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Evaluation of Nutritionally Enhanced Low-Fat Beef Burgers for Elderly with Chia Seed Flour as a Functional Fat Substitute

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ABSTRACT

Seniors nutrition involves many age-related digestive health challenges and increased needs from animal protein. In this study a low-fat beef burger was developed by incorporating chia seed flour at levels (0-2.5-5-7.5-10%) as a fat substitute. The effect of chia flour on chemical, antioxidative, technological, sensory, nutritional characteristics were investigated. Chemical analysis showed that chia seed samples were superior in fiber, fat, and ash (31.83, 32.37, and 4.85 g/100 g) compared to beef (5.57 and 1.25 g/100 g), respectively. The fiber content of fortified burgers reached 1.38, 2.78, 3.96, and 4.62 g/100 g at the respective substitution levels, with no significant differences in protein. Chia seeds showed high antioxidant capacity (DPPH) due to their contents of phenolic compounds (82.99 mg GAE/g), flavonoids (9.18 mg CE/g), and tannins (15.20 mg TAE/g). Technological properties improved progressively; water-holding capacity increased from 72.3 ± 1.2% (control) to 82.3 ± 1.0% in the 10% chia flour treatment, while cooking yield improved from 68.9% to 78.1%. The 5% chia flour treatment recorded improved technological properties and higher sensory acceptability, whereas higher concentrations (7.5–10%) resulted in a slight decrease in sensory scores. Nutritionally, a 100 g portion of the 10% chia flour burger provided about 18% of the recommended daily fiber requirements and 23% of protein. Therefore, chia seeds represent a promising addition to traditional beef burgers, reformulating them into functional foods suitable for older adults by reducing animal fat, increasing fiber content, and maintaining the nutritional value of beef without compromising technological aspects.

Keywords: chia, nutrition; beef burgers; seniors, antioxidative capacity, cooking yield, functional, fiber.

INTRODUCTION

Older adults have distinct nutritional requirements due to age-related physiological changes, including reduced muscle mass, altered fat metabolism, and slower gastrointestinal motility. Adequate intake of high-quality animal protein is essential to preserve lean body mass and prevent Sarcopenia, while moderate fat intake supports energy balance and nutrient absorption. In addition, dietary fiber is equally important to enhance digestive function and prevent constipation, a common issue in aging populations (Volkert *et. al*., 2019).

Nutrient Recommendations for older adults (≥ 65 years) for Protein, according to ESPEN 1.0–1.2 g protein/kg/day, rising to 1.2–1.5 g protein/kg/day for those who are active or ill (Volkert, 2015). Regarding Fiber, EFSA (2010) recommends 25 g/day for typical adults to support bowel function, cardiovascular, and metabolic health. While estimated energy daily requirements are approximately 2000 kcal/day for moderately active older adults. That can be interpreted for a reference body weight of 70 kg was used (i.e., protein requirement ≈ 84 g/day, assuming 1.2 g/kg/day; fiber 25 g/day; energy 2000 kcal/day) according to (USDA, 2020).

Meat products are nutrient-dense foods that provide mainly proteins, vitamins and other vital minerals like iron and zinc, as well as high-quality protein and B vitamins (Ahmad *et al*., 2018). However, because of their high saturated fat content, which possess health risks, especially for older people at risk for cardiovascular illnesses, red meat products have been stigmatized during the past twenty years (Ding *et al.,* 2018).

Eventhough, fats play an essential role in rheological, structural and binding qualities of meat, especially in the ground and emulsified meat products (Selani *et al.,* 2016). Fats also crucial in the texture of meat products. They contribute to its water-binding capacity and act as stabilizers for protein gel networks, which affects the emulsion stability of emulsion-based products (Jiménez Colmenero, 2000). Thus, the increasing interest in creating reduced-fat formulations that preserve these desired qualities of these meat products to reduce fat is challenging technique.

Chia seeds (*Salvia hispanica L.*) have emerged as a promising functional ingredient for meat product reformulation. They are nutritionally rich, containing high levels of omega-3 fatty acids (Coates, 2011), dietary fiber (Reyes-Caudillo *et al.,* 2008), and antioxidants (da Silva Marineli *et al*., 2015). Their unique ability to form mucilage gels when hydrated (Capitani *et al*., 2012)makes them particularly suitable as fat replacers, potentially enhancing the texture and water retention of meat products.

