. cineraria gums A and B were found to be within the FAO recommended limits set for gum Arabic [20]. The data also reveals the dependence of quality of gum on careful sorting of samples and support the recent findings reported in the literature [5]. The protein content was calculated from determined nitrogen values by applying conversion factor 6.53 reported for mesquite and other gums. The respective values of gums studied in the present work are similar to nitrogen contents reported for of the mesquite gum from other prospis species [5, 21, 22] but appear to be higher than the respective values reported for the gum Arabic [3, 23]. The Nitrogen and protein content gum samples studied in this work were not found to depend on the nature and quantity of impurities as reported in the case of some other mesquite gums [5], conversely the type and age of species seemed to affect the nitrogen content of gum. P. cineraria gums had higher nitrogen content than p. glandulosa and the age of former species is also far higher than the latter species. Moreover it may also be due to the fact that p. cineraria has inherent ability to fix atmospheric nitrogen whereby its nitrogen content of gum is enhanced [10]. The PH value of the 10% gum solutions indicated fair degree of acidity present in all classes of the gums with p. cineraria gum having values very close to those reported for gum Arabic [24] but p. glandulosa samples exhibited lower acidity. In general PH values of p.cineraria gum classified samples followed the order A < B < C and that of P. glandulosa samples as Alluvial lesser than desert.

(Table 1). It has been reported [5, 7] that glucouronic acid content and PH of gums are directly related therefore gum Arabic having glucouronic acid content 15 – 16 % is more acidic than gum mesquite which has respective acid content as low as 5- 7 % .The glucouronic acid content of p. cineraria and p. glandulosa gums is given in table 1. It may be seen that glucouronic acid content of p. cineraria samples does not approach to the respective values reported for gum Arabic despite of having PH values very close to its 10% solutions. The glucouronic acid values of p. glandulosa gum on the other hand are consistent with its PH values.

Table 1 Comparative Account Of Physicochemical Properties Of Prosopis Species P. Cineraria And P. Glandulosa From Thar Desert Pakistan

Property	P. Cineraria gum			P. Glandulosa gum	
	A	B	C	Alluvial	Desert
Moisture %	8 ± 1.5	6.2 ± 1.4	6.8 ±1.8	10.3 ± 2.1	14.0 ± 1.8
Ash %	3.1 ± 0.15	2.6 ± 0.12	6.8 ± 0.1	9.3 ± 0.12	6.5 ± 0.21
N_2 %	2.2 ± 0.03	3.2 ± 0.01	3.2 ± 0.05	1.1 ± 0.02	1.54 ± 0.02
Proteins %	14.36 ± 0.09	20.89 ± 0.15	20.89 ± 0.07	7.18 ± 0.18	10.05 ± 0.13
pH	4.0 ± 0.012	4.3 ± 0.011	4.5 ± 0.014	5.3± 0.011	5.6 ± 0.014
η(ml/g)	13.6 ± 0.018	13.2 ± 0.1	13.0 ± 0.02	11.8 ±0.02	10.6 ± 0.03
M v($x10^5$)	6.12	5.96	5.87	6.14	5.52
$[\propto]_D^{20}$	+84.36	+85.35	+75.0	+71.32	+73.25
Tannin %	0.32 ± 0.02	0.48 ± 0.04	0.63 ± 0.02	1.7 ± 0.04	1.9 ± 0.06
Insoluble matter %	0.81 ± 0.016	0.72 ± 0.021	1.32 ± 0.026	1.74 ± 0.015	1.89 ± 0.018
Glucouronic acid %	11.3 ± 0.23	10.1 ± 0.34	12.5 ± 28	6.2 ± 0.22	7.1 ± 0.18

The positive optical rotation data indicated some degree of heterogeneity present within the sorted classes of gums of both the species. P. cineraria samples presented interesting features in terms of having identical specific rotation values of class A and Class B samples but showed lower values for class C samples.

It has been reported that in natural gums the chiral centers of their polysachharide fractions and peptidic linkages determine the value of optical rotation [5] therefore any variation in their optical rotation values of may reflect the extent of changes in chemical constitution. It is therefore likely that P cineraria gum samples A and B exuding on branches of trees are of slightly different constitution as compared to samples C exuding on main trunk of trees. No such differences optical rotation values were noted in the case of p. glandulosa gum classes and that their values were comparable to class C p. cineraria gum samples. It has also been suggested that higher dextrorotatory values reflect higher gum quality therefore it is concluded that p. cineraria gums A and B are of better quality as compared to p. glandulosa gums.

