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Assessment of physical and structural characteristics of almond gum

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ABSTRACT

Almond gum was investigated for its physical and structural characteristics in comparison to gum arabic. Among physical properties, bulk density was found to be 0.600 ± 0.12 g/mL and 0.502 ± 0.20 g/mL for almond and gum arabic respectively. Almond gum (0.820 ± 0.13 g/mL) displayed the maximum value for tapped density. Compressibility index of exudate gum powders varied from 26.79 ± 1.47 to 37.46 ± 0.50% and follow the order gum arabic > almond gum. Almond gum demonstrated good flow characteristics when compared to gum arabic. True density showed significant difference ($p < 0.05$) among the exudate samples and it was recorded higher for gum arabic. The maximum value of porosity recorded in case of gum arabic indicates the presence of large number of interstitial spaces among its particles. Almond gum had fair flow character while good for the other exudate gum powder. Almond gum had relatively higher mineral content than gum arabic. The oil holding capacity of exudate gums varied from 0.87 ± 0.05 to 0.92 ± 0.02 g/g. Exudate powder samples were found to lie in the first quadrant of the hue angle (0–90°) corresponding to the range of reddish–purple to yellow. The absence of peaks in the X-ray diffractograms of exudate samples reflects their amorphous nature. SEM micrographs revealed a lot of variability in shape and size of the exudate particles.

1. Introduction

A large number of plant gum exudates have been discovered in the last few decades. The typical examples of this category include gum arabic, gum ghatti, gum karaya and tragacanth gum. These natural gums, secreted by trees and shrubs, solidify upon exposure to air and heat of the sun which hardens them into different shapes including tears, semisolid nodules and lumps. Phenomenon of exudation does not happen in normal trees. However, it is an absolute response against the stimuli of changing external environment. Exudate gums are produced in response to biotic and abiotic stressors like infection, insect attack, and mechanical or chemical injury and such phenomena of exudation are known as gummosis [1]. These exudates are therefore produced as a result of defence to seal wounds, site of infection or injury of a tree. Gum yield is influenced by various controlling factors such as tapping intensity, rainfall, and temperature. Ballal et al. [2] found positive correlation of yield with tapping intensity, rainfall and the minimum and maximum temperatures at tapping time, and negative correlation with tapping time and the minimum and maximum temperatures at gum collection. Gum production increases at high temperatures and limited moisture [3]. Yields can be increased by making incisions in the bark or stripping it from the tree or shrub [4]. Vilela and Ravetta [5] reported increased exudation from the wounded trees of genus *Prosopis* (*P. chilensisand P. nigra*) during late summers. It is evident from earlier studies that exudate gums are safe for human consumption as being used as pharmaceutical substances or as food additives in addition to other industrial uses [6–8]. They vary in their physicochemical and functional properties to a great deal which is due to source specificity and most importantly governed by discrepancy of agro-climatic conditions.

Physical properties like bulk density, tapped density, porosity, wettability, particle size and their distribution are the indicators that determine the quality of powders [9]. These also affect their functionality. Reducing food substances to desirable particle sizes are primarily important for mixing two different food ingredients for formulating a uniformly blended finished food product. Any difference in the particle size of ingredients may result in their improper mixing due to weight discrepancy leading to non-uniform (defective) finished product. Therefore, the knowledge of density and its related properties will be instrumental in the successful development of food formulations involving exudate gums as ingredients.

Almond (*Prunus dulcis*), native to central Asia (Iran, India and Pakistan), belongs to rosaceae family [3]. In India, it is usually cultivated for its nut production or as an ornamental plant.

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It is commonly known as Badam in Indian subcontinent and spatially distributed in the states of Jammu and Kashmir and Himachal Pradesh. Natural polysaccharides are known to possess anti-cancerous [10,11], antioxidant and anti-inflammatory properties [12–14]. Therefore, a growing quest is developing among food scientists for new sources of biopolymers to be used in food industry. In this direction, almond gum has been identified as a novel gum, an exudate collected from trunk, branches and fruits of almond tree that could be utilized in food and allied industries on a large scale. Ethylene or ethylene-releasing compounds such as ethephon (2-chloroethyl-dioxido-oxophosphorane) stimulate gum formation [15] in trees and fruits of stone-fruit species of the *Rosaceae* family, such as almonds [16]. Almond gum has received less attention in India, resulting in total wastage of this exudate. The state can produce sizeable quantities of this gum which could accomplish to broaden the spectrum of its use in food products. This natural polysachharide is almost colourless, odourless and non-toxic which may qualify it as an additive in wide variety of food systems. Almond gum is a natural polymer composed, on dry weight basis, of proteins (2.45%), fats (0.85%) and carbohydrates (92.36%). Carbohydrates comprise of arabinose (46.83%), galactose (35.49%) and uronic acid (5.97%) with traces of rhamnose, mannose and glucose [6]. The gum exudate is also a rich source of various minerals including sodium, potassium, magnesium, calcium and iron [17]. It is a better emulsifier than gum arabic [18] and a proven antioxidant and antimicrobial source capable of enhancing biological and functional properties in diverse food formulations [19]. Growing demand for exudate gums has prompted us towards the discovery of new exudate gums that could substitute the major exudates in diverse food applications with better functional properties than the existing ones. The selection of an exudate gum as a food additive will be determined by its physicochemical characteristics and interaction with water [20,21]. To our knowledge there is no such report available on exudate from almond tree. Therefore, the aim of the present study was to evaluate the physical and structural characteristics of almond gum exudate in comparison to gum arabic.

