Extraction of gum from Chia seeds and study of its chemical Composition and its Antibacterial ability

Zainulabdeen Ali Kadhim AL-Zurfi and Laith Fareed Hasan Al-Obaidi

Department of Food Sciences, Faculty of Agriculture, University of Kufa, Republic of Iraq

Corresponding author Email: laithf.alobaidi@uokufa.edu.iq

DOI: https://doi.org/10.36077/kjas/2025/v17i1.11104

Received date: 12/1/2023

Accepted date: 28/2/2023

Abstract

The current study aimed to extract gum from chia seeds, study its chemical composition, and determine the optimal conditions for extracting gum from seeds, which included (soaking temperature, soaking period, and mixing ratio), as well as studying the inhibitory activity of gum against some types of bacteria that cause food spoilage. The results of the chemical composition of the gum extracted from chia seeds indicated that the gum contained 6.88% protein, 3.12% fat, 5.60% ash, 2.43% moisture and 81.97% carbohydrates. The results of determining the optimal conditions for the production of extracted plant gum showed that the highest yield of gum reached (9.54%) when extracted at a temperature of (30 C°) and a mixing ratio of (1:40) and a soaking time (60 minutes). This treatment differed significantly from the rest of the treatments were at the level of ($p < 0.05$), while the lowest yield was recorded for the extracted gum (1.30%) at a temperature of (40 C°), mixing ratio (1:20), and at soaking time (120 minutes). The active groups were identified in the plant gum by Fourier Trans Form Infra-red (FTIR) spectroscopy, and it was observed that groups ((OH), ((C-H), (C-O), (C-O-C), (C=O), (COO-) and (H-H) or (C-H) in the gum extracted from chia seeds. The inhibitory activity of the extracted plant gum was also tested against some types of bacteria that cause food spoilage, including *Staphylococcus aureus*, *Escherichia coli*, and *Klebsiella pneumoniae*, and at different concentrations (200, 300, and 400)micrograms. The highest inhibition ability of the gum was against *Escherichia coli* with a diameter of 23 mm and at a concentration of 400 micrograms, while the lowest inhibition ability was against *Staphylococcus aureus* with a diameter of 14 mm at a concentration of 200 micrograms.

Keywords: chia seed gum, gum yield, antibacterial, FTIR, Functional properties**.**

Introduction

Chia (*Salvia hispanica L.*) is a perennial herbaceous plant that is grown in summer. Chia seeds are good food because of the elements and benefits they contain; they contain Omega 3 and 6, in addition to calcium, magnesium, iron, and potassium. It is also considered one of the seeds rich in fiber and gluten-free protein, so eating it is safe for people who suffer from chronic allergic diseases to gluten (23).

In recent years, vegetable gums have become popular in the food industry as dietary fiber supplements, tissue modifiers, gelling agents, thickeners, stabilizers, emulsifiers, bulking agents, encapsulators, synergistic inhibitors, and film/coating agents. Vegetable gums are also in great demand in the industries, pharmaceutical, medical, cosmetic, and biomedical; in addition to that, there is an increasing research focus on gums due to the diversity in their structural composition, functions, and ease of modification; and gum is one of the most prominent ingredients in liquid, semi-solid, and high-solid food products that provide the required texture, appearance, and stability, thus a request to find new plant gums to meet the industrial demand, especially in the food industry (20).

Chia seeds are used in food industries that need to stabilize their weak texture, as the gum of chia seeds is located in the first three layers of the seed layer. When the seeds are moistened, fibers begin to appear, and it is a unique phenomenon for the formation of a gelatinous mass rich in sugars, where the percentage of sugars reaches 71.22 % (24). Many studies, including (32 and 8) , confirmed that the importance of gum has increased recently after studying the functional properties of gum, which played the main role in its use in many food applications.

(29) indicated that the gum extracted from chia seeds contains 78.3% carbohydrates, an amount of protein estimated at about (6.5%), a small amount of fat (2.1%), in addition to crude fibers (5.6%) and minerals (3.2%).

In another study conducted on vegetable gum prepared from chia seeds, it contained 71.22% of polysaccharides, and this percentage was close when compared to the percentage of polysaccharides present in gum extracted from flax seeds, which amounts to 75%, while the percentage was 80% in mustard seeds and 98% in xanthan gum (34 ,31 and 9). The vegetable gum prepared from chia seeds was described as a source of polysaccharides due to its gummifying properties in aqueous solutions, even if it was in low concentrations (24).

