Proceedings of the Pakistan Academy of Sciences: B
Life and Environmental Sciences 62(3): 239-248 (2025)

ISSN (Print): 2518-4261; ISSN (Online): 2518-427X
http://doi.org/10.53560/PPASB(62-3)1111

Pakistan Academy of Sciences

Research Article

Nutritional Evaluation of Gum Arabic and Its Food Products Locally Prepared in Tharparkar, Sindh, Pakistan

Pawan Kumar[1], Aijaz Hussain Soomro[1], Asadullah Marri[1], Omer Mukhtar Tarar[2], Nida Shaikh[1], Asif Irshad[3*], Allah Bux Baloch[1], and Muhammad Dawood[1]

[1]Institute of Food Sciences and Technology, Sindh Agriculture University, Tandojam, Hyderabad, Pakistan

[2]Food and Marine Resources Research Centre, Pakistan Council of Scientific & Industrial Research (PCSIR), Laboratories Complex, Karachi, 75280, Pakistan

[3]Department of Food Preservation, Technical Wing of Colleges, Higher & Technical Education Department, Balochistan, Pakistan

Abstract: Gum Arabic is an edible, dried, gummy exudate extracted from the stems and branches of *Acacia Senegal*. It is commonly used in the pharmaceutical and food industries as an emulsifier and stabilizer agent. The present study assessed the nutritional composition of gum Arabic (T_1) and its food products, namely T_2 (Khorak) and T_3 (Gond Pak), which were locally prepared in Tharparkar, Sindh, Pakistan. Gum Arabic was sourced from the local tree *Acacia Senegal,* whereas its food products, i.e., Khorak and Gond Pak, were prepared and evaluated for proximate composition, amino acids profiling, minerals, and vitamins quantification. The observed results showed significant differences ($p \leq 0.05$) among treatments. The T_1 exhibited higher values for ash (3.17%), dietary fiber (66.10%), titratable acidity (1.5%), valine (0.30 mg/g), serine (0.68 mg/g), potassium (254.22 mg/100g), sodium (118.55 mg/100g), calcium (7976.30 mg/kg), magnesium (2061.5 mg/kg), iron (76.57 mg/kg), and thiamine (7.74 mg/100g). T_2 showed higher pH (5.47), moisture (11.61%), carbohydrate (39.25%), energy value (308.65 kcal/100g), methionine (0.02 mg/g), isoleucine (0.16 mg/g), leucine (0.68 mg/g), tyrosine (0.39 mg/g), lysine (3.35 mg/g), vitamin A (141.33 IU/100g), vitamin C (4.65 mg/100g), niacin (26.25 mg/100g), and pyridoxine (0.06 mg/100g). T_3 had higher protein (12.29%), crude fat (15.99%), aspartic acid (1.66 mg/g), threonine (0.533 mg/g), glutamic acid (4.43 mg/g), proline (0.079 mg/g), glycine (0.446 mg/g), alanine (0.443 mg/g), phenylalanine (0.54 mg/g), histidine (0.20 mg/g), tryptophan (0.92 mg/g), riboflavin (0.71 mg/100g), folate (21.97 mg/100g), and cyanocobalamin (1.17 mg/100g). Cysteine, arginine, vitamin D, E, pantothenic acid, and biotin were not detected in any treatments. The study concludes that gum Arabic and its food products are highly nutritious, suggesting their suitability for consumption in regions with prevalent malnutrition.

Keywords: Gum Arabic, Traditional Foods, Nutritional Composition, Amino Acids, Malnutrition, Tharparkar Sindh.

1. INTRODUCTION

Gum Arabic, as defined by the FAO/WHO Joint Expert Committee for Food Additives (JECFA), is a dried exudate that is extracted from the stems of *A. Senegal* Willdenow or closely related species of Acacia (family Leguminosae) [1]. Gum Arabic is obtained from the hardened secretions found on the injured stems and branches of the *Acacia Senegal* trees, which are then harvested as air-dried globules. It is a complex, branched polysaccharide. It exists as a weak acidic salt or as a neutral polymer that dissolves in water. Its low-solution viscosity, non-digestibility, and safety make it a popular emulsifier, stabilizer, and thickening agent in industrial food manufacturing. In addition to having good solubility, low viscosity, a good binding effect, and the capacity to create films, it also emulsifies well and retains volatile components in food products. In confections, it is used to stop

Received: January 2025; Revised: August 2025; Accepted: September 2025
* Corresponding Author: Asif Irshad <asifirshadbaloch@gmail.com>

sugar from crystallizing. It is used as a glaze in candies. It finds larger employment in flavor encapsulation and is utilized in bakery, dairy, and soft and alcoholic items. It acts as a clouding agent or flavoring stabilizer in alcoholic beverages [2, 3]. It is certified as a safe dietary fiber by the Food and Drug Administration (FDA) [4, 5]. It is one of the oldest and most significant industrial gums in the world, consisting of proteins, minerals, and arabinogalactan polysaccharides [6, 7]. In Pakistan, agriculture is a climate-sensitive sector. Most of the regions are facing severe water shortages along with changes in rainfall patterns, specifically in the least developed area, i.e., Tharparkar [8]. Tharparkar is an arid region located in the southeastern part of the Sindh province of Pakistan and is experiencing drought as a regular phenomenon [9]. The region of Tharparkar is blessed with a wide range of drought-tolerant crops, including *Acacias, i.e., Acacia Senegal*. The gum obtained from *Acacia Senegal* is abundantly produced in the area. The locals use it extensively for a variety of food-related and medicinal purposes. The food-related uses of gum Arabic are common among the people of Tharparkar. The people of Tharparkar prepare some traditional foods from gum Arabic, and they believe that this natural substance exerts beneficial effects on health if consumed through food products. Traditional foods are generally a combination of energetic staples with other available ingredients [10]. Traditional recipes for intermixing cultures, mixed habitation, and resources are mostly prepared from local plants and can play a vital role in community nutrition. Most people in Tharparkar use gum Arabic to prepare some traditional foods, such as Khorak and Gond Pak. The present study was conducted to evaluate the nutritional composition of gum Arabic and its locally prepared food products, i.e., Khorak and Gond Pak from Tharparkar, Sindh, Pakistan, by analyzing their proximate composition, amino acid profile, mineral, and vitamin contents, to determine their potential contribution towards improving nutrition and combating malnutrition in the region.

