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Improving the Functional Properties and Prolonging the Shelf of a Locally Made Burger by Adding Chia Seed Gel

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Abstract

Chia gel is a heteropolysaccharide complex gel primarily composed of unrefined fibre and carbohydrates. The study included the extraction of gel from Chia seeds. The extract exhibited a significant capacity to thicken, emulsify, and stabilize food compositions. The physical characteristics of Chia seed extract were assessed in terms of its primary components, which included moisture, ash, carbohydrates, protein and oil composition. Chia gel was utilized to substitute 1%, 2%, 3%, and 4% of the fat content in the burger processing. Substituting fat with Chia seed gel as an emulsifier has shown a statistically significant impact on the standard chemical, physical, and sensory characteristics. After comparing many samples, the results of the current research demonstrated that burgers prepared with 3% Chia seed gel had improved organoleptic qualities and were potentially technologically made.

Keywords:

Chia seeds, burger, oil holding capacity, water holding capacity, TBA, PV.

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Introduction

Southern Mexico is the native home of the edible Chia seed (Salvia hiapanica). Chia seeds contain substantial quantities of antioxidants, polyunsaturated fats such as linoleic and alpha-linolenic acids, dietary fibre, and protein (Porras-Loaiza et al., 2014). Commercially available in India, Chia seeds are regarded as a "Super food." Chia flour's incorporation in baked goods is seen as a value addition because of its nutritional qualities and ability to bind fat (Coorey et al., 2014).

Immersing Chia seeds in water enables them to produce mucilage polysaccharides, which are a form of transparent capsule that possess intriguing characteristics for the cosmetic, food, and pharmaceutical industries (Reyes-Caudillo et al., 2008, Al-Dabagh & Salih, 2020), Chia seeds maintain their integrity over extended periods post-cleaning and drying due to their antioxidant properties, which prevent the breakdown of essential oils (Hossain et al., 2024). Chia seeds possess a significant water-holding capacity (WHC) and include soluble fibre within their distinctive structure. This fibre is speculated to be a tetrasaccharide composed of 4-O-methyl glucopyranoside units which branche from a b-Dxylopyranosyl main chain (Lin et al., 1994). The procedure of extracting gel from Chia seeds involves multiple challenging steps. Previous studies indicate that the extraction yield varied between 4% and 7% when conducted at a temperature of 80 ºC (Muñoz et al., 2012).

The primary procedures for extracting Chia seed mucilage involve hydration, extraction, drying, and filtering (Karimov et al., 2024). Furthermore, microwave extraction (MAE) is an emerging technique that is attracting significant interest owing to its superior efficiency relative to conventional approaches (Niazi, 2017). Meat and meat products contain high levels of saturated fatty acids in addition to bad cholesterol, which has a direct negative impact on human health (Sanjay Yadav et al., 2018).

The fat content in meat and meat products significantly influences sensory attributes like juiciness, texture, and flavour, alongside its direct impact on the functional properties, which include cooking decline, emulsion stability, water holding capacity, and physical characteristics (Selaniet et al., 2016).

High consumption of saturated fat may result in the development of chronic diseases (Ding et al., 2018, Al-ghanimi & Alrubeii, 2024). The growing need for healthier food has encouraged the creation of meat products with reduced fat content.

Material and Methods

Chia seeds and fresh buffalo thigh, double-acting, were acquired from the local markets in Baghdad.

Chia Seed Gel Extraction

A 1:40 ratio of gel to water was implemented for extraction. An overhead mixer operated at 2000 rpm for 3 hours to combine the seeds with distilled water, followed by gel extraction from the seeds using a centrifuge set at 3000 rpm for 50 minutes at 37 °C. Three layers were collected after 50 minutes. The excess water in the top layer has been eliminated. The deposition of the seeds at the base facilitated the extraction of the gel from the intermediate layer. The gel was partly dehydrated at 40°C for 30 minutes and thereafter kept in sealed containers at ambient temperature (Chavan et al., 2017).

Chemical Composition Analysis

Moisture Content

Utilizing the methodology outlined in (ISO 1442, 2023), the moisture content of the samples was assessed, employing the following formula for estimation:

$$-Moisture\ content\ (\%)\ =\frac{(W1 - W2)}{W1}\ X\ 100$$

W1: weight (g) of sample before drying

W2: weight (g) of sample after drying

Crude Protein Determination: The Kjeldahl reference technique was used to ascertain crude protein levels (Standard, I. S. O, 1978). The protein content is determined using the following equation:

$$-Protein\ (\%)\ =\frac{(A-B)*N*14.007*6.25}{W}$$

A: Volume of 0.2N hydrochloric acid (ml) used in sample titration.

