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PHYTOTHERAPEUTIC POTENTIAL OF *SORGHUM BICOLOR* L.

Actuality. *In modern phytotherapy there is a growing interest in the use of plants with rich chemical composition and medicinal properties. Grain sorghum (Sorghum bicolor L.) is characterized by a high content of antioxidants, in particular polyphenols and other biologically active compounds, which provides its significant therapeutic potential. However, despite the numerous scientific data on the chemical composition of sorghum, its use in the prevention and treatment of chronic diseases is still underestimated.*

The purpose of the study – is to scientifically substantiate the prospects of using Sorghum bicolor L. in the prevention and treatment of chronic diseases by studying its chemical composition, pharmacological activity and therapeutic potential.

Material and methods. *A review of scientific literature was conducted using Scopus, Web of Science and Google Scholar databases. The publications of the last 10 years covering the chemical composition, pharmacological properties and functional capabilities of sorghum were analyzed.*

Research results. *Sorghum is characterized by a rich composition of phenolic acids, such as ferulic, gallic, and vanillic acids, which have antioxidant and anti-inflammatory properties. Its dietary fiber content and low glycemic index make sorghum valuable for people with diabetes and metabolic syndrome. Polyphenolic compounds in sorghum have been shown to help prevent oxidative stress, regulate inflammation and strengthen the cardiovascular system.*

Conclusion. *Sorghum bicolor L. is a promising crop for use in phytotherapy due to its antioxidant, anti-inflammatory and cardioprotective properties. Due to its unique chemical composition, it can be considered as a promising ingredient for the creation of functional foods and phytotherapeutic products. Further research could expand the use of sorghum in nutrition and dietetics.*

Key words: *Sorghum bicolor L., phytotherapy, biologically active substances, antioxidants, polyphenols, anti-diabetic properties, alternative medicine, functional foods.*

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ФІТОТЕРАПЕВТИЧНИЙ ПОТЕНЦІАЛ ЗЕРНА *SORGHUM BICOLOR* L.

Актуальність. *У сучасній фітотерапії зростає інтерес до використання рослин із багатим хімічним складом і лікувальними властивостями. Сорго зернове (Sorghum bicolor L.) вирізняється високим вмістом антиоксидантів, зокрема поліфенолів та інших біологічно активних сполук, що забезпечує його значний терапевтичний потенціал. Однак, незважаючи на численні наукові дані про хімічний склад сорго, його застосування у профілактиці й лікуванні хронічних захворювань досі недооцінене.*

Мета дослідження *– наукове обґрунтування перспектив використання Sorghum bicolor L. у профілактиці та лікуванні хронічних захворювань, через вивчення його хімічного складу, фармакологічної активності та терапевтичного потенціалу.*

Матеріал і методи. *Проведено огляд наукової літератури з використанням баз даних "Scopus", "Web of Science" та "Google Scholar". Здійснено аналіз публікацій за останні 10 років, у яких висвітлено хімічний склад, фармакологічні властивості та функціональні можливості сорго.*

Результати дослідження. *Сорго характеризується багатим складом фенольних кислот, як-от ферулова, галова, ванілінова, які володіють антиоксидантними та протизапальними властивостями. Вміст харчових волокон і низький глікемічний індекс роблять сорго цінним для людей із діабетом і метаболічним синдромом. Доведено, що поліфенольні сполуки сорго сприяють запобіганню окиснювальному стресу, регуляції запальних процесів і зміцненню серцево-судинної системи.*

Висновок. *Sorghum bicolor L. є перспективною культурою для використання у фітотерапії завдяки своїм антиоксидантним, протизапальним і кардіопротекторним властивостям. Завдяки своєму унікальному хімічному складу може розглядатися як перспективний інгредієнт для створення функціональних харчових продуктів і фітотерапевтичних препаратів. Подальші дослідження можуть розширити застосування сорго в нутриціології та дієтології.*

Ключові слова: *Sorghum bicolor L., фітотерапія, біологічно активні речовини, антиоксиданти, поліфеноли, антидіабетичні властивості, нетрадиційна медицина, функціональні продукти харчування.*

