Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387
Print ISSN 3007-2379

Development And Evaluation Of Flaxseed Enriched Crackers

Aatikah Nadeem Qureshi*
Student of BS Human Nutrition and Dietetics, Department of Human Nutrition and Food Technology, Superior University Lahore Email: aatikahnq13@hotmail.com
Ameena Qaiser Butt
Lecturer, Department of Human Nutrition and Food Technology, Faculty of Allied Health Sciences, Superior University, Lahore
Laiba Haider
Student of BS Human Nutrition and Dietetics, Department of Human Nutrition and Food Technology, Superior University Lahore
Shanza Israr
Student of BS Human Nutrition and Dietetics, Department of Human Nutrition and Food Technology, Superior University Lahore
Minhal Mustafa
Student of BS Human Nutrition and Dietetics, Department of Human Nutrition and Food Technology, Superior University Lahore
Saher Qamar
Student of BS Human Nutrition and Dietetics, Department of Human Nutrition and Food Technology, Superior University Lahore
Mehwish Younas
Student of BS Human Nutrition and Dietetics, Department of Human Nutrition and Food Technology, Superior University Lahore
Kainaat Arshad
Student of BS Human Nutrition and Dietetics, Department of Human Nutrition and Food Technology, Superior University Lahore

Author Details

Keywords: Hypertension Management, Blood Pressure, Flaxseeds, Oats, Nutritional Yeast, Sensory Evaluation

Received on 13 May 2026
Accepted on 12 June 2026
Published on 19 June 2026

Corresponding E-mail & Author*:
Aatikah Nadeem Qureshi*
Email:aatikahnq13@hotmail.com

Abstract

Background: Hypertension is the third leading risk factor for cardiovascular diseases. Nearly 9.4 million deaths per year are due to hypertension. It increases the risk of other major health issues like heart diseases, renal failure, stroke, and organ failure. Hypertension is caused mainly due to unhealthy dietary habits. High salt intake, excess body fat, and physical inactivity, obesity, low fruit and vegetable consumption are all reasons of increased hypertension risk. Chronic hypertension can cause serious problems such as stroke, heart attack, kidney damage, and blindness if not managed appropriately. Hypertension management relies heavily on dietary modifications, with snacking playing a vital role in maintaining normal blood pressure. Healthy snacking options are important for individuals with hypertension to prevent complications and improve quality of life. Traditional snacks option falls short in providing nutritional benefits and less sodium content, leading to the need for innovative and nutrient dense alternatives. Polyphenols and flavonoids have been shown to possess anti-inflammatory and cardiovascular-protective effects. **Materials and Methods:** Flaxseeds enriched crackers are made from different

percent of flaxseed powder in it. All of our components for the crackers are locally sourced. The crackers were prepared in the culinary lab of Superior University, Lahore. The chemical analysis of crackers included phenolic compounds, ash, fiber, protein, fat, and carbohydrates. A 9-point hedonic scale was used for sensory evaluation, which included color, flavor, texture, aroma, and overall acceptability. **Results:** The results of flaxseeds enriched crackers show that the treatments had varying impacts on the nutritional and compositional parameters. Total carbohydrates exhibited a slight decrease over time, with T0 and T1 maintaining the highest values. Moisture content fluctuated through T0 to T3. Total ash content increased significantly through T3. Fiber content progressively increased, particularly in T3. Protein content also increased from T1 to T3, with the least value observed in T0. Fat content fluctuated, increasing from T1 to T3. **Conclusion:** Overall, the data suggest that the treatments positively influence fiber, protein and phenolic content. Among all the treatments evaluated, T3 emerged as a clear standout in laboratory tests, while T2 stood out the most in sensory evaluation.

Introduction

Hypertension is one of the leading risk factors for cardiovascular diseases worldwide and contributes significantly to global mortality and morbidity. It is associated with serious health complications, including stroke, heart attack, kidney failure, and organ damage [1]. Unhealthy dietary habits such as excessive salt consumption, low fruit and vegetable intake, obesity, and physical inactivity are major contributors to the increasing prevalence of hypertension. Although pharmacological treatments are available, long-term medication use may lead to side effects, highlighting the importance of dietary and lifestyle modifications for effective blood pressure management [2,3].

