July – September, 2026
Original Article
DOI: http://dx.doi.org/10.30867/action.v11i3.3092
Pages: 828 – 839
AcTion: Aceh Nutrition Journal
p-issn 2527-3310; e-issn 2548-5741

Effect of pineapple (*Ananas comosus*) juice containing flesh and core on serum total cholesterol in overweight and obese working women: a quasi-experimental study

Efek pemberian intervensi jus nanas (Ananas comosus) dengan kandungan daging buah dan core terhadap kolesterol total pada wanita pekerja overweight dan obesitas: studi kuasi-eksperimental

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Article History:
Received: December 27, 2025; Revised: March 10, 2026; Accepted: April 09, 2026; Published: September 02, 2026.

Publisher:
Politeknik Kesehatan Aceh
Kementerian Kesehatan RI

Abstract

Obesity among Indonesian adults is increasing, with a higher prevalence in women than in men, contributing to elevated total cholesterol levels and cardiometabolic risk. Working women may also experience greater stress, which can adversely affect cholesterol levels through hormonal responses and unhealthy eating habits. Pineapple contains bromelain and dietary fiber that may support cholesterol control, with bromelain occurring in greater amounts in the core than in the flesh of the fruit. This study aimed to evaluate the effect of pineapple juice prepared from both the flesh and core on total cholesterol levels in working women. Methods: A quasi-experimental pre-posttest study was conducted among 34 working female employees at Great Giant Food. The participants received the assigned intervention for 14 days at a dose equivalent to 142 g/70 kg body weight. Data were analyzed using paired *t*-tests or Wilcoxon signed-rank tests for within-group comparisons and independent *t*-tests or Mann–Whitney U tests for between-group comparisons. The change in total cholesterol levels differed significantly between the groups (p = 0.041). However, within-group changes were not significant in either the control (p = 0.053) or intervention group (p = 0.268). In conclusion, pineapple juice containing both flesh and core may favorably influence total cholesterol levels; however, the absence of significant within-group changes indicates that the findings should be interpreted cautiously.

Keywords: Bromelain, pineapple juice, total cholesterol, working women

Abstrak

Obesitas pada orang dewasa di Indonesia terus meningkat dan lebih banyak terjadi pada perempuan. Kondisi ini dapat meningkatkan kadar kolesterol total serta risiko penyakit kardiovaskular dan diabetes melitus tipe 2. Perempuan pekerja juga lebih rentan mengalami stres yang dapat memengaruhi kadar kolesterol melalui respons hormonal dan pola makan tidak sehat. Nanas mengandung bromelain dan serat pangan yang berpotensi membantu mengendalikan kolesterol. Kandungan bromelain lebih tinggi pada bagian *core* dibandingkan daging buah. Penelitian ini bertujuan menilai pengaruh jus nanas yang dibuat dari daging buah dan *core* terhadap kolesterol total. Metode, penelitian kuasi-eksperimental dengan desain *pre-posttest* dilakukan pada 34 perempuan pekerja di Great Giant Food. Intervensi diberikan selama 14 hari dengan dosis setara 142 g/70 kg berat badan. Analisis dalam kelompok menggunakan uji *t* berpasangan atau Wilcoxon *signed-rank*, sedangkan analisis antarkelompok menggunakan uji *t* independen atau Mann–Whitney. Hasil, perubahan kolesterol total berbeda secara signifikan antara kelompok (p = 0,041). Namun, perubahan dalam masing-masing kelompok tidak signifikan, baik pada kelompok kontrol (p = 0,053) maupun intervensi (p = 0,268). Kesimpulan, jus nanas yang mengandung daging buah dan *core* berpotensi memberikan pengaruh yang menguntungkan terhadap kolesterol total. Namun, karena perubahan dalam masing-masing kelompok tidak signifikan, hasil ini perlu ditafsirkan secara hati-hati.

