



DEVELOPMENT OF MUFFINS USING PROTEINS EXTRACTED FROM GARDEN CRESS SEEDS AND CHIA SEEDS BY ALKALINE METHOD

A. Jyothirmai*, Dr. M. Panchala Raju*, K. Archana, B. Bharathi

Department of Food Science and Technology, School of Agriculture sciences

Malla Reddy University, Maisammaguda-500100

*Corresponding Author E-mail: mprraju05@gmail.com

ABSTRACT

Garden cress and chia seeds were selected as raw materials for protein extraction and subsequent development of eggless muffins. Protein isolates were obtained through alkaline extraction followed by isoelectric precipitation, and both the seed powders and extracted proteins were analysed for their physicochemical properties. Proximate analysis showed that raw garden cress powder had the highest fat ($22.04 \pm 0.32\%$), fibre ($8.08 \pm 0.54\%$), and ash content ($4.95 \pm 0.30\%$), while chia seed protein concentrate exhibited the highest protein content ($84.73 \pm 0.77\%$). Chia seeds also recorded the highest moisture ($4.12 \pm 1.20\%$) and carbohydrate content ($65.74 \pm 0.12\%$).

FTIR analysis confirmed the proteinaceous nature of both garden cress and chia seed protein powders through characteristic peaks corresponding to hydroxyl, carbonyl, amide, and peptide bond functional groups. These findings were consistent with previous studies on seed protein isolates.

The extracted proteins were incorporated into eggless muffins, and sensory evaluation using a 9-point hedonic scale indicated that the control and T1 samples received the highest scores for appearance, flavour, taste, texture, and overall acceptability, with no significant differences between them. Sensory acceptance declined progressively in T2 and T3, with T3 receiving the lowest ratings.

Texture profile analysis revealed that T1 muffins were softer and less gummy and chewy than the control, whereas T3 exhibited higher adhesiveness and maintained hardness and chewiness similar to the control. Cohesiveness increased in all treatment groups, while resilience decreased compared to the control.

Overall, the results demonstrate that proteins extracted from garden cress and chia seeds can be successfully utilized in the preparation of eggless muffins. Among the treatments, T1 showed sensory and textural properties most comparable to the control, indicating the potential of these seed proteins as functional ingredients in bakery products.

Keyword: Alkaline protein extraction, Garden seeds, Chia seeds, Muffins

1. INTRODUCTION

Eggless muffins have emerged as a significant innovation in contemporary food science and consumer markets, driven primarily by rising health concerns, dietary restrictions, and ethical considerations. These muffins serve as an inclusive alternative for individuals with egg allergies, vegans, and those aiming to reduce cholesterol intake while maintaining desirable taste and texture. The shift toward eggless formulations aligns with global trends favoring plant-based and allergen-free foods, which contribute to healthier

and more sustainable eating habits (Khalifa et al., 2024).

The development of plant-based egg analogs and egg-mimicking products is motivated by consumer demand for sustainability and decreased allergenicity, alongside preferences for flexitarian diets. However, challenges in replicating the sensorial and textural qualities of traditional eggs remain, necessitating ongoing innovation to optimize the techno-functional properties of eggless ingredients and formulations (Khalifa et al., 2024). Such efforts enhance the

quality and acceptability of eggless muffins, promoting their wider adoption in the food industry.

Moreover, eggless muffin formulations contribute to reducing the environmental impact associated with conventional egg production, which involves animal welfare concerns and considerable resource use. Market studies illustrate consumer willingness to pay premiums for products with higher animal welfare standards and reduced environmental footprints, underscoring the importance of sustainable alternatives like eggless baked goods (Rahmani et al., 2019; Zakowska-Biemans & Tekien, 2017).

Research focusing on optimizing eggless muffins includes reformulation strategies to enhance nutritional profiles such as fiber enrichment and sugar or fat reduction without significantly compromising sensory and physical quality. For example, incorporation of ingredients like inulin and green banana flour in muffins can improve fiber content and reduce glycemic response while maintaining consumer acceptability and shelf-life stability (Harastani et al., 2021). Similar strategies involve using oleogel as a solid fat replacer, which enhances oxidative stability and the functional properties of muffins (Jeong et al., 2021).

Innovative ingredient combinations not only address dietary needs but also promote health benefits, such as increased protein content and antioxidant capacity, exemplified by the use of edible insect flours in muffins—a related emerging area with sustainability and nutrition advantages (Zielinska et al., 2021). Understanding consumer attitudes and sensory preferences is crucial for the successful adoption of novel formulations, with acceptance influenced by taste, texture, and familiarity, alongside reduced food neophobia (Mazurek et al., 2024; Wendin & Nyberg, 2021).

Eggless muffins represent an important advancement in food innovation by catering to diverse consumer needs, including health, ethical, and environmental considerations. Ongoing research and technological advancements focusing on ingredient functionality and sensory quality are essential to optimize their acceptability and nutritional value, thus supporting broader market adoption and sustainable consumption patterns (Harastani et al., 2021; Khalifa et al., 2024).

Muffins are popular as convenient ready-to-eat foods. Eggs are crucial in baking due to their properties such as binding, leavening, and emulsifying, which enhance volume, texture, flavor, and color, along with their nutritional value (Geera et al., 2011). However, the demand for egg reduction or elimination in cake formulations has

risen, driven by manufacturers' desire for lower costs and longer shelf life, as well as consumer allergies and health concerns linked to egg proteins like avidin. The vegan population is also increasing (Hedayati et al., 2021). Common egg alternatives include whey protein isolates, plant proteins, soy ingredients, wheat gluten, and various gums, which fulfill specific functional roles in ingredient mixtures.

Replacement of animal proteins could be interesting for the food industry because it allows long-term cost savings, among other reasons. Replacing egg/milk protein (50–100 wt %) by lentil protein (LP) was evaluated on angel cake/muffin quality. The replacement did not significantly affect final product volume, neither the muffins nor the angel food cakes. LP did not affect dough formation and contributed to hold crumb structure building an entangled network in both cake products. In addition, angel cakes and muffins containing LP had significantly lower baking loss than the control.

The plant-based protein market is undergoing a paradigmatic metamorphosis, precipitating a burgeoning demand for sustainable and efficacious methods to extract and process plant proteins from seeds, thereby mitigating environmental degradation and fostering a more equitable food system (Siddiqui et al., 2024).

The proximate composition of flaxseed reveals a notable abundance of fats, proteins, and fibers, with a comparatively low carbohydrate content, and exhibits variability in constituent levels potentially attributable to environmental factors (Adam Omer Ishag et al., 2020). Legumes proximate composition exhibits a paradigmatic abundance of macronutrients (Karlsson et al., 2024).

