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COMPARATIVE ANALYSIS OF THE EFFECT OF NATURAL SUGAR AND STEVIA ON THE BIOCHEMICAL PARAMETERS, BLOOD PROFILE, MDA, AND BODY WEIGHT OF RABBITS FROM NEW ZEALAND

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Abstract

This study compared the metabolic effects of stevia versus natural sugar in New Zealand White rabbits (n=30) over 30 days. Animals were divided into control, natural sugar (5% solution), and stevia (5 mg/kg/day) groups, with comprehensive metabolic profiling conducted at days 0, 15, and 30. The natural sugar group developed significant metabolic alterations, including elevated glucose (186.5 ± 5.2 vs. 112.0 ± 5.2 mg/dL in stevia, ($p < 0.0001$), uric acid (4.54 ± 0.05 vs. 2.53 ± 0.05 mg/dL), creatinine (1.81 ± 0.03 vs. 0.65 ± 0.03 mg/dL), and oxidative stress markers (78% increase in MDA levels). In contrast, the stevia group maintained metabolic parameters comparable to controls, showing no adverse effects on glucose homeostasis, lipid profiles, or oxidative stress markers. Natural sugar consumption also led to pronounced dyslipidemia (total cholesterol: 118.6 ± 2.59 vs. 61.1 ± 2.59 mg/dL in stevia) and greater weight gain (3.37 ± 0.42 vs. 2.84 ± 0.42 kg), while stevia demonstrated only moderate weight effects without metabolic disruption. Hematological analysis revealed no significant differences between groups. These findings indicate that stevia, unlike natural sugar, does not induce metabolic dysfunction and may

serve as a healthier alternative sweetener. Further long-term studies are needed to confirm these protective effects.

Keywords: Natural Sugar, Stevia, MDA biochemical parameters, NewZealand rabbits.

تحليل مقارن لتأثير السكر الطبيعي وستيفيا على المؤشرات البيوكيميائية، وصورة الدم، ومستوى المالونداياالديهيد (MDA)، ووزن الجسم في الأرانب النيوزيلندية

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الخلاصة

هدفت هذه الدراسة إلى مقارنة التأثيرات الأيضية لسكر ستيفيا مقابل السكر الطبيعي في أرانب نيوزيلندا البيضاء (ن=30) على مدى 30 يوماً. تم تقسيم الحيوانات إلى ثلاث مجموعات: مجموعة تحكم، مجموعة سكر طبيعي (محلول 5%)، ومجموعة ستيفيا (5 مل غ/كغ/يوم)، مع إجراء تحليل شامل للمؤشرات الأيضية في الأيام 0، 15، و30. أظهرت مجموعة السكر الطبيعي اضطرابات أيضية كبيرة تشمل: ارتفاع مستويات الجلوكوز (186.5 ± 5.2 مقابل 112.0 ± 5.2 ملغ/دل في مجموعة ستيفيا، $p < 0.0001$) زيادة حمض البوليك (4.54 ± 0.05 مقابل 2.53 ± 0.05 ملغ/دل) ارتفاع الكرياتينين (1.81 ± 0.03 مقابل 0.65 ± 0.03 ملغ/دل) زيادة مؤشرات الإجهاد التأكسدي (78% ارتفاع في مستويات MDA) في المقابل، حافظت مجموعة ستيفيا على استقرار أيضي مشابه لمجموعة التحكم، دون أي تأثيرات سلبية على: توازن الجلوكوز مستويات الدهون مؤشرات الإجهاد التأكسدي كما أدى استهلاك السكر الطبيعي إلى: خلل في دهون الدم (الكوليسترول الكلي: 118.6 ± 2.59 مقابل 61.1 ± 2.59 ملغ/دل في ستيفيا) زيادة أكبر في الوزن (3.37 ± 0.42 مقابل 2.84 ± 0.42 كغ) بينما أظهرت ستيفيا تأثيرات متوسطة على الوزن دون أي اضطرابات أيضية. التحاليل الدموية لم تظهر فروقاً معنوية بين المجموعات. الاستنتاجات: تثبت هذه النتائج أن ستيفيا، على عكس السكر الطبيعي، لا تسبب اختلالاً في التمثيل الغذائي، مما يدعم استخدامها كمحلي بديل أكثر أماناً. هناك حاجة لمزيد من الدراسات طويلة المدى لتأكيد هذه التأثيرات الوقائية.