According to Weber *et al*., (1991), chia seeds are a potential source of protein (19–27 g/100 g). Compared to other conventional crops including wheat, corn, rice, oats, barley, and amaranth, it has a higher protein content (Ayerza and Coates, 2005). Chia's amino acid composition has no limiting factors in the adult diet, despite the fact that it is not commercially farmed as a protein source (Bushway *et al*., 1981). According to da Silva Marineli *et al*., (2014), chia

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might have antioxidant properties in vivo. They have demonstrated that chia seeds and oil correct plasma lipid peroxidation, which is elevated by a high-fat diet, and enhance antioxidant status. Guard against the oxidative damage that diet-induced obesity causes in rats, due to their low SFA content and healthy omega 6/omega 3 ratio (Ayerza and Coates, 2005), chia oil may be an interesting alternative to improve the nutritional quality of burgers.

A recent study by Câmara *et al. (*2020) examined the use of chia mucilage gels (CMG) to replace 50% of pork-back fat in meat emulsions, also assessing the effect of varying CM concentrations. The results showed that neither fat nor liquid exudation was affected by fat reduction or CMG addition. However, certain CMG formulations slightly enhanced water retention capacity, suggesting its potential as an effective water-binding agent in meat systems. The inclusion of CMG slightly increased the hardness and chewiness of the sausages, likely due to reduced fat content and the thickening, high-fiber nature of chia mucilage. Overall, the study concluded that incorporating CMG into emulsion-based meat products did not significantly alter technological properties while improving emulsion stability.

Yüncü *et al*., (2022) used chia mucilage (CM) as fat replacer at levels of 5% , 10%, and 15%, to examine the nutritional value and technological attributes of beef patties cooked by different cooking methods (grilling and pan-frying). They reported an increased dietary fiber and decreased fat contents with potential enhancing ω-3 and ω-6 contents while reducing atherogenicity and thrombogenicity indices associated with cardiac diseases risk. Adding CM also improved the product's nutritional and technological properties.

This suggests that chia mucilage may serve as a promising alternative to saturated fats in emulsified meat formulations, offering not only enhanced technological performance but also added health benefits aligned with current nutritional guidelines for healthy aging. Previous studies have demonstrated the successful incorporation of chia seeds in chicken and pork products (Paula *et al*., 2019), fish burger (Riernersman and Marí, 2016) and beef burger (Heck *et al*., 2017).

The current study aime to develop a reduced-fat beef burger designed for elderly people as a high protein convenient food, using chia seed flour as a fat substitute and source of fiber at 2.5, 5, 7.5, and 10% levels of substitution. In addition, to assess the effects on the technological and sensory aspects of prepared beef burger, targeting older adults nutritional needs.

MATERIALS AND METHODS

Materials:

Chia seeds (*Salvia hispanica L*) were purchased from local market branded Abu Ouf, in Mansoura, Egypt. The beef meat, fat, and other ingredients were provided from the local market, Egypt. All chemicals and reagents were provided by ElGomhoryia Company for Chemicals and Drugs, Cairo, Egypt.

Methods

Preparation of Chia Seeds Flour:

Chia seeds were milled with electric grinder (Moulinex, France) to obtain whole chia seeds flour, and then it was frozen at −18˚C until used.

Preparation of Beef Burger:

Preparation of beef burger was carried out according to (Elkatry and Elsawy, 2021)and (Troutt *et al.,* 1992) in formulas shown in (Table A). Burgers were packed and kept at -18 °C. The substitution levels of whole chia flour were (0, 2.5%, 5%, 7.5%, and 10%). the used levels of chia seed flour were carefully selected to comply with the Egyptian Standard Specification No. 1688/2005 for frozen beef burgers. This standard permits the addition of natural fillers and plant-based fiber sources within limits not exceeding 10% of product (EOS, 2005).

Table A. Beef Burger Formulation using Different Chia Seeds Flour levels

Formulas	% Components					
	Meat	Onion	Salt	Spices	Animal Fat	Chia flour
Control	67	15.5	1.25	1.25	15	-
CF 2.5	67	15.5	1.25	1.25	12.5	2.5
CF 5	67	15.5	1.25	1.25	10	5
CF 7.5	67	15.5	1.25	1.25	7.5	7.5
CF 10	67	15.5	1.25	1.25	5	10

CF 2.5 = 2.5% fat substituted by chia flour; CF 5 = 5% fat substituted by chia flour; CF7.5 = 7.5% fat substituted by chia flour, CF 10% = 10% fat substituted by chia flour.

