

<sup>1</sup>Tatiana Borisovna  
Trofimova

<sup>1</sup>Andrey Anatolevich  
Kislitsyn

<sup>1,2</sup>Valeriy Mikhailovich  
Poznyakovsky

<sup>3\*</sup>Boisjoni Tokhiriyon

<sup>3</sup>Nadezhda Nikolaevna  
Danko

<sup>4</sup>Nina Grigorievna  
Chelnakova

## Development and the Study of the New Plant-Based Enterosorbent Tablets



**Abstract:** - With the increasing number of patients suffering from IBS with constipation, medical specialists are giving more attention to plant-based dietary supplements. The health benefits associated with plant-based dietary supplements in nutrition prophylaxis and diet therapy are highly valued, as they assist in preventing and treating constipation and other IBS symptoms. A new plant-based enterosorbent tablets with microcrystalline cellulose; lactobacillus complex; Rosa canina fruits; anthelmintic complex with tansy and buckthorn bark; sublimated beets; polysorbavit; and senna were developed. Organoleptic and physico-chemical properties, microbiological indicators of quality and safety were studied during the production stage and after storing for 39 months. Twenty adult patients aged between 39 and 54 and diagnosed with IBS-C were selected for a 15-day-long clinical trial. The control group was made up of 15 patients with characteristics similar to the main group for age and sex match. Positive changes in the quality of life were confirmed by both the laboratory tests and the patient's subjective assessment. The plant-based enterosorbent tablets assist in reducing the clinical manifestations of IBS-C and improve overall well-being.

**Keywords:** Dietary supplement, Plant-based, Enterosorbent, IBS, Constipation

### I. INTRODUCTION

Contemporary dietary needs incorporate several nutrition-related concerns, with dietary supplements being one of the potential solutions to managing nutritional inadequacies, weight control, boosting energy as well as prophylaxis. Selected dietary supplements are used in combination therapy for chronic diseases [1-5]. Plant-based enterosorbents have recently experienced growing popularity as effective and safe dietary supplements. They are used to treat general malaise, fever, nausea, diarrhea, as well as overall discomfort. Since general intoxication caused by various endogenous and exogenous factors is a common syndrome in many different diseases, it is important to address this syndrome in order to improve general well-being and accelerate the recovery from infectious diseases, the dysfunctional disorders of the biliary tract, and irritable bowel syndrome (IBS). With the increasing number of patients suffering from IBS with constipation (IBS-C), medical specialists are giving more attention to nutrition prophylaxis and diet therapy with plant-based dietary supplements as they assist in preventing and treating constipation and other IBS symptoms. Plant-based dietary supplements in nutrition prophylaxis and diet therapy are becoming more common in outpatient treatment [6-9]. To meet the growing demand, new plant-based enterosorbent tablets were developed.

<sup>1</sup> Department of Technological Entrepreneurship, Kuzbass State Agricultural Academy, Kemerovo, Russia.

<sup>2</sup>Scientific and Educational Center for Applied Biotechnology and Nutrition, Kemerovo State Medical University, Kemerovo, Russia.

<sup>3</sup>Department of Management, Entrepreneurship and Engineering, Ural State University of Economics, Ekaterinburg, Russia.

<sup>4</sup>Institute of Sports, Tourism and Service, South Ural State University (national research university), Chelyabinsk, Russia.

\* Corresponding author

*Stages of Drug Development***II. MATERIALS AND METHODS**

The pharmaceutical composition of the new plant-based enterosorbent tablets includes microcrystalline cellulose (MCC); lactobacillus complex; Rosa canina fruits; anthelmintic complex with tansy and buckthorn bark; sublimated beets; polysorbovit; and senna.