The nuanced interplay between particle size distribution and the multifaceted properties of a powder precipitates a far-reaching impact on the overall quality, functionality, and processability of the material, highlighting the paramount necessity of meticulously calibrating particle size distribution to unlock optimal performance and desired product characteristics (Lai et al., 2024).

Muffins are popular as convenient ready-to-eat foods. Eggs are crucial in baking due to their properties such as binding, leavening, and emulsifying, which enhance volume, texture, flavor, and color, along with their nutritional value (Geera et al., 2011). However, the demand for egg reduction or elimination in cake formulations has risen, driven by manufacturers' desire for lower costs and longer shelf life, as well as consumer allergies and health concerns linked to egg proteins like avidin. The vegan population is also increasing

(Hedayati et al., 2021). Common egg alternatives include whey protein isolates, plant proteins, soy ingredients, wheat gluten, and various gums, which fulfill specific functional roles in ingredient mixtures.

Replacement of animal proteins could be interesting for the food industry because it allows long-term cost savings, among other reasons. Replacing egg/milk protein (50–100 wt %) by lentil protein (LP) was evaluated on angel cake/muffin quality. The replacement did not significantly affect final product volume, neither the muffins nor the angel food cakes. LP did not affect dough formation and contributed to hold crumb structure building an entangled network in both cake products. In addition, angel cakes and muffins containing LP had significantly lower baking loss than the control. The most important parameter in various food products is the high content of dietary fibre, both soluble and insoluble. This influences the sensorial and textural properties of bakery and confectionery products such bread, muffins and plant-based meat analogues (Ahsan et al., 2024; Červenka et al., 2019; van Esbroeck et al., 2024).

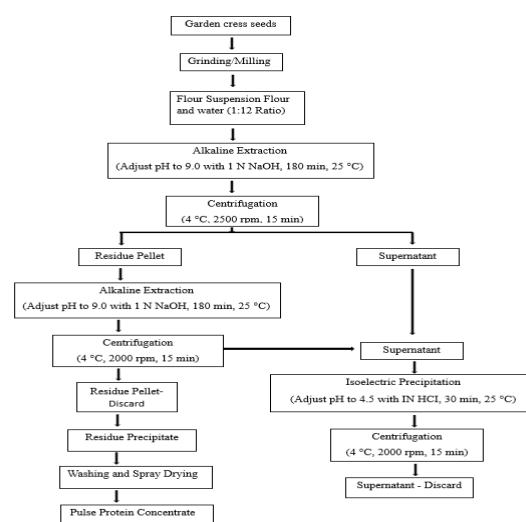
Snehal Doke and Manisha Guha, (2014) studied that *Lepidium sativum*, commonly known as garden cress is a fast growing annual herb that is native to Egypt and West Asia, although it is now cultivated in the entire world. Its seeds are rich source of proteins, dietary fiber, omega-3 fatty acids, iron, other essential nutrients and phytochemicals. Garden cress is widely used in folk medicine for the treatment of hyperactive airways disorders, such as asthma, bronchitis and cough. Seeds are considered to be galactagogue, emmenagogue and recommended in inflammation, bronchitis, muscular pain and rheumatism. The present review deals with nutritional, phytochemical, antimicrobial, toxicology and medicinal potential of garden cress seeds. It highlights anti-diabetic, laxative, hypocholesterolemia, fracture healing, analgesic, coagulant, diuretic, hepatoprotective, anti-asthmatic, antidiarrheal, anti-spasmodic and anti-cancer activities of garden cress seeds. It also focuses on food products developed using garden cress seed or its fractions.

2. MATERIALS AND METHODS

Preparation of Garden cress seed powder



Extraction of protein by alkaline extraction



The alkaline extraction procedure described by Penchalaraju et al. (2024) was followed with slight modifications. The plant seeds such as chia seeds and garden cress seeds were milled, and the resulting flour and water were used in a ratio of 1:12 to create a flour suspension for alkaline extraction. The pH was adjusted to 9 using 1 N NaOH, and the mixture was kept at room temperature (25 °C) for 180 minutes. The mixture was centrifuged at 2500 RPM for 15 min, supernatant and residue precipitates were obtained. To increase the yield of the protein alkaline extraction procedure is repeated for the residue. The supernatants were collected and subjected to isoelectric precipitation by adjusting the pH to 4.5 with 1 N HCl for 30 minutes at room temperature (25°C). The precipitated protein extract was subsequently rinsed with water. Generally, spray drying, drum drying and freeze drying can be employed to dry the protein extracts (Boye & Barbana, 2012; Cui et al., 2020). The collected supernatants were combined and subjected for washing with water to neutralize the protein extract and subjected for spray drying at a inlet temperature ranged from 80 °C to 100 °C and feed flow rate varied from 20 mL/min to 25 mL/min.

The protein concentrate obtained from the plant sources are kept under refrigeration conditions until used for further analysis.

2.2 Development of muffins using plant proteins from chia seeds and garden cress seeds

Table 2.1 formulation of muffins using chia and garden cress seeds protein

Ingredients (%)	Control	T1	T2	T3
Wheat flour	35	35	45	20
Sugar	25	10	12	12
Butter	15	11	11	10
Baking Powder	02	02	02	02
Salt	1	1	1	1
Egg	11	-	-	-
Chi seed protein concentrate	-	15	10	25
Garden cress seed protein concentrate	-	15	10	25
Milk	10	10	8	4
Vanilla Essence	1	1	1	1

The formulation of the muffins were presented in Table 3.1. The selected text presents a formulation table with four samples: one control and three test samples (T1, T2, T3). The control sample contains wheat flour, sugar, butter, baking powder, salt, egg, milk, and vanilla essence but does not include any plant protein concentrates. The three test samples (T1, T2, T3) each include either chia seed protein concentrate or garden cress seed protein concentrate at 15%, 10%, and 25% respectively, replacing part of the wheat flour content.

Thus, the control sample is the one without any addition of plant protein concentrates, while T1, T2, and T3 are the three test samples with different levels of plant protein concentrates added.

The ingredients for the Control, T1, T2, and T3 formulations are as follows: wheat flour is used at 35%, 35%, 45%, and 20% respectively; sugar is included at 25%, 10%, 12%, and 12%; butter is added at 15%, 11%, 11%, and 10%; baking powder is consistently 0%, 2%, 0%, and 2%; salt is present at 1%, 1%, 1%, and 1%; egg is included at 11% in control, and omitted in T1, T2 and T3; chi seed protein concentrate is added at 0%, 15%, 10%, and 25%; garden cress seed protein concentrate is also at 0%, 15%, 10%, and 25%; milk is used at 10%, 10%, 8%, and 4%; and vanilla essence is constant at 1% for all formulations. Wheat flour provides the structural framework and texture for the muffins. Sugar adds sweetness and contributes to browning and moisture retention. Butter imparts richness, tenderness, and flavor to the muffins. Baking powder acts as a leavening agent, helping

the muffins rise and become fluffy. Salt enhances flavor balance and strengthens the dough structure. Egg binds the ingredients together, adds moisture, and contributes to the muffin's structure. Chia seed protein concentrate (in T1, T2 and T3) enriches the muffins with additional protein and may improve texture and nutritional value. Garden cress seed protein concentrate (in T1, T2 and T3) similarly adds protein content and nutritional benefits. Milk provides moisture, aids in dissolving sugar and salt, and contributes to the muffin's tenderness and flavor. Vanilla essence adds aroma and enhances the overall flavor profile of the muffins.