Kata Kunci: Bromelain, jus nanas, kolesterol total, wanita pekerja

Introduction

Indonesia is experiencing a triple burden of malnutrition, with obesity being a major concern (Fatmaningrum et al., 2022). National data indicate that obesity among adults older than 18 years continues to rise, with a prevalence consistently higher in women than in men, increasing from 14.7% to 15.7% in men and from 29.6% to 31.2% in women (Kemenkes, 2018; 2023). Obesity contributes to adipocyte hypertrophy and dysfunction, which increases the secretion of proinflammatory adipokines and lipid production, thereby elevating the risk of dyslipidemia (Khutami et al., 2022). Similarly, among individuals aged ≥ 15 years, dyslipidemia based on abnormal lipid profiles has become more common, with total cholesterol increasing from 7.6% to 11.7% and borderline cholesterol from 21.2% to 27.8% (Kemenkes, 2018; 2023).

Total cholesterol represents the combined levels of HDL, LDL, and VLDL per deciliter of blood, and excessive concentrations can accumulate along the arterial walls, forming plaques that may obstruct blood flow, particularly in the coronary vessels (Amelia et al., 2021; Fandini et al., 2023). A review by Prel et al. (2024) of studies published between 1999 and 2022 showed that work-related stress was consistently associated with depression and that women appeared to be more susceptible to occupational stress than men (Prel et al., 2024). Such stress can reduce productivity, increase absenteeism, impair well-being, and increase the risk of cardiovascular diseases and type 2 diabetes. Evidence also indicates that working women experience higher stress levels than do housewives (Harilal & Santhosh, 2017). Stress may encourage the intake of high-sugar and high-fat comfort foods that provide temporary emotional relief and may alleviate chronic stress-related anxiety (Goens et al., 2023). In addition, stress is associated with unhealthy eating patterns, such as overeating, irregular meals, and increased fast food consumption, all of which contribute to obesity (Kim & Woo, 2025). Stress stimulates the release of cortisol and catecholamines, disrupts lipid metabolism, reduces lipid clearance, and increases the risk of dyslipidemia, including elevated total cholesterol (Liu et al., 2021; Tuminah et al., 2022). Older age further increases the risk of obesity, especially when combined with excessive energy intake and low levels of physical activity. Adipose tissue dysfunction promotes altered fat accumulation through pro-inflammatory signaling, senescent cell buildup, SASP expression, and reduced preadipocyte differentiation (Malandrino et al., 2024).

Recent reviews have shown that plant-based functional foods may produce clinically meaningful lipid-lowering effects and serve as complementary strategies for managing dyslipidemia, particularly in women with higher cardiometabolic risk or statin intolerance (Jacobo-Velázquez, 2025). Pineapples contain bromelain, a bioactive compound with antioxidant, anti-inflammatory, antimicrobial, and antidepressant properties (Balbeid, 2017; Jančič & Gorgieva, 2022; Lee et al., 2018). It is also rich in dietary fiber and bromelain, with a fiber content of 9.07 g per 100 g, which may help in regulating cholesterol levels (Seenak et al., 2021). Bromelain also has anti-inflammatory effects and may influence adipocyte metabolism, thereby reducing comorbidities associated with excess adiposity (Sethia & Polak-szczybyło, 2025). This compound is found in both the flesh and core of pineapples, although the core is often discarded because of its firmer texture and lower sweetness (Dewi et al., 2024; Khairina et al., 2023). Research has shown that 200 mL of pineapple juice contains 106.33 ± 0.14 mg/mL of bromelain (Wan et al., 2023). Processing pineapple into juice allows both the flesh and core to be used in a more acceptable manner. Bromelain can be absorbed in the intestine without losing its biological activity and is considered to have low toxicity and minimal side effects (Hikisz & Bernasinska-Slomczewska, 2021; Sansar & Yesilkaya, 2022). In animal studies, pineapple juice prepared from the flesh at 7 mL/kg body weight for 14 days significantly improved total cholesterol, LDL, triglyceride, VLDL, and HDL levels (Tijjani et al., 2020). In humans, Sasmithae et al. (2023) found that Parigi pineapple flesh at a dose equivalent to 142 g/70 kg adult for six days reduced LDL levels in 30 medical students (Sasmithae et al., 2023). Similarly, Hulu and Chaniago (2021) reported a significant effect of pineapple juice after 7 days in 30 participants, although they recommended a longer intervention period for future studies.