Material and Methods

Sample collection and cleaning

Chia seeds were purchased from a market in the city of Baghdad, cleaned of impurities, and kept in the freezer at a temperature of -18 C until use.

Aqueous Extraction of Chia Seed Gum

The gum of chia seeds was extracted according to the method mentioned by (16), with some modifications, by mixing the seeds with distilled water in different proportions, then soaking the seeds in water for different periods of time and at different temperatures, mixing the mixture with an electric mixer, and separating the gel by filtration with a piece of cloth. The gum was extracted by adding ethyl alcohol (96%) at a ratio of (2:1) (filters: alcohol) (v/v) for two hours, the gum was isolated by filtration with a cotton sieve, and the gum was dried in an oven at a temperature of 40–45 °C for 24 hours, after which the dried gum was ground with an electric grinder and the powder was kept in dry, sealed bottles in the refrigerator until use.

Gum Yield (Y)

The percentage of gum yield was calculated according to what was mentioned by (26), from the following equation:

$$\text{Yield (\%)} = \frac{\text{Weight of extracted gum after drying (g)}}{\text{The weight of the seeds (g) taken for the extraction process}} \times 100$$

Determination of the Optimal Conditions for Gum Extraction

The optimal conditions for extracting gum from chia seeds were studied by examining the effect of each of the mixing ratios of seeds to distilled water, soaking periods, and extraction temperatures with a fixed pH of 7 in the extraction solution on the final yield of gum, as shown in Table 1.

Table 1. The treatments used in the research to study the best conditions for extracting chia seed gum

No.	Temperature	Mixing ratio	Marinating time	pH
1	20 C◦	1:20	30 min	7
2	30 C◦	1:30	60 min	7
3	40 C◦	1:40	120 min	7

Chemical Analysis of Chia Gum

The chemical composition of chia seed gum extracted for each of moisture, ash, fat, and protein was estimated according to the standard methods mentioned in (1). It was conducted in three replicates and expressed in percentages. As for the percentage of carbohydrates, it was calculated using the difference method and according to the following equation:

Total Carbohydrates (%) = 100 - (Moisture + Ash + Protein + Fat) %

Determination of active groups in plant gum using the FTIR infrared device

The method described by (23) and (30) was adopted to diagnose the active aggregates present in the plant gum as the sample was prepared for examination, which is the plant gum in a dry form, as it was ground for the purpose of diagnosing these aggregates. We took a small amount of the sample and put it on the lens of the FTIR Spectrum device and then covered it with a transparent glass cover. As the device is equipped with a small chamber for measuring and adjusting the temperature and contains an indicator and a source of infrared radiation (4000–650 cm^{1}), the sample was placed in the device for a period of 16 seconds and gave results in the form of peaks within certain frequencies, indicating the type of active bonds and aggregates present in the vegetable gum.

Determination of some functional properties of chia seed gum

Viscosity measurement

The method of (27) was followed with some modifications to measure the viscosity of dried gum powder using a Brookfield viscometer after 24 hours of wetting the gum by 0.5:100 (w/v) in distilled water using Spindle No. 4 at a speed of 60 r/min at a temperature of 25°C, an average of three readings were taken.

Water Binding capacity (WBC)

The ability to bind water was estimated by mixing 0.2 g of gum powder with 10 ml of distilled water with an electrostatic mixer for 1 minute, and then the solution was centrifuged using a centrifuge at 2200 rpm for 30 minutes, the floating part was discarded, the wet samples were weighed, and the water binding capacity was expressed as the number of grams of water absorbed per gram of the sample (21).

Oil Binding Capacity(OBC)

The (21) method was used to estimate the ability of gum powder to bind oil, as this property was estimated according to the steps used in estimating the ability to bind water, but by replacing 10 ml of distilled water with sunflower oil, and the ability to bind oil was expressed by the number of grams of oil absorbed per gram of the sample.