B: Volume of 0.2N HCl (mL) used in the blank titration.

N: HCl normality

W: weight of sample (g).

14.007: nitrogen atomic weight

6.25: protein nitrogen conversion factor.

Ash Determination

The ash content has been estimated using the reference technique described by (AOAC International, 2000) and was calculated according to the following equation:

$$-Ash(\%)=\frac{Weight\ of\ Ash}{Weight\ of\ Sample}*100$$

Fat Determination

The procedure outlined in (Association of Official Analytical Chemists and Association of Official Agricultural Chemists (US), 1931) was carried out to for calculating the the total fats in the samples, utilising petroleum ether as the solvent. A rotary evaporator was used to evaporate the solvent at temperatures between 40 and 60 C. The below equation was used to calculate the fat content:

$$-Fat(\%)=\frac{Weight\ of\ fat}{Weight\ of\ Sample}*100$$

Denaturation Temperature (Td)

The approach outlined in (Pati et al., 2010) was utilized to assess the temperature at which the seed gel breakdown. The method employing temperature-induced viscosity alterations measured with an Ostwald viscometer. The temperature was incrementally increased to 20, 25, 30, 35, 40, 45, 50, and 55 °C, Each temperature was subjected to a 30 min. incubation period. The measurement of viscosity is illustrated as follows:

$$\frac{\eta_2\ Sample\ viscosity}{\eta_1\ Water\ viscosity} = \frac{P_2 t_2}{P_1 t_1}$$

t1: water traversal time.

P1: water density (1 g/ml).

t2: water traversal time.

P2: sample density (0.982 g/ml). Below is the calculation method of the fractional viscosity at each temperature:

Fractional viscosity = (measured viscosity at each time - minimum viscosity) / (maximum viscosity - minimum viscosity).

Denaturation temperature (Td) is the temperature at which the fractional viscosity (η) reaches 0.5, indicating it is half of the maximum value (1).

Emulsifying ability (EA) and Emulsifying Stability (ES)

The methodology referenced in (Coorey et al., 2014) was used to quantify (EA) and (ES). The outcome of EA was represented as a percentage and is determined according to the following formula:

$$-EA\ (\%) = \frac{Total\ emulsified\ layer}{Total\ Volume\ of\ Suspension} * 100$$

The below formula was used to estimate the ES of the emulsified layer:

$$-ES\ (\%) = \frac{Total\ emulsified\ layer}{Total\ volume\ of\ suspension} * 100$$

Antioxidant Assay

The approach described in (Salman et al., 2019) was followed for the purpose of evaluating α,α-diphenyl-β-picrylhydrazyl (DPPH) free radicals scavenging efficiency. A low absorbance result suggests enhanced DPPH scavenging action, expressed as:

$$-Scavenging\ activity\ (\%) = \frac{(Blank\ A517 - sample\ A517)}{Blank\ A517} * 100$$

Water Holding Capacity (WHC)

To assess the water holding capacity (WHC), the procedure outlined in (Cumby et al., 2008) was implemented by determining the weight difference. WHC was determined by calculating the amount of water absorbed per (g) of Chia seed gel.

$$-WHC\left(\frac{g}{g}\right) = \frac{(Weight\ of\ wet\ sample - Weight\ of\ dry\ sample)}{Weight\ of\ the\ dry\ sample}$$

Oil Absorption Capacity (OAC)

The determination of OAC was performed using the approach described in (Monteiro & Prakash, 1994), with several modifications included. The OAC was measured as the amount of oil absorbed per gr of the sample according to the following equation:

$$-OAC\left(\frac{g}{g}\right) = \frac{(Weight\ of\ wet\ sample - Weight\ of\ dry\ sample)}{Weight\ of\ dry\ sample}$$

Peroxide values (PV)

The approach mentioned in (Sallam & Samejima, 2004) was followed for the purpose of estimating the peroxide number (POV) of the burger by applying the following equation: which was represented as milli equivalent peroxide per kg of sample:

$$(S \times N) / W\} \times 1000 = PV\ (mEq / kilogram)$$

Where N is the sodium thiosulfate solution's normalcy and S is the titration volume (milliliter). (N = 0.01); W, is the sample weight (g).

