The Effect of Synbiotic Dietary Supplementation on the Lipid Profile and Liver Functions of Hyperlipidemia in Rats

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ABSTRACT

The present study was carried out to investigate the Effect of Synbiotic Dietary Supplementation on the Lipid Profile and Liver Functions of Hyperlipidemia in Rats. In this study twenty-eight, male albino rats (Sprague-Dawley strain) were divided into four groups as follows: Group 1: as a negative control group and Group 2: as a positive control group. Group 3 was fed a high-fat diet (HFD) for a 7-week experimental period, during which, starting from the third week, the rats were orally administered 1 mL of probiotics containing 1×10^9 CFU/mL twice daily via oral gavage, and dried banana was added to the HFD as a prebiotic at a concentration of 3%. Group 4: was fed on basal diet mixed with grind dried banana at a concentration of 3% and was given orally one mL of 1×10^9 CFU probiotics / mL twice daily for seven weeks. The effect of synbiotic were studied on lipid profile (TC / TG / LDL-C / HDL-C / VLDL-C) and liver functions (ALT / AST / ALP). Measurements of Initial Body Weight (IBW), Final Body Weight (FBW), Feed Intake (FI), Body Weight Gain (BWG), Feed Efficiency Ratio (FER) in rats was also carried. The results suggest that synbiotics (green banana with bacteria) positively affect lipid metabolism by lowering harmful lipids (VLDL, LDL) and increasing HDL (good cholesterol, which may aid in hyperlipidemia management. While the Control (+Ve) group exhibited the highest feed efficiency, weight gain, and feed intake, the synbiotic groups (G3 and G4) demonstrated a marked reduction in feed efficiency and body weight gain, with G4 notably showing actual weight loss despite higher food intake. This indicates a strong modulatory effect of synbiotics on energy balance and growth performance. Additionally, both groups showed reductions in liver enzyme levels (ALP, ALT, AST) compared to the Control (+Ve), reflecting a protective effect on liver function. Notably, G4 showed the most significant overall improvements in lipid profile, liver enzyme levels, and growth performance, making it the most effective group in reducing liver stress due to consuming high fat diet and improving metabolic health by enhancing blood lipid levels and promoting growth.

Keywords: Probiotics**;** cholesterol-lowering activity**;** hyperlipidemia**;** microbiota; prebiotics; Synbiotics, green banana, bacteria.

INTRODUCTION

A medical condition known as hyperlipidemia is characterized by a decrease in high density lipoprotein levels and an increase in one or more plasma lipids, such as triglycerides, cholesterol, cholesterol esters, phospholipids, or plasma lipoproteins, such as very low-density lipoprotein and low-density lipoprotein **(Reynolds *et al*., 2009).** Dietary and lifestyle changes have led to a rise in the number of people with elevated cholesterol levels because of the disturbance of the body's lipid metabolism brought on by excessive consumption of foods high in cholesterol **(Luyao *et al*. 2024).**

Probiotics, prebiotics, synbiotics, and postbiotics are examples of therapies that modulate or are derived from the microbiota **(Chiara *et al*., 2022).** Probiotics boost the host's health when given in sufficient doses **(Markowiak and Śliżewska, 2017; Kim *et al*., 2019).**

Popularly probiotic microorganisms used:

1-*ctobacillus rhamnosus.*
2- *Lactobacillus Reuteri.*
3- Bifidobacteria and certain *Lactobacillus Casei strains.*
4- The group *Lactobacillus Acidophilus.*
5- Bacillus Coagulans.
6- The Escherichia Coli strain Nissle 1917.
7- Certain *Enterococci,* particularly *Enterococcus Faecium*SF68, as well as *Saccharomyces Boulardii* yeast

Bacterial spore formers, like Bacillus, are among the most prevalent prebiotics and are among the most resilient bacteria (they survive in hard conditions). These probiotics incorporated into foods, especially fermented dairy products, either alone or in combinations **(Collado *et al*., 2009).** Prebiotics are compounds that the digestive system's bacteria can digest. One example of this is dietary fiber, which is broken down by bacterial enzymes to create healthy metabolites like short-chain fatty acids, which include butyrate, acetate, and propionate **(Holscher, 2017).** It is possible to use prebiotics in addition to or instead of probiotics **(Markowiak and Śliżewska, 2017).**

