Trends in Food Science & Technology 106 (2020) 160–170

Contents lists available at ScienceDirect

Trends in Food Science & Technology

journal homepage: www.elsevier.com/locate/tifs

Review

Oilseed proteins – Properties and application as a food ingredient

Klaudia Kotecka-Majchrzak [a], Agata Sumara [b], Emilia Fornal [b], Magdalena Montowska [a,*]

[a] Department of Meat Technology, Poznan University of Life Sciences, Wojska Polskiego 31, Poznan, 60-624, Poland
[b] Department of Pathophysiology, Medical University of Lublin, Jaczewskiego 8b, Lublin 20-090, Poland

ARTICLE INFO

Keywords:
Oilseed
Protein
Essential amino acid
Functional characteristic
Allergenicity
Biopeptide

ABSTRACT

Background: In recent years, various oilseeds have been increasingly used for food purposes. Whole seeds, oils, meal and cake by-products are valuable sources of nutritional and bioactive components. Their properties are widely promoted by nutritionists and food producers, and therefore the interest of consumers in new pro-health ingredients is growing rapidly around the world. Nowadays, new trends are being evaluated by food scientist and industry to partially replace animal proteins with proteins of vegetable origin, contributing not only to improvement of the pro-health values of meat products, but also corresponding to the need of many scientists, activists and government agencies to reduce meat production for ethical reasons and care for the environment.
Scope and approach: This review summarizes the nutritional and pro-health properties of eleven selected oilseeds, namely, chia, coconut, evening primrose, hemp, flax, milk thistle, nigella, pumpkin, rapeseed, sesame and sunflower, with emphasis on their application to improve food products characteristics, oilseed protein composition and proteins and peptides biological activity, as well as potential allergenicity.
Key findings and conclusions: The presence of biologically active proteins and peptides having antioxidant, antihypertensive or neuroprotective properties, as well as a relatively well-balanced profile of exogenous amino acids with sulphur-containing amino acids, makes oilseed proteins a valuable functional component or an alternative source of protein, especially for bakery and meat industries. The low allergenicity of pumpkin and hemp seeds and potential non-allergenicity of chia, evening primrose, milk thistle, and nigella also weighs in favour of their application as functional ingredients in newly-formulated foods.

1. Introduction

Oilseeds and oils obtained from them are becoming more and more popular ingredients added to food products, and therefore the worldwide cultivation of oil plants is systematically growing. Oilseeds accumulate roughly at least 15% of fat, but at the same time, they are a source of valuable protein. By squeezing the oil from seeds in cold-pressed oil production, a cake, a by-product rich in protein and fibre is obtained. When the seeds are roasted before the oil is pressed, and then the oil is extracted from the seeds with organic solvents, the final product is called post-extraction meal. Oilcake and meal are used as components of feed for livestock.

But in recent years, various oilseeds have been increasingly used for food purposes. Refined edible oils are a raw material for the production of margarine, confectionery, bakery -and meat products. Unrefined cold-pressed oils are frequently sold in small dark bottles as pro-health ingredients to enrich the taste of salads, dressings and pastes. Oils are rich in essential unsaturated n-3 and n-6 fatty acids and various bioactive compounds, such as phytosterols, tocopherols and phenolic compounds, and also bioactive proteins and peptides (Hidalgo & Zamora, 2006). Their impact on human health is invaluable because they guarantee the absorption of fat-soluble vitamins and contribute to the proper functioning of the endocrine system or neurotransmission. Oilcakes or meals have been tested as a raw material for the production of protein isolates and hydrolysates (Achouri, Nail, & Boye, 2012; Bučko, Katona, Popović, Vaštag, & Petrović, 2015; Kaushik et al., 2016; Mamone, Picariello, Ramondo, Nicolai, & Ferranti, 2019; Raikos et al., 2017). In turn, whole or ground seeds are used as seasonings or additional ingredients, inter alia in bakery and meat products. They are increasingly used as a component in the production of enriched or functional foods.

In recent years, functional and enriched products have been of interest to food technologists and have become increasingly popular among many consumers around the world. Functional foods are foods that, in addition to being a source of nutrients, provide consumers with other pro-health benefits. Usually, one or more ingredients containing bioactive compounds are added to the food product, which are not found

* Corresponding author. , .
E-mail addresses: magdalena.montowska@gmail.com, magdalena.montowska@up.poznan.pl (M. Montowska).

https://doi.org/10.1016/j.tifs.2020.10.004
Received 23 July 2019; Received in revised form 6 August 2020; Accepted 4 October 2020
Available online 6 October 2020
0924-2244/

in natural conditions or are present in small amounts. These specified compounds must have a proven beneficial effect on human health (Malomo, He, & Aluko, 2014). Thus, oilseeds rich in fibre, sterols, unsaturated fatty acids, proteins and biopeptides are excellent functional ingredients.

In the case of meat products, which are the main source of protein in the conventional diet, it has become more and more popular to reduce the share of the meat-fat fraction in the product by replacing it with vegetable oil, vegetable protein or fibre. As a result, a product enriched with polyunsaturated fatty acids or with reduced energy value is obtained (Zduńczyk & Jankowski, 2013), as well as the desired effect of an increase in the amount of substitutes for animal proteins in meat products. Replacing animal proteins with proteins of vegetable origin contributes not only to improvement of the pro-health values of the meat product but also corresponds to the need of many scientists, activists and government agencies to reduce meat production for ethical reasons and care for the environment. As replacements for meat proteins, in addition to proteins from leguminous plants, proteins from oilseeds, fungi and algae as well as proteins from insects are increasingly used (Jones, 2016).

Over 200 species of oil plants are grown all over the world. The most important ones in food production are soy, rapeseed, sunflower, coconut, olive and peanut. Flax, cotton and sesame seeds are used to a lesser extent. In recent years, other less popular oleaginous seeds, such as chia, evening primrose, hemp, nigella, milk thistle, and pumpkin, have gained in importance. In this article, we pay special attention to the oilseed proteins. Oil processing by-products rich in those proteins of excellent nutritive and bioactive properties are interesting raw materials that offer possibilities to develop healthier products or new functional foods.

The purpose of this review was to characterize briefly and compare the nutritional and pro-health properties of eleven selected oilseeds, namely, chia (*Salvia hispanica* L.), coconut (*Cocos nucifera* L.), evening primrose (*Oenothera biennis* L.), hemp (*Cannabis sativa* L.), flax (*Linum usitatissimum* L.), milk thistle (*Silybum marianum* L.*)*, nigella (*Nigella sativa or N. indica*), pumpkin (*Cucurbita pepo* L.), rapeseed (*Brassica napus* L.), sesame (*Sesamum indicum* L.) and sunflower (*Helianthus annuus* L.), with emphasis on oilseeds protein composition and protein and peptide biological activity, as well as potential allergenicity. These oilseeds, whole or ground, oil cake or meal, and extracts and protein hydrolysates produced from them, contain high protein levels and they are attracting more and more attention from food technologists as a functional component or as an alternative source of protein, especially for bakery and meat industries.

2. Composition of essential amino acids

Plant proteins are deficient in essential exogenous amino acids and have a lower content or are deprived primarily of lysine, isoleucine, tryptophan, methionine and valine. In order to substitute great amounts of meat protein in a product for proteins of vegetable origin, it would be advisable to use two or three types of raw vegetable material with a complementary amino acid composition, to provide the organism with all exogenous amino acids using the principle of complementation. Providing the right content of essential exogenous amino acids is necessary because they are responsible for the correct 'protein turnover', i.e. constant exchange of body proteins.

Comparison of the typical essential amino acid composition of selected oilseeds with WHO/FAO/UNU standard protein (2007), soybean and chicken meat, pork and beef is shown in Table 1. The sum of exogenous amino acids in the oilseeds discussed shows considerable differences, it ranging from 2.27 g to 51.85 g per 100 g in coconut kernel and milk thistle defatted flour, respectively, while, the standard protein contains 25.64 g essential amino acids per 100 g of product, and chicken meat 10.11 g.

The percentage distribution of essential amino acids is shown in Fig. 1. The differences observed in the amino acid content may be caused by plant variety and genetic diversity, different cultivation conditions and geographical latitude (sun exposure, rainfall, temperature, soil fertility), growing conditions, seed maturity and time of harvest, as well as application of various analytical methods. Leucine and valine are the amino acids present at the highest concentrations in oilseed proteins, whereas sulphur-containing amino acids, methionine and cysteine, and hydrophobic tryptophan are present in the lowest amounts. However, there are exceptions for chia (9%), hemp (8%), and sesame (8%) seed proteins which are relatively rich in methionine. These values are at a level comparable with the methionine content of chicken (9%). Evening primrose seeds are also rich in tryptophan (15%). In general, oilseed proteins have a relatively well-balanced profile but the amino acid content may be altered during industrial oil extraction and further thermal processing (Aider & Barbana, 2011). The addition of a protein source richer in sulphur-containing amino acids would improve the nutritional value of foods, and it is likely that selected oilseed proteins could replace legumes, at least in part, in meat products.

3. Food allergenicity

The problem of food allergies has become extremely important due

Table 1
Typical essential amino acid composition of oilseeds, soybean and raw meat (in grams per 100 g).

