The Annals of the University Dunarea de Jos of Galati
Fascicle VI – Food Technology (2024), 48(2), 9-26

ORIGINAL RESEARCH PAPER

OIL SEED MEALS AND PASTA: A NEW DIMENSION IN BY-PRODUCT VALORIZATION

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Received on 29 July 2024
Revised on 11 October 2024

Abstract

This study investigates the incorporation of oilseed meals—specifically pumpkin seed, sunflower seed, and walnut meal—into pasta formulations to enhance nutritional properties and technological functionality. The proximate composition analysis demonstrated that these meals can significantly increase the protein content of food matrixes, with pumpkin seed meal achieving a protein level of 46.15% and sunflower seed meal offering a substantial carbohydrate level of 36.46%, indicative of high fiber content. Pasta samples were prepared by partially substituting the wheat flour with 5.0% and 10.0% walnut, sunflower, and pumpkin seed meal.
Fortified pasta samples exhibited improved protein content and amino acid profiles, notably increasing lysine levels, which are typically deficient in wheat-based products. Technological functionality assessments revealed that pasta enriched with up to 10% oilseed meals maintained acceptable cooking quality, with losses ranging from 3.25% to 6.34%, ensuring nutrient retention post-cooking. Sensory evaluations indicated high consumer acceptability, scoring between 7.4 and 8.6 out of 9, highlighting their potential market appeal. The check-all-that-apply analysis further differentiated fortified samples through aroma, taste, and texture descriptors. Among formulations, the pasta enriched with 10% pumpkin seed meal emerged as the most successful, offering the most balanced improvements in both nutritional value and cooking quality. This research underscores the dual benefits of utilizing oilseed meals: improving pasta's nutritional value while supporting sustainability through efficient by-product utilization.

Keywords: oilseed meal, pasta, walnut, pumpkin, sunflower, protein, amino acids

https://doi.org/10.35219/foodtechnology.2024.2.01

Introduction

The contemporary world characterized by a sedentary approach to daily living and a tendency toward consumption of highly caloric and low-quality nutritive foods impacted negatively the prevalence of obesity, cardiovascular diseases, type 2 diabetes, and similar chronic diseases (Iglesia *et al*., 2019; Petruk, 2020). Due to this fact, there has been a strong focus on health in recent years (Dinu *et al*., 2017), consequently, consumers are increasingly inclined towards the purchase of healthier products (Capcanari *et al*., 2022; Stan *et al*., 2023). One of the most accessible and widely used strategies to eliminate nutritional deficiencies in the population's diet and to prevent various diseases is the inclusion of functional food ingredients, which have beneficial effects on human health (Bharat Helkar and Sahoo, 2016; Covaliov *et al*., 2021). Thus, in the food industry, considerable attention is being given to the development and production of fortified products for dietary and functional purposes, containing biologically active substances or natural components that can alter the biological value of foods (Popovici *et al*., 2019; Delfanian and Sahari, 2020; Khajavi *et al*., 2020; Ahmad *et al*., 2022; Covaliov *et al*., 2023).

Pasta is among the most consumed foods globally. Some of the important findings revealed that pasta continues to be a weekly, or sometimes daily, indulgence internationally (Altamore *et al*., 2020; Shah *et al*., 2024). Durum wheat semolina is widely considered to be the best raw material in order to manufacture pasta. Its components can be divided into three groups, of which the greatest value is given to the starch (70-80 %), proteins (up to 15%), and the rest contains small amount of fiber, lipids, vitamins, and minerals. In other words, classical pasta lacks almost any allusion of a ‘biological’, value (Dziki, 2021; Covaliov *et al*., 2022).

Additionally, pasta can be considered as the most convenient product that can be easily manipulated in order to increase or decrease its nutritional value according to the further nutritional plan (Carpentieri *et al*., 2022). The practice of enhancing pasta products is not questionable. Protein enrichment, for instance, is much older with documented evidence being in existence for more than five and a half decades (Piazza *et al*., 2023; Teterycz and Sobota, 2023). Several reasons for enriching pasta have been stated in the literature including, nutritional value improvement; utilization of local raw materials; using by-products; making pasta with no gluten; or manufacturing pasta products that possess extra health benefits. Increase of nutritional value has been the most common feature highlighted because, traditional pasta lacks certain amino acids such as lysine and threonine (Pahwa *et al*., 2020).

Presently, pasta manufacturers are implementing plans of introducing and launching pasta with additives such as poultry (breast of carcass), veal, fish, soy, peas, and lens flour, isolates of vegetable proteins, dried and compressed yeast and brewer’s yeast and other food products labeled as healthy (Conte *et al*., 2021; Dello Russo *et al*., 2021; Sajdakowska *et al*., 2021; Fantechi *et al*., 2023).

Globally, oil industry by-products, namely nut and oilseed meals, contain high levels of polyunsaturated fatty acids and enhanced protein quality, including essential amino acids like lysine and threonine, which are often lacking in standard pasta recipes (Arrutia *et al*., 2020; Kotecka-Majchrzak *et al*., 2020; Ermosh *et al*., 2021;

Sá *et al*., 2021; Radu *et al*., 2024). In addition, numerous studies confirmed biologically active potential of oil meals in terms of bioactive compounds such as polyphenols, vitamins, etc., and their antioxidant potential (Ibagon *et al*., 2021; Petraru *et al*., 2021; Multescu *et al*., 2022; Gheise *et al*., 2023; Wen *et al*., 2023). Moreover, He *et al*. (2022) demonstrated their beneficial effect on health, especially on the suppression of the weight gain and adiposity. Furthermore, it should be noted that the utilization of such by-products fits well into the concept of sustainability due to the envisaged efficient pragmatic use and minimization of waste in the production of foods.

The incorporation of oilseed meals in pasta production is an example of a circular economy, thus having positive impacts on both individual health and the environment. This fact aligns perfectly with one of the European Green Deal's strategies: A healthy food system for people and the planet, which involves the support of sustainable food production and the promotion of more sustainable food consumption and healthy diets (Djaoudene *et al*., 2023). Therefore, the development of technology for producing pasta with enhanced biological value, leveraging local plant materials, becomes both pertinent and timely.

This study aims to investigate the incorporation of oilseed meals into pasta formulations to improve the nutritional value and functional properties of the final product. By enhancing the protein, fat, and essential nutrient content, as well as evaluating the effects on cooking quality and sensory characteristics, this research seeks to provide a sustainable and health-conscious alternative for consumers in today's dietary landscape.

Materials and methods

Băneasa wheat flour, (type 000, producer M.P. Băneasa – Moară, Buftea, Romania) and tap water were selected to be two major raw materials that were used in the production of pasta. According to its label, the flour's chemical composition was: carbohydrates 71.0%, proteins 11.0%, fat 0.7%, fibre 2.5%, and ash 0.5% (i.e. moisture content 14.3%). Oilseed meals (pumpkin (POm), sunflower (SfOm)) and walnut (WOm)) were provided by the local oil producer Mira (Chisinau, Republic of Moldova) in March 2024, right after the oil cold pressing.

