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RESEARCH ARTICLE

# Modulatory Effects of *Brassica rapa* Polysaccharides on Metabolic Obesity and Blood Biochemistry in Experimental Models of Diabetes and Hyperlipidemia

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**Abstract**

Polysaccharides extracted from *Brassica rapa* (turnip) seeds were investigated for their potential hypolipidemic and hypoglycemic effects in rat models of hyperlipidemia and alloxan-induced diabetes mellitus. The polysaccharides were obtained through hot water extraction and ethanol precipitation, followed by deproteinization, ion-exchange chromatography, and gel filtration. Chemical characterization by GC/MS and IR spectroscopy revealed that the dominant monosaccharides were arabinose and galactose, indicating an arabinogalactan structure. *In vivo* experiments showed that oral administration of *Brassica rapa* polysaccharides (BRP) significantly reduced blood glucose levels, total cholesterol, triglycerides, and LDL-C, while increasing HDL-C and total protein. BRP also normalized ALT and AST activities and improved the activity of digestive enzymes such as amylase and glucosidase. Correlation analysis revealed strong positive associations between body weight and triglycerides (r = 0.78), and between glucose and amylase activity (r = 0.69), indicating the polysaccharides' role in modulating lipid and carbohydrate metabolism. The histological and biochemical improvements observed in treated animals suggest that BRP exerts its beneficial effects through multiple mechanisms, including antioxidant, anti-inflammatory, and enzyme-modulating activities. These findings support the therapeutic potential of *Brassica rapa* polysaccharides as functional agents for the management of metabolic disorders such as type 2 diabetes and hyperlipidemia.

**Keywords:** *Brassica rapa*, Polysaccharides, Alloxan diabetes, Hyperlipidemia, Body weight, ALT, ACT, Glucosidase, Amylase, Biochemical parameters, Pancreas, Digestive enzymes, Rats

## Introduction

In 2023, STADA conducted an international public opinion poll on health issues in Uzbekistan with the participation of Human research (stada.com "Mass media/health reports/stada-health"). In Uzbekistan, the company's partner in the study was Republican Center for Public Opinion Research (Ijtimoy Fikr), which received the data during a telephone survey. About 2,000 people were interviewed in each country. A total of 32,013 respondents aged 18 to 99 took part in the survey. According to the study, 24% of the surveyed Uzbek residents began to see doctors more often, 22% noted that they underwent preventive medical examinations more often, and 21% of respondents began to eat healthier food. Taking vitamins was noted by 14% of respondents. 12% of respondents began to buy more medicines. Over the past 12 months, residents of Uzbekistan have become more likely to undergo preventive medical examinations, which are the main factor in maintaining proper health and detecting diseases at an early stage in order to increase the chances of effective treatment. Currently, 56% of Uzbek residents are overweight. This was discussed at a meeting with the President on the development of the social sphere. It was noted that there are many problems in the healthcare sector that need to be addressed. In particular, it was said that in addition to being overweight, 30% of citizens suffer from chronic diseases. In this regard, the nationwide movement "Proper nutrition and healthy lifestyle" has been organized in the country. Hyperlipidemia is one of the key risk factors for developing metabolic and cardiovascular diseases. Lipid metabolism disorders are often accompanied by liver damage, pancreatic dysfunction, and changes in the activity of digestive enzymes. Induced hyperlipidemia is an experimental model widely used to evaluate the effectiveness of lipid-lowering drugs. The present study investigated the effect of *Brassica rapa* polysaccharides on body weight, blood chemistry, and digestive enzyme activity in rats with hyperlipidemia caused by a high-fat diet. Plant polysaccharides, in particular polysaccharides isolated from the seeds of local turnips endemic to Uzbekistan, are able to regulate metabolism, have hypolipidemic and anti-inflammatory effects. The aim of this study was to study the effect of *Brassica rapa* polysaccharides on blood biochemical parameters and enzymatic activity in rats with induced hyperlipidemia.

One of the urgent tasks of modern experimental pharmacology is to establish biochemical links between disorders of carbohydrate and lipid metabolism underlying the development of type 2 diabetes mellitus and concomitant hyperlipidemia, and to find ways to treat these diseases with active substances isolated from plant sources widely distributed in Uzbekistan. Given the increasing interest in the use of natural biologically active compounds, including plant polysaccharides, the present study aims to investigate the possible modulating effect of *Brassica rapa* polysaccharides on metabolic disorders in experimental animals. Plant polysaccharides, including those isolated from *Brassica rapa* (turnip), are of interest as potential biologically active substances with immunomodulatory [1] and metabolically activating properties [2]. Type 2 diabetes mellitus and hyperlipidemia are interrelated metabolic disorders that often develop in parallel and exacerbate each other. Lipid metabolism disorders in diabetic patients can be both a consequence of insulin resistance and the result of compensatory hyperinsulinemia leading to atherogenic dyslipidemia. In experimental animal models of diabetes, hyperlipidemia is manifested by increased levels of triglycerides, total cholesterol, and low-density lipoproteins (LDL), which indicates a violation of lipid homeostasis. The present study investigated the effect of *Brassica rapa* polysaccharides on body weight, glucose levels, and basic biochemical parameters of the blood lipid spectrum in laboratory animals with experimentally induced diabetes. The results showed that the use of polysaccharides was accompanied by a decrease in glucose and triglycerides, normalization of body weight and partial restoration of the lipid profile, which may indicate their potential ability to modulate both carbohydrate and lipid metabolism. Thus, the revealed dynamics of changes confirms the existence of a close relationship between diabetic and lipid disorders and also suggests the involvement of *Brassica rapa* polysaccharides in the regulation of metabolic pathways underlying both pathological conditions. The data obtained can serve as a basis for further research in the field of the development of phytotherapeutic agents of complex action in metabolic syndrome.

The aim of this study was to identify the hypoglycemic activity of the endemic vegetable crop *Brassica rapa*, to evaluate the effect of polysaccharides isolated from *Brassica rapa* seeds on body weight dynamics, blood biochemical parameters and digestive enzyme activity in rats with induced hyperlipidemia, to evaluate the effect of *Brassica rapa* polysaccharides on lipid and carbohydrate metabolism in experimental hyperlipidemia and diabetes, based on biochemical data to analyze the relationship between hyperlipidemia (GLP) and type 2 diabetes mellitus (DM2). Identification of the relationship between the development of hyperglycemia and dyslipidemia on the background of induction of metabolic disorders will help to assess the potential of polysaccharides from *Brassica rapa* seeds in correcting these changes. As part of the experiment, the dynamics of body weight, glucose levels, total cholesterol, triglycerides, and high- and low-density lipoproteins in animal blood serum were studied. Analysis of the obtained data allowed us to establish that the introduction of *Brassica rapa* polysaccharides leads to normalization of biochemical parameters, which may indicate the presence of hypoglycemic and hypolipidemic activity in these compounds.