2. MATERIALS AND METHODS

2.1. Raw Materials

Gum Arabic was gathered from the native trees of *Acacia Senegal* of the Tharparkar district (24.8777° N, 70.2408° E). The samples of gum Arabic were kept in a glass jar and transported to the Laboratories of the Institute of Food Sciences and Technology, Sindh Agriculture University, Tandojam. For the preparation of Khorak and Gond Pak, the materials (i.e., sugar, ghee, butter, all-purpose wheat flour, coconut powder, small cardamom, almond, and black raisin) were purchased from the local market of Hyderabad city and were used to prepare the study samples.

2.2. Preparation of Samples

The gum Arabic was sorted based on its crystal clarity, washed to remove dust, air dried, ground with an electric grinder, screened using an 80-mesh sieve, collected in a clean and sterilized airtight glass jar, properly labeled, and stored until further use by following the method of Abel *et al.* [11] with minor modifications.

2.3. Preparation of Khorak and Gond Pak

The traditional food, Khorak, was prepared as per the method used by the local women of Tharparkar, Sindh. Table 1 shows the list of ingredients and their quantity used in making Khorak. For preparing Khorak, the gum Arabic was roasted in butter and cooled. On the other side, wheat flour was also roasted in butter and set aside to cool. After that, water, butter, and sugar were added to a pan and heated on a low flame to prepare a thick concentrate. Finally, roasted gum Arabic, roasted flour, ground almond, black raisin, and small cardamom were added, and the content was mixed properly. Khorak was kept in airtight glass jars, labeled, and kept under refrigeration till analysis.

Table 2 represents the list of ingredients and their quantity for preparing Gond Pak. The Gond Pak was prepared by roasting gum Arabic in butter.

Table 1. List of ingredients and their quantity used in Khorak preparation.

Ingredients	Quantity (g)
Wheat flour	200
Gum Arabic	200
Butter	200
Sugar	300
Almond	50
Black raisin	20
Small cardamom	10

Table 2. List of ingredients and their quantity used in Gond Pak preparation.

Ingredients	Quantity
Gum Arabic	400 gm
Butter	150 gm
Water	100 mL
Sugar	300 gm
Coconut powder	150 gm
Almond	50 gm
Poppy seeds	10 gm

After that, a pan containing water, butter, and sugar was placed on a low flame to prepare a concentrate. The roasted gum Arabic, coconut powder, and poppy seeds were added, and the content was mixed properly. After mixing, the content was poured into a flat plate, garnished with shredded almonds and peanuts, allowed to cool, and set. Finally, the set dessert (Gond Pak) was cut into uniform pieces using a stainless-steel knife and kept in airtight glass jars, labeled, and kept under refrigeration temperature till further analysis.

2.4. Nutritional Analysis of Gum Arabic, Khorak, and Gond Pak

2.4.1. Proximate analysis

A pH meter (Model HI, Hanna Instruments, Italy) was used to measure the pH value of the gum Arabic and its food products according to the method of AOAC [12]. Crude protein (%), moisture (%), ash (%), crude fat (%), dietary fiber (%), and titratable acidity (%) were analyzed by following the standard methods of AOAC [12].

A difference method was used to determine the samples' available carbohydrate content. The percentage of moisture, protein, fat, ash, crude, and dietary fiber was subtracted to determine the amount of carbohydrates by following the Hart and Fisher [13] method. This value was treated as a carbohydrate and was calculated using the following equation.

Carbohydrate (NFE g%) = 100 − (protein+ lipid + moisture +ash + fiber)

Energy or calorific value was calculated based on the method outlined by Paul and Southgate [14], using energy conversion factors of protein, fat, and carbohydrates in the foods. The calculation was performed using the standard conversion factors: 4 kcal/g for protein, 9 kcal/g for fat, and 3.75 kcal/g for carbohydrates.

2.4.2. Amino acid analysis

Acid hydrolysis was performed according to the procedure outlined in AOAC [12] through the Ion Exchange Chromatographic method. Food samples (100 mg) were taken in separate digestive tubes with the addition of HCl (6N; 5 mL) carrying 0.1% Phenol and kept for 18-24 hours at 110 °C. The hydrolyzed samples were dried by vacuum evaporation at 60 °C in a rotary evaporator. Then, it was rinsed with 20 mL of water and re-evaporated. The washing and evaporating process was carried out twice. 50 mL of sodium citrate buffer was used to make up the final volume. Before injection, samples were filtered through a 0.22-micron filter, with a 20 µL volume being introduced into the amino acid analyzer. The analysis was conducted using an application data book and a Shim-Pack Amino-Na column (4.6 mm internal diameter by 100 mm length) as part of the Shimadzu HPLC amino acid analysis system. A fluorescence detector was utilized with an excitation wavelength of 350 nm and an emission wavelength of 450 nm. Peaks were identified through a post-column derivatization reaction, where eluted amino acids reacted with o-phthalimide (OPA).