Amino acid	Ile	Leu	Lys	Met	Cys	Phe	Tyr	Thr	Trp	Val	AA sum	Reference
Standard protein	3.01	5.30	4.50	2.21		3.81		2.30	0.61	3.90	25.64	WHO/FAO/UNU 2007
Soybean seeds	1.97	3.47	2.37	0.59	0.80	2.25	1.35	1.63	0.57	1.94	16.94	Carrera et al. (2011)
Chia seeds	0.73	1.35	0.98	0.80	0.53	1.10	0.58	0.76	0.79	0.93	8.55	Ziemichód, Wójcik, and Różyło (2019)
Coconut kernel, desiccated	0.22	0.43	0.31	0.12	0.11	0.29	0.16	0.22	0.06	0.35	2.27	Danish food composition databank, 2019
Evening primrose[a]	0.83	1.54	0.26	0.60	0.60	0.41	0.71	1.58	1.31	1.07	8.91	Gołąbczak et al. (2005)
Flaxseed (brown)	0.87	1.18	0.75	0.32	0.32	0.95	0.53	0.72	0.30	1.07	7.01	Klimek-Kopyra, Zając, Micek, & Borowiec, 2013; USDA, 2019
Hemp seeds	1.29	2.16	1.28	0.93	0.67	1.45	1.26	1.27	0.37	1.78	12.46	USDA, 2019
Milk thistle (defatted flour)	5.41	9.84	7.38	2.46	2.16	6.10	5.41	5.12	nd	7.97	51.85	Apostol & Iorga, 2017
Nigella seeds[a]	0.64	1.11	0.63	0.23	0.19	0.64	0.54	0.63	0.12	0.82	5.54	Al-Gaby (1998)
Pumpkin seeds	1.29	2.49	1.36	0.73	0.39	1.81	1.19	1.04	0.61	1.71	12.62	Danish food composition databank, 2019
Rapeseed (meal)	1.25	2.51	2.04	0.47	0.59	1.44	0.99	1.59	0.43	1.55	12.86	Mejicanos and Nyachoti (2018)
Sesame	0.79	1.48	0.64	0.67	0.43	0.99	0.78	0.80	0.37	1.02	7.97	Danish food composition databank, 2019
Sunflower seeds	0.92	1.40	0.86	0.53	0.38	1.05	0.57	0.81	0.35	1.11	7.98	Danish food composition databank, 2019
Beef (raw, lean, 3% fat)	0.97	1.71	1.82	0.57	0.23	0.86	0.68	0.85	0.11	1.08	8.88	USDA, 2019
Pork (raw, lean, 4% fat)	0.96	1.68	1.81	0.56	0.24	0.90	0.89	0.89	0.27	1.06	9.26	USDA, 2019
Chicken (raw breast, skinless)	1.10	1.86	2.16	0.58	0.24	0.91	0.81	1.01	0.28	1.16	10.11	USDA, 2019

[a] Approximate values converted from the seed protein isolate or cake.

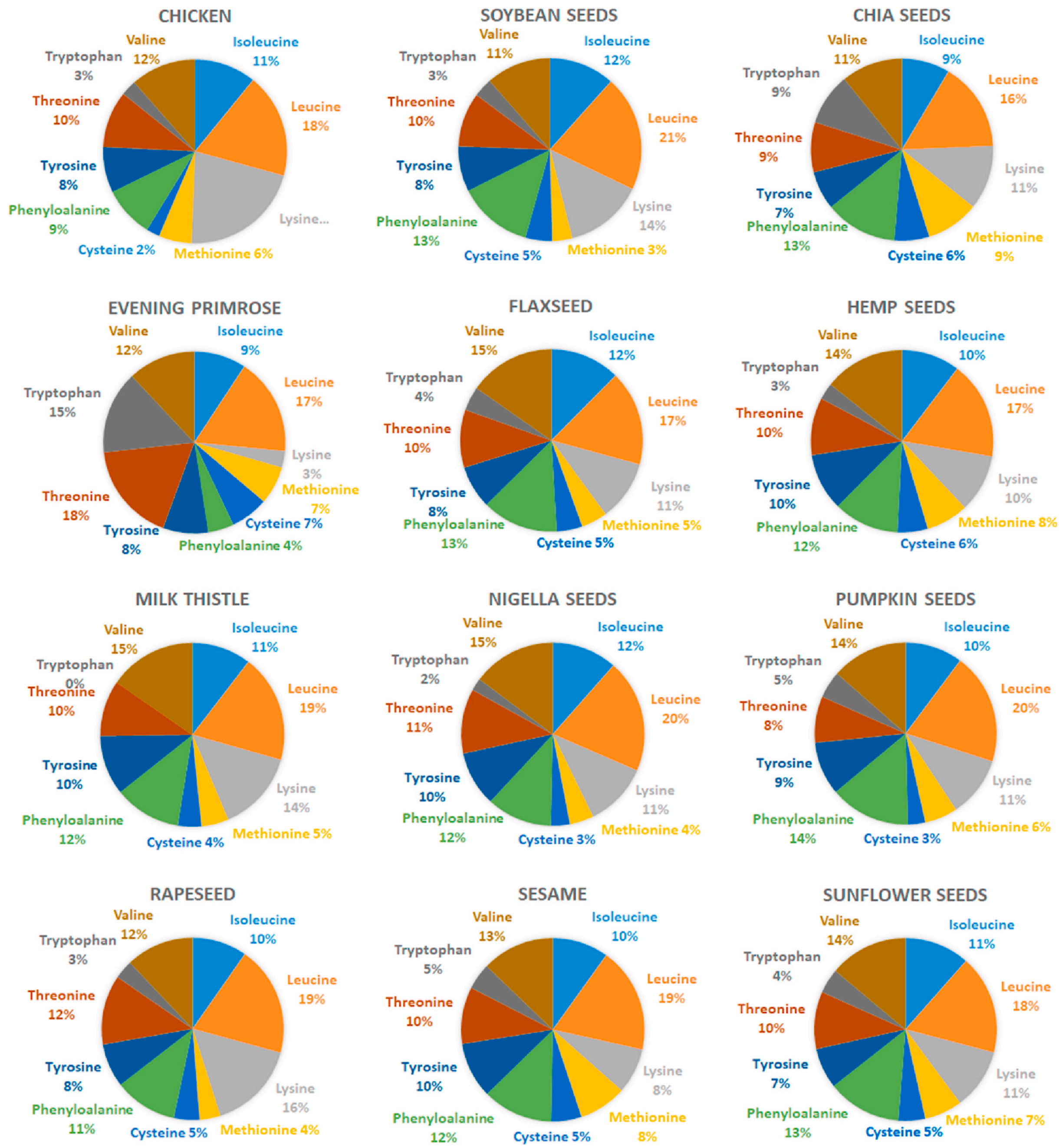

Fig. 1. Percentage distribution of essential amino acids in chicken meat, soybean and selected oilseeds.

to the observed increase in the occurrence of allergies around the world in the last 20 years (Pali-Schöll et al., 2019). Allergies are more and more common in adults over 20 and even in 50–60-year-olds. The number of people suffering from food allergies in the United States and Europe is growing, but there is no definite answer to the question of what is causing this phenomenon (Kamdar et al., 2015).

Among the undesirable reactions to foods are food intolerances (non-allergic food hypersensitivity) which are non-physiological non-immune responses to food intake, i.e. toxic or metabolic-biochemical reactions. There is a risk that products in which standard proteins have been replaced with proteins from new sources, e.g. meat products containing larger amounts (over 10%) of oilseed proteins, will cause undesirable gastrointestinal symptoms. Of the seeds discussed in this paper, only sesame seeds are on the list of major allergens, but on the basis of clinical history and positive skin prick tests (SPT), adults have been diagnosed with allergies caused by sunflower seeds and other plants including avocados, carrots, kiwi, cumin seeds and parsley (Kamdar et al., 2015). However, technological processes commonly used in food processing (heat treatment, high pressure, enzyme treatment) may, on the one hand, reduce the allergenicity of proteins by changing the spatial structure or destroying their epitopes and, on the other hand, increase the allergenicity of proteins as a result of changes in protein structure or the formation of new neo-allergic factors. The allergenic potential of oilseed proteins discussed in the present article is shown in Fig. 2.

The processes of enzymatic hydrolysis divide proteins into polypeptides, changing and reducing the allergenic properties of molecules in some cases. *In vivo* studies in mice have shown that protein hydrolysates obtained from defatted and ground sunflower and rapeseed have no significant toxicological or metabolic effects and therefore can be considered as alternative sources of protein and food ingredients

Fig. 2. Allergenic potential of oilseed proteins.

(Canistro et al., 2017). Other studies have shown that enzymatic hydrolysis of soy protein isolate (SPI) does not reduce allergenicity, and hydrolysis with chymotrypsin or bromelain even has the potential to increase SPI allergenicit (Panda, Tetteh, Pramod, & Goodman, 2015), with β-conglycinin fragments responsible for the observed higher allergenic potential of digested SPI. Allergen homology may explain the occurrence of cross-reaction in people with other food allergies.

The EFSA Scientific Opinion recommends that the available risk assessment approaches that could assist risk management decisions on allergen labelling are (a) a traditional risk assessment using the no observed adverse effect level (NOAEL) approach and uncertainty factors, (b) a bench mark dose (BMD) approach, (c) a margin of exposure (MoE) approach and (d) probabilistic models (EFSA NDA Panel EFSA Panel on Dietetic Products, Nutrition and Allergies, 2014). Thus, in order to approve new sources of protein as potential food ingredients, not only should potential allergens be identified but there should also be assessment of how the digestive process affects the allergenicity of a given protein, estimation of the dose of protein exposure, its physicochemical properties and cross-reactivity, and examination of the individual immune response in subjects.

4. Nutritional properties and biopeptide activity of selected oil seeds

4.1. Chia seeds

Chia seeds are edible seeds of *Salvia hispanica* L., a flowering plant native to central and southern Mexico. The growing interest in the potential of chia results from its nutritional and medicinal values. Chia seeds are rich source of fatty acids, among others polyunsaturated fatty acids, omega-3, protein, dietary fiber, vitamins, mainly from group B (B_1, B_2) and minerals such as phosphorus, calcium, magnesium (Hrnčič, Iwanowski, & Knez, 2020; Marineli et al., 2014). Chia seeds also contain compounds with significant antioxidant potential. Currently, chia seeds are increasingly used in the food industry, whole or ground, they are added to bakery products, cakes, and energy bars. Excellent water-absorbing capacity of seeds (12 times of their weight) and development of mucilaginous coating when it is mixed into liquids are used to create new products of a gel texture, such as energy gels for athletes and modern gelatinous desserts.

Due to the high content of protein and fibre, protein content in chia seeds amounts to 18.18 g/100 g (Table 2), and the presence of both exogenous and endogenous amino acids, chia seeds can be used in slimming diets, as well as in vegan and vegetarian diets, as a complementary source of protein. The main protein fractions extracted from chia seed flour were globulins and albumins (52% and 17.3%, respectively), whereas glutelins and prolamins constituted minor fractions of 14.5% and 12.7% (Sandoval-Oliveros & Paredes-López, 2013). Electrophoretic separation revealed reduced protein bands in the range of 15–50 kDa and most abundant globulin fraction contained mostly 11S and 7S proteins. Among proteins identified from chia seeds are those responsible for the metabolic functions of the seeds as well as lipid production and storage (Grancieri, Martino, & Gonzalez de Mejia, 2019).