MCC is a source of dietary fiber, which stimulates gastrointestinal (GI) tract motility. MCC, like other dietary fibers, possesses mechanical and sorption properties [10-12]. In the stomach, MCC absorbs liquid, increases in volume, and helps to prevent overeating by causing a sense of fullness. In the GI tract, MCC binds harmful substances and their waste products, and sorbs heavy metals, and radionuclides; in the stomach, it binds excess gastric juice and hydrochloric acid; in the intestine, it binds bile acids, bilirubin, and cholesterol, thereby reducing the acidity of gastric juice and bile. In the small intestine, MCC mechanically cleanses the mucous membrane, therefore, improving parietal digestion and intestinal absorption. MCC enhances peristalsis and thus assists in transferring the food bolus (chyme). The importance of healthy gut microbiota is well-known. As good bacteria feed on fiber, sufficient fiber intake is vital for healthy gut microbiota. Healthy gut microbiota produces group B vitamins, vitamin PP, and vitamin K. MCC can be used to treat poisoning (same as activated charcoal), improve digestion, prevent and inhibit the growth of neoplasms, as well as the formation of bladder and kidney stones, to lose weight, and it is also used in combination therapy for diabetes, atherosclerosis, coronary heart disease, and gastroenterological diseases.

Lactobacillus complex contains Lactobacillus plantarum 8 P-A3. Lactic acid bacteria are necessary to ensure robust overall health. Lactobacilli help with immune support, produce interferon, folic acid, as well as accumulate biotin and vitamin K [13-15]. Although most Lactobacilli are commonly found in the small intestine, thanks to their antigenic properties they assist in maintaining normal biocenosis of the mucous membranes lining the respiratory tract. In women, lactobacilli help maintain healthy vaginal mucosa and prevent yeast infection. Lactic acid bacteria assist in maintaining a healthy GI tract and are used in intestinal disorders, colitis, candidiasis, and dysbacteriosis.

Rosa canina fruits contain a unique composition of biologically active compounds, among them provitamin A, vitamins C, K, B2, E, bioflavonoids (kaempferol, quercetin), tannins and pectins, macro- and microelements [16-20]. Mixtures with Rosa canina fruits usually have a pleasant taste and are used in combination therapy for the prevention and treatment of different diseases. They possess anti-inflammatory, diuretic, hemostatic properties, assist in supporting a healthy immune system, and can be also used as a mild laxative since they contain organic acids and pectins.

Anthelmintic complex with tansy and buckthorn bark has proven to be effective in the combination therapy and prevention of giardiasis, ascariasis, and enterobiasis. Buckthorn bark stimulates bowel muscle contractions, so it possesses a laxative effect. Tansy helps promote bile flow and possesses anthelmintic properties. Tansy contains the essential oil, which is applied in treating infections caused by pyogenic and enteric-typhoid microorganisms, and roundworms (pinworms, Ascaris) as an anthelmintic. Tansy tones the muscles of the GI tract, acts as an anti-inflammatory agent, and is used in treating intestine diseases, gastric and duodenal ulcers.

Sublimated beets contain fiber, sugars, mineral salts, group B vitamins, betaine, and pectin. Fibre assists in increasing intestinal motility and stimulates the secretion of digestive juices and bile. Pectin helps to lower low-density lipoprotein and remove toxic substances. Betaine improves metabolic processes and liver function. Beetroot has a mild laxative effect, which helps to improve peristalsis and cleanse the intestines [21-25].

Polysorbovit is an enterosorbent based on modified low-esterified citrus pectin. It has antacid and enveloping properties [26-28]. In the stomach, polysorbovit turns into a dense gel that envelops the gastric wall and, thanks to its high water-retaining capacity, starts swelling. The gel protects the stomach wall from hydrochloric acid and digestive enzymes, stimulates blood circulation in the upper layers of the stomach walls, which improves their nutrition and oxygen supply. Polysorbovit binds toxins, secondary metabolites, and GI hormones. Once in the small intestine, polysorbovit exhibits the same effect as in the stomach; therefore, it assists in treating inflammation in duodenitis, enteritis, gastroenteritis, spasmodic colitis, and IBS. As the main components of

polysorbovit are pectins, polysorbovit possesses a high water-retaining capacity, is effective in improving bowel movements, and assists in firming up stools.

The qualitative and quantitative composition of the formula of the new dietary supplement is as follows: in mg per 1 tablet (500 mg): Polysorbovit - 166.7; sublimated beets - 66.67; tansy (flowers) - 25; Rosa canina (fruits) - 16.67; senna (leaves) - 16.67; Lactogum (concentrated dry starter) – 8.33; MCC - 200. Biochemical and pharmacological characteristics of the ingredients were taken into account when developing the formula.