2. Materials and methods

2.1. Materials

Almond gum nodules were collected afresh by hand-picking from different almond trees (*Prunus dulcis*) in Budgam, Jammu and Kashmir, India during the month of August 2015. Gum arabic (*Acacia senegal*) was obtained from Himedia Mumbai, India.

2.2. Sample preparation

The exudate gums were dried in hot air oven at 65 °C. The dried gum was milled to fine powder. The powdered gum exudate (almond or arabic) was mixed with deionized water and gently stirred overnight on a magnetic stirrer for complete hydration of the gum. Insoluble mass including hydrogel obtained post hydration was separated by filtration using Whatman No.1 filter paper and the filtrate was oven dried at 65 °C. The dried gum was milled and passed through sieve no. 100 and stored in dessicator for further analysis.

2.3. Physicochemical properties

2.3.1. Determination of angle of repose

Angle of repose (θ) was measured using a fixed height funnel fitted at the height of 10 cm from the base (the funnel is 60°, 10 cm in diameter, 0.7 cm internal stem diameter with 9.6 cm stem length). 20 g of the powder was allowed to flow through the funnel into the base and a pile was formed at the base. The angle of repose was then calculated as follows:

$$Angle\ of\ repose(\theta) = Tan^{-1}(\frac{h}{r}) \quad (1)$$

where *h* and *r* are the height and radius of the pile, respectively.

2.3.2. Compressibility index

The compressibility index of exudate gum was determined according to Carr's Index after determining bulk and tapped densities. 20 g of the dried gum was taken into 50 mL graduated measuring cylinder and the initial volume (V_0) was recorded. The cylinder was then tapped 100 times using bulk density apparatus (ACM-157, Acmus Technocracy, New Delhi) to achieve a final volume (V_f). The bulk density was calculated from the initial volume and tapped density from the final volume after hundred tappings. Carr's Index was then determined by the following equation [22].

$$carr's\ index = \frac{Tapped\ density - Bulk\ density}{Tapped\ density} \times 100 \quad (2)$$

2.3.3. Hausner ratio

Hausner ratio measures cohesiveness of the exudate gum powder. It was calculated using the measured values of bulk density and tapped density as per the following equation.

$$Hausner\ ratio = \frac{Tapped\ density}{Bulk\ density} \quad (3)$$

2.3.4. True density

True density of exudate samples was measured using the method as suggested by Santhalakshmy et al. [23]. Briefly, 1 g of dried powder sample was transferred into a 10 mL measuring cylinder with a glass stopper. A total of 5 mL of petroleum ether was then added to this sample and shaken for some time so that all the particles were suspended. Finally, the wall of the cylinder was rinsed with 1 mL of petroleum ether and the total volume of the petroleum ether and suspended particles were read. The powder density was calculated as follows:

$$True\ density = \frac{Weight\ of\ the\ powder\,(g)}{Total\ volume\ of\ petroleum\ ether\ and\ suspended\ particles\,(mL) - 6} \quad (4)$$

2.3.5. Porosity

Porosity was determined from the measured values of true density and tapped density as given by the following formula.

$$Porosity\,(\%) = \frac{True\ density - Tapped\ density}{True\ density} \times 100 \quad (5)$$

2.3.6. Moisture content

Moisture content was expressed as percentage weight loss on drying (% LOD). 2 g of ground gum sample was weighed and oven dried at 105 °C for 5 h to a constant weight. The experiment was done in triplicate. The percent loss on drying was then calculated as follows Rankell et al. [24]:

$$\%\ loss\ on\ drying = \frac{weight\ of\ water\ in\ sample}{total\ weight\ of\ dried\ sample} \times 100 \quad (6)$$

2.3.7. Determination of protein, fat and carbohydrate

The protein and fat content was analysed for exudate gums using AOAC standard methods [25]. Carbohydrate was calculated by difference as given by Balaghi et al. [26].