Peptides released from chia seed proteins demonstrate promising health-enhancing bioactivity (Fig. 3). Chia protein hydrolysates

Table 2
Comparison of nutritional values of eleven oilseeds (value per 100 g).

Oilseed	Energy [kcal]	Protein [g]	Carbohydrates [g]	Fat [g]	SFA [g]	MUFA [g]	PUFA [g]	Fibre [g]	Reference
Chia seeds (*Salvia hispanica* L.)	534	18.18	4.59	32.16	3.66	7.53	28.73	33.37	da Silva et al., 2017; USDA 2019
Coconut kernel, desiccated (*Cocos nucifera* L.)	685	6.5	27	61.3	53.3	2.37	0.38	nd[a]	Danish food composition databank, 2019
Evening primrose (*Oenothera biennis* L.)	435	18	44.6	24	4	14.2	81.8	44	Zadernowski, Polakowska-Nowak, Rashed, and Kowalska (1999)
Flaxseed (*Linum usitatissimum* L.)	530	20.3	28.9	37.1	3.66	7.52	28.73	24.5	Soni, Katoch, Kumar, & Verma, 2016; USDA, 2019
Hemp seeds (*Cannabis sativa* L.)	553	24.8	38.1	24.5	10.89	13,11	75.11	4.0	Siano et al., 2019; USDA, 2019
Milk thistle (*Silybum marianum* L.)	370	22.5	42.35	28.53	16.26	22.36	60	26.6	El-haak, Atta, Rabo, & F, 2015; Meddeb, Rezig, Abderrabba, Lizard, and Mejri (2017)
Nigella seeds (*Nigella sativa* L.; *N. indica*)	349	18.09	29.18	32.74	16.64	22.47	60.17	6.39	Mamun & Absar, 2018; Sultan et al. (2009)
Pumpkin seeds (*Cucurbita pepo* L.)	568	36.3	2.0	45.9	7.61	13.49	19.93	9.4	Danish food composition databank, 2019
Rapeseed (*Brassica napus* L.)	572	19	20	54.2	6.3	72.8	20.9	23.2	Yoshie-Stark et al., 2008; Orsavova, Misurcova, Ambrozova, Vicha, and Mlcek (2015)
Sesame seeds (*Sesamum indicum* L.)	605	15.67	18.44	56.56	7.39	19.43	21.08	8.22	Dravie, 2020; Danish food composition databank, 2019
Sunflower seeds (*Helianthus annuus* L.)	620	24.2	13.6	54.4	5.44	19.82	23.53	9.9	Danish food composition databank, 2019

[a] nd – data not found.

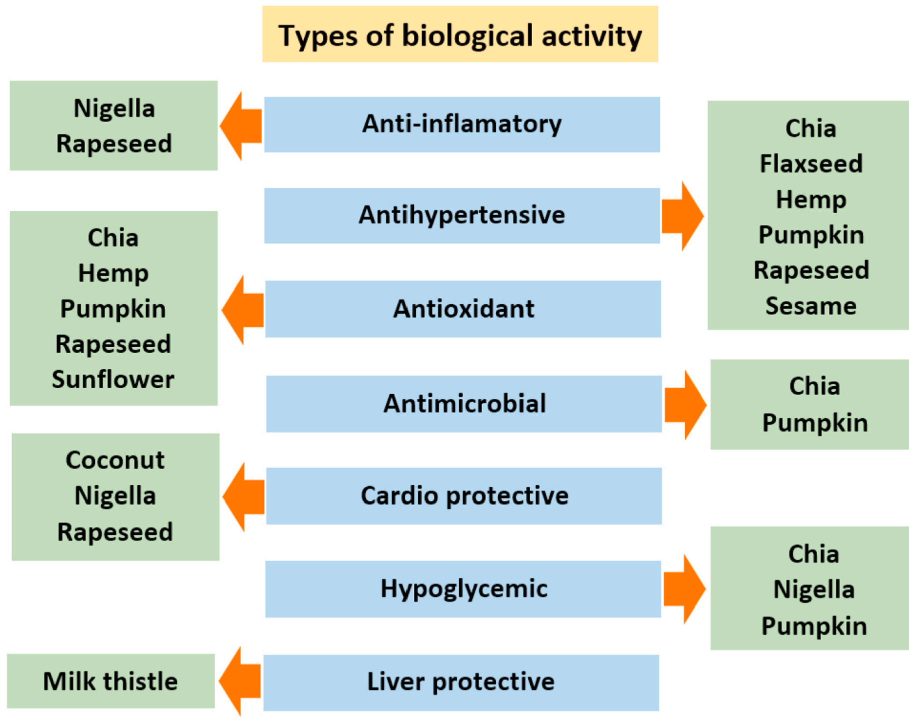

Fig. 3. Biological activity of oilseed proteins and peptides.

produced with commercial microbial proteases (i.e. Alcalase and Flavourzyme) showed antimicrobial activity against *S. aureus* (Coelho, Soares-Freitas, Areas, Gandra, & Salas-Mellado, 2018) as well as ACE-I inhibitory activity (Segura Campos, R, Peralta González, Chel Guerrero, & Betancur Ancona, 2013). Bioactive peptides with antioxidant activity were generated by enzymatic hydrolysis with papain from the chia by-product of oil production (Cotabarren et al., 2019). Therefore, chia seed proteins are a potential bioactive ingredient and supplement in functional food, especially since allergens derived from chia seeds have not been reported.

Recently, chia seeds have been used as an animal fat replacement and to improve the physicochemical properties of restructured ham-like products. A combination of 1.0% ground chia seeds and 0.5% carrageenan increased water-holding capacity (WHC) and emulsifying effect of restructured ham (Ding et al., 2018). Chia's addition also caused lower oxidation of lipids and proteins during refrigerated storage. The replacement of up to 20% chicken skin with chia flour in chicken nuggets increased content of dietary fibre and polyunsaturated fatty acids, and the nuggets containing 10% chia flour kept most of their good technological characteristics (Barros et al., 2018). In another study, chia mucilage gels were tested to substitute 50% of pork back fat in the emulsified meat model systems (Câmara et al., 2020). Mechanical properties of chia mucilage resisted thermal treatment, the mucilage addition improved emulsion stability whereas affected the cohesiveness, elasticity, and the hardness of the meat products.

4.2. Coconut

Coconut palm (*Cocos nucifera* L.) is a plant characterized by low farming economy and is therefore a valuable raw material for the industry. In recent years, its production has increased significantly, which has caused a number of adverse consequences for the natural environment, including deforestation of tropical forests and disturbance of the ecosystem for many animals. Coconut kernel is the main edible part of the coconut, and is used for the production of refined and unrefined oil, coconut milk, coconut flour and shreds. These ingredients are widely used for food purposes, mainly in the production of bakery and confectionery products. Coconut kernel is characterized by a significant content of carbohydrates, mainly sucrose, fat (including mainly saturated fatty acids), proteins, fibre and minerals as well as polyphenols and tocopherols with antioxidant properties (Appaiah, Sunil, Kumar, & Gopala Krishna, 2014).

Defatted coconut flour protein consists mainly of the globulin and albumin fractions, accounting for 40% and 21% of the total protein, respectively. The globulin fraction consists of one 53 kDa major polypeptide and five less abundant subunits (MW 34, 27, 25, 22 and 20 kDa). Two major polypeptides (25 and 18 kDa) are observed in the albumin fraction. The acid-soluble glutelin-1 fraction amounts to 14.4%. Basic-soluble glutelin-2 and prolamin fractions account for less than 5% of the total protein (4.8% and 3.3%, respectively) (Kwon, Park, & Rhee, 1996; Li, Zheng, Zhang, Xu, & Gao, 2018). So far, no food allergy to coconut proteins has been confirmed, while the bioactive properties of these proteins, mainly antioxidant activity, have been described. Globulin, glutelin and prolamin fractions exhibit good radical-scavenging activity and ion chelating ability and also protect DNA from oxidative damage. Several potentially biologically active peptides derived from globulin and glutelin-2 coconut fractions have been identified by LC-MS/MS (Li et al., 2018).

Due to their good antioxidant potential, but also their unfavourable content of saturated fatty acids, as well as the ecological problem, the widespread use of coconut palms in the food industry may be controversial. It is worth stressing that consumers are becoming more and more conscious and demanding. They want to consume products with an appropriate nutritional composition, including enriched products, but also more and more consumers, especially in developed countries, note the environmental footprint of food consumed.

4.3. Evening primrose seeds

Evening primrose *(Oenothera biennis* L.*)* is an oily medicinal plant originating from North America and now widely cultivated in Europe. Evening primrose seeds are rich in polyunsaturated fatty acids, mainly γ-linolenic acid (GLA) at 7–10% of oil content and linoleic acid (LA), and phytochemical constituents having broad pharmacological activity

(Ghasemnezhad & Honermeier, 2008). The seeds have been used for baking cakes and bread, and the seed oil as a salad dressing. Most of the published studies focus on evening primrose seed oil which currently is sold worldwide as a health food supplement.

Seed protein fractions have not been studied. However, it was reported that evening primrose cake, a by-product obtained by cold pressing the oil from evening primrose seeds, contains a relatively high level of crude protein (21.3%) and fibre (22.7%), and thus can be used as a valuable feed component for ruminants due to its high content of sulphur amino acids. The cake nutrient efficiency is affected by a high dietary fibre content but the digestibility is considerably improved when the cake protein isolate is partially hydrolysed by proteolytic enzymes (Gołąbczak, Strąkowska, & Konstantynowicz, 2005). The latest research by Hadidi, Ibarz, and Pouramin (2020), showed that structural and techno-functional properties of protein extracted from defatted evening primrose seed cakehave changed with the implementation of ultrasound-assisted alkaline extraction and enzymatic deamidation by protein-glutaminase. Protein solubility, WHC, emulsifying activity, foam capacity and stability enhanced after the method optimization. Allergy cases for ingestion of evening primrose proteins have not been reported; also, to date, the bioactive properties of these proteins have not yet been described.