Sample	Fat	Fibre	Protein	Ash	Moisture	Carbohydrates
Garden cress Raw powder	22.04 ± 0.32 ^a	8.08 ± 0.54 ^a	24.73 ± 0.77 ^b	4.95 ± 0.30 ^a	6.12 ± 0.79 ^a	34.08 ± 2.50 ^b
Garden cress Protein concentrate	3.46 ± 0.49 ^b	2.33 ± 0.10 ^c	83.83 ± 1.45 ^a	3.39 ± 0.20 ^b	4.14 ± 0.12 ^b	2.86 ± 1.79 ^d
Chi seed protein concentrate	1.04 ± 0.32 ^c	2.08 ± 0.54 ^c	84.73 ± 0.77 ^a	2.95 ± 0.30 ^c	3.12 ± 0.79 ^a	6.08 ± 2.50 ^c
Chi seeds	1.42 ± 0.12 ^c	4.12 ± 1.12 ^b	21.48 ± 1.40 ^b	3.12 ± 2.12 ^b	4.12 ± 1.20	65.74 ± 0.12 ^a



3. RESULTS AND DISCUSSION

3.1 Proximate composition of chia seeds and Garden cress seeds and their extracted proteins

Values are expressed as Mean $\pm$ SD ($n=3$). The values in the same column with different superscript letters are significantly different ($p > 0.05$) according to the Duncan Multiple comparison test. The text compares the nutritional contents of chia seeds, garden cress seeds, and their protein concentrates. It shows the amounts of fat, fiber, protein, ash, moisture, and carbohydrates in each.

The proximate composition of chia seeds and Garden cress seeds and their extracted proteins was analyzed. The highest values for each proximate parameter were showing as follows: Fat was being highest in Garden cress Raw powder at 22.04 ± 0.32 ; Fibre was being highest in Garden cress Raw powder at 8.08 ± 0.54 ; Protein was being highest in Chi seed protein concentrate at 84.73 ± 0.77 ; Ash was being highest in Garden cress Raw powder at 4.95 ± 0.30 ; Moisture was being highest in Chi seeds at 4.12 ± 1.20 ; Carbohydrates were being highest in Chi seeds at 65.74 ± 0.12 .

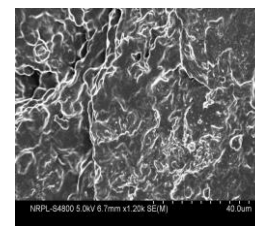
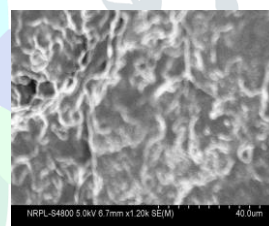
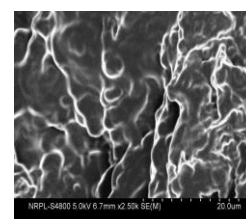
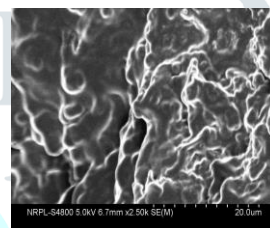
The lowest values for each proximate parameter were being recorded as follows: Fat was being lowest in Chi seed protein concentrate at 1.04 ± 0.32 ; Fibre was being lowest in Chi seed protein concentrate at 2.08 ± 0.54 ; Protein was being lowest in Garden cress Raw powder at 24.73 ± 0.77 ; Ash was being lowest in Chi seed protein concentrate at 2.95 ± 0.30 ; Moisture was being lowest in Garden cress Protein concentrate at 2.86 ± 1.79 ; Carbohydrates were lowest in Garden cress Protein concentrate at 2.86 ± 1.79 .

The text describes the analysis of the basic nutritional components (proximate composition) of chia seeds, Garden cress seeds, and their protein extracts. It shows which samples had the highest and lowest amounts for each nutrient measured: Fat was highest in Garden cress raw powder (22.04 ± 0.32) and lowest in chia seed protein concentrate (1.04 ± 0.32). Fibre was highest in Garden cress raw powder (8.08 ± 0.54) and lowest in chia seed protein concentrate (2.08 ± 0.54). Protein was highest in chia seed protein concentrate (84.73 ± 0.77) and lowest in Garden cress raw powder (24.73 ± 0.77). Ash content was highest in Garden

cress raw powder (4.95 ± 0.30) and lowest in chia seed protein concentrate (2.95 ± 0.30). Moisture content was highest in chia seeds (4.12 ± 1.20) and lowest in Garden cress protein concentrate (2.86 ± 1.79). Carbohydrates were highest in chia seeds (65.74 ± 0.12) and lowest in Garden cress protein concentrate (2.86 ± 1.79). This means that the raw Garden cress seeds had more fat, fibre, and ash, while the chia seed protein concentrate had the most protein but the least fat and fibre. Chia seeds themselves had the most moisture and carbohydrates (Malik & Riar, 2022; Vera C et al., 2023., Gabal ., 2024).

3.2 Surface features of Extracted plant proteins from chia seeds and garden cress seeds

Morphological analysis of plant proteins extracted from chia seeds and garden cress seeds alkaline extraction followed by isoelectric precipitation were analyzed by Scanning Electron Microscope at $20 \mu\text{m}$ and $4 \mu\text{m}$ and the micrographs of SEM are presented in Figure 3.1 to 3.4.



Scanning electron microscope was used to determine the surface features of pulse protein concentrates. All the samples exhibited the collapsed and wrinkled surface. It may be due to the presence of uneven shrinkage of particles containing water and protein, and higher moisture evaporation flux during drying process. Brishti et al. (2020) reported similar findings for spray-dried mung bean protein with collapsed and wrinkled structures. A high concentration gradient exists between the droplet particle and the drying medium, and there is a complex interchange in the moisture diffusivity of protein.