Thio Barbituric Acid Reactive Substance (TBARS)

Applying the methodology developed by (Witte et al., 1970), TBA was prepared each day. The TBA value was determined as milliliters of malonaldehyde (MDA) per kilogram of beef.

TBA value (mg MDA/kg meat) = 5.7 X Abs.532 nm

Determination of pH Value

For the purpose of measuring pH, the homogeneous mixture was filtered and a pH meter was used after calibration at pH 4 and 7 (17).

Antimicrobial Activity

Using the methods outlined by the American Public Health Association (Downes & Ito, 2001).

Sensory Evaluation

Burger preparation involved grinding the beef meat separately using a Gosonic, China 1800 w Max plate, and then dividing the ground meat into five treatments (Zangana & Al-Shamery, 2016). The entire amount of ground beef meat—2.0% sodium-chloride was utilized in the formulation. As a control (CONT). Four different treatments, each with a Chia addition of 1%, 2%, 3%, and 4%. Following the formation of the burger, 100 g portions were hand formed with an Inox burger maker machine resulting in 10 cm in diameter and roughly 1 cm in thickness. Samples of burgers from each treatment were weighed separately and cooked for two minutes on each side on a clam-shell grill that had been preheated to 150 °C.

Result and Discussions

The chemical composition of the chia seeds under investigation is presented in Table (1). Numerous researches (Ullah et al., 2016; Das, 2018; Mohd Ali et al., 2012; Kulczyński et al., 2019), have examined the chemical composition of Chia seed. Level of lipid 31%, carbs 35%, and proteins 16% are found in Chia seeds. In comparison to the protein levels found in rice (6.5%), corn (9.4%), quinoa (14.1%), and wheat (12.6%), Chia seeds exhibit a protein content that surpasses these grains by 16% (Repo-Carrasco-Valencia et al., 2010; Ullah et al., 2016; Noshe & Al-Bayyar, 2017). Agronomic and environmental factors are the primary determinants of Chia seed protein content (Ullah et al., 2016).

Statistical Analysis

The SAS (Cary, 2012) software was utilized to ascertain the impact of variance variables on the study parameters. In this study, the means were significantly compared using the least significant difference (LSD) method (ANOVA/two way).

Table 1. Chemical composition of Chia seed

Chemical composition	%
Protein	16
Moisture	17.22
Fat (oil)	31
Ash	0.78
Carbohydrate	35

Viscosity

The viscosity of a fluid is a measure of the internal friction that causes it to resist flowing, which in turn is a measure of the fluid's consistency (Bourne, 2002). Figure 1 illustrates how variations in temperature influence the viscosity of the samples. The rise in viscosity correlates with the greater proportion of sample present in the solution alongside the heightened concentration levels. The findings indicate an inverse relationship between rising temperatures and the reduction in viscosity of the samples. This observation aligns with results from comparable studies (Garcia-Ochoa & Casas, 1992; Casas et al., 2000) on guar gum and carob gum, which can be explained by the thermal effects on molecular behavior at elevated temperatures. The rise in temperature led to a reduction in the viscosity of all samples. both (Garcia-Ochoa & Casas, 1992; Casas et al., 2000), observed corresponding results with guar gum and locust bean gum, attributing these findings to thermal effects on molecules at elevated temperatures.