4.4. Flaxseed

Common flax *(Linum usitatissimum* L.*)* is a plant grown in over 50 countries. The pro-health effect of flaxseed consumption is influenced by the high content of protein, essential unsaturated fatty acids, primarily α-linolenic acid, antioxidants, microelements and lignans. Flaxseed can be a perfect complement to the daily diet, especially in vegetarian, vegan and other diets deprived of animal protein and fish fats (Kajla, Sharma, & Sood, 2015). But in the beef patties research, the higher addition of golden flaxseed reduced the acceptability of the product (Novello, Schiessel, Santos, & Pollonio, 2019). The addition of flaxseed (seed or flour, and oil) varied from 2.5% to 5%. The increase in the content of ash, protein, fat, carbohydrate, energy value, and *n*-3 fatty acids was reported in raw beef patties and likewise heated to 200 °C, while cholesterol content decreased. The reduction in cholesterol was more significant for raw patties than for cooked ones (12.8% vs 9.7%).

The main storage proteins found in various types of linseed include the fraction of the high molecular weight globulin linin (252–298 kDa), which consists of five globular 11–12S polypeptide subunits with molecular weights of 14.4, 24.6, 30.0, 35.3 and 50.9 kDa. The low molecular weight fraction is conlinin, a well water-soluble protein, with a 2S albumin-type structure and a MW of 16–17 kDa. Linin and conlinin account for 64–66% and ~42%, respectively, of all flaxseed proteins (Bekhit et al., 2018; Kaushik et al., 2016).

Flaxseed protein has been analysed for allergenic activity. It has been proven that it could be an initiator of food allergies in adult patients, but in some of them there was cross-reactivity with five other seeds, i.e. peanuts, soy, rape, lupine and wheat. The fraction of the population studied (0.15%) had a food allergy to fresh seeds and positive prick-in-prick (PIP) tests to heated and extruded flaxseed. Clinically significant allergens present in industrial products have a molecular weight of 25–38 kDa. Significant modifications in protein structures after industrial treatment have been shown using FTIR spectroscopy, and may be the cause of adverse reactions in people suffering from allergies (Fremont et al., 2010).

Some peptides isolated from flaxseed have been discovered to be biologically active, for example several of the 25 known cyclic peptides also called cyclolinopeptides (CLs) show potent osteoclast differentiation inhibition activity and a potential role in bone remodelling (Kaneda et al., 2016). Thermoase-digested flaxseed protein hydrolysate obtained from defatted flaxseed flour demonstrates inhibition of angiotensin I-converting enzyme (ACE) and very weak renin-inhibitory activity in hypertensive rats (Nwachukwu, Girgih, Malomo, Onuh, & Aluko, 2014). Up to 24 h after oral administration (200 mg/kg body weight), systolic blood pressure in rats decreases significantly, likely due to activity of the 1–3 kDa and 3–5 kDa peptide fractions of the flaxseed protein hydrolysate.

4.5. Hemp seeds

Hemp *(Cannabis sativa* L.*)* is an annual herbaceous plant that has been grown for thousands of years and has been used as a source of fibre, medicine and food. At present, low drug varieties of hemp containing up to 0.3% delta-9-tetrahydrocannabinol (THC) – the main psychoactive substance of *Cannabis* – can be legally cultivated for industrial purposes in most countries around the world. Seeds and meals are especially rich in protein, and a well-balanced content of the two essential polyunsaturated fatty acids, i.e. an LA and alpha-linolenic acid ratio between 2:1 and 3:1 is favourable for human nutrition. In addition, small amounts of cannabidiol (CBD), β-sitosterol, terpenes and methyl salicylate detected in hempseed oil contribute to various desirable pharmacological properties including antiepileptic, antimicrobial, anti-inflammatory and cytoprotective properties (Oomah, Busson, Godfrey, & Drover, 2002). Recently, several studies have evaluated the use of hemp seed flour as a substitute for milk, wheat and meat protein in bakery and extruded products, infant formula and also chopped semi-finished meat products where 10% of minced beef is replaced with the same amount of hemp flour (Naumova, Lukin, & Bitiutskikh, 2017; Wang & Xiong, 2019).

Pork loaves examined with the addition of hemp seeds, de-hulled hemp seeds, hemp flour, and hemp protein at the levels of 5% were characterized by higher hardness and higher fibre content (Zając et al., 2019). Additionally, the content of minerals such as magnesium, manganese, iron and copper increased, besides PUFA content. Moreover, there was no development of pathogenic microflora, and the consumers' acceptance was satisfactory. Zahari et al. (2020) investigated the possibility of substitution of hemp protein concentrate for soy protein isolate in the high moisture meat analogues produced by extrusion. The texture of the product containing up to 60% hemp protein was comparable to the SPI product; the hemp protein concentrate absorbed less water and required a higher denaturation temperature.

Total hemp protein consists mainly of a single globular storage protein, edestin (approximately 65%), and the low molecular weight (below 20 kDa) albumin fraction accounts for 25% of storage proteins. Edestin is a hexamer composed of three acidic and three basic subunits with molecular weight of 34 and 20 kDa, respectively (Aiello et al., 2016; Malomo et al., 2014). Hemp seed proteins have not been reported to be the trigger for IgE-mediated food allergy; on the contrary, hemp proteins previously linked to the allergic response caused by exposure to hemp leaves or *Cannabis* smoke inhalation are likely to be inactivated during the process of gastrointestinal digestion (Mamone et al., 2019).

Recent studies performed *in vivo* have demonstrated that hemp seed proteins hydrolysed with gastrointestinal enzymes (pepsin, pancreatin and trypsin) release bioactive peptides with pro-health and pharmaceutical value, including ACE inhibition, antioxidant activity and anti-hypertensive effects (Wang & Xiong, 2019). For example, short-chain (≤5 amino acids) hypotensive biopeptides reduce systolic blood pressure in spontaneously hypertensive rats by 40 mmHg 4 h after oral administration (Girgih et al., 2014).

4.6. Milk thistle seeds

Milk thistle *(Silybum marianum* L. Gaertner*)* is an annual plant indigenous to the Mediterranean area and Central Asia (India, Pakistan). Milk thistle pharmacological properties are connected with a high content of silymarin – a complex of seven flavonolignans and one flavonoid (taxifolin) that comprises up to 80% of milk thistle extract. Silymarin has efficacy in the treatment of toxic and alcoholic liver diseases, liver cirrhosis, viral hepatitis and mushroom poisoning (Polyak et al., 2010). Analysis of the functional properties of proteins extracted from the milk thistle seeds showed that the proteins have the ability to retain water and absorb fat, therefore they can be used as fillers in the production of acidic foods, such as meat products, milk and meat analogues, and beverages rich in protein (Li et al., 2013).

Protein isolate prepared from defatted powder of milk thistle seeds contains dominant albumin and globulin fractions followed by a small amount of glutelins and prolamins (Li at al., 2013). The protein fractions obtained are composed of polypeptides in the molecular mass range of 16–112 kDa. No allergic reactions to milk thistle proteins have been reported. There is little information on the bioactive properties of the protein fractions of the milk thistle seeds. The milk thistle seed flour incorporated in wheat bread at a level of 3% gives the best rheological characteristics and prospective results for reducing liver damage in male rats (Shahat, Hussein, & Hady, 2016). Therefore, defatted milk thistle seeds (in the form of flour) may be successfully used for functional food production.

4.7. Nigella seeds

Nigella sativa L. (or *N. indica)*, commonly known as black cumin or black seeds, is a herbaceous plant originating from Iraq and Turkey. The seeds have a strong bitter taste and are used as a spice or flavouring additive in curries, sweet cumin pastry and cheese, for sprinkling on bread, for flavouring vinegar and as a traditional remedy for asthma, bronchitis, rheumatism and other inflammatory diseases in native Asian medicine due to their broad therapeutic properties including antioxidant, anti-inflammatory and antimicrobial activity (Mukhtar, Qureshi, Anwar, Mumtaz, & Marcu, 2019; Srinivasan, 2018).

Glutelin and albumin fractions are the predominant proteins in *Nigella* species seeds, followed by prolamin and globulin fractions (Al-Gaby, 1998; Alu'datt et al., 2016). Soluble extract of the whole seeds shows a number of protein bands (six intense) ranging from 94 to 10 kDa. Since cases of allergy to *Nigella* sp. -have not yet been reported, nigella seed proteins likely are not allergenic factors. On the contrary, supplementation with nigella seeds or their boiled extracts has beneficial or prophylactic effects on patients with some diseases of the respiratory system, i.e. asthma symptoms, chest wheezing, impaired pulmonary function or allergic rhinitis are significantly reduced or less frequent when the treatment period lasts from 2 weeks to 3 months (Tavakkoli, Mahdian, Razavi, & Hosseinzadeh, 2017).

In food products, the effects of addition of nigella oil on the functional characteristics were mainly investigated, for instance, the addition of oil caused up to 60% slower lipid oxidation compared to control samples but negative changes in the taste and texture properties of pork patties were not observed (Wojtasik-Kalinowska et al., 2017). Shelf life of minced beef meat supplemented with cold-pressed nigella seed oil was extended due to the slower growth of pathogenic microflora, and in meat with the addition of 4% nigella oil after 15 days of refrigerated storage, the resistance to the growth of *Salmonella enteritidis* was higher than that of *Listeria monocytogenes* (Mahgoub, Osman, & Ramadan, 2017). When nigella seeds ethanolic extracts were added to chicken meatballs (1.2 g/100 g of meat batter) the oxidative changes slowed down during refrigerated storage due to significantly higher phenolic content and higher DPPH radical scavenging activity compared to nigella water extract (Zwolan et al., 2020). The addition of nigella, in the form of seeds and oil, is also used in the production of dairy functional food such as cheese or butter, where the share of nigella components contribute to the improvement of the nutritional value of the product, enhancement of antioxidant activity, extend their shelf life and, importantly, it is often preferred by consumers (Cakir, Cakmakci, & Hayaloglu, 2016).

4.8. Pumpkin seeds

Pumpkin *(Cucurbita* sp.*)* is widely cultivated on all continents. Seeds are characterized by their high biological and nutritional value due to the high content of oil and valuable protein. In addition, they are a source of carotenoids and bioactive compounds such as tocopherols, sterols, α-carotene and lutein, as well as vitamins and minerals. Pumpkin oil is popular for salads, but the main by-product of its production is the oil cake rich in valuable proteins (up to 65%) which has potential to be used as a functional food ingredient.