Functional foods have gained considerable attention as natural approaches for preventing and managing hypertension. Flaxseeds, oats, and nutritional yeast are rich sources of dietary fiber, omega-3 fatty acids, antioxidants, and bioactive compounds that have been shown to support cardiovascular health and blood pressure regulation [4]. The development of nutrient-dense snack products incorporating these ingredients may provide healthier alternatives to conventional snacks, which are often high in sodium, sugar, and unhealthy fats. Therefore, this study aimed to formulate flaxseed-enriched crackers with oat flour and nutritional yeast and evaluate their nutritional and sensory qualities as a potential functional food for individuals with hypertension [5,6].

Previous studies have demonstrated a strong relationship between dietary habits and hypertension risk. Research indicates that high sodium intake, obesity, and low consumption of fruits, vegetables, and dietary fiber contribute significantly to elevated blood pressure [7]. Dietary approaches such as the DASH diet and increased intake of whole grains have been shown to improve cardiovascular health and reduce hypertension. Oats, in particular, contain β-glucan, a soluble fiber that helps lower cholesterol levels, improve lipid profiles, enhance insulin sensitivity, and contribute to blood pressure regulation. Regular consumption of oat-based products has therefore been recommended as part of a heart-healthy diet [8,9].

Flaxseeds have been extensively studied for their nutritional and therapeutic properties. They are rich in alpha-linolenic acid (ALA), lignans, dietary fiber, and high-quality protein, all of which contribute to cardiovascular protection [10]. Studies have reported that regular flaxseed consumption can reduce blood pressure, improve lipid metabolism, decrease inflammation, and lower the risk of cardiovascular diseases. Nutritional yeast also provides valuable nutrients, including essential amino acids, β-glucans, and B vitamins, which support heart health and immune function. The combination of flaxseeds, oats, and nutritional yeast in functional food products offers a promising strategy for developing nutritious snacks that may aid in hypertension management [11,12].

This study contributes to the development of healthier snack alternatives for individuals at risk of hypertension by utilizing locally available ingredients such as flaxseeds, oats, and nutritional yeast. The findings provide evidence regarding the nutritional composition and sensory acceptability of flaxseed-enriched crackers, supporting their potential use as functional foods. The study may help food manufacturers formulate nutrient-dense products with improved health benefits while also increasing consumer awareness about dietary approaches for hypertension prevention and management. Additionally, it promotes the incorporation of natural, affordable, and heart-friendly ingredients into daily diets [13,14].

The development of flaxseed-enriched crackers demonstrated the potential of functional foods in supporting hypertension management through improved nutrition. The study showed that incorporating flaxseeds, oat flour, and nutritional yeast enhanced the nutritional quality of crackers by increasing fiber, protein, and phenolic contents while maintaining acceptable sensory characteristics. Among the treatments evaluated, T3 exhibited the most favorable nutritional profile, whereas T2 achieved the highest sensory acceptability. These findings suggest that flaxseed-enriched crackers can serve as a nutritious and acceptable snack option that may contribute to cardiovascular health and support dietary strategies aimed at controlling hypertension [15,16].

MATERIALS AND METHODOLOGY

This study was conducted over a period of four months to develop and evaluate flaxseed-enriched crackers as a healthier snack option for individuals with hypertension. Crackers were formulated using varying proportions of oat flour, flaxseed powder, and nutritional yeast, while a control treatment was prepared without these functional ingredients. All formulations were prepared and analyzed in the culinary laboratory of Superior University, Lahore, using standardized procedures. The developed crackers were subjected to proximate analysis, including moisture, protein, fat, fiber, ash, and total polyphenolic content, as well as sensory evaluation using a nine-point hedonic scale. Data were analyzed using SPSS version 26.0, and statistical significance was determined at $p < 0.05$. The study demonstrated that the incorporation of flaxseed powder, oat flour, and nutritional yeast successfully enhanced the nutritional quality of crackers while maintaining acceptable sensory characteristics. The findings suggested that flaxseed-enriched crackers have the potential to serve as a functional food product that may contribute to improved dietary management of hypertension through increased intake of dietary fiber, antioxidants, and other beneficial nutrients [17,18].

RESULTS:

Proximate analysis interpretation:

The proximate analysis results are shown in two extensive matrices that systematize the research outcomes. In Table 4, the ANOVA results for the proximate analysis of flaxseed crackers, provides crucial statistical indicators comprising sum of squares (SS), degrees of freedom (df), mean square (MS), F-values, and p-values for each nutritional component. This table demonstrates that all measured parameters-moisture, lipid, crude protein, crude fiber, crude ash and polyphenols-show statistically significant differences ($p<0.05$) among the various formulations, with fiber exhibiting the most substantial variation, as evidenced by its exceptionally high F-value of 1876.667.