### III. RESULTS AND DISCUSSION

Organoleptic and physico-chemical properties, microbiological indicators of quality and safety were studied during the production stage and after storing at a temperature of 25° C in a dry, dark place for 39 months. The data on product safety and nutritional value are presented in **Table 1**. As the data demonstrates, 39-month-long storage did not affect either the quality or potency of the plant-based enterosorbent tablets; therefore, the formula met the requirements for food safety and nutrition.

Parameter	Description
Appearance	Oval tablets
Color	Raspberry color, specks are acceptable.
Taste and smell	Distinctive
Average weight per tablet, mg	500(450 - 550)
Anthraquinones, mg per 1 tablet (=>)	0.125
Soluble dietary fiber, mg per 1 tablet (=>)	25
Bioflavonoids in terms of rutin, mg per 1 tablet (=>)	0.5

The plant-based enterosorbent tablets possess an increased sorption capacity. Therefore, even small amounts of the supplement can bind and retain exogenous and endogenous toxins.

A randomized clinical trial was carried out. Twenty adult patients aged between 39 and 54 and diagnosed with IBS-C were selected to be treated with the dietary supplement for 15 days. The control group was made up of 15 patients with characteristics similar to the main group for age and sex match.

All participants underwent biochemical tests to determine sugar, protein, etc, as well as liver function tests, both at the start and at the end of the clinical trial. Clinical evaluation of the effectiveness of the dietary supplement was performed on Days 15 and 16. All patients had disorders of the motor and evacuation functions of the GI tract. The causes for the disorders were determined to be polyetiological. The changes, that occurred in the state of the main group of patients during treatment, were found to be positive (**Table 2**). In the main group, the average weakness score decreased by 72%, and the average fatigue score decreased by 56% at the end of the clinical trial. The participants of the control group, who followed a common diet recommended for easing IBS symptoms, demonstrated only slight positive changes.

Subjective symptoms	Main, n =20		Control, n =15		The significance level	
	Before treatment	Day 10	Before treatment	Day 10	Before treatment	Day 10
1. Weakness	4.3±0.4	1.2±0.7*	4.4±0.6	3.8±1.1	0.45	0.004

2. Fatigue	4.1±0.9	1.8±0.8*	4.2±0.8	3.8±0.9	0.61	0.022
3. Stomach heaviness	4.2±0.9	2.2±0.4*	4.5±0.8	3.8±0.6	0.85	0.025
4. Bowel movement frequency (fewer than once per day)	4.1±0.9	1.1±0.3*	4.4±0.8	3.5±0.9	0.98	0.009

Note: \* -  $p < 0.05$  when compared with the initial data

It is noteworthy that, in the main group, bowel movement frequency has improved by 3.7 times, while the common diet for IBS had only a slightly favorable effect on the GI tract. Positive changes in the manifestation of the IBS symptoms were accompanied by positive changes registered in the biochemical profile, particularly the changes that were indicated by the liver function tests (**Table 3**). The value for the Thymol test demonstrated an average 1.5 times decrease in the patents from the main group.

Parameter	Main, n =20		Control, n =15		The significance level	
	Before treatment	Day 10	Before treatment	Day 10	Before treatment	Day 10
the Thymol test	3.7±1.2	2.4±0.8*	3.8±1.0	3.5±1.3	0.56	0.045

Note: \* -  $p < 0.05$  when compared with the initial data.

The findings of the clinical trial revealed that the continual treatment with the new plant-based enterosorbent tablets within the course of medication resulted in a decrease in the level of free cholesterol in the blood serum, reducing the average group value of this indicator from  $5.8 \pm 0.6$  to  $5.1 \pm 0.8$  mmol/l.

When evaluating patients' quality of life, it was found that the plant-based enterosorbent tablets help improve overall well-being and boost energy. Positive changes in the quality of life were confirmed by both the laboratory tests and the patient's subjective assessment. Therefore, the supplement assists in reducing the clinical manifestations of IBS-C and improves overall well-being. The polyvalent influence of the components was registered in body regulatory systems. Taking into account the changes in the values of the Thymol test, the plant-based enterosorbent tablets demonstrated a certain hepatoprotective effect.

Therefore, it can be recommended to consume the supplement as an effective therapy for IBS-C, especially for overweight patients. Given the positive changes in the parameters of the biochemical profile and improved quality of life recorded in the patients from the main group, it should be pointed out that the studied plant-based enterosorbent tablets can be applied for prophylactic purposes, for example for hypokinetic biliary dyskinesia, and for improving the functional activity of the GI tract, especially in case of hypodynamia, hard physical labor or excess weight.