Scanning electron microscopy (SEM) was employed to analyze the surface morphology of pulse protein concentrates, revealing that all samples exhibited characteristic collapsed and wrinkled surfaces. These morphological features are likely a consequence of uneven shrinkage occurring within the particles, which comprise both water and protein components (Zhang et al.,

2022). During the drying process, differential

FTIR Functional Groups	Garden cress seed protein powder	Chia seed protein powder
O-H (3200-3500 cm^{-1})	3269.59 cm^{-1}	3260.20 cm^{-1}
C-H (2800–3300 cm^{-1})	2851.39 cm^{-1} 2922.36 cm^{-1}	2850 cm^{-1}
C=O (1600-1700 cm^{-1})	1627.50 cm^{-1}	1620 cm^{-1}
Amide (N-H bending) (1400-1500 cm^{-1})	1403.00 cm^{-1} 1542.90 cm^{-1}	1400 cm^{-1}
C-O (1000-1300 cm^{-1})	1258.33 cm^{-1}	1250 cm^{-1}

moisture loss leads to internal stresses that cause the particle surfaces to collapse and wrinkle. This phenomenon is further influenced by a high moisture evaporation flux, which intensifies the

Samples	Appearance	Flavour	Taste	Texture	Overall acceptability
Control (Muffin)	8.74 $\pm$ 0.40 ^a	8.24 $\pm$ 0.37 ^a	8.86 $\pm$ 0.43 ^a	8.70 $\pm$ 0.42 ^a	8.80 $\pm$ 0.38 ^a
T1	8.60 $\pm$ 0.39 ^a	8.14 $\pm$ 0.55 ^a	8.80 $\pm$ 0.65 ^a	8.60 $\pm$ 0.48 ^a	8.62 $\pm$ 0.47 ^a
T2	8.25 $\pm$ 0.44 ^b	8.05 $\pm$ 0.62 ^b	7.93 $\pm$ 0.76 ^b	7.22 $\pm$ 0.40 ^b	7.35 $\pm$ 0.48 ^b
T3	6.78 $\pm$ 0.48 ^c	7.60 $\pm$ 0.55 ^c	6.98 $\pm$ 0.71 ^c	6.55 $\pm$ 0.63 ^c	6.68 $\pm$ 0.74 ^c

shrinkage effects. The dynamic interplay between moisture diffusion inside the particles and the drying medium creates a complex environment that governs the final particle structure. Supporting this observation, Brishti et al. (2020) reported similar surface characteristics in spray-dried mung bean protein powders, where the particles also displayed collapsed and wrinkled morphologies (Mori et al., 1984; Pal et al., 2020a, 2020b). This similarity suggests that the drying-induced surface deformation is a common feature across different types of pulse proteins subjected to spray drying. The high concentration gradient between the droplet particle and the surrounding drying air accelerates moisture transfer, contributing to rapid drying and uneven particle shrinkage. Consequently, the resulting surface morphology reflects the combined effects of moisture diffusivity, evaporation rate, and protein matrix behavior during drying. Understanding these surface changes is essential for optimizing drying conditions and improving the functional properties of pulse protein concentrates in various food applications (Garcia-Perez et al., 2011; Li et al., 2025).

3.3 FTIR Spectra analysis of Extracted plant proteins from Chia seeds and garden cress seeds

FTIR is used to identify the functional groups present in particular substances. FTIR spectra data was presented in table 3.2. The functional and structural groups were identified in their respective regions using FTIR.

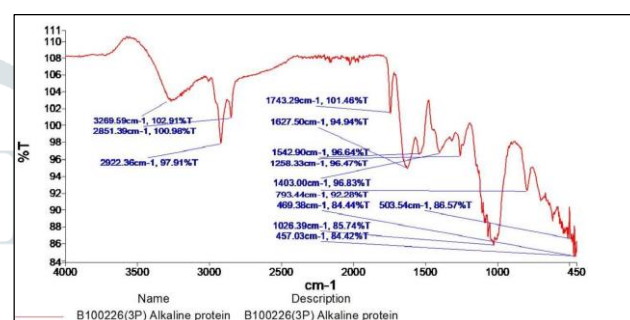
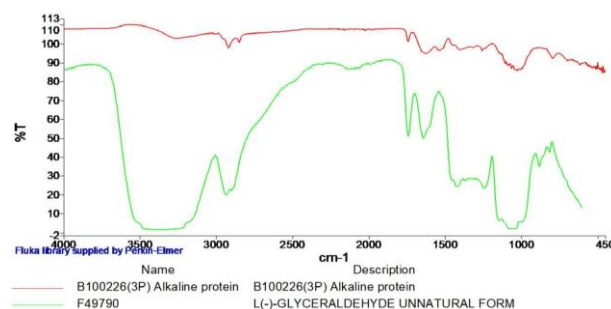


Table 3.2 Ftir analysis of garden cress seed protein powder

The FTIR spectra reveal distinct characteristic peaks that correspond to specific functional groups present in both garden cress seed protein powder and chia seed protein powder, highlighting their molecular composition. The O-H stretching vibrations, observed prominently around 3269.59 cm^{-1} for garden cress and 3260.20 cm^{-1} for chia seed protein powder, indicate the presence of hydroxyl groups, which are typically associated with alcohols and phenols. Additionally, the C=O stretching peaks detected near 1627.50 cm^{-1} and 1620 cm^{-1} confirm the existence of carbonyl groups in both samples, suggesting the presence of amide bonds characteristic of protein structures. Further analysis shows the presence of C-H stretching vibrations within the range of 2800–3300 cm^{-1} , appearing at 2851.39 cm^{-1} for garden cress and between 2922.36 cm^{-1} and 2850 cm^{-1} for chia seed protein powder, which are indicative of aliphatic hydrocarbons in the protein matrix. The spectra also exhibit peaks around 1540 cm^{-1} , corresponding to N-H bending vibrations, which further support the presence of amide linkages in the protein structures. Peaks observed near 1400 cm^{-1} are attributed to C-N stretching vibrations, indicating the presence of peptide bonds. These combined spectral features confirm the complex

proteinaceous nature of both garden cress and chia seed protein powders. Additional research studies have reported similar FTIR spectral characteristics in seed protein powders, supporting the findings for garden cress and chia seed proteins. Gomaa *et al.* (2018) observed prominent O-H stretching vibrations around $3200\text{--}3400\text{ cm}^{-1}$ in legume protein isolates, indicating hydroxyl groups involved in hydrogen bonding, consistent with the peaks at $\sim 3260\text{--}3270\text{ cm}^{-1}$ in garden cress and chia seed proteins. Their study also confirmed amide I band presence near 1650 cm^{-1} , corresponding to C=O stretching vibrations of peptide bonds, aligning with the $\sim 1620\text{--}1627\text{ cm}^{-1}$ peaks observed here.

