Menoufia J. Food & Dairy Sci., Volume 9 Issue 5 (2024): 45 - 54

MENOUFIA JOURNAL OF
FOOD AND DAIRY SCIENCES

https://mjfds.journals.ekb.eg

EFFECT OF DIETARY INTERVENTION WITH SEEDS AND SPROUTS OF BROCCOLI ON THE NONALCOHOLIC FATTY LIVER IN THE ALBINO RAT MODEL

Shahin, Kh. A. A.; Gharib, Mai A. and El – Gazar, Mona Kh. G.

Nutrition and Food Sciences Dept., Faculty of Home Economics – Menoufia University

Received: Sep. 20, 2024 Accepted: Nov. 3, 2024

ABSTRACT: Nonalcoholic fatty liver disease (NAFLD) affects approximately one billion individuals globally, highlighting a pressing need for effective preventive and therapeutic strategies. Broccoli, recognized for its exceptional nutrient profile, is rich in polyphenols, flavonoids, and isothiocyanates, with broccoli sprouts particularly noted for their high sulforaphane content—a compound with demonstrated health benefits. Long-term broccoli consumption has been shown to regulate liver lipid metabolism and mitigate hepatic lipidosis. This study aimed to evaluate the effects of broccoli seeds and sprouts on biochemical markers in a rat model of induced NAFLD. Thirty adult male albino rats were randomly assigned to six groups: negative control, positive control, and four experimental groups supplemented with 2.5% or 5% broccoli seeds (SG1, SG2) or sprouts (BG1, BG2) for 28 days. Results indicated improved body weight gain across all treatment groups, with no significant differences observed between 5% seed and 2.5% sprout groups. Biochemical analyses revealed that the BG2 group exhibited the most favorable reductions in total cholesterol and triglycerides, while HDL levels improved significantly in SG2 and BG2. Liver enzymes (ALT and ALP) decreased markedly in SG2 and BG1. These findings suggest that daily consumption of broccoli seeds and sprouts enhances liver health, supporting their potential role in preventing hepatic damage and managing fatty liver disease.

Keywords: Broccoli sprouts, sulforaphane, polyphenols, flavonoids, isothiocyanates, hepatic lipidosis, liver health, hepatoprotective, dietary intervention, functional foods.

INTRODUCTION

Hepatomegaly, or enlarged liver, and steatohepatitis, or inflammation of the liver, are the three main characteristics of nonalcoholic fatty liver disease (Cobbina *et al.*, 2017). Moreover, a fatty alteration (steatosis) affecting over 5% of hepatocytes will be mentioned. Globally, nonalcoholic fatty liver disease (NAFLD) is the most prevalent chronic liver disease (El-Sayed *et al.*, 2019). It is estimated to afflict approximately 1 billion individuals worldwide (Castera *et al.*, 2019).

Non-alcoholic fatty liver disease (NAFLD) is defined as the liver expression of dyslipidemia, insulin resistance, and obesity. However, it can also occur in patients with low body mass index (Marjot *et al.*, 2020). NAFLD is the hepatic manifestation of insulin resistance or metabolic syndrome, which is specifically linked to obesity, type 2 diabetes mellitus, high triglyceride levels, and low levels of high-density lipoprotein cholesterol (Rezk *et al.*, 2020).

Broccoli is among the most renowned cruciferous vegetables, now classified under the Brassicaceae family. Scientifically known as *Brassica oleracea L.*, broccoli contains numerous bioactive compounds, including vitamin C, flavonoids, and glucosinolates (Celia *et al.*, 2022). It also contains higher protein than most other vegetables (Verma *et al.*, 2017).

Extensive research highlights broccoli's health benefits, including its effectiveness in preventing obesity, reducing the risk of cardiovascular disease, and improving hyperlipidemia (Jeffery & Araya, 2009). Rich in polyphenolic compounds with potent antioxidant properties, broccoli may also play a role in mitigating oxidative stress-related disorders,

*Corresponding author: Kmona2022@gmail.com

such as cardiovascular and neurological diseases (Khedr *et al.,* 2020).

These chemoprotective effects have been attributed to broccoli's high levels of glucosinolates, which can be transformed by myrosinase into bioactive isothiocyanates (Shapiro *et al.,* 2001). Among isothiocyanates, sulforaphane (SF) is the most widely studied, and the evidence of its beneficial effects is the strongest.

The compounds glucoraphanin and sulforaphane, key bioactive constituents in broccoli, are highly abundant in germinating broccoli seeds and sprouts due to changes in physiological and biochemical metabolism (Gu et al., 2012). During germination, sprout length, root length, and fresh weight progressively increased with time. A rapid spike in the respiratory rate was observed between 24 and 36 hours of germination, after which it stabilized at a high level.