2.4.3. Mineral analysis

Sodium, Potassium, Calcium, and Magnesium were analyzed following the standard methods outlined in AOAC [12]. Dry ashing was used in the muffle furnace to remove the organic matrix. Atomic absorption spectrophotometry was used to test the analyte after the remaining ash was dissolved in diluted acid. To determine Ca and Mg only, 0.1% (w/v) La was included in each standard and test solution's final dilution using $LaCl_3$ solution. To determine Na and K, 0.5% (w/v) Cs (0.04M) was made by adding CsCl solution to the final dilution of each reference and test solution. Blanks had been prepared and carried throughout the process. For each mineral to be identified, a calibration curve showing concentration vs absorbance was prepared. Flame parameters were followed by the directions of the instrument manufacturer's instructions.

According to the instrument instruction manual, calibration solutions were created to cover the linear range of the calibration curve. Similar procedures were used to assay the samples. Each mineral's concentration was determined from its calibration curve, and the concentration in the test sample was calculated while taking dilutions and test portion size into account.

2.4.4. Vitamins analysis

2.4.4.1. Fat-soluble vitamins β-carotene

HPLC was used to estimate the β-carotene using the official method outlined in AOAC [12]. The sample was homogenized and saponified in an ethanolic potassium hydroxide solution, and the β-carotene that was released was completely extracted using organic solvents. Using reversed-phase HPLC, retinol content was separated from a portion of the extract. Quantification was done by the β-carotene standard.

2.4.4.2. Vitamin A, D, and E

The samples were prepared using the methodology outlined by Kirk and Sawyer [15]. Then, the liquid chromatographic analysis was conducted per the guidelines established by Agilent Technology [16]. First, weigh 5.0 g of finely ground and homogenized samples and transfer them into a 100 mL round-bottom flask. Added 25 mL of absolute ethanol to dissolve the sample matrix, and after dissolving, added 10 mL of 50% potassium hydroxide (KOH) solution along with 0.5 g pyrogallol. The mixture was subjected to saponification under reflux conditions at 70 - 80 °C for 30 minutes with continuous stirring. After rapid cooling, the saponified mixture was transferred into a separating funnel. Vitamins A, D, and E were extracted with diethyl ether (3 × 25 mL). The ether extracts were washed with distilled water until a neutral pH was achieved. Anhydrous sodium sulphate was used to dry the mixture of extracts, and then a lower pressure was used to evaporate them completely. The dried residue was reconstituted in 5 mL of methanol. A 0.45 µm membrane filter was used to filter the solution before it was placed in amber HPLC vials for examination. Stock standard solutions of Vitamins A, D, and E were prepared in methanol at a concentration of 1 mg/mL. Working standard solutions were prepared by serial dilution to obtain concentrations of 5, 10, 20, 40, and 80 µg/mL. Each standard solution was injected into the HPLC, and the peak area versus concentration was plotted to create a standard calibration curve. Vitamin concentrations in the samples were calculated using the regression equations obtained from the standard calibration curves.

2.4.4.3. Water-soluble vitamins

Following the procedure outlined by Kirk and Sawyer [15], water-soluble vitamins were subjected to a liquid chromatographic analysis under the guidelines established by Agilent Technology [16]. First, weigh 10.0 g of the sample and add the sample to 90 mL of distilled water, and homogenize for 2 minutes using a high-speed homogenizer to produce a 10% (w/v) homogenate. Transferred 10.0 mL of the homogenized suspension to a 250 mL conical flask. To the 10.0 mL homogenate aliquot, 50.0 mL of 5 N HCl was added, capped the flask, and placed in a boiling-water bath at 100 ± 2 °C.

After 30 minutes, removed the flask and allowed it to cool to room temperature (20–25 °C). Adjusted the pH to 4.0–4.5 using 2.5 M sodium acetate buffer. Added 5.0 mL of a 10% (w/v) Taka-diastase (α-amylase) solution to the digest. Incubated the mixture at 45 ± 2 °C for 3.0 hours in a shaking/temperature-controlled water bath (set to 100 rpm agitation for mixing). After the 3-hour incubation, the digest was cooled to room temperature and filtered through Whatman No.1 filter paper to remove coarse solids. Transferred the filtrate to a 100 mL volumetric flask and made up to the mark with distilled water (final volume = 100 mL). Before HPLC injection, a portion of the extract was filtered through a 0.2 µm syringe filter into HPLC vials.

Prepared the primary stock standard solutions by accurately weighing reference standards and dissolving them in deionized water. From each stock, a working standard was prepared by pipetting 1.0 mL of stock into a 50.0 mL volumetric flask and diluting to the mark with deionized water. From the working standard, a five-point calibration series by serial dilution to cover the expected sample concentration range. Plotting a standard curve between concentrations and peak area, followed by linear least squares regression, yielded a regression equation that was used to estimate vitamin content in a variety of samples.