Introduction. Actuality. Modern medicine and pharmacy are increasingly turning to phytotherapy as a source of effective, safe and environmentally acceptable methods of disease prevention and treatment. Against the backdrop of the global increase in chronic diseases such as metabolic syndrome, cardiovascular disease, diabetes, and the search for alternatives to synthetic drugs, rare crops rich in biologically active substances deserve special attention. In this context, *Sorghum bicolor* L. (grain sorghum) opens up new opportunities for phytotherapy due to its unique properties (Cardoso et al., 2017; Birhanu, 2021; Khoddami et al., 2023).

Sorghum bicolor L. is characterized by a high concentration of polyphenolic compounds, in particular flavonoids, tannins and anthocyanins, which have a pronounced antioxidant, anti-inflammatory and anti-diabetic effect (Ofosu et al., 2020). For example, sorghum anthocyanins demonstrate antioxidant activity with an IC_{50} of 5,4–7,2 μg/ml, which contributes to its effectiveness in preventing oxidative stress. In addition, the high content of dietary fiber (up to 6,3 g/100 g of product) improves gastrointestinal function and reduces the risk of cardiovascular disease. An important aspect is that sorghum does not contain gluten, which makes it safe for people with celiac disease or gluten sensitivity (Cardoso et al., 2017; Hong et al., 2020; Mohamed et al., 2022).

Despite numerous scientific data on the chemical composition and biological activity of sorghum, its role in phytotherapy is still underestimated. The study of this issue indicates a significant interest of scientists in the phytotherapeutic potential of *Sorghum bicolor* L. In particular, the study by Jingwen Xu confirms that *Sorghum bicolor* L. grain is a valuable source of phenolic compounds, in particular ferulic, gallic, vanillic acids, luteolin, apigenin and 3-deoxyanthocyanidins (3-DXA). These bioactive components have antioxidant, anti-inflammatory, antiproliferative, antidiabetic and antiatherogenic activity, which justifies the prospects of using sorghum in herbal medicine. Due to the ability of these compounds to neutralize oxidative stress, regulate inflammatory processes and inhibit pathological cell proliferation, sorghum can be considered as a functional ingredient in the development of herbal medicines and dietary supplements for the prevention of cardiovascular, metabolic and oncological diseases (Xu et al., 2018).

J.K.P. Vanamala highlights that *Sorghum bicolor* L. grain contains a significant amount of bioactive compounds, in particular phenolic acids and flavonoids, which exhibit antioxidant, anti-inflammatory and anticancer activity. The high concentration of these compounds, especially in lignocellulosic biomass, opens up prospects for the use of sorghum in herbal medicine for the prevention and maintenance therapy of chronic diseases, including colorectal cancer. A review of scientific data confirms that sorghum phytochemical components can play an important role in reducing inflammation and oxidative stress, which are key factors in the development of cancer and metabolic pathologies. This substantiates the feasibility of further research on the extraction of sorghum bioactive substances and their integration into phytotherapeutic preparations. (Vanamala et al., 2018).

Linda Dykes emphasizes that sorghum is a rich source of phytochemicals, the content of which largely depends on the plant genotype. The main bioactive components of sorghum include phenolic acids, flavonoids, condensed tannins, polycosanols, phytosterols, stilbenes, and phenolamides. The largest amount of these compounds is contained in the bran fraction, which leads to high antioxidant, anti-inflammatory and metabolic activity of sorghum. According to research, sorghum phytochemicals have demonstrated anti-diabetic, hypolipidemic (cholesterol-lowering), anti-inflammatory and anti-tumor properties, making this crop promising for use in herbal medicine and nutrition (Dykes, 2019).