كلمات مفتاحية: سكر طبيعي، ستيفيا، MDA، الارانب النيوزلندية.

Introduction

The consumption of dietary sugars, particularly in the form of sucrose and high-fructose corn syrup, has become a major public health concern due to its association with metabolic disorders. Excessive sugar intake contributes significantly to the global burden of obesity, type 2 diabetes mellitus (T2DM), and cardiovascular diseases (CVDs) (22). The metabolic consequences of high sugar consumption include insulin resistance, dyslipidemia, and systemic inflammation, all of which are key components of metabolic syndrome (32). In response to these risks, the World Health Organization (WHO) strongly recommends reducing free sugar intake to less than 10% of total daily energy consumption, with further benefits observed at levels below 5% (41).

Natural non-caloric sweeteners, such as Stevia rebaudiana Bertoni, have gained attention as potential alternatives to sugar. Stevia contains bioactive compounds known as steviol glycosides, which provide a sweet taste without contributing to caloric intake or glycemic response (4). Beyond its role as a sweetener, stevia has demonstrated anti-hyperglycemic, anti-inflammatory, and antioxidant properties in both animal and human studies (6). These characteristics suggest that stevia may not only serve as a sugar substitute but also offers protective metabolic effects, unlike natural sugars, which have been linked to oxidative stress and metabolic dysregulation (19).

Oxidative stress is a critical mediator in the pathogenesis of metabolic diseases, and malondialdehyde (MDA), a byproduct of lipid peroxidation, serves as a reliable biomarker for assessing oxidative damage (7). Elevated MDA levels have been correlated with insulin resistance, inflammation, and the progression of atherosclerosis (39). Dietary habits, particularly high sugar intake, significantly influence oxidative stress markers, with studies showing that excessive sucrose consumption increases MDA production and reduces antioxidant defenses (13). Therefore, evaluating MDA levels alongside traditional metabolic parameters—such as blood glucose, lipid profiles, and liver enzymes—provides a comprehensive assessment of the physiological impact of sweeteners (3).

Animal models play a crucial role in nutritional research, and the New Zealand white rabbit has been widely used due to its metabolic similarities to humans, particularly in lipid and carbohydrate metabolism (38). Rabbits develop diet-induced metabolic syndrome features, including dyslipidemia and insulin resistance, making them an ideal model for studying the effects of dietary interventions (1). Previous studies have successfully utilized this model to investigate the metabolic effects of various sweeteners, including artificial and natural alternatives (34).

Emerging evidence suggests that sweeteners influence not only metabolic pathways but also gut microbiota composition, which plays a pivotal role in overall metabolic health (9). While artificial sweeteners have been associated with gut dysbiosis and glucose intolerance (33), the effects of stevia on the microbiome remain less understood. Preliminary studies indicate that stevia may have a more favorable impact on gut bacteria compared to synthetic sweeteners, but further research is needed to confirm these findings (10).

This study explores the effect of stevia and natural sugar consumption on the body weight, blood profile, MDA level, and biochemical parameters of New Zealand rabbits.

The results can help guide future nutritional biochemistry research and diet choices by providing a better insight into the metabolic effects of various sweeteners. In order to provide evidence-based choices on whether stevia is acceptable as a sugar substitute, this study compares these parameters under controlled experimental conditions.

