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Effects of fiber and resistant starch in "*Mangpis*" cookies on changes in blood lipid profile in obese patients obesity

Efek serat dan pati resisten kukis "Mangpis" terhadap perubahan profil lipid darah pada penderita obesitas

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Abstract

Abnormal lipid profiles can cause obesity-associated heart diseases. Increased total cholesterol, Low-Density Lipoprotein (LDL), triglyceride (TG), and High-Density Lipoprotein (HDL) levels are indicators of obesity. This study aimed to identify the dietary fiber and resistant starch in *mangpis* cookies and analyze the effects of *mangpis* cookies on reducing lipid profiles. This study used a *pre-test* and *post-test* design to measure lipid profiles before and after eating *mangpis*. *Mangpis* cookies were prepared without wheat flour and replaced with 50% *Bruguiera gymnorhiza* mangrove flour and 50% banana flour. This experiment was conducted on 16 obese subjects. The sampling technique used was purposive. A decrease in the lipid profile was observed based on the results of blood tests before and after consumption *of mangpis* cookies. The effect of consumption of *mangpis* cookies on reducing lipid profiles was assessed using the Paired T-test and Wilcoxon test. The results of the analysis of the content of food fiber and resistant starch contained in the *mangpis* cookies were 7,86 ± 004 and 6,65 ± 0,01 with p value TG (p=0,001 and HDL (p=0,01). In conclusion, *mangpis* cookies were identified to contain 17,8% dietary fiber and 15% resistant starch, which could have an influence on the lipid profile, especially TG levels.
Keywords: Fiber, lipid profile, *mangpis*, Starch resistant

Abstrak

Profil lipid tidak normal penyebab terjadinya penyakit jantung pada obesitas. Peningkatan kadar kolesterol total, LDL (*Low Density Lipoprotein),* TG (trigliserida) dan rendahnya kadar HDL (*High Density Lipoprotein)* merupakan indikatornya. Penelitian bertujuan untuk mengidentifikasi serat pangan dan pati resisten kukis *mangpis* serta menganalisis efek pemberian kukis *mangpis* terhadap penurunan profil lipid. Metode menggunakan desain rancangan *pre-test* dan *post-test* untuk mengukur profil lipid sebelum dan setelah mengkonsumsi kukis *mangpis.* Kukis *mangpis* adalah kukis yang dibuat tanpa tepung terigu dan menggantinya dengan 50% tepung mangrove jenis *Bruguiera gymnorhiza* dan 50% tepung pisang kepok. Subjek adalah 16 orang penderita obesitas. Teknik pengambilan sampel berdasarkan purposive sampling. Penurunan profil lipid dilihat berdasarkan hasil pemeriksaan darah sebelum dan setelah mengkonsumsi kukis *mangpis*. Efek konsumsi kukis *mangpis* terhadap penurunan profil lipid menggunakan uji T berpasangan dan uji *Wilcoxon*. Hasil analisis kandungan serat pangan dan pati resisten yang terkadung dalam kukis *mangpis* adalah sebesar 7,86±0,04 dan 6,65±0,01, dengan nilai p pada TG (0,001) dan HDL (0,01). Kesimpulan, bahwa kukis *mangpis* teridentivikasi mengandung 17,8% serat pangan dan 15% pati resisten dan berpengaruh terhadap profil lipid salah satunya yaitu kadar TG.
Kata Kunci: *Mangpis*, pati resisten, profil lipid, serat

Introduction

Obesity develops insulin resistance to the action of cellular insulin, which is characterized by a reduced capacity of insulin to inhibit hepatic glucose production and its ability to increase glucose uptake into fat and muscle (Samuel et al., 2012). Human studies have shown that changes in body weight are associated with insulin sensitivity, suggesting a cause-and-effect relationship between obesity and insulin resistance. The relationship between weight change and insulin resistance may be partly due to the role of adipose tissue in obesity (Tchernof & Després, 2013). Adipose tissue not only stores lipids but also functions as an endocrine organ that secretes cytokines and peptide hormones that contribute to weight regulation and energy metabolism (Park et al., 2006). An imbalance in the lipid profile of the body greatly influences