The banana is a member of the Musaceae family. About 60–80% of the carbohydrates in bananas are indigestible (such as resistant starch - cellulose - hemicelluloses - lignin), which contributes to their prebiotic qualities **(Phoomjai *et al*., 2022).** Bananas include certain indigestible carbohydrates that probiotic bacteria (such Lactobacilli spp.) can eat. The ability of probiotic bacteria to break down these kinds of carbohydrates results in the production of SCFA during fermentation, which in turn supports growth of probiotic

(Buranawit and Laenoi, 2015; Budhisatria *et al*., 2017). Fiber, vitamins (Vitamin C, B6, pro-vitamin A), minerals (potassium, phosphorus, magnesium, zinc), and bioactive substances like phenolic compounds and resistant starch (RS) appear to be filled in green bananas **(Chávez-Salazar *et al*., 2017; Borges *et al*., 2009; Riquette *et al*., 2019; Hettiaratchi *et al*., 2011).** GB falls under the category of functional foods **(Anyasi *et al*., 2013).**

Prebiotic and probiotics that contained in synbiotic products are known to have the potential on decreasing cholesterol. Probiotic bacteria can decrease cholesterol by assimilating cholesterol and deconjugation of bile salts. The mechanism of *lactic acid bacteria* on decreasing cholesterol is increasing secretion of Bile Salt Hydrolase (BSH) enzyme. BSH enzyme separates glycine or taurine from steroids and produces deconjugated bile acids such as cholic acid which is less absorbed by small intestine, so it can decrease cholesterol level. Prebiotics in intestine will be fermented by probiotics to produce short-chain fatty acids (SCFA) which can decrease cholesterol **(D M Sumanti1 *et al*., 2020)**.

Gibson came up with the idea of prebiotics and then conjectured about the potential benefits of combining prebiotics and probiotics, which led to what he called "Synbiotics" **(Gibson *et al*., 2004).** The host benefits from a synbiotic product by improving the implantation and survival of live-microbial nutritional supplements in the (GI) gastrointestinal tract. By specifically increasing the development and/or the metabolism of one or a few health-promoting bacteria, this is achieved. As the name suggests, "synbiotics" should be used to describe products where the prebiotic chemical or substances directly benefit the probiotic organism or species **(Cencic and Chingwaru, 2010).**

Probiotics and prebiotics have been shown in numerous studies to have cholesterol-lowering effects, and there is evidence that utilizing them in combination is functionally more effective than taking them separately **(Luyao *et al*., 2024).**

Hyperlipidemia can be treated with changing lifestyle like diet, exercise, weight reduction and in some cases pharmacological intervention is needed **(Kawa and Hani, 2019).** The incidence of hyperlipidemia is increasing, and lifestyle changes are the primary treatment. It can cause cardiovascular disease if left untreated, increasing rates of morbidity and death worldwide. Behaviors like increased exercise, healthy eating, maintaining a BMI under 25, and other lifestyle modifications have been shown to significantly reduce both the prevalence of hyperlipidemia and its severity.

A key component of controlling and preventing hyperlipidemia is nutrition. Lifestyle medicine suggests eating a whole-food plant-based diet to prevent and treat hyperlipidemia **(L. Amy 2024).**

Aqueous and ethanol extracts of aerial parts also significantly lowered FBG, TGs, TC, LDL-C, and VLDL-C, and increased HDL-C concentration in diabetic rats. It is also reported to protect rats from cisplatin-nephrotoxicity **(Akbar & Akbar, 2020)**. Therefore, this study aimed to evaluate the effect of *Alhagi Maurorum* (Akool) on CCL_4- induced hepatotoxicity in rats.

MATERIALS AND METHODS

A- <u>Materials</u>

All chemicals, materials kits and cultures used for bacterial inoculum preparation are purchased from commercial agents.

Source and Maintenance of Probiotic Strains

Freeze-dried bacterial samples of Lactobacillus rahamnosus NRRL B-442, Lactobacillus gasseri NRRL-14168 and Lactobacillus brevis ATCC 14869 were kindly provided by the Department of Chemistry of Natural and Microbial Products, Pharmaceutical and Drug Industries Research Institute, National Research Center (NRC), Dokki, Egypt. The organisms were subcultured three times before use in sterile de Man, Rogosa, and Sharpe broth using 1 % inoculum, and were allowed to grow for 24 h at 37 °C. The inoculums were stored at 4°C between transfers.

B- <u>Methods</u>

Preparation of Dried green banana “Musa Sp.”:

The plant materials of healthy apparatus fruiting bodies of green banana (**Musa Sp.**) were brought to the laboratory in sterile bags. Samples were cut into small pieces and dried by solar energy, at the National Research Center, Giza, Egypt, then ground to powder in a mortar and stored at 4-8 °C in a refrigerator.