Nechiporenko *et al.* (2021) reported C-H stretching vibrations in the range of $2800\text{--}3000\text{ cm}^{-1}$ for plant protein isolates, attributed to aliphatic side chains, which matches the $2850\text{--}2922\text{ cm}^{-1}$ peaks in both garden cress and chia seed protein powders. They also highlighted the significance of amide bands (N-H bending) around $1400\text{--}1550\text{ cm}^{-1}$, consistent with the $1400\text{--}1543\text{ cm}^{-1}$ peaks seen in the current samples. Similar FTIR profiles were reported by other researchers studying seed proteins, such as Wang *et al.* (2019), who identified characteristic amide I and II bands at approximately 1650 cm^{-1} and 1540 cm^{-1} , supporting the assignment of carbonyl and N-H bending functional groups in protein structures. These studies collectively validate the identification of hydroxyl, carbonyl (amide), and aliphatic hydrocarbon groups in seed protein powders, reinforcing the molecular composition inferred from the FTIR spectra of garden cress and chia seeds.

3.4 Sensory evaluation of developed muffins



The sensory evaluation presents mean scores with standard deviations for five sensory attributes such as Appearance, Flavour, Taste, Texture, and Overall acceptability across four samples: Control (Muffin), T1, T2, and T3. The Control sample received the highest scores in all attributes, with Appearance rated 8.74 ± 0.40 , Flavour 8.24 ± 0.37 , Taste 8.86 ± 0.43 , Texture 8.70 ± 0.42 , and Overall acceptability 8.80 ± 0.38 , all marked with the letter "a" indicating no significant

difference within this group. Sample T1 showed similar scores to the Control, with Appearance at 8.60 ± 0.39 , Flavour 8.14 ± 0.55 , Taste 8.80 ± 0.65 , Texture 8.60 ± 0.48 , and Overall acceptability 8.62 ± 0.47 , also marked "a," suggesting comparable sensory qualities. Sample T2 displayed a noticeable decline in scores, with Appearance at 8.25 ± 0.44 , Flavour 8.05 ± 0.62 , Taste 7.93 ± 0.76 , Texture 7.22 ± 0.40 , and Overall acceptability 7.35 ± 0.48 , all marked "b," indicating a statistically significant difference from the Control and T1 samples. Sample T3 had the lowest scores across all attributes: Appearance 6.78 ± 0.48 , Flavour 7.60 ± 0.55 , Taste 6.98 ± 0.71 , Texture 6.55 ± 0.63 , and Overall acceptability 6.68 ± 0.74 , all marked "c," showing a further significant decrease compared to the other samples. This pattern suggests that sensory acceptance decreases progressively from Control and T1 through T3, with Appearance and Overall acceptability following this trend consistently. The Control (Muffin) and T1 samples exhibited similarly high scores across all sensory attributes, significantly outperforming T2 and T3, with T3 receiving the lowest scores in appearance, flavour, taste, texture, and overall acceptability, demonstrating a marked decline in sensory quality from Control/T1 to T3.

The sensory evaluation results summarized in Table 3.1 illustrate a clear hierarchy in acceptability across the four muffin samples: Control, T1, T2, and T3. The Control and T1 samples share statistically similar, highest mean scores in all five sensory attributes such as Appearance, Flavour, Taste, Texture, and Overall acceptability with ratings ranging approximately from 8.14 to 8.86, all denoted with the letter "a." This indicates no significant difference between these two groups in sensory quality, suggesting that whatever modifications or treatments distinguish T1 from the Control sample did not adversely affect sensory acceptance.

In contrast, sample T2 shows moderate but statistically significant declines in all evaluated attributes, with mean scores ranging from 7.22 to 8.25 and designated by the letter "b." This reflects a perceptible decrease in sensory appeal relative to Control and T1. The lowest sensory scores belong to sample T3, with means between 6.55 and 7.60 and marked "c," highlighting a further significant reduction in sensory quality compared to all other groups.

This descending pattern from Control/T1 to T2 and then to T3 signifies that sensory acceptance progressively diminishes as the sample deviates from the original formulation or preparation in these groups. Appearance and Overall acceptability scores closely follow this trend, reinforcing their

Parameter (%)	Control	T1	T2	T3
Protein	06.30 ± 1.50 ^d	35.70 ± 0.64 ^c	43.60 ± 0.60 ^b	54.80 ± 0.64 ^a
Total Carbohydrates	41.10 ± 1.40 ^a	19.20 ± 1.00 ^b	17.90 ± 0.80 ^c	19.10 ± 0.80 ^b
Total Fat	10.70 ± 0.124 ^a	09.50 ± 1.00 ^a	09.00 ± 1.00 ^a	07.80 ± 1.00 ^b
Dietary fiber	03.90 ± 0.40 ^a	0.30 ± 1.00 ^b	0.40 ± 0.35 ^b	0.50 ± 0.40 ^b
Total Ash	01.20 ± 0.48 ^a	01.30 ± 0.40 ^a	1.40 ± 0.40 ^a	1.60 ± 0.40 ^a

role as key drivers of consumer perception and preference. The marked decline by T3 across all sensory dimensions underscores a threshold beyond which modifications may significantly impair sensory appeal.

Contextually, these findings align well with broader empirical observations in the literature regarding fiber enrichment or ingredient modifications in baked cereal foods such as muffins. Meta-analytical evidence shows that even small increases (e.g., 2 g/100 g) in fiber fortification can cause moderate to large reductions in flavor, appearance, and overall acceptability in similar products (Grigor *et al.*, 2015). Interestingly, while texture acceptability in muffins and bread may improve with fortification when the base product has low sensory acceptability, texture is adversely affected when the base acceptability is already

high. This may help explain why Control and T1 maintain high sensory scores, while T2 and especially T3 suffer declines in texture and other attributes, reflecting complex interactions of ingredient changes with baseline quality.

Furthermore, the sensory decline pattern observed from Control and T1 maintaining high acceptability to T3 showing substantial reductions corroborates the notion that food format and initial product acceptability modulate consumer sensory responses to modifications. Similar trends have been reported in other sensory studies, where ingredient incorporation (e.g., grape pomace in whole-wheat muffins) led to increased hardness and changes in texture parameters without a significant detriment to overall acceptability at moderate inclusion levels but could potentially affect perception at higher levels or different formulations (Ortega-Heras *et al.*, 2019).

In summary, the sensory evaluation results express a consistent and statistically validated decline in acceptability from Control and T1 to T3 in muffins, across Appearance, Flavour, Taste, Texture, and Overall acceptability. This pattern is consistent with evidence that fiber enrichment or ingredient modifications influence sensory

attributes with effects dependent on the baseline quality of the product and the extent of modification (Grigor *et al.*, 2015; Ortega-Heras *et al.*, 2019). The data imply that formulations similar to Control and T1 hold promise for maintaining consumer acceptability, whereas extensive alterations exemplified by T3 adversely impact sensory quality and thus likely consumer preference.

3.5 Proximate composition of Muffins

The values are expressed as mean ± SD (n=3). The values in the same row with different superscript letters are significantly different (P < 0.05) as per the Duncan Multiple comparison.