Previous studies have not optimized pineapple use because they have mainly used the flesh, even though the core has higher bromelain activity. Therefore, in this study, we developed a functional juice from both the flesh and core of the fruit. In addition, earlier research has not specifically examined working women as a target population. Based on this gap, the present study aimed to investigate the effect of pineapple (*Ananas comosus*) juice prepared from the flesh and core on total cholesterol levels in overweight and obese working women.

Methods

This study adopted a quasi-experimental design with a pre–posttest control group and was conducted at Great Giant Food, Lampung, Indonesia, between August and September 2025. Although this design is appropriate for preliminary intervention research, it may limit internal validity because of the potential for confounding and selection biases. To reduce these risks, participants were allocated using stratified random sampling, baseline characteristics were assessed, and potential confounders were controlled for in the statistical analysis.

The sample was selected using stratified random sampling with a single-blind design, in which participants were first categorized into overweight and obese groups and then randomly assigned using a lottery. The participants were working women from various departments who provided their written informed consent. Sample size estimation was performed using GPower, based on the mean and standard deviation values from previous studies, namely those by Cherubini and MacDonald (2021) and Ley et al. (2016), to determine the effect size used. This yielded an effect size of 0.48, power of 0.8, 95% confidence interval, and alpha error of 0.05 (Cherubini & Macdonald, 2021; Ley et al., 2016). A total of 34 women were enrolled, reflecting the G-Power calculation with an additional 20% allowance for potential dropouts, resulting in 17 participants per group.

The inclusion criteria required women aged 20–49 years who were employed at Great Giant Food, classified as overweight or obese with a BMI of at least 23, in good physical and mental health, non-shift workers, willing to participate, without a pineapple allergy, and capable of reading, writing, and communicating effectively. The exclusion criteria included the use of cholesterol-lowering or antidepressant medications and the presence of chronic gastrointestinal diseases such as GERD, Irritable Bowel Syndrome (IBS), and Inflammatory Bowel Disease (IBD).

Prior to enrollment, prospective participants underwent measurements of body weight and height to calculate BMI and completed questionnaires regarding their medical history, dietary habits, and allergies. Participants who met the criteria were allocated to two groups: an intervention group receiving pineapple juice and a control group receiving stevia-sweetened water. Blood samples for total serum cholesterol analysis were collected from the cubital vein on two occasions: before and after the intervention. Participants were instructed to fast for approximately 12 h before sample collection. The baseline assessment involved the measurement of total cholesterol. Participants consumed the assigned intervention once daily for 14 days at a dosage equivalent to 142 g per 70 kg body weight. During the intervention period, they were instructed to maintain a food record to capture dietary intake, and they received prior instruction and education on the proper completion of the form. To reduce potential side effects, participants were advised to consume the intervention after eating or when their stomach was not empty. On day 15, the participants returned for post-intervention evaluations, during which only the total cholesterol level was measured.

For the pineapple juice, Smooth Cayenne pineapple with 75% ripeness, indicated by 3/4 of the peel turning yellow, was used. The pineapple was peeled, and the flesh was separated from the core. The juice was prepared using a proportion of 75% flesh and 25% core based on the total dose weight without adding water or sugar. Both the flesh and core were blended separately and weighed according to the required dose for each participant. The control group received liquid stevia, yellow food-grade and halal coloring, and mineral water. Liquid stevia was added at 1 drop (0.05 mL) per 300 mL of mineral water, and yellow food coloring was added at 1 drop (0.05 mL) per 700 mL of water. These components were combined in 2,100 mL of mineral water, and the final mixture was prepared according to the designated dose for each participant. Intervention adherence was monitored through direct observation during consumption, follow-up requests for photographic evidence of beverage consumption, and review of consumption data recorded in food records.