Powdered pumpkin seeds (2%) have been used to modify poultry burgers to improve their quality properties which increased lipid stability during burgers' storage (Longato et al., 2017). The addition of microencapsulated chia and pumpkin oils to mayonnaise had little effect on its texture and rheology, however, the obtained product had higher thermal stability and was enriched with PUFAs (Rojas et al., 2019). Moreover, there were no sensory differences between the samples containing microcapsules up to 5% (wt) and the base-mayonnaise. Recently, the protein and pectin from pumpkin seeds and peels have also been investigated for the development of modern, safe edible films that might be applied further on, for instance, protection of sliced fruits or sweets (Lalnunthari, Devi, & Badwaik, 2020).

The major fraction of pumpkin seed protein contains the 12S globulin cucurbitin (total MW ~325 kDa) composed of six similar subunits of 54 kDa. Another fraction contains low molecular weight 2S albumins of 12.5 kDa, which are composed of two chains with MW of 4.8 and 7.9 kDa. These both 12S and 2S protein fractions make up 59% of the total protein content in pumpkin seeds. Less abundant fractions are prolamins and glutelins (3.1%) (Bučko et al., 2015; Rezig et al., 2013). Allergic reactions to pumpkin seeds are very rare, although the seeds are widely used in various foods. Only a few cases of anaphylaxis have been described so far after eating food containing pumpkin seeds. The allergens responsible have not yet been well characterized. When performing immunoblot analysis of the binding of the IgE antibodies with pumpkin seed, various proteins reacted with the patients' serum; among others, a 14 kDa protein likely a homologue of profilin, a 12 kDa protein, and also slight cross-reactivity with hazelnut 11S globulin were detected (Chatain, Pin, Pralong, Jacquier, & Leccia, 2017; Rodríguez-Jiménez, Domínguez-Ortega, Ledesma, González-García, & Kindelan-Recarte, 2010).

Pumpkin seed proteins are becoming a desirable ingredient in food products due to their bioactive potential. However, their increasingly common addition to food may be the cause of more frequent food allergies in the future. Antioxidant and ACE-inhibitor activity of proteins (cucurbitins) and protein isolates obtained from *C. pepo* seeds has been demonstrated. Proteins and peptides released from Musky pumpkin seeds (*C. moschata*) have antifungal, antimicrobial and hypoglycemic activity (Ozuna & León-Galván, 2017). The globulin fraction of *C. moschata* shows very strong antioxidant activity when radical and hydrogen peroxide scavenging, lipid peroxidation and reducing power assays are performed, whereas, its albumins fraction shows good milk-clotting and caseinolytic activity required for cheese ripening; therefore, the proteins have potential to be used as substitutes for commercial animal rennet (Dash & Ghosh, 2017).

4.9. Rapeseed

Rape *(Brassica napus* L.*)* is one of the most important oily plants in the world. Due to the nutritional value of rapeseed oil, i.e. the content of unsaturated fatty acids, omega-3 and omega-6 acids and fat-soluble vitamins, and lack of cholesterol, nutritionists recommend its regular consumption. In addition, rapeseed oil contains compounds that accompany triacylglycerols, such as tocopherols, sterols, phenolic compounds, carotenoids and phospholipids (Aider & Barbana, 2011). Edible rapeseed oil is characterized by a low content of erucic acid which has a toxic effect contributing to the fatty body parenchyma and myocardial damage.

Rapeseed is not only a great source of unsaturated fatty acids but also protein. Rapeseed proteins have been classified into four fractions, i.e. the water-soluble albumins, salt-soluble globulins, ethanol-soluble prolamins, and glutelins which are insoluble in all solvents. The two main types of storage proteins are cruciferin which is a 12S globulin, and napin which is a 2S albumin, representing 60% and 20% of the total protein content in mature seeds, respectively (Aider & Barbana, 2011; Raikos et al., 2017). So far, no allergy to rapeseed has been described but cross-reactivity between mustard and rapeseed caused by sequence homology of the 2S albumin has been confirmed (Lee, Hefle, & Taylor, 2008).

Rapeseed proteins have been used for many years for the production of functional foods, including bakery products, beverages, dairy and egg substitutes, processed meat products, salad dressings, sauces and flavourings (Guo, Tian, & Small, 2010). Cruciferin and napin proteins in the amount of 10% can be successfully introduced to various fruits and vegetable-based juices and flavoured drinks. For meat products such as bologna, hot dogs, ham, sausages, meat-based soups, etc., the addition of rapeseed proteins in the amount of 2% does not change the sensory perception, while the nutritional value of the product is considerably improved (Von Der Haar et al., 2014). Besides, the cost related to the partial modification of the meat fraction into a plant fraction is relatively low, which confirms the promising prospect of using rapeseed proteins.

An additional argument for using rapeseed proteins as an ingredient or substitute for animal proteins in food products gives a report confirming the formation of bioactive peptides during their digestion. Numerous peptides produced from rapeseed proteins have been described and identified as having bioactive activity, namely ACE inhibitory activity, antioxidant activity, bile acid-binding capacity, antithrombotic activity and cell growth effects (Aider & Barbana, 2011). These peptides can have a positive effect on regulation of the cardiovascular and immune systems.

4.10. Sesame seeds

Indian sesame *(Sesamum indicum* L.*)* is one of the oldest oil plants used in the food industry. Sesame is used in three forms: as unprocessed seeds, for example as an addition to salads, as sesame paste – tahina, and sesame oil (Saatchi, Kiani, & Labbafi, 2019). Sesame oil, due to its nutritional value, is a perfect complement to the daily diet, especially a vegetarian or vegan diet. It contributes to the reduction of blood lipids and cholesterol in the plasma, lowers blood pressure and acts neuroprotectively (Borchani, Besbes, Blecker, & Attia, 2010; Hsu & Parthasarathy, 2017). Sesame and sunflower seeds and oils are analysed frequently for a partial replacement of animal fat in meat products and influence on their functional properties. When part of pork fat was replaced with pre-emulsified sesame oil, the meat batter had enhanced texture characteristics (hardness, gumminess, chewiness) and sensory acceptability similar to that of a high-fat product (Zhuang et al., 2016).

The proteins contained in sesame seeds are primarily storage proteins. Based on their solubility, they are classified mainly as globulins which amount to 67.3%. Albumin, glutelins and prolamins are found in much smaller amounts of 8.6%, 6.9% and 1.4%, respectively. Sesame globulins are divided into two fractions of α-globulins (~80%) and β-globulins (20%) (Achouri et al., 2012; Saatchi et al., 2019). Sesame proteins are among the 14 main food allergens. In recent years, there has been a significant increase in food allergies caused by the reaction to sesame, among both children and adults. The reason is likely the prevalence of sesame consumption in the form of an addition to highly processed food, fast foods, sweets or bakery products (Adatia, Clarke, Yanishevsky, & Ben-Shoshan, 2017).

Seven allergens found in sesame seeds have been identified, five of which are storage proteins. Two of them, Ses i 1 and Ses i 2, belong to the albumin-like family, and are 2S albumins having molecular weights of 9 and 7 kDa, respectively. The next three allergens, Ses i 6, Ses i 7, and Ses i 3, are 11S globulins of 52 kDa and 57 kDa and a 7S vicilin-type globulin of 45 kDa, respectively. The other two main sesame seed allergens that have been identified as also being responsible for anaphylactic reactions are structural proteins, oleosins, present in the oil body fractions of sesame seeds, that have molecular weights of 17 kDa and 14 kDa and are labelled as Ses i 4 and Ses i 5, respectively (Leduc et al., 2006; Ma et al., 2020).

Little is known about the biological activity of sesame protein. Regular consumption of meal obtained from black sesame seeds may be beneficial for the prevention of cardiovascular disease in people with hypertension. Women and men consuming sesame flour for a period of 4 weeks had significantly decreased systolic blood pressure and malondialdehyde level, and an increased level of vitamin E (Wichitsranoi et al., 2011). The possible antihypertensive effect is likely caused by improved antioxidant status and the reduction of oxidant stress.

4.11. Sunflower seeds

Sunflower *(Helianthus annuus* L.*)* is one of the four major oil plants grown all over the world. Sunflower seeds are mainly consumed in unprocessed form in salads and snacks, as well as in processed form as oil. Its regular consumption contributes to the reduction of cholesterol and increased antioxidant activity (Bester, Esterhuyse, Truter, & van Rooyen, 2010). This is related to the presence of bioactive compounds such as peptides and fatty acids, including conjugated linoleic acid (CLA). The protein extracted from sunflower seeds is a valuable macronutrient that recently has attracted more attention. The main storage proteins constitute about 85% of the total protein content and are characterized by a high content of two protein fractions, i.e. 11S helianthinin and 2S albumins (Žilić et al., 2010). The 11S helianthinin belongs to the legumin-like family of globulins.

Considerable variation in the proportions of different protein fractions has been described; globulins constituting the majority of sunflower proteins occurr in the range of about 40%–90%, whereas albumin accounts for about 10–30% of all proteins. Glutelins, especially prolamins, occurr in small amounts (González-Pérez & Vereijken, 2007). In a recent study, using the mass spectrometry methods, the amino acid composition and post-translational modifications of the main storage 2S albumin were analysed. Four main sunflower seed albumins, namely SESA2-1, SESA2-2, SESA20-2 and a family of SESA3 isoforms, have been described (Franke, Colgrave, Mylne, & Rosengren, 2016), whereas, four sunflower allergens have been reported to the allergen database (WHO/IUIS Allergen Nomenclature), including only one that has been confirmed to be administered via the oral route. This is the seed non-specific lipid-transfer protein AP10 labelled as Hel a 3 and having a molecular weight of 9 kDa.

Of various biological activities, the antioxidant activity of sunflower proteins has been examined. It has been demonstrated that chelating peptides can be produced during the digestion of sunflower proteins and have a protective role due to their antioxidant properties (Megías et al., 2008). Purified sunflower chelating peptides obtained from protein hydrolysates with pepsin and pancreatin are enriched in histidine and arginine, and were 2.5 times more antioxidant compared to the parent protein hydrolysate.

5. Conclusions

Oilseeds and meal or cake are protein-rich raw materials which are a valuable source of nutritional and bioactive components. Therefore, in recent years, oilseeds have become a more and more popular alternative protein source in the food and nutraceutical industries. Their properties are widely promoted by nutritionists and food producers, and therefore the interest of consumers in the new pro-health ingredients is growing rapidly around the world. Various processed food products, especially meat, bakery and dairy products, may be supplemented with oilseed meal or oilseed protein hydrolysates to be dedicated to consumers struggling with some health problems such as food allergies, intestinal diseases, metabolic syndrome, cancer and neurodegenerative diseases.

