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A REVIEW: USING LEGUMES TO DEVELOP PRODUCTS FOR PATIENTS WITH PSYCHIATRIC DISORDERS

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Abstract
Mortality rates and co-morbidities are high in people with psychiatric disorders. These patients have unhealthy dietary habits, which include increased consumption of fast food, snacks, sweets, saturated fats, and reduced consumption of protein, fruits, vegetables, and legumes, which contributes to the risk of developing chronic diseases such as obesity, type 2 diabetes, and cardiovascular disease. Unhealthy and monotonous eating habits lead to a significant lack of nutrients such as protein, omega-3 fatty acids, B-group vitamins, and fibre. The aim of the literature review is to investigate the main diet problems of patients with psychiatric disorders and, based on the studies on the nutritional value of legumes, to evaluate their suitability for the development of new products for patients with psychiatric disorders. Studies show the beneficial effects of legumes on the regulation of rapid fluctuations in cholesterol, blood pressure, excess body weight, and glucose levels, which in general delay the formation of inflammation and reduce the risk of psychiatric disorders. The benefits of legumes are due to their high protein and fibre content, low fat content, and content of iron, copper, magnesium, zinc, and B-group vitamins. In addition, legumes contain bioactive compounds that contribute to the prevention of chronic diseases.
Key words: psychiatric disorders, legumes, health, nutrients.

Introduction

Mental and behavioural disorders are divided into – organic mental disorders, including symptomatic, schizophrenia, schizotypal disorders and nightmares, mental retardation, neurotic, stress-related, and somatoform disorders, mood disorders, mental developmental disorders, behavioural and emotional disorders that usually begin in childhood and adolescence, adult personality and behavioural disorders and behavioural syndromes related to physiological disorders and somatic disorders (Šica, Pulmanis, & Taube, 2017). Each of the mentioned disorders has symptoms characteristic of its group of diagnoses, which can worsen the general well-being of the patient and contribute to other co-morbidities, which create the need for food adapted to them, respecting physiological needs. In the following text, two groups of diseases will be discussed – schizophrenia and depression (mood disorders), which often can be combined. Therefore, psychoeducation is an essential and integral part of them, which also includes the application of appropriate, high-quality nutrition to patients.

Individuals with depression have a 30% increased risk of cardiovascular disease compared to non-depressed individuals. A prospective cohort study (n=323.709) found that depression was associated with a 31% increased risk of myocardial infarction and a 36% increased risk of coronary death compared to people without depression (Wu & Kling, 2016). Sympathetic hyperactivity may increase the risk of poor cardiovascular outcomes, including sudden death (A. B. Levine, L.M. Levine, & T.B. Levine, 2013).

Depressed patients typically have higher levels of circulating catecholamines – a marker of sympathetic activation – causing an increase in heart rate and blood pressure, while reducing coronary blood flow and increasing systemic vascular resistance, and contributing to the risk of coronary heart disease (Nasiłowska-Barud *et al*., 2017). Stress and anxiety cause excessive activation of the HPA (Hypothalamic-pituitary axis) and the sympathetic nervous system, increasing cortisol and catecholamine levels respectively – these changes can result in inflammation, metabolic disorders, platelet activation, endothelial dysfunction, hypertension, and insulin resistance, leading to an atherosclerosis and coronary development or progression of heart disease (Tully *et al*., 2013; Fiedorowicz, 2014; Goldstein *et al*., 2015). Patients with depression and anxiety are mostly characterized by loss of energy, anhedonia (inability to feel pleasure), and inability to concentrate, which interferes with daily activities. In severe cases, this can lead to a lack of self-care and loss of personal hygiene, such as infrequent dental and oral hygiene, which contributes to gingivitis, xerostomia, and oral candidiasis (Torales *et al*., 2017). Depressed patients have marked loss of appetite and nutrients due to malnutrition. Against the background of depression, eating disorders often develop, which contribute to weight loss. The exclusion of important protein-rich products from the diet, such as meat, fish, and dairy products, hinders the recovery process (Lin *et al*., 2021; Cao *et al*., 2019). Nutrition plays an important role in reducing psychiatric symptoms because there are hypotheses that certain nutrients, which are necessary for the effective functioning of