Sample nutrient analysis was performed to determine the dietary fiber levels, bromelain content, and bromelain enzymatic activity per 100 g of the sample. Dietary fiber was assessed using the gravimetric–enzymatic method, bromelain content was measured using ethanol extraction, and bromelain activity was measured using the Casein Digestion Unit (CDU) method. Total cholesterol levels were determined using the CHOD-PAP method.

Dietary intake data obtained from respondents were processed using Nutrisurvey 2007 and subsequently analyzed using IBM SPSS version 25. The data for this study were processed using IBM SPSS version 25. Prior to the analysis, the data underwent editing, coding, data entry, and tabulation. The analysis began with a normality test. For normally distributed data, paired comparisons were conducted using the paired t-test, whereas non-normally distributed data were analyzed using the Wilcoxon signed-rank test. Differences between the intervention and control groups were examined using an independent t-test for normally distributed data and the Mann–Whitney U test for non-normally distributed data. A 95% confidence interval (CI) was used for all statistical procedures. There were no missing data in this study; therefore, all participants were included in the final analyses. An ANCOVA was conducted to analyze the influence of confounding variables. The analysis employed Total cholesterol was the dependent variable, pineapple juice intervention was the independent variable, and age and nutritional status were the confounding variables.

Ethical approval for this study was granted by the Research Ethics Committee of Universitas Brawijaya and documented in Ethical Clearance No. 239/UN10.F17.10.4/TU/2025, in accordance with the established ethical standards.

Result and Discussion

The study included 34 participants who were assigned to either the control group or the intervention (pineapple juice) group, with 17 individuals in each group. The assessed characteristics included age, BMI classification, and total cholesterol levels. The subject characteristics table showed no significant differences in nutritional status or age between the control and intervention groups ($p > 0.05$), whereas total cholesterol levels differed significantly between the groups. This indicates that the two groups differed in their characteristics. The data are presented in the table below.

Table 1. Subject characteristics

Characteristic	Control		Intervention		p-value
	n	%	n	%	
Age (years)					
20-29	6	35.3	4	23.5	0.458[a]
30-49	11	64.7	13	76.5	
BMI status					
Overweight	2	11.8	2	11.8	0.775[a]
Obesity	15	88.2	15	88.2	
Total cholesterol					
Normal (≤200 mg/dL)	15	88.2	10	58.8	0.007*[b]
High (>200 mg/dL)	2	11.8	7	41.2	

*p-value; a Mann–Whitney test; b independent t-test; significant at p < 0.05; BMI = Body Mass Index

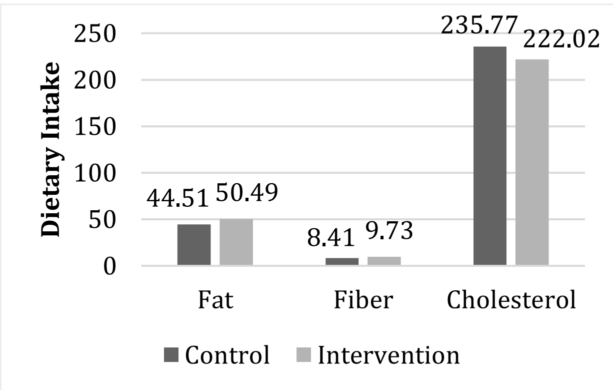
Table 2. Differences in changes in serum cholesterol levels

Parameter	Group	Control	Intervention
		Mean ± SD	Mean ± SD
Total cholesterol (mg/dL)	Before	163.06±26.36	195.35±37.73
	After	170.65±25.04	189.35±38.55
	p-value	0.053	0.268

p-value was calculated using the paired t-test (significant at $p < 0.05$)

The table indicates that most participants were aged 30–49 years. The majority had a nutritional status classified as obesity. Elevated total cholesterol levels were observed in nine participants (26.5 %), compared with participants whose levels were within the normal range. Based on the analysis of preliminary dietary data collected before the study, participants' staple food consumption was irregular, with 50% reporting consumption 2 times/day. Participants frequently consumed snacks, with 44.1% consuming savory snacks 4–7 times/week, and rarely consumed fruit, with 44.1% consuming fruit 1–3 times/week. In addition to the participants' dietary habit records, data on their food consumption throughout the 14-day intervention were documented, as shown in the dietary intake chart.