In recent years, considerable progress has been made in the knowledge of amino acid composition and the nutritional and health benefits of oilseeds derived from various plants; however, many of less abundant proteins still need to be characterized, and the protein and peptide bioactivity requires deeper scientific exploration. Numerous peptides released from chia, hemp, nigella, pumpkin, rapeseed proteins have been described and identified as having bioactive activity, namely ACE inhibitory activity, antioxidant activity, *anti*-inflamatory, antimicrobial, hypoglycemic or cardioprotective effects. However, there is still little information on the bioactive properties of evening primrose, milk thistle, and sesame proteins. Additional studies are needed to investigate the health benefits using clinical and animal models. The low allergenicity of pumpkin and hemp seeds or potential non-allergenicity of evening primrose, milk thistle, nigella and chia, when compared with legume proteins, also weighs in favour of their application as functional ingredients in newly formulated foods. In some cases, obstacles such as poor protein solubility or adverse digestive effects require further analysis and remedial measures. Despite this, oilseed proteins have great potential as functional ingredients or protein substitutes in the food industry.

Declaration of interests

The authors declare that they have no financial or commercial conflict of interest.

The study was supported by the National Science Centre, Poland (project number 2017/25/B/NZ9/02000).

References

Achouri, A., Nail, V., & Boye, J. I. (2012). Sesame protein isolate: Fractionation, secondary structure and functional properties. *Food Research International, 46*(1), 360–369. https://doi.org/10.1016/j.foodres.2012.01.001

Adatia, A., Clarke, A. E., Yanishevsky, Y., & Ben-Shoshan, M. (2017). Sesame allergy: Current perspectives. *Journal of Asthma and Allergy, 10*, 141–151. https://doi.org/10.2147/JAA.S113612

Aider, M., & Barbana, C. (2011). Canola proteins: Composition, extraction, functional properties, bioactivity, applications as a food ingredient and allergenicity - A practical and critical review. *Trends in Food Science & Technology, 22*(1), 21–39. https://doi.org/10.1016/j.tifs.2010.11.002

Aiello, G., Fasoli, E., Boschin, G., Lammi, C., Zanoni, C., Citterio, A., et al. (2016). Proteomic characterization of hempseed (*Cannabis sativa* L.). *Journal of Proteomics, 147*, 187–196. https://doi.org/10.1016/j.jprot.2016.05.033

Al-Gaby, A. M. (1998). Amino acid composition and biological effects of supplementing broad bean and corn proteins with *Nigella sativa* (black cumin) cake protein. *Nahrung, 42*(5), 290–294.

Alu'datt, M. H., Rababah, T., Alhamad, M. N., Gammoh, S., Ereifej, K., Alodat, M., et al. (2016). Antioxidant and antihypertensive properties of phenolic protein complexes in extracted protein fractions from *Nigella damascena* and *Nigella arvensis*. *Food Hydrocolloids, 56*, 84–92. https://doi.org/10.1016/j.foodhyd.2015.12.008

Apostol, L., Iorga, C. S., Moşoiu, C., Mustăţea, G., & Cucu, Ş. (2017). Nutrient composition of partially defatted milk thistle seeds. *Scientific Bulletin. Series F. Biotechnologies, XXI*, 165–170.

Appaiah, P., Sunil, L., Kumar, P. K. P., & Gopala Krishna, A. G. (2014). Composition of coconut testa, coconut kernel and its oil. *Journal of the American Oil Chemists' Society, 91*(6), 917–924. https://doi.org/10.1007/s11746-014-2447-9

Barros, J. C., Munekata, P. E. S., Pires, M. A., Rodrigues, I., Andaloussi, O. S., Rodrigues, C. E. C., et al. (2018). Omega-3- and fibre-enriched chicken nuggets by replacement of chicken skin with chia (*Salvia hispanica* L.) flour. *LWT – Food Science and Technology, 90*, 283–289. https://doi.org/10.1016/j.lwt.2017.12.041

Bekhit, A. E. D., Shavandi, A., Jodjaja, T., Bircha, J., Teh, S., Ahmed, I. A. M., et al. (2018). Flaxseed: Composition, detoxification, utilization, and opportunities. *Biocatalysis and Agricultural Biotechnology, 13*, 129–152. https://doi.org/10.1016/j.bcab.2017.11.017

Bester, D., Esterhuyse, A. J., Truter, E. J., & van Rooyen, J. (2010). Cardiovascular effects of edible oils: A comparison between four popular edible oils. *Nutrition Research Reviews, 23*(2), 334–348. https://doi.org/10.1017/S0954422410000223

Borchani, C., Besbes, S., Blecker, C., & Attia, H. (2010). Chemical characteristics and oxidative stability of sesame seed, sesame paste, and olive oils. *Journal of Agricultural Science and Technology A, 12*, 585–596.

Bučko, S. D., Katona, J. M., Popović, L. M., Vaštag, Ž. G., & Petrović, L. B. (2015). Functional properties of pumpkin (*Cucurbita pepo*) seed protein isolate and hydrolysate. *Journal of the Serbian Chemical Society, 80*, 1–7. https://doi.org/10.2298/JSC150615081B

Cakir, Y., Cakmakci, S., & Hayaloglu, A. A. (2016). The effect of addition of black cumin (*Nigella sativa* L.) and ripening period on proteolysis, sensory properties and volatile profiles of Erzincan Tulum (Şavak) cheese made from raw Akkaraman sheep's milk. *Small Ruminant Research, 134*, 65–73. https://doi.org/10.1016/j.smallrumres.2015.12.004

Câmara, A. K. F. I., Okuro, P. K., Lopes da Cunha, R., Herrero, A. M., Ruiz-Capillas, C., & Pollonio, M. A. R. (2020). Chia (*Salvia hispanica* L.) mucilage as a new fat substitute in emulsified meat products: Technological, physicochemical, and rheological characterization. *LWT – Food Science and Technology, 125*(109193). https://doi.org/10.1016/j.lwt.2020.109193

Campos, S., R, M., Peralta González, F., Chel Guerrero, L., & Betancur Ancona, D. (2013). Angiotensin I-converting enzyme inhibitory peptides of chia (Salvia hispanica) produced by enzymatic hydrolysis. *International Journal of Food Science, 158482*. https://doi.org/10.1155/2013/158482

Canistro, D., Vivarelli, F., Ugolini, L., Pinna, C., Grandi, M., Antonazzo, I. C., et al. (2017). Digestibility, toxicity and metabolic effects of rapeseed and sunflower protein hydrolysates in mice. *Italian Journal of Animal Science, 16*(3), 462–473. https://doi.org/10.1080/1828051X.2017.1298410

Carrera, C. S., Reynoso, C. M., Funes, G. J., Martínez, M. J., Dardanelli, J., & Resnik, S. L. (2011). Amino acid composition of soybean seeds as affected by climatic variables. *Pesquisa Agropecuária Brasileira, 46*(12), 1579–1587.

1764-1489.19 Chatain, C., Pin, I., Pralong, P., Jacquier, J. P., & Leccia, M. T. (2017). Medicinal bioactivites and allergenic properties of pumpkin seeds: Review upon a pediatric food anaphylaxis case report. *European Annals of Allergy and Clinical Immunology, 6*, 244–251. https://doi.org/10.23822/EurAnnACI.

Coelho, M. S., Soares-Freitas, R. A., Areas, J. A., Gandra, E. A., & Salas-Mellado, M. (2018). Peptides from chia present antibacterial activity and inhibit cholesterol synthesis. *Plant Foods for Human Nutrition, 73*, 101–107. https://doi.org/10.1007/s11130-018-0668-z

Cotabarren, J., Rosso, A. M., Tellechea, M., García-Pardo, J., Rivera, J. L., Obregón, W. D., et al. (2019). Adding value to the chia (*Salvia hispanica* L.) expeller: Production of bioactive peptides with antioxidant properties by enzymatic hydrolysis with papain. *Food Chemistry, 274*, 848–856. https://doi.org/10.1016/j.foodchem.2018.09.061

Danish food composition databank. (2019). *National food institute*. Food data: Technical University of Denmark version 4. https://frida.fooddata.dk/?lang=en/. (Accessed 29 July 2020).

Dash, P., & Ghosh, G. (2017). Proteolytic and antioxidant activity of protein fractions of seeds of. *Cucurbita moschata. Food Bioscience, 18*, 1–8. https://doi.org/10.1016/j.fbio.2016.12.004

Ding, Y., Lin, H., Lin, Y., Yang, D., Yu, Y., Chen, J., et al. (2018). Nutritional composition in the chia seed and its processing properties on restructured ham-like products. *Journal of Food and Drug Analysis, 26*(1), 124–134. https://doi.org/10.1016/j.jfda.2016.12.012

Dravie, Emmanuel, et al. (2020). Antioxidant, phytochemical and physicochemical properties of sesame seed (*Sesamum indicum* L). *Scientific American*, (e00349)https://doi.org/10.1016/j.sciaf.2020.e00349

EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies). (2014). Scientific Opinion on the evaluation of allergenic foods and food ingredients for labelling purposes. *EFSA Journal, 12(11)*(3894). https://doi.org/10.2903/j.efsa.2014.3894

El-haak, M. A., Atta, B. M., Rabo, A., & F, F. (2015). Seed yield and important seed constituents for naturally and cultivated milk thistle (*Silybum marianum*) plants. *Egyptian Journal of Experimental Biology, 11*(2), 141–146.

Franke, B., Colgrave, M. L., Mylne, J. S., & Rosengren, K. J. (2016). Mature forms of the major seed storage albumins in sunflower: A mass spectrometric approach. *Journal of Proteomics, 147*, 177–186. https://doi.org/10.1016/j.jprot.2016.05.004

Fremont, S., Moneret-Vautrin, D. A., Franck, P., Morisset, M., Croizier, A., Codreanu, F., et al. (2010). Prospective study of sensitization and food allergy to flaxseed in 1317 subjects. *European Annals of Allergy and Clinical Immunology, 42*(3), 103–111.