2.4.4.4. Vitamin C

The total vitamin C content, identified as ascorbic acid, was measured using LC-UV. A phosphate buffer (pH 2.5) served as the mobile phase for separation on a C_{18} reverse-phase column, with detection occurring at 248 nm. An automated LC system featuring a pump for continuous delivery at 0.5–1.0 mL/min and a precision injection device for 50 µL. A UV detector with a stable baseline was set at 248 nm. The UV-VIS detector was in place. Suitable 5 µm monomeric silica-based C18 reverse phase column (nominally 150 × 4 mm) [17].

2.5. Statistical Analysis

A total of three replications were studied for all tests. The collected data from the study were tabulated and analyzed using the statistical procedure of analysis of variance (ANOVA). The method outlined by Gomez and Gomez [18] was used to further compute significant differences in the mean using the least significant difference (LSD) at a 0.05% level of probability.

3. RESULTS

3.1. Proximate Composition

Gum Arabic, Khorak, and Gond Pak significantly differed ($p \leq 0.05$) in their average proximate composition, as shown in Table 3. Gum Arabic had the lowest pH, protein, moisture, fat, carbohydrate, and energy value among the three, while Khorak had the highest pH, moisture, carbohydrate, and energy value. Gond Pak had the highest protein and crude fat.

3.2. Amino Acid Analysis

Gum Arabic and its food products, Khorak and Gond Pak, displayed significant differences ($P \leq 0.05$) in their amino acid profiles as shown in Table 4. Gond Pak had the highest levels of most amino acids analyzed, including aspartic acid, threonine, glutamic acid, proline, glycine, alanine, phenylalanine, histidine, and tryptophan. Methionine, isoleucine, leucine, tyrosine, and lysine were highest in Khorak. Serine and valine were highest in gum Arabic, while cysteine and arginine were not detected in any of the samples.

3.3. Mineral Analysis

The mineral content of gum Arabic was significantly higher ($P \leq 0.05$) than that of Khorak and Gond Pak across all measured elements. Potassium, sodium, calcium, magnesium, and iron were all highest in gum Arabic, followed by Khorak and Gond Pak, as shown in Table 5. These findings highlight the distinct mineral profiles of these three food products, with gum Arabic offering the most concentrated source of these essential minerals.

3.4. Vitamins Analysis

Gum Arabic, Khorak, and Gond Pak were significantly different ($P \leq 0.05$) in their vitamin content. Khorak had the highest vitamin A, C, niacin, and pyridoxine, while Gond Pak had the

Table 3. Average proximate Content/ Composition of gum Arabic and its food products.

Content/Composition	Treatments			LSD (0.05)	SE ±
	T_1	T_2	T_3		
pH Value	4.92 ± 0.005c	5.47 ± 0.01a	5.16 ± 0.005b	0.0007557	0.0002722
Crude Protein%	3.41 ± 0.09c	7.96 ± 0.27b	12.29 ± 0.18a	0.5261	0.1895
Moisture%	8.30 ± 0.03c	11.61 ± 0.11a	8.95 ± 0.27b	0.2857	0.1029
Ash%	3.17 ± 0.02a	1.02 ± 0.03c	1.23 ± 0.11b	0.1867	0.0672
Crude Fat%	0.35 ± 0.075b	15.49 ± 0.87a	15.99 ± 0.29a	1.2794	0.4608
Dietary Fiber%	66.10 ± 0.43a	24.66 ± 0.40c	37.30 ± 0.44b	1.1261	0.4056
Carbohydrate%	18.66 ± 0.40c	39.25 ± 1.47a	24.22 ± 1.09b	2.9028	1.0455
Titratable Acidity%	1.50 ± 0a	0.14 ± 0.01b	0.13 ± 0.005b	0.0151	0.0005443
Energy value (kcal/100g)	82.14 ± 1.87c	308.65 ± 3.7a	277.87 ± 2.9b	7.0104	2.5250

T_1 = Gum Arabic, T_2 = Khorak, T_3 = Gond Pak, LSD = Least Significant Difference, SE = Standard Error

Table 4. Average amino acid content of gum Arabic and its food products.

Amino acid content (mg/g)	Treatments			LSD (0.05)	SE ±
	T_1	T_2	T_3		
Aspartic acid	0.698 ± 0.00b	0.37 ± 0.01c	1.663 ± 0.00a	0.0122	0.0004384
Threonine	0.39 ± 0.001b	0.14 ± 0.01c	0.533 ± 0.001a	0.0122	0.0004384
Serine	0.68 ± 0.001a	ND	ND	0.0001308	0.004714
Glutamic acid	0.578 ± 0.001c	1.39 ± 0.015b	4.43 ± 0.001a	0.0192	0.0006909
Proline	0.041 ± 0.00c	0.06 ± 0.001b	0.079 ± 0.00a	0.0122	0.0004384
Glycine	0.188 ± 0.00b	0.12 ± 0.01c	0.446 ± 0.00a	0.0122	0.0004384
Alanine	0.13 ± 0.00b	0.14 ± 0.01b	0.443 ± 0.00a	0.0122	0.0004384
Valine	0.303 ± 0.01a	ND	0.302 ± 0.00a	0.0001603	0.0005774
Methionine	ND	0.02 ± 0.01a	ND	0.0131	0.0003714
Isoleucine	ND	0.16 ± 0.01a	0.117 ± 0.00b	0.0125	0.0004497
Leucine	ND	0.68 ± 0.01a	0.03 ± 0.001b	0.0125	0.0004497
Tyrosine	ND	0.39 ± 0.01a	0.199 ± 0.00b	0.0125	0.0004497
Phenylalanine	ND	0.43 ± 0.01b	0.547 ± 0.00a	0.0125	0.0004497
Histidine	0.163 ± 0.001b	0.05 ± 0.01c	0.204 ± 0.00a	0.0122	0.0004384
Tryptophan	ND	0.32 ± 0.01b	0.921 ± 0.00a	0.0125	0.0004497
Lysine	ND	3.35 ± 0.01a	0.099 ± 0.00b	0.0125	0.0004497
Cysteine	ND	ND	ND	-	-
Arginine	ND	ND	ND	-	-

T_1 = Gum Arabic, T_2 = Khorak, T_3 = Gond Pak, LSD = Least Significant Difference, SE = Standard Error, ND = Not detected

Table 5. Average mineral Content/ Composition of gum Arabic and its food products.