## Materials and methods

### Preparation of polysaccharides from *Brassica rapa* seeds

Turnip seeds collected in July 2020 in the territory of Uzbekistan (Namangan region, Mingbulak district) were used to isolate polysaccharides. The seeds were pre-cleaned and crushed in a laboratory shredder. Degreasing and removal of low molecular weight impurities. For degreasing, the raw materials were extracted with petroleum ether in a Soxlet apparatus for 72 h. The fat-free seeds were dried at room temperature. To remove low molecular weight impurities and coloring substances, the raw materials were extracted in a Soxlet apparatus with a mixture of chloroform and 96% ethyl alcohol (1:2). The raw materials were dried in air until the odor of solvents was removed. Extraction of water-soluble polysaccharides. To isolate water-soluble polysaccharides, fat-free seeds were extracted 3 times with water in a water bath at 95 °C with a reverse refrigerator (the ratio of raw materials and extractant 1:20, 1:15 and 1:15). The duration of each extraction was 2 h. The obtained aqueous extracts were combined and evaporated on a rotary evaporator at a temperature of 50 °C to 1/5 of the volume. From the resulting concentrate, water-soluble polysaccharides were precipitated by adding 4 times the volume of 96% ethyl alcohol and left at 4 °C overnight. The precipitate was separated by centrifugation, washed with ethyl alcohol, and freeze-dried. Deproteinization of polysaccharides. The sum of polysaccharides was deproteinized using the Savage method [3]. A 3-fold volume of $CHCl_3$-n-BuOH was added to the aqueous solution of the sum of polysaccharides (ratio 4:1) and transferred to the dividing funnel. The funnel was vigorously shaken for 5 min and the mixture was kept for 3 h to achieve a 2-phase equilibrium. The organic phase with residual proteins (bottom layer) was removed. This procedure was repeated 6 times. Turnip seed polysaccharides were precipitated with 3 volumes of ethyl alcohol from the aqueous phase. After filtration, the precipitate was washed with absolute ethanol and dried in air. Determination of polysaccharide content. The quantitative content of polysaccharides was determined by the Phenol-sulfuric acid method [4] according to the calibration schedule for glucose. Optical density was measured on a METASH UV-5100 spectrophotometer (Shanghai, China). Ion exchange chromatography. Anion exchange chromatography was used to isolate the polysaccharide. A 100 mg sample of polysaccharide was dissolved in 5 mL of distilled water and applied to a column (16x3.5 cm) with DEAE-650C TOYOPEARL (TOSOH, Japan) balanced with distilled water. After loading the sample, the column was eluted with distilled water, and then successively with 0 - 1.0 M gradient NaCl solution at a rate of 1.0 mL/min. Fractions (10.0 mL) were collected by a fraction collector. The carbohydrate content in the fractions was determined by the phenol-sulfuric acid method, using glucose as the standard. The fraction corresponding to the individual peaks was combined, concentrated, dialyzed, and freeze-dried. Gel filtration of polysaccharides. Neutral and eluted polysaccharides (20 mg each) at 0.1 M NaCl were dissolved in 2 mL of water and applied to a column ($70\times1.8$ $cm^2$) with Sephadex G-100. The column was eluted with distilled water at a flow rate of 40 mL/h. The carbohydrate content in the samples was determined by the phenol-sulfuric acid method, using glucose as the standard. Fractions with a volume of 13 mL were selected. Fractions corresponding to individual peaks were combined, concentrated to a minimum volume, dialyzed and freeze-dried. Monosaccharide composition of polysaccharides. After gel filtration, the polysaccharide (3 mg) was dissolved in 2.5 mL of 2 M trifluoroacetic acid in a 5 mL ampoule, hydrolyzed at 110 °C for 6 h, and the cooled reaction mixture was centrifuged at 3,000 rpm for 5 min. To remove the trifluoroacetic acid hydrolysate, a dry methanol solution was added 3 times in 5 mL and the methanol was evaporated on a rotary evaporator. The 5 mg of hydroxylamine hydrochloride and 1 mg of isonitol were added to the dry hydrolysate and dissolved in 0.5 mL of pyridine. The solution was heated at 90 °C for 30 min, cooled to room temperature, 0.5 mL acetic anhydride was added and acetylated for 30 min at 90 °C. The reaction mixture was dried in a nitrogen stream. Alditol acetate derivatives of monosaccharide standards (L-Fruc, L-Rib, L-Rha, L-Ara, L-Xyl, D-Man, D-Glc and D-Gal) were obtained as described above. Synthesized alditol acetate derivatives analyzed by Gas chromatography/GC/MS mass spectrometry (Thermo Finnigan TRACE 2000/MS column, DB-5MS (30 m H 0.25 mm H 0.25 mm), temperature range from 180 to 270 °C at 20 °C/min, with 270 °C held for 25 min). The peaks corresponding to alditol acetates and their fragments were determined by their mass spectra and GC separation time. The ratio of monosaccharides to polysaccharides was determined by comparing peak areas. IR spectroscopy. The IR spectra of the samples were taken on an IRTracer-100 SHIMADZU IR Fourier spectrometer (Japan), system 2000 in the frequency range 400 - 4,000 $cm^{-1}$. To capture the spectra of the studied samples, they were captured by the method of disturbed total internal reflection (ATR) spectroscopy in the infrared region with Fourier transform spectroscopy.

**Animal ethics**

All preoperative and experimental protocols were read and approved slowly by the Institutional Committee for Animal Use and Care. The animals lived in vivarium rooms under controlled conditions, relative humidity of 55% - 65%, ambient temperature of 22 ± 2 °C, and had free access to water and normal laboratory chow. All animal handling and care procedures rigorously followed the European Directive 2010/63/EU on the protection of animals used for scientific purposes. Ethical approval for this research was provided by the Institute of Bioorganic Chemistry, Academy of Sciences of the Republic of Uzbekistan, Animal Ethics Committee (Protocol No. 133/1a/h, 4 August 2014).

The use of polysaccharides isolated from *Brassica rapa* seeds in rat models with diabetes mellitus (alloxan model) and hyperlipidemia. A model of chemically induced diabetes mellitus using alloxan was used to study the hypoglycemic activity of BRP polysaccharide from *Brassica rapa* turnip seeds. The study was conducted on rats. The animals were divided into groups. On the second day after the induction of diabetes mellitus, animals were intragastrically injected with BRP polysaccharide from turnip seeds *Brassica rapa* and inulin as a reference substance as an antidiabetic agent for the prevention and treatment of diabetes mellitus) for 14 days. On days 7 and 14, blood samples were taken from animals to determine glucose levels and hematological analysis. Hyperlipidemia was induced by the introduction of a high-fat diet (HFD) for 8 weeks. The diet consisted of 60% fat, 20% carbohydrates and 20% protein. Biochemical parameters (blood glucose, total cholesterol, TG, LDL C, HDL C), liver enzymes (AST, ALT) and enzymes of lipid metabolism.

The animals were randomly divided into 4 groups of 10 rats each: 1. Control group (C): Standard diet. 2. The hyperlipidemia (HFD) model: A high-fat diet. 3. Positive control (HFD + Metmorfin): High-fat diet + metmorphine (dose 95 mg/kg body weight). 4. Group with polysaccharides (HFD + PS): High-fat diet + *Brassica rapa* polysaccharides (dose 20 mg/kg body weight).

Polysaccharides and metmorphine were administered daily for 4 weeks. *Brassica rapa* polysaccharide extract was obtained by hot water extraction followed by ethanol purification. Biochemical parameters were determined using standard kits: Total protein by biuret reaction, ALT and AST colorimetrically, amylase and glucosidase enzymatically. Polysaccharides extracted from the seeds of the *Brassica rapa* seeds have demonstrated potential in regulating lipid metabolism in animal models of hyperlipidemia. Assessment of body weight and digestive enzymes. The body weight of the animals was measured weekly. The activity of digestive enzymes (amylase) was determined in blood serum using appropriate commercial kits.

**Biochemical analyses**

After the experiment was completed, blood was taken from the tail vein to determine the following parameters: Glucose level, total cholesterol (OH), triglycerides (TG), low-density lipoproteins (LDL) and high-density lipoproteins (HDL), aminotransferase activity (ALT, AST).

**Statistical processing of the results**

Statistical processing of the obtained data was carried out using the Microsoft Office Excel computer program and the online MedStatictica program.

## Results and discussion

**Results**

*Brassica rapa* seeds collected in the Namangan region were used to isolate water-soluble polysaccharides. The seeds were pre-cleaned, ground, and degreased. Water extractions were used to isolate polysaccharides. Polysaccharides were precipitated from aqueous solutions with the addition of ethanol in a ratio of 1:4 (by volume). The yield of polysaccharides was 1.6%. Next, the carbohydrate composition of the isolated polysaccharides was quantified using the phenol-sulfuric acid method. The total amount of carbohydrates was 30.3%, which means that there are impurities in the isolated polysaccharide. Further, the isolated polysaccharides were deproteinized by the Savage method. After deproteination, the amount of protein in the samples was determined using the Lowry method. The results showed that the isolated polysaccharide contains trace amounts of proteins and peptides. A sample of polysaccharide was passed through DEAE-650C. First, they were washed with water and then with a gradient NaCl solution (0 - 1 M). As shown in **Figure 1**, neutral polysaccharides were separated by washing with distilled water, obtaining 1 polysaccharide fraction (BSP-1), anionic polysaccharides were eluted with 0.1 (BSP-2), 0.3, 0.5 and 0.8 M NaCl solutions. This indicates that this sample consists of a neutral and anionic polysaccharide.