#### IV. CONCLUSION

The findings of the conducted clinical trial revealed the potential application of the plant-based enterosorbent tablets for restoring the GI tract, improving bowel movement and liver function. It can also be administered to healthy people for preventive purposes to support good health.

ACKNOWLEDGMENTS: N/A

CONFLICT OF INTEREST: N/A

FINANCIAL SUPPORT: N/A

ETHICS STATEMENT: The study was conducted according to the guidelines of the Declaration of Helsinki.

## REFERENCES

- [1] Austrrievsky AN, Vekovtsev AA, Pozniakovskiy VM. Healthy food products: New technologies, quality assurance, application efficiency. Publishing house of SU: Novosibirsk, Russia; 2005. 416 p.
- [2] Gerasimenko NF, Poznyakovskiy VM, Chelnakova NG. Methodological aspects of full-fledged, safe nutrition: Importance in maintaining health and working capacity. *Man Sport Med.* 2017;17(1):79-86.
- [3] Poznyakovskiy VM, Chugunova OV, Tamova MY. Food ingredients and dietary supplements. M.: INFRA-M; 2017. 143 p.
- [4] Spirichev VB, Shantyuk LN, Poznyakovskiy NM. Enrichment of food products with vitamins and minerals. Science and technology. 2nd ed. Novosibirsk: Siberian Univ. Publishing House; 2005. 548 p.
- [5] Elamin SM, Redzuan A, Aziz SAA, Hamdan S, Masmuzidin MZ, Shah NM. Impacts of Educational Interventions on Glycemic Control in Children and Adolescents with Type 1 Diabetes Mellitus. *Arch Pharm Pract.* 2023;14(4):13-31. <https://doi.org/10.51847/4PWgp3vYN3>
- [6] Patel NV. 'Let food be thy medicine': Diet and supplements in irritable bowel syndrome. *Clin Exp Gastroenterol.* 2021; 14:377-84. doi:10.2147/CEG.S321054
- [7] Huang H, Lu L, Chen Y, Zeng Y, Xu C. The efficacy of vitamin D supplementation for irritable bowel syndrome: A systematic review with meta-analysis. *Nutr J.* 2022;21(1):24. doi:10.1186/s12937-022-00777-x
- [8] Satish Kumar L, Pugalenth LS, Ahmad M, Reddy S, Barkhane Z, Elmadi J. Probiotics in irritable bowel syndrome: A review of their therapeutic role. *Cureus.* 2022;14(4):e24240. doi:10.7759/cureus.24240
- [9] Aldossary KM. Awareness and attitude towards premenstrual syndrome among foundation year students at Princess Nourah University: Cross-sectional study. *J Adv Pharm Educ Res.* 2024;14(2):97-102. <https://doi.org/10.51847/NiMK5Lzbat>
- [10] Nsor-Atindana J, Chen M, Goff HD, Zhong F, Sharif HR, Li Y. Functionality and nutritional aspects of microcrystalline cellulose in food. *Carbohydr Polym.* 2017; 172:159-74. doi: 10.1016/j.carbpol.2017.04.021
- [11] Ellwood K. Functionality and nutritional aspects of microcrystalline cellulose in food. *J Food Nutr Popul Health.* 2022;9:49.
- [12] Mashreghi D, Fakoor M, Arti H, Mohammadhoseini P, Mousavi S, Goharpey S, et al. Investigating the effective factors on rehabilitation in anterior cruciate ligament reconstruction based on Lysholm knee score. *J Adv Pharm Educ Res.* 2024;14(3):43-8. <https://doi.org/10.51847/W4m2xHgTH7>
- [13] Wang Y, Wu J, Lv M, Shao Z, Hungwe M, Wang J, et al. Metabolism characteristics of lactic acid bacteria and the expanding applications in the food industry. *Front Bioeng Biotechnol.* 2021; 9:612285. doi:10.3389/fbioe.2021.612285
- [14] Nguyen NK, Dong NT, Nguyen HT, Le PH. Lactic acid bacteria: Promising supplements for enhancing the biological activities of kombucha. *Springerplus.* 2015; 4:1-6. doi:10.1186/s40064-015-0872-3