Evaluation of the inhibitory effectiveness of vegetable gum

Detection of the inhibitory activity of gum against test bacteria isolates (*Staphylococcus aureus*, *Escherichia coli, and Klebsiella pneumoniae*) by using the well diffusion method to study the effect of gum extracted from chia seeds in bacteria (17). Where the agar medium (Muleer Hinton) was inoculated with test bacteria by spreading 0.1 ml of the bacterial suspension that containing 1.5 x ^{8}10 cells/ml, holes of 5 mm in diameter were made on the surface of the culture medium by means of a cork borer. Concentrations of chia seed gum were prepared by dissolving the gum in distilled water, with three concentrations that included (200, 300, and 400) micrograms, respectively, then 0.1 milliliter was taken from the concentrations and placed in the hole, then the dishes were incubated for 24±2 hours in the incubator at a temperature of 37°C. The diameter of the inhibition zone was measured. The inhibition zone around each hole or the transparent halo surrounding the disc that is free from growth, as its diameter is directly proportional to the inhibitory activity of the plant gum.

Results and Discussion

The yield of chia seed gum under different extraction conditions

Table (2) displays the yield of chia seed gum extracted under various conditions, such as extraction at different extraction temperatures (20°C, 30°C, and 40°C) and different mixing ratios (seeds: water (w/v)) (1: 20, 1:30, and 1:40) during different soaking times (30, 60, and 120) minutes at a constant pH (pH = 7).The highest yield of gum was 9.54% when extracted at a temperature of 30 °C with a mixing ratio of 1:40 and a soaking time of 60 minutes; this treatment differed significantly from the rest of the treatments at the level of ($p<0.05$), while the lowest yield was recorded for the extracted gum (1.30%) at a temperature of 40 °C with a mixing ratio of 1:20 and a soaking time of 120 minutes.

The results of the table indicated that the highest yield of gum at a temperature of 20 °C was at a mixing ratio of 1:20 and a soaking time of 60 minutes, as the yield was 7.29%, while the lowest yield of gum was recorded at 2.21% at a mixing ratio of 1:40 and a soaking time of 30 minutes. At a temperature of 30 °C, the results showed that the highest yield of gum was (9.54%) at a mixing ratio of (1:40) and a soaking time of (60 minutes), while the lowest yield of gum was at a mixing ratio of (1:30) and a soaking time of (30 minutes), where it reached (1.61%). When the effect of 40 °C on gum yield was tested, the highest yield was at a 40:1 mixing ratio and a 60-minute soaking time, which was

6.48%, while the lowest yield was at a 40:1 mixing ratio and a 30-minute soaking time, which was 1.30%. (33) studied the effect of ultrasound and heat on the extraction yield of chia seed gum. As heat and ultrasound extraction gave a greater yield of gum, the yield ranged from 6.92 to 10.52 % compared to heat extraction alone, where the yield ranged between 1.03 and 1.86%. (22) conducted a study to extract gum from chia seeds, where 100 grams of whole seeds were added to a volumetric flask containing water with a mixing ratio of 1:40 (seeds/water), the pH was changed to pH = 8, the temperature was controlled at 80 °C, and the seeds were mixed and soaked for two hours; the yield of gum reached 6% under these conditions. (23) investigated the optimal extraction process at 80 °C with a seed-to-water mixing ratio of 1:40, yielding 7% gum.

Table 2. Yield (%) of chia seed gum under different extraction conditions

Soaking time (min)			Mixing ratio	Extraction heat
120	60	30		
6.65	7.29	4.50	1:20	20 C◦
4.43	5.40	3.96	1:30	
5.10	6.79	2.21	1:40	
2.71	5.48	4.02	1:20	30 C◦
3.87	6.43	1.61	1:30	
7.23	9.54	5.66	1:40	
1.30	1.49	1.82	1:20	40 C◦
2.80	4.66	2.55	1:30	
3.49	6.48	5.43	1:40	
0.68			LSD	

* Each number represents as three replicates.