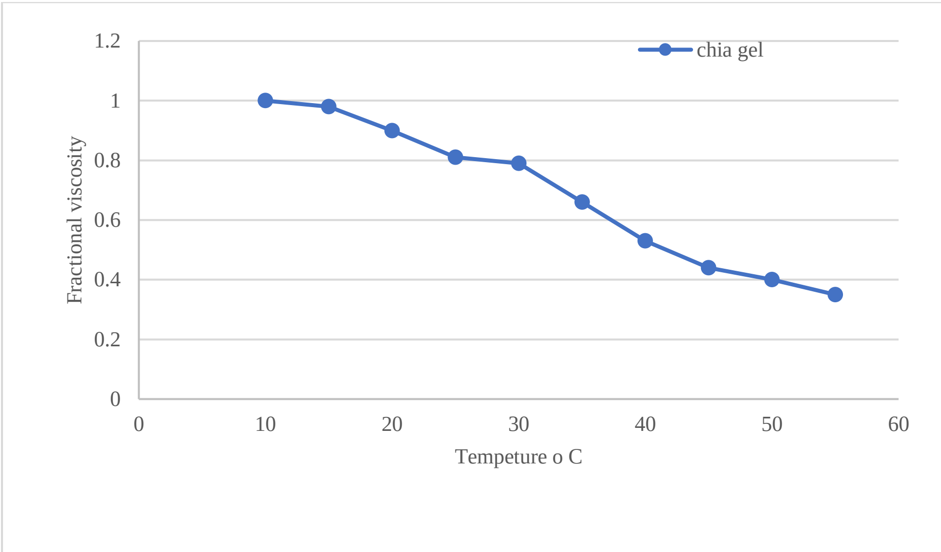


Figure 1. Influence of temperature on chia seed gel viscosity

DPPH Radical- Scavenging Activity

The findings from the antioxidant test revealed that Chia seeds exhibited an activity level of 73%, corroborated by earlier studies that demonstrate the capacity of Chia seeds to eliminate free DPPH radicals and diminish iron ions (Campos, 2018; Reyes-Caudillos et al., 2008) Moreover, natural antioxidants, such as tocopherols, phytosterols, carotenoids, and polyphenols, the main compounds that enhance the antioxidant properties of chia seeds, are present in chia seed oil at high levels.

Activity and Stability of the Emulsion

The stability of the emulsifying agent during decomposition was assessed, along with the capability of the emulsifier in forming a water-in-oil emulsion. Table (2) demonstrates that the emulsion activity of Chia seed gel was recorded at 63.12% and 68.79%, respectively, which is characteristic of polysaccharides. The findings from a study carried out by (Onweluzo et al., 1995) regarding the impact of emulsifiers on three varieties of tropical legumes: Afzelia africana, Detarium microcarpum, and Mucuna flagellum, indicated that the emulsification performance of lupin protein isolate (53%) is significantly inferior to that of CSG emulsifier, yet comparable to that of Chia seed gel (Hossain et al., 2024). The Chia seed gel had the best emulsion stability at 69%, whereas guar gum demonstrated the lowest at 35%.

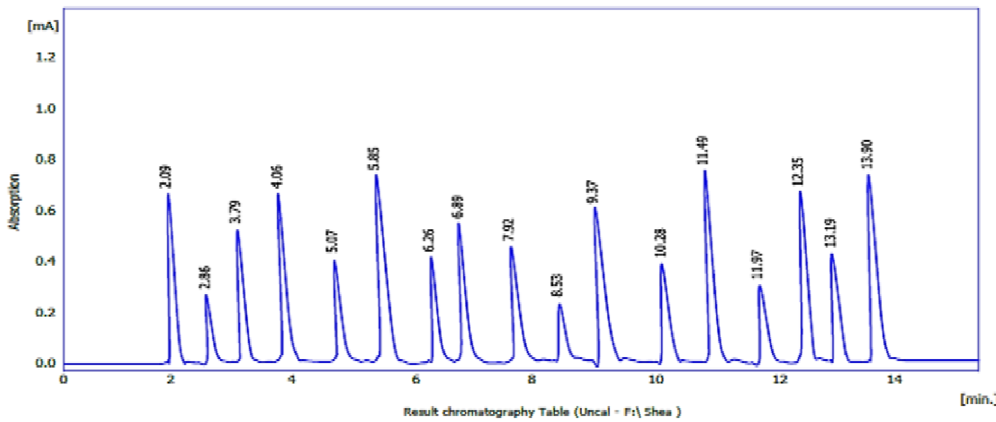
CSG has superior emulsification activity and produces more resilient emulsions than the other evaluated materials, including commonly used guar gum and gelatin. A study conducted by (Onweluzo et al., 1995) revealed that the emulsion stabilities of Afzelia africana and Mucuna flagellum gums were 55.73% and 80%, respectively. Conversely, in comparison to the findings of the study by (Coorey et al., 2014), the lupin protein extract demonstrated a comparable improvement, rising from 53% to 89% and from 46% to 95% for two distinct lupin species, respectively. The elevation of the emulsified layer during heating can originate from temperature-dependent structural changes that improve its orientation at the water-oil interface.The rise in the emulsified layer upon heating may result from temperature-dependent alterations in structure that enhance its direction within the water-oil interphase.

Table 2. EA and ES of Chia seed gel

Sample	Emulsion activity (%)	Emulsion stability (%)
Chia seed gel	63.12	68.79

Amino Acid Composition Analyses

Figure (2) illustrates the analysis of ten external amino acids, such as arginine, leucine, phenylalanine, valine, and lysine. These amino acids showed an increase in concentration. Several naturally occurring amino acids, including glutamic acid, aspartic acid, alanine, serine, and glycine, are found in significant concentrations (Nitrayová et al., 2014; Haytowitz et al., 2019; Bushway et al., 2019).