Ghasemnezhad, A., & Honermeier, B. (2008). Yield, oil constituents, and protein content of evening primrose *(Oenothera biennis L.)* seeds depending on harvest time, harvest method and nitrogen application. *Industrial Crops and Products, 28*(1), 17–23. https://doi.org/10.1016/j.indcrop.2007.12.006

Girgih, A. T., He, R., Malomo, S., Offengenden, M., Wu, J., & Aluko, R. E. (2014). Structural and functional characterization of hemp seed (*Cannabis sativa* L.) protein-derived antioxidant and antihypertensive peptides. *Journal of Functional Foods, 6*, 384–394. https://doi.org/10.1016/j.jff.2013.11.005

González-Pérez, S., & Vereijken, J. M. (2007). Sunflower proteins: Overview of their physicochemical, structural and functional properties. *Journal of the Science of Food and Agriculture, 87*, 2173–2191. https://doi.org/10.1002/jsfa.2971

Gołąbczak, J., Strąkowska, J., & Konstantynowicz, A. (2005). Dynamics of evening primrose protein hydrolysis. *Chemical Papers, 59*(6a), 409–412.

Grancieri, M., Martino, H. S. D., & Gonzalez de Mejia, E. (2019). Chia seed (*Salvia hispanica* L.) as a source of proteins and bioactive peptides with health benefits: A review. *Comprehensive Reviews in Food Science and Food Safety, 18*, 480–499. https://doi.org/10.1111/1541-4337.12423

Guo, X., Tian, S., & Small, D. M. (2010). Generation of meat-like flavourings from enzymatic hydrolysates of proteins from *Brassica sp*. *Food Chemistry, 119*, 167–172. https://doi.org/10.1016/j.foodchem.2009.05.089

Hadidi, M., Ibarz, A., & Pouramin, S. (2020). Optimization of extraction and deamidation of edible protein from evening primrose (*Oenothera biennis* L.) oil processing by-products and its effect on structural and techno-functional properties. *Food Chemistry, 334*(127613). https://doi.org/10.1016/j.foodchem.2020.127613

Hidalgo, F. J., & Zamora, R. (2006). Peptides and proteins in edible oils: Stability, allergenicity, and new processing trends. *Trends in Food Science & Technology, 17*, 56–63. https://doi.org/10.1016/j.tifs.2005.10.006

Hrnčič, M. K., Iwanowski, M., Cör, D., & Knez, Ž. (2020). Review: Chia seeds (*Salvia hispanica* L.): An overview—phytochemical profile, isolation methods, and Application. *Molecules 25(1), 11*. https://doi.org/10.3390/molecules25010011

Hsu, E., & Parthasarathy, S. (2017). Anti-inflammatory and antioxidant effects of sesame oil on atherosclerosis: A descriptive literature review. *Cureus, 9*(7), e1438. https://doi.org/10.7759/cureus.1438

Jones, O. G. (2016). Recent advances in the functionality of non-animal sourced proteins contributing to their use in meat analogs. *Current Opinion in Food Science, 7*, 7–13. https://doi.org/10.1016/j.cofs.2015.08.002

Kajla, P., Sharma, A., & Sood, D. R. (2015). Flaxseed - a potential functional food source. *Journal of Food Science & Technology, 52*(4), 1857–1871. https://doi.org/10.1007/s13197-014-1293-y

Kamdar, T. A., Peterson, S., Lau, C. H., Saltoun, C. A., Gupta, R. S., & Bryce, P. J. (2015). Prevalence and characteristics of adult-onset food allergy. *The Journal of Allergy and Clinical Immunology: In Practice, 3*(1), 114–115. https://doi:10.1016/j.jaip.2014.07.007.

Kaneda, T., Yoshida, H., Nakajima, Y., Toishi, M., Nugroho, A. E., & Morita, H. (2016). Cyclolinopeptides, cyclic peptides from flaxseed with osteoclast differentiation inhibitory activity. *Bioorganic & Medicinal Chemistry Letters, 26*, 1760–1761. https://doi.org/10.1016/j.bmcl.2016.02.040

Kaushik, P., Dowling, K., McKnight, S., Barrow, C. J., Wang, B., & Adhikari, B. (2016). Preparation, characterization and functional properties of flax seed protein isolate. *Food Chemistry, 197*, 212–220. https://doi.org/10.1016/j.foodchem.2015.09.106

Klimek-Kopyra, A., Zając, T., Micek, P., & Borowiec, F. (2013). Effect of mineral fertilization and sowing rate on chemical composition of two linseed cultivars. *Journal of Agricultural Science, 5*, 224–229. https://doi.org/10.5539/jas.v5n1p224

Kwon, K., Park, K. H., & Rhee, K. C. (1996). Fractionation and characterization of proteins from coconut (*Cocos nucifera* L.). *Journal of Agricultural and Food Chemistry, 44*, 1741–1745. https://doi.org/10.1021/jf9504273

Lalnunthari, C., Devi, L. M., & Badwaik, L. S. (2020). Extraction of protein and pectin from pumpkin industry by-products and their utilization for developing edible film. *Journal of Food Science & Technology, 57*, 1807–1816. https://doi.org/10.1007/s13197-019-04214-6

Leduc, V., Moneret-Vautrin, D. A., Tzen, J. T. C., Morisset, M., Guerin, L., & Kanny, G. (2006). Identification of oleosins as major allergens in sesame seed allergic patients. *Allergy, 61*, 349–356. https://doi.org/10.1111/j.1398-9995.2006.01013.x

Lee, P. W., Hefle, S. L., & Taylor, S. L. (2008). Sandwich enzyme-linked immunosorbent assay (ELISA) for detection of mustard in foods. *Journal of Food Science, 73*(4), 62–68. https://doi.org/10.1111/j.1750-3841.2008.00725.x

Li, F., Wu, X., Zhao, T., Li, F., Zhao, J., & Yang, L. (2013). Extraction, physicochemical, and functional properties of proteins from milk thistle *Silybum marianum* L. Gaernt seeds. *International Journal of Food Properties, 16*, 1750–1763. https://doi.org/10.1080/10942912.2011.608176

Li, Y., Zheng, Y., Zhang, Y., Xu, J., & Gao, G. (2018). Antioxidant activity of coconut (*Cocos nucifera* L.) protein fractions. *Molecules, 23*, 707. https://doi.org/10.3390/molecules23030707

Longato, E., Lucas-González, R., Peiretti, P. G., Meineri, G., Pérez-Alvarez, J. A., Viuda-Martos, M., et al. (2017). The effect of natural ingredients (Amaranth and pumpkin seeds) on the quality properties of chicken burgers. *Food and Bioprocess Technology, 10*, 2060–2068. https://doi.org/10.1007/s11947-017-1978-0

Mahgoub, S. A. M., Osman, A., & Ramadan, M. F. (2017). Inhibitory effect of Nigella sativa oil against *Listeria monocytogenes* and *Salmonella Enteritidis* inoculated in minced beef meat. *Journal of Food Measurement and Characterization, 11*, 2043–2051. https://doi.org/10.1007/s11694-017-9587-1

Ma, X., Li, H., Zhang, J., Huang, W., Han, J., Ge, Y., et al. (2020). Comprehensive quantification of sesame allergens in processed food using liquid chromatography-tandem mass spectrometry. *Food Control, 107*(106744). https://doi.org/10.1016/j.foodcont.2019.106744

Malomo, S. A., He, R., & Aluko, R. E. (2014). Structural and functional properties of hemp seed protein products. *Journal of Food Science, 79*(8), 1512–1521. https://doi.org/10.1111/1750-3841.12537

Mamone, G., Picariello, G., Ramondo, A., Nicolai, M. A., & Ferranti, P. (2019). Production, digestibility and allergenicity of hemp (*Cannabis sativa L.*) protein isolates. *Food Research International, 115*, 562–571. https://doi.org/10.1016/j.foodres.2018.09.017

Mamun, M. A., & Absar, N. (2018). Major nutritional compositions of black cumin seeds – cultivated in Bangladesh and the physicochemical characteristics of its oil. *International Food Research Journal, 25*(6), 2634–2639.

Marineli, R. S., Moraes, É. A., Lenquiste, S. A., Godoy, A. T., Eberlin, M. N., & Maróstica, M. R. (2014). Chemical characterization and antioxidant potential of Chilean chia seeds and oil (*Salvia hispanica L.*). *LWT – Food Science and Technology, 59*(2), 1304–1310. https://doi.org/10.1016/j.lwt.2014.04.014

Meddeb, W., Rezig, L., Abderrabba, M., Lizard, G., & Mejri, M. (2017). Tunisian milk thistle: An investigation of the chemical composition and the characterization of its cold-pressed seed oils. *International Journal of Molecular Sciences, 18*, 2582. https://doi.org/10.3390/ijms18122582

Megías, C., Pedroche, J., Yust, M. M., Girón-Calle, J., Alaiz, M., Millán, F., et al. (2008). Production of copper-chelating peptides after hydrolysis of sunflower proteins with pepsin and pancreatin. *LWT – Food Science and Technology, 41*(10), 1973–1977. https://doi.org/10.1016/j.lwt.2007.11.010

Mejicanos, G. A., & Nyachoti, C. M. (2018). Effect of tail-end dehulling of canola meal on apparent and standardized ileal digestibility of amino acids when fed to growing pigs. *Animal Feed Science and Technology, 243*, 102–111. https://doi.org/10.1016/j.anifeedsci.2018.07.011

Mukhtar, H., Qureshi, S. A., Anwar, F., Mumtaz, M. W., & Marcu, M. (2019). *Nigella sativa L.* Seed and seed oil: Potential sources of high-value components for development of functional foods and nutraceuticals/pharmaceuticals. *Journal of Essential Oil Research, 31*(3), 171–183. https://doi.org/10.1080/10412905.2018.1562388

Naumova, N., Lukin, A., & Bitiutskikh, K. (2017). Organoleptic evaluation of the quality of the enriched chopped semi-finished meat products. *Bulletin of the Transilvania University of Brasov. Forestry, Wood Industry, Agricultural Food Engineering. Series II, 10*, 125–132.

Novello, D., Schiessel, D. L., Santos, E. F., & Pollonio, M. A. R. (2019). The effect of golden flaxseed and by-product addition in beef patties: Physicochemical properties and sensory acceptance. *International Food Research Journal, 26*(4), 1237–1248.