A study by Hee-Sop Lee confirms that sorghum bran with a high polyphenol content (genotypes PI570481, SC84, Sumac) may be promising for the prevention of obesity. The extracts of these genotypes reduced lipid accu-

mulation, inhibited adipogenesis, lipogenesis, oxidative stress (ROS) and MAPK signaling pathways in 3T3-L1 fat cells, indicating their anti-adipogenic activity. The results obtained indicate the potential use of sorghum bran with a high polyphenol content in phytotherapy to prevent metabolic disorders associated with obesity (Lee et al., 2022)

In view of this, there is a need to scientifically substantiate the phytotherapeutic potential of *Sorghum bicolor* L., in particular its antioxidant, cardioprotective and antidiabetic properties, in order to create new functional foods, dietary supplements and medicines. A comprehensive study of this crop in the context of its role in the prevention and treatment of chronic diseases is important for the development of modern herbal medicine and opens up prospects for the introduction of environmentally friendly and highly effective methods of public health improvement.

The aim – is to scientifically substantiate the prospects for the use of *Sorghum bicolor* L. (grain sorghum) in the prevention and treatment of diseases by analyzing its chemical composition, pharmacological activity and therapeutic potential. In the framework of this study, based on the literature data, it was provided:

– studying the chemical composition of grain sorghum, the content of minerals, vitamins, amino acid composition of proteins, concentration of phenolic acids that ensure their biological activity;

– assessment of pharmacological properties (antioxidant, antidiabetic, anti-inflammatory, cardioprotective);

– determination of the current areas of application of *Sorghum bicolor* L. in phytotherapy and creation of functional foods, dietary supplements and medicines.

Thus, the purpose of the article is to form a scientific basis for the introduction of this culture into the practice of preventive medicine, nutrition and alternative therapies.

Materials and methods of the research. A review of the literature is presented. To prepare this review article, modern methods of analyzing scientific literature and data were used. At the same time, a systematic search and analysis of publications in databases such as Scopus, Web of Science, and Google Scholar was carried out. The main attention is paid to the works of the last 10 years, which cover the chemical composition, pharmacological properties and therapeutic potential of *Sorghum bicolor* L.

The review includes original studies, meta-analyses, systematic reviews, patents and monographs related to antioxidant, antidiabetic, cardioprotective and other properties of grain sorghum. The sources were selected using the following keywords: *Sorghum bicolor* L., antioxidants, phytotherapy, prevention of chronic diseases, polyphenols, gluten.

The data obtained were systematized and analyzed using the methods of comparison and generalization. The results of experimental and clinical studies confirming the effectiveness of *Sorghum bicolor* L. in the prevention and treatment of chronic diseases were also taken into account.

Research results and discussion. Sorghum (*Sorghum bicolor* L.), one of the oldest cereal crops in the Poaceae family, is a globally important crop due to its versatility and high nutritional value. Originally from subtropical Africa, sorghum has spread to all continents, becoming the main source of food for millions of people, especially in arid regions such as South Africa and Asia, Latin America, Australia (Teferra & Awika, 2019). Its unique ability to withstand extreme climatic conditions, including drought, heat and low soil fertility, makes sorghum not only a strategic food crop, but also a component of global food security (Mbulwe & Ajayi, 2020).

Sorghum belongs to the kingdom Plantae, order Angiosperms and Monocotyledon, family Poaceae, subfamily Panicoideae, tribe Andropogoneae, suborder Saccharinae, genus Sorghum, species *Sorghum bicolor* L. (Hariprasanna & Patil, 2015).

Sorghum is characterized by high nutritional value compared to other cereals due to its unique chemical composition. It contains proteins, fats, carbohydrates, non-starchy polysaccharides, and a wide range of biologically active compounds: B vitamins, fat-soluble vitamins (D, E, K), trace elements (iron, zinc, magnesium) and macronutrients (calcium, potassium). In addition, grain is a source of non-nutritive biologically active substances, including carotenoids and polyphenolic compounds, which provide its high antioxidant activity (Waniska & Rooney, 2000; Pontieri et al., 2022). According to studies (Chikara et al., 2018), the biologically active components of sorghum determine its antioxidant, anti-inflammatory and antitumor activity, promote the neutralization of free radicals and prevent the development of oxidative stress, which makes this crop promising for use in functional nutrition and herbal medicine (tables 1, 2, 3).

Table 1

Chemical composition of grain *Sorghum bicolor* L.