No	Reten. Time [min]	Area [mAU.s]	Height [mAU]	Amount (µg/gm)	Calculation	Peak type	Compound Name
1	2.09	7452.55	621.50	16.95	Calibration carve	Order	Aspartic acid
2	2.86	3256.98	212.65	12.89	Calibration carve	Order	Asparagine
3	3.79	5211.45	500.80	19.88	Calibration carve	Order	Lysine
4	4.06	7859.52	625.90	17.82	Calibration carve	Order	Serine
5	5.07	8265.49	313.66	14.51	Calibration carve	Order	Threonine
6	5.85	4200.14	601.45	11.62	Calibration carve	Order	Isoleucine
7	6.26	8621.55	320.80	19.06	Calibration carve	Order	Alanine
8	6.89	4526.55	501.51	14.05	Calibration carve	Order	Valine
9	7.92	6320.12	213.60	16.71	Calibration carve	Order	Tyrosine
10	8.53	7455.08	500.88	10.24	Calibration carve	Order	Arginine
11	9.37	5263.65	522.65	9.66	Calibration carve	Order	Cysteine
12	10.28	5214.56	338.90	19.08	Calibration carve	Order	Methionine
13	11.49	2985.80	521.45	13.52	Calibration carve	Order	Proline
14	11.97	5621.45	220.80	18.02	Calibration carve	Order	Histidine
15	12.35	7542.62	520.80	14.55	Calibration carve	Order	Lucien
16	13.19	7412.65	322.64	20.38	Calibration carve	Order	Phenylalanine
17	13.90	5923.66	592.56	10.69	Calibration carve	Order	Glycine
	Total						

Figure 2. Chia seed gel Amino acid analysis

Water Holding Capacity

The greatest WHC of the Chia seed gel, as indicated in Table (3), was 88 g for 3 days and 167 g for 6 days in 3%. According to (Savita et al., 2004), soluble fiber and protein degradation may have optimized the water-holding capacity (WHC) of Chia seed gel, hence augmenting its swelling ability. Proteins are fundamental to the structural composition of viscous foods, such as soups, broths, doughs, and baked goods. The findings presented in (Alfredo et al., 2009; Baquero & Bermúdez, 1998) indicate that the water-holding capacity (WHC) of Chia seed gel exceeds that of the fiber-rich fraction of Chia seeds, which is measured at 15.41 g/g fiber, as well as that of passion fruit peel, recorded at 8.7 g/g fiber. Furthermore, (Sáenz et al., 2007) findings showed that orange waste exhibited a comparable range of 7.65–8.23 g/g fiber.

Table 3. The WHC of Chia seed gel on burger during storge period

Period	Sample	WHO (g/g)	L.S.D (P-value)
0 day	Control	62	8.92 * (0.0284)
	1%	69	
	2%	60	
	3%	61	
	4%	58	
3 days	Control	71	11.61 ** (0.0076)
	1%	78	
	2%	85	
	3%	88	
	4%	90	

6 days	Control	80	17.52 ** (0.0001)
	1%	93	
	2%	142	
	3%	167	
	4%	178	
9 days	Control	96	26.95 ** (0.0001)
	1%	123	
	2%	156	
	3%	164	
	4%	172	
L.S.D (P-value)	---	24.459 ** (0.0001)	---
* (P≤0.05), ** (P≤0.01).			

Oil Holding Capacity (OHC)

Table (4) displays that the greatest OHC of Chia seed gel was 14.95 and 22.27 g/g for three days for 4%. This indicates that the gel has adequate oil holding capability (OHC), hence contributing significantly to food processing, since fat influences taste preservation and enhances the sensation of food taste. The OHC values of Chia seeds exhibited comparable values to those of Arabic gum, ranging from (8-9 g oil/g fiber). In contrast, the OHC values of Chia seed gel were notably higher than those of guar gum and xanthan gum (4-6 g oil/g fiber), suggesting a connection between the physical entrapment of oil within molecules like lipids and proteins and their functional characteristics.

The protein and lipid content, particle size, and lack of hemicellulose are all plausible factors contributing to the reported OHC in Chia gums. The OHC values of Chia gum can be linked to its protein and fat content, along with additional characteristics like particle size and the lack of hemicellulose.

