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Innovative Biotechnological Variants of Nutritional Supplements Targeting Gut Dysbiosis and Their Clinical Evaluation

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ABSTRACT

This study focuses on novel biotechnological formulations of nutritional supplements designed to support individuals dealing with gut dysbiosis. Four distinct supplements have been formulated to help prevent and manage gastrointestinal disorders, each with specific properties. The first supplement incorporates modified sorbents to neutralize bacterial endotoxins. The second supplement consists of microencapsulated live strains of *Bifidobacterium* and *Lactobacillus* to support immune function. The third supplement contains bacterial metabiotics that facilitate endotoxin absorption and promote a balanced intestinal microbiota. The fourth supplement is derived from plant-based components that encourage the growth of beneficial microbiota by suppressing the proliferation of yeasts and pathogenic bacteria, while also having protective and anti-inflammatory properties. A clinical trial was conducted with 10 volunteers aged 33-72 years, who consumed these four supplements orally. The dosage regimen and duration of treatment were systematically tested, evaluated, and validated. Various health parameters, including biochemical, hematological, and immunological blood profiles, along with fecal sugar levels, occult blood in feces, and coprogram results, were assessed before and after supplementation. The findings confirmed the effectiveness of these nutritional supplements in alleviating gut dysbiosis.

Keywords: Efficiency, Gut dysbiosis, Nutritional supplements biotechnological forms, Preventive measures

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Introduction

The normal microbiota consists of various microbial communities, each defined by a specific composition of microorganisms. These microbes colonize the skin and mucous membranes, acting as the body's first nonspecific defense against harmful internal and external influences. A dense microbial film, comprising approximately 100 billion microbial cells, covers the intestinal walls, mucosal surfaces, and skin. Furthermore, a stable microbiological status plays a key role in ensuring the proper function of all bodily organs and systems [1-5].
The majority of the microbiota is concentrated in the intestine, making it particularly vulnerable to disruptions caused by an unnatural lifestyle. Factors such as emotional and psychological stress, poor dietary habits, excessive medication use, and other detrimental behaviors can negatively impact gut health. Since intestinal function is

essential to overall well-being, gastrointestinal disorders are among the most frequent reasons for seeking medical attention. Additionally, imbalances in gut flora have been associated with various conditions, including cardiovascular and autoimmune diseases, liver and kidney disorders, allergies, skin conditions, and psychological issues such as depression [1-11].

As microbiota serves as a reliable and objective marker of health and nutrition, restoring microbial balance through dietary strategies is essential for maintaining overall well-being [12-20]. This study focuses on novel biotechnological formulations of nutritional supplements designed to support individuals dealing with gut dysbiosis.

Materials and Methods

The ArtLife Company focused on developing biologically active compounds and utilizing advanced biotechnological approaches:

- Nutritional supplement 1 is formulated to aid metabolic detoxification and enhance gut biocenosis. It incorporates modified sorbents capable of neutralizing bacterial endotoxins.
- Nutritional supplement 2 consists of a biotechnological blend of probiotics and prebiotics. The probiotics include live microencapsulated strains of Bifidobacterium and Lactobacillus, which contribute to immune system support and overall health maintenance.
- Nutritional supplement 3 is a specialized biotechnological complex containing bacterial metabiotics. This formulation selectively binds endotoxins while acting as both a prebiotic and metabolic agent to promote gut biocenosis.
- Nutritional supplement 4 is a plant-based biotechnological formulation designed to support the balance of beneficial gut microflora and strengthen the body's natural defenses. It inhibits the proliferation of pathogenic bacteria and yeast fungi, encourages the colonization of beneficial bacterial strains, enhances immune protection, and exerts significant anti-inflammatory properties.

The clinical trials assessing the effectiveness of the formulated products included 10 volunteers, consisting of 1 male and 9 females, aged 33 to 72 years, all of whom were white-collar professionals.

Participants were motivated by various factors, including improving their overall health, achieving weight reduction, and alleviating discomfort associated with digestive disorders.

Several detrimental influences impacted their well-being, such as poor dietary habits, excess body weight, and emotional and psychological stress.

To evaluate the impact of the supplements, the volunteers underwent a series of laboratory tests before and after the intervention. These assessments included hematological, biochemical, and immunological blood analyses, as well as fecal sugar and fecal occult blood tests.

Following extensive clinical and laboratory evaluations, diagnoses among the participants included fatty liver disease (six individuals), obesity (six individuals), pancreatitis (four individuals), hypothyroidism (four individuals), chronic gastritis and duodenal ulcer (eight individuals), gallstone and acalculous cholecystitis (four individuals), irritable bowel syndrome (four individuals), and a history of stomach resection (one individual).

Results and Discussion

Each participant exhibited varying degrees of gut microbiota imbalance, ranging from mild to severe.

Before and following the program, all individuals completed a questionnaire designed to assess their physical well-being on a 10-point scale.

The volunteers adhered to the prescribed regimen of the formulated biological compounds, as outlined in **Table 1**.

Table 1. Schedule for nutritional supplement consumption.

Nutritional supplements and their form	Dosage and administration
Supplement 1–hard gelatin capsule with enteric coating	One capsule two times a day with a meal. Oral administration. Duration–45 days.
Supplement 2–colloidal solution	One teaspoon three times a day between meals. Duration–30 days.

Nutritional supplement 3–hard gelatin capsule	One capsule two times a day, 30 minutes before breakfast and thirty minutes before bedtime. Oral administration. Duration–45 days. It cannot be taken together with supplement 1.
Supplement 4–hard gelatin capsule with enteric coating	One capsule four times a day, with a meal or immediately after a meal. Administration- oral. Duration–45 days

Various dysfunctions across organs and systems were identified during the assessment of patients' physical health **(Table 2)**.