Table 3.3 showed the proximate composition of muffins. The protein content in the Control sample was 6.30 ± 1.50%, which increased progressively across treatments T1, T2, and T3, reaching 54.80 ± 0.64% in T3. Total carbohydrates were highest in the Control at 41.10 ± 1.40%, then decreased significantly in T1 (19.20 ± 1.00%), T2 (17.90 ± 0.80%), and slightly increased again in T3 (19.10 ± 0.80%). Total fat content was recorded as 10.70 ± 1.24% in the Control, with marginal reductions observed in T1 (9.50 ± 1.00%), T2 (9.00 ± 1.00%), and T3 (7.80 ± 1.00%). Dietary fiber was 3.90 ± 0.40% in the Control, but it decreased notably in T1 (0.30 ± 1.00%), and remained low in T2 (0.40 ± 0.35%) and T3 (0.50 ± 0.40%). Total ash content showed a slight increase from 1.20 ± 0.48% in the Control to 1.60 ± 0.40% in T3, with intermediate values in T1 (1.30 ± 0.40%) and T2 (1.40 ± 0.40%).

Table 3.1 presents the proximate composition of muffins subjected to different treatments, namely Control, T1, T2, and T3. These treatments demonstrate significant variations in key nutritional parameters including protein, total carbohydrates, total fat, dietary fiber, and total ash content.

The protein content shows a marked increase across the treatments compared to the control. The Control muffins contain 6.30 ± 1.50% protein, which significantly rises to 35.70 ± 0.64% in T1, 43.60 ± 0.60% in T2, and reaches the highest level of 54.80 ± 0.64% in T3. This progressive enhancement suggests that the treatments involve ingredient modifications or fortifications aimed at increasing the protein level, which could improve the nutritional quality and functional properties of the muffins.

Total carbohydrates exhibit an inverse trend relative to protein content. The Control muffins have the highest carbohydrate percentage at 41.10 ± 1.40%, while the treated samples show a substantial reduction: 19.20 ± 1.00% in T1, 17.90

$\pm 0.80\%$ in T2, and $19.10 \pm 0.80\%$ in T3. This decrease may be attributed to the substitution or supplementation of carbohydrate-rich ingredients with proteinaceous or fiber-rich components, consequently lowering the carbohydrate fraction.

The total fat content remains relatively stable among Control, T1, and T2, with values of $10.70 \pm 1.24\%$, $9.50 \pm 1.00\%$, and $9.00 \pm 1.00\%$, respectively, showing no significant differences. However, T3 exhibits a noticeable decline to $7.80 \pm 1.00\%$, which could be linked to modifications in the fat source or reduction in fat content during formulation adjustments.

Dietary fiber content displays a contrasting pattern. The Control muffins contain $3.90 \pm 0.40\%$ dietary fiber, significantly higher than the treated samples, which range from $0.30 \pm 1.00\%$ in T1 to $0.50 \pm 0.40\%$ in T3. This reduction might indicate that the treatments focus primarily on protein enhancement at the expense of fiber content, or that fiber-rich ingredients were partially replaced.

Total ash content, indicative of the mineral content, remains relatively consistent across all samples, ranging from $1.20 \pm 0.48\%$ in Control to $1.60 \pm 0.40\%$ in T3. The slight increase in ash content in treated muffins suggests minor changes in mineral composition due to ingredient variation or fortification.

Overall, the data reveal that the treatments significantly influence the proximate composition of muffins, particularly enhancing protein content while reducing carbohydrate and dietary fiber levels. These compositional changes reflect strategic formulation modifications aimed at improving the nutritional profile, potentially targeting specific dietary needs such as higher protein intake. The consistency in fat and ash content indicates controlled adjustments to maintain other nutritional aspects.

SUMMARY

The garden cress seeds and Chia seeds were collected and subjected for milling to prepare fine powder. The powder obtained from milling was used for extraction of protein using alkaline extraction followed by isoelectric precipitation.

Proximate analysis was conducted on both the raw seed powder and the extracted protein powder derived from garden cress and chia seeds. The findings indicated that the highest fat content was found in the raw garden cress powder at 22.04 ± 0.32 . The raw garden cress powder also had the highest fiber content at 8.08 ± 0.54 . The protein content peaked in the chia seed protein concentrate at 84.73 ± 0.77 . The ash content was greatest in the raw garden cress powder at 4.95 ± 0.30 . Chia seeds had the highest moisture content at 4.12 ± 1.20 ,

while their carbohydrate content was also the highest at 65.74 ± 0.12 .

The lowest values for each proximate parameter were being recorded as follows: Fat was being lowest in Chi seed protein concentrate at 1.04 ± 0.32 ; Fibre was being lowest in Chi seed protein concentrate at 2.08 ± 0.54 ; Protein was being lowest in Garden cress Raw powder at 24.73 ± 0.77 ; Ash was being lowest in Chi seed protein concentrate at 2.95 ± 0.30 ; Moisture was being lowest in Garden cress Protein concentrate at 2.86 ± 1.79 ; Carbohydrates were lowest in Garden cress Protein concentrate at 2.86 ± 1.79 . Scanning electron microscope was used to determine the surface features of pulse protein concentrates. All the samples exhibited the collapsed and wrinkled surface. It may be due to the presence of uneven shrinkage of particles containing water and protein, and higher moisture evaporation flux during drying process.

The FTIR spectra showed distinct peaks that are indicative of specific functional groups found in both garden cress seed protein powder and chia seed protein powder, shedding light on their molecular makeup. The O-H stretching vibrations, prominently seen around 3269.59 cm^{-1} for garden cress and 3260.20 cm^{-1} for chia seed protein powder, suggest the presence of hydroxyl groups, commonly linked to alcohols and phenols. Moreover, the C=O stretching peaks identified near 1627.50 cm^{-1} and 1620 cm^{-1} confirm the presence of carbonyl groups in both samples, indicating amide bonds typical of protein structures. Further examination reveals C-H stretching vibrations within the $2800\text{--}3300 \text{ cm}^{-1}$ range, appearing at 2851.39 cm^{-1} for garden cress and between 2922.36 cm^{-1} and 2850 cm^{-1} for chia seed protein powder, which point to aliphatic hydrocarbons in the protein matrix. The spectra also show peaks around 1540 cm^{-1} , corresponding to N-H bending vibrations, further supporting the presence of amide linkages in the protein structures. Peaks near 1400 cm^{-1} are linked to C-N stretching vibrations, indicating peptide bonds. These combined spectral features confirm the complex proteinaceous nature of both garden cress and chia seed protein powders. Additional research studies have reported similar FTIR spectral characteristics in seed protein powders, supporting the findings for garden cress and chia seed proteins.