Indicator	Content, %
Proteins	8–18
Fats	1–5
Carbohydrates (including starch)	up to 80
Dietary fiber	4,5–6,5
Sugars	0,09–2,9

Table 1 shows the chemical composition of *Sorghum bicolor* L., which makes it a promising ingredient for

functional foods and medicines (Khalid et al., 2022). Proteins (8–18%) contain essential amino acids that play an important role in maintaining immunity and tissue repair, which is critical in disease prevention (Khoddami et al., 2023). Fats (1–5%) are low in saturated fatty acids, which reduces the risk of cardiovascular disease, and contain beneficial fat-soluble vitamins such as vitamin E. Carbohydrates (up to 80%, including starch) provide a long-lasting supply of energy, while sorghum's low glycemic index makes it valuable for people with diabetes or metabolic syndrome (Martino et al., 2012). Dietary fiber (4,5–6,5%) helps to normalize the gastrointestinal tract, lowers blood cholesterol and supports the intestinal microbiota, which is an important factor in strengthening the immune system and preventing chronic diseases. Sugars (0,09–2,9), although they contain a small amount of natural monosaccharides, are an easily accessible source of energy (Khoddami et al., 2023).

Thus, the components of sorghum, in particular the high content of polyphenols and dietary fiber, enhance its potential in phytotherapy. This opens up opportunities for its use in the treatment and prevention of metabolic disorders, cardiovascular diseases and inflammatory processes.

Table 2

Mineral content in grain of *Sorghum bicolor* L.

Indicator	Content mg/100 g
Potassium	220–530
Calcium	0–12
Magnesium	90–250
Phosphorus	146–300
Iron	1,6–4,5
Copper	0,3–1,0
Zinc	0,4–3,7
Sodium	5,5–16
Manganese	1,2–2,4
Sulfur	90–96
Molybdenum	0,04–0,2
Selenium	0,04
Cobalt	0,02

The mineral content of *Sorghum bicolor* L. grain demonstrates a rich mineral composition, which emphasizes its value as a functional food product with phytotherapeutic potential. In particular: potassium (220–530 mg/100 g) – supports the normal functioning of the cardiovascular system and regulates water-salt balance, which is key in the prevention of hypertension and edema. Magnesium (90–250 mg/100 g) – plays an important role in energy metabolism, nervous system function and muscle contraction, and has anti-stress and cardioprotective properties (Rao et al., 2018) Phosphorus (146–300 mg/100 g) – is necessary for the formation of bones and teeth, as well as for maintaining energy metabolism in cells. Iron (1,6–4,5 mg/100 g) – contributes to hematopoiesis and prevention of anemia, especially important for women and children. Zinc (0,4–3,7 mg/100 g) – is critical for the functioning of the immune system, wound healing and DNA synthesis. Manganese (1,2–2,4 mg/100 g) – is involved in the metabolism of carbohydrates and lipids, and also provides antioxidant protection of cells. Sulfur (90–96 mg/100 g) – plays a key role in the synthesis of proteins, enzymes and compounds containing sulfur, such as glutathione, which is a powerful antioxidant (Rajendran & Kandasamy, 2011). Molybdenum (0,04–0,2 mg/100 g) – is important for enzymatic processes, in particular for the metabolism of sulfur-containing amino acids. Selenium (0,04 mg/100 g) – has antioxidant properties, helps prevent cancer and supports thyroid function (Jing et al., 2008; Suganyadevi et al., 2013). Cobalt (0,02 mg/100 g) – is a component of vitamin B12, which is important for hematopoiesis and nervous system functioning (Shegro et al., 2012; Espitia-Hernández et al., 2022).

In general, the rich mineral profile of sorghum grain provides it with significant potential for maintaining health and preventing various diseases. Particularly important is the presence of trace elements (selenium, zinc, iron), which have a powerful antioxidant and immunomodulatory effect, making sorghum promising in herbal medicine and functional food.

Table 3

Vitamin content in grain of *Sorghum bicolor* L.