Chemical Analysis

Proximate Chemical Composition:

Moisture, protein, fat, fiber, and ash contents of raw samples were determined according to the methods of (A.O.A.C., 2000). Total carbohydrates were calculated by the difference. All proximate composition experiments were performed in triplicate and expressed as g/100 g of burger.

Phytochemical Analysis:

Preparation of Chia Seeds Extract:

The alcoholic extract was prepared using (70%) ethanol following the procedure of (Issa *et al*., 2016). The mixture was cooled to room temperature and filtered three times using Watman filter paper No. 1. and the filtrate was concentrated by rotary evaporator. The extract was kept at 4 ºC for analyses.

1. Total Tannin Contents:

The tannin contents were analyzed following the procedure of vanillin-hydrochloride assay (Aberoumand, 2009) as gram tannic acid equivalents /100-gram dry plant.

2. Total phenolic contents:

Total phenolic contents were determined using Folin and Ciocalteu, (1927) method. As modified and described by (Cicco *et al*., 2009), (Wolfe *et al.,* 2003) and (Issa *et al*., 2016), in which the standard curve of Gallic acid was used to calculate the distinguished values as milligram Gallic acid equivalents/grams of the dried seeds.

3. Total Flavonoid Contents:

Total Flavonoid Content was articulated as milligram catechin equivalent per gram of the dry weight of chia. The test was run using aluminum chloride colorimetric assay following the procedure reported by (Zhishen *et al*., 1999). The total flavonoids were estimated at standard curve ($y = 0.0028\ x$, $r^2 = 0.988$). All photometric assays were carried out using Spectrophotometric (Spekol 11 spectrophotometer, analytic Jena AG, Jena, Germany).

Antioxidant Activity using DPPH assay

The antioxidant capacity of the ethanol extract of the chia seeds samples was investigated following the DPPH colorimetric method using ascorbic acid as a standard by way of the assay reported by (Kitts *et al*., 2000) and calculated stratifying the subsequent equation (Eq.:

$$\% \, DPPH^{\bullet} \text{ remaining} = [DPPH^{\bullet}]_{T} / [DPPH^{\bullet}]_{T=0} \times 100$$

The values of % DPPH remaining were plotted versus mg extract/mL using an exponential curve to identify the effective concentration “IC^{50}”. IC^{50} indicated the constitutes amount of antioxidants needed to decrease the initial concentration of DPPH solution by 50%.

Water Holding Capacity (WHC) of The Beef Burger Samples:

Water holding capacity test (WHC) of burger formulas was measured according to the method described by Honikel (1998).

Cooking yield of The Beef Burger Formulas:

The samples of burgers were cooked by a grill at 180 °C for 10 min according to the method described by (Hernández-Alhambra *et al*., 2024). The cooking yield of beef burgers before and after cooking were determined (Aleson-Carbonell *et al*., 2005) using equation :

Cooking yield (%) = Cooked beef weight × 100

Sensory Analysis of Burger Formulas:

Cooked Burger samples were tested for sensory evaluation according to Meilgard *et al*., (1991). Thirty panelists at Food industries Dept. Faculty of Agriculture, Mansoura University. Tested quality attributes: color, odor, taste, tenderness, juiciness, and overall acceptability, using a 1–9 point hedonic as follows: very good 9-8, 7-6, fair 5-4, poor 3-2 and very poor 1-0.

Estimated Nutritional Value:

Total Energy (TE): was calculated according to energy content as: 1 gram of protein = 4.0 kcal, 1 gram of total carbohydrate = 4.0 kcal. 1 gram of fat = 9.0 kcal. The total calories were expressed as kcal /g (USDA, 2020).

%RDA Calculation: for a reference body weight of 70 kg was used (protein requirement ≈ 84 g/day, assuming 1.2 g/kg/day; **fiber 25 g/day; energy 2000 kcal/day) according to (USDA, 2020):**

Energy (%RDA) = (per-100 g caloric content) ÷ 2000 kcal × 100

Protein (%RDA) = (per-100 g protein content) ÷ 84 g × 100

Fiber (%RDA) = (per-100 g fiber content) ÷ 25 g × 100

Statistical Analysis

The data was analyzed using SPSS version 22, USA. One-way analysis of variance (ANOVA) with $P \leq 0.05$ was carried out to identify significant differences among all used parameters by Duncan’s test.