Meals powder manufacturing

The oilseed meals were supplied in the form of cakes formed during the pressing of oils. Before these meals could be used as raw materials for the pasta production, they were crumbled and then milled in a coffee bean miller (BCG111; KitchenAid, US) and then manually sieved through a mesh with 200 micrometers cell size.

Proximate composition

The proximate composition parameters were determined for both the used oilseed meals and the obtained pasta samples. The moisture content was determined by drying the samples to a constant weight according to (ISO 771:2021, 2021). The ash content was determined by incinerating the samples in a furnace at a temperature of 550 ± 2 °C, following the standardized (ISO 749:1977, 1977) method. The fat content was determined using the Soxhlet method, employing hexane as the solvent (ISO 734:2023, 2023). For protein quantification, the nitrogen content was assessed by the Kjeldahl method, and subsequently, the conversion factor of 6.25 was applied (ISO 16634-1:2008, 2008). Carbohydrate content was determined by the difference from the other experimentally determined components.

Pasta manufacture

The preparation technology of oil meals enriched pasta was based on the modification of the classic recipe, prepared according to AACC Method 62-40.01. The control sample was prepared using 100% wheat flour. The dough for pasta was prepared using a Russell Hobbs Kitchen (Go Create White Kitchen Stand Mixer 25930; UK) Stand Mixer. Tap water was added to the flour (ratio 35:100 by weight), and mixed for 25 min at speed 2 in order to obtain the pasta dough. The spaghetti of length 200 mm and about 2.5 mm thickness was shaped using a hand pasta maker machine (Nuvantee, Italy). The enriched pasta was prepared by substituting wheat flour with 5.0% and 10.0% of the above-mentioned oil meals. In all instances of incorporating oil meals, the moisture content of the powders was considered. Subsequent efforts were made to create pasta by substituting 15.0% and 20.0% of oil meal powder for wheat flour. However, achieving dough with a standardized moisture content of 35.0 ± 1.0% proved challenging due to the absence of 'free' water, probably because of the addition of oil meals that had a higher amount of proteins and fiber, which eased the transition of water into a bound state. Amounts of additions in pasta dough below 10% were reported and by other authors, who mentioned the same negative effect on dough when using higher concentration (Zaky *et al.*, 2022). As a result, when investigating the impact of oil meals inclusion on pasta structure and quality, the addition was limited to a maximum of 10.0% of the wheat flour mass. Thus, seven samples were evaluated: control, pumpkin seed oil meal pasta (POmP5% and POmP10%), sunflower seed oil meal pasta (SfOmP5% and SfOmP10%) and walnut meal pasta (WOmP5% and WOmP10%). After preparation, pasta was left to cool at ambient temperature for 15 min, then dried for 10 h at 50 ± 2 °C in an SLN75 (POL-EKO- -APARATURA, Poland) drying oven, allowed to cool at ambient temperature, packed in polyethylene bags and stored at room temperature of 21 ± 2 °C for further research.

Color determination

The color of uncooked enriched pasta was analyzed using the CIELAB space, with a Konica Minolta CR-400 (Japan) colorimeter. Before assessment, dry uncooked pasta was milled and sifted in order to obtain a homogenous powder. In triplicate measurements, $L*$, $a*$, and $b*$ color coordinates were determined for each sample of pasta. ΔE color difference and Whiteness Index (*WI*) was determined for every sample of pasta according to formulas presented below.

$$\Delta E = \sqrt{(L_{sample} - L_0)^2 + (a_{sample} - a_0)^2 + (b_{sample} - b_0)^2} \quad (1)$$

$$WI = 100 - \sqrt{(100 - L)^2 + a^2 + b^2} \quad (2)$$

Cooking quality of pasta

The assessment of the culinary properties was done by cooking 20 g of spaghetti in 300 ml of boiling water for 7 min, after which the following characteristics were measured (A.A.C.C., 2012).

Optimal cooking time

Cooking time, as determined by the guidelines outlined in AACC Method 66-50, is an important parameter that reflects the quality of pasta. Prolonged cooking duration typically results in higher starch, vitamin, and protein loss from the pasta into the boiling environment. To pinpoint the optimal cooking time, during boiling, at 15 – second intervals, up to three pasta pieces were extracted, pressed between glass slides, and visually inspected for the disappearance of the white core.

Swelling index and water absorption index

Swelling index (SI) determination involved the drying of cooked pasta at 105 ± 2 °C until constant weight, while water absorption index (WAI) determination consisted in the calculation of the amount of absorbed water during cooking. These two indices were evaluated according to the procedure described by Gull et al. (2018) and calculated according to the following formulas:

$$SI = \frac{W_{cd} - W_d}{W_d} (wt\%) \quad (3)$$

$$WAI = \frac{W_{cd} - W_r}{W_r} (wt\%) \quad (4)$$

where: Wcd – weight of cooked drained pasta (g); Wd – weight of pasta after drying (g); Wr – weight of uncooked pasta, wt% – weight percent (Gull *et al*., 2018).

Cooking loss (CL)

Cooking loss index shows the total soluble solids (%) that passed into the boiling water and was determined according to (AACC, 2012), by evaporating the cooking water at 100 ± 2 °C into an oven to dryness.

Sensorial analysis

In order to perform the sensorial test, pasta samples were cooked in the same day. Seventy untrained panelists (aged 20 to 60 years old), participated in this study and appreciated the quality of pasta based on the 9-point hedonic scale from "dislike extremely" to "like extremely", respectively (1—dislike extremely, 2—dislike very much, 3—dislike, 4—dislike slightly, 5—neither like nor dislike, 6—like slightly, 7—like, 8—like very much and 9—like extremely). Evaluated parameters included color, appearance, flavor, taste, texture, and overall acceptability. Each parameter was carefully assessed to provide a comprehensive understanding of the pasta's sensory characteristics.

Check-All-That-Apply (CATA)

Check-All-That-Apply (CATA) analysis, which involves presenting panelists with a list of attributes and asking them to select all the attributes they perceive in each sample was conducted. This method allows for a comprehensive assessment of various sensory characteristics. The study involved 13 semi-trained panelists who evaluated the pasta samples based on attributes presented in table 1.

Table 1. CATA analysis terms.

Product attribute	CATA terms
Color and appearance	light yellow, brownish, greenish, dark, spotty, uneven, uniform
Texture	smooth, rough, grainy, soft, medium, fir, crumbly, cohesive, very cohesive, non-sticky, slightly sticky, very sticky
Aroma	nutty, earthy, vegetal, strong bitterness, slight bitterness
Taste	nutty, bitter, oily, earthy, moldy

Subsequently, after evaluating the pasta, parameters that were mentioned the least and did not statistically differentiate the samples were eliminated based on Cochran's Q test, with the aim of obtaining more accurate data.

Statistical analysis

All experiments were performed in triplicates. The results are given as mean ± standard deviation (SD). The data were statistically analyzed by ANOVA and Tukey tests ($\alpha = 0.05$). The CATA analysis was performed using XLStat software version 7.5.2 for Excel.

Results and discussion

Proximate composition of walnut and oil seeds meal

The quality of the additional raw materials used in pasta production was evaluated by determining the moisture, fat, protein, and ash content, with the carbohydrate content calculated by difference. The values of the mentioned parameters are indicated in Table 2.