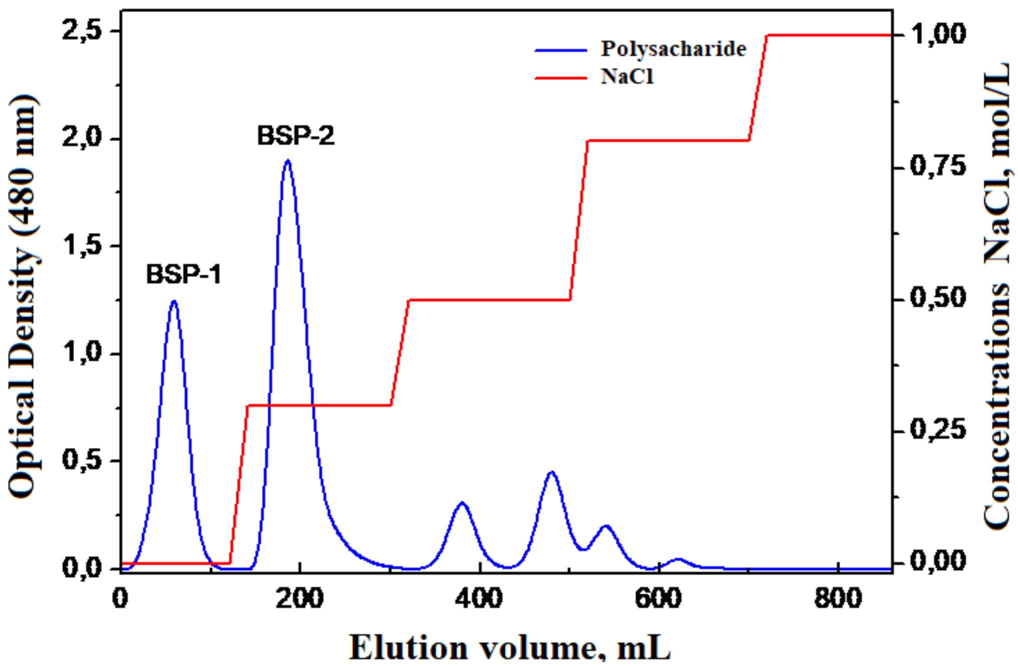


**Figure 1** Ion exchange chromatogram of the isolated polysaccharide at DEAE-650 S (eluent - 0.1 M NaCl gradient, elution rate - 1 mL/min).

The major polysaccharide fractions BSP-1 and BSP-2 were further separated and sequentially purified through the Sephadex G-100 column (**Figure 2**).

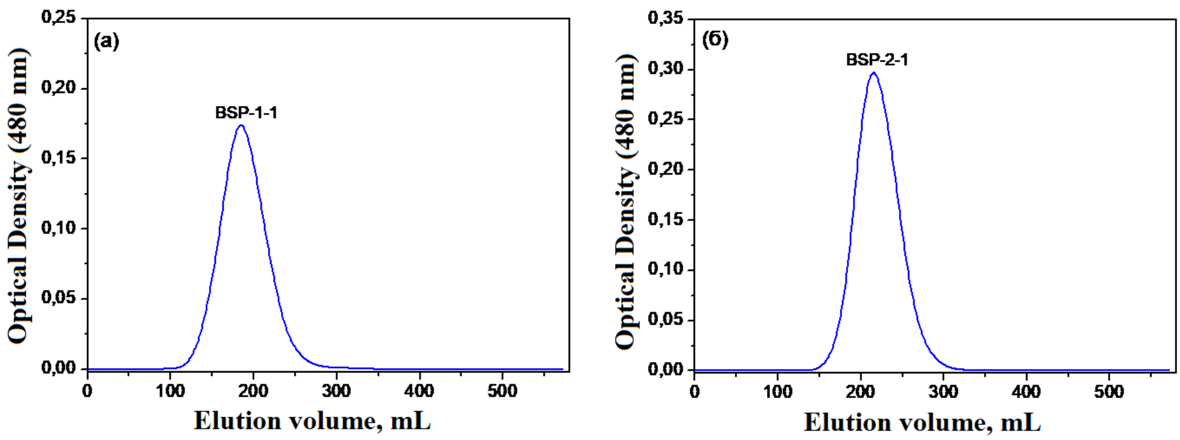


**Figure 2** Gel chromatogram of neutral polysaccharides (BSP-1-1) (a) and anionic polysaccharides (BSP-2-1) (b) isolated from *Brassica rapa* seeds (on Sephadex G-100, eluent distilled water, elution rate-0.65 mL/min).

The results showed that the polysaccharide samples consisted of homogeneous polysaccharides. Two main polysaccharide peaks, BSP-1-1 and BSP-2-1, were collected and freeze-dried. Further studies were carried out to determine the monosaccharide composition of the isolated polysaccharides. The monosaccharide composition of BSP 1-1 and BSP-2-1 was determined by hydrolysis of trifluoroacetic acid and GC/The MS method of analysis. The results are shown in the **Figure 3**.

**Table 1** Monosaccharide composition of isolated polysaccharides.

| № | Polysaccharide fractions | Ribose, % | Arabinose, % | Mannose, % | Glucose, % | Galactose, % |
|---|---|---|---|---|---|---|
| 1. | BSP-1-1 | 5.05 | 56.38 | 5.87 | 8.63 | 24.05 |
| 2. | BSP-2-1 | 6.35 | 60.15 | 7.19 | 4.12 | 22.16 |

The results show that polysaccharides consist mainly of arabinose and galactose residues. Other monosaccharides were found in their composition in trace amounts.

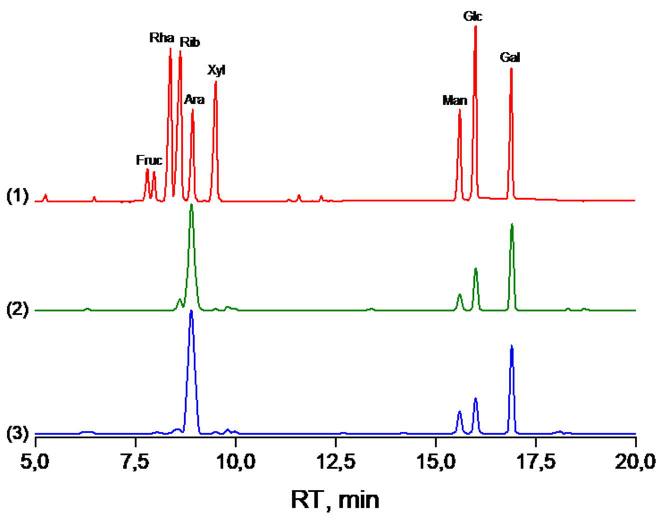


**Figure 3** GC spectra/MS of aldite acetate derivatives of standard monosaccharides (1), monosaccharides in the isolated polysaccharide BSP-1-1 (2) and BSP-2-1 (3) of *Brassica rapa* seeds.

IR spectroscopic studies of the isolated polysaccharides were performed. The results are shown in **Figure 3**. Absorption bands corresponding to the polysaccharide were observed in the IR spectrum. The band between 3,200 - 3,400 cm$^{-1}$ represents the Oh-H valence vibrations. Characteristic signals for symmetrical stretching of H-C-H bonds were observed at 2,935 cm$^{-1}$ [5]. In the region of 2,360 cm$^{-1}$, characteristic signals corresponding to C= On the binding of adsorbed $CO_2$ were observed. Absorption bands characteristic of the Oh-bound water molecule in the samples and protein C=O bonds were observed in the region of 1,637 cm$^{-1}$ [6]. Asymmetric valence fluctuations at 1,521 cm$^{-1}$ corresponding to C=O (specific for proteins and peptides) were observed only in the crude and deproteinized extract. In the deproteinized extract, the intensity of the peaks decreased significantly. This shows that after deproteination, the number of proteins and peptides decreased significantly. No peaks were observed in BSP-1-1 and BSP-2-1 in this region, which indicates that the samples were completely purified of proteins and peptides after separation. Absorption at 1,418 cm$^{-1}$ is represented by asymmetric valence vibrations of C-H bonds (-$CH_2$ groups) corresponding to polysaccharides. Characteristic peaks for the C-O-C bond in the pyranose ring of the monosaccharide unit of polysaccharides were observed at 1,140 cm$^{-1}$. Absorption bands of valence vibrations corresponding to C-O-C glycosidic bonds between monosaccharide residues were observed in the range of 1,072 cm$^{-1}$ [7,8]. Absorption at 1,039 cm$^{-1}$ is represented by valence vibrations of C-O from the side carbinol groups (C-OH). Characteristic signals of deformation vibrations of α-glycoside bonds between pyranose forms of polysaccharides were detected at 862 cm$^{-1}$. IR spectroscopic studies have shown that the isolated polysaccharides from *Brassica rapa* turnip seeds consist mainly of α-bound pyranose residues. The analysis of the composition of monosaccharides showed that the composition of the neutral polysaccharide BSP-1-1 is represented by monosaccharides in the following composition: Ribose - 5.05%, arabinose - 56.38%, mannose - 5.87%, glucose - 8.63% and galactose - 24.05%. The composition of the anionic polysaccharide BSP - 2-1 is represented by monosaccharides: Ribose - 6.35%, arabinose - 60.15%, mannose - 7.19%, glucose - 4.12% and galactose - 22.16%. It was found that the isolated polysaccharides consist mainly of arabinose (BSP-1-1 - 56.3%, BSP-2-1 - 60%) and galactose (BSP-1-1 - 24%, BSP-2-1 - 22%). Based on the data obtained, it can be assumed that the studied polysaccharides from turnip seeds *Brassica rapa* belong to the type of arabinogalactanes. Based on the results of studying the acute toxicity properties of BSP polysaccharide from *Brassica rapa* turnip seeds, it was found that this substance belongs to Class V compounds - it practically does not contain toxic substances.