Indicator	Content mg/100 g
B1 (Thiamine)	0,36–0,39
B2 (Riboflavin)	0,13
B3 (Niacin)	3,77–4,4
B5 (Pantothenic Acid)	1,18
B6 (Pyridoxine)	0,4–0,46
C (Ascorbic Acid)	0,4–0,6
E (Tocopherol)	0,8–1,02
H (Biotin)	0,02

Such nutrients as vitamins are involved in the metabolism of living organisms. Both a deficiency and an excess of vitamins can lead to the development of dangerous diseases. Sorghum grain contains both water-soluble and fat-soluble vitamins. The water-soluble vitamins found in sorghum grain include thiamine (B1), riboflavin (B2), niacin (B3), pantothenic acid (B5), pyridoxine (B6), biotin (H), and ascorbic acid (C). The fat-soluble vitamin present is E (tocopherol) (Chhikara et al., 2018; USDA, 2019).

According to scientific research, thiamine, which influences brain functions and higher nervous activity,

protects the body from aging, and acts as an antioxidant, is present in sorghum grain at a concentration of 0,36–0,39 mg/100 g (Chhikara et al., 2018).

Vitamin B2 is present in lower amounts than vitamin B1, at 0,13 mg/100 g, but it plays a critical role in the synthesis of enzymes involved in cellular respiration and antioxidant defense. The highest concentration is found in vitamin B3 ("niacin" or "niacinamide"), which contributes to the regulation of fat and carbohydrate metabolism, supports skin health, the nervous system, and the digestive tract, with levels in sorghum grain ranging from 3,77 to 4,4 mg/100 g. Vitamin B5 (pantothenic acid), which is involved in the synthesis of coenzyme A essential for fat and protein metabolism, is present at 1,18 mg/100 g. Vitamin B6 (pyridoxine, 0,4–0,46 mg/100 g) is vital for amino acid metabolism and neurotransmitter synthesis, impacting nervous system function and immune responses (USDA, 2019).

Ascorbic acid is formed in the grain from the moment of germination. It is a powerful antioxidant that promotes collagen synthesis, supports the immune system and increases iron absorption. Vitamin C contained in grain and its processed products was 0,4–0,6 mg/100 g. Vitamin H (biotin, 0,02 mg/100 g) – participates in the metabolism of fats, proteins and carbohydrates, affects skin and hair health (Cardoso et al., 2017).

The presence of fat-soluble vitamin E was found in the grain in the amount of 0,8–1,02 mg/100 g, which protects cell membranes from oxidative stress and promotes cardiovascular health.

The presence of the fat-soluble vitamin E in sorghum grain, at a concentration of 0,8–1,02 mg/100 g, ensures protection of cellular membranes from oxidative stress and supports cardiovascular health.

This vitamin profile makes *Sorghum bicolor* L. a valuable component of functional nutrition. The presence of B vitamins, particularly thiamine, niacin, and pyridoxine, highlights its importance in maintaining energy metabolism, nervous system function, and immunity. Meanwhile, vitamins C and E, due to their antioxidant properties, enhance the potential of sorghum for preventing chronic diseases and supporting health under oxidative stress conditions.

Sorghum bicolor L. is distinguished by its unique and exceptionally rich phenolic composition, surpassing that of other cereal crops and, in some cases, even fruits and vegetables, depending on the genotype of the plant. The primary phenolic compounds include phenolic acids, 3-deoxyanthocyanidins, and condensed tannins (Ofosu et al., 2020; Olawole et al., 2019). Notably, the majority of these phenolic compounds are concentrated in the bran portion of the grain. Among the main flavonoids identified in sorghum grain, five anthocyanidins stand out: apigenidin, apigenidin-5-glucoside, luteolinidin, luteolinidin-5-glucoside, and 3-deoxyanthocyanidin. These compounds not only contribute to the unique organoleptic properties of sorghum but also play a significant role in its biological activity, including antioxidant, anti-inflammatory, and other therapeutic properties (Pontieri et al., 2022). Another unique feature of sorghum is that it is a naturally gluten-free grain, making it a valuable source of nutrition for individuals with celiac disease or gluten intolerance. Its applications cover a wide range of products, including flakes, snacks, baked goods, functional beverages, and other food innovations, demonstrating its potential in creating both traditional and specialized dietary products (Salazar-López et al., 2018; Sun et al., 2020).