ANOVA disclosed noteworthy differences ($p<0.05$) amid all the treatment groups (To, T1, T2, and T3) for carbohydrates, ash, moisture, lipid, protein, polyphenols and fiber contents. The extremely low values, suggests that the noted modifications are because of the integration of flaxseed contrary to random variation. The highest F-values were noted for fiber (F=1876.667), carbohydrates (F=982.245), and polyphenols

(F=595.316), explaining a strong impact of flaxseed enhancement on these nutritional boundaries. For that reason, null hypothesis that all of the treatments have same means was denied, that proved that flaxseed incorporation in the crackers changes the nutritional constitution of the crackers.

Table 5 presents the mean value with standard deviation for each proximate parameter across the four different treatment formulation (To-T3). The table 5 reveals the distinct patterns in nutritional composition: T3 containing the highest number of polyphenols in it (52.30±0.54), while T_0 showed the least number of polyphenols in it (35.42±0.45). Both tables work synergistically, with the statistical significance of differences in terms of actual compositional values, together providing a complete picture of how formulation variations affect the nutritional profile of flaxseed enriched crackers.

Table 4 ANOVA for proximate analysis of flaxseed enriched crackers.

Parameters	SS	df	MS	F-value	P-value
Carbohydrates (%)	1631.827	3	543.942	982.245	0.000
Moisture (%)	4.689	3	1.563	15.575	0.001
Ash (%)	4.488	3	1.496	7.019	0.012
Lipids (%)	22.954	3	7.651	26.282	0.000
Protein (%)	167.608	3	55.869	349.021	0.000
Polyphenols (%)	466.758	3	155.586	595.316	0.000
Fiber	347.653	3	115.884	1876.667	0.000

Table 5 Impact of different treatment on mean of proximate analysis of the flaxseed enriched crackers.

	T_0	T_1	T_2	T_3
Carbohydrates (%)	68.01±0.82	47.93±0.75	42.15±0.71	37.4±0.69
Ash (%)	1.23±0.23	1.78±0.40	2.33±0.54	2.87±0.59
Moisture (%)	2.1±0.36	2.76±0.27	3.27±0.30	3.79±0.33
Lipids (%)	14.50±0.68	16.85±0.46	17.5±0.48	18.17±0.51
Protein (%)	9.2±0.25	15.82±0.21	17.42±0.24	19.03±0.69
Polyphenols (%)	35.42±0.45	43.63±0.52	47.96±0.53	52.30±0.54
Fiber (%)	4.8±0.18	14.86±0.24	16.81±0.27	18.77±0.29

Sensory Evaluation of Flaxseed Enriched Crackers:

A semi-trained panel evaluated the sensory attributes of flaxseed enriched crackers and the results of the crackers are analyzed in the table 6. The table 6 shows T2 (8.13±0.96) with the highest scoring for crispiness. Taste wise T0 (8.46±0.32) got the highest scoring while in treated batches T2 (7.65±1.01) was more likely to be accepted by the participants. T2 (8.35±1.01) batch is the most liked batch with the highest overall acceptability in treated batches. T2 (8.21±1.01) batch scored the highest for texture or mouth-feel of the cracker in the treated batches. In terms of aroma in treated batches T2 (7.62±1.32) scored the highest as compared to T1 and T3.

Table 6 Mean and sensory analysis of flaxseed enriched crackers

	T_0 (control)	T_1	T_2	T_3
Crispiness	7.90±0.49	7.35±1.26	8.13±0.96	7.56±1.09
Taste	8.46±0.32	5.96±1.29	7.65±1.01	7.01±1.05
Texture	7.91±0.71	7.33±0.98	8.21±1.01	7.41±0.97
Aroma	7.91±0.62	7.01±1.10	7.62±1.32	7.41±1.05
Overall Acceptability	7.56±0.52	7.64±1.03	8.35±1.01	7.23±0.98