Materials and Methods

Experimental Animals and Housing Conditions: Thirty New Zealand white rabbits aged 6–8 weeks (body weight 1.5 ± 0.12 kg) were housed individually in stainless steel cages (60×40×35 cm) at the University of Anbar animal house. The environment was strictly controlled (22±2 °C, 50-60% relative humidity, 12-h light/dark cycle) based on international standards for laboratory rabbits (3). All the rabbits received:

- Normal pelleted feed (18% protein, 2.5% fat, 12% fiber)
- Unlimited access to filtered water
- Regular daily medical checkups by a professional veterinarian

Study Design and Treatment Groups: After acclimatization, the rabbits were randomly allocated into three weight-matched groups (n=10/group):

1. Control: standard diet + 1 mL distilled water (oral gavage).
2. Sucrose: standard diet + 5% sucrose solution (equivalent sweetness to stevia dose).
3. Stevia: standard diet + 5 mg/kg/day stevia extract (≥95% steviol glycosides; purity verified by HPLC).

The stevia dose was selected based on previous metabolic experiments demonstrating efficacy without toxicity in rabbits (10 and 24). Fresh solutions were prepared daily in distilled water and administered by oral gavage at 09:00 h to minimize circadian variability.

Blood Collection Protocol: Rigorous standardization was implemented for all sampling procedures:

- Timing: collections between 08:00-10:00 h (fasted state) on days 0, 15, and 30
- Technique: aseptic marginal ear vein puncture using 23G needles (BD PrecisionGlide)
- Sample processing:
    - 2 mL in EDTA tubes (BD Vacutainer) for immediate hematology.
    - 2 mL in serum tubes (clotted 30 min at RT, then centrifuged at 3000×g/10 min/4°C).
- Storage: serum aliquots at -80 °C until analysis (maximum 4 weeks).

Hematological Analysis: A Sysmex KX-21N analyzer calibrated for rabbit specimens was used to perform complete blood counts in less than two hours (15). Among the items in the quality control methodology were:

1. Daily calibration with species-specific controls (Sysmex Animal Hematology Control)
2. Duplicate analysis for samples with abnormal indices (CV <5%)
3. Strict hemolysis rejection criteria (plasma hemoglobin >0.2 g/dL)

Statistical Analysis: SAS statistical software (SAS Institute Inc., version 9.4, Cary, NC, USA) was utilized for analysis. Experimental data were analyzed through completely randomized design analysis. Mean ± standard deviation (SD) was shown to represent the results. Duncan's multiple comparisons test was utilized to compare groups. Statistical significance level was $p < 0.0001$ (18).

Results and Discussion

Biochemical Parameters: A comparison of biochemical measurements showed pronounced treatment-induced effects throughout the experimental duration of 30 days (Table 1). At the initial study time point (Day 0), no differences existed in albumin, creatinine, glucose, and uric acid levels between the control, stevia sugar, and natural sugar groups ($p<0.0001$). However, on Day 15, the rabbits receiving natural sugar had considerably higher levels of all of these biochemical markers in comparison to the control and stevia sugar groups ($p<0.0001$), which continued through Day 30.

Of particular interest was the stability of biochemical profiles within the stevia sugar group, which was similar to the control group over the study duration. This metabolic stability is consistent with research by (31) who indicated slight perturbation of glucose homeostasis in rodent models fed extracts of stevia. In the same view, (29) showed that stevia glycosides support normal liver function without altering albumin synthesis pathways in comparison to calorific sweeteners.

On Day 30, the natural sugar group had significantly higher levels of albumin concentration (5.43 ± 0.06 g/dL), creatinine level (1.81 ± 0.03 mg/dL), glucose level (186.5 ± 5.2 mg/dL), and uric acid levels (4.54 ± 0.05 mg/dL) than the stevia sugar group (3.62 ± 0.06 g/dL, 0.65 ± 0.03 mg/dL, 112.0 ± 5.2 mg/dL, and 2.53 ± 0.05 mg/dL, respectively) and the control groups. These results are in line with research by (2), who showed that high-sucrose diets cause systemic metabolic disturbances, such as glucose intolerance and abnormal protein metabolism in laboratory animals.

This corroborates the results by (40), who documented the linkage between carbohydrate use and early signs of sort damage. Moreover, (12) offered evidence of incessant hyperglycemia augmenting glomerular filtration. This consistent hyperglycemia also underlies the raised creatinine levels seen in the animals on the sugar diet in this study.