Mineral content	Treatments			LSD (0.05)	SE ±
	T_1	T_2	T_3		
Potassium (mg/100g)	254.22 ± 0.5a	112.49 ± 0.1b	84.77 ± 0.33c	1.1241	0.4086
Sodium (mg/100g)	118.55 ± 0.2a	39.35 ± 0.06b	39.53 ± 0.15b	0.5198	0.1872
Calcium (mg/kg)	7976.3 ± 12a	1485.7 ± 9.5c	1680.7 ± 13b	142.66	51.383
Magnesium (mg/kg)	2601.5 ± 39a	1238.1 ± 7.9b	1200.5 ± 9b	39.900	14.371
Iron (mg/kg)	76.57 ± 1.15a	46.551 ± 0.2b	44.659 ± 0.3c	1.0830	0.3901

T_1 = Gum Arabic, T_2 = Khorak, T_3 = Gond Pak, LSD = Least Significant Difference, SE = Standard Error

highest riboflavin, folate, and cyanocobalamin. Gum Arabic had the highest thiamine, while vitamin D, E, pantothenic acid, and biotin were not detected in any of the treatments, as shown in Table 6. Overall, Khorak appears to be the most vitamin-rich of the three, followed by Gond Pak and Gum Arabic.

4. DISCUSSION

The kingdom Plantae boasts over 1350 species [19], with *Acacia Senegal* and *Acacia Seyal* being crucial for gum Arabic production. This ancient gum, derived from Acacia trees, serves as a stabilizer, emulsifier, and thickening agent in various food products. The present study analyzed gum Arabic from Acacia trees in the Tharparker district of Sindh, Pakistan, examining its chemical composition and nutritional value, along with traditional recipes from gum Arabic, i.e., Khorak and Gond Pak.

The therapeutic uses of Acacia plants, particularly gum Arabic, have been extensively documented in folklore and tradition [20]. William

Table 6. Average vitamin content of gum Arabic and its food products.

Vitamin content	Treatments			LSD (0.05)	SE ±
	T_1	T_2	T_3		
Vitamin A (IU/100g)	78.33 ± 0.75b	141.33 ± 1.5a	12.67 ± 1.52c	1.2766	3.5443
Vitamin D (IU/100g)	ND	ND	ND	-	-
Vitamin E (IU/100g)	ND	ND	ND	-	-
Vitamin C (mg/100g)	0.72 ± 0.005c	4.65 ± 0.000a	1.12 ± 0.003b	0.0008861	0.0003192
Thiamine (mg/100g)	7.74 ± 0.005a	4.16 ± 0.005b	2.06 ± 0.005c	0.0007557	0.0002722
Riboflavin (mg/100g)	0.27 ± 0.05c	0.32 ± 0.005b	0.71 ± 0.05a	0.0007557	0.0002722
Niacin (mg/100g)	2.47 ± 0.05c	26.25 ± 0.01a	4.83 ± 0.01b	0.0151	0.0005443
Pantothenic acid (mg/100g)	ND	ND	ND	-	-
Pyridoxine (mg/100g)	ND	0.06 ± 0.005a	0.01 ± 0b	0.0007557	0.0003722
Biotin (mg/100g)	ND	ND	ND	-	-
Folate (mg/100g)	8.58 ± 0.05b	4.20 ± 0c	21.97 ± 0.01a	0.0131	0.0004717
Cyanocobalamin (mg/100g)	0.67 ± 0.05b	0.61 ± 0.005c	1.17 ± 0.05a	0.014	0.034

T_1 = Gum Arabic, T_2 = Khorak, T_3 = Gond Pak, LSD = Least Significant Difference, SE = Standard Error, ND = Not detected