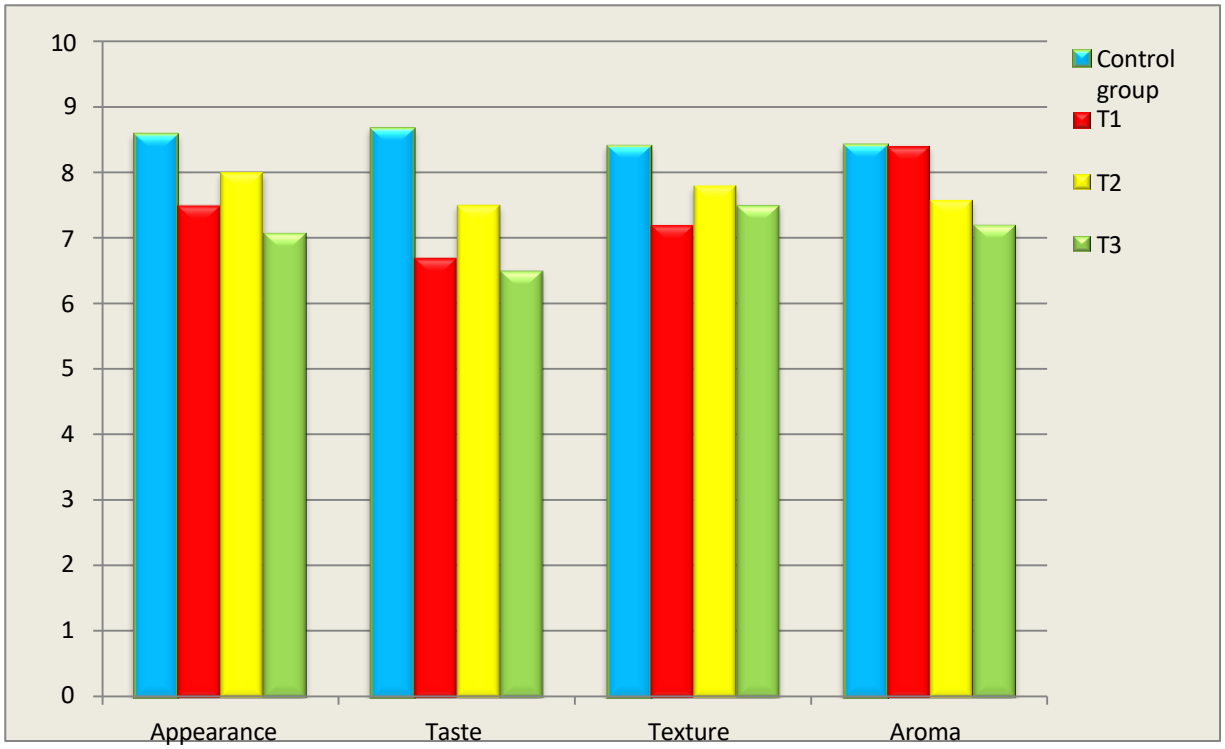

Figure 1: Sensory evaluation chart

DISCUSSION

The present study formulated flaxseed-enriched crackers with oat flour and nutritional yeast as a functional food option for hypertensive individuals. Proximate analysis revealed significant differences ($p<0.05$) across all treatment groups (T0–T3) for all nutritional parameters, confirming that flaxseed incorporation substantially alters the nutritional profile of crackers [19].

Carbohydrate content declined progressively from T0 (68.01±0.82%) to T3 (37.4±0.69%), while protein increased from 9.2±0.25% in T0 to 19.03±0.69% in T3, reflecting the high protein content of flaxseed. Fiber content showed the most significant increase, rising from 4.8±0.18% in T0 to 18.77±0.29% in T3, consistent with the known fiber-rich composition of flaxseed (Pramanik et al., 2023) [20]. Polyphenol content also increased progressively from T0 (35.42±0.45 g/100g) to T3 (52.30±0.54 g/100g), supporting the antioxidant potential of flaxseed-enriched products. These findings align with Xi et al. (2023), who demonstrated that oat-based diets improve sodium control in hypertensive patients, and with Watanabe et al. (2020), who reported anti-hypertensive properties of flaxseed attributed to alpha-linolenic acid (ALA), lignans, and dietary fiber [21,22].

Sensory evaluation indicated that T2 achieved the highest overall acceptability (8.35±1.01) among treated formulations, while T3 demonstrated superior nutritional composition [23]. This suggests that T2 offers the best balance between palatability and health benefit, whereas T3 is most suitable for targeted hypertension management due to its highest fiber, protein, and polyphenol content. Consumer acceptability is a critical factor in long-term dietary adherence, as emphasized by Bakhetia et al. (2024) [24,25].

For hypertensive patients looking for wholesome and appetizing meal alternatives, the creation of flaxseed crackers enhanced with oat flour and nutritional yeast presents a potential answer. In order to avoid complications, hypertension, a non-communicable chronic disease, needs to be carefully managed in terms of nutrition and lifestyle. Blood pressure control mostly depends on dietary interventions and foods with anti-hypertensive qualities [26].