The rise in uric acid levels in the carbohydrate group (4.54 ± 0.05 mg/dL) as compared to the control group (2.48 ± 0.05 mg/dl) and stevia carbohydrate group (2.53 ± 0.05 mg/dl). This supports the finding of the unfavorable effect of sugars on absorption. As noted by (17), this hyperuricemia may cause strong purine disintegration as well as weakened renal clearance. Fructose was projected as a uric acid builder and a key driver of metabolic conditions.

The natural sugar group showed dramatic increases in glucose levels from baseline (109.5 ± 5.2 mg/dL) to Day 30 (186.5 ± 5.2 mg/dL), an increase of nearly 70%. This hyperglycemia is likely on account of lowered insulin sensitivity, as (27) show extreme and oxygen diets reduce insulin indicating the adeptness of minor tissues. In the control and stevia sugar groups, the latest asserted fixed sweet liquid levels during the entire experiment, extending to 111.7 ± 5.2 mg/dL for the control group and 112.0 ± 5.2 mg/dL for the stevia group, thereby displaying maintained glycemic control.

Table 1: Summary of Biochemical Parameters Across Treatments and Time Points.

Parameter	Day	control (Mean ± SE)	stevia sugar (Mean ± SE)	natural sugar (Mean ± SE)	Significance
Albumin (g/dL)	0	3.39 ± 0.06^{b}	3.42 ± 0.06^{b}	3.73 ± 0.06b	p<0.0001
	15	3.49 ± 0.06^{b}	3.52 ± 0.06^{b}	5.13 ± 0.06^{a}	p<0.0001
	30	3.59 ± 0.06^{b}	3.62 ± 0.06^{b}	5.43 ± 0.06^{a}	p<0.0001
Creatinine (mg/dL)	0	0.55 ± 0.03^{b}	0.56 ± 0.03^{b}	0.53 ± 0.03b	p<0.0001
	15	0.65 ± 0.03^{b}	0.65 ± 0.03^{b}	1.61 ± 0.03^{a}	p<0.0001
	30	0.65 ± 0.03^{b}	0.65 ± 0.03^{b}	1.81 ± 0.03^{a}	p<0.0001
Glucose (mg/dL)	0	109.8 ± 5.2^{b}	109.8 ± 5.2^{b}	109.5 ± 5.2b	p<0.0001
	15	113.7 ± 5.2^{b}	114.1 ± 5.2^{b}	172.5 ± 5.2^{a}	p<0.0001
	30	111.7 ± 5.2^{b}	112.0 ± 5.2^{b}	186.5 ± 5.2^{a}	p<0.0001
Uric Acid (mg/dL)	0	2.30 ± 0.05^{b}	2.32 ± 0.05^{b}	2.35 ± 0.05b	p<0.0001
	15	2.41 ± 0.05^{b}	2.43 ± 0.05^{b}	4.27 ± 0.05^{a}	p<0.0001
	30	2.48 ± 0.05^{b}	2.53 ± 0.05^{b}	4.54 ± 0.05^{a}	p<0.0001

Values are presented as mean ± SE. Different superscript letters in the same row indicate significant differences between groups ($p < 0.0001$).

Oxidative Stress Marker – MDA: Malondialdehyde (MDA), a key indicator of oxidative stress and lipid peroxidation, demonstrated significant position-dependent differences during the whole of the preliminary conclusion (Figure1). At standard, MDA levels were similar across all position groups (control: 1.57 ± 0.04 nmol/mL; stevia hydrogen: 1.57 ± 0.04 nmol/mL; open carbohydrate: 1.53 ± 0.04 nmol/mL), meaning identical oxidative levels at the study's beginning. By Day 15, there was a significant difference, with the unrefined oxygen group producing remarkably elevated MDA levels (2.53 ± 0.04 nmol/mL) compared to the control and stevia oxygen groups at 1.67 ± 0.04 nmol/mL; p<0.0001).