High-performance liquid chromatography (HPLC) analysis revealed that glucoraphanin content increased during the early stages (0–12 hours) of germination, reaching its peak concentration of 6.30 mg/g at 72 hours. Conversely, sulforaphane levels exhibited an initial dramatic decrease during the first day of germination, followed by a gradual increase, peaking at 3.38 mg/g at 48 hours before declining again (Gu *et al.,* 2012).

Dietary supplementation with broccoli sprout extract containing the SF precursor is highly effective in improving liver function through the reduction of oxidative stress. Indole-3-carbinol is a unique nutrient found in cruciferous vegetables. Indoles, especially I3C and DIM as phytochemicals, exert anti-fibrosis, anti-tumor, anti-oxidant, immunomodulatory, detoxification, and anti-inflammation effects on hepatic protection through pleiotropic mechanism (Wang *et al.,* 2016). Indoles modulate the enzymes that are relevant to hepatitis viral replication, lipogenesis, and the metabolism of ethanol and some hepatotoxic substances to protect the liver (Anderton *et al.,* 2004). Broccoli sprouts were found to be high in protein and low in fat. Linoleic and linolenic acids were abundant in the lipids found in the sprouts. Furthermore, sprouts contain a high amount of sulforaphane, which has health-promoting properties (Lobez *et al.,* 2013). Thus, the main purpose of this study is to investigate the effect of dietary intervention with broccoli seeds and sprouts on the liver functions of rats induced with NAFLD.

MATERIALS AND METHODS

Broccoli seeds were purchased from the Organic Food Company “SHANA” in the Egyptian Governorate of Menoufia. Cholesterol powder was obtained from Morgan Co. Cairo, Egypt. Adult normal male white albino rats Sprague Dawley strain was obtained from Vaccine and Immunity Organization, Ministry of Health, Helwan Farm, Cairo, Egypt.

Biological experiment

Sprouting broccoli seeds

Broccoli sprouts are derived from broccoli seeds (Brassica oleracea l. Botrytis var.) grown and harvested after 7-day-old sprouts. The sprouts were mashed by a blender. Mashed broccoli sprouts were given to treated rats’ groups freshly (Puspitasari *et al.,* 2019).

Induction of Nonalcoholic Fatty Liver Disease (NAFLD)

The rats were fed on a high-fat diet (45%) for 4 weeks (AIN 1993), which was prepared according to the American Institute of Nutrition (Thomas *et al.,* 1992). Moreover, infected rats were administered with 10% fructose in the drinking water (HF/HF) (Xu *et al.,* 2010)

Experimental design

The experiment was conducted by the Research Ethics Committee of the Faculty of Science, Menoufia University, Egypt (Approval No. MUFHE/S/NFS/2/24).

Thirty adult male white albino rats, Sprague Dawley Strain, 8 weeks of age, weighing (120±10g) were used in this experiment. All rats were fed on a basal diet prepared according to the American Institute of Nutrition (Thomas *et al.,* 1992) for 7 consecutive days.

After the adaptation period, five rats were assigned to the negative control group (ve-), while the remaining rats were divided into the following groups: a positive control group (ve+) consisting of five rats fed a standard diet throughout the study period, and experimental groups (n=20), where the rats were administered different doses of broccoli sprouts and seeds for 28 days. The experimental rats were further divided into four subgroups, with five rats in each group: Subgroup (SG1) was fed a standard diet and administered broccoli seeds (2.5%); Subgroup (SG2) was fed a standard diet and administered broccoli seeds (5%); Subgroup (BG1) was fed a standard diet and administered broccoli sprouts (2.5%); and Subgroup (BG2) was fed a standard diet and administered broccoli sprouts (5%).

At the beginning of the experiment, blood samples were collected from the rats to obtain baseline values before the dietary intervention. At the end of the experimental period, the rats in each group were fasted for 12 hours, then sacrificed, and blood samples were collected from the hepatic portal vein into clean, dry centrifuge tubes. The samples were centrifuged at 4000 rpm for 10 minutes to separate the serum, which was then stored in a deep freezer until analysis.

Diets

Basal diet (Standard diet) was prepared according to the American Institute of Nutrition (AIN, 1993).