The pineapple juice sample analysis showed that 100 g contained 4.9% dietary fiber, 1.2% bromelain, and bromelain enzyme activity of 1.97 CDU/mg. The dietary fiber content of the pineapple juice sample can be classified as a dietary fiber source because it contains more than 3 g per 100 g (Badan et al., 2022).



The data indicated that both the intervention and control groups consumed low amounts of dietary fiber, below 30 g per day, based on age and sex recommendations (Menteri et al., 2019). The mean intake did not differ significantly between the two groups, as indicated by p-values greater than 0.05 for fat intake ($p = 0.257$), fiber ($p = 0.181$), and cholesterol ($p = 0.704$). The intervention group (pineapple juice) had a higher mean fat and fiber intake than the control group, whereas the control group had a higher mean cholesterol intake than the intervention group.

The findings further indicated that serum total cholesterol levels in the control group showed no significant change before and after the intervention, as reflected by a p-value of 0.053, which exceeds 0.05, based on a within-group comparison with a 95% confidence interval. Despite this, the mean values showed an increase in total cholesterol, with a mean difference of −7.588, indicating an increase in serum total cholesterol at the second measurement. Similarly, in the intervention group (pineapple juice), no significant difference was observed between pre- and post-intervention cholesterol levels ($p = 0.268$). However, the positive mean difference indicates a decrease in serum total cholesterol after the intervention, with a mean change of 6 mg/dL, indicating that the second measurement was lower than the first. Data on the mean differences in total cholesterol levels before and after treatment in both the control and intervention (pineapple juice) groups, as well as the comparison between these groups, are shown in Table 3.

Table 3. Comparison of changes in serum total cholesterol levels between the control and intervention groups

Group/Parameter	Total cholesterol (mg/dL)
Control	-7.59±15.004
Intervention	6±21.558
p-value	0.041*

*p-value; independent t-test; significant at $p < 0.05$

Based on the data presented in the table, there was a significant difference in serum total cholesterol levels between the control and intervention groups, with a p-value of 0.041, which was below 0.05. When assessed based on the difference between pre- and post-intervention values in both groups, the between-group comparison showed a significant difference.

Table 4. ANCOVA test on serum total cholesterol with age and nutritional status

Group/Variable	Control		Intervention	
	Mean	p-value	Mean	p-value
Age (years)				
20-29	170.11	0.915	179.39	0.319
30-49	170.94		192.42	
BMI status				
Overweight	162.05	0.387	195.81	0.701
Obesity	171.79		188.49	

ANCOVA test, significant if p-value < 0.05

The table above illustrates the influence of confounding variables, such as age and nutritional status, on total cholesterol levels. Based on these values, there was no significant influence of age or nutritional status on total cholesterol levels ($p > 0.05$).

The nutritional content reported in this study may differ from that reported in other studies because of several factors, including the pineapple variety, the part of the pineapple used, and the measurement method. This is supported by the bromelain content in this study, which differed from that reported in a previous study using pineapple juice: 106.33 mg/mL in 200 mL, which, when converted, is 10.3 g/100 g, compared to 1.2 g/100 g in the present study. This difference may be influenced by the testing methods, as a previous study used High-Performance Liquid Chromatography (HPLC), whereas the present study used ethanol extraction (Wan et al., 2023). The difference between these two methods is that the HPLC method can obtain pure bromelain, whereas the extraction method obtains Crude Bromelain (*Crude Bromelain*) (Zhou & Ye, 2021).