This situation changed by Day 30, with the organic hydrogen-improved animals showing further increases in MDA (2.73 ± 0.04 nmol/mL), while the control and stevia oxygen groups registered fixed levels at 1.67 ± 0.04 nmol/mL). The strong increase in MDA levels seen in the carbohydrate group (from 1.53 ± 0.04 nmol/mL at Day 0 to 2.73 ± 0.04 nmol/mL by Day 30) shows heightened lipid peroxidation and oxidative stress, most likely due to metabolic dysregulation. This oxidative reaction to excessive hydrogen absorption was noted by (42), who demonstrated that persistent natural compound element use considerably raises lipid peroxidation levels. More recently, (26) support this finding noticing an increase in oxidative stress biomarkers, such as MDA, following extreme and high oxygen loads in models.

The almost 78% increase in MDA levels in the unaffected sugar group from start to Day 30 shows significant oxidative damage to basic membranes and macromolecules. (20) explained the reasons underlying carbohydrate-inferred oxidative stress, showing that overdone sweet liquid absorption generates sensitive oxygen variety through multiple pathways, containing polyol road flux, leading glycation end-produce establishment, and mitochondrial electron transport chain dysfunction. In contrast, the MDA levels in the control and stevia sugar groups during the entire 30-day study implies that stevia does not encourage oxidative stress, unlike organic carbohydrates. This finding is consistent with (35), who noted antioxidant characteristics in steviol

glycosides, indicating the possibility of counteracting potential oxidant-supporting disorders.

Additionally, (5) reported that stevia compounds mobilize nuclear erythroid 2-related factor 2 (NRF2) signaling pathways that upregulate inner antioxidant justification schemes, potentially demonstrating the anti-oxidative stress observed in the stevia carbohydrate group. The protection of oxidative equilibrium in the stevia sugar group regardless of consumption shows an important metabolic benefit over natural carbohydrate. As oxidative stress plays a main role in the pathogenesis of metabolic disorders, containing diabetes and heart failure (36), the differential factors on MDA levels from stevia and natural carbohydrates may have major implications for complete strength outcomes.

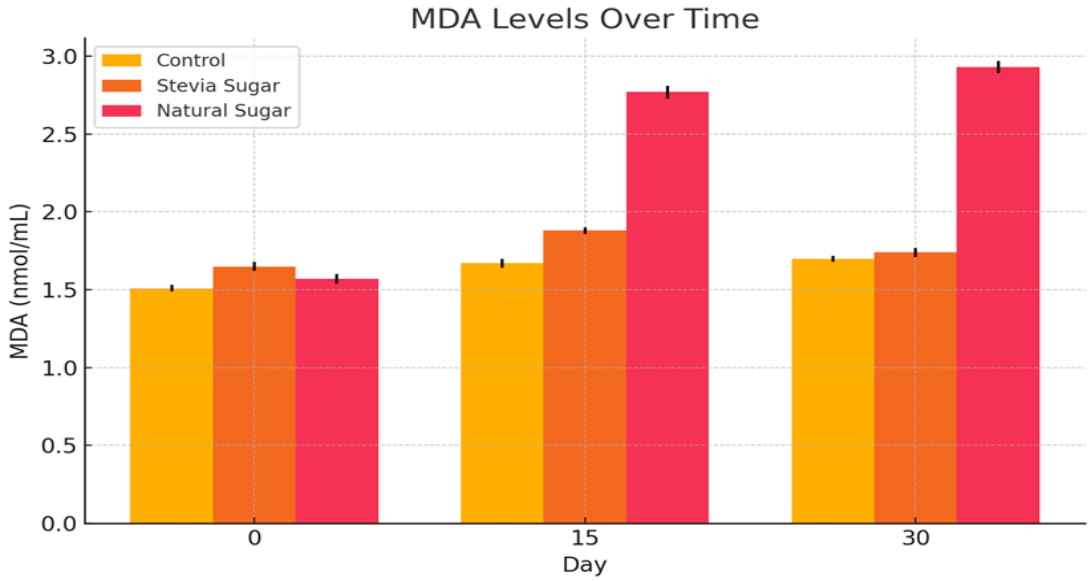

Figure 1: Summary of MDA Parameter Across Treatments and Time Points.

chart showing the MDA levels over time for the Control, Stevia Sugar, and Natural Sugar groups.