the brain, also affect the biological and neurochemical activities related to one of the nosological entities – the development and progression of depression (Popa & Ladea, 2012). Studies report that a high levels of vegetable, fruit, nuts, cereal, legumes, and a low consumption of meat or meat products and whole fat dairy gave greater importance to the synthesis of the monoamines, glutamate and GABA (Gamma-amino acid), which are responsible for the distribution of serotonin, dopamine, and noradrenaline, which in turn are responsible for mood regulation (Lopresti *et al*., 2013). The dopaminergic system is improved by polyunsaturated fatty acids, especially omega-3, proteins, B-group vitamins, and minerals but hindered by fats and sugars. Changes in amino acids such as tryptophan, valine, leucine, isoleucine, phenylalanine, and tyrosine have been observed in depressed patients (Lim *et al*., 2016).

Schizophrenic patients, depending on their accompaying symptoms, may develop a lack of interest, apathy, and fatigue, which leads to a reduced appetite, leading to long-term weight loss (Oudman *et al*., 2021). Studies have shown that 61% of schizophrenic patients have poor dental health due to dry mouth from antipsychotic medications, infrequent teeth brushing, extrapyramidal symptoms (hand tremors), and frequent smoking, which is more common than in the general population or patients with other mental health conditions and disorders (Torales *et al*., 2017). Early death in patients with schizophrenia may be associated with preventable medical conditions, namely cardiovascular disease, chronic obstructive pulmonary disease (COPD), metabolic syndrome, type 2 diabetes, and cancer risk (Crump *et al*., 2013; Smith *et al*., 2013; Laursen *et al*., 2019). Cross-sectional studies show that patients who suffer from schizophrenia consume more refined and processed products in their diet, which worsens the overall symptomatology of the diagnosis (Lichtenthal *et al*., 2018; Laursen *et al*., 2019). In patients with schizophrenia, the use of antipsychotic drugs is an integral part of the treatment of clinical symptoms. Many of these drugs are associated with significant weight gain, central obesity, and the development of metabolic disorders. Meta-analysis studies emphasize that one of the main factors that determine cardiometabolic abnormalities is related to increased food calories and unhealthy food choices, which interact with antipsychotic drugs and cause health problems. The use of antipsychotic medications may increase the risk of coronary heart disease by increasing sympathetic nervous system activity and blocking peripheral dopamine receptors (Correll *et al*., 2015). Mental disorders are associated with comorbidities such as obesity, hypertension, dyslipidaemia, increased triglyceride levels and decreased high-density lipoprotein cholesterol (HDL), impaired glucose tolerance, or insulin resistance. Lifestyle (smoking, physical inactivity, unhealthy dietary habits), as well as medications, may play a role in the prevalence of metabolic syndrome (A.B. Levine, L.M. Levine, & T.B. Levine, 2013). Patients taking antipsychotic medications have increased appetite and cravings for sweet foods and beverages, and decreased intake of healthy foods such as vegetables and fruits, leading to an increased risk of inflammation and worsened overall diagnostic status (Teasdale *et al*., 2018). Patients with schizophrenia generally have poor dietary habits characterized by increased intake of sodium, cholesterol, saturated fat, sugar (refined foods, white sugar) and reduced fibre intake, omega – 3 fatty acids, and vitamin D levels, which worsens mental disorders and contributes to other diseases, such as obesity and metabolic syndrome (Onaolapo & Onaolapo, 2021). Studies report that reduced omega-3 fatty acids and increased omega-6 fatty acids cause or worsen neuroinflammation, worsening the severity of schizophrenia symptoms (Onaolapo & Onaolapo, 2021). In schizophrenic patients, unhealthy eating practices are due to dysregulation of the reward circuitry due to increased dopamine activity in the mesolimbic pathway and brain regions responsible for cognitive control (Onaolapo & Onaolapo, 2021). Dysregulation of the reward circuit has also been linked to obesity, eating disorders, food cravings, and addictive behaviours. Food sensitivity, characterized by elevated levels of immunoglobulin G antibodies to wheat gluten, beef, and casein, has also been observed in schizophrenia (Severance *et al*., 2012; Lionetti *et al*., 2015). Many studies report high levels of homocysteine, as well as low levels of vitamins B_9, B_{12}, vitamin C, and vitamin E in patients with schizophrenia. Deficiencies or excesses of essential micronutrients, including calcium, zinc, selenium, copper, and manganese, have been observed in patients with schizophrenia (Onaolapo & Onaolapo, 2021). Research shows that the diet taken by patients with psychiatric disorders is of great importance, which includes more intake of plant products, such as legumes. Legumes have a positive effect on health due to their low glycemic index, high content of fiber, protein, B-group vitamins and minerals, which could improve the health of patients with psychiatric disorders.