It should be noted that sorghum is underutilized, but it has great potential in the face of current global challenges, such as pandemics. Thanks to its rich chemical composition, sorghum can become a strategic tool in strengthening immunity, fighting chronic diseases and maintaining public health in times of crisis. Its resistance to unfavorable climatic conditions and low resource requirements for cultivation are key to ensuring the creation of functional products with therapeutic effects.

The research on the pharmacological properties of Sorghum bicolor L. opens up new horizons for the development of effective drugs in traditional and modern medicine. Various biologically active components of this plant have prospects in the treatment of inflammatory processes, cardiovascular diseases, as well as in the fight against oxidative stress, which helps reduce the risk of developing chronic diseases (Paiva et al., 2015) (fig. 1).

Phenolic acids, which belong to the group of phenolic compounds, are among the most important components of sorghum in terms of their potential for health promotion. In addition, sorghum is characterized by a high concentration of phenolic acids, in particular ferulic, gallic, and vanillic acids, which have antioxidant and anti-inflammatory properties (Dykes et al., 2009). Despite the high concentration of phytochemicals in this grain and its importance as an important food crop, there is currently a significant scientific gap in research on the impact of sorghum consumption on human health, particularly in the context of its effect on pathogenic processes such as inflammation (table 4).

Table 4 shows the content of phenolic acids in sorghum, which varies within certain values for each of them. Phenolic acids are a variety of biologically active compounds that provide sorghum grain with antioxidant, anti-inflammatory and other beneficial properties. In addition, protocatechuic acid has the highest concen-

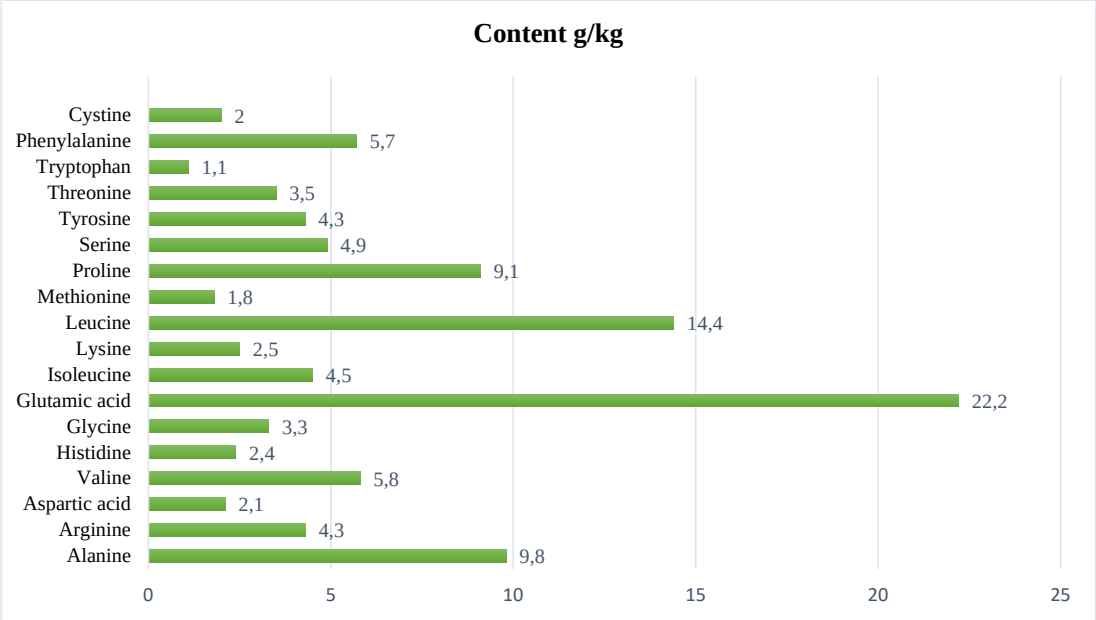

Fig. 1. Amino acid composition of grain proteins *Sorghum bicolor* L.