The results of intrinsic viscosity [ɳ] are also shown in Table 1. The results obtained in case of p. glandulosa gums are similar to those reported for mesquite gums from other prosopis species but the respective values in the case of p. cineraria gums are slightly higher. It has been suggested that the intrinsic viscosity values depend on the size of macromolecular species in solution and that these species are of relatively lower size in mesquite gum than gum Arabic therefore in the case of present studies it can also be concluded that macromolecular species in p. glandulosa gum solutions are of relatively smaller sizes than those of p. cineraria gums. The viscosity average molecular weight calculated by mark-Houwinkk-Sakurada equation using K= 1.47X10-2 and $\alpha = 0.50$ reported for mesquite gum, show that the values obtained in the case of p. glandulosa gum are higher than those reported for mesquite gums in literature [7, 25] and that in the case of p. cineraria gums these values approach to the values of gum Arabic. Thus variations exist in the intrinsic viscosity and related parameters in the case of gum exuded by prosopis species as in the case of gum Arabic exuded by acacia fabaceae species [18, 20].

The presence of tannins in prosopis gums has been one of the major obstacles in the commercialization of these natural exudates. As in the case of other prosopis species the gum samples of p. cineraria and p. glandulosa were also found to contain tannins. The percentage content of these undesirable constituents was lower in class A and B p. cineraria samples but fairly high in class C and in both of the p. glandulosa samples (Table 1). During sampling it was observed that gum samples of p. cineraria classified as samples A and B exuded as clear nodules with minimum contact with tree barks and had low tannin content compared to Class C samples which exuded in the form striations located between and underneath the barks. The barks of p. cineraria contain tannins in appreciable quantities [10] therefore it is likely that some proportion of tannins in gum samples originate from the tree barks. It is therefore worthwhile that classification and sorting techniques are applied to get samples of low tannin content and pave way for commercialization of prosopis gums [5].

The amino acid profile of the gum samples is shown in Table 2. It may be noted that there are significant differences in the nature and content of amino acids in two species. In comparison with p. cineraria gums the P. glandulosa gums are found to be rich in Arganine, Alanine, Hydroxyproline, lucine, serine, tyrosine and threonine where as p. cineraria gum samples resulted to be rich in Aspartic acid, Glutamic acid, Histidine, and phenylalanine. In addition to this the residues per 10,000 residues of glycine and lycine were found to be comparable in gum samples of both of species. In general the predominant amino acids in both of the gum samples of prosopis species followed the order as Hydroxyproline > Tyrosine > Aspartic acid > Serine. These results differ from the amino acid profiles of commercial mesquite gum samples which were reported be rich in serine, aspartic acid and valanine.(Lopez-Franco et al 2011) but the quantitative profiles of amino acids are consistent with the respective nitrogen content of gum samples. More data is however required to clearly define the ranges of amino acid content of gum yielding prosopis species as has been done in the case acacia gums [17, 26-28].

Table 2 Amino Acid Composition (Residues Per 10000 Residues) Of Gum Samples Of Prosopis Species, P. Cineraria And P. Glandulosa Of Thar Desert Pakistan

Amino acid	P. Cineraria gum			P. Glandulosa gum	
	A	B	C	Alluvial	Desert
Arginine	28	36	40	55	45
Alanine	48	50	58	65	70
Aspartic acid	210	207	190	180	170
Glutamic acid	72	67	67	50	55
Glycine	73	65	60	73	62
Hydroxylamine	300	330	338	360	380
Histidine	70	72	65	45	40
Lysine	59	52	48	40	52
Leucine	48	48	45	65	55
Methionine	ND	ND	38	12	24
Phenylalanine	33	38	38	15	98
Serine	170	160	160	190	195
Tyrosine	270	279	263	315	326
Threonine	80	86	75	90	110

The gum samples were also studied for their cationic composition and presence of toxic metals. The results shown in Table 3 reveal that both of gums have sodium potassium calcium and magnesium in predominant concentration and comparatively p. cineraria gum has higher content of calcium magnesium and potassium ions than p. glandulosa. Moreover the copper iron and aluminium content of gums of both the species is comparable and independent of any classes. The presence of any of the toxic metals lead cadmium and mercury was not detected and the data is consistent with cationic composition of gum Arabic [14].

Table 3 Cationic Composition (Ppm) Of Gum Ash Samples Of P. Cineraria And P. Glandulosa Species Of Thar Desert Pakistan.

Species	Cu	Fe	Mn	Al	Ca	Mg	Na	K
p. cineraria	40	112	30	15	120000	45000	3600	170000
P. glandulosa	36	168	62	20	116000	31000	4200	155000

V. Conclusions

The hot and dry weather of thar desert offers ideal conditions for prosopis species to exude gums of varying quality in fairly reasonable quantities. P. cineraria gums have high potential for use as food additives provided samples are classified carefully. Quality wise P. cineraria gum is better than P. glandulosa gums as the former has low tannin, ash, moisture and insoluble matter content. P. glandulosa gum samples bear some difference in their color with regard to its origin making it easier to identify the area from where gum samples belonged, but do not exhibit any significant changes In their chemical composition. It is also concluded that as with gum Arabic the prosopis gums should also be subjected to the application of classification and sorting procedures in order to utilize maximum quantities of these natural exudates of wildly growing plants.

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