Table 2. Self-assessment of physical health before and after consumption of biologically active compounds: survey results.

Organs and systems health	Before treatment (points)	After treatment (points)
Skin, hair, nails (hair loss, brittle nails)	9	2
Mouth, nose, pharynx (coated tongue, dry skin)	6	1
Gastrointestinal tract (flatulence, rumbling)	10	1
Nervous system (weakness, fatigue, dizziness)	10	0
Musculoskeletal system (pains, crepitus)	6	4
Stool (consistency, frequency, constipation)	8	1

*Note: 0–no changes; 10–pronounced changes

The nutritional therapy led to improvements ranging from 60-100% in the participants' physical health. All volunteers (100%) demonstrated positive changes in cholestasis, cytolysis, and lipid metabolism **(Table 3)**. Five tests were conducted throughout the program, with blood samples collected both before and after the supplement administration each time.

Table 3. Variations in blood chemistry values before and following the intake of supplements.

Biochemical indicators	1st test		2nd test		3rd test		4th test		5th test	
	Before	After	Before	After	Before	After	Before	After	Before	After
ALAT U/L	N	N	N	N	72	28	N	N	N	N
AST U/L	N	N	N	N	68	32	N	N	N	N
GGTP U/L	N	N	45.5	26.1	92.59	59	N	N	N	N
Total cholesterol mmol/l	5,.3	3,68	7.09	6.5	7.13	6.28	8.23	6.57	6.8	5.4
LDL, mmol/l	3.72	2,12	4.7	3.4	4.72	3.96	5.64	5.08	4.0	3.6
HDL, mmol/l	1.09	1,26	1.3	1.4	1.7	1.6	1.44	1.36	1.1	1.2
Glucose, mmol/l	N	N	7.3	6.2	6.8	5.8	6.8	5.28	5.8	5.2

Stool examinations conducted on 6 volunteers (60%) before the treatment revealed previously undiagnosed latent disaccharidase deficiency that was absent in all of them (0%) after completing the program.

Analysis of the gut microbiota before the program showed microbial imbalances in 100% of the volunteers, including a lack of protective symbionts (such as *Bifidobacterium*, *Lactobacillus*, and *Escherichia coli* (Lac +)) and the presence of harmful microorganisms (like *Klebsiella pneumonia* and *Candida albicans*). Following the 45-day program, microbiota restoration was observed in 9 participants (90%) **(Table 4)**.

Table 4. Alterations in the gut microbial composition.

Patient №	Before the program	After the program
1	*Escherichia coli* (Lac-)- 10^8 CFU/g, *Escherichia coli* (Lac+) -5x10^7 CFU/g	*Escherichia coli* (Lac-) – not detected *Escherichia coli* (Lac+) - 10^8 CFU/g
2	Low level of *Escherichia coli* (Lac+) - 10^5 CFU/g	*Escherichia coli* (Lac+) - 10^8 CFU/g
3	*Pseudomonas aeruginosa* - 10^6 CFU/g	not detected
4	Low levels of *Bifidobacterium* and *Lactobacillus* bacteria	Up to normal - 10^8 CFU/g - 10^6 CFU/g
5	*Klebsiella pneumonia* - 10^8 CFU/g	not detected
6	*Candida albmans*	not detected
7	Low levels of *Bifidobacterium* and *Lactobacillus* bacteria	*Bifidobacterium* level -normal, *Lactobacillus* -10^5 CFU/g
8	Low levels of *Bifidobacterium* and *Lactobacillus* bacteria	normal
9	Low levels of *Bifidobacterium* and *Lactobacillus* bacteria	normal
10	Low levels of *Bifidobacterium* and *Lactobacillus* bacteria	normal

At the start of the program, participants experienced changes in bowel movements, ranging from constipation to diarrhea, along with bloating, gas, abdominal rumbling, and pain in various areas with different sensations. Mucus presence in stool was noted in every test. After completing the program, 8 participants (80%) no longer experienced these issues, and 2 participants (20%) reported fewer symptoms. All individuals exhibited improvements in their co-program **(Table 5)**.

Table 5. Modifications in stool examination outcomes

Patient №	Before the program	After the program
1	Extracellular starch+ intracellular starch+iodoph. flora+	Soaps single units
2	Neutral fat+ soaps + extracellular starch+	Extracellular starch+
3	Extracellular starch + plant cells+ neutral fat+ mucus+	Extracellular starch +
4	Fatty acids+ extracellular starch+ iodophilic flora+	Not detected
5	Iodophilic flora +fatty acids+	Not detected
6	Fatty acids+ soaps+, extracellular starch+	Extracellular starch single units
7	Neutral fat(single units)+, mucus+(specific weight 1.026u), Candida albicans-5X10^5 CFU/ml(vaginal) (((vaginal)вагинальная	Neutral fats (single units), sp.w. 1.018 + not detected
8	Soaps++, fatty acids+, mucus+ Candida albkans- 5X10^5 CFU/ml(vaginal)	Soaps+ not detected
9	Soaps(single units), mucus+	Soaps single units+
10	Soaps ++ starch++ fatty acids+	Soaps + starch +

The participants rated their experience with the 45-day supplement evaluation course as excellent (60%), and good (40%), and none reported it as unsatisfactory (0%).

Conclusion

In summary, the findings demonstrate the effectiveness of the developed supplements in enhancing gut dysbiosis.

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Conflict of Interest: None

Financial Support: None

Ethics Statement: The research was carried out following the principles outlined in the Declaration of Helsinki.

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