Table 2. Proximate composition of walnut, sunflower and pumpkin seeds oil meals.

	Moisture, %	Fat, %	Proteins, %	Carbohydrate*, %	Ash, %
POm	6.89 ± 0.09^{ab}	15.91 ± 0.19	46.15 ± 0.25^{b}	25.49 ± 0.16^{a}	5.56 ± 0.12^{b}
SfOm	7.73 ± 0.13^{b}	17.35 ± 0.34	32.18 ± 0.12^{ab}	36.46 ± 0.18^{b}	6.28 ± 0.09^{c}
WOm	5.83 ± 0.08^{a}	36.58 ± 0.22	25.11 ± 0.18^{a}	28.61 ± 0.14^{ab}	3.87 ± 0.07^{a}

a-c: in each column different letters mean significant differences ($p<0.001$). * calculated by difference. POm – pumpkin oil meal; SfOm – sun flower oil meal; WOm – walnut oil meal.

The results indicate significant variations in the composition of the different oilseed meals. Pumpkin seed oil meal (POm) exhibited the highest protein concentration of 46.15%. This is significantly greater than sunflower seed oil meal (SfOm) with an amount of 32.18% and walnut oil meal (WOm) with 25.11%. Multiple authors have extensively discussed the protein profiles of these oilseed meals, particularly emphasizing the inclusion of essential amino acids (Nourmohammadi *et al*., 2017; Oseyko *et al*., 2020; Burbano and Correa, 2021). Due to their amino acids profile, the application of oilseed meals as animal feed has proven to be an efficient process in promoting animal growth. Studies have demonstrated that the high protein and essential amino acid contents in these meals contribute positively to the overall health and growth performance of livestock (Singh and Prasad, 1979; Greiling *et al*., 2018; Sezgin and Aydın, 2021; Xiao-dan *et al*., 2024). In addition to applications in animal nutrition, these oil meals demonstrate a favorable nutritional profile that can bring significant benefits to human nutrition as well. For instance, a study by Sá *et al*. (2023) highlighted that raw pumpkin seed meal contains up to 45% protein and has an in vitro protein digestibility of 86%, making it an excellent nutritional choice. Moreover, Gao *et al*. (2022) showed that biscuits made from pumpkin seed meal contained 20.4% protein and 19.1% dietary fiber, along with a low glycemic index of 40.5, making them suitable for a healthy diet. In the same vein, Mao and Hua (2012) mentioned that defatted walnut flour could be a good resource of essential amino acids for adults.

Regarding fat, walnut oil meal (WOm) demonstrated the highest fat content of 36.52%, which is consistent with findings reported by several authors (Bakkalbasi *et al*., 2015; Burbano and Correa, 2021) who also observed elevated fat levels in walnut meals, pointing on the high concentration of polyunsaturated fatty acids (≈70%). On the other hand, Pop *et al*. (2020) mentioned a lower fat content of walnut press-cake of 21.93%. This discrepancy can be explained by the different ways of oil extraction, subject that has been addressed by numerous researchers (Labuckas *et al*., 2014; Khan *et al*., 2018; Elouafy *et al*., 2022). Conversely, pumpkin seed oil meal (POm) and sunflower seed oil meal (SfOm) showed relatively lower fat contents of 15.91% and 17.35% respectively.

Impact of oil seed meals on pasta nutritional aspects

The proximate composition of pasta samples is presented in table 3.

Table 3. Proximate composition of pasta samples, %.

	Moisture	Fat	Proteins	Carbohydrate*	Ash
Control	9.91 ± 0.17^{a}	0.50 ± 0.01^{a}	11.59 ± 0.11^{a}	77.47 ± 0.13^{c}	0.53 ± 0.06^{a}
POmP5%	10.16 ± 0.17^{a}	1.30 ± 0.04^{b}	13.35 ± 0.24^{ab}	74.40 ± 0.14^{b}	0.79 ± 0.01^{b}
POmP10%	10.68 ± 0.13^{ab}	2.01 ± 0.04^{c}	14.87 ± 0.14^{b}	71.42 ± 0.21^{a}	1.02 ± 0.04^{d}
SfOmP5%	10.55 ± 0.15^{ab}	1.37 ± 0.05^{b}	12.57 ± 0.14^{ab}	74.69 ± 0.22^{b}	0.82 ± 0.02^{c}
SfOmP10%	11.06 ± 0.21^{b}	2.15 ± 0.04^{c}	13.44 ± 0.14^{ab}	72.27 ± 0.16^{a}	1.08 ± 0.03^{d}
WOmP5%	10.13 ± 0.11^{a}	2.38 ± 0.03^{c}	12.25 ± 0.14^{ab}	74.55 ± 0.14^{b}	0.70 ± 0.04^{b}
WOmP10%	10.21 ± 0.14^{a}	4.07 ± 0.05^{d}	12.84 ± 0.14^{ab}	72.02 ± 0.24^{a}	0.85 ± 0.04^{c}

a-d: in each column different letters mean significant differences ($p<0.001$). * calculated by difference. POmP – pasta with pumpkin seed oil meal; SfOmP – pasta with sun flower seed oil meal; WOmP – pasta with walnut oil meal.

The obtained results show that the inclusion of oil seed and walnut meals in pasta formulations boost their nutritional value compared to control sample, whereas fat, protein and ash content of enriched pasta samples varied by 1.30 – 4.07%, 12.25 – 14.87 and 0.70 – 1.08% respectively, depending on the type and amount of oil meals. The smallest increase in total mineral content or ash was over 30% for the WOmP5% sample, while in the samples with 10% oilseed meal addition, the ash content increased by 92%, 104%, and 61% for the POmP, SfOmP, and WOmP samples, respectively, compared to the control sample. Among the mineral substances, it is important to highlight the significant potassium content in walnut meal — 1.39% of DM (Gheise *et al.*, 2023) and the zinc content in pumpkin seed meal — 30.3 μg/g.

It is also worth mentioning that the addition of oilseed meals not only quantitatively enhances the nutritional value of pasta but also qualitatively. As mentioned above, wheat pasta is low in essential amino acids such as lysine and threonine. Studies indicate that pumpkin seed meal, for example, contains six times more lysine (1.24 g/100 g) than wheat flour (0.23 g/100 g). In the case of threonine, it is present in pumpkin seed meal at a quantity of 0.99 g/100 g compared to 0.28 g/100 g in wheat flour (Litvynchuk *et al.*, 2022).

In Table 4, is presented the calculated essential amino acid composition of the used oilseed meals, alongside their contributions to the nutritional profile of fortified pasta formulations. The amino acid content in wheat flour is compared with that from pumpkin seed, sunflower seed, and walnut seed meals, highlighting the potential enhancements in the nutritional value of pasta through the incorporation of these by-products.

Table 4. Essential amino acid composition (mg/g protein) of wheat flour and oilseed meals and their contribution to fortified pasta (Shoup *et al.*, 1966; Jørgensen *et al.*, 1984; Burbano and Correa, 2021; Sá *et al.*, 2021).