RESULTS AND DISCUSSION

Proximate Composition of Raw Ingredients (Beef and Chia Flour):

As shown in table (1), Chia seed flour demonstrated a high concentration of the three major macronutrients (proteins, lipids, and crude fiber) that makes it particularly notable for its elevated levels of fiber (31.8%) contributing to improved digestion, satiety, and metabolic health. these findings aligned with (Mohammed *et al*., 2019). While beef remains a rich source of high-quality, complete animal protein (26.58%), chia flour still provides a considerable amount of plant-based protein, making it suitable as food constituent without compromising nutrient content. A remarkable Fat content of 32.37g/100g in chia seeds makes it suitable ingredient in fatty products with advance of healthy lipid profile. Chia flour also showed higher ash content (4.85 ± 0.5 g/100 g) compared to lean beef (1.25 ± 0.3 g/100 g), indicating a richer mineral profile. This agrees with findings from (Coelho, M.S. and Salas-Mellado, M., 2014) who reported moisture content of different varieties of chia seeds from 7.23 to 10.67%, crude fat 31.48 to 42.45%, crude ash was 3.63 to 6.82%, crude fiber 30.95 to 38.65 % and protein 17.82 to 28.97%.

Chia seed flour stands out as a nutrient-dense plant-based ingredient, especially high in fiber, healthy fats, and minerals. In contrast, lean beef is superior in high-quality protein and moisture. Together, both foods offer complementary nutritional benefits and could play synergistic roles in a balanced diet for elderly population.

Table 1. Proximate composition of raw chia flour and beef (g/100 g) :

Component g/100 g	Chia flour	Lean Beef
Moisture	6.71±0.36	66.48± 1.1
Protein	17.30±0.05	26.58± 0.5
Fat	32.37± 0.6	5.57± 0.7
Crude fiber	31.83±0.15	0 ± 0.0
Ash	4.85 ± 0.5	1.25± 0.3
Carbohydrates	6.76 ± 0.1	0± 0.0

Data are (Mean+- SD).

Phytochemical Compounds Content Of Chia Seeds Extract :

As presented in Figure (1). The results revealed that the ethanol extract of chia seeds is particularly rich in phenolic compounds, with a recorded value of 82.99 mg gallic acid equivalent (GAE)/g dry extract. In addition, it contained 9.18 mg catechin equivalent (CE)/g of flavonoids and 15.20 mg tannic acid equivalent (TAE)/g of tannins. These findings align with previous studies reporting chia seeds as a valuable source of polyphenolic compounds with strong antioxidant potential. According to Reyes-Caudillo *et al.* (2008), (Alvarez-Chavez *et al*., 2012) and (Coelho, M.S. and Salas-Mellado, M., 2014) confirmed the presence of significant flavonoid content in chia extracts, primarily Quercetin and Kaempferol derivatives. Phenolic compounds are widely recognized for their role in mitigating oxidative stress by neutralizing reactive oxygen species (ROS), and their presence underscores the potential of chia extract in developing functional foods.

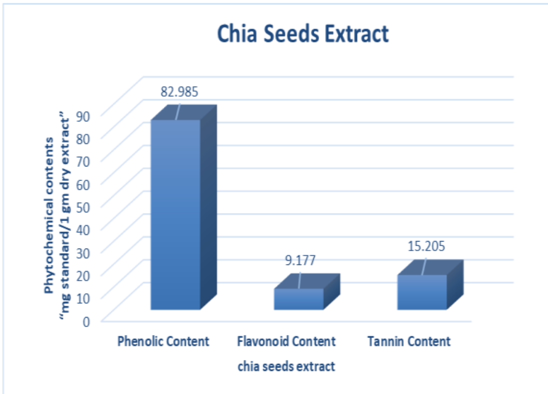

Fig. 1. A Comparison of phytochemical compounds content in chia seeds extract.

Phenolic Content “mg gallic acid/1 gm dry extract”, Flavonoid Content “mg catechin acid/1 gm dry extract”, Tannin Content “mg tannic acid/1 gm dry extract”.

Furthermore, the moderate levels of flavonoids and tannins also support the bioactivity of the extract. These compounds contribute to anti-inflammatory, antimicrobial, and anti-carcinogenic effects, as suggested by Ixtaina *et al.* (2010). Overall, the phytochemical profile of chia seeds extract reinforces its potential as a natural antioxidant source. These findings support the use of chia-based ingredients in the formulation of functional meat products, senior nutrition, and preventive health applications, especially those targeting oxidative stress and chronic inflammatory states.

DPPH Scavenging Activity

The antioxidant activity of chia seeds extract was evaluated using the DPPH (2,2-diphenyl-1-picrylhydrazyl) free radical scavenging assay, and the results are summarized in figures (2,3,4). The scavenging activity increased with increasing extract concentration, indicating a dose-dependent antioxidant behavior.