Chemical composition of chia seed gum

Table (3) shows the results of analyzing the chemical composition of chia seed gum, which included estimating the percentages of moisture, protein, fat, ash, and carbohydrates. The percentage of moisture was 2.43%, and this percentage is lower than what was found by (29) who indicated that the percentage of moisture of chia seed gum was 3.9%. The moisture content of chia seed gum was 6.83 % in the study of (33), while (10) found that the moisture content of chia seed gum was 9.60 %. (19) indicated that the general moisture content should fall within the international specifications range (13%–15%) for Gum Arabic. The difference in moisture content may be due to the method of extraction and drying of the gum. The percentage of protein in the gum of chia seeds was 6.88%, while (3) found that the percentage of protein in the gum extracted from white chia seeds was 4.91%, while the percentage of protein in the gum extracted from black seeds was 5.58%. The percentage in this study was lower than what was found by (29), where the percentage of protein was 2.6%. (19) mentioned that Gum Arabic has a protein content ranged from 1.5%-3.0%.Thus, the reason for the difference in percentages may be due to the different extraction methods and the methods used in protein determination. The same table also indicated that the percentage of fat in chia seed gum powder amounted to 3.12%, which is consistent with what was found by (6) for gum purified from chia seeds, which amounted to 3.10%, whereas, (33) obtained a residual fat percentage in the purified gum of chia seeds at about 2.70%., and the variation in fat percentages may be attributed to the different methods of extracting the fat, the conditions for its estimation, and the type of seeds used. As for the percentage of ash in the gum of chia seeds, it amounted to 5.6%, which is higher than what was found by. (29) in the gum of chia seeds, which amounted to 0.8%, while. (10) obtained an ash percentage for the gum of chia seeds that amounted to 6.26%, while., (6) obtained an ash percentage of 9.64% in the gum of chia seeds. The difference may be due to the difference in the plant content of mineral elements and the different methods of extracting and purifying the gum. The current study also showed that the percentage of carbohydrates in chia seed gum amounted to 81.97%, which is consistent with what was reached by. (33) for chia seed gum, which amounted to 81.53%, while. (2) found that the percentage of carbohydrates in the gum of chia seeds amounted to 67.58%, and the percentage of total carbohydrates in the gum powder depends on the content of the gum in terms of protein and fat remaining after extraction.

Table 3. The chemical composition of chia gum

The component	Percentage (%)
moisture	2.43
protein	6.88
Fat	3.12
Ash	5.60
Carbohydrates	81.97

Active Aggregates Identified by FTIR Technology in Vegetable Gum Extracted from Chia Seeds

The diagnosis of chia seed gum with the FTIR device revealed the frequencies of the infrared beams of the active groups of the prepared chia seed gum, as shown in Table (4) three clear absorption bands at an absorbance frequency of 3429.43 cm^{-1} for the vegetable gum prepared from chia seeds, which is due to the presence of the OH group strongly, and the presence of these aggregates strongly gives the total composition of carbohydrates present in chia seeds. The results of the same table also indicated that the gum sample extracted from chia seeds gave a band with an absorption frequency of 2931.80 cm^{-1}, which is due to the presence of groups (C = C) strongly represented by the methyl group (CH_3) and aromatic rings that indicate the presence of flavonoids and phenolic compounds in the vegetable gum, and this was confirmed by. (30). The sample also gave bands at a frequency of 1726.29 cm^{-1} for the vegetable gum prepared from chia seeds, which is due to the presence of aggregates (C = O). The same table also showed that the sample contained bands at a frequency between 1654.92 cm^{-1} and 1643.35 cm^{-1} for the gum prepared from chia seeds, which belongs to the group (COO^-) represented by the presence of uronic acid (24). The presence of these aggregates varies depending on the quality of the vegetable gum prepared from chia seeds, as indicated by (23) by the appearance of different absorption peaks in strength and intensity, with frequencies close to the frequencies of the studied samples.

Table 4. Infrared absorption bands of vegetable gum prepared from chia seeds

No.	Wavelength cm^{-1}	The type of bond
1	3429.43	The OH stretching of the hydroxyl group represents the NH stretching of the protein content
2	2931.8	C-H represents the group of the homologue group (CH_3) of the aromatic rings and the flavovidins
3	1396.46 1321.24 1298.09 1255.66 1155.38 1056.99	C-O or C-O-C vibrations of the glycosidic bond ring
4	1726.29 1654.92 1643.35 1612.49	C=O represented by the presence of uronic acid
5	1595.13 1533.41 1517.98 1446.61 1415.75	COO^- represents the stretching vibrations of the O-H aggregates in ethanol and water
6	712.38 640.37 530.42	H-H or C-H affinity for water and alcohol

Determination of some functional properties of chia seed gum

Viscosity measurement

Table (5) shows the viscosity of chia seed gum at a concentration of 0.5%, which amounted to 271centipoise (cP). (4) found that the purified gum Arabic contained a viscosity of 124 cP, while (15) indicated that the viscosity of okra gum reached 228.78 cP, while (35) indicated that the gum extracted from seven varieties of flaxseeds ranged from 65 to 1211 cP. (11) stated that the reason for the high viscosity of the gum is due to its low amount of protein, as the viscosity increases with the decrease in the percentage of protein in the gum, and the high viscosity of the gum can be used in many food and industrial applications.