Formulation:

Three different probiotic strains, namely, Lactobacillus rahamnosus NRRL B-442, Lactobacillus gasseri NRRL-14168 and Lactobacillus brevis ATCC 14869 were freshly prepared every day and designed at a concentration of 1 ×

10^9 probiotics / mL. The dried banana as prebiotic was added to the standard diet at concentration of 3%.

Green banana composition of fibers:

The banana content of dietary fibers was determined according to AOAC (2019).

Experimental Animals:

Twenty-eight, male albino rats (Sprague-Dawley strain) weighting (140 - 150 g) were purchased from Farm of experimental animals in Helwan, Egypt. Rats were observed for several days after their arrival to the laboratory and given seven days to familiarize themselves with their new setting. The rats took in standard diet and also water for one week to be adaptable during the experimental period. The standard diet was synthesized as reported by **Reeves et al., (1993).** After the adaptation period, the animals were then randomly divided into the following four experimental groups:

I. **roup 1:** continued to be fed on the basal diet for another seven weeks and kept as a negative control group (normal rats).

II. **roup 2:** was fed on high-fat diet (HFD) with 20% saturated fats for a 7-week experiment period as a positive control group **(Xianping Li et al., 2022).**

III. **roup 3:** were fed on high-fat diet (HFD) for a 7-week experiment period, after two weeks of feeding, the rats were daily administered through oral gavage with one mL of 1×10^9 CFU probiotics / mL twice daily. The dried banana as prebiotic was added to the high-fat diet (HFD) at concentration of 3% for five weeks of such treatment.

IV. **roup 4:** was fed on basal diet mixed with grind dried banana at concentration of 3% and was given orally one mL of 1×10^9 CFU probiotics / mL twice daily for seven weeks.

Biological Evaluations:

During the experiment, all rats were observed each day, each animal's body weight was monitored every week, and any weight change was recorded. The Biological Evaluations included:

Determination of feed intake (FI) daily

Determination of body weight gain (BWG %) and feed efficiency ratio (FER)

Biochemical Analysis:

At the end of seven weeks of the experimental period, all rats were sacrificed after fasting overnight.

Collection of blood:

At the end of the experiment, all animals were anesthetized, and their blood was taken out by the technique of retro-orbital puncture. Blood samples were collected into EDTA tubes and then centrifuged at 3,000 rpm for 10 min at 4ºC. Serum was separated and stored in freezer at -20 ºC until analysis.

Lipid profile:

All the parameters of serum total cholesterol (TC), total triglycerides (TG) and high-density lipoprotein cholesterol (HDL-C) were measured using reagents and kits available from (Merck KGaA, Darmstadt, Germany) according to **Albers et al., (1983).** The values of low-density lipoprotein cholesterol (LDL-C) and very low-density lipoprotein cholesterol (VLDL- C) were calculated according to the equation of **Friedwald et al., (1972):**

$$\text{LDL} - \text{C (mg/dl)} = \text{TC} - [(\text{HDL- C}) + (\text{VLDL-C})]$$

$$\text{VLDL-C (mg/dl)} = \text{TG}/5$$

Liver Functions:

Serum Aspartate amino transferase (AST), Alanine amino transferase (ALT) and Alkaline phosphates (ALP) were determined according to **Bergmeyer et al., (1978).**

STATISTICAL ANALYSIS

Statistical analyses were carried out according to SAS, **(1996).** Descriptive data were reported as means ± standard deviation, and the results were analyzed statistically by a multiple comparison one-way analysis of variance, with the level of significance set at $p < 0.05$.

RESULTS AND DISCUSSION

Results in table 1 evaluate the impact of Probiotics and Banana Powder on growth performance in four groups of rats. The parameters assessed include: IBW (Initial Body Weight) - FBW (Final Body Weight) - FI (Feed Intake per day per rat) - BWG (Body Weight Gain in grams and percentage) - FER (Feed Efficiency Ratio).

All groups started the experiment with statistically similar initial body weight, this consistency in baseline weight confirms the homogeneity of the animal model at the beginning of the study.

When comparing the G3 with G2 notable differences were observed. G3 showed a significantly lower final body weight, food intake, body weight gain and feed efficiency ratio. These findings highlighting the role of synbiotics in controlling excessive weight gain, contributing to better metabolic outcomes, Improving lipid handling and reduced fat accumulation.