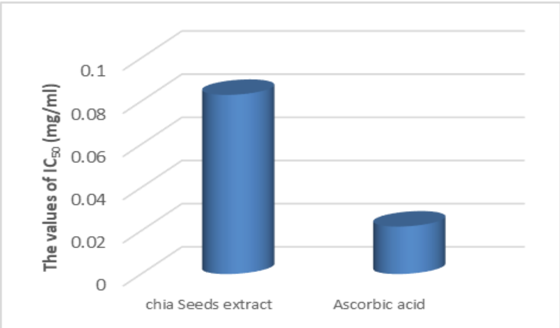

Fig. 2. IC_{50} (mg/ml)) of chia seed extract.

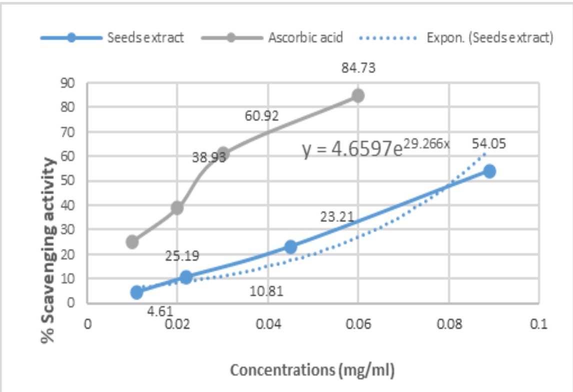

Fig. 3. The Scavenging activity of chia seed extract

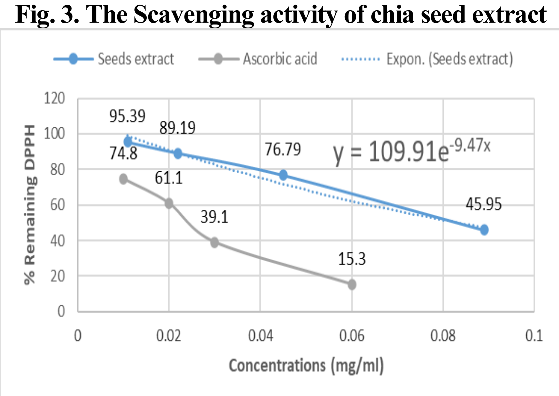

Fig. 4. The percentage of remaining DPPH of chia seed extract

At the highest tested concentration (0.089 mg/ml), the chia extract demonstrated a DPPH radical scavenging activity of 54.05%, corresponding to 45.95% remaining DPPH, while at the lowest concentration (0.011 mg/ml), the activity declined to only 4.61% scavenging. The calculated IC_{50} value (the concentration required to inhibit 50% of DPPH radicals) for the chia extract was 0.083 mg/ml, which, although higher than that of the reference antioxidant ascorbic acid (IC_{50} = 0.022 mg/ml), still reflects a moderate antioxidant potential. These findings are consistent with previous reports suggesting that chia seeds possess considerable antioxidant capacity attributed to their high content of polyphenolic compounds, especially phenolic acids and flavonoids (Reyes-Caudillo *et al.*, 2008; Ixtaina *et al.*, 2010). However, the lower potency compared to ascorbic acid can be attributed to the complex nature of plant-based extracts, where synergistic and antagonistic interactions between compounds may influence activity. Moreover, the observed IC_{50} value of chia extract is comparable to other edible seed extracts with established antioxidant potential, indicating that chia can serve as a natural antioxidant for functional foods (Coelho, M.S. and Salas-Mellado, M., 2014). The gradual reduction in % scavenging at lower concentrations also reflects the typical behavior of phenolic-rich extracts as well.These results further support the phytochemical data presented earlier, where the high phenolic and flavonoid content in the extract was highlighted aligned with (Coelho, M.S. and Salas-Mellado, M., 2015). Collectively, the findings validate the potential of chia seed extract as a bioactive ingredient for mitigating oxidative stress in food systems or biological models.

Proximate Composition of Beef Burger Formulas with Chia Seed (g/100g dry weight):

Results in Table (2) indicate significant differences ($p<0.05$) between treatments within rows. In terms of individual component, an obvious Fat Reduction shown in linear decrease ($p<0.001$) from 15.2% (control) to 9.26% (10% chia), representing almost 40% reduction in total fat content. Progressive increase in fiber ($p<0.001$) from 0% to 4.6%, with 10% chia. Differences in both traditional and reformulated burgers. In particular, the reformulated burger has a considerable higher dietary fiber accompanied with lower total fat.