Essential Amino acid	Wheat Flour (Control pasta)*	Pumpkin seed			Sunflower seed			Walnut		
		Meal*	Pasta 5%	Pasta 10%	Meal*	Pasta 5%	Pasta 10%	Meal *	Pasta 5%	Pasta 10%
Valine	9.6	40.0	14.77	18.39	46.9	14.02	17.57	28.5	11.41	12.94
Isoleucine	15.9	38.0	19.66	22.29	40.5	18.82	21.15	64.5	20.55	24.49
Leucine	38.2	61.0	42.08	44.79	66.0	41.50	44.14	62.7	40.54	42.53
Histidine	24.2	23.0	24.00	23.85	14.8	23.09	22.19	17.5	23.56	23.02
Methionine + cysteine	31.0	26.0	30.15	29.55	13.0	28.86	27.16	3.9	28.41	26.21
Triptophan	-	n.d.	0.00		n.d.	0.00	0.00	9.1	0.87	1.61
Phenylalanine + tyrosine	54.5	55.0	54.59	54.64	100.9	60.00	64.41	47.3	53.81	53.23
Lysine	15.7	36.0	19.15	21.57	46.6	19.37	22.30	36.2	17.66	19.32
Threonine	22.9	35.0	24.96	26.40	13.9	21.83	20.98	17.1	22.35	21.87

* – data were taken from literature, for pasta were calculated.

Based on the data obtained in Table 4 regarding the essential amino acid composition in fortified pasta with 5% and 10% oilseed meals, several key observations can be made. The inclusion of pumpkin seed meal, sunflower seed meal, and walnut meal has resulted in substantial increases in certain amino acids compared to the wheat flour control sample. Notably, lysine, often the limiting amino acid in cereals, shows an appreciable increase with the use of oilseed meals. For the pumpkin seed meal-fortified pasta, lysine content increases from 15.7 mg/g protein in the control pasta to 19.15 mg/g protein and 21.57 mg/g protein in the 5% and 10% fortified pasta, respectively. This suggests that incorporating oilseed meals can address lysine deficiencies commonly found in cereal-based diets, enhancing the nutritional profile of pasta. Similarly, other essential amino acids experience increases, like isoleucine and tryptophan, which although absent in some meal varieties, exhibit expansion in walnuts' fortified pasta with 0.87 mg/g protein and 1.61 mg/g protein at 5% and 10% fortification. Valine and leucine also see beneficial increments, providing a more balanced amino acid profile, essential for protein synthesis and muscle health (Gorissen and Phillips, 2019).

The positive effect of the oil meals incorporation on nutritional value of pasta has been also reported in numerous studies. Padalino *et al*. (2018) outlined a considerably improvement of the bioactive components in pasta enriched with 10% olive oil meal paste, and namely, the PUFA/SFA ratio was higher than the control and the total polyphenols content showed an upward trend 82.39 μg/g DW to 245.08 μg/g DW (Padalino *et al*., 2018). Zaky *et al*. (2022) mentioned the same effect of sunflower meal protein isolate in the case of pasta fortification.

Impact of oil seed meals on pasta technological functionality parameters

Determining the technological functionality indices of pasta is essential for assessing how oilseed meal additions affect the product's integrity during cooking. Parameters such as swelling index (SI), water absorption index (WAI), optimal cooking time, and cooking loss, as presented in Table 5, provide valuable insights into the influence of these additives on pasta's physical attributes.

Table 5. Cooking quality indices of pasta samples

	SI, g H_2O (g pasta)$^{-1}$	**WAI, g (100 g)$^{-1}$**	**Optimal cooking time**	**Cooking Loss, %**
Control	2.36±0.01^{a}	1.83±0.01^{a}	6 min 15 s	3.25±0.04^{a}
POmP 5%	2.12±0.08^{a}	1.75±0.02^{a}	5 min 30 s	5.21±0.12^{b}
POmP 10%	1.96±0.04^{a}	1.71±0.02^{a}	5 min 15 s	6.34±0.09^{c}
SfOmP 5%	1.62±0.03^{a}	1.80±0.01^{a}	6 min 00 s	4.78±0.14^{ab}
SfOmP 10%	1.56±0.02^{a}	1.78±0.01^{a}	5 min 45 s	6.16±0.07^{c}
WOmP 5%	2.01±0.01^{a}	1.78±0.02^{a}	5 min 45 s	4.67±0.22^{ab}
WOmP 10%	1.87±0.03^{a}	1.74±0.01^{a}	5 min 30 s	6.09±0.16^{c}

a-c: in each column different letters mean significant differences ($p<0.001$). SI – swelling index, WAI – water absorbtion index, POmP – pasta with pumpkin seed oil meal, SfOmP – pasta with sun flower seed oil meal, WOmP – pasta with walnut oil meal.

Cooking losses are largely attributed to soluble proteins. The pasta cooking losses during the optimal cooking time ranged from 3.25% to 6.34%. The highest loss was observed in pasta samples with 10% pumpkin seed meal, which is consistent with its higher protein content (Table 2) (Zaky *et al*., 2022). Nevertheless, all samples fell within the acceptable technological limit for pasta cooking losses of 8%. Similar values were reported by different authors when fortifying pasta with flaxseeds oil meal (Zarzycki *et al*., 2020), groundnut meal (Mridula *et al*., 2016), sunflower oil meal (Zaky *et al*., 2022) and other plant additions (Covaliov *et al*., 2022).

The addition of oil meals decreased the optimal cooking time from 6 min 15 s for the control sample to values that ranged between 5 min 15 s and 6 min 00 s. Zarzycki *et al*. (2020) attributes this to the physical disruption of the gluten matrix caused by the presence of non-traditional ingredients in the pasta, which can facilitate water diffusion and reduce the product's cooking time.

Swelling index manifested a slight decreasing trend with the addition of oil meals. The highest decrease was recorded for samples with the addition of sunflower oil meal, 1.56 g H_2O (g pasta)$^{-1}$ for SfOmP 10% compared with 2.36 g H_2O (g pasta)$^{-1}$ for control sample. Several authors attributed this fact to the competition between starch and fibers for water absorption during pasta preparation, which reduces starch swelling capacity (Foschia *et al*., 2015; Padalino *et al*., 2018). The same decreasing trend was also observed in the water absorption index. Several authors attempt to explain this by suggesting that proteins in the additives create a strong matrix that surrounds the starch granules in wheat flour, thereby inhibiting water penetration into the starch granules and consequently restricting the water absorption index (Padalino *et al*., 2018). On the other hand, Simonato *et al*. (2019) mentioned an increase of these two indices when supplemented pasta with olive pomace, clarifying that the addition of fiber in a pasta dough can cause a structure modification, thus allowing a quicker water penetration in the pasta matrix and consequently an earlier starch gelatinization may be induced.

Color parameters

The color of food is considered the most crucial factor in aroma perception; it sets consumers' expectations of how those food products will taste, as well as the pleasure or distaste of experiencing them (Velasco *et al*., 2016). In table 6 are presented the main chromatic parameters of uncooked pasta. A decreasing trend in lightness (L^*) was observed with the addition of oil meals, with this effect being more pronounced as the concentration of oil meals increased.