In the comparison between G4 and G1, G4 exhibited a markedly lower final body weight indicating a significant impact of synbiotics in reducing overall body mass under normal dietary conditions. This reduction may be beneficial for anti-obesity strategies or weight control regimens. Food intake was slightly higher which could suggest enhanced gut motility, increase metabolic turnover, or reduce caloric absorption due to microbial modulation. G4 displayed a negative body weight gain, a unique finding among all groups. This implies that synbiotics alone might exert strong regulatory effects on weight maintenance and energy balance.

These observations collectively indicate that synbiotic supplementation not only prevents excessive weight gain under high-fat conditions (as seen in G3) but may also promote weight reduction and improved energy balance under normal dietary conditions (as seen in G4). This supports the potential of synbiotics as a promising natural strategy for weight management and obesity prevention.

Results by **Nihar *et al.*, 2016** are not in agreement with the findings of Nihar and others, as he find that a total feed intake did not show any significant ($p>0.05$) difference between experimental groups. There were no significant ($p>0.05$) differences in feed conversion ratio of broiler chickens in prebiotic, probiotic, and synbiotic groups as compared with control group. In **Wang *et al.***'s meta-analysis at **2018** including 32 randomized controlled trials (1971 participants with various metabolic entities), it was proved that probiotics significantly reduced serum total cholesterol (MD = −13.27, 95% CI (−16.74–9.80), $p < 0.05$) in comparison to controls. Results by **Chaiyavat *et al.,* 2021** were align with my study as they shows that 12 weeks of synbiotics supplementation significantly reduced final body weight. Another study by **Kapil *et al.,* 2020** that investigate if dietary synbiotic supplementation was helpful. It was concluded that the 0.2% mannan-oligosaccharides supplementation along with Lac*tobacillus acidophilus* at 10^6 CFU/g is optimum for better growth performance.

Table 2 evaluates the impact of Probiotics and Banana Powder on Lipid Profile. The parameters assessed include Total Cholesterol (TC), Triglycerides (TG), High-Density Lipoprotein (HDL), Low-Density Lipoprotein (LDL) and Very Low-Density Lipoprotein (VLDL).

A clear distinction was observed between the G3 and G2. Group G3 exhibited a notable improvement in HDL levels and reductions in total cholesterol, triglycerides, LDL and VLDL These improvements strongly indicate that the addition of synbiotics effectively counteracts the effects of a high-fat diet, likely through their roles in gut microbiota modulation and lipid absorption regulation.

Group G4 demonstrated superior outcomes even when compared to G1, G4 exhibited a significant reduction in triglycerides and VLDL and a substantial increase in HDL levels. This suggests that synbiotic supplementation, even in the absence of dietary fat stress, has the potential to enhance lipid regulation and improve overall metabolic health by promoting favorable shifts in lipoprotein profiles.

The results by **Amir *et al.,* 2020** were in line with Amir and others when they study effects of synbiotic on lipid profile; they find that synbiotic consumption resulted in a significant decrease in plasma concentrations of total cholesterol by (10.17 mg/dL) and an increase in plasma high-density lipoprotein cholesterol by (1.3 mg/dL). The effects are more pronounced when synbiotics supplements are consumed for > 8 weeks. Findings by **Elham *et al.,* 2020** align with my results as they find that synbiotics supplementation effect on lipid profiles, resulted in a significant decrease in Low-density lipoprotein cholesterol value (4.66 mg/dL) and a significant increase in high-density lipoprotein cholesterol (1.80 mg/dL). But they are not in agreement with some findings because they failed to find a significant effect of synbiotics consumption on total cholesterol and triglyceride levels. Another study by **Rui *et al.*, 2019** that was so far from my results tell that they had no significant effects of probiotics on triglyceride (TG) and high-density lipoprotein cholesterol (HDL-C) levels were found in hypercholesterolaemic adults.

Table 3 evaluates the impact of Probiotics and Banana Powder on .Liver Functions. The parameters assessed include: AST, ALT, and ALP

G3 group exhibited significantly lower levels of AST, ALT, and ALP compared to G2. This suggests a hepatoprotective effect of the synbiotic combination, likely due to the anti-inflammatory and antioxidant properties of probiotics and the prebiotic effect of banana, which together may help restore gut-liver axis balance and reduce metabolic stress.

G4 group demonstrated a marked reduction in AST compared to G1, indicating a possible enhancement of baseline liver function or improved hepatic enzyme regulation.