The literature review aims to investigate the main diet problems of patients with psychiatric disorders and, based on the studies on the nutritional value of legumes, to evaluate their suitability for the development of new products for patients with psychiatric disorders.

Materials and Methods

The information was searched in *Google Scholar*, *Web of Science*, and *Scopus* original studies and reviews published in English and Latvian in the period from 2005 to 2022. The search for information was based on the following conditions: the main health problems of patients with psychiatric disorders, the provision of necessary nutrients, and the health effects of leguminous products. Full-text papers were included in this review. The monographic method was used in this study. The following keywords were used to select scientific literature: psychiatric disorders, mental health, schizophrenia, depression, symptoms, nutrition, nutrients, protein, B-group vitamins, fibre, minerals, legumes, peas (*Pisum*), beans (*V. faba*), and antioxidants.

Results and Discussion

Protein is one of the essential nutrients in mental health, and its insufficiency leads to abnormal levels of neurotransmitters and disturbances in cognitive behaviour (Sato *et al*., 2020). Dietary protein is made up of about 20 different amino acids, of which tryptophan and tyrosine are abundant in milk, cheese, meat, eggs, chicken, fish, beans (*V. faba*), oats, nuts, and whole grains. A poor tryptophan diet reduces serotonin levels in the brain, leading to anxiety, obsessions, and compulsions, which are symptoms of depression (Chávez *et al*., 2017). Dietary intake of tryptophan reduces stress and cortical hormones associated with depression (Koopmans *et al*., 2005). A study testing three different legume pastes together with wheat semolina and two control groups of a casein and soluble milk proteins drink found equivalent results associated with increased lean mass and maintenance of muscle mass in the legume and casein group (Berrazaga *et al*., 2020). Depending on the legume variety, the protein content varies widely from 20 to 35%, the essential amino acid being lysine, leucine, and phenylalanine (Kumari & Deka, 2021). Sulphur-containing amino acids, such as methionine and cysteine, are in reduced quantities compared to meat products. A recent study showed that pea protein hydrolysates can inhibit a metabolic by-product, nitric oxide, which can cause excessive cell damage (Lu *et al*., 2020). One of the proteins found in legumes, called lectins or phytohemagglutinin, is able to agglutinate the red blood cells found (Kumari & Deka, 2021). Lunasin is a peptide found in legumes that has multiple health-promoting effects, such as anti-inflammatory, cholesterol-lowering, anti-cancer, and antioxidant effects. The resistance of lunasin to gastric enzymes preserves its functionality and thus promotes its bioavailability (Hernandez-Ledesma, Hsieh, & Lumen 2016).