The same decreasing tendency was manifested and by a^* (redness) and b^* (yellowness) parameters. The most drastic decrease in the L^*, a^*, and b^* parameters was observed in the case of the sample SfOmP10%. Consequently, L^* reached values of 43.17 compared to 63.25 for the control sample; the redness (a^*) became less pronounced with values of 1.27 compared to 7.46 for the control sample, and the yellow-blue component (b^*) reached minimal values of 4.98 compared to 38.35. Similar outcomes were reported by Bianchi *et al*. (2021) for pasta enriched with different agro-industrial by-products. Conversely, several researchers reported an increase in *a** and *b** parameters when incorporated watermelon rind powder (Ho and Che Dahri, 2016) or apple by-product in pasta formulation (Lončarić *et al.*, 2014).

Table 6. Impact of oil seeds and walnut meal on **c**hromatic parameters of uncooked pasta.

	L*	***a****	***b****	***ΔE***	***WI***
Control	63.25±0.21[c]	7.46±0.01[d]	38.35±0.04[d]		46.36±0.04[c]
POmP 5%	52.12±0.16[bc]	3.12±0.02[b]	13.11±0.04[c]	27.92±0.12[a]	50.26±0.08[d]
POmP 10%	48.52±0.22[b]	2.18±0.02[ab]	12.21±0.04[c]	30.47±0.09[b]	47.05±0.11[c]
SfOmP 5%	43.52±0.26[a]	2.32±0.01[ab]	8.06±0.12[b]	36.51±0.14[c]	42.90±0.08[a]
SfOmP 10%	43.17±0.17[a]	1.27±0.01[a]	4.98±0.09[a]	39.43±0.07[d]	42.94±0.05[a]
WOmP 5%	46.42±.0.23[ab]	7.05±0.02[d]	11.36±0.14[c]	31.81±0.22[b]	44.78±0.22[b]
WOmP 10%	45.34±0.13[ab]	6.52±0.01[c]	9.42±0.07[b]	34.04±0.16[c]	44.15±0.16[b]

a-d: in each column different letters mean significant differences (p<0.001). POmP – pasta with pumpkin seed oil meal, SfOmP – pasta with sun flower seed oil meal, WOmP – pasta with walnut oil meal, *L* – lightness, *a* – redness, *b* – yellowness, *ΔE* **–** color difference, *WI* – whiteness index.

Sensory analysis

For sensory analysis, six main characteristics were assessed (color, appearance, flavor, taste, texture, and overall acceptability). The obtained scores are presented in Figure 1.

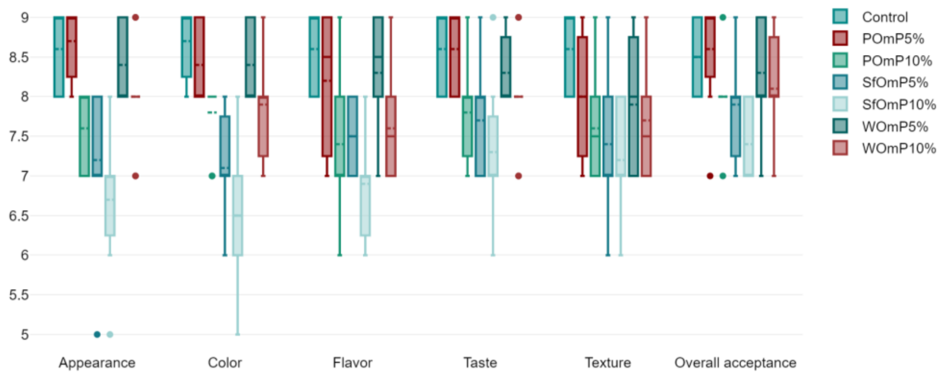

Figure 1. Boxplot for sensory analysis of pasta samples.

POmP5%—pasta with 5% addition of pumpkin seeds oil meal, POmP10%— pasta with 10% addition of pumpkin seeds oil meal, SfOmP5%— pasta with 5% addition of sunflower seeds oil meal, SfOmP10%— pasta with 10% addition of sunflower seeds oil meal, WOmP5%— pasta with 5% addition of walnut oil meal, WOmP10%— pasta with 5% addition of walnut oil meal.

From the obtained diagram, it is evident that the samples recorded scores ranging between 5 (neither like nor dislike) and 9 (like extremely). In fact, scores of 5 were given by some panelists only to the pasta enriched with sunflower meal, suggesting that it had a less favorable impact on the appearance and color parameters. Nonetheless, the mean values for overall acceptability were: 8.5 for the control sample, 8.6 for the POmP5% sample, 8.0 for the POmP10% sample, 7.9 for the SfOmP5% sample, 7.4 for the SfOmP10% sample, 8.3 for the WomP5% sample, and 8.1 for the WomP10% sample. Consequently, all samples fall within the range of "like – like extremely," indicating that each type of pasta enriched with meals could potentially find a niche in the consumer market. This is especially true given that recent studies suggest today's consumers are seeking sustainable products that are in harmony with the environment, promote health, and address climate change concerns (Capcanari *et al*., 2023).

Check-All-That-Apply (CATA)

Analyzing the data presented in the CATA plot (Figure 2), a significant difference between the control sample and the fortified samples can be easily observed.

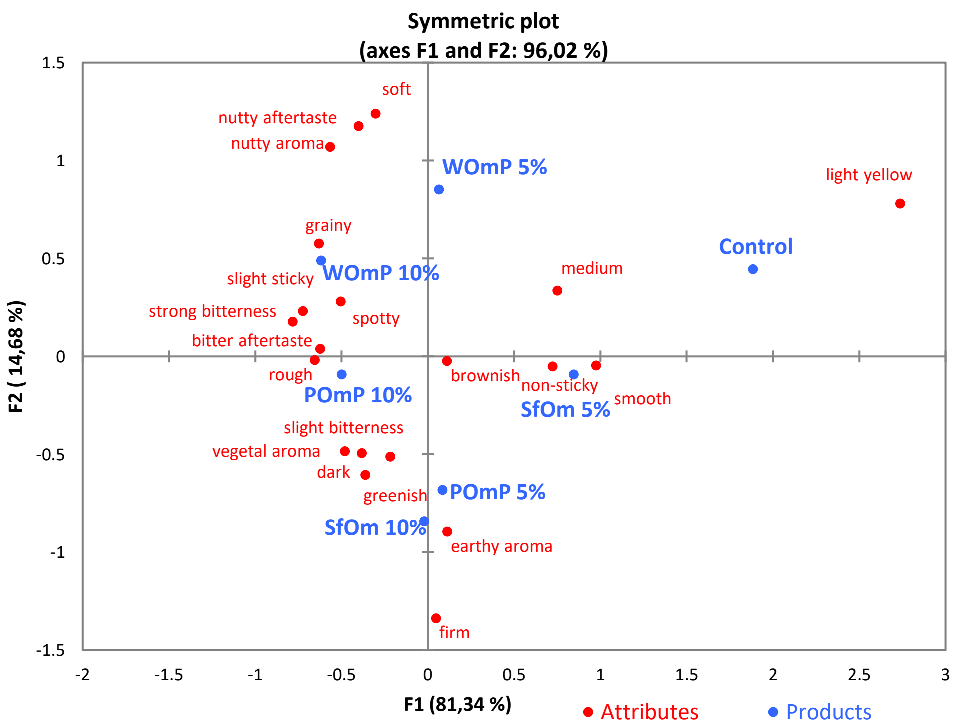

Figure 2. Visualized results of the check-all-that-apply (CATA) analysis of the seven pasta samples.