Considering Protein, no significant changes were observed ($p=0.15$), maintaining the high protein quality of beef. Moderate increase in ash ($p<0.05$) reflecting chia's higher mineral content with Expected increase in Carbohydrates ($p<0.001$) from chia's natural polysaccharides, remaining at nutritionally modest levels (<6%). This finding demonstrates that chia seed incorporation at 5-7.5% achieves optimal balance with 29-40% fat reduction and 2.8-3.9g fiber/100g. The results are align with (Heck *et al.*, 2017 and 2019) and Yüncü *et al.*, (2022).

Noteworthy, the Egyptian Standard Specification No. 1688/2005 for frozen beef burgers was considered for filler addition that do not compromise the core composition of the product in terms of protein, fat, and moisture content. Accordingly, the applied levels of chia flour did not exceed the allowable thresholds for added ingredients and maintained the nutritional balance and quality attributes of the product in accordance with recognized food safety and quality criteria.

The comparison between treatments highlights chia's superior fiber content (absent in beef), the data supports the nutritional rationale for combining these ingredients in burger reformulation.

Table 2. Proximate composition of beef burger formulas with different concentrations of chia seeds flour (g/100g dry weight):

Chemical Content	Burger Formulas				
	(Control)	CF 2.5%	CF 5%	CF 7.5%	CF 10%
Moisture	62.36±0.27[d]	63.37±0.12[c]	65.21±0.37[b]	65.94±0.33[a]	61.85±0.39[d]
Protein	19.51±0.32[a]	18.80±0.1[b]	18.65±0.27[bc]	18.32±0.17[c]	18.34±0.21[c]
Fat	18.81±0.44[a]	17.21±0.25[b]	15.51±0.34[c]	13.80±0.16[d]	12.22±0.24e
Ash	3.06±0.02[a]	3.08±0.08[a]	3.09±0.06	3.11±0.12[a]	3.14±0.09[a]
Fibers	0.00	1.38±0.28[d]	2.78±0.31[c]	3.96±0.67[b]	4.62±0.15[a]

CF 2.5 = 2.5% fat substituted by chia flour; CF 5 = 5% fat substituted by chia flour; CF7.5 = 7.5% fat substituted by chia flour, CF 10% = 10% fat substituted by chia flour.

Means within the same row having different small letters have significant differences among treatments at a significance level of P ≤ 0.05.

Technological Performance of Burger Formulas:

Data from Table (3) showed that, Chia flour CF incorporation improved water-holding capacity (WHC) (control: 72.5 ± 1.2% vs. 10% chia: 82.3 ± 1.0%). This represents a notable enhancement in the treatment's ability to retain moisture during processing and cooking. Similarly, the cooking yield improved from (68.9 ± 1.1%) in control sample to (78.1 ± 1.0) with added 10% chia flour, indicating reduced cooking losses. attributable to chia's mucilaginous polysaccharides (Capitani *et al.*, 2012; Coorey *et al.,* 2014, Heck *et al.*, 2019). The CF5% chia treatment optimized cooking yield (95.2 ± 1.1%). similar findings from (Camara *et. al.,* 2020) and (Yüncü *et al.,* 2022) who reported a reserved mechanical property of meat emulsions after thermal treatment.

Table 3. Effect of chia flour addition on water-holding capacity (whc) and cooking yield of beef burgers:

Parameter / Formula	WHC %	Cooking Yield %
(Control)	72.5 ± 1.2[c]	68.9 ± 1.1[c]
C2.5%	75.8 ± 1.0[bc]	71.4 ± 1.2[bc]
C5%	78.6 ± 1.1[b]	74.2 ± 1.1[b]
C7.5%	81.9 ± 0.9[a]	77.5 ± 0.9[a]
C10%	82.3 ± 1.0[a]	78.1 ± 1.0[a]

CF 2.5 = 2.5% fat substituted by chia flour; CF 5 = 5% fat substituted by chia flour; CF7.5 = 7.5% fat substituted by chia flour, CF 10% = 10% fat substituted by chia flour. (Mean ± SD).

Similar letters in same column denote non-significant difference between groups by Duncan test

As well as, meat emulsion stability was improved with the addition of chia. Yogesh *et al*., (2015) reported similar effect from flaxseed that reduced fat release during cooking improved fat retention in the final product. Fat reduction typically reduces WHC, but the functional hydrocolloid behavior of chia offsets this loss and even surpasses the WHC of control burgers (Pintado *et al.,* 2016). Similar results from (Heck *et. al.,* 2017) from burgers subjected to replacing 50% of the fat component by microparticles containing chia and linseed oils, the lipid reformulation improved cooking loss and fat retention significantly.