and Phillips [21] noted that gum Arabic is water-soluble, with a pH value around 4.5. However, in the present study, gum Arabic's pH remained at 4.92, while Khorak and Gond Pak had pH values of 5.47 and 5.16, respectively. Nour [22] reported similar pH values for gum Arabic, i.e., 4.35-4.64. A relatively greater pH value of traditional recipes, i.e., Khorak and Gond Pak, might be associated with the ingredients used to prepare these dishes. Titratable acidity, an indicator of organic acid [23], was 1.5%, 0.14%, and 0.13% in gum Arabic, Khorak, and Gond Pak, respectively. This indicates a substantial level of organic acid content in these commodities. Moisture content in gum Arabic was 8.30%, differing from El-Kheir *et al.* [24], i.e., 10 to 16.15%. Khorak and Gond Pak had moisture contents of 11.61% and 8.95%, respectively. The fact behind the low content of moisture in Khorak and Gond Pak is linked with the minimal use of extraneous water during their preparation. Ash content, reflecting total mineral content, was 3.17%, 1.02%, and 1.23% in gum Arabic, Khorak, and Gond Pak, respectively. In connection with Ali and Daffalla [25], the ash content in gum Arabic was recorded to be 2.5%. However, the present findings for ash content align with the findings of Lelon *et al.* [26], which suggest that gum Arabic from Acacia Senegal had ash content ranging from 2.72 to 3.16%. The protein content in gum Arabic, Khorak, and Gond Pak was 3.41%, 7.96%, and 12.29%, with higher protein content in traditional recipes due to protein-rich ingredients (i.e., almond, coconut, poppy seeds, etc.). In a similar study, Ali and Daffalla [25] found the protein content of gum Arabic to be 2.2%. Gum Arabic had a negligible fat content (0.35%), while Khorak (15.49%) and Gond Pak (15.99%) exhibited higher fat content. The fat content of gum Arabic is less; however, it has great potential to disperse fat micelles in a food product since it is an emulsifier [27]. Dietary fiber content was 66.10% in gum Arabic, 24.66% in Khorak, and 37.30% in Gond Pak. Dietary fiber is crucial, with some types acting as prebiotics, benefiting gut bacteria and overall health [28]. Many researchers, including Niamah *et al.* [29] and Talib *et al.* [30], determined that gum Arabic, rich in dietary fiber, behaves as a prebiotic in yogurt, highlighting its substantial fiber content. Carbohydrate levels were highest in Khorak (39.25%), followed by Gond Pak (24.22%) and Gum Arabic (18.66%). Carbohydrates are the main constituents of gum Arabic. According to Dauqan and Abdullah [31], gum Arabic's composition changes with climate and soil, but it's always a complex sugar molecule (polysaccharide) with calcium, magnesium, and potassium. Traditional recipes, with their added table sugar, have even higher carbohydrate content. The energy values (kcal/100g) were 308.65, 277.87, and 82.14 for Khorak, Gond Pak, and gum Arabic, respectively, indicating higher nutritional value

in traditional recipes made from gum Arabic. The higher energy value of the traditional recipes made from gum Arabic shows their nutritional value.

Amino acids are needed for the survival, development, growth, and reproduction of all organisms [32]. The polysaccharide in gum Arabic is associated with a certain protein fraction in which hydroxyproline and proline are the chief types of amino acids. In the present study, some essential and non-essential amino acids were analyzed in gum Arabic, Khorak, and Gond Pak, revealing significant amino acid content. Among different amino acids, serine was recovered considerably in gum Arabic, i.e., 0.68 mg/g in comparison to Khorak and Gond Pak. Khorak displayed higher methionine content (0.02 mg/g), while Gond Pak contained significant levels of aspartic acid (1.663 mg/g), threonine (0.533 mg/g), glutamic acid (4.435 mg/g), proline (0.079 mg/g), glycine (0.446 mg/g), histidine (0.204 mg/g), and alanine (0.443 mg/g). Valine content was similar in both gum Arabic and Gond Pak (0.303 mg/g). Gum Arabic lacked detectable amounts of methionine, isoleucine, leucine, tyrosine, phenylalanine, tryptophan, lysine, cysteine, and arginine. In contrast, Khorak and Gond Pak contained reasonable quantities of these amino acids. Gum Arabic revealed the presence of valine and histidine among essential amino acids, emphasizing their importance in human protein formation. In a similar study, Nour [22] found that *Acacia laeta* gum had the highest amino acid content, followed by A. Senegal, A. polyacantha, and A. seyal gums. A. Senegal gum was rich in serine (0.26%) and aspartic acid (0.22%), while A. seyal gum contained notable amounts of serine (0.22%), aspartic acid (0.14%), and glutamic acid (0.13%). A. polyacantha gum featured aspartic acid (0.24%) and serine (0.21%), and A. laeta gum contained serine (0.43%) and hydroxyproline (0.31%). Overall, the present study underscores the significance of amino acids in gum Arabic composition.

Assessing mineral content in a food commodity is an imperative approach to understanding dietary importance. In this study, the mineral content of gum Arabic, Khorak, and Gond Pak was investigated, focusing on potassium, sodium, calcium, magnesium, and iron. Although minerals constitute only 5% of the typical human diet, they play a crucial role in maintaining normal health and bodily functions. Macrominerals, required in amounts exceeding 100 mg/day, and trace minerals needed in smaller quantities 1–100 mg/day by adults, make up less than 0.01 percent of total body weight [33], were examined. Gum Arabic exhibited the highest levels of potassium (254.22 mg/100g), sodium (118.55 mg/100g), calcium (7976.3 mg/kg), magnesium (2601.5 mg/kg), and iron (76.57 mg/kg) compared to Khorak and Gond Pak. Among the traditional recipes, Khorak had higher potassium (112.49 mg/100g), magnesium (1238.1 mg/kg), and iron (46.55 mg/kg) content than Gond Pak, while Gond Pak contained more sodium (39.53 mg/100g) and calcium (1680.7 mg/kg). Previous studies highlighted the remineralizing effects of gum Arabic, emphasizing its role in enhancing remineralization activities in the body, possibly through polysaccharide salts of potassium, calcium, and magnesium. However, mineral content characterization of gum Arabic is not widespread in scientific literature, potentially due to varietal differences [34, 35].

A substantial number of micronutrients, i.e., vitamins, along with macronutrients, are needed to maintain a sound metabolic system in the human body [36]. The present study focused on assessing the vitamin composition of gum Arabic and its food products. The analysis revealed significant amounts of water-soluble vitamins such as vitamin C and various B complexes (B1, B2, B3, B6, B9, and B12), as well as the presence of fat-soluble vitamin A. Notably, vitamins D, E, B5, and B7 were not detected in any of the samples examined. Interestingly, a prior study by Ajayi *et al.* [37] on the nutritional potential of seeds from the gum Arabic tree found almost all water- and fat-soluble vitamins in the Acacia seeds.