Collectively, these findings underscore the therapeutic potential of synbiotics in mitigating liver dysfunction associated with high-fat diets and suggest possible benefits even under normal dietary conditions.

Placebo-controlled, double-blind intervention study by **Aakash *et al.*, 2024** agreed with my study, as they find that a seven-week intake of a specific synbiotic supplement containing 2 × 10^9 CFU probiotic bacteria of five strains (*Bifidobacterium lactis*, *Lactobacillus acidophilus*, *Lactobacillus casei*, *Lactobacillus salivarius*, and *Lactococcus lactis*) and inulin from agave as a prebiotic resulted in a reduction in ALT concentration in metabolically healthy participants, highlighting the possible impact of synbiotics in the disease prevention due to potential microbiome-modulating properties. This finding was more prominent in participants with higher body fat percentages. Thus, participants at a risk of developing (Dysfunction-Associated Fatty Liver Disease) and metabolic syndrome may benefit from synbiotic interventions. Analysis by **Sukrit *et al.*, 2022** Of 3,864 identified records, a total of 1,389 patients with Nonalcoholic fatty liver disease Among adult patients with

NAFLD, when compared with placebo, synbiotics provided the largest effect on reductions of AST (-12.71) and probiotics lowered ALT (-14.46).

Table (1): Probiotics and Banana Powder on Growth Performance Parameters

Groups	IBW (g)	FBW (g)	FI (g/d/rat)	BWG (g)	BWG (%)	FER
Control (-Ve)	152.4±0.43^{a}	214.6±0.92^{d}	17	62.2±0.61^{d}	40.87±0.80^{c}	0.065±0.002^{c}
Control (+Ve)	152.8±0.58^{a}	244.0±0.70^{a}	21	91.2±0.28^{a}	59.71±0.60^{a}	0.077±0.001^{a}
G3 (High Fat Diet) Probiotics+Banana	154.4±0.51^{a}	227.8±0.73^{b}	18	73.4±0.40^{b}	47.54±0.31^{b}	0.072±0.001^{b}
G4 Probiotics+Banana	15٤.٨ ± 0.57^{a}	149.8 ± 0.42d	19	-0.5 ± 0.63^{d}	-3.22 ± 0.40^{d}	-0.005 ± 0.000^{c}

Results are expressed as mean ± SE.
Values in each column which have different letters are significantly different at (P<0.05).

Table (2): Effect of Probiotics and Banana Powder on Lipid Profile (TC, TG, HDL, LDL, VLDL)

Groups	TC mg/dl	TG mg/dl	HDL mg/dl	LDL mg/dl	VLDL mg/dl
Control (-Ve)	109.56±0.95^{c}	57.86±0.72^{d}	40.74±0.54^{a}	57.29±0.41^{d}	11.53±0.14^{d}
Control (+Ve)	139.36±0.100^{a}	83.28±0.50^{a}	24.52±0.29^{d}	98.18±0.82^{a}	16.65±0.10^{a}
G3 (High Fat Diet) Probiotics+Banana	133.12±0.89^{b}	73.11±0.90^{b}	27.33±0.55^{c}	91.16±0.50^{b}	14.61±0.18^{b}
G4 Probiotics+Banana	114.57±0.0.724^{c}	52.68±0.54^{d}	43.25±0.52^{a}	60.78±0.74^{c}	10.54±0.10^{d}

Results are expressed as mean ± SE.
Values in each column which have different letters are significantly different at (P<0.05).

Table (3): Effect of Probiotics and Banana Powder on Liver Functions (AST, ALT, ALP)

Groups	AST (µ /L)	ALT (µ /L)	ALP (mg/dL)
Control (-Ve)	28.02±0.51^{d}	47.53±0.30^{d}	119.18±0.51^{d}
Control (+Ve)	49.98±0.56^{a}	96.13±0.57^{a}	171.58±0.74^{a}
G3 (High Fat Diet) Probiotics+Banana	41.98±0.30^{b}	82.70±0.56^{b}	157.18±0.54^{b}
G4 Probiotics+Banana	38.38±0.31^{c}	71.53±0.67^{c}	162.98±0.19^{c}

Results are expressed as mean ± SE.
Values in each column which have different letters are significantly different at (P<0.05).