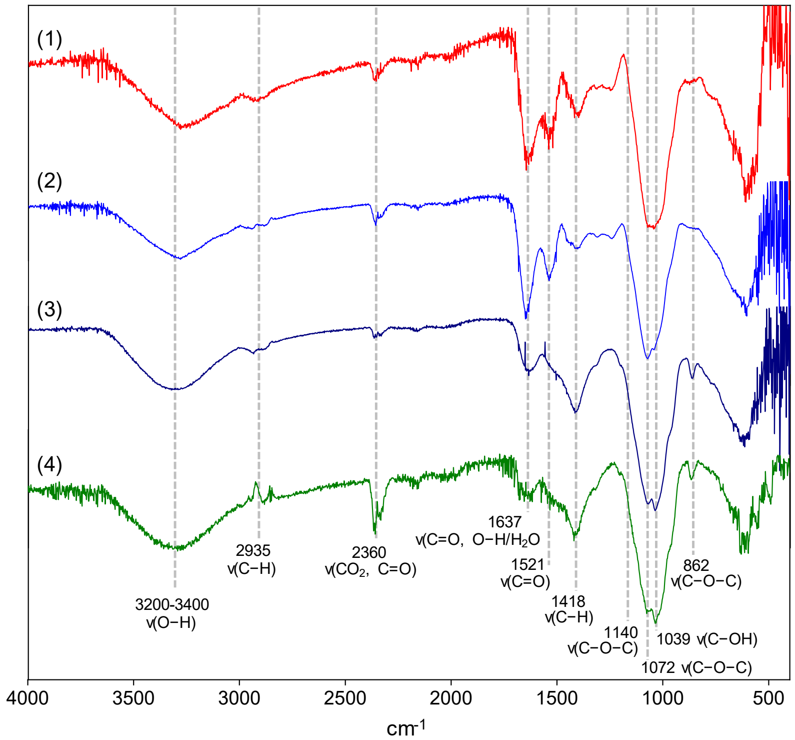


**Figure 4** IR spectra of crude (1), deproteinized (2) polysaccharides, BSP-1-1 (3) and BSP-2-1 (4) isolated from *Brassica rapa*.

The biological activity of polysaccharides depends on the molecular weight (MW), monosaccharide composition, type of glycosidic bonds, and sulfate content [9]. In our studies, *Brassica rapa* polysaccharides belonging to the arabinogalactane type were used at doses of 25, 50 and 75 mg/kg. *Brassica rapa* polysaccharides effectively reduce glycemia and improve the lipid profile due to their antioxidant and anti-inflammatory effects. Randomized clinical trials, clarification of bioavailability, pharmacokinetics, and long-term safety are necessary for implementation in clinical practice.

Macroscopic examination of the organs of rats with hyperlipidemia showed that a high-fat diet in animals caused liver steatosis, inflammation and amyloid deposits (**Figure 5**). Treatment with *Brassica rapa* polysaccharides at a dose of 25 mg/kg reconfigured the metabolism, reducing the level of lipids through

LPL, GPR reptors, and other targets. This is manifested in a decrease in the level of total cholesterol (OX), triglycerides (TG), LDL cholesterol and fatty liver infiltration [10,11], increased expression of LPL (lipoprotein lipase) in the liver and adipose tissue, a key enzyme that promotes the utilization of triglycerides, as well as in the modulation of PPG receptors (in particular, GPR41/GPR43) involved in fatty acid metabolism and regulation through short-chain fatty acids (SCFA), in parallel, an improvement in the intestinal microbiota and SCFA production is observed, which also activates PPG receptors, contributing to a decrease in lipids and inflammation [12]. Decreased concentrations of markers (IL 6, TNF α, ICAM 1 and VCAM 1), increased fat and energy balance [13,14]. The authors indicated that the republic supports many active formats: Presidents, isocyanates [15], turnip extract prevents obesity and suppresses the accumulation of fat cells; it induces the expression of β3-adrenergic receptors (β3-AR) [16]. A study of the metabolic syndrome called lactose (MS) showed that you are part of the group leading the republic, which was an important fusion of blood lipid levels and an increase in the levels of governmental glutathione and liver glycogen in the blood, which indicates the positive influence of the republic on the mathematical world [17]. Hyperlipidemia, a pathological increase in blood lipids, has long been recognized as a risk factor for cardiovascular diseases. However, the effect on carbohydrate metabolism and the development of T2DM is being actively investigated. Another observation is that with DM2, metabolic paternalism is observed: Atherogenic dyspepsia (elevated LDL and triglyceride levels, decreased HDL levels) is often correlated with personality and environment. Diabetes mellitus (DM) and hyperlipidemia often combine and worsen each other, increasing the risk of atherosclerosis. *Brassica rapa* contains polysaccharides, trace elements and phytochemical compounds that exhibit hypoglycemic, hypolipidemic, antioxidant and anti-inflammatory effects. Induced hyperlipidemia is an experimental model widely used to evaluate the effectiveness of lipid-lowering drugs. The present study examined the effect of polysaccharides on body weight, blood chemistry, and digestive enzyme activity in rats with hyperlipidemia caused by a high-fat diet. Plant polysaccharides, in particular polysaccharides isolated from brassica rapeseed seeds, have the potential to modulate metabolism, have hypolipidemic and anti-inflammatory effects. Thus, Brass polysaccharides effectively reduce Chris's filmmakers to a giperlipidemic model for annual joint action on LPL, GPR41/GPR43, SCFA and space helmets. The mechanism by which lipid reduction is achieved is complex, as it affects multiple targets and cellular signaling pathways [18].

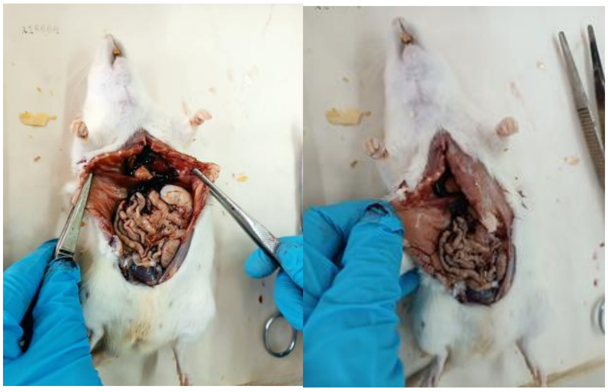

**Figure 5** Macroscopic examination of the organs of rats with hyperlipidemia.

BSP polysaccharide from *Brassica rapa* turnip seeds reduced glycemia, cholesterol, and LDL cholesterol, but a number of models showed elevated cholesterol, AST, and reduced HDL cholesterol. When eating high-fat foods in mice, TG and cholesterol accumulate in the liver, and the balance of HDL is disrupted LDL, steatosis and inflammation develop. Previously, our research on animal a diabetes model (alloxan rats) have shown: After 7 days, glucose concentration dropped from ~16.2 to 10.5 mmol/L (−35%) when taking BSP at 10 mg/kg, which is more effective than inulin (~24% decrease). After 14 days, blood sugar levels approached the norm, 2.53 - 3.14 mmol/L (control - 8.40 mmol/L) (**Figure 6**).