Table 4. The OHC of Chia seed gel on burger during stored period

Period	Sample	OHC (g/g)	L.S.D (P-value)
0 day	Control	8.82	1.064 NS (0.628)
	1%	8.29	
	2%	8.53	
	3%	8.65	
	4%	8.78	
3 days	Control	9. 31	3.514 * (0.0385)
	1%	9. 87	
	2%	10.86	
	3%	11.93	
	4%	14.95	
6 days	Control	16.44	4.137 ** (0.0091)
	1%	18.76	
	2%	19.99	
	3%	20.08	
	4%	22.27	
9 days	Control	19.5	5.135 ** (0.0074)
	1%	22.9	
	2%	23.0	
	3%	25.65	
	4%	26.34	
L.S.D (P-value)	---	5.281 ** (0.0001)	---
* (P≤0.05), ** (P≤0.01).			

Peroxide Values Determination (PV)

The peroxide value provides an easy method of determining the level of primary lipid oxidation. For the purpose of determining the quality of meat and its products, the peroxide value scale is used as a main indicator of fat oxidation levels.

The effects of various time incubation treatments on the peroxide test were displayed in Table (5). No impact of Chia seed gel on the hydrogen peroxide test results was noted prior to storage (0 days). Extended storage durations correlated with elevated peroxide readings, despite significant differences ($p<0.05$) attributable to treatments.

The results demonstrated that in the meat burger treated with Chia seed gel. Burgers treated with 4% Chia seed gel had higher antioxidant properties than those treated with conventional methods. Throughout the storage procedure, the hydrogen peroxide levels in the control samples exhibited an increasing trend in comparison to the values in the other samples. Burgers treated with Chia seed gel had a higher antioxidative effect on the peroxide value than the control. According to a phenolic content study, the concentration of phenolic components in dried Chia seeds amounted to 8.8%. The peroxide value increased very slightly over the storage period in all treatments except control, which was similarly consistent with the findings of (Georgantelis et al., 2007) on beef burgers treated with rosemary extract.

Table 5. Effect of peroxide value for Chia seed gel during storage of beef burger

Treatment	Mean ±SE of PV (mEq/Kg)				LSD value
	0day	3 days	6 days	9 days	
Control	0.665 ±0.07 A d	4.50 ±0.50 A c	10.83 ±0.83 A b	14.16 ±0.83 A a	2.514 *
1%	0.615 ±0.02 A d	4.33 ±0.33 AB c	7.99 ±0.34 B b	11.16 ±0.17 B a	0.978 *
2%	0.580 ±0.02 A c	4.33 ±0.01 AB b	7.16 ±0.50 BC a	7.16 ±0.17 C a	1.034 *
3%	0.600 ±0.00 A c	3.33 ±0.33 BC b	5.50 ±0.50 C b	11.83 ±1.17 AB a	2.580 *
4%	0.580 ±0.02 A d	2.49 ±0.16 C c	6.16 ±0.50 BC b	11.16 0.17± B a	1.084 *
LSD value	0.117 NS	1.143 *	2.025 *	2.382 *	---
Means of uppercase characters in the same column and lowercase letters in the same row differed significantly. *P ≤ 0.05.					

TBARS Values

Table (6) lists the beef burger's TBARS values. On the first day of storage, there were no variations in the pan-grilled beef burger's TBARS values. Both control samples (1.45 mg MDA/kg) and Chia gel sample (6.98 mg MDA/kg) exhibited elevated TBARS values at ($p<0.05$) after 9 days of storage, despite minor variations throughout the storage period.

Because Chia gel contains bioactive substances as mrycetin, quercetin, rosmarinic acid, and caffeic acid, among others, it demonstrated antioxidant properties in pan-grilled beef burgers (Zaki, 2018; Pintado et al., 2016) In addition, a significant ($p<0.05$) interaction between the Chia gel and the cooking method was recorded.

The incorporation of chia gel into grilled beef burgers resulted in elevated TBARS levels. The observed increase can be linked to the elevated levels of polyunsaturated fatty acids present in the mucilage, resulting in a rise in lipid oxidation.

When Chia butter extract was added to pork burgers in place of pork fat, the TBARS levels rose considerably; these findings are in line with the study's findings by (Urgu-Öztürk et al., 2020).

However, findings of (Zaki, 2018) noted that samples made with Chia seeds had lower TBARS values than controls made with hog fat.