Water Binding Capacity (WBC)

Based on the results obtained in Table (5), the value of the water binding capacity of the gum extracted from chia seeds was 17.9 g water / g gum powder, which was higher than what was found by (28) who indicated that the ability to bind water to the gum of chia seeds amounted to 15.41 g of water / g of gum powder, similar to that of guar gum (25 g water / g powder) but about 4 times higher than that of Gum Arabic. High solubility and high water binding capacity are desirable for the use of gum in food applications to increase viscosity, and to stabilize emulsions (14). This also indicates a potential utility of chia seed gum as a functional ingredient in processed foods.

Oil Binding Capacity (OBC)

Table (5) shows the ability of the gum of chia seeds to bind the oil, as the ability to bind was 23.2 g of oil / g of gum powder, the results also showed the superiority of gum extracted in this study to bind oil compared to guar gum, which was 0.57 g oil/g gum powder, and xanthan, which was 0.79 g oil/g gum powder. (18) found that the oil-binding ability of chia seed gum was 25.7 g oil/g gum powder. The percentage of oil-binding ability recorded in chia gum may be due to its protein and oil content and other factors such as particle size and absence of hemicellulose. The high ability to bind the oil increases the retention of the flavoring materials because they are dissolved in the oil, which increases the acceptance of the product, this feature is of great importance in processed foods, as it improves flavor and increases mouth sensation in foods (12).

Table 5. Functional properties of chia seed gum solution

Properties	Chia seed gum
Viscosity (cp)	271
Water Binding Capacity (g water/g gum powder)	17.9
Oil Binding Capacity (g oil/g gum powder)	23.2

Inhibitory effectiveness of gum prepared from chia seeds against some food pathogenic bacteria. It is clear from the results shown in Table(6) that the chia seed gum extracted has a clear inhibitory effect towards the studied bacterial isolates in varying proportions according to the type of bacteria isolate and the concentration used of the gum, and that the difference in these inhibition rates may be attributed to the different composition of the cell wall and the outer membrane of Gram-positive bacteria and Gram-negative bacteria. The sensitivity of bacteria towards the gum of chia seeds varied, as an increase in the inhibition ability towards the studied bacteria was observed with an increase in the concentration of the gum. The inhibition diameters of chia seed gum towards *Staphylococcus aureus* at concentrations of 200, 300, and 400 micrograms were 14 mm, 16 mm, and 21 mm, respectively, while the average diameters of chia seed gum inhibition against *Escherichia coli* at the same concentrations were 17 mm, 19 mm, and 23 mm, respectively. As for the average diameters of inhibition of chia seeds gum against *Klebsiella pneumoniae* bacteria, they were (15, 16, and 20) mm, respectively. This result was consistent with what (7) indicated: that the effect of gum prepared from chia seeds gave good efficacy against pathogenic bacteria. These findings support what (25) found: that phenolic compounds, which make up a large portion of the seed gum, are effective at inhibiting *Staphylococcus aureus* bacteria, which cause food spoilage; he also stated that the gum contains active compounds such as tannins, alkaloids, resins, and flavonoids, and that the gum should be considered an inhibitor for the growth of some types of microorganisms, particularly pathogens.

Table 6. Inhibitory effectiveness of vegetable gum prepared from chia seeds against some pathogenic bacteria

Microscopic organism	Concentration	Inhibition diameter
Staphylococcus aureus	200 micro grams	14 mm
	300 micro grams	16 mm
	400 micro grams	21 mm
Escherichia coli	200 micro grams	17 mm
	300 micro grams	19 mm
	400 micro grams	23 mm
Klebsiella pneumoniae	200 micro grams	15 mm
	300 micro grams	16 mm
	400 micro grams	20 mm

Conflict of interest

The authors declare no conflict of interest.

References

1. A.O.A.C. 1983 .“Official Methods of Analysis,” 13th Edition, Association of Official Analytical Chemists, Washington DC, pp. 755-800.