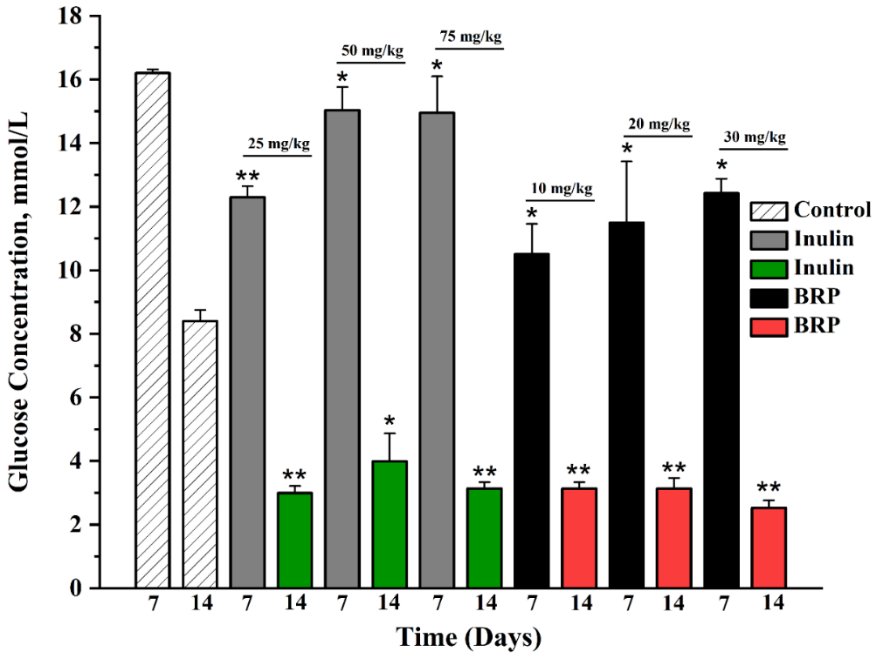


**Figure 6** Carbohydrate metabolism in the alloxan-induced model of diabetes.

**Table 2** Biochemical changes in the DM model (alloxan model).

| Parameters* | Intact | Control | Inulin 25 mg/kg | Inulin 50 mg/kg | Inulin 75 mg/kg | BRP 10 mg/kg | BRP 20 mg/kg | BRP 30 mg/kg |
|---|---|---|---|---|---|---|---|---|
| WBC, $10^9$/L | 13.2 ± 0.8 | 23.9 ± 1.6 | 31 ± 8.0 | 27.8 ± 2.2* | 13.1 ± 2.7 | 27.8 ± 2.7* | 26 ± 3.6* | 15.0 ± 1.4 |
| Lym, % | 0.7 ± 0.1 | 0.8 ± 0.04 | 0.7 ± 0.08 | 0.6 ± 0.1 | 0.7 ± 0.1 | 0.8 ± 0.03 | 0.7 ± 0.01 | 0.6 ± 0.11 |
| Gran, % | 0.2 ± 0.1 | 0.2 ± 0.05 | 0.2 ± 0.06 | 0.3 ± 0.1 | 0.4 ± 0.1 | 0.2 ± 0.03 | 0.2 ± 0.01 | 0.3 ± 0.04 |
| Mid, % | 0.1 ± 0.02 | 0.1 ± 0.002 | 0.1 ± 0.021 | 0.1 ± 0.01 | 0.1 ± 0.02 | 0.1 ± 0.01 | 0.1 ± 0.005 | 0.2 ± 0.07 |
| RBC, $10^{12}$/L | 7.7 ± 0.1 | 7.8 ± 0.3 | 7.5 ± 0.1 | 7.6 ± 0.3 | 8.8 ± 0.7 | 7.3 ± 0.2 | 7.5 ± 0.2 | 8.1 ± 0.5 |
| HGB, g/L | 149.3 ± 4.6 | 140.5 ± 1.5 | 142,5 ± 3.5 | 143.7 ± 4.4 | 173.7 ± 14.7 | 144.7 ± 2.0 | 150 ± 2.1 | 153.0 ± 4.0 |
| PLT, $10^9$/L | 456.7 ± 92.4 | 196.5 ± 3.5 | 305 ± 13.7 | 151 ± 13.6* | 371.7 ± 48.9 | 189.7 ± 6.54* | 376.7 ± 1.92 | 523.5 ± 7.75 |

* - $p < 0.05$ in relation to the control group

* Note: Leukocytes - WBC, percentage of lymphocytes - Lym%, percentage of granulocytes - Gran%, percentage of average leukocytes - Mid%, concentration of lymphocytes - Lym#, concentration of granulocytes - Gran#, concentration of average leukocytes - Mid#, erythrocytes - RBC, hemoglobin - HGB, platelets - PL.

According to the results shown in **Table 2**, the data on the content of leukocytes (WBC, 109/l) in the blood of animals of intact and experimental groups in all studied doses of the 2 substances on day 7 differ sharply, which is consistent with the literature data, however, in large doses: 75 mg/kg of inulin and 30 mg/kg. The BRP polysaccharide leukocytes are almost equal to the index of the intact group. The erythrocyte count (RBC, 1012/l) in all studied doses of both substances of the experimental groups did not differ from the indicator of the intact group. The platelet count (PLT, 109/L) is normal in the intact group only in the case of inulin at a dose of 75 mg/kg and BRP polysaccharide at doses of 20 and 30 mg/kg. Despite the short duration of treatment after the induction of diabetes mellitus (7 days), BRP polysaccharide from turnip seeds *Brassica rapa* exhibits antidiabetic properties. As the data shown in **Table 2** showed, the content of leukocytes (WBC, 109/L) in the blood of animals of intact and experimental groups on day 14 in high doses differs sharply, which is consistent with the literature data, however, in high doses: 75 mg/kg of inulin and 30 mg/kg of BRP polysaccharide from the white blood cell count of *Brassica rapa* turnip seeds has not changed, the indicators are comparable to those of the intact group. The erythrocyte count (RBC, 1,012/L) in all studied doses of both substances of the experimental groups did not differ from the indicator of the intact group. Platelet counts (PLT, 109/L) in the experimental groups with a high dose of both substances, similar on day 7 to the index of the intact group, were slightly increased on day 14. During the 14-day treatment after the induction of diabetes mellitus, all blood parameters and immunocompetent cells (leukocytes, erythrocytes and platelets) recovered to a normal physiological state with intragastric administration of inulin and BRP polysaccharide from *Brassica rapa* turnip seeds, which indicates the potential antidiabetic and hypoglycemic effects of the studied substances.

Reducing blood glucose levels (antidiabetic effect) of turnip polysaccharides may be justified by their ability to activate certain enzymes involved in carbohydrate metabolism. This effect is realized through the activation of glycolysis, stimulation of the activity of amylase and other digestive enzymes, increased sensitivity to insulin, inhibition of gluconeogenesis in the liver, etc. biochemical mechanisms: 1. Activation of glycolysis: Polysaccharides can promote the activation of key enzymes of the glycolytic pathway, such as glucokinase and phosphofructokinase, which enhances the utilization of glucose by cells and helps to reduce its concentration in the blood. 2. Stimulation of the activity of amylase and other digestive enzymes: A number of studies have shown that certain polysaccharides can regulate the activity of α-amylase and α-glucosidase. This can slow down the breakdown of complex carbohydrates to glucose in the intestine, reducing the postprandial (after eating) rise in blood sugar levels. 3. Increased insulin sensitivity: Some turnip polysaccharides can affect tissue sensitivity to insulin by activating enzymes involved in the insulin signaling pathway, such as protein kinase B (Akt) and AMP-activated protein kinase (AMPK). This improves the uptake of glucose by cells. 4. Inhibition of gluconeogenesis in the liver: Polysaccharides can inhibit enzymes responsible for the synthesis of glucose in the liver (for example, glucose-6-phosphatase), which also helps to reduce blood glucose levels. Thus, the antidiabetic effect of turnip polysaccharides is related to their ability to regulate the activity of enzymes involved in the main metabolic pathways of carbohydrates, including glycolysis, gluconeogenesis, digestion, and insulin signaling.

This study made it possible to plan and conduct studies on the effect of polysaccharides isolated from *Brassica rapa* seeds in glucose and lipid metabolism, which examines enzymes that regulate liver lipid activity, body weight dynamics with blood biochemical parameters and digestive enzyme activity, as well as the relationship between diabetes mellitus and hyperlipidemia in induced hyperlipidemia in rats (**Figure 7**).

Consumption of *Brassica rapa* polysaccharide by animals was accompanied by a moderate increase in body weight in rats compared with the control group at a dose of 25 mg/kg. There was a statistically significant increase in the mass of the liver and spleen, which indicates the activation of metabolic and immune processes. The increase in body weight was not accompanied by a violation of the proportions of organ mass, which indicates the potential safety of the administered substance at this dose.

When consuming a high-fat diet, mice accumulate TG and cholesterol in the liver, and the balance of HDL is disrupted /LDL, steatosis and inflammation develop (**Table 3**). Animal studies with a hyperlipidemia model have shown:

After 14 days, the levels of total protein, cholesterol, glucose, HDL and LDL in the blood serum approached the norm, 2.53 - 3.14 mmol/L (control - 8.40 mmol/L).