Nwachukwu, I. D., Girgih, A. T., Malomo, S. A., Onuh, J. O., & Aluko, R. E. (2014). Thermoase-derived flaxseed protein hydrolysates and membrane ultrafiltration peptide fractions have systolic blood pressure-lowering effects in spontaneously hypertensive rats. *International Journal of Molecular Sciences, 15*, 18131–18147. https://doi.org/10.3390/ijms151018131

Oomah, B. D., Busson, M., Godfrey, D. V., & Drover, J. C. G. (2002). Characteristics of hemp (*Cannabis sativa L.*) seed oil. *Food Chemistry, 76*(1), 33–43. https://doi.org/10.1016/S0308-8146(01)00245-X

Orsavova, J., Misurcova, L., Ambrozova, J. V., Vicha, R., & Mlcek, J. (2015). Fatty Acids composition of vegetable oils and its contribution to dietary energy intake and dependence of cardiovascular mortality on dietary intake of fatty Acids. *International Journal of Molecular Sciences, 16*, 12871–12890. https://doi.org/10.3390/ijms160612871

Ozuna, C., & León-Galván, M. F. (2017). Cucurbitaceae seed protein hydrolysates as a potential source of bioactive peptides with functional properties. *BioMed Research International, 2017*(2), 1–16. https://doi.org/10.1155/2017/2121878

Pali-Schöll, I., Verhoeckx, K., Mafra, I., Bavaro, S. L., Mills, C. E. N., & Monaci, L. (2019). Allergenic and novel food proteins: State of the art and challenges in the allergenicity assessment. *Trends in Food Science & Technology, 84*, 45–48. https://doi.org/10.1016/j.tifs.2018.03.007

Panda, R., Tetteh, A. O., Pramod, S. N., & Goodman, R. E. (2015). Enzymatic hydrolysis does not reduce the biological reactivity of soybean proteins for all allergic subjects. *Journal of Agricultural and Food Chemistry, 63*(43), 9629–9639. https://doi.org/10.1021/acs.jafc.5b02927

Polyak, S. J., Morishima, C., Lohmann, V., Pal, S., Lee, D. Y. W., Liu, Y., et al. (2010). Identification of hepatoprotective flavonolignans from silymarin. *Proceedings of the National Academy of Sciences, 107*(13), 5995–5999. https://doi.org/10.1073/pnas.0914009107

Raikos, V., Neacsu, M., Duthie, G., Nicol, F., Reid, M., Cantlay, L. L., et al. (2017). Proteomic and glucosinolate profiling of rapeseed isolates from meals produced by different oil extraction processes. *Journal of Food Processing and Preservation, 41*(4), 1–8. https://doi.org/10.1111/jfpp.13060

Rezig, L., Chibani, F., Chouaibi, M., Dalgalarrondo, M., Hessini, K., Guéguen, J., et al. (2013). Pumpkin (*Cucurbita maxima*) seed proteins: Sequential extraction processing and fraction characterization. *Journal of Agricultural and Food Chemistry, 61*, 7715–7721. https://doi.org/10.1021/jf402323u

Rodríguez-Jiménez, B., Domínguez-Ortega, J., Ledesma, A., González-García, J. M., & Kindelan-Recarte, C. (2010). Food allergy to pumpkin seed. *Allergologia et Immunopathologia, 38*(1), 50–51. https://doi.org/10.1016/j.aller.2009.07.001

Rojas, V. M., da Costa Baptista Marconi, L. F., Guimarães-Inácio, A., Leimann, F. V., Tanamati, A., Gozzo, A. M., et al. (2019). Formulation of mayonnaises containing PUFAs by the addition of microencapsulated chia seeds, pumpkin seeds and baru oils. *Food Chemistry, 274*, 220–227. https://doi.org/10.1016/j.foodchem.2018.09.015

Saatchi, A., Kiani, H., & Labbafi, M. (2019). A new functional protein-polysaccharide conjugate based on protein concentrate from sesame processing by-products: Functional and physico-chemical properties. *International Journal of Biological Macromolecules, 122*, 659–666. https://doi.org/10.1016/j.ijbiomac.2018.10.122

Sandoval-Oliveros, M. R., & Paredes-López, O. (2013). Isolation and characterization of proteins from chia seeds (*Salvia hispanica L.*). *Journal of Agricultural and Food Chemistry, 61*(1), 193–201. https://doi.org/10.1021/jf3034978

Shahat, M. S., Hussein, A. S., & Hady, E. A. (2016). Preparation of bread supplemented with milk thistle flour and its effect on Acute hepatic damage caused by carbon tetrachloride in rats. *Middle East Journal of Applied Sciences, 6*(3), 531–540.

Siano, F., Moccia, S., Picariello, G., Russo, G. L., Sorrentino, G., Di Stasio, M., et al. (2019). Comparative study of chemical, biochemical characteristic and ATR-FTIR Analysis of seeds, oil and flour of the edible fedora cultivar hemp (*Cannabis sativa* L.). *Molecules, 24*, 83. https://doi.org/10.3390/molecules24010083

da Silva, P, B., Anunciação, P. C., Matyelka, J. C.da, Della Lucia, C. M., Martino, H. S. D., et al. (2017). Chemical composition of Brazilian chia seeds grown in different places. *Food Chemistry, 221*, 1709–1716. https://doi.org/10.1016/j.foodchem.2016.10.115

Soni, R. P., Katoch, M., Kumar, A., & Verma, P. (2016). Flaxseed – composition and its health benefits. *Research in Environment and Life Sciences, 9*(3), 310–316. http://rels.comxa.com/fullpapers9/volume9paper92.pdf.

Srinivasan, K. (2018). Cumin (*Cuminum cyminum*) and black cumin (*Nigella sativa*) seeds: Traditional uses, chemical constituents, and nutraceutical effects. *Food Quality and Safety, 2*, 1–16. https://doi.org/10.1093/fqsafe/fyx031

Sultan, M. T., Butt, M. S., Anjum, F. M., Jamil, A., Akhtar, S., & Nasir, M. (2009). Nutritional profile of indigenous cultivar of black cumin seeds and antioxidant potential of its fixed and essential oil. *Pakistan Journal of Botany, 41*(3), 1321–1330.

Tavakkoli, A., Mahdian, V., Razavi, B. M., & Hosseinzadeh, H. (2017). Review on clinical trials of black seed (*Nigella sativa*) and its Active constituent, thymoquinone. *Journal of Pharmacopuncture, 20*(3), 179–193. https://doi.org/10.3831/KPI.2017.20.021

U.S Department of Agriculture. (2019). Agricultural research Service. *FoodData Central*. https://fdc.nal.usda.gov/. (Accessed 29 July 2020).

Von Der Haar, D., Müller, K., Bader-Mittermaier, S., & Eisner, P. (2014). Rapeseed proteins – production methods and possible application ranges. *OCL Oilseeds and fats, Crops and Lipids, 21*(1), D104. https://doi.org/10.1051/ocl/2013038

Wang, Q., & Xiong, Y. L. (2019). Processing, nutrition, and functionality of hempseed protein: A review. *Comprehensive Reviews in Food Science and Food Safety, 10*, 1541–4337. https://doi.org/10.1111/1541-4337.12450

Wichitsranoi, J., Weerapreeyakul, N., Boonsiri, P., Settasatian, C., Settasatian, N., Komanasin, N., et al. (2011). Antihypertensive and antioxidant effects of dietary black sesame meal in pre-hypertensive humans. *Nutrition Journal, 10*(82). http://www.nutritionj.com/content/10/1/82.

Wojtasik-Kalinowska, I., Guzek, D., Brodowska, M., Godziszewska, J., Górska-Horczyczak, E., Pogorzelska, E., et al. (2017). The effect of addition of *Nigella sativa* L. oil on the quality and shelf life of pork patties. *Journal of Food Processing and Preservation, 41*(6). https://doi.org/10.1111/jfpp.13294

Yoshie-Stark, Y., Wada, Y., & Wäsche, A. (2008). Chemical composition, functional properties, and bioactivities of rapeseed protein isolates. *Food Chemistry, 107*, 32–39. https://doi.org/10.1016/j.foodchem.2007.07.061

Zadernowski, R., Polakowska-Nowak, H., Rashed, A. A., & Kowalska, M. (1999). Lipids from evening primrose and borage seeds. *Oilseed Crops, 2*, 581–590.

Zahari, I., Ferawati Ferawati, F., Helstad, A., Ahlström, C., Östbring, K., Rayner, M., et al. (2020). Development of high-moisture meat Analogues with hemp and soy protein using extrusion cooking. *Foods, 9*, 772. https://doi.org/10.3390/foods9060772

Zając, M., Guzik, P., Kulawik, P., Tkaczewska, J., Florkiewicz, A., & Migdał, W. (2019). The quality of pork loaves with the addition of hemp seeds, de-hulled hemp seeds, hemp protein and hemp flour. *LWT – Food Science and Technology, 105*, 190–199. https://doi.org/10.1016/j.lwt.2019.02.013

Zduńczyk, Z., & Jankowski, J. (2013). Poultry meat as functional food: Modification of the fatty acid profile – a review. *Annals of Animal Science, 13*(3), 463–480. https://doi.org/10.2478/aoas-2013-0039

Zhuang, X., Han, M., Kang, Z., Wang, K., Bai, Y., Xu, X., et al. (2016). Effects of the sugarcane dietary fiber and pre-emulsified sesame oil on low-fat meat batter physicochemical property, texture, and microstructure. *Meat Science, 113*, 107–115. https://doi.org/10.1016/j.meatsci.2015.11.007

Ziemichód, A., Wójcik, M., & Różyło, R. (2019). *Ocimum tenuiflorum* seeds and *Salvia hispanica* seeds: Mineral and amino acid composition, physical properties, and use in gluten-free bread. *CyTA - Journal of Food, 17*(1), 804–813. https://doi.org/10.1080/19476337.2019.1658645

Žilić, S., Barać, M., Pešić, M., Crevar, M., Stanojević, S., Nišavić, A., et al. (2010). Characterization of sunflower seed and kernel proteins. *International Scientific Journal, 33*(52), 103–114. https://doi.org/10.2298/HEL1052103Z

Zwolan, A., Pietrzak, D., Adamczak, L., Chmiel, M., Kalisz, S., Wirkowska-Wojdyła, M., et al. (2020). Effects of Nigella sativa L. seed extracts on lipid oxidation and color of chicken meatballs during refrigerated storage. *LWT – Food Science and Technology, 130*(109718). https://doi.org/10.1016/j.lwt.2020.10971