In the control and intervention groups, the absence of significant differences in serum total cholesterol levels before and after treatment, based on the collected data, could be attributable to several factors, including the low mean fiber intake of <30 g/day and high cholesterol intake of >200 mg/d (Carson & Anderson, 2020; Menteri et al., 2019). This is supported by studies indicating that dyslipidemia is multifactorial and involves genetic, dietary, and lifestyle factors, in which unhealthy eating habits, such as high consumption of saturated fats, trans fats, and refined sugars, and low fiber intake, are major contributors to the development of dyslipidemia (Berisha et al., 2025). If the recommended energy intake for obese women is 1200-1500 kcal, with fat providing 20-25% of the total energy, then the recommended fat intake is 26.67-33.33 g/day for 1200 kcal or 33.33-41.67 g/day for 1500 kcal (Handa et al., 2025; Pribadi et al., 2024). Compared with these recommendations, the fat intake of the study participants in both the control and intervention groups was higher than the recommended amount.

Aisyah et al. (2025) also stated that cholesterol levels can be affected by high-fat food intake and low-fiber consumption (Aisyah et al., 2025). The results of this study are not consistent with those of Efianty et al. (2023), who showed that total cholesterol levels before and after pineapple juice administration differed significantly at a dose of 142 g/70 kg body weight for 6 days using Parigi pineapple in 43 male and female students from the 2020 class of the Faculty of Medicine, University of Palangka Raya. Participants were 19-23 years old, with the maximum age reported as 20 years (51.2%), and most research participants were female (55.8%) (Efianty et al., 2023). Based on this comparison, the characteristics of the research participants differed by age and gender. In the present study, the participants were women aged 20-49 years, with the largest proportion in the 30-49-year age range (70.6%). Age and sex affect total cholesterol levels; as age increases, the risk of developing hypercholesterolemia increases, and women are at greater risk than men because women have higher fat reserves and produce more diverse hormones that cause fat accumulation in the hips and breasts (Fandini et al., 2023).

In addition, nonsignificant differences in total cholesterol levels may also be caused by hereditary factors, which play a major role in determining individual serum cholesterol levels. These include genetic mutation disorders inherited from parents with heterozygous traits that produce only half the normal number of LDL receptors. A lower-than-normal number of LDL receptors can cause familial hypercholesterolemia, a condition in which the body is unable to regulate LDL levels in the blood, thereby affecting the total cholesterol levels in affected individuals (Aisyah et al., 2025).

In addition, the serum total cholesterol levels before treatment differed significantly between the control and intervention groups, which may have affected the results. This is supported by the statement that in quasi-experimental designs (QEDs), the groups being compared can differ systematically in various baseline characteristics because of confounding variables, which can limit the validity of the conclusions drawn (Andrade, 2021). Moreover, the primary threat to the internal validity of QEDs is the lack of equivalence between the comparison and intervention groups or time periods, arising from differences in participant characteristics, settings, or time frames involved (Handley et al., 2021). The absence of a significant effect in the ANCOVA results may be explained by residual bias related to confounding variables that were not measured or accounted for in the analysis (Desai, 2024). This is supported by the statement that a known confounder may have been measured, but its control may still be incomplete, and residual confounding from unmeasured factors may remain (Verbeek et al., 2021).

This study also showed a difference in the mean serum total cholesterol values between the control and intervention groups before and after treatment: values increased in the control group and decreased in the intervention group. The observed difference in serum total cholesterol levels may have been influenced by the pineapple juice intervention; however, the significant baseline imbalance between groups reduced group comparability and limited the extent to which the effect could be attributed solely to the intervention. The improvement in serum total cholesterol levels can contribute to improving lipid profiles, although this study still showed a significant decrease.