5. CONCLUSIONS

Among the treatments studied, gum Arabic exhibited favorable nutrient content, particularly in minerals, amino acids, and dietary fiber. Khorak demonstrated higher average values for fat, carbohydrates, energy value, certain vitamins (A and C), and amino acids, while Gond Pak stood out for its significant protein and vitamin content. It is noteworthy that some amino acids (cysteine and arginine) and vitamins (pantothenic acid, biotin, D, and E) were not detected in any of the treatments. The study concludes that gum Arabic and its derived

food products, i.e., Khorak and Gond Pak, are highly nutritious, containing essential nutrient components like dietary fiber, minerals, vitamins, and amino acids. It is suggested that gum Arabic, Khorak, and Gond Pak are ideal for human consumption since they are composed of essential nutrients. Therefore, gum Arabic, Khorak, and Gond Pak should be incorporated into the diet, particularly in regions where conditions like malnutrition, kwashiorkor, wasting, stunting, and other diet-specific diseases are frequently prevalent.

6. CONFLICT OF INTEREST

The authors confirm that there are no conflicts of interest.

7. ETHICAL STATEMENT

The present study did not involve any ethical issues concerning human or animal subjects.

8. REFERENCES

1. Mortensen, F. Aguilar, R. Crebelli, A. Di Domenico, M.J. Frutos, P. Galtier, D. Gott, U. Gundert-Remy, C. Lambre, J.C. Leblanc, O. Lindtner, P. Moldeus, P. Mosesso, A. Oskarsson, D. Parent-Massin, I. Stankovic, I. Waalkens-Berendsen, R.A. Woutersen, M. Wright, M. Younes, L. Brimer, A. Christodoulidou, F. Lodi, A. Tard, and B. Dusemund. Re-evaluation of acacia gum (E 414) as a food additive. *EFSA Journal* 15(4): 5089 (2017).
2. N.A. Afoakwah, M.G. KomLa, A. Ali, and S. Ahmed. Extraction, structural properties, and applications of gum arabic (Chapter 13). In: Natural Gums: Extraction, Properties, and Applications. S. Ahmed and A. Ali (Eds.). *Elsevier* pp. 347-371 (2023).
3. S. Patel and A. Goyal. Applications of Natural Polymer Gum Arabic: A Review. *International Journal of Food Properties* 18(5): 986-998 (2015).
4. M.A. Hassanien. The protective and antioxidant effects of Arabic gum: a review of recent evidence using the new PubMed system. *International Journal of Community Medicine and Public Health* 7: 356-360 (2019).
5. S. Elshama. The preventive role of Arabic gum in the treatment of toxicity. *Open Access: Toxicology & Research* 1(1): 27-29 (2018).
6. M. Abdin, A.E. El-Beltagy, M.E. El-Sayed, and M.A. Naeem. Production and characterization of sodium alginate/gum Arabic-based films enriched with *Syzygium cumini* seeds extracts for food application. *Journal of Polymers and the Environment* 30(4): 1615-1626 (2022).
7. A.H. Jarrar, L. Stojanovska, V. Apostolopoulos, J. Feehan, M.A.F. Bataineh, L.C. Ismail, and A.S. Al Dhaheri. The effect of gum arabic (*Acacia senegal*) on cardiovascular risk factors and gastrointestinal symptoms in adults at risk of metabolic syndrome: A randomized clinical trial. *Nutrients* 13(1): 194 (2021).
8. A. Hayat. Situational analysis of existing drought conditions and mitigation strategies in Thar: a case study of Nagarparker. Ph.D. Thesis. *National University of Sciences and Technology (NUST), Islamabad, Pakistan* (2017).
9. S.U. Shah and J. Iqbal. Spatial–temporal variations of vegetation and drought severity across Tharparkar, Pakistan, using remote sensing-derived indices. *Journal of Applied Remote Sensing* 10(3): 036005 (2016).
10. L.F. D'Antuono. Traditional foods and food systems: a revision of concepts emerging from qualitative surveys on-site in the Black Sea area and Italy. *Journal of the Science of Food and Agriculture* 93(14): 3443-3454 (2013).
11. S.E.R. Abel, Y.A. Yusof, N.L. Chin, L.S. Chang, H.M. Ghazali, and Y.N. Manaf. Characterization of physicochemical properties of gum arabic powder at various particle sizes. *Food Research* 4(S1): 107-115 (2020).
12. K. Helrich (Ed.). Official Methods of Analysis: Association of Official Analytical Chemists, 15th Edition. *Association of Official Analytical Chemists, Inc. Suite 400, 2200 Wilson Boulevard, Arlington, Virginia, 22201, USA* (1990). https://law.resource.org/pub/us/cfr/ibr/002/aoac.methods.1.1990.pdf
13. F.L. Hart and H.J. Fisher. Introduction-General methods for proximate and mineral analyses. In: Modern Food Analysis. F.L. Hart and H.J. Fisher (Eds.). *Springer, Berlin, Heidelberg* pp. 1-27 (1971).
14. A.A. Paul, and D.A.T. Southgate. McCance and Widdowson's. The Composition of Foods. *HMSO/ Royal Society of Chemistry, London* pp. 5-7 (1988).
15. R.S. Kirk and R. Sawyer (Eds.). Pearson's composition and analysis of foods. 9th Edition. *Longman Group Ltd., Essex, UK* (1991).
16. Agilent Technology. *The Essential Chromatography and Spectroscopy Catalog* (2009-2010). https://www.agilent.com/Library/catalogs/Public/5990-3699EN.pdf
17. A.R. Brause, D.C. Woollard, and H.E. Indyk. Determination of total vitamin C in fruit juices