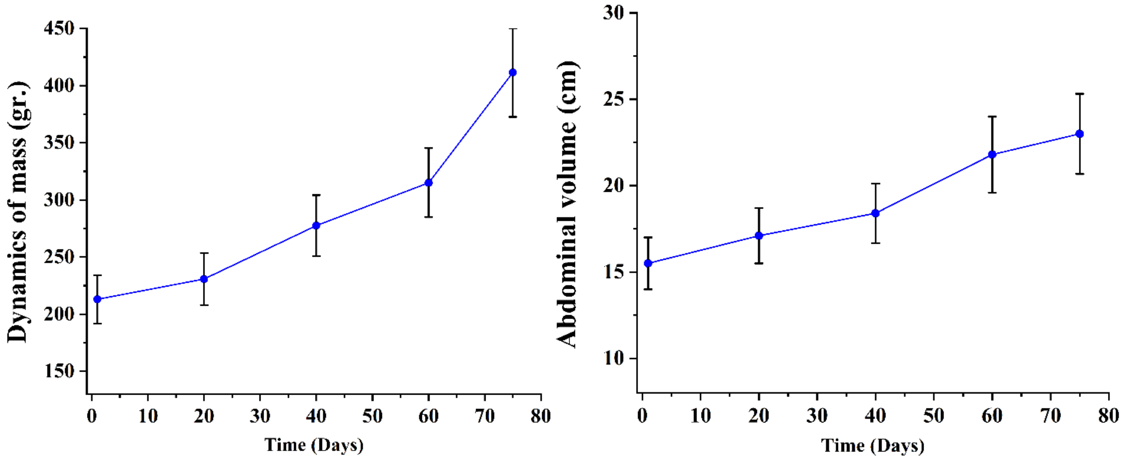


**Figure 7** Initial and final parameters of animals during induction of hyperlipidemia for 75 days.

**Table 3** Changes in metabolic syndrome parameters in animals treated with hyperlipidemia for 14 days with metmorphine and *Brassica rapa* polysaccharides.

| Parametrs | The initial | Control | Metmorfin 95 mg/kg | BSP 25 mg/kg |
|---|---|---|---|---|
| Dynamics of mass (gr.) | 213.0 ± 21.2 | 411.5 ± 38.9 | 357 ± 34.9 | 334.3 ± 33.3* |
| Abdominal volume (cm) | 15.5 ± 1.5 | 23.0 ± 2.32 | 20.5 ± 2.0** | 18.8 ± 1.8** |
| Liver (mg) | 7.8 ± 0.79 | 13.7 ± 1.4 | 12.6 ± 1.2** | 9.4 ± 0.94** |
| Heart (mg) | 0.9 ± 0.085 | 1.5 ± 0.13 | 1.5 ± 0.11** | 1.2 ± 0.12** |
| The spleen (mg) | 1.0 ± 0.11 | 1.1 ± 0.1 | 1.3 ± 0.1** | 1.4 ± 0.14** |
| Lungs (mg) | 1.2 ± 0.13 | 2.4 ± 0.22 | 2.7 ± 0.21** | 2.1 ± 0.22** |
| Kidneys (mg) | 0.9 ± 0.075 | 1.4 ± 0.13 | 1.4 ± 0.11** | 1.2 ± 0.11** |
| The fat layer (mg) | 2.4 ± 0.25 | 8.6 ± 0.84 | 7.9 ± 0.78** | 3.4 ± 0.35** |

* - $p < 0.05$ relative to the initial data;
** - $p < 0.05$ in relation to the control group

***Dynamics of body weight***

The introduction of *Brassica rapa* polysaccharides at dose 25 mg/kg caused a significant ($p < 0.05$) increase in body weight in animals of the control group who received only a diet, compared with the intact group. However, in the groups receiving *Brassica rapa* polysaccharides in various doses, there was a slowdown in the rate of body weight gain. This indicates a possible modulating effect of these biologically active substances on lipid metabolism and energy exchange in general. The mechanism of origin of type 2 diabetes mellitus on the background of body obesity is a complex process involving the interaction of genetic, metabolic and environmental factors. There are several key mechanisms that link obesity to the development of diabetes. Firstly, insulin resistance is one of the central mechanisms of the development of type 2 diabetes mellitus. Obesity, especially the accumulation of adipose tissue in the abdominal area (visceral obesity), is associated with impaired insulin function. Adipose tissue, especially visceral tissue, is an active endocrine organ that secretes various molecules, including cytokines, hormones, and free fatty acids. These substances can negatively affect the sensitivity of cells to insulin. In particular, free fatty acids (for example, palmitic acid) disrupt the normal functioning of insulin receptors, which leads to a decrease in the effectiveness of insulin. This, in turn, causes the need to increase its production by the pancreas, which over time can lead to its depletion. Secondly, the effect of inflammation. Obesity is accompanied by chronic low-level inflammation. Adipose tissue, especially visceral tissue, secretes various inflammatory mediators such as cytokines (e.g., interleukin-6 and TNF-α), which can disrupt insulin signaling. These inflammatory molecules affect the metabolism of carbohydrates, fats, and proteins, exacerbating insulin resistance. Chronic inflammation also contributes to the dysfunction of pancreatic beta cells, which reduces their ability to synthesize insulin. Thirdly, a violation of fat metabolism against the background of obesity increases the level of free fatty acids in the blood, which can lead to a violation of lipid metabolism. These acids have a toxic effect on pancreatic beta cells, disrupting their function and promoting apoptosis (programmed cell death). This impairs the ability of the pancreas to produce insulin, which contributes to the development of hyperglycemia and diabetes mellitus. Fourth, ectopic fat accumulation, with the development of obesity, fat can be deposited not only in subcutaneous, but also in extravascular tissues (for example, in the liver, muscles and pancreas). Fat cells in these tissues contribute to the deterioration of insulin sensitivity, disrupting the normal metabolism of carbohydrates and fats. This can lead to abnormalities in glucose regulation and the development of diabetes. Fifth, decreased insulin secretion. Obesity can also affect the secretion of insulin by beta cells of the pancreas. Against the background of insulin resistance, beta cells begin to compensate for the body's increased need for insulin by increasing its production. However, over time, this compensatory increase may not be sufficient, and the pancreas may not be able to cope with the required level of insulin production. This leads to a decrease in insulin secretion and the development of hyperglycemia. Obesity is associated with changes in the composition of the microbiota, which can affect inflammatory processes, the metabolism of fatty acids and carbohydrates, as well as the functioning of the intestinal barrier. This, in turn, can contribute to the development of diabetes.

***Biochemical parameters of blood***

Changes in the activity of ALT (alanine aminotransferase) and ACT (aspartate aminotransferase) enzymes in hyperlipidemia in a mouse model can serve as an indicator of liver damage associated with impaired lipid metabolism. ALT is more specific to the liver, reflecting hepatocellular damage, ACT is found not only in the liver, but also in the heart, muscles, and kidneys, so its increase may reflect a more systemic lesion. With hyperlipidemia, ALT and ACT levels increase in mice, which is often observed with induced hyperlipidemia (for example, a high-fat diet). This indicates fatty liver infiltration - steatosis. Damage to hepatocytes leads to the release of these enzymes into the bloodstream. ACT/ALT ratio: With liver steatosis, ALT > ACT is more common, which may indicate more pronounced damage, fibrosis, or additional muscle destruction. The association with inflammation and oxidative stress is expressed in the fact that hyperlipidemia causes oxidative stress, provoking inflammation in the liver. It can also increase ALT and ACT levels. Changes in ALT and ACT levels in hyperlipidemia in rats reflect the degree of liver damage and can be used as a biochemical marker of the toxicity of a high-fat diet (**Table 4**).