Sensory Acceptability of Beef Burger Formulas:

Table (4) represents effect of the inclusion of chia flour as a fat substitute in beef burgers showed a positive impact on juiciness, which increased with higher chia levels. Consumer panels rated 2.5-5% chia burgers equivalently to controls for appearance, flavor, juiciness, and tenderness. This is consistent with the high water-holding capacity of chia that due to its mucilaginous fiber and hydrocolloid-forming ability (Coorey *et al*., 2014) and (Camara *et al., 2020*). Flavor and appearance scores slightly declined at higher levels (7.5–10%), likely due to chia's earthy taste and the dark color it imparts (Pintado *et al*., 2016) plus the increased hardness (Camara *et al.,* 2020).

Tenderness and overall acceptability remained high up to 7.5%, but began to decline at 10%, suggesting that chia flour levels above 7.5% may alter the texture matrix of the burger unfavorably. Similar sensory thresholds were reported by (Scapin *et al*., 2015)in chia-enriched patties.

Optimal inclusion appears to be 5–7.5%, balancing improved functional properties with minimal sensory compromise, a finding supported by (Paula *et al*., 2019), who reported that up to 5% chia inclusion maintained acceptable sensory scores in meat formulations.

Table 4. Sensory attributes of burger formulas with different chia flour levels:

Beef burger Formulas/ Attributes	(Control)	CF 2.5%	CF 5%	CF 7.5%	CF 10%
Appearance	8.08±0.15[a]	7.88±0.12[b]	7.70±0.14[c]	7.32±0.15[d]	6.78±0.16[e]
Flavor	8.26±0.15[a]	8.11±0.18[b]	7.89±0.15[c]	7.62±0.15[d]	7.12±0.14[e]
Juiciness	8.05±0.17[e]	8.27±0.12[d]	8.38±0.14[c]	8.60±0.15[b]	8.85±0.14[a]
Tenderness	8.19±0.11[c]	8.29±0.12[b]	8.32±0.17[a]	7.90±0.15[ab]	7.90±0.22[d]
Overall Acceptability	8.19±0.15[c]	8.30±0.21[b]	8.42±0.13[a]	8.09±0.14[d]	7.31±0.11[e]

CF 2.5 = 2.5% fat substituted by chia flour; CF 5 = 5% fat substituted by chia flour; CF7.5 = 7.5% fat substituted by chia flour, CF10% = 10% fat substituted by chia flour.

Means within the same row having different small letters have significant differences among treatments at a significance level of P ≤ 0.05.

Contribution of Beef burger Formulas to Recommended Nutritional Daily Allowances (%RDA) for Elderly:

In line with evidence-based recommendations, optimal protein intake for older adults is significantly higher than the minimum RDA of 0.8 g/kg/day, with a target of 1.2 g/kg/day (≈84 g/day for a 70 kg individual) to better support muscle mass, physical function, and metabolic health (Trumbo *et al.,* 2010; Bauer *et al.,* 2013). Meanwhile, 25 g of dietary fiber daily is supported by EFSA for roles in digestive health, cholesterol management, and metabolic regulation (EFSA, 2010).

Accordingly, as shown in table (5), a 100 g portion of chia-infused burger (CF5 at 10%) supplies 13.5 % of daily energy needs and~23 % of the daily protein requirement, indicating that multiple servings or protein across meals is needed to meet goals. Dietary fiber contributions are more substantial in chia treatments CF5 delivers around 18 % of daily needs per 100 g portion, compared to just 2 % from the control. A progressive increase in fiber content is linked to higher substitution levels. Caloric contribution declines modestly with increasing chia substitution, enhancing nutrient density and aligning with reduced energy needs typical in older populations. These findings agree with Yüncü *et al.,* (2022). Aligning with recommendations to combat age-related risks of cardiovascular disease and metabolic syndrome (Reinders *et al.,* 2021). Additionally, chia fats contributes essential omega-3 fatty acids, which have been shown to support cognitive and cardiovascular health in elderly populations (Godos *et al.,* 2021) and (Heck *et al.,* 2017).

Thus, chia flour enhances the functional nutritional profile of beef burgers—offering a meaningful boost in fiber and modest protein support. Nevertheless, it should be consumed alongside other high-quality protein sources across meals to meet elevated protein requirements in older adults.