Biological Evaluation

The following formula assessed body weight gain:

$$Body\ Weight\ gain\ (g)\ = \frac{Final\ weight\ - Initial\ weight}{Initial\ weight}$$

During the experimental period, the net food intake was daily recorded, while body weight was weekly recorded. The net feed intake and gained body weight were used for the calculation of feed efficiency ratios (FER) as follows:

$$FER\ \% = \frac{Body\ weight\ gain\ (g)}{Food\ intake\ (g)} \times 100$$

Biochemical Analysis

The lipid profile included the determination of serum total cholesterol using the colorimetric method described by Thomas *et al.* (1992). Serum triglycerides were measured using an enzymatic method, following the protocols of Young *et al.* (1975) and Fossati *et al.* (1982). High-density lipoprotein cholesterol (HDL-c) was determined according to the method described by Friedewald *et al.* (1972) and Gordon *et al.* (1977). Very low-density lipoprotein cholesterol (VLDL-c) was calculated in mg/dl using the formula provided by Schmitt *et al.* (1964):

VLDLc (mg/dl) = Triglycerides / 5

Calculation of low-density lipoprotein cholesterol (LDLc)c was calculated in mg/dl according to (Schmitt *et al.*, 1964) as follows:

$$\boldsymbol{LDL - c\ \left(\frac{mg}{dl}\right) =}$$

$$\boldsymbol{Total\ cholesterol - \ (HDL - c\ +\ VLDL - c).}$$

Liver function tests included the determination of serum alanine aminotransferase (ALT), which was carried out according to the method described by Clin (1980). Serum aspartate aminotransferase (AST) was determined following the method of Hafkenscheid *et al.* (1979). The determination of serum alkaline phosphatase (ALP) was performed according to the method outlined by Moss *et al.* (2016)

Statistical Analysis

Data was analyzed using SPSS version 22.0 software. Results were expressed as mean ± standard deviation (SD) and evaluated by one-way ANOVA followed by a post hoc test. A p-value of less than 0.05 was considered statistically significant.

RESULTS AND DISCUSSION

The dietary intervention with broccoli seeds and sprouts resulted in the following observations regarding body weight gain percentage (BWG%), feed efficiency ratio (FER), and feed intake (FI): There was no significant difference in the mean BWG values between the 5% broccoli seeds group (SG2), 2.5% broccoli sprouts group (BG1), and the negative control group (G1). However, these groups demonstrated notable improvement, with mean BWG values of 23.60 ± 20.29 g (SG2), 15.60 ± 15.04 g (BG1), and 18.40 ± 10.57 g (G1), respectively (Table 1). The dietary intervention with broccoli seeds and sprouts resulted in the following observations regarding body weight gain percentage (BWG%), feed efficiency ratio (FER), and feed intake (FI): There was no significant difference in the mean BWG values between the 5% broccoli seeds group (SG2), 2.5% broccoli sprouts group (BG1), and the negative control group (G1). However, these groups demonstrated notable improvement, with mean BWG values of 23.60 ± 20.29 g (SG2), 15.60 ± 15.04 g (BG1), and 18.40 ± 10.57 g (G1), respectively.

The BG2 group (5% broccoli sprouts) showed the most substantial improvement in BWG, with a mean value of 7.40 ± 8.44 g. These results indicate that the dietary inclusion of broccoli, particularly at higher concentrations of sprouts, positively influenced weight gain and overall nutritional outcomes.

Regarding food intake (FI), no significant difference was observed between the 2.5% broccoli sprouts, 5% broccoli sprouts, and negative control groups after the dietary intervention. Nonetheless, improvements were noted in the BG1, BG2, and G1 groups, with mean values of 22.06±0.15, 22.81±0.23, and 22.36±0.38 g, respectively.

In terms of food efficiency ratio (FER), no significant distinctions were found between all treatment groups. Similarly, in a study by Aranaz *et al.* (2019), rats exhibited reduced body weight gain and food efficiency, as well as reductions in retroperitoneal fat mass and adipocyte size, after 10 weeks of broccoli supplementation. This was linked to the downregulation of Cebpa, Srebp1, Fasn, and Adipoq expression in adipocytes. These findings provide new insights into the potential role of broccoli components in preventing metabolic syndrome.

Obesity is associated with a chronic, low-grade inflammatory state that promotes oxidative stress in various metabolic tissues, contributing to insulin resistance and conditions like nonalcoholic fatty liver disease (NAFLD). A study by Xu *et al.* (2018) highlighted the beneficial role of glucoraphanin, a precursor of the Nrf2 activator sulforaphane, in alleviating obesity. This is achieved by enhancing energy expenditure, promoting the browning of white adipose tissue, and reducing obesity-induced inflammation through the polarization of M2 macrophages and a decrease in metabolic endotoxemia, which helps mitigate insulin resistance.

Pereira *et al.* (2018) emphasized the importance of the gut microbiota in regulating lipid metabolism. The ability of glucoraphanin to modulate the gut microbiota offers a promising mechanism for preventing high-fat diet (HFD)-induced obesity. In addition, Rosendale *et al.* (2012) suggested that glucoraphanin may exert its anti-obesity effects by altering the abundance of specific bacterial phylotypes, possibly linked to its antibacterial properties, as further supported by Sofrata *et al.* (2011). These findings underscore the potential of glucoraphanin as a natural compound for combating obesity and associated metabolic disorders.