Table 4

Concentration of phenolic acids in grain of *Sorghum bicolor* L.

Phenolic acids	Content mg/g
Vanillic	15,4–23,4
Gallic	14,8–21,5
p-Coumaric	41,9–71,9
Protocatechuic	150,3–178,2
Syringic	15,7–17,5
Ferulic	120,5–173,5

tration among the studied acids, with its content ranging from 150,3 to 178,2 mg/g. This indicates its potential for providing antioxidant protection of the body. Ferulic acid ranks second in terms of content, with a concentration of 120,5 to 173,5 mg/g, which confirms its importance in maintaining health due to its anti-inflammatory properties. Coumaric acid has a significant content ranging from 41,9 to 71,9 mg/g, which can also have a significant effect on health. Others, such as vanillic, gallic, and syringic acids, have lower acid content, but nevertheless play an important role in the overall biochemical composition of sorghum (Dykes et al., 2009).

It should be noted that grain sorghum (*Sorghum bicolor* L.) is a unique crop due to its rich chemical composition, which opens up wide opportunities for its use in herbal medicine and alternative medicine. Due to its high content of biologically active substances, the plant has significant potential for the prevention and treatment of various diseases (Salazar-López et al., 2018) (fig. 2).

Sorghum, as one of the most widely used cereals, has significant potential in alternative medicine due to its bioactive compounds, such as phytochemicals, antioxidants and anti-inflammatory components. Traditionally used in folk healing practices, sorghum is gaining popularity due to its medicinal properties, particularly in the fight against inflammatory diseases, digestive disorders and other pathologies.

In this regard, scientific research is increasingly focusing on the possibility of using sorghum in alternative medicine as a natural component for the prevention and treatment of various diseases (Moustafa-Farag et al., 2020) (fig. 3).

Sorghum has the potential to become a basis for production (Khalid et al., 2022):

– functional foods to prevent diabetes and obesity;
– natural antioxidant complexes to fight aging;
– supplements to support immunity, detoxify substances and improve digestion.

Sorghum is an environmentally friendly crop that can be grown with minimal pesticide use due to its natural resistance to pests and diseases. This is in line with current trends in herbal medicine and ecological medicine, which are focused on reducing the chemical burden on the human body. The use of sorghum in functional foods and herbal remedies contributes to the concept of healthy eating and improves the quality of life by helping to prevent chronic diseases, improve digestion and strengthen the immune system. Given its beneficial properties, sorghum can become a component in the creation of environmentally friendly and effective health care products.

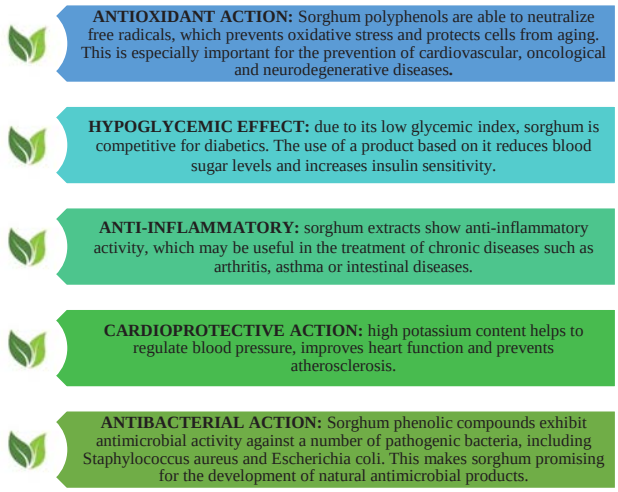

Fig. 2. Therapeutic potential of Sorghum bicolor L. in phytotherapy

Conclusions. So, let's summarize the above:

1. *Sorghum bicolor* L. is a promising crop for use in phytotherapy and functional foods due to its rich chemical composition, including antioxidants such as phenolic acids, vitamins, flavanoids, including anthocyanins and minerals. The components provide antioxidant, anti-inflammatory, anti-diabetic and cardioprotective properties of the culture.