Table 6. Effect TBARS of different concentrations of Chia gel on a beef burger at storage period

Treatment	Mean ±SE of TBA (MDA/ Kg)				LSD value
	0day	3 days	6 days	9 days	
Control	1.45 ±0.03 C d	4.23 ±0.10 A c	6.81 ±0.08 A b	10.59 ±0.42 A a	0.854 *
1%	0.740 ±0.06 D d	3.60 ±0.04 B c	5.26 ±0.01 B b	9.02 ±0.08 B a	0.212 *
2%	1.86 ±0.14 B d	4.04 ±0.14 A c	5.48 ±0.06 B b	8.79 ±0.04 B a	0.422 *
3%	2.14 ±0.14 AB c	2.11 ±0.12 C c	4.88 ±0.74 B b	7.81 ±0.08 C a	1.514 *
4%	2.39 ±0.11 A d	4.09 ±0.05 A b	3.59 ±0.09 C c	6.98 ±0.12 D a	0.389 *
LSD value	0.392 *	0.356 *	1.230 *	0.731 *	---
Means of uppercase characters in the same column and lowercase letters in the same row differed significantly. *P ≤ 0.05.					

The Effect of pH

The alterations in pH levels of fresh burgers preserved at 4°C for 9 days due to the incorporation of Chia seed gel (Salvia hispanica) are presented in Table (7). A rise in pH was noted with extended storage duration across all assessed treatments (Saleh et al., 2022). Comparable results were reported by (Georgantelis et al., 2007) in a study of pork sausage stored at refrigeration temperatures for 20 days, and by (Brannan, 2008) in a study indicating a rise in pH levels in chilled chicken. An observable rise in the population of psychrotrophic bacteria, known for their production of proteases, could potentially explain this phenomenon. When bacteria begin producing proteases, they grow on amino acids rather than glucose. When amino acids are used, amines and ammonia are produced, which raises pH (Terra et al., 2008). Significant differences in pH values ($P \leq 0.05$) have been observed for all treatments over throughout the duration of the 9 days storage period.

Table 7. Effect of PH of different concentration of Chia seed gel on beef burger at storage period

Treatment	Mean ±SE of PH				LSD value
	0day	3 days	6 days	9 days	
Control	5.85 ±0.05 AB d	6.05 ±0.05 BC c	6.85 ±0.05 A b	8.35 ±0.05 A a	0.196 *
1%	5.95 ±0.05 A d	6.10 ±0.00 AB c	6.55 ±0.05 B b	7.80 ±0.02 C a	0.138 *
2%	5.85 ±0.05 AB c	5.95 ±0.05 C c	6.60 ±0.10 B b	7.95 ±0.05 BC a	0.259 *
3%	5.70 ±0.00 B d	6.20 ±0.00 A b	6.05 ±0.05 D c	7.85 ±0.05 C a	0.138 *
4%	5.85 ±0.05 AB c	6.15 ±0.05 AB b	6.30 ±0.00 C b	8.05 ±0.05 B a	0.170 *
LSD value	0.162 *	0.140 *	0.215 *	0.162 *	---
Means of uppercase characters in the same column and lowercase letters in the same row differed significantly. *P ≤ 0.05.					

Antimicrobial Activity

The findings of the present investigation demonstrated in figure (3) that the Chia gel extract is superior to other forms of bacteria and fungus in inhibiting the most significant bacteria in 2% at 9 days. After specific chemical components (active groups) were found in Chia seed gel extract, it was determined that Chia seeds possess several active groups, including tannins, flavonoids, resins, and additional substances (Terra et al., 2008). The ability of fresh beef burgers to tolerate positive microorganisms. Because of this, the cooked beef burgers were within the legal bounds, indicating that the processing was done under hygienic conditions that were sufficient and in accordance with good manufacturing procedures. Total aerobic mesophilic and psychrotrophic microorganism counts were conducted (figure 3) to confirm the shelf life of the refrigerated beef burger. These measurements provide an estimation for the total number of coexisting microbes across a broad spectrum of temperatures, playing a crucial role in evaluating the quality, safety, and health of meat products.