The glucoraphanin-enriched diet resulted in significant changes in the fecal microbiota's composition, including an increase in the relative abundance of Bacteroidetes and a reduction in the Firmicutes/Bacteroidetes (F/B) ratio. A high F/B ratio is indicative of obesity-driven dysbiosis, often associated with high-fat consumption.

Table (1). The effect of seeds and sprouts of broccoli on the average values of FI, FER, and BWG

Groups \ Parameters	BWG (g/28d)	FI (g/day)	FER (g/rat/day)
	Mean ±SD	Mean ±SD	Mean ±SD
Negative control (G1)	18.40^{bc}±10.57	22.36^{a}±0.38	0.82^{b}± 0.47
Positive control(G2)	50.60^{a}±12.03	20.64^{c}±0.40	2.45^{a}± 0.59
Seeds 2.5%(G3)	28.60^{b}±8.35	20.12^{d}±0.19	0.97^{b}±0.34
Seeds 5%(G4)	23.60^{bc}±20.29	21.54^{b}±0.33	1.13^{b}±0.32
Sprouts 2.5%(G5)	15.60^{bc}±15.04	22.06^{a}±0.15	0.87^{b}±0.26
Sprouts 5%(G6)	7.40^{c}±8.44	22.81^{a}±0.23	1.28^{b}±0.37

Note: Values are expressed as means±SD, means in the same columns with different letters are significantly ($P \leq 0.05$), SG1: group supplemented with broccoli seeds 2.5%; SG2: group supplemented with broccoli seeds 5%; BG1: group supplemented with broccoli sprouts 2.5%; BG2: group supplemented with broccoli sprouts 5%. BWG: Body Weight Gain, FI: Feed Intake, FER: Feed Efficiency ratio.

The impact of broccoli seeds and sprouts on the level of lipid profiles is shown in Table 2. The impact of broccoli seeds and sprouts on the level of lipid profiles is shown in Table 2. After the dietary intervention, there was no significant difference in the mean values of (SG2) and (BG1) for TC between seeds (5%) and sprouts (2.5%); they were, respectively, 145.20±4.98 and 141.07±13.57 mg/dl. Among the experimental groups, BG2 had the greatest significant improvement, with a mean of 113.4 ±7.58 mg/dl.

By comparison with other groups, BG2 showed the greatest improvement in TG (61.67±6.22 mg/dl). After the dietary intervention, there was no significant difference in the mean values of HDL, SG1 and BG1, between seeds 2.5%, and sprouts 2.5 %; the mean values were 47.15±2.13 and 46.19±1.91 mg/dl, respectively.

Among the experimental groups, BG2 has the greatest improvement in LDL, with a mean improvement of 33.62 ±1.72 mg/dl. Following the dietary intervention, there was no significant difference in the mean values of VLDL between seeds 5% and sprouts 2.5%; instead, (SG2) and (BG1) improved; the mean values were 16.59±1.88 and 16.64±3.26 mg/dl, respectively. BG2 had a lower mean value (14.43±1.06 mg/dl) than the other treated groups.

Recent research has explored the impact of a broccoli-rich diet on plasma LDL cholesterol levels, suggesting that broccoli may play a role in regulating the liver's lipid trafficking processes. Studies have shown that incorporating more broccoli into the diet can reduce the risk of lipidosis (Chen *et al.*, 2016). As a result, broccoli sprouts have emerged as an affordable, practical, and cost-effective addition to a balanced diet. The sprouts used in this study were found to be low in fat and high in protein, with their lipid composition predominantly consisting of linoleic and linolenic acids. These sprouts also offer a rich source of flavonoids, polyphenols, and essential amino acids, alongside significant levels of sulforaphane, a compound known for its health-promoting properties.

Moreover, broccoli sprouts were found to have the highest biochemical composition and nutrient content, which can be attributed to the germination process, as discussed by Palak *et al.* (2016). Further supporting these findings, Xu *et al.* (2020) demonstrated that glucoraphanin, a key compound found in broccoli, significantly reduced visceral fat and liver weight in mice with high-fat diet (HFD)-induced obesity, thus alleviating hepatic steatosis. These results are consistent with a previous study by Nagata *et al.* (2017), which showed that glucoraphanin administration led to limited weight gain and a reduction in fat mass in HFD-fed mice, suggesting its potential for mitigating obesity and liver damage.

High glucoraphanin broccoli consumption significantly lowers plasma low-density lipoprotein cholesterol (LDL-C), according to data from two separate human studies (Armah *et al.*, 2015).