POmP5%—pasta with 5% addition of pumpkin seeds oil meal, POmP10%— pasta with 10% addition of pumpkin seeds oil meal, SfOmP5%— pasta with 5% addition of sunflower seeds oil meal, SfOmP10%— pasta with 10% addition of sunflower seeds oil meal, WOmP5%— pasta with 5% addition of walnut oil meal, WOmP10%— pasta with 5% addition of walnut oil meal.

The term “light yellow” appeared alone in the right of the plot and the control sample was the one described with this descriptor. According to the plot, the samples with added oil meals had a corresponding aroma and aftertaste. The samples with a 10% addition of meals were rated as spotty, likely due to the difficulty in completely homogenizing the pasta dough mixture. These samples also received the bitterness rating, which could be attributed to the potential rancidity of the fats in the meal compositions, particularly in the case of walnut meal, which has the highest fat content. Additionally, the fortified samples exhibited a softer texture compared to the control sample.

Conclusions

The composition analysis of the oilseed meals revealed that pumpkin seed and sunflower seed meals, in particular, can serve as excellent sources of protein and fiber, thereby enhancing the nutritional profile of fortified pasta products.

Nutritionally, protein content in enriched pasta ranged from 12.25% to 14.87%, compared to 11.59% in the control sample, indicating a notable enhancement. Fat content also increased from 0.50% in the control to a peak of 4.07% in pasta with 10% walnut meal, while ash content, indicating mineral presence, ranged from 0.70% to 1.08%, up from 0.53% in the control. The fortified pasta showed an enhanced content of essential amino acids, particularly lysine, which increased from 15.7 mg/g protein in the control pasta to 21.57 mg/g protein in pasta fortified with 10% pumpkin seed meal. This aligns with addressing the typical lysine deficiency found in cereal-based diets, thus improving the nutritional balance of the pasta.

In terms of technological functionality, the addition of oil meals affected the cooking quality by reducing the optimal cooking time and slightly decreasing the swelling and water absorption indices. The incorporation of oilseed meals in pasta formulations resulted in cooking losses ranging from 3.25% to 6.34%, all within acceptable limits, indicating that the enriched pasta retains a substantial amount of its nutrients even after cooking.

The color parameters of the pasta also change significantly, with a noticeable reduction in lightness, redness, and yellowness as the concentration of oil meals increases.

Sensory analysis revealed all enriched samples were well-received, with preference scores ranging from 7.4 to 8.6 on a scale from 1 to 9, all falling within the "like - like extremely" category. Sunflower meal-enriched pasta was slightly less favored in appearance and color. Among the various formulations, pasta enriched with 10% pumpkin seed meal showed the most significant improvements in both nutritional value and technological functionality, representing the most successful enhancement in this study.

Acknowledgments

The research was supported by the Project 23.70105.5107.06T "Valorization of vegetable proteins from secondary products of the local fat and oil industry", being implemented at the Technical University of Moldova.

References

A.A.C.C. 2012. Approved Method of AmericanAssociation of Cereal Chemists, published byAmerican Association of Cereal Chemists, Ins. St.Paul, Minnesota, US.

Ahmad, I., Hao, M., Li, Y., Zhang, J., Ding, Y., Lyu, F. 2022. Fortification of yogurt with bioactive functional foods and ingredients and associated challenges—A review. *Trends in Food Science & Technology*, **129**, 558–580.

Altamore, L., Ingrassia, M., Columba, P., Chironi, S., Bacarella, S. 2020. Italian Consumers' Preferences for Pasta and Consumption Trends: Tradition or Innovation? *Journal of International Food & Agribusiness Marketing*, **32**(4), 337–360.

Arrutia, F., Binner, E., Williams, P., Waldron, K.W. 2020. Oilseeds beyond oil: Press cakes and meals supplying global protein requirements. *Trends in Food Science & Technology*, **100**, 88–102.

Bakkalbasi, E., Meral, R., Dogan, I.S. 2015. Bioactive Compounds, Physical and Sensory Properties of Cake Made with Walnut Press-Cake. *Journal of Food Quality*, **38**(6), 422–430.

Bharat Helkar, P., Sahoo, A. 2016. Review: Food Industry By-Products used as a Functional Food Ingredients. *International Journal of Waste Resources*, **6**(3), 1000248.

Bianchi, F., Tolve, R., Rainero, G., Bordiga, M., Brennan, C.S., Simonato, B. 2021. Technological, nutritional and sensory properties of pasta fortified with agro-industrial by-products: A review. *International Journal of Food Science & Technology*, **56**(9), 4356–4366.

Burbano, J.J., Correa, M.J. 2021. Composition and physicochemical characterization of walnut flour, a by-product of oil extraction. *Plant Foods for Human Nutrition*, **76**(2), 233–239.

Capcanari, T., Chirsanova, A., Covaliov, E., Radu, O., Siminiuc, R. 2022. Pastry sauce with carob (Ceratonia siliqua) powder. *Ukrainian Food Journal*, **11**(2), 235–258.

Capcanari, T., Covaliov, E., Negoița, C., Siminiuc, R., Chirsanova, A., Reșitca, V., Țurcanu, D. 2023. Hemp Seed Cake Flour as a Source of Proteins, Minerals and Polyphenols and Its Impact on the Nutritional, Sensorial and Technological Quality of Bread. *Foods*, **12**(23), 4327.

Carpentieri, S., Larrea-Wachtendorff, D., Donsì, F., Ferrari, G. 2022. Functionalization of pasta through the incorporation of bioactive compounds from agri-food by-products: Fundamentals, opportunities, and drawbacks. *Trends in Food Science & Technology*, **122**, 49–65.

Conte, P., Piga, A., Del Caro, A., Urgeghe, P.P., Fadda, C. 2021. Italian Dried Pasta: Conventional and Innovative Ingredients and Processing. In F. Boukid (Ed.), Cereal-Based Foodstuffs: *The Backbone of Mediterranean Cuisine* (pp. 89–116). Springer International Publishing.

Covaliov, E., Capcanari, T., Reșitca, V., Chirsanova, A. 2023. Quality evaluation of sponge cake with milk thistle (*Silybum marianum* L.) seed powder addition. *Ukrainian Food Journal*, **12**, 7-20.

Covaliov, E., Deseatnicova, O., Resitca, V., Suhodol, N., Grosu, C., Siminiuc, R. 2022. Impact of plant additives: Parsley (*Petroselinum crispum*) leaves and red bell pepper

(*Capsicum annuum*) on the quality of eggless wheat pasta. *Czech Journal of Food Sciences*, **40**(4), 281–289.