- [15] Yagubova EY, Gusenova GT, Zubiyeva FV, Berezhnaya VV, Pulatova KM, Tomboidi KK, et al. Evaluation of the neuroprotective effect of root and leaf extracts of *Chlorophytum comosum*. *J Adv Pharm Educ Res.* 2023;13(3):52-5. <https://doi.org/10.51847/W5wvQzvguf>
- [16] Hendrysiak A, Brzezowska J, Nicolet N, Bocquel D, Andlauer W, Michalska-Ciechanowska A. Juice powders from rosehip (*Rosa canina* L.): Physical, chemical, and antiglycation properties. *Molecules.* 2023;28(4):1674. doi:10.3390/molecules28041674
- [17] Demir F, Özcan M. Chemical and technological properties of rose (*Rosa canina* L.) fruits grown wild in Turkey. *J Food Eng.* 2001;47(4):333-6. doi:10.1016/S0260-8774(00)00129-1
- [18] Arazi H, Eghbali E. Possible effects of beetroot supplementation on physical performance through metabolic, neuroendocrine, and antioxidant mechanisms: A narrative review of the literature. *Front Nutr.* 2021; 8:660150. doi:10.3389/fnut.2021.660150
- [19] Domínguez R, Cuenca E, Maté-Muñoz JL, García-Fernández P, Serra-Paya N, Estevan MC, et al. Effects of beetroot juice supplementation on cardiorespiratory endurance in athletes. A systematic review. *Nutrients.* 2017;9(1):43. doi:10.3390/nu9010043
- [20] Varoneckaitė M, Jasinskaitė K, Varoneckas A, Vasiliauskas A, Lektas M. External Apical Root Resorption in Clear Aligner Vs. Fixed Orthodontic Appliances: Systematic Review and Meta-Analysis. *Ann Dent Spec.* 2024;12(3):15-22. <https://doi.org/10.51847/YxGPFR62jS>
- [21] Jandosov J, Alavijeh M, Sultakhan S, Baimenov A, Bernardo M, Sakipova Z, et al. Activated carbon/pectin composite enterosorbent for human protection from intoxication with xenobiotics Pb(II) and sodium diclofenac. *Molecules.* 2022;27(7):2296. doi:10.3390/molecules27072296
- [22] Boccuzzi L, Infante M, Ricordi C. The potential therapeutic role of vitamin D in inflammatory bowel disease. *Eur Rev Med Pharmacol Sci.* 2023;27(10).
- [23] Sun R, Niu Y, Li M, Liu Y, Wang K, Gao Z, et al. Emerging trends in pectin functional processing and its fortification for synbiotics: A review. *Trends Food Sci Technol.* 2023; 134:80-97.
- [24] Xu R, Li Q, Wang H, Su Y, Zhu W. Reduction of redox potential exerts a key role in modulating gut microbial taxa and function by dietary supplementation of pectin in a pig model. *Microbiol Spectr.* 2023;11(1):e03283-22.

- [25] Bhat R, Zagmutt S, Jiménez-Altayó F, Toyo EM, Ramadani AP, Shanbhag P. Antihyperlipidemic and Antiobesity Effects of *Parmotrema tinctorum* Ethanolic Extract in Olive Oil-Induced Hyperlipidemic Rats. *Int J Pharm Res Allied Sci.* 2024;13(3):35-43. <https://doi.org/10.51847/fr2uZ8PoRp>
- [26] Tokhiriyon B, Poznyakovsky V, Beliaev N. Biologically active complex for the functional support of the connective tissues: Scientific rationale, clinical evidence. *Int J Pharm Res Allied Sci.* 2019;8(1):115-22.
- [27] Tokhiriyon B, Pozdnykovsky VM, Lapina V, Donskova L. Nutritional supplement for indigenous intestinal microflora: Manufacturing, quality and effectiveness evaluation. *InE3S Web of Conferences 2021 (Vol. 270, p. 01009).* EDP Sciences.
- [28] Tsvetkova DD, Marangozov SD, Kostadinova II. Pharmacological Activity of Metal-Based Organic Complexes Against Different Viral Diseases. *Pharmacophore.* 2024;15(3):1-11. <https://doi.org/10.51847/ITDUIEZZj3>