Table (2): The effect of seeds and sprouts of broccoli on the levels of lipid profiles

Groups	Tc (mg/dl)	TG (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)
Negative control(G1)	78.27^{e}±2.28	58.59^{d}±7.64	36.83^{c}±1.31	29.67^{e}±2.40	11.08^{d}±1.53
Positive control(G2)	184.63^{a}±6.93	112.62^{a}±11.29	32.37^{d}±1.82	73.63^{a}±5.23	24.94^{a}±1.91
Seeds 2.5%(G3)	156.38^{b}±5.48	87.53^{b}±12.37	47.15^{b}±2.13	41.62^{c}±3.87	17.50^{b}±2.47
Seeds 5%(G4)	145.20^{c}±4.98	83.22^{bc}±16.30	49.70^{a}±1.90	36.59^{cd}±2.66	16.59^{bc}±1.88
Sprouts 2.5%(G5)	141.07^{c}±13.57	72.19^{cd}±5.35	46.19^{b}±1.91	50.71^{b}±7.25	16.64^{bc}±3.26
Sprouts 5%(G6)	113.4^{d}±7.58	61.67^{d}±6.22	48.27^{ab}±1.52	33.62^{de}±1.72	14.43^{c}±1.06

Note: Values are expressed as means±SD, means in the same columns with different letters are significantly ($P \leq 0.05$), SG1: group supplemented with broccoli seeds 2.5%; SG2: group supplemented with broccoli seeds 5%; BG1: group supplemented with broccoli sprouts 2.5%; BG2: group supplemented with broccoli sprouts 5%. TC: Total Cholesterol Test, TG: Triglycerides Test, HDL: high-density lipoprotein, LDL: low-density lipoprotein, VLDL: very low-density lipoprotein.

Table 3 illustrates the effect of broccoli seeds and sprouts on liver enzymes. Following dietary intervention, there was no significant difference in the mean values of AST between the groups administered seeds at 2.5% and 5%. However, improvements were observed in both (SG1) and (SG2), with mean values of 189.74±9.36 and 171.30±5.48 mg/dl, respectively.

Similarly, after dietary intervention, there was no significant difference in the mean values of ALP between the groups administered seeds at 2.5%, seeds at 5%, and sprouts at 2.5%. Despite this, improvements were recorded in (SG1), (SG2), and (BG1), with mean values of 267.30±13.77, 249.40±13.50, and 252.00±13.09 mg/dl, respectively.

Following dietary intervention, there was no significant difference in the mean values of ALT between the groups administered seeds at 5% and sprouts at 2.5%. However, improvements were observed in both (SG2) and (BG1), with mean values of 76.10±1.98 and 74.41±2.94 mg/dl, respectively.

Among the experimented groups, BG2 showed the most significant amelioration, with mean values of 146.00±12.57, 64.42±2.33, and 200.60±14.91 U/L for AST, ALT, and ALP, respectively. This indicates that broccoli inhibited the continued development of nonalcoholic fatty liver disease (NAFLD) and improved liver health.

These findings align with the research of Palak *et al.* (2016), who demonstrated that incorporating broccoli into the diet has significant public health implications for supporting liver health, especially in overweight individuals. Their study showed that broccoli consumption effectively reduced hepatic lipidosis in rats, highlighting its potential to combat liver fat accumulation. Furthermore, Chen *et al.* (2016) emphasized the health benefits of broccoli sprouts, identifying them as a convenient functional food that enhances liver function. Their study revealed that regular broccoli consumption regulates hepatic macrophage activation, minimizes liver damage, and provides protective effects against liver tumorigenesis. Together, these studies underscore the role of broccoli as a valuable dietary component for promoting liver health and preventing disease progression.

These findings reinforce the importance of broccoli as part of a dietary intervention for liver health, especially in preventing and managing NAFLD.

Table 3: The effect of seeds and sprouts of broccoli on the liver function.

Groups	AST (U/L)	ALT (U/L)	ALP (U/L)
Negative control (G1)	$127.45^{d}\pm22.53$	$55.05^{e}\pm4.13$	$101.09^{d}\pm6.30$
Positive control(G2)	$236.26^{a}\pm34.95$	$101.14^{a}\pm6.05$	$333.46^{a}\pm19.98$
Seeds 2.5%(G3)	$189.74^{b}\pm9.36$	$84.89^{b}\pm3.47$	$267.30^{b}\pm13.77$
Seeds 5%(G4)	$171.30^{bc}\pm5.48$	$76.10^{c}\pm1.98$	$249.40^{b}\pm13.50$
Sprouts 2.5%(G5)	$151.56^{cd}\pm2.78$	$74.41^{c}\pm2.94$	$252.00^{b}\pm13.09$
Sprouts 5%(G6)	$146.00^{d}\pm12.57$	$64.42^{d}\pm2.33$	$200.60^{c}\pm14.91$

Note: Values are expressed as mean±SD, means in the same columns with different letters are significantly ($P\leq0.05$), SG1: group supplemented with broccoli seeds 2.5%; SG2: group supplemented with broccoli seeds 5%; BG1: group supplemented with broccoli sprouts 2.5%; BG2: group supplemented with broccoli sprouts 5%. LSD: Least significant difference. AST, Aspartate aminotransferase, ALT, Alanine transferase, ALP, and Alkaline phosphatase.