Legumes, as good sources of slow-release carbohydrate including dietary fiber and slow digestive starches reduce blood glucose response, cholesterol, create a favourable microbiome for *Lactobacillus* and *Bifidobacterium* bacteria, and reduce appetite (Kadyan *et al*., 2022). The low glycaemic index of legumes is a possible mechanism involved in the modulation of the inflammatory process. Considering that the gut microbiota is altered in patients with psychiatric disorders, legumes contribute to their improvement due to the resistant starch and fibre they contain (Teasdale, Mörkl, & Müller-Stierlin, 2020).

Legumes contain about 16% to 20% of the soluble fibre fraction, which plays an essential role in the absorption of water in the intestines, facilitating the faster movement of intestinal contents and reducing constipation. Clinical studies and epidemiological studies show that dietary fibre in legumes reduces blood cholesterol levels (Becerra-Tomás *et al*., 2019; Martín-Cabrejas, 2019). This fact is very important in the prevention of cardiovascular diseases.

Legumes are low in sodium (3–41 mg 100 g^{-1}) and high in potassium (616–2300 mg 100 g^{-1}), which is very important for maintaining normal blood pressure. The most important minerals in legumes are calcium (32–394 mg 100 g^{-1}), phosphorus (203–800 mg 100 g^{-1}), magnesium (58–472 mg 100 g^{-1}), iron (3.2–10 mg 100 g^{-1}), and zinc (1.6–6.3 mg 100 g^{-1}) (Martín-Cabrejas, 2019). These trace elements are essential in the metabolic processes of many cells and are antioxidants that slow down the natural ageing process. The presence of phytic acid in legumes causes the formatted of insoluble complexes with divalent cations (Ca^{2+}, Fe^{2+}, Zn^{2+}), which interferes with their absorption and thus reduces their bioavailability. Although legumes are high in iron, their bioavailability is lower than in animal products. The vitamin content of legumes varies widely and includes B-group vitamins such as B_1 (0.3–1.6 mg 100 g^{-1}), B_2 (0.12–0.33 100 g^{-1}) and B_3 (4.7 mg 100 g^{-1}). (Martín-Cabrejas, 2019), which play an essential role in energy metabolism. The importance of vitamins, especially B-group vitamins, has been given great importance in psychiatric disorders. A large number of observational studies show that patients with psychiatric disorders have reduced levels of B_9, B_{12}, B_6, and choline. Meta-analysis studies show that a positive effect that improved the overall psychological state was a dose of vitamin B_6 of 1200 mg day^{-1}, a dose of vitamin B_{12} of 400 µg day^{-1}, and a dose of B_9 of 0.5–15 mg day^{-1} (Firth *et al*., 2017). The level of vitamin C in legumes is quite low 0.4–27.7 mg 100 g^{-1} dry matter.

The amount of phytosterols in legumes depends on the variety of the legume. The main phytosterols are β-sitosterol and D5-avenasterol (Abbas & Ahmad, 2018). Plant secondary metabolites have

a potential effect on obesity, and atherosclerosis, as well as reducing total cholesterol and low-density lipoprotein cholesterol (LDL) serum levels, as well as causing a significant increase in high-density lipoprotein cholesterol (HDL) (Becerra-Tomás *et al*., 2019; Martín-Cabrejas, 2019).

The pea fatty acid profile mainly has a component of linoleic, linolenic, and palmitic acids, showing a promising antihyperlipidemic effect, reducing the risk of diabetes, including the level of oxidative stress, and preventing organ damage, namely the liver, kidney, and testis (Kumari & Deka, 2021). In the body, α-linolenic acid is converted to docosahexaenoic acid and eicosapentaenoic acid (Sublette *et al*., 2011). Research shows that depressed patients have lower blood levels of omega-3 fatty acids and lower levels of docosahexaenoic acid and eicosapentaenoic acid (Liao *et al*., 2019). A deficiency of omega-3 fatty acids leads to neural functional impairment by changes in the structure or function of membrane-bound enzymes, protein receptors, and ion channels (Sinclair *et al*., 2016). Dietary intake of omega-3 fatty acids improves depression scores (Banikazemi *et al*., 2015) and also improves adaptive coping in stressful situations (Gonzales *et al*., 2015). Omega-3 fatty acids protect against depression, possibly by modulating serotonergic, dopaminergic, and adrenergic transmission (Liperoti *et al*., 2009).