Covaliov, E., Grosu, C., Popovici, V., Capcanari, T., Siminiuc, R., Reşitca, V. 2021. Impact of sea buckthorn berries (*Hippophae rhamnoides*) on yoghurt biological value and quality. *Annals of the University Dunarea de Jos of Galati*, *Fascicle VI: Food Technology*, **2**(45), 62-76. ISSN 1843-5157. DOI:

Delfanian, M., Sahari, M.A. 2020. Improving functionality, bioavailability, nutraceutical and sensory attributes of fortified foods using phenolics-loaded nanocarriers as natural ingredients. *Food Research International*, **137**, 109555.

Dello Russo, M., Spagnuolo, C., Moccia, S., Angelino, D., Pellegrini, N., Martini, D. 2021. Nutritional Quality of Pasta Sold on the Italian Market: The Food Labelling of Italian Products (FLIP) Study. *Nutrients*, **13**(1), 171.

Dinu, M., Pagliai, G., Sofi, F. 2017. A Heart-Healthy Diet: Recent Insights and Practical Recommendations. *Current Cardiology Reports*, **19**(10), 95.

Djaoudene, O., Bachir-Bey, M., Cásedas, G., Les, F., López, V. 2023. Phenolic compounds recovery from date seed and assessment of their antioxidant and enzyme inhibitory properties. *The Annals of the University Dunarea de Jos of Galati. Fascicle VI - Food Technology*, **47**(2), 190–206.

Dziki, D. 2021. Current Trends in Enrichment of Wheat Pasta: Quality, Nutritional Value and Antioxidant Properties. *Processes*, **9**(8), 1280.

Elouafy, Y., El Yadini, A., El Moudden, H., Harhar, H., Alshahrani, M.M., Awadh, A.A.A., Goh, K.W., Ming, L.C., Bouyahya, A., Tabyaoui, M. 2022. Influence of the Extraction Method on the Quality and Chemical Composition of Walnut (*Juglans regia* L.) Oil. *Molecules*, **27**(22), 7681.

Ermosh, L.G., Prisuhina, N.V., Koch, D.A., Eremina, E.V. 2021. The use of oilseed cake for supplementation of bakery products. *IOP Conference Series: Earth and Environmental Science*, **677**(2), 022090.

Fantechi, T., Contini, C., Casini, L. 2023. Pasta goes green: Consumer preferences for spirulina-enriched pasta in Italy. *Algal Research*, **75**, 103275.

Foschia, M., Peressini, D., Sensidoni, A., Brennan, M.A., Brennan, C.S. 2015. How combinations of dietary fibres can affect physicochemical characteristics of pasta. *LWT - Food Science and Technology*, **61**(1), 41–46.

Gao, D., Helikh, A., Duan, Z., Liu, Y., Shang, F. 2022. Development of pumpkin seed meal biscuits. *Eastern-European Journal of Enterprise Technologies*, **2**(11(116)), 36–42.

Gheise, N.J.E., Riasi, A., Shahneh, A.Z., Naseri, V., Kafilzadeh, F., Bolandnazar, A., Ahmadi, F. 2023. Comparative evaluation of nutrient composition, in vitro nutritional value, and antioxidant activity of de-oiled meals from walnut, hazelnut, almond, and sesame. *Tropical Animal Health and Production*, **55**(5), 333.

Gorissen, S.H.M., Phillips, S.M. 2019. Branched-Chain Amino Acids (Leucine, Isoleucine, and Valine) and Skeletal Muscle. In *Nutrition and Skeletal Muscle* (pp. 283–298). Elsevier.

Greiling, A.M., Schwarz, C., Gierus, M., Rodehutscord, M. 2018. Pumpkin seed cake as a fishmeal substitute in fish nutrition: Effects on growth performance, morphological traits and fillet color of two freshwater salmonids and two catfish species. *Archives of Animal Nutrition*, **72**(3), 239–259.

Gull, A., Prasad, K., Kumar, P. 2018. Nutritional, antioxidant, microstructural and pasting properties of functional pasta. *Journal of the Saudi Society of Agricultural Sciences*, **17**(2), 147–153.

He, X., Chen, D., Guo, Y., Zhang, X., Ma, Y., Zhao, S. 2022. Walnut meal extracts rich in polyphenols mitigate insulin resistance and modulate gut microbiota in high fat diet-fed rats. *Journal of Medicinal Food*, **25**(6), 618–629.

Ho, L.-H., Che Dahri, N. 2016. Effect of watermelon rind powder on physicochemical, textural, and sensory properties of wet yellow noodles. *CyTA - Journal of Food*, 1–8.

Ibagon, J.A., Lee, S.A., Stein, H.H. 2021. Sunflower expellers have greater ileal digestibility of amino acids than sunflower meal, but there are only minor variations among different sources of sunflower meal when fed to growing pigs. *Journal of Animal Science*, skab198.

Iglesia, I., De Miguel-Etayo, P., Battelino, T., Moreno, L.A. 2019. Trends, insights, and approaches to diet and obesity. In *Trends in Personalized Nutrition* (pp. 137–167). Elsevier.

ISO 734:2023. Oilseed meals—Determination of oil content—Extraction method with hexane (or light petroleum).

ISO 749:1977. Oilseed residues—Determination of total ash.

ISO 771:2021. Oilseed meals—Determination of moisture and volatile matter content.

ISO 16634-1:2008. Food products—Determination of the total nitrogen content by combustion according to the Dumas principle and calculation of the crude protein content.

Jørgensen, H., Sauer, W.C., Thacker, P.A. 1984. Amino acid availabilities in soybean meal, sunflower meal, fish meal and meat and bone meal fed to growing pigs. *Journal of Animal Science*, **58**(4), 926–934.

Khajavi, M.Z., Abhari, K., Barzegar, F., Hosseini, H. 2020. Functional Meat Products: The New Consumer's Demand. *Current Nutrition & Food Science*, **16**(3), 260–267.

Khan, G.M., Khan, N.M., Khan, Z.U., Ali, F., Jan, A.K., Muhammad, N., Elahi, R. 2018. Effect of extraction methods on structural, physiochemical and functional properties of dietary fiber from defatted walnut flour. *Food Science and Biotechnology*, **27**(4), 1015–1022.

Kotecka-Majchrzak, K., Sumara, A., Fornal, E., Montowska, M. 2020. Oilseed proteins – Properties and application as a food ingredient. *Trends in Food Science & Technology*, **106**, 160–170.

Labuckas, D., Maestri, D., Lamarque, A. 2014. Effect of different oil extraction methods on proximate composition and protein characteristics of walnut (*Juglans regia* L.) flour. *LWT - Food Science and Technology*, **59**(2), 794–799.

Litvynchuk, S., Galenko, O., Cavicchi, A., Ceccanti, C., Mignani, C., Guidi, L., Shevchenko, A. 2022. Conformational Changes in the Structure of Dough and Bread Enriched with Pumpkin Seed Flour. *Plants*, **11**(20), 2762.

Lončarić, A., Kosović, I., Jukić, M., Ugarčić, Ž., Piližota, V. 2014. Effect of apple by-product as a supplement on antioxidant activity and quality parameters of pasta. *Croatian Journal of Food Science and Technology*, **6**(2), 97–103.