2. The high concentration of phenolic acids, such as ferulic, gallic and protocatechuic acids, helps prevent oxidative stress and regulate inflammatory processes, which makes sorghum an effective tool in the prevention of diseases, including cardiovascular and metabolic diseases.

3. Due to the absence of gluten in its content, sorghum is a valuable source of nutrition for people with celiac disease and gluten sensitivity, and its dietary fiber helps to normalize digestion, maintain the intestinal microbiome and lower cholesterol levels.

4. Biologically active substances of sorghum, in particular anthocyanins, flavonoids and tannins, have significant therapeutic potential in the treatment of inflammatory and neurodegenerative diseases, as well as in the fight against aging and cancer.

5. The environmental sustainability of sorghum, including its natural resistance to pests and diseases, ensures minimal use of pesticides, which is in line with modern environmental trends in herbal medicine and the creation of environmentally friendly products.

6. Despite the significant potential of sorghum, there is a scientific gap in research on its long-term impact on human health and the mechanisms of action of its biologically active components, which requires further basic and clinical research.

7. The use of sorghum opens up opportunities for the creation of innovative functional foods, dietary supplements and herbal remedies aimed at preventing chronic diseases, strengthening immunity and maintaining overall health.

These findings emphasize the importance of sorghum as a multifunctional component for healthy nutrition and herbal medicine, and outline areas for further research to expand its use in the medical and food industries.

Prospects for further research. Further research on *Sorghum bicolor* L. as a promising crop for phytotherapy has a significant potential and can be directed to the following aspects a detailed analysis of biologically active substances such as polyphenols (anthocyanins, flavonoids, tannins), as well as their quantitative and qualitative composition depending on the variety, hybrid and growing conditions, geographical region and processing technology; experimental studies to investigate the mechanisms of action of biologically active sorghum compounds, in particular their antioxidant, antidiabetic, anti-inflammatory and cardioprotective activity; development of functional foods, dietary supplements, and beverages based on *Sorghum bicolor* L. for the prevention and treatment of chronic diseases; assessment of the safety of long-

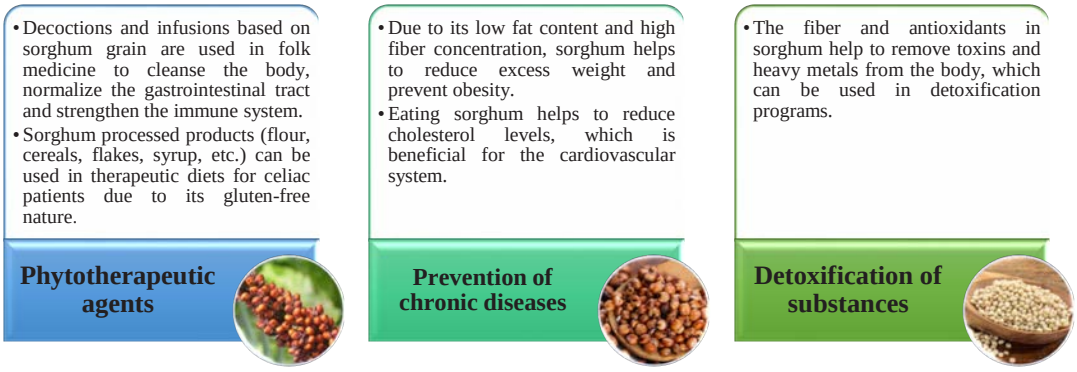

Fig. 3. The use of *Sorghum bicolor* L. in alternative medicine

term use of sorghum-based products, in particular in case of diseases associated with allergies or sensitivity to certain food components; studying the possibilities of using *Sorghum bicolor* L. in the treatment of other pathologies, such as neurodegenerative diseases and cancer or autoimmune conditions, given the anti-inflammatory and antioxidant potential of the crop; developing a nutrition program and prevention strategies based on the use of sorghum products, taking into account the absence of gluten, which makes this crop promising for people with celiac disease and other gluten-related disorders.

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