Conclusion

The utilization of functional foods represents a promising strategy for managing and preventing nonalcoholic fatty liver disease (NAFLD) and its associated complications. Among these, broccoli has emerged as an effective natural intervention, demonstrating remarkable benefits in mitigating hepatic lipidosis, improving hepatic lipid metabolism, and supporting weight management. This study highlights that the most significant improvements in liver function and lipid profiles were achieved with a 5% supplementation of broccoli sprouts in the diet. The inclusion of broccoli not only promotes liver health but also offers potential long-term protective effects against the progression of fatty liver disease. Therefore, incorporating broccoli into daily dietary practices is strongly recommended as a preventive and therapeutic approach to enhance liver function and reduce the risk of NAFLD. These findings emphasize the critical role of functional foods in maintaining metabolic health and preventing chronic diseases.

REFERENCES

Khedr, A. A.; El-Kholie, E. M.; Refaat, W. A. and Habib, M. A. (2020). Potential Effect of Broccoli to Reduce the Side Effects of Cisplatin Chemotherapy in Adult Rats. Journal of Home Economics, 30(1): e2.

Sofrata, A.; Santangelo, E. M.; Azeem, M.; Borg-Karlson, A. K.; Gustafsson, A. andPütsep, K. (2011). Benzyl isothiocyanate, a major component from the roots of Salvadora persica is highly active against Gram-negative bacteria. PloS one, 6(8): e23045.

Moschen, A. R.; Wieser, V. and Tilg, H. (2012). Dietary factors: major regulators of the gut's microbiota. Gut and liver, 6(4): 411.

Ain, A. (1993). American institute of nutrition purified diet for laboratory rodent: final report to J. Nutrition, 123: 1939-1951.

Anderton, M. J.; Manson, M. M.; Verschoyle, R. D.; Gescher, A.; Lamb, J. H.; Farmer, P. B. and Williams, M. L. (2004). Pharmacokinetics and tissue disposition of indole-3-carbinol and its acid condensation products after oral administration to mice. Clinical cancer research, 10(15), 5233-5241.

Armah, C. N.; Derdemezis, C.; Traka, M. H.; Dainty, J. R.; Doleman, J. F.; Saha, S. and Mithen, R. F. (2015). Diet rich in high glucoraphanin broccoli reduces plasma LDL cholesterol: Evidence from randomized controlled trials. Molecular nutrition & food research, 59(5): 918-926.

Castera, L.; Friedrich-Rust, M. and Loomba, R. (2019). Noninvasive assessment of liver disease in patients with nonalcoholic fatty liver disease. Gastroenterology, 156(5): 1264-1281.

Chen, Y. J.; Wallig, M. A. and Jeffery, E. H. (2016). Dietary broccoli lessens development of fatty liver and liver cancer in mice given diethylnitrosamine and fed a western or control diet. The Journal of nutrition, 146(3): 542-550.

Nasrin, S.; Kawser, M.; Ahmed, S. U. N.; Sadi, S. K. S.; Khan, M. N. I. and Islam, S. N. (1964). Influence of Sociodemography on Biochemical Profile of Type 2 Diabetic Patients Undergoing Zinc Supplementation. Clin Chem, 9.

Rosendale, D.; Butts, C.; de Guzman, E.; Maddox, I.; Martell, S.; McIntyre, L. and Ansell, J. (2012). Short Communication The contribution of dietary broccoli sprouts towards the microbial metabolite profile in the hind gut of mice. International Journal of Food Science and Technology, 1.

Jeffery, E. H. and Araya, M. (2009). Physiological effects of broccoli consumption. Phytochemistry Reviews, 8: 283-298.

El Hendy, H. A.; Yousef, M. I. and El-Naga, N. I. A. (2001). Effect of dietary zinc deficiency on hematological and biochemical parameters and concentrations of zinc, copper, and iron in growing rats. Toxicology, 167(2): 163-170.

SA Ahmed, Z. (2020). Effect of White, Black Rice and their Mixtures on Induced-Hypercholesterolemia in Rats. Home Econ. J. 36(2):109-128.

Durrington, P. N. and Miller, J. P. (1982). High-density lipoprotein cholesterol: methods and clinical significance. CRC Critical Reviews in Clinical Laboratory Sciences, 18(1): 31-78.

Botros, M. and Sikaris, K. A. (2013). The de ritis ratio: the test of time. The Clinical Biochemist Reviews, 34(3): 117.