The plant proteins of garden cress seeds and Chia seeds were used as major raw materials to develop eggless muffins along with control sample. The developed experimental samples namely T1, T2 and T3 and control samples were subjected for sensory evaluation using 9 point hedonic scale. The sensory evaluation results indicated that that The

Control sample received the highest scores in all attributes, with Appearance rated 8.74 ± 0.40 , Flavour 8.24 ± 0.37 , Taste 8.86 ± 0.43 , Texture 8.70 ± 0.42 , and Overall acceptability 8.80 ± 0.38 , all marked with the letter "a" indicating no significant difference within this group. Sample T1 showed similar scores to the Control, with Appearance at 8.60 ± 0.39 , Flavour 8.14 ± 0.55 , Taste 8.80 ± 0.65 , Texture 8.60 ± 0.48 , and Overall acceptability 8.62 ± 0.47 , also marked "a," suggesting comparable sensory qualities. Sample T2 displayed a noticeable decline in scores, with Appearance at 8.25 ± 0.44 , Flavour 8.05 ± 0.62 , Taste 7.93 ± 0.76 , Texture 7.22 ± 0.40 , and Overall acceptability 7.35 ± 0.48 , all marked "b," indicating a statistically significant difference from the Control and T1 samples. Sample T3 had the lowest scores across all attributes: Appearance 6.78 ± 0.48 , Flavour 7.60 ± 0.55 , Taste 6.98 ± 0.71 , Texture 6.55 ± 0.63 , and Overall acceptability 6.68 ± 0.74 , all marked "c," showing a further significant decrease compared to the other samples. This pattern suggests that sensory acceptance decreases progressively from Control and T1 through T3, with Appearance and Overall acceptability following this trend consistently. The Control (Muffin) and T1 samples exhibited similarly high scores across all sensory attributes, significantly outperforming T2 and T3, with T3 receiving the lowest scores in appearance, flavour, taste, texture, and overall acceptability, demonstrating a marked decline in sensory quality from Control/T1 to T3.

The Control and T1 samples share statistically similar, highest mean scores in all five sensory attributes such as Appearance, Flavour, Taste, Texture, and Overall acceptability with ratings ranging approximately from 8.14 to 8.86, all denoted with the letter "a." This indicates no significant difference between these two groups in sensory quality, suggesting that whatever modifications or treatments distinguish T1 from the Control sample did not adversely affect sensory acceptance.

The textural properties of the muffins developed under four different conditions showed that hardness values were 750.12 ± 48.12 g for Control, 708.24 ± 42.04 g for T1, 824.95 ± 56.14 g for T2, and 848.24 ± 31.80 g for T3, with T1 being significantly softer than Control, T2 not significantly different from Control or T1, and T3 similar to Control but harder than T1. Adhesiveness values were -0.50 ± 0.08 gs for Control, -0.60 ± 0.32 gs for T1, -1.18 ± 0.24 gs for T2, and -2.24 ± 0.24 gs for T3, where T3 exhibited the highest adhesiveness. Springiness percentages were $1.00 \pm 0.01\%$ for Control, $0.64 \pm 0.10\%$ for T1, $0.75 \pm 0.12\%$ for T2, and $0.90 \pm 0.10\%$ for T3,

with Control and T3 having the highest springiness and T1 the lowest. Cohesiveness percentages were $0.76 \pm 0.02\%$ for Control, $0.88 \pm 0.02\%$ for T1, $0.90 \pm 0.02\%$ for T2, and $0.902 \pm 0.02\%$ for T3, with all treatments showing significantly higher cohesiveness than Control. Gumminess values were 814.32 ± 45.20 g/s for Control, 614.24 ± 12.04 g/s for T1, 724.00 ± 20.24 g/s for T2, and 820.20 ± 40.20 g/s for T3, with T1 being significantly less gummy than Control, while T2 and T3 were not significantly different from Control. Chewiness values were 820.24 ± 40.12 g/s for Control, 620.20 ± 10.40 g/s for T1, 740.24 ± 20.40 g/s for T2, and 818.20 ± 40.12 g/s for T3, with T1 showing the lowest chewiness and Control and T3 being similar. Resilience values were 0.20 ± 0.04 g for Control, 0.10 ± 0.02 g for T1, 0.11 ± 0.01 g for T2, and 0.11 ± 0.02 g for T3, with all treatments having significantly lower resilience than Control.

Overall, compared to the Control sample, treatments T1, T2, and T3 show variations in texture: T1 generally softens hardness, gumminess, chewiness, and resilience; T3 tends to have higher adhesiveness and maintains hardness and chewiness similar to Control; cohesiveness increases in all treatments. These differences indicate that the treatments affect the muffins' structural and sensory characteristics. In conclusion, the garden cress seeds and Chia seeds protein had the potential ability and more suitable to develop muffins.

The development of muffins relies on a precise interplay of ingredient selection, mixing techniques, and baking conditions to achieve the characteristic texture, flavor, and appearance that consumers expect. This process involves careful formulation of dry ingredients including flour, sugar, baking powder, and salt—and wet ingredients, such as eggs, milk, and fat sources like butter or oil.

REFERENCE

- Abd El-Salam, K., Toliba, A., El-Shourbagy, G., & El-Nemr, S. (2019). CHEMICAL AND FUNCTIONAL PROPERTIES OF GARDEN CRESS (*Lepidium sativum* L.) SEEDS POWDER. *Zagazig Journal of Agricultural Research*, 46(5), 1517–1528. <https://doi.org/10.21608/zjar.2019.48168>
- Abdel Ghani, A. E., Al-Saleem, M. S. M., Abdel-Mageed, W. M., Abouzeid, E. M., Mahmoud, M. Y., & Abdallah, R. H. (2023). UPLC-ESI-MS/MS Profiling and Cytotoxic, Antioxidant, Anti-Inflammatory, Antidiabetic, and Antiobesity Activities of the Non-Polar Fractions of *Salvia hispanica* L. Aerial Parts.