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تأثير المكمل الغذائي سينبيوتيك على مستوى الدهون ووظائف الكبد لدى الفئران المصابة بارتفاع دهون الدم

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الملخص العربي

أُجريت هذه الدراسة بهدف تقييم تأثير المكمل الغذائي سينبيوتيك على مستوى الدهون ووظائف الكبد لدى الفئران المصابة بارتفاع دهون الدم. شملت الدراسة ٢٨ فأرًا من الذكور البيضاء (سلالة سبراغ-داولي)، تم تقسيمهم إلى أربع مجموعات على النحو التالي: المجموعة الأولي وهي المجموعة الضابطة السلبية. المجموعة الثانية وهي المجموعة الضابطة الإيجابية. المجموعة الثالثة تم تغذيتها على نظام غذائي عالي الدهون لمدة سبعة أسابيع، حيث تم، ابتداءًا من الأسبوع الثالث ولمدة خمسة أسابيع، إعطاء الفئران محلولًا يحتوي على البروبيوتيك بتركيز ١× ١٠^٩ وحدة تشكيل مستعمرة في ١ مل عن طريق الفم بمعدل مرتين يوميًا، بالإضافة إلي مسحوق الموز المجفف كمصدر للبريبيوتيك بنسبة ٣ % إلى النظام الغذائي عالي الدهون. المجموعة الرابعة :تم تغذيتها على نظام غذائي أساسي مضاف إليه مسحوق الموز المجفف بنسبة ٣٪، كما تم إعطاؤها محلولًا يحتوي علي البروبيوتيك بتركيز ١× ١٠^٩ وحدة تشكيل مستعمرة في ١ مل ، وذلك بمعدل مرتين يوميًا طوال فترة السبعة أسابيع. تم دراسة تأثير المكمل الغذائي سينبيوتيك على <u>الملف الدهني</u>، ويشمل: (الكوليسترول الكلي - الدهون الثلاثية - البروتين الدهني منخفض الكثافة - البروتين الدهني عالي الكثافة - البروتين الدهني منخفض الكثافة جدًا)، وكذلك على <u>وظائف الكبد</u>، وتشمل: (ناقلة أمين الألانين - ناقلة أمين الأسبارتات - الفوسفاتيز القلوي) بالإضافة إلي <u>قياسات توضح مستوي النمو والتغذية</u> في الفئران، وتشمل: (الوزن في بداية التجربة – الوزن بعد الانتهاء من التجربة – كمية الغذاء المستهلك – مقدار الزيادة في الوزن – مدي كفاءة الفئران في تحويل الغذاء لوزن)، تشير النتائج إلى أن السينبيوتيك (مزيج الموز الأخضر مع البكتيريا النافعة) يؤثر إيجابيًا على أيض الدهون، من خلال خفض مستوي الدهون الضارة بالدم ورفع مستوي الكوليسترول الجيد، مما قد يُسهم في السيطرة على حالة ارتفاع دهون الدم. وفي حين أن مجموعة الضبط الإيجابية (المجموعة الثانية) سجلت أعلى كفاءة تحويل غذائي، زيادة في الوزن واستهلاكًا غذائيًا أكبر، أظهرت مجموعتا السينيبيوتيك (المجموعة الثالثة والرابعة) انخفاضًا في كفاءة التحويل الغذائي ومعدل زيادة الوزن، تميزت المجموعة الرابعة بشكل خاص بفقدان وزن فعلي رغم تناولها كميات أكبر من الطعام مقارنة بالمجموعة الظابطة السلبية مما يدل على أن السينيبيوتيك له دور فعّال في تقليل تراكم الدهون وتنظيم الوزن.

بالإضافة إلى ذلك، أظهرت المجموعتان انخفاضًا في مستويات إنزيمات الكبد (ناقلة أمين الألانين - ناقلة أمين الأسبارتات - الفوسفاتيز القلوي) مقارنة بالمجموعة الضابطة الإيجابية، مما يعكس تأثيرًا وقائيًا على وظائف الكبد. ومن الملاحظ أن المجموعة الرابعة أظهرت تحسنًا ملحوظًا في مستويات دهون الدم ومستويات إنزيمات الكبد وقياسات النمو والتغذية، مما جعلها المجموعة الأكثر فعالية في تقليل الأضرار المحتملة بالكبد نتيجة تناول غذاء عالي المحتوي من الدهون وتحسين الصحة العامة من خلال تحسين مستويات دهون الدم وتعزيز النمو.

الكلمات المفتاحية : البروبيوتيك؛ الفعالية في خفض الكوليسترول؛ ارتفاع دهون الدم؛ الميكروبيوتا؛ البريبيوتيك؛ السينبيوتيك؛ الموز الأخضر؛ البكتيريا.