Hematological Parameters: Analysis of hematological parameters (Table 2) disclosed no statistically significant differences among the three treatment groups. However, there were significant variances in white blood cell counts at 7.25 ± 3.25 $\times 10^3/\mu L$ for the control, 9.66 ± 5.61 $\times 10^3/\mu L$ for the stevia carbohydrates, and 12.55 ± 6.36 $\times 10^3/\mu L$ for common sugar, while platelet counts were 123.00 ± 99.47 $\times 10^3/\mu L$, 229.00 ± 185.00 $\times 10^3/\mu L$, and 553.00 ± 185.00 $\times 10^3/\mu L$, respectively. These differences do not offer any statistical meaning. The lack of significant hematological changes did not substantially impact hematopoietic functions over the 30-day experimental period. However, the elevated WBC and platelet counts in the unrefined sugar group, while not having any statistical significance, merit further study over longer durations.

These findings are consistent with (21) who documented minor changes in the hematological parameters from the consumption of sweeteners in tests on animals. Interestingly, (36) stated that constant hyperglycemia can induce skin redness, potentially illustrating the statistical increase in WBC counts observed in the common sugar group. Additionally, (16) disclosed that sensitive thrombocytosis can occur as an

adverse or unwanted secondary effect to metabolic stress, that could account for the raised platelet flows in the natural carbohydrate-augmented rabbits.

While this experiment did not yield significant hematological differences, the statistical trends warrant further analysis over longer durations. (17) showed that extended exposure to sweeteners significantly alter bone essence microenvironments and hematopoietic stem container function, suggesting that hematological impacts may be seen over longer durations.

Table 2: Blood Picture Parameters Across Treatments.

Parameter	control (Mean ± SE)	stevia sugar (Mean ± SE)	natural sugar (Mean ± SE)	Statistical Significance
WBC (×10³/µL)	7.25 ± 3.25a	9.66 ± 5.61	12.55 ± 6.36	NS
Lymph (×10³/µL)	1.91 ± 0.97 a	2.97 ± 1.68	4.37 ± 2.08	NS
Gran (×10³/µL)	5.42 ± 1.84	5.34 ± 3.52	7.03 ± 3.52	NS
Mid Cells (×10³/µL)	1.04 ± 0.20	1.54 ± 0.35	1.15 ± 0.35	NS
RBC (×10⁶/µL)	5.24 ± 0.25	4.76 ± 0.44	5.38 ± 0.44	NS
HGB (g/dL)	14.00 ± 0.56	13.60 ± 0.96	15.30 ± 0.96	NS
HCT (%)	0.43 ± 0.06	0.30 ± 0.11	0.33 ± 0.11	NS
MCV (fL)	82.93 ± 13.12	63.10 ± 22.73	62.10 ± 22.73	NS
MCH (pg)	26.70 ± 0.85	28.70 ± 1.28	28.60 ± 1.28	NS
MCHC (g/dL)	35.30 ± 4.94	45.45 ± 8.58	46.05 ± 8.58	NS
PLT (×10³/µL)	123.00 ± 99.47	229.00 ± 185.00	553.00 ± 185.00	NS
MPV (fL)	8.10 ± 0.78	5.55 ± 1.16	5.65 ± 1.16	NS
PDW (%)	8.17 ± 1.51	5.60 ± 2.61	5.25 ± 2.61	NS
PCT (%)	1.07 ± 0.48	2.66 ± 0.91	2.82 ± 0.91	NS

Values are presented as mean ± SE. Different superscript letters in the same row indicate significant differences between groups ($p < 0.0001$).

Lipid Profile: The lipid limits displayed pronounced negative effects (Table 3). While no significant differences were noticed at the base level, marked changes were seen by Day 15 in the open sugar group which developed considerably elevated levels of total cholesterol (104.2 ± 2.56), triglycerides (134.3 ± 2.68), and VLDL (26.86 ± 0.54) compared to the control and stevia sugar groups ($p<0.05$). These lipid differences were more severe by Day 30, with the everyday carbohydrate group showing further increases in cholesterol (118.6 ± 2.59), triglycerides (149.2 ± 2.68), and VLDL (29.84 ± 0.54).