Magnesium is essential as a cofactor in many enzymatic reactions in the body, and the nervous system is involved in nerve transmission and neuromuscular regulation (Gröber *et al*., 2015). Magnesium deficiency is associated with symptoms of depression and other mood disorders, while the moderate intake is associated with depression risk (Li *et al*., 2018). Zinc deficiency impairs the accumulation of polyunsaturated fatty acids throughout the body and causes rapid mood swings (Ekong & Iniodu, 2021).

The phenolic compounds in legume seeds act as anti-nutritional compounds, but they can also act as antioxidants due to their ability to chelate metal ions, inhibit lipid peroxidation, and scavenge free radicals. The phenolic compounds found in legume seeds include tannins, phenolic acids, anthocyanins, and flavonoids. The phenolic compounds in legume seeds have antibacterial, antiviral, anti-inflammatory, and anti-allergic activities, as well as reducing the risk of cancer, heart disease, and diabetes. In total phenolics versus antioxidant activities, fermented legume seeds have higher antioxidant potential. The balance between anti-nutrient and antioxidant effects present in legume seeds will help improve nutrient utilization, thereby providing potential nutritional agents for human health (López-Amorós *et al*., 2006., Bosi *et al*., 2019). The antioxidant saponin present in legumes has shown anticarcinogenic, antimutagenic, hypoglycaemic, hypocholesterolaemic, liver otoprotective, immunomodulatory, and neuroprotective activity in animal (*in vivo*) and *in vitro* studies (Kumar & Pandey, 2020).

Studies have shown that legume intake has a positive effect on cardiovascular risk by reducing triglycerides, LDL blood levels and increasing HDL levels. All the results obtained are highly dependent on the number of servings of legumes consumed, the duration of the studies (from weeks to years), as well as the type of legumes consumed. Systematic reviews, where a total of 371 randomized and controlled trials were evaluated, emphasize that positive results have been observed with the intake of 150 g of cooked legumes per day, for at least eight weeks (Becerra-Tomás *et al*., 2019; Ferreira *et al*., 2021; Gao *et al*., 2019; Martín-Cabrejas, 2019). Epidemiological and clinical studies have shown the positive effects of bean (*V. faba*) consumption in reducing the risk of coronary heart disease and cardiovascular disease, which can be attributed to the high content of soluble fibre, which reduces blood triglyceride and cholesterol levels. The low glycaemic index of legumes is a possible mechanism involved in the modulation of the inflammatory process. Considering that the intestinal microbiota is altered in patients with psychiatric disorders, legumes contribute to their improvement thanks to the resistant starch and fibre they contain.

Epidemiological and clinical studies have shown the positive effects of bean (*V. faba*) consumption in reducing the risk of coronary heart disease and cardiovascular disease, and generally reducing the progression of psychiatric diseases (Teasdale *et al*., 2020).

Conclusions

Patients with psychiatric diseases have pronounced unhealthy eating habits which do not contribute to recovery but also increase the risk of developing chronic diseases. Due to their protein, low glycemic index, fiber, B-group vitamin content, minerals and phenols, legumes could be a good raw material for the development of new products for patients with psychiatric disorders. Many studies clearly show the beneficial effects of legumes on blood cholesterol levels, blood pressure regulation, reducing excess body weight, maintaining muscle mass and reduction glucose levels. However, further research is needed to be able to develop an appropriate product for this group of patients, taking into account legume digestibility and patients' eating issues.

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