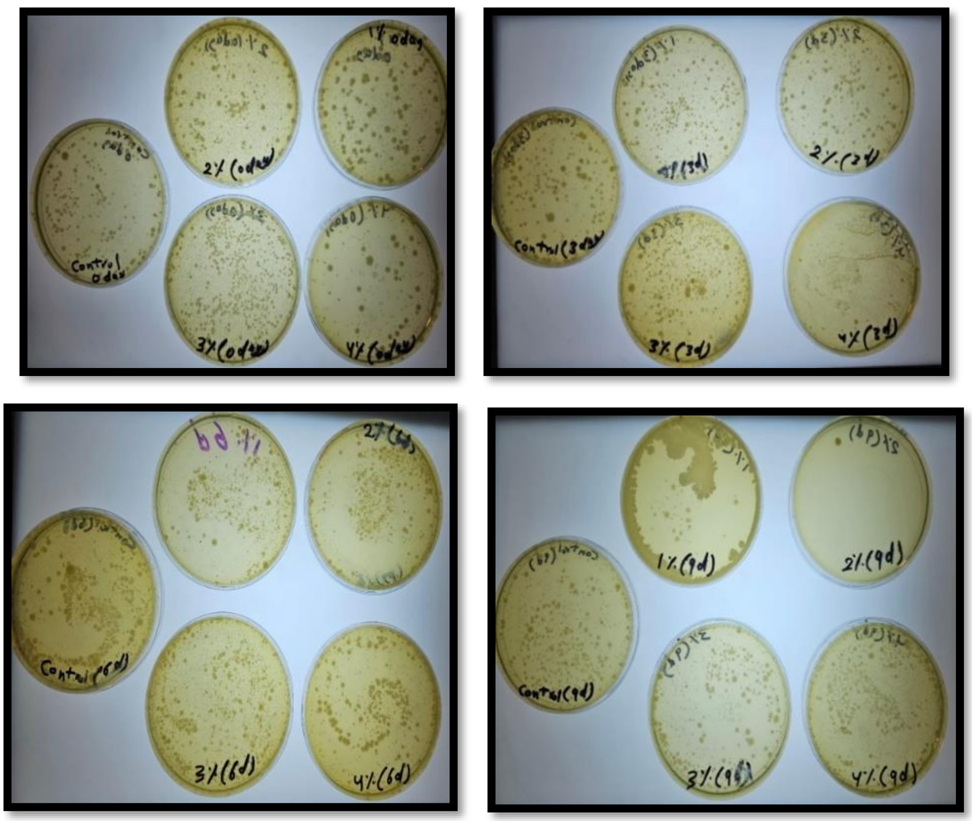


Figure 3. Effect of Chia gel concentration on antimicrobial activity in beef burger

Sensory Evaluation

Due to the activities of fat in meat products, one of the limiting constraints for fat- methods is their sensory characteristics. Customers' desire to buy is influenced by a variety of organoleptic characteristics, including texture, flavor, mouthfeel, color, and odor, in addition to safety. Table (8) displays the beef burger's sensory scores. With the exception of juiciness, the cooking technique generally had the most impact on the sensory characteristics. The grilled beef burger received superior ratings for all sensory attributes (3% compared to 4%). The majority of experimental groups had sensory scores of about 4. Therefore, it could be said that consumers liked all beef burgers, and that those made with less beef fat were actually.

Table 8. Effect of Chia gel concentration in beef burger sensory evaluation

Treatment	Mean ±SE				
	Texture	**Flavor**	**Mouth feel**	**Color**	**Odor**
Control	3.58 ±0.28 ab	3.67 ±0.25	3.83 ±0.27	3.75 ±0.32	4.25 ±0.22 a
1%	3.00 ±0.38 b	3.50 ±0.23	3.58 ±0.31	4.17 ±0.24	3.91 ±0.19 ab
2%	3.17 ±0.29 ab	3.50 ±0.31	3.25 ±0.28	4.00 ±0.27	3.58 ±0.26 b
3%	3.91 ±0.26 a	3.67 ±0.25	3.67 ±0.25	4.16 ±0.27	3.92 ±0.19 ab
4%	3.33 ±0.21 ab	3.33 ±0.35	3.08 ±0.36	4.08 ±0.28	3.75 ±0.25 ab
LSD value	0.841 *	0.811 NS	0.843 NS	0.799 NS	0.636 *
Means having with the different letters in same column differed significantly. * ($P \leq 0.05$).					

Conclusion

The results of this study highlight the significant physicochemical properties of Chia gums for their use in food production. Chia gum that had some of its fat removed showed a significant capacity for WHC (147 g/g) and (OHC) of 19.99 g/g over a period of 6 days at a concentration of 2%. The findings from several previous studies, along with the current investigation, have demonstrated that Chia seed gum serves as a significant nutritional element due to its emulsifying and stabilizing characteristics.

Author Contributions

All Authors contributed equally.

Conflict of Interest

The authors declared that no conflict of interest.

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