**Table 4** *In vivo* activity under conditions of hyperlipidemia induced in rats (M ± m, n = 4 - 6).

| Parameters* | Physiological norm | Control | Metmorfin 95 mg/kg | BRP 20 mg/kg |
|---|---|---|---|---|
| Total cholesterol mmol/L | 1.7 ± 0.05 | 2.9 ± 0.25 | 1.9 ± 0.18* | 1.79 ± 0.02* |
| Triglycerides mmol/L | 0.89 ± 0.03 | 1.45 ± 0.142 | 1.1 ± 0.11 | 1.0 ± 0.087* |
| High-density lipoproteins, riglycerides, HDL mmol/L | 0.84 ± 0.082 | 0.44 ± 0.041 | 0.89 ± 0.086* | 0.92 ± 0.09* |
| Low-density lipoproteins, LDL mmol/L | 0.69 ± 0.06 | 1.2 ± 0.12 | 0.75 ± 0.072* | 0.88 ± 0.078* |
| Glucose | 4.2 ± 0.4 | 10.2 ± 1.0 | 6.8 ± 0.67* | 6.2 ± 0.6* |
| ALT | 58 ± 4.9 | 89.7 ± 8.9 | 71.5 ± 6.9 | 69.2 ± 6.8 |
| ACT | 46.8 ± 3.8 | 69.8 ± 6.82 | 52.4 ± 5.1 | 54.3 ± 5.2 |
| Total protein | 69.0 ± 6.0 | 48.1 ± 4.6 | 56.8 ± 5.8 | 65.8 ± 5.4* |
| Glucosidase | 1.95 ± 0.32 | 2.01 ± 0.31 | 1.98 ± 0.12 | 2.045 ± 0.26 |

| Parameters* | Physiological norm | Control | Metmorfin 95 mg/kg | BRP 20 mg/kg |
|---|---|---|---|---|
| Pancreatic amylase | 2929.0 ± 38.7 | 2969.8 ± 39.8 | 2982.4 ± 39.2 | 2981.1 ± 40.2 |
| Amylase of the small intestine | 28.87 ± 2.37 | 34.26 ± 3.4 | 34.10 ± 3.3 | 29.85 ± 2.9 |

* - $p < 0.05$ in relation to the control group

In animals with hyperlipidemia, there was an increase in total cholesterol (OH), triglycerides (TG), low-density lipoproteins (LDL) and a decrease in high-density lipoproteins (HDL). After the introduction of *Brassica rapa* polysaccharides for 4 weeks, there was a significant decrease in OH and TG levels, a restoration of the LDL/HDL ratio, and a decrease in serum glucose levels. These changes correlated with a slowdown in body weight gain, which suggests that a decrease in hyperlipidemia is directly related to the regulation of energy metabolism. Activity of digestive enzymes. Glucosidases (e.g. maltase, sucrase and isomaltase) break down disaccharides into monosaccharides (e.g. glucose), which are absorbed into the blood. Hyperlipidemia: The direct effect is not well understood, but microcirculation disorders and chronic inflammation can reduce the activity of glucosidases. 2. Alpha-amylase of the pancreas. Alpha-amylase breaks down starch into oligosaccharides. Hyperlipidemia: Can cause pancreatitis, which leads to a sharp increase in the level of amylase in the blood. Chronic inflammation or lipotoxicity can reduce the enzymatic activity of the pancreas over time. To assess the effect of polysaccharides on enzymatic activity, serum levels of pancreatic and small intestine amylase were measured. In animals treated with *Brassica rapa* polysaccharides, amylase activity was increased, which may be a compensatory reaction to excess fats and carbohydrates. After the introduction of polysaccharides, normalization of these parameters was observed: Lipase activity decreased to values close to the intact group, amylase showed a tendency to stabilize, trypsin activity changed slightly, indicating a selective effect on carbohydrate-fat metabolism.

***Correlation analysis***

Correlation analysis showed significant relationships ($p < 0.05$) between body weight dynamics and the following indicators: Direct correlation between body weight and TG (r = 0.78) and OH (r = 0.72), positive correlation between amylase activity and glucose level (r = 0.69). *Brassica rapa* polysaccharides and metmorphine contributed to the reduction of these indicators. The introduction of *Brassica rapa* polysaccharides contributed to the restoration of the activity of these enzymes, which indicates a positive effect on digestive function. These data confirm the hypothesis that *Brassica rapa* polysaccharides are able to modulate metabolic processes, affecting both the blood lipid spectrum and the enzymatic activity of the digestive system, which, in turn, affects the body weight of animals. Studies of the interaction of *Brassica rapa* polysaccharides with animal weight dynamics, blood biochemical parameters, and digestive enzyme activity in induced hyperlipidemia in rats show promising results. In particular, *Brassica rapa* polysaccharides demonstrated the ability to reduce the levels of total cholesterol (TC), triglycerides (TG) and low-density lipoproteins (LDL-C) in the blood serum of rats, as well as increase the level of high-density lipoproteins (HDL-C). Thus, *Brassica rapa* polysaccharides have an effect on the dynamics of animal weight, blood biochemical parameters and the activity of digestive enzymes in induced hyperlipidemia in rats, which opens up prospects for their use as functional additives for the correction of lipid metabolism disorders. The results of this study confirm the hypothesis that *Brassica rapa* polysaccharides have hypolipidemic and hypoglycemic effects. Weight loss and normalization of blood biochemical parameters may be associated with improved lipid metabolism and restoration of liver function. The effect on the activity of digestive enzymes may indicate an improvement in digestive function and nutrient absorption. The introduction of *B. rapa* polysaccharides led to normalization of ALT and AST levels (approaching the control values), as well as to an increase in the activity of amylase and glucosidase to physiological values. The total protein in the blood did not significantly change in the group of animals treated with *Brassica rapa* polysaccharides.

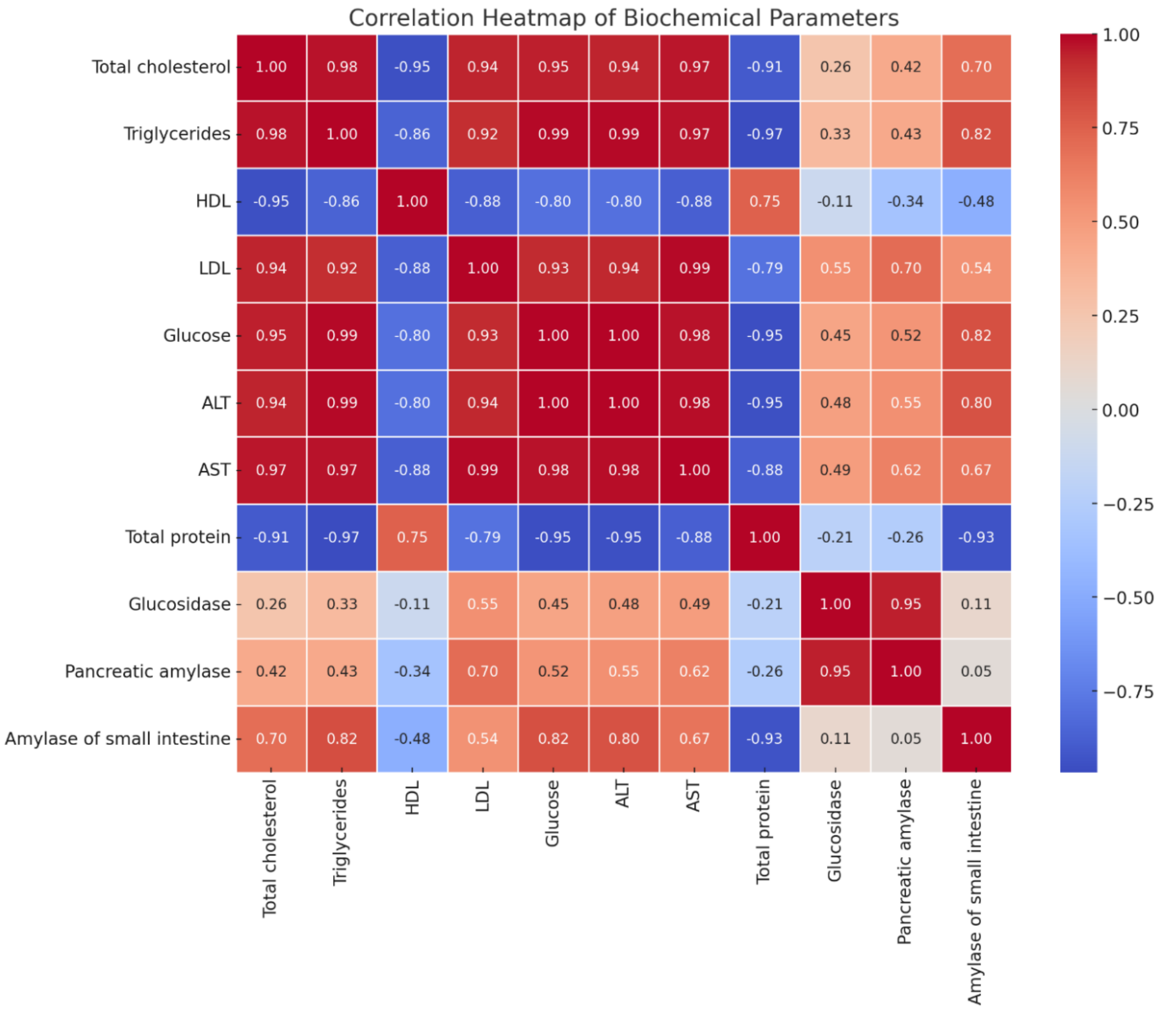


**Figure 8** Correlation heatmap of biochemical parameters in rats under hyperlipidemia conditions. The heatmap illustrates Pearson correlation coefficients between major serum biochemical markers measured across experimental groups (Physiological Norm, Control, Metformin 95 mg/kg, and BRP 20 mg/kg). Strong positive correlations are observed among lipid profile components (total cholesterol, triglycerides, LDL), as well as between glucose and liver enzymes (ALT, AST). In contrast, HDL shows a significant inverse correlation with atherogenic and hepatotoxic indices. Color intensity represents the strength and direction of the correlation (Red: Positive; Blue: Negative).