Botros, M. and Sikaris, K. A. (2013). The de ritis ratio: the test of time. The Clinical Biochemist Reviews, 34(3):117.

Latté, K. P.; Appel, K. E. and Lampen, A. (2011). Health benefits and possible risks of broccoli–an overview. Food and Chemical Toxicology, 49(12): 3287-3309.

López‐ Cervantes, J.; Tirado‐ Noriega, L. G.; Sánchez‐ Machado, D. I.; Campas‐ Baypoli, O. N.; Cantú‐ Soto, E. U. and Núñez‐ Gastélum, J. A. (2013). Biochemical composition of broccoli seeds and sprouts at different stages of seedling development. International journal of food science & technology, 48(11): 2267-2275.

M. El-sayed, M.; r M. Rezk, S. and Asmaa, B: Evaluation of Effect of Omega -3 Fatty Acids and Probiotics in Rats with Nonalcoholic Fatty Liver Disease (NAFLD) Induced by Special Diet. J. Home Economics. 2019

Montaner, C.; Mallor, C.; Laguna, S. and Zufiaurre, R. (2023). Bioactive compounds, antioxidant activity, and mineral content of bróquil: A traditional crop of Brassica oleracea var. italica. Frontiers in Nutrition, 9, 1006012.

Koeckerling, D.; Marjot, T. and Cobbold, J. (2022). Non-alcoholic Fatty Liver Disease. In Liver Disease in Clinical Practice (pp. 127-149). Cham: Springer International Publishing.

Moss, D. W. (1982). Alkaline phosphatase isoenzymes. Clinical chemistry, 28(10): 2007-2016.

Nagata, N.; Xu, L.; Kohno, S.; Ushida, Y.; Aoki, Y.; Umeda, R. and Ota, T. (2017). Glucoraphanin ameliorates obesity and insulin resistance through adipose tissue browning and reduction of metabolic endotoxemia in mice. Diabetes, 66(5): 1222-1236.

Palak, S. K.; Thakur, A. and Kohli, K. (2016). Broccoli: An insight into formulation and patentability aspects. Drug Des, 5(139): 2169-0138.

Park, E. J.; Lee, Y. S.; Kim, S. M.; Park, G. S.; Lee, Y. H.; Jeong, D. Y. and Lee, H. J. (2020). Beneficial effects of Lactobacillus plantarum strains on non-alcoholic fatty liver disease in high fat/high fructose diet-fed rats. Nutrients, 12(2): 542.

Aranaz, P.; Navarro-Herrera, D.; Romo-Hualde, A.; Zabala, M.; López-Yoldi, M.; González-Ferrero, C. and González-Navarro, C. J. (2019). Broccoli extract improves high fat diet-induced obesity, hepatic steatosis and glucose intolerance in Wistar rats. Journal of Functional Foods, 59: 319-328.

Puspitasari, A. and Handayani, N. (2019). Broccoli sprouts juice prevents lens protein aggregation in streptozotocin-induced diabetic rat. International Journal of Ophthalmology, 12(9): 1380.

Jin, Z.; Fang, Z.; Pei, Z.; Wang, H.; Zhu, J.; Lee, Y. K. and Chen, W. (2021). A low molecular weight brown algae Laminaria japonica glycan modulation of gut microbiota and body weight in mice. Food & function, 12(24): 12606-12620.

Mishra, S. K.; Suh, W. I.; Farooq, W.; Moon, M.; Shrivastav, A.; Park, M. S. and Yang, J. W. (2014). Rapid quantification of microalgal lipids in aqueous medium by a simple colorimetric method. Bioresource technology, 155: 330-333.

Shapiro, T. A.; Fahey, J. W.; Wade, K. L.; Stephenson, K. K. and Talalay, P. (2001). Chemoprotective glucosinolates and isothiocyanates of broccoli sprouts: metabolism and excretion in humans. Cancer Epidemiology Biomarkers & Prevention, 10(5): 501-508.

Thomas, L.; Leyh, H.; Marberger, M.; Bombardieri, E.; Bassi, P.; Pagano, F. and Ishak, L. (1999). Multicenter trial of the quantitative BTA TRAK assay in the detection of bladder cancer. Clinical chemistry, 45(4): 472-477.

Verma, D.; Yadav, RK.; Yadav, M.; Rani, B.; Chharang, B.; Sharma, A. and Maheshwari, RK: Delightful Broccoli: Nutritional information& Health benefits. J. Chem. Environ. 2017. Sci. 5(5): 91-93.

Wang, S. Q.; Cheng, L. S.; Liu, Y.; Wang, J. Y. and Jiang, W. (2016). Indole-3-carbinol (I3C) and its major derivatives: their pharmacokinetics and important roles in hepatic protection. Current drug metabolism, 17(4): 401-409.