Numerous researches have demonstrated the anti-hypertensive benefits of Linum Usitatissimun, a seed well known for its nutritional and therapeutic properties. Bioactive substances found within the seeds have a chance to enhance sodium sensitivity and control blood pressure. In order to produce a functional food product that may meet the dietary requirements of hypertensive patients, we used flaxseed powder in our study to make crackers enhanced with oat flour and nutritional yeast [27,28].

By our research, flaxseed crackers may be a better choice for those hypertensive individuals who are looking for yummy and wholesome foods. There are several limitations to take into account; our research shows the potential advantages of flaxseed crackers enhanced with oat flour and nutritional yeast for hypertensive individuals. To prove the effectiveness of these crackers in treating hypertension and to establish the ideal dosage and duration of intake, more study is required. To learn more about the mechanisms of action of the bioactive components in flaxseed crackers, more research is also required to determine their bio-availability and bioactivity [29,30].

CONCLUSION:

The incorporation of flaxseed in cracker offers a promising approach for developing functional food for hypertension management which includes alpha linolenic acid, omega 3 fatty acid, lignans, dietary fiber, moisture content, protein, lipids, polyphenols, and glucose. These crackers demonstrated improved blood pressure regulation and nutritional profile. The different formulation (T1, T2, T3), showed variations in nutritional characteristics. T1 is better for glycemic control due to high oats but only modest for BP. T3 is the best for hypertension due to the highest flaxseed content, fiber content and also lignans. Making T3 is more favorable for hypertensive patient. Sensory evaluation show that cracker was acceptable and palatable. This innovative food product has the potential to support hypertension management and provide essential nutrients while serving as a healthy low sodium snack options.

REFERENCES:

Meher M, Pradhan S, Pradhan SR, PRADHAN DS. Risk factors associated with Hypertension in young adults: a systematic review. Cureus. 2023 Apr 12;15(4).

Ballut OM, Alzahrani AA, Alzahrani RA, Alzahrani AT, Alzahrani RA, Alzahrani MF, Alzahrani YK, Alghamdi NA, Alghamdi RH, Ballut O, Alzahrani Sr MF. The impact of non-pharmacological interventions on blood pressure control in patients with hypertension: A systematic review. Cureus. 2023 Nov 7;15(11).

Olombrada E, Mesias M, Morales FJ. Risk/benefits of the use of chia, quinoa, sesame And flax seeds in bakery products. An update review. Food Reviews International. 2024 May 18;40(4):1047-68.

Nie Y, Wang Y, Hui J, Shao D, Chen R, Deng Q, Chen Y, Wang X, Zhu D. The impact of flaxseed (Linum usitatissimum L.) oil supplementation on human health: A human-centric evidence-graded approach. Nutrients. 2025 May 25;17(11):1791.

Theodoridis X, Chourdakis M, Chrysoula L, Chroni V, Tirodimos I, Dipla K, Gkaliagkousi E, Triantafyllou A. Adherence to the DASH diet and risk of hypertension: a systematic review and meta-analysis. Nutrients. 2023 Jul 24;15(14):3261.

Chen Z, Liang W, Liang J, Dou J, Guo F, Zhang D, Xu Z, Wang T. Probiotics: Functional food ingredients with the potential to reduce hypertension. Frontiers in Cellular and Infection Microbiology. 2023 Jul 3;13:1220877.

Cicero AF, Veronesi M, Fogacci F. Dietary intervention to improve blood pressure Control: beyond salt restriction. High Blood Pressure & Cardiovascular Prevention. 2021 Nov;28(6):547-53.

Rahfiludin MZ, Asna AF, Hidayanti L. Contribution of Snacks and Physical Activities To Elevated Blood Pressure of Adolescent Girls in West Java, Indonesia. Malaysian Journal of Medicine and Health Sciences. 2023 Jul 31;19(4):53-60.

Meriles SP, Piloni R, Cáceres GV, Penci MC, Marín MA, Ribotta P, Martínez ML. Compositional characteristics, texture, shelf-life and sensory

quality of snack crackers Produced from non-traditional ingredients. International Journal of Food Science and Technology. 2022 Aug;57(8):4689-96.

Pramanik J, Kumar A, Prajapati B. A review on flaxseeds: Nutritional profile, health Benefits, value added products, and toxicity. EFood. 2023 Oct;4(5):e114.