and related products by liquid chromatography: interlaboratory study. *Journal of AOAC International* 86(2): 367-374 (2003).
18. K.A. Gomez and A.A. Gomez (Eds.). Statistical procedure for agricultural research (2nd Edition). *Jhon Willey and Sons, New York* (1984).
19. B.R. Maslin, J.T. Miller, and D.S. Seigler. Overview of the generic status of Acacia (Leguminosae: Mimosoideae). *Australian Systematic Botany* 16(1): 02008 (2003).
20. S. Malviya, S. Rawat, M. Verma, and A. Kharia. Preliminary phytochemical investigations of *the Acacia nilotica* Linn plant. *Journal of Current Pharma Research* 1(2): 91-100 (2011).
21. G.O. Phillips and P.A. Williams. Introduction to food hydrocolloids. In Handbook of hydrocolloids, 3rd Edition. *Woodhead Publishing* pp. 3-26 (2021).
22. A.A. Nour. Physicochemical characteristics of some Acacia gums. *International Journal of Agricultural Research* 7(8): 406-413 (2012).
23. C. Tyl and G.D. Sadler. pH and Titratable Acidity. In: Food Analysis, 5th Edition. S.S. Nielson (Ed.). *Springer* pp. 389-406 (2017).
24. M.K.S. El-Kheir, A.E.G.A. Yagoub, and A.A.A. Baker. Emulsion-stabilizing effect of gum from *Acacia Senegal* (L) Willd. the role of quality and grade of gum, oil type, temperature, stirring time, and concentration. *Pakistan Journal of Nutrition* 7(3): 395-399 (2008).
25. K.S.E. Ali and H.M. Daffalla. Physicochemical and functional properties of the gum arabic from *Acacia Senegal*. *Annals: Food Science and Technology* 19(1): 27-34 (2018).
26. J.K. Lelon, I.O. Jumba, J.K. Keter, W. Chemuku, and F.D.O. Oduor. Assessment of physical properties of gum arabic from *Acacia senegal* varieties in Baringo District, Kenya. *African Journal of Plant Science* 4(4): 95-98 (2010).
27. L. Bai, S. Huan, Z. Li, and D.J. McClements. Comparison of emulsifying properties of food-grade polysaccharides in oil-in-water emulsions: Gum arabic, beet pectin, and corn fiber gum. *Food Hydrocolloids* 66: 144-153 (2017).
28. G.R. Gibson, K.P. Scott, R.A. Rastall, K.M. Tuohy, A. Hotchkiss, A. Dubert-Ferrandon, and S. Macfarlane. Dietary prebiotics: current status and new definition. *Food Science and Technology Bulletin: Functional Foods* 7(1): 1-19 (2010).
29. A.K. Niamah, S.T.G. Al-Sahlany, and A.J. Al-Manhel. Gum arabic uses as prebiotic in yogurt production and study effects on physical, chemical properties and survivability of probiotic bacteria during cold storage. *World Applied Sciences Journal* 34(9): 1190-1196 (2016).
30. M.A. Talib, O.A. Rayis, E.H. Konozy, and M.A. Salih. Effect of gum arabic (prebiotic) on physicochemical and organoleptic properties of yogurt (probiotic). In: Gum Arabic. Structure, Properties, Application and Economics. A.A. Mariod (Ed.). *Academic Press* pp. 167-171 (2018).
31. E. Dauqan and A. Abdullah. Utilization of gum arabic for industries and human health. *American Journal of Applied Sciences* 10(10): 1270-1279 (2013).
32. G. Wu, Z. Wu, Z. Dai, Y. Yang, W. Wang, C. Liu, and Y. Yin. Dietary requirements of "nutritionally non-essential amino acids" by animals and humans. *Amino Acids* 44: 1107-1113 (2013).
33. E. Tako. Dietary Trace Minerals. *Nutrients* 11: 2823 (2019).
34. B.H. Ali, A. Ziada, and G. Blunden. Biological effects of gum arabic: A review of some recent research. *Food and Chemical Toxicology* 47(1): 1-8 (2009).
35. D. Yebeyen, M. Lemenih, and S. Feleke. Characteristics and quality of gum arabic from naturally grown *Acacia senegal* (Linne) Willd. trees in the Central Rift Valley of Ethiopia. *Food Hydrocolloids* 23(1): 175-180 (2009).
36. I.J. Salma, M.A.M. Sajib, M. Motalab, B. Mumtaz, S. Jahan, M.M. Hoque, and B.K. Saha. Comparative evaluation of macro and micro-nutrient elements and heavy metal contents of commercial fruit juices available in Bangladesh. *American Journal of Food and Nutrition* 3(2): 56-63 (2015).
37. K. Ajayi, O.T. Adepoju, O.M. Taiwo, S.T. Omojola, and M.E. Aladetuyi. Nutritional potential of underutilized gum arabic tree seeds (*Acacia nilotica*) and locust bean seeds (*Parkia biglobosa*). *African Journal of Food Science* 12(8): 1650 (2018).