2. Akcicek, A., Bozkurt, F., Akgül, C., & Karasu, S. 2021. Encapsulation of olive pomace extract in rocket seed gum and chia seed gum nanoparticles: Characterization, antioxidant activity and oxidative stability. Foods, 10(8), 1735.

3. Al-Azzawi, Roaa Nayef Abdullah. 2018. A study of some functional properties of vegetable gel prepared from sage seeds .. Salvia hispanica.L and its use in the manufacture of creamy ice cream and biscuits Thesis. Master in faculty of Agriculture . Food science- University of Baghdad..

4. Bilal, S.; Dabo, M.; Momoh, D. B. and Abubakar, S. (2015). Refining and Characterization of gum arabic using vacuum filtration method for application in oil and gas drilling fluid formutation. Journal of Experimental Research , 3(2):73-79.

5. Coelho, M. S., & Salas-Mellado, M. D. L. M. 2014. Chemical characterization of chia (Salvia hispanica L.) for use in food products. Journal of Food and Nutrition Research, 2(5), 263-269.

6. Darwish, A. M., Khalifa, R. E., & El Sohaimy, S. A. 2018. Functional properties of chia seed mucilage supplemented in low fat yoghurt. Alexandria Science Exchange Journal, 39(July-September), 450-459.

7. De silva B. P . 2016. Concentration of Nutrients and Bioactive Compounds in Chia (Salvia hispanica L.) Protein Quality and Iron Bioavailabilty in Wistarrats . University of Viçosa .pp:101 .

8. Dick, M.; Maria,T.H.; Gomaa,A.; Subirade,M.; Rios,A.D. and Hickmann,S.F. 2015. Edible Film Production from Chia Seed Mucilage : Effect of Glycerol Concentration on its Physicochemical and Mechanical Properties , Carbohydrate Polymers,130:198-205.

9. Food and Drug Administration – FDA. 1996. Low fat yogurt, 21 CFR 131.203, code of federal regulations. Washington, DC: US Department of Health and Human Services.

10. Hijazi, T., Karasu, S., Tekin-Çakmak, Z. H., & Bozkurt, F. 2022. Extraction of natural gum from cold-pressed chia seed, flaxseed, and rocket seed oil by-product and application in low fat vegan mayonnaise. Foods, 11(3), 363.

11. Hosseini-Parvar, S. H., Matia-Merino, L., Goh, K. K. T., Razavi, S. M. A., & Mortazavi, S. A. (2010). Steady shear flow behavior of gum extracted from Ocimum basilicum L. seed: Effect of concentration and temperature. *Journal of food engineering*, *101*(3), 236-243.

12. Hussain, S., Anjum, F. M., Butt, M. S. and Sheikh, M. A. (2008). Chemical composition and functional properties of flaxseed (Linum usitatissimum) flour. Sarhad Journal Database, 24(4): 649-653

13. Ibrahim, Orouba Muhammad Saeed and Abd, Majid Mahmoud and Abdel Moneim, Aladdin. 2009. Evaluation of the effectiveness of water and oil extract of rosemary Rosmerinus officinalis in inhibiting some pathogenic microorganisms, Iraqi Veterinary Medical Journal, 33 (2): 36-40 .

14. Jindal, M., Kumar, V., Rana, V., & Tiwary, A. K. (2013). Exploring potential new gum source Aegle marmelos for food and

pharmaceuticals: Physical, chemical and functional performance. Industrial Crops and Products, 45, 312-318.

15. Kaewmanee, T.; Bagnasco, L.; Benjakul, S.; Lanter, S.; Morelli, C. F.; Speranza, G. and Cosulich, M. E. (2014). Characterization of mucilage extracted from seven ltalian cultivars of flax .J. Food Chem., 148: 60 – 69.

16. Kilor, V. and Bramhe, N. N. 2014 . Developement of effective extraction method for (Lepidium sativum) seed mucilage with higher yield. Journal of Advanced Pharmacy Education and Research, 4(3): 35360.

17. Mahmoud, M.J.; Jawad, A.J.; Hussain, A.M.; Al-Omeri, M.&Al-Naib, A. 1989 . In vitro antimicrobial activity of Salsola resmarinus and Adiantum capillusveneris. Int, J. Crude Drug Res., 27: 14-16.