Xu, L.; Nagata, N. and Ota, T. (2018). Glucoraphanin: a broccoli sprout extract that ameliorates obesity-induced inflammation and insulin resistance. Adipocyte, 7(3): 218-225.

Xu, Z. J.; Fan, J. G.; Ding, X. D.; Qiao, L. and Wang, G. L. (2010). Characterization of high-fat, diet-induced, non-alcoholic steatohepatitis with fibrosis in rats. Digestive diseases and sciences, 55: 931-940.

Gu YingJuan, G. Y.; Guo QiangHui, G. Q.; Zhang Liang, Z. L.; Chen ZhiGang, C. Z.; Han YongBin, H. Y. and Gu ZhenXin, G. Z. (2012). Physiological and biochemical metabolism of germinating broccoli seeds and sprouts

LOGAN, J. E. (2012). in Clinical Chemistry. Clinical Biochemistry: Contemporary Theories and Techniques, 43.

Younossi, Z. M.; Koenig, A. B.; Abdelatif, D.; Fazel, Y.; Henry, L. and Wymer, M. (2016). Global epidemiology of nonalcoholic fatty liver disease—meta‐ analytic assessment of prevalence, incidence, and outcomes. Hepatology, 64(1): 73-84.

تأثير التدخل الغذائي لبذور وبراعم البروكلي على الكبد الدهنى غير الكحولي في فئران ألبينو

خالد عبد الرحمن علي شاهين، مي عبد الخالق غريب، منى خالد جمال الجزار

قسم التغذية وعلوم الأطعمة، كلية الاقتصاد المنزلي، جامعة المنوفية

الملخص العربي

تشير التقديرات إلى أن مرض الكبد الدهني غير الكحولي (NAFLD) يؤثر على حوالي مليار شخص في جميع أنحاء العالم، مما يجعله من التحديات الصحية البارزة. يُعتبر البروكلي من الأطعمة الغنية بالعديد من المركبات الفعالة مثل البوليفينول، الفلافونويد، و الإيزوثيوسيانات، بالإضافة إلى كونه مصدراً ممتازاً لـ السلفورافان الذي يعرف بفوائده الصحية العديدة. كما تشير الأبحاث إلى أن البروكلي يمكن أن يساهم في الحد من تطور NAFLD من خلال تقليل مستويات الدهون الثلاثية في الكبد. كما أن الاستهلاك المنتظم للبروكلي قد يساعد في تعديل استقلاب الدهون وتقليل مخاطر الإصابة بالكبد الدهني.

يهدف هذا البحث إلى دراسة تأثير التدخل الغذائي باستخدام بذور وبراعم البروكلي على مستويات الدهون ووظائف الكبد في الفئران المصابة بـNAFLD. تم إجراء التجربة على ثلاثين من ذكور الفئران البيضاء البالغة، مقسمة إلى ست مجموعات: مجموعة ضابطة سلبية، مجموعة ضابطة إيجابية، وأربع مجموعات تجريبية تم إعطاؤها جرعات مختلفة من بذور وبراعم البروكلي (٢,٥% و٥%) لمدة ٢٨ يوماً. كما أظهرت النتائج تحسناً في زيادة وزن الجسم بعد التدخل الغذائي، مع عدم وجود فرق معنوي بين مجموعة البذور ٥% ومجموعة البراعم ٢,٥%. فيما يتعلق بالدهون الثلاثية (TC) والجلسريدات الثلاثية (TG)، كانت مجموعة البروكلي بتركيز ٥% هي الأفضل مقارنة بالمجموعات الأخرى. كما تحسن مستوى الليبوبروتينات مرتفعة الكثافة (HDL) في مجموعات براعم وبذور البروكلي عند تركيز ٥%، دون وجود فرق معنوي. أما بالنسبة لإنزيمات الكبد (ALT وALP)، فلم تسجل تغييرات كبيرة في مجموعة البذور ٥% ومجموعة البراعم ٢,٥%، حيث كان متوسط القيم (٦٥,٢٨±٧,٠٦ و٨٥,٣٤±٢,٧٩ وحدة/لتر) و(٦٩,٣٢±١,٩٩ و٨٦,٥٥±١,٠٧ وحدة/لتر) على التوالي. في الختام، يُظهر استهلاك بذور وبراعم البروكلي تأثيراً إيجابياً على وظائف الكبد، مما يجعلها خياراً غذائياً مميزاً لتقليل تلف الكبد ومكافحة الكبد الدهني غير الكحولي.

الكلمات المفتاحية: براعم البروكلي، السلفورافان، البوليفينولات، الفلافونويدات، الأيزوثيوسيانات، التنكس الدهني الكبدي، صحة الكبد، الوقاية الكبدية، التدخل الغذائي، الأطعمة الوظيفية.