Mao, X., Hua, Y. 2012. Composition, Structure and Functional Properties of Protein Concentrates and Isolates Produced from Walnut (*Juglans regia* L.). *International Journal of Molecular Sciences*, **13**(2), 1561–1581.

Mridula, D., Gupta, R.K., Bhadwal, S., Khaira, H., Tyagi, S.K. 2016. Optimization of food materials for development of nutritious pasta utilizing groundnut meal and beetroot. *Journal of Food Science and Technology*, **53**(4), 1834–1844.

Multescu, M., Marinas, I.C., Susman, I.E., Belc, N. 2022. Byproducts (Flour, Meals, and Groats) from the vegetable oil industry as a potential source of antioxidants. *Foods*, **11**(3), 253.

Nourmohammadi, E., SadeghiMahoonak, A., Alami, M., Ghorbani, M. 2017. Amino acid composition and antioxidative properties of hydrolysed pumpkin (*Cucurbita pepo* L.) oil cake protein. *International Journal of Food Properties*, **20**(12), 3244–3255.

Oseyko, M., Romanovska, T., Shevchyk, V. 2020. Justification of the amino acid composition of sunflower proteins for dietary and functional products. *Ukrainian Food Journal*, **9**(2), 394–403.

Padalino, L., D'Antuono, I., Durante, M., Conte, A., Cardinali, A., Linsalata, V., Mita, G., Logrieco, A., Del Nobile, M. 2018. Use of Olive Oil Industrial By-Product for Pasta Enrichment. *Antioxidants*, 7(4), 59.

Pahwa, A., Khamrui, K., Prasad, W. 2020. Influence of oat flour on pasting properties of flour blends, cooking quality and sensory attributes of vermicelli. *The Annals of the University Dunarea de Jos of Galati Fascicle VI – Food Technology*, **44**(2), 70–84.

Petraru, A., Ursachi, F., Amariei, S. 2021. Nutritional characteristics assessment of sunflower seeds, oil and cake. Perspective of using sunflower oilcakes as a functional ingredient. *Plants*, **10**(11), 2487.

Petruk, K.C. 2020. The modern plague of obesity: A holistic guide to challenge the major health threat of the 21st century. *FriesenPress*.

Piazza, L., Ratti, S., Girotto, F., Cappellozza, S. 2023. Silkworm pupae derivatives as source of high value protein intended for pasta fortification. *Journal of Food Science*, **88**(1), 341–355.

Pop, A., Păucean, A., Socaci, S.A., Alexa, E., Man, S.M., Mureșan, V., Chiş, M.S., Salanță, L., Popescu, I., Berbecea, A., Muste, S. 2020. Quality Characteristics and Volatile Profile of Macarons Modified with Walnut Oilcake By-Product. *Molecules*, **25**(9), 2214.

Popovici, V., Radu, O., Hubenia, V., Boaghe, E., Capcanari, T., Popovici, C. 2019. Physico-chemical and sensory properties of functional confectionery products with Rosa Canina powder. *Ukrainian Food Journal*, **8**, 815-827.

Radu, O., Covaliov, E., Capcanari, T. 2024. Technological properties and functional food potential of oilseed cakes. *Ukrainian Food Journal*, **13**(2), 287–302.

Sá, A.G.A., Pacheco, M.T.B., Moreno, Y.M.F., Carciofi, B.A.M. 2023. Processing effects on the protein quality and functional properties of cold-pressed pumpkin seed meal. *Food Research International*, **169**, 112876.

Sá, A.G.A., Silva, D.C.D., Pacheco, M.T.B., Moreno, Y.M.F., Carciofi, B.A.M. 2021. Oilseed by-products as plant-based protein sources: Amino acid profile and digestibility. *Future Foods*, **3**, 100023.

Sajdakowska, M., Gębski, J., Jeżewska-Zychowicz, M., Jeznach, M., Kosicka-Gębska, M. 2021. Consumer Choices in the Pasta Market: The Importance of Fiber in Consumer Decisions. *Nutrients*, **13**(9), 2931.

Sezgin, A., Aydın, B. 2021. Effect of replacing dietary soybean meal with pumpkin (Cucurbita pepo) seed cake on growth, feed utilization, haematological parameters and fatty acid composition of mirror carp (*Cyprinus carpio*). *Aquaculture Research*, **52**(11), 5870–5881.

Shah, P., Mehta, N., Shah, S. 2024. Exploring the factors that drive millet consumption: Insights from regular and occasional consumers. *Journal of Retailing and Consumer Services*, **76**, 103598.

Shoup, F.K., Pomeranz, Y., Deyoe, C.W. 1966. Amino Acid Composition of Wheat Varieties and Flours Varying Widely in Bread-Making Potentialities. *Journal of Food Science*, **31**(1), 94–101.

Simonato, B., Trevisan, S., Tolve, R., Favati, F., Pasini, G. 2019. Pasta fortification with olive pomace: Effects on the technological characteristics and nutritional properties. *LWT*, **114**, 108368.

Singh, K.S., Prasad, C.M. 1979. Feeding value of sunflower and groundnut cakes for broilers. *Animal Feed Science and Technology*, **4**(2), 143–159.

Stan, L., Nistor, O.V., Milea, Ș.A., Andronoiu, D.G., Vasile, A.M., Râpeanu, G., Stănciuc, N. 2023. Low-sugar apples jam with hibiscus extract: Textural, phytochemical and nutritional aspects. *The Annals of the University Dunarea de Jos of Galati. Fascicle VI - Food Technology*, **47**(1), 110–124.

Teterycz, D., Sobota, A. 2023. Use of high-protein and high-dietary-fibre vegetable processing waste from bell pepper and tomato for pasta fortification. *Foods*, **12**(13), 2567.

Velasco, C., Michel, C., Youssef, J., Gamez, X., Cheok, A.D., Spence, C. 2016. Color–taste correspondences: Designing food experiences to meet expectations or to surprise. *International Journal of Food Design*, **1**(2), 83–102.

Wen, C., Zhang, Z., Cao, L., Liu, G., Liang, L., Liu, X., Zhang, J., Li, Y., Yang, X., Li, S., Ren, J., Xu, X. 2023. Walnut protein: a rising source of high-quality protein and its updated comprehensive review. *Journal of Agricultural and Food Chemistry*, **71**(28), 10525–10542.

Xiao-dan, S., Ruj, Z., Ling, S., Ze-zheng, S., Shu-yi, L.I., Xing-xing, D., Ying, B.A.I., Li, M.A. 2024. Application of walnut cake and meal in animal production. *Feed Research*, **47**(1), 158.

Zaky, A.A., Hussein, A.S., Mostafa, S., Abd El-Aty, A.M. 2022. Impact of sunflower meal protein isolate supplementation on pasta quality. *Separations*, **9**(12), 429.

Zarzycki, P., Sykut-Domańska, E., Sobota, A., Teterycz, D., Krawęcka, A., Blicharz-Kania, A., Andrejko, D., Zdybel, B. 2020. Flaxseed enriched pasta—chemical composition and cooking quality. *Foods*, **9**(4), 404.