These findings are supported by (24) who documented similar dyslipidemia conditions in animal models absorbing high-organic compounds composed of carbon diets. Recent inquiries by (27) on latent sucrose-inferred dyslipidemia, showed that excessive sugar intakes upregulate hepatitis lipogenesis while impairing lipoprotein removal as occurs in hyperlipidemia.

Notably, stevia sugar dominance resulted in lipid results corresponding to the control group over the study period, and showed no meaningful differences between these two groups at any time points. This supports growing evidence that stevia displays a metabolically favorable alternative to caloric sweeteners, as noted by (28) in their review of the effects on cardiometabolic stones. Supporting this conclusion, an inclusive metabolomic analysis by (14) showed that stevia glycosides do not turn on lipogenic pathways in hepatocytes, unlike oxygen-holding sweeteners that induce

hepatic triglyceride synthesis. Further research by (37) found that stevia compounds actually prevent key enzymes involved in cholesterol combination, potentially indicating the friendly lipid profiles noted in the stevia group in this study.

Additionally, (25) revealed that steviol glycosides harmonize negative acid absorption and enhance minor cholesterol approval, thus contributing to their neutral or conceivably advantageous characteristics on lipid homeostasis.

Table 3: Lipid Profile Comparison (Mean ± SE) by Treatment and Time Point.

Lipid	Treatment	Day 0	Day 15	Day 30
Cholesterol	**control**	56.6 ± 2.55 (a)	59.9 ± 2.56 (a)	58.4 ± 2.59 (a)
	stevia sugar	59.8 ± 2.55 (a)	62.9 ± 2.56 (a)	61.1 ± 2.59 (a)
	natural sugar	60.3 ± 2.55 (a)	104.2 ± 2.56 (b)	118.6 ± 2.59 (b)
Triglycerides	**control**	76.6 ± 2.75 (a)	79.9 ± 2.68 (a)	78.4 ± 2.68 (a)
	stevia sugar	79.8 ± 2.75 (a)	82.9 ± 2.68 (a)	81.1 ± 2.68 (a)
	natural sugar	80.3 ± 2.75 (a)	134.3 ± 2.68 (b)	149.2 ± 2.68 (b)
VLDL	**control**	15.32 ± 0.55 (a)	15.98 ± 0.54 (a)	15.68 ± 0.54 (a)
	stevia sugar	15.96 ± 0.55 (a)	16.58 ± 0.54 (a)	16.22 ± 0.54 (a)
	natural sugar	18.86 ± 0.55 (a)	26.86 ± 0.54 (b)	29.84 ± 0.54 (b)

Values are presented as mean ± SE. Different superscript letters in the same row indicate significant differences between groups ($p < 0.0001$).

Body Weight: Body weight measurements (Table 4) revealed different levels of weight gain depending on sweetener type. While no significant differences were observed between treatment groups at baseline, evident weight variations emerged by Day 15 ($p<0.0001$). The natural sugar group shown the highest weight gain (3.38 ± 0.39), followed by the stevia sugar group (2.81 ± 0.39), with the control showed the smallest weight change (1.55 ± 0.39). This pattern continued through Day 30, with weights of 3.37 ± 0.42, 2.84 ± 0.42, and 1.59 ± 0.42 for normal sugar, stevia carbohydrate, and control groups, respectively.

The in-between weight gain noticed in the stevia carbohydrate group - greater than control but less than unrefined carbohydrate - indicates that while stevia is not entirely metabolically inert in regard to the weight factor, it is a good alternative to natural sugar. This finding aligns with (8) who showed different weight gains across various sweetener types in laboratory animals. (30) suggest that stevia compounds may adjust incretin hormone secretions and feeding indicating pathways differently than caloric sweeteners, conceivably explaining the different weight gains noticed in our stevia group.

Recent reports by (11) further elucidated the basic differences in the roles of stevia and organic compounds composed of carbon, demonstrating that stevia glycosides stimulate specific hypothalamic neurocircuits involved in strength equilibrium. Additionally, metabolic chamber studies by (4) disclosed that animals absorbing stevia-sweetened solutions had bigger resting strengths compared to those absorbing isocaloric sucrose answers, conceivably contributing to the characteristic weight gain patterns seen in this study.