Table 5. Contribution of beef burger formulas to the recommend dietary allowances (%RDA) for elderly:

Nutrient / Treatment	Energy (%RDA)	Protein (% RDA)	Fiber (%RDA)
C1 (Control)	15.6%	21.1%	2.0%
CF2 (2.5%)	15.1%	21.5%	4.9%
CF3 (5%)	14.6%	22.0%	9.1%
CF4 (7.5%)	14.0%	22.6%	15.6%
CF5 (10%)	13.5%	23.1%	18.4%

Requirements are based on a reference body weight of 70 kg was used (protein requirement ≈84 g/day, assuming 1.2 g/kg/day; fiber 25 g/day; energy 2000 kcal/day) according to (USDA,2020).

CONCLUSION

To conclude, this study highlights the role of chia seed incorporation—particularly at levels ≥7.5% as a fat substitute in enhancing the protein/fiber balance for healthy aging and antioxidant capacity of beef burgers ingredients, addressing the often-overlooked need for high quality protein and fiber food sources. The findings support the feasibility of reformulating traditional meat products with plant-based ingredients to meet the nutritional requirements of the aging population. Chia addition contributes beneficially to the overall nutrient profile by significantly increasing dietary fiber content and providing additional protein and fat support, without compromising product integrity, offering a single-ingredient innovation for the development of functionally enhanced meat products aligned with healthy aging strategies.

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تقييم برجر اللحم البقري المنخفض الدهن والمُدعم غذائيًا باستخدام دقيق بذور الشيا كمُحسِّن وظيفي للدهون لتغذية كبار السن

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الملخص

يُعاني كبار السن من تحديات في صحة الجهاز الهضمي واحتياجات مرتفعة للبروتين الحيواني مرتبطة بالسن. لذا تمت في هذه الدراسة تحسين برجر اللحم البقري منخفض الدهن باستخدام دقيق بذور الشيا كبديل للدهون بنسب (٢,٥، ٥، ٧,٥، ١٠٪). أظهرت نتائج الاختبارات الكيميائية تفوقً عينات بذور الشيا في محتواها من الألياف، الدهون، والرماد (٣١,٨٣، ٣٢,٣٧، ٤,٨٥ جم/١٠٠ جم) مقارنة باللحم (٥,٥٧، ١,٢٥ جم) علي التوالى. وبلغ محتوى الألياف في البرجر المدعم (١,٣٨، ٢,٧٨، ٣,٩٦، ٤,٦٢ جم/١٠٠ جم) عند نسب الإحلال المذكورة، دون فروق معنوية في البروتين.تميزت بذور الشيا بقدرة مضادة للأكسدة(DPPH) عالية نتيجة لمحتواها من المركبات الفينولية (٨٢,٩٩ ملجم مكافئ حمض الجاليك/جم)، والفلافونويدات (٩,١٨ ملجم مكافئ الكاتيشين/جم)، والتانينات (١٥,٢٠ ملغم مكافئ حمض التانيك/جم). اظهرت نتائج الخصائص التكنولوجية تحسنًا تدريجيًا؛ حيث ارتفعت القدرة على الاحتفاظ بالماء من ٧٢,٣±١,٢٪ (الكونترول) إلى ٨٢,٣±١,٠٪ في العينة المحتوية على (١٠٪ دقيق بذور شيا)، وتحسن عائد الطهي من ٦٨,٩٪ إلى ٧٨,١٠%. كما سجلت المعاملة باضافة ٥٪ دقيق بذور شيا تحسن الصفات التكنولوجية وارتفاع قيم القبولًا الحسيً في حين أن اضافة التركيزات الأعلى من دقيق الشيا (٧,٥–١٠٪) أدت إلى انخفاض طفيف في قيم التقييم الحسي. من الناحية التغذوية، فإن الحصة الواحدة (١٠٠ جم) من المعاملة باضافة 10% دقيق بذور الشيا توفر نحو ١٨٪ من الاحتياجات اليومية الموصى بها للألياف و٢٣٪ من البروتين لكل ١٠٠ جم. وبالتالي، لذا تُمثل بذور الشيا إضافة واعدة للبرجر التقليدي ليصبح غذاءً وظيفيًا مناسبًا لكبار السن، من خلال تقليل نسب الدهون الحيوانية، وزيادة محتوى الألياف، مع الحفاظ على القيمة الغذائية الموجودة في اللحم البقري.