- Plants, 12(5), 1062.
<https://doi.org/10.3390/plants12051062>
- Abdulaziz, N. T., Mohammed, E. T., Khalil, R. R., & Mustafa, Y. F. (2024). Unrevealing the total phenols, total flavonoids, antioxidant, anti-inflammatory, and cytotoxic effects of
- Abid, S. F., Basharat, S., Arshad, M., Saba, S., & Zahid, S. Z. (2022). Health Benefits of Garden Cress Seeds. *Riphah Journal of Allied Health Sciences*, 01(02), 40–46.
<https://doi.org/10.53389/rjahs.2022010202>
- Agarwal, A., Rizwana, R., Tripathi, A. D., Kumar, T., Sharma, K. P., & Patel, S. K. S. (2023). Nutritional and Functional New Perspectives and Potential Health Benefits of Quinoa and Chia Seeds. *Antioxidants*, 12(7), 1413.
<https://doi.org/10.3390/antiox12071413>
- Ahmed, M., Eldanasoury, M. M., El-Khamissi, H., & Taie, H. A. (2023). Phytochemicals, Phenolic Compounds and Antioxidant Activity of Garden cress (*Lepidium sativum* L.) seeds. *Al-Azhar Journal of Agricultural Research*, 0(0), 0.
<https://doi.org/10.21608/ajar.2023.184022.1111>
- Arifin, N., M.A, S. N. I., & Huda-Faujan, N. (2019). Physical properties and consumer acceptability of basic muffin made from pumpkin puree as butter replacer. *Food Research*, 840–845.
[https://doi.org/10.26656/fr.2017.3\(6\).090](https://doi.org/10.26656/fr.2017.3(6).090)
- Azene, M., Habte, K., & Tkuwab, H. (2022). Nutritional, health benefits and toxicity of underutilized garden cress seeds and its functional food products: a review. *Food Production, Processing and Nutrition*, 4(1).
<https://doi.org/10.1186/s43014-022-00114-z>
- Bhatia, K., & Bhasin, A. (2023). Exploring the versatile potential of garden cress seeds: Therapeutic applications and industrial utilization: A comprehensive review. *The Pharma Innovation*, 12(9), 101–108.
<https://doi.org/10.22271/tpi.2023.v12.i9b.22647>
- Boopathy, P., & Indhu, K. (2020). Effectiveness of Garden Cress Seeds Nutrition Therapy Provided by 13-18 Years Adolescent Girls in Sivagangai District. Zenodo (CERN European Organization for Nuclear Research).
<https://doi.org/10.5281/zenodo.6351254>
- Chinma, C. E., Ezeocha, V. C., Adedeji, O. E., Ayo-Omogie, H. N., Oganah-Ikujenyo, B. C., Anumba, N. L., Enimola, G. E., Adegoke, D. O., Alhassan, R., & Adebo, O. A. (2023).
- Du, H., Baek, I., Jang, Y., Said, N. S., & Lee, W. Y. (2025). Effects on Physicochemical, Nutritional, and Quality Attributes of Fortified Vegan Muffins Incorporated with Hempseed as an Alternative Protein Source. *Foods* (Basel, Switzerland), 14(4), 601.
<https://doi.org/10.3390/foods14040601>
- Garden Cress seed ethanolic extracts. Review of Clinical Pharmacology and Pharmacokinetics - International Edition, 38(2), 187–196.
<https://doi.org/10.61873/agnd5435>
- Germinated Bambara groundnut (*Vigna subterranea*) flour as an ingredient in wheat bread: Physicochemical, nutritional, and sensory properties of bread. *Journal of Food Science*, 88(6), 2368–2384.
<https://doi.org/10.1111/1750-3841.16585>
- Hernández-López, I., Alamprese, C., Cappa, C., Prieto-Santiago, V., Abadias, M., & Aguiló-Aguayo, I. (2023). Effect of Spirulina in Bread Formulated with Wheat Flours of Different Alveograph Strength. *Foods*, 12(20), 3724.
<https://doi.org/10.3390/foods12203724>
- Khalid, W., Arshad, M. S., Aziz, A., Rahim, M. A., Qaisrani, T. B., Afzal, F., Ali, A., Ranjha, M. M. A. N., Khalid, M. Z., & Anjum, F. M. (2022). Chia seeds (*Salvia hispanica* L.): A therapeutic weapon in metabolic disorders. *Food Science & Nutrition*, 11(1), 3–16.
<https://doi.org/10.1002/fsn3.3035>
- Lahiri, B., & Rani, R. (2020). Garden Cress Seeds: chemistry, medicinal properties, application in dairy and food industry: A Review. *Emergent Life Sciences Research*, 06(02), 01–04.
<https://doi.org/10.31783/elsr.2020.620104>
- Motyka, S., Koc, K., Ekiert, H., Blicharska, E., Czarnek, K., & Szopa, A. (2022). The Current State of Knowledge on *Salvia hispanica* and *Salviae hispanicae* semen (Chia Seeds). *Molecules*, 27(4), 1207.
<https://doi.org/10.3390/molecules27041207>
- Pandurangan, S.-B., Al-Maiman, S. A., Al-Harbi, L. N., & Alshatwi, A. A. (2020). Beneficial Fatty Acid Ratio of *Salvia hispanica* L. (Chia Seed) Potentially Inhibits Adipocyte Hypertrophy, and Decreases Adipokines Expression and Inflammation in Macrophage. *Foods*, 9(3), 368.
<https://doi.org/10.3390/foods9030368>
- Rabail, R., Sultan, M. T., Khalid, A. R., Sahar, A. T., Zia, S., Kowalczewski, P. Ł., Jeżowski, P., Shabbir, M. A., & Aadil, R. M. (2022). Clinical, Nutritional, and Functional Evaluation of Chia Seed-Fortified Muffins. *Molecules*, 27(18), 5907.
<https://doi.org/10.3390/molecules27185907>
- Rita, L., Southern, J., Laponogov, I., Higgins, K., & Veselkov, K. (2024). Optimizing Ingredient Substitution Using Large Language Models to Enhance Phytochemical Content in Recipes. *Machine Learning and Knowledge Extraction*,

- 6(4), 2738–2752.
<https://doi.org/10.3390/make6040131>
- Sarkar, A., Miah, M. S., Masum, M., Amin, M. S. A., & Alam, M. (2025). Fortification of wheat biscuits with chia seed fiber and flower waste: Nutritional, antinutritional, functional, and storage properties. *Applied Food Research*, 5(1), 100864.
<https://doi.org/10.1016/j.afres.2025.100864>
- Singh, C. S., & Paswan, V. K. (2017). The Potential of Garden Cress (*Lepidium sativum* L.) Seeds for Development of Functional Foods. Institute for New Technologies.
<https://doi.org/10.5772/intechopen.70355>.
- Utarova, N., Kakimov, M., Gajdzik, B., Wolniak, R., Nurtayeva, A., Yeraliyeva, S., & Bembenek, M. (2024). Development of Gluten-Free Bread Production Technology with Enhanced Nutritional Value in the Context of Kazakhstan. *Foods* (Basel, Switzerland), 13(2), 271.
<https://doi.org/10.3390/foods13020271>
- Zúñiga-López, M. C., Maturana, G., Campmajó, G., Saurina, J., & Núñez, O. (2021). Determination of Bioactive Compounds in Sequential Extracts of Chia Leaf (*Salvia hispanica* L.) Using UHPLC-HRMS (Q-Orbitrap) and a Global Evaluation of Antioxidant In Vitro Capacity. *Antioxidants*, 10(7), 1151.
<https://doi.org/10.3390/antiox10071151>.