Table 4: Weight Measurements (Mean ± SE) by Treatment and Time Point.

Time Period	control	stevia sugar	natural sugar	Statistical Significance
0 day	1.54 ± 0.38a	1.58 ± 0.38a	1.60 ± 0.38a	NS
15 day	1.55 ± 0.39a	2.81 ± 0.39b	3.38 ± 0.39c	**
30 day	1.59 ± 0.42a	2.84 ± 0.42b	3.37 ± 0.42c	**

Values are presented as mean ± SE. Different superscript letters in the same row indicate significant differences between groups ($p < 0.0001$).

Integrated Metabolic Effects: The inclusive metabolic characteristics observed across biochemical, lipid, and pressure limits reveal that a close-knit pattern of metabolic dysregulation guides natural carbohydrate use. The concurrent elevations in organic compounds composed of carbon, lipids, oxidative stress indicators, and body weight imply interconnected pathophysiological devices. As noted by (43) in their overall metabolomic findings, excessive sugar intake induces a slew of metabolic issues that together affect various body systems.

The improved oxidative stress (as indicated by elevated MDA levels) seen in this study's organic sugar group likely contributed to the higher metabolic disorders, as oxidative damage can hinder insulin signaling pathways and aggravate dyslipidemia. This relationship was clearly shown by (20), who stated that antioxidant supplementation weakened both hyperglycemia and dyslipidemia in animal models, highlighting the main function of oxidative stress in metabolic disorders caused by excessive sugar. In contrast, the metabolic levels maintained in the stevia carbohydrate group across diversified limits underscores the potential benefits of non-caloric sweeteners derived from stevia sugar.

(35) revealed that steviol glycosides offer accompanying multiple metabolic supervisory pathways, containing AMPK activation, a heterotrimeric serine/threonine kinase (α/β/γ subunits) that functions as a cellular energy sensor, and peroxisome proliferator-activated receptor gamma (PPAR-γ timbre). This conceivably explains their characteristics on sweet liquid homeostasis, lipid absorption, and burden regulation as distinguished from caloric sweeteners. Additionally, research by (5) using stable isotope tracer methodologies demonstrated that, unlike sucrose, stevia compounds do not contribute carbon skeletons to de novo lipogenesis pathways, further elucidating the mechanistic basis for the differential metabolic effects observed between these sweetener types.

This study's findings suggest stevia as a hopeful alternative to natural sugar for individuals seeking to achieve metabolic health. While not entirely noncommittal in its metabolic effects, as shown in the intermediate weight gain in the stevia group, this everyday sweetener appears to avoid the more severe metabolic disorders associated with conventional sugar consumption. Further studies analyzing chronic effects would provide valuable insights into the sustained metabolic impacts of these different sweetener options.

Conclusions

This study showed that stevia sugar produces fewer adverse metabolic effects than herbal sugar in New Zealand rabbits over a 30-day time frame. While natural sugar consumption led to significant increases in biochemical markers, lipid profiles, and

body weight, stevia sugar treatment produced profiles that were overall similar to the control group for all maximum biochemical and lipid values, with an intermediate effect on body weight.

These findings substantiate that stevia is a metabolically superior alternative to herbal sugar, potentially alleviating the risks of consuming too much sugar. The stability of glucose, lipid profiles, and markers of oxidative pressure in the stevia group attests to its capacity as a cost-effective sweetener for metabolic fitness control programs.

Additional work is required to determine the long-term consequences of stevia consumption, dose-response relationships, and mechanisms for the demonstrated metabolic benefits. Furthermore, investigation of tissue-specific response and gene expression profiles will further explain the molecular mechanisms responsible for the differential metabolic effects.

Supplementary Materials:

No Supplementary Materials.

Author Contributions:

Imad Dawood Saleh: methodology, writing—original draft preparation: M.A. Shahooth and Al-Rawi: F. T. writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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Raw data available.

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The authors declare no conflict of interest.

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