**Discussion**

Based on the obtained biochemical data, it is possible to analyze the relationship between hyperlipidemia (HLP) and type 2 diabetes mellitus (DM). Hyperlipidemia is an important risk factor for the development of diabetes mellitus [19-21]. Hyperlipidemia is a condition characterized by abnormal levels of lipids in the blood, in particular, elevated levels of total cholesterol (OH), triglycerides (TG) and low-density lipoprotein cholesterol (LDL-C), in addition to reduced levels of high-density lipoprotein cholesterol (HDL cholesterol). These changes are often accompanied by fatty liver and obesity [22]. From a biochemical point of view, a high-fat diet can cause an inflammatory reaction of the body [23] and increase the production of reactive oxygen species [24]. Currently, hyperlipidemia is mainly treated with diet or medication, among which statins are the most widely used lipid-lowering drugs; however, after discontinuation of medication, relapse is often observed

[25]. Patients with hyperlipidemia often use herbal products as an additional remedy. alternative or as an additional therapy [26]. Some common mechanisms of action of these herbs include inhibition of lipid biosynthesis by inhibiting HMG-CoA reductase [27,28], as well as inhibition of other enzymes of cholesterol biosynthesis and lipolysis [29,30]. These herbs also control the level of lipids in the blood by regulating the process of lipid absorption, as well as the excretion of lipids and cholesterol from the body [31-34]. Many natural polysaccharides have been shown to have therapeutic effects on hyperlipidemia, although a comprehensive understanding of these properties has not yet been achieved. the effect remains unclear. The biological activity of polysaccharides depends on the molecular weight (MW), monosaccharide composition, type of glycosidic bonds, and sulfate content [35]. The mechanism by which lipid reduction is achieved is complex, as it affects multiple targets and cellular signaling pathways. One of the potential sources of biologically active polysaccharides *Brassica rapa* polysaccharides effectively reduce glycemia and improve the lipid profile due to their antioxidant and anti-inflammatory effects. Randomized clinical trials, clarification of bioavailability, pharmacokinetics, and long-term safety are necessary for implementation in clinical practice (**Figure 8**).

Studies have shown that turnips contain many active substances: Glucosides, isothiocyanates [36], turnip extract prevents obesity and suppresses the accumulation of fat cells; it induces the expression of β3-adrenergic receptors (β3-AR). Studies of the metabolic syndrome caused by fructose (MS) have shown that in rats in the turnip-treated group, there was a significant decrease in blood lipids and an increase in the level of reduced glutathione and liver glycogen in the blood, indicating a positive effect of turnips on metabolic syndrome citations.

***The relationship between HLP and DM***

HLP and DM, especially type 2 diabetes mellitus (T2DM), often coexist and enhance the pathophysiological effects of each other, increasing the risk of cardiovascular diseases (CVD). Their relationship is due to a variety of metabolic and molecular mechanisms. Metabolic basis - in DM2, insulin resistance, a key pathogenetic factor, leads to impaired lipid metabolism. Insulin normally inhibits lipolysis in adipocytes, and when it is not active enough, the release of free fatty acids (FFA) into the bloodstream increases. FFA increases the production of very low-density lipoproteins (VLDL) in the liver and reduces the clearance of lipids from the blood, which leads to hypertriglyceridemia and a decrease in the level of high-density lipoproteins (HDL). Thus, with T2DM, the following are more often observed: An increase in triglycerides; a decrease in HDL; an increase in small dense particles of low-density lipoproteins (LDL) with high atherogenic activity. The effect of hyperlipidemia on the development of diabetes. Dyslipidemia also contributes to the development of insulin resistance and type 2 diabetes. Excess circulating FFA disrupts the function of insulin-dependent tissues (muscle and liver), reducing insulin sensitivity. Moreover, lipotoxicity can cause dysfunction of beta cells of the pancreas, reducing insulin secretion. The oxidation of lipids in mitochondria leads to the accumulation of toxic intermediates (diacylglycerols, ceramides), which increase inflammation and metabolic stress. Inflammation and endothelial dysfunction are associated with chronic subclinical inflammation. Increased levels of pro-inflammatory cytokines (TNF-α, IL-6, CRP) enhance insulin resistance and promote atherogenesis. Endothelial dysfunction, characteristic of both DM and GLP, plays a key role in the development of micro- and macrovascular complications. According to data from large cohort studies (for example, UKPDS, Framingham Heart Study), the presence of dyslipidemia in DM patients is associated with a 2-4-fold increase in the risk of CVD. Also, elevated triglyceride levels and a decrease in HDL precede the development of T2DM, which indicates the prognostic value of the lipid profile. Given the close relationship between diabetes and GLP, comprehensive treatment should include correction of lipid metabolism: Lifestyle changes, the use of statins, fibrates, PCSK9 inhibitors and omega-3 fatty acids.

HLP has long been recognized as a risk factor for cardiovascular diseases. However, the effect on carbohydrate metabolism and the development of T2DM is being actively investigated. Particular attention is paid to metabolic patterns in DM2: Atherogenic dyslipidemia (elevated LDL cholesterol and triglycerides, decreased HDL) is often combined with insulin resistance and obesity. HLP and DM often combine and worsen each other, increasing the risk of atherosclerosis. *Brassica rapa* contains polysaccharides, phytochemical compounds and trace elements that exhibit hypoglycemic, hypolipidemic, antioxidant and anti-inflammatory effects. Induced hyperlipidemia is an experimental model widely used to evaluate the effectiveness of lipid-lowering drugs. The present study examined the effect of polysaccharides on body weight, blood chemistry, and digestive enzyme activity in rats with hyperlipidemia caused by a high-fat diet. Plant polysaccharides, in particular polysaccharides isolated from *Brassica rapa* seeds, have the potential to modulate metabolism, have hypolipidemic and anti-inflammatory effects.

## Conclusions

A high-fat diet in mice causes a cascade of events, from hyperlipidemia and liver steatosis to inflammation and amyloid deposits. However, interventions such as *Brassica rapa* polysaccharides can reconfigure metabolism by reducing lipid levels through various targets: LPL, GPR receptors, etc. *Brassica rapa* turnip polysaccharides can play an important role in the complex therapy of hyperlipidemia and diabetes mellitus. They affect the mechanisms of carbohydrate and fat metabolism, improve insulin sensitivity, and have antioxidant and anti-inflammatory effects. However, additional clinical studies are required to definitively assess their effectiveness and safety. *Brassica rapa* polysaccharides have shown promise in the fight against hyperlipidemia and diabetes: They improved lipid and carbohydrate metabolism, had antioxidant and anti-inflammatory activity. This study allows us to conclude that it has pharmacological properties, exhibits hypoglycemic and hypolipidemic activity and can be used in traditional medicine in combination with other medicinal plants. Therefore, further research will be devoted to the study of the mechanism of action. Polysaccharides from *Brassica rapa* seeds effectively restore enzymatic activity and biochemical parameters in hyperlipidemia, which allows them to be considered as promising biologically active substances with the potential to correct metabolic disorders. *Brassica rapa* polysaccharides have a beneficial effect on body weight dynamics, blood biochemical parameters, and digestive enzyme activity in rats with induced hyperlipidemia. These data indicate the potential of *Brassica rapa* polysaccharides as a promising component of functional products and nutraceuticals for the prevention and correction of metabolic disorders.

## Declaration of generative AI in scientific writing

"Only minimal assistance was used from QuillBot for paraphrasing selected sentences. All scientific content, interpretation, and conclusions were developed independently by the authors."

## CRediT author statement

**Dilnoza Abdulgafurova**: Investigation (*in vivo* experiments), **Dilfuza Amanlikova**: Investigation (*in vivo* experiments), **Lazizbek Makhmudov**: Investigation (*in vivo* experiments), **Nodira Obidova**: Resources (substance preparation), Methodology, **Izzatullo Abdullaev**: Writing - original draft, Conceptualization, **Munojat Oripova**: Resources (substance preparation), Data curation, **Zulfizar Kuziyeva**: Resources (substance preparation), Validation, **Yuliya Oshchepkova**: Supervision, Project administration.

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