Raza N, Sadaf A, Mushtaq R, Mehmood MA, Amrao L, Islam F, Afzaal M, Shah MA. % and Health Potential of Edible Seeds: Micronutrient Bioavailability and Mechanistic Insights. Food Science & Nutrition. 2026 Feb;14(2):e71480.

Nikolić V, Žilić S, Simić M, Šavikin K, Stević T, Živković J, Sarić B, Milovanović D, Kandić Raftery V. Characterization and potential food applications of oat flour and husks from differently Colored genotypes as novel nutritional sources of bioactive compounds. Foods. 2024 Nov 28;13(23):3853.

Leszczyńska D, Wirkijowska A, Gasiński A, Średnicka-Tober D, Trafiałek J, Kazimierczak R. Oat and oat processed products—Technology, composition, Nutritional value, and health. Applied Sciences. 2023 Oct 13;13(20):11267.

Garcia-Castro A, Román-Gutiérrez AD, Castaneda-Ovando A, Carino-Cortes R, Acevedo-Sandoval OA, Lopez-Perea P, Guzmán-Ortiz FA. Cereals as a source of bioactive compounds with anti-hypertensive activity and their intake in times of COVID-19. Foods. 2022 Oct 16;11(20):3231

Shelestun A, Eliseeva T. Nutritional Yeast What it is and what it does.

Journal of Healthy Nutrition and Dietetics. 2021;4(18):50-4.

Mark AM. Understanding high blood pressure (hypertension). The Journal of the American Dental Association. 2025 Feb 1;156(2):176.

Carey RM, Wright Jr JT, Taler SJ, Whelton PK. Guideline-driven management of hypertension: an evidence-based update. Circulation research. 2021 Apr 2;128(7):827 46.

Duan W, Zheng B, Li T, Liu RH. Oats and Their Health Benefits. Journal of Food & Nutritional Sciences. 2023;5(1):9-16. 18

Moghadam EF, Khaghani L, Shekarchizadeh-Esfahani P. Flaxseed lowers blood pressure in hypertensive subjects: a meta-analysis of randomized controlled trials. Clinical nutrition research. 2024 Oct 29;13(4):295.

Manimurugan C, Sujatha M, Rathnakumar AL, Sandhanalakshmi M, Zanwar AA. Role of flaxseed (Linum usitatissimum L.) in disease prevention and treatment. Asian Pacific Journal of Tropical Biomedicine. 2023 Jul 1;13(7):277-86.

Stepień AE, Trojniak J, Tabarkiewicz J. Anti-Oxidant and Anti-Cancer Properties of

Flaxseed. International Journal of Molecular Sciences. 2025 Jan 30;26(3):1226.
Paudel D, Dhungana B, Caffe M, Krishnan P. A review of health-beneficial properties of oats. Foods. 2021 Oct 26;10(11):2591.
Alemayehu GF, Forsido SF, Tola YB, Amare E. Nutritional and phytochemical composition and associated health benefits of oat (Avena sativa) grains and oat-based fermented food products. The Scientific World Journal. 2023;2023(1):2730175.
Raj P, Bouchard J, Martineau-Côté D, Malunga L, L'Hocine L, Yu L, Sobhi B, Achouri A, Pitre M, Thandapilly SJ, Netticadan T. Oat-Protein-Based Diet Lowers Blood Pressure and Prevents Cardiac Remodeling and Dysfunction in Spontaneously Hypertensive Rats. Nutrients. 2024 Nov 13;16(22):3870.
Xi H, Zhou W, Niu Y, Zhu R, Wang S, Guo Y, Liu W, Xiong X, Guo L. Effect of oat consumption on blood pressure: A systematic review and meta-analysis of randomized controlled trials. Journal of the Academy of Nutrition and Dietetics. 2023 May 1;123(5):809-23.
Jeanne JF, Malaab J, Vanhove A, Mourey F, Talmatkadi M, Schück S. Natural Language Processing and Machine Learning Techniques for Analyzing Conversations About Nutritional Yeasts in the United States and France: Retrospective Social Media Listening Study. JMIR infodemiology. 2025 May 1;5:e60528.
Szydłowska J, Gładysz K, Żuchnik O, Król O, Kwiatkowski P, Kuczyńska B, Czelej M, Kłos A, Gieroba K, Szydłowski M. Benefits of nutritional yeast for children on vegan diet. Journal of Education, Health and Sport. 2023;13(1):209-15.
Karslı AN. Novel nutritional yeast formulation as a functional ingredient for healthy snacks [thesis]. 2025.