Dietary fiber in pineapple juice, especially soluble fiber, can help improve serum total cholesterol levels by shaping the gut microbiota and promoting the production of metabolites (short-chain fatty acids, SCFAs) with pleiotropic effects. These effects can be anti-inflammatory through the inhibition of the NF-κB signaling pathway, thereby reducing the production of proinflammatory mediators (Niero et al., 2023). Bromelain can lower total cholesterol levels by reducing hepatic lipid accumulation through the activation of the AMPK-autophagy pathway and increasing bile acid metabolism and fatty acid oxidation (Hu et al., 2022; Tarantino et al., 2021). In addition, bromelain can act as an anti-inflammatory and antioxidant through several mechanisms, including suppression of the expression of inflammatory mediators (G-CSF, IL-1β, IL-6, and TNF-α) and cellular adhesion molecules through inhibition of the NF-κB and MAPK pathways, reduction of malondialdehyde (MDA) and myeloperoxidase (MPO) levels in tissues, and increase in glutathione (GSH) and superoxide dismutase (SOD) levels (Dilek Acar et al., 2025; Hong et al., 2021).

The results of this study are consistent with those of a study conducted by Seenak et al. (2021), in which the administration of a pineapple powder solution to rats fed a high-cholesterol diet at a dose of 200 mg/kg BW for 8 weeks significantly reduced total cholesterol levels compared with the group that received only a high-cholesterol diet (Seenak et al., 2021). Another study consistent with the present findings reported a significant difference between a group of obese rats not given pineapple juice and obese rats given pineapple juice at a dose of 15% of the water consumed (v/v) for 5 weeks (Ahmed, 2016). However, some studies are inconsistent with the present findings. In a study conducted by Khairunnisa et al. (2025), elderly men with hypercholesterolemia received interventions, including pineapple yogurt and nutrition education, for 7 days, but no significant difference was observed; the study recommended increasing the intervention duration and dose (Khairunnisa et al., 2025).

In the control group, the administration of stevia solution had no impact on serum total cholesterol levels. This finding is not consistent with previous studies showing that administration of stevia extract to hyperlipidemic albino mice at a dose of 200-500 ppm/kg BW for 8 weeks could potentially be a promising nutraceutical therapy for the management of hyperlipidemia and related complications because of its hypolipidemic ability (Ahmad et al., 2018). This difference in results may be due to differences in the dose of stevia solution and the duration of the intervention.

This study has several strengths, including the recruitment of female workers from various departments at Great Giant Food, the use of a dietary assessment method, namely a food record, to record participants' food intake throughout the study, the preparation of pineapple juice from both the flesh and core without added water or sugar, which differs from previous research, and the use of readily available raw materials. In addition, this study may help increase pineapple consumption among individuals who have received information about the benefits of pineapple associated with bromelain and fiber. Cooperation between researchers and companies may also improve company policies related to the consumption of juice and fruit as substitutes for snacks that are high in sodium and fat, for example, during meetings.

The limitations of this study include the lack of combining the intervention with dietary and physical activity settings, the lack of strict control over either, and the lack of analysis of the overall lipid profile. In addition, detailed data on the respondents' characteristics, including physical activity, smoking habits, marital status, and other factors, were not available. The quasi-experimental design may have introduced bias because external factors could have affected the results and the characteristics may have differed between the groups. In addition, the sample size may have been insufficient for the analysis.

Conclusion

This study showed that pineapple juice consumption improved serum total cholesterol levels. However, these results were not statistically significant. Other factors that may affect the total cholesterol levels should also be considered.

Future research should re-analyze the dose and timing of the intervention and test other lipid profile measures, such as HDL and triglyceride levels, to provide more optimal results. In addition, future studies should collect data on physical activity, smoking habits, and marital status to enrich the results and discussion and optimize the intervention by combining pineapple juice administration with dietary intake and physical activity settings. High-Performance Liquid Chromatography (HPLC) methods can be used for bromelain analysis.

In addition, to minimize bias in quasi-experimental studies, several measures can be taken, including conducting ANCOVA statistical tests, collecting additional data to support inferences, such as physical activity and dietary intake, using more than one control group, and using matching, stratification, or partial randomization so that the distribution of confounding factors is more balanced.

Acknowledgements

We thank Great Giant Food for allowing us to conduct the research at the site. We also thank all those who contributed to the research and writing of the article. All authors confirm the absence of any conflicts of interest in this study. This study received no financial support or grants from any funding institution, including public, commercial, or nonprofit organizations. AI was used to paraphrase the sentences in this manuscript.

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