18. Maira, R. S. C; C. S Norma; R R. Gabriel;C. G. Luis and David, B. A.2014. Chemical and functional properties of chia seed (Salvia hispanica L.) gum. International Journal of Food Science, 5(3): 1-5.
19. Mariod, A. A. (2018). Gum Arabic: structure, properties, application and economics. Academic Press.

20. Mirhosseini, H., & Amid, B. T. 2012. Influence of chemical extraction conditions on the physicochemical and functional properties of polysaccharide gum from durian (Durio zibethinus) seed. Molecules, 17(6), 6465-6480.

21. Monrroy, M.; E.Garcia ;K.Rios and Garcia, J. R.2017. Extraction and physicochemical characterization of mucilage from (Opuntia cochenillifera L.) miller. Journal of Chemistry, 10: 1-9.

22. Munda, E., Kaur, N., & Borah, A. 2022. Health benefits and utilization of Chia seed mucilage: A. review The Pharma Innovation Journal 2022; SP-11(6): 937-943

23. Muñoz Hernández, L. 2012. Mucilage from chia seeds (Salvia hispanica): microestructure, physico-chemical characterization and applications in food industry. Thesis PhD in Engineering Sciences . Pontificia Universidad Catolia De Chile Escuela DE Ingenieria.120pp

24. Munoz, L. A. ; A.Cobos.; O. Diaz. and Aguilera J. M. 2012. Chia seeds: microstructure, mucilage extraction and hydration, Journal of Food Engineering, 108, 216-224.

25. Nile, S. H.; Nile, A. S and Keum, Y. 2017. Total Phenolics, Antioxidant, Antitumor, and Enzyme Inhibitory Activity of Indian Medicinal and Aromatic Plants Extracted with Different Extraction Methods, 3 Biotech ,7:76.

26. Razavi, S. M. A.; S. A. Mortazavi; L. Matia-Merino; S. H. Hosseini-Parvar; A. Motamed zadegan and Khanipour, E. 2009. Optimization study of gum extraction from basil seeds (Ocimum basilicum L.). International Journal of Food Science and Technology 44: 1755–1762.

27. Salehi, F. and Kashaninejad, M.2017. Effect of drying methods on textural and rheological properties of basil seed gum. International Food Research Journal, 24(5): 2090-2096.

28. Segura-Campos, M. R., Ciau-Solís, N., Rosado-Rubio, G., Chel-Guerrero, L., & Betancur-Ancona, D. 2014 . Chemical and functional properties of chia seed (Salvia hispanica L.) gum. International journal of food science, 2014.

29. Timilsena ,Y.P.; Adhikari,R.; Barrow, C.J. and Adhikari, B. 2016. Physicochemical and Functional Properties of Protein Isolate Produced from Australina Chia seed , Food Chemistry, 212: 648-656.

30. Timilsena ,Y.P.; Stefan, R.A. and Adhikari, K.B. 2015. Molecular and Functional Characteristics of Purified Gum from Australina Chia Seed , Carbohydrate Polymers,8:1-34.

31. Ullah, R.; Nadeem, M.; Khalique, A.; Imran, M.; Mehmood, S.; Javid, A and Hussain, J. 2016 .Nutritional and Therapeutic Perspectives of Chia *Salvia hispanica* L.: a Review. Journal of Food Science and Technology ,53(4):1750–1758.

32. Vega, L. M. S and Campos, M. R. S. 2016.Edible Films : Properties, Industrial Applications and Salvia hispanica as Material for Their Development, Global advanced research journal of agricultural science , 5(10): 361-382.

33. Wang, W. H., Lu, C. P., & Kuo, M. I. 2022. Combination of ultrasound and heat in the extraction of chia seed (Salvia hispanica L.) mucilage: impact on yield and technological properties. Processes, 10(3), 519.

34. Warrand ,J. ; Michand ,P. ; Picton ,P.; Muller,L.; Curtosis , G.; Ralainiring,B. and Curtosis ,R. 2005. Structural Investigation of The Neutral Polysaccharide of Linumusita tissimuml Seed Mucilage, International Journal of Biological Macromolecules , 35 (3-4) : 121-125.

35. Zaharuddin, N. D.; Noordin, M. I. and Kadivar, A. (2014). The use of Hibiscus esculentus (okra) gum in sustaining the release of propranolol hydrochloride in a solid oral dosage form. Hindaw Publishing Corporation,BioMed Research International, Volume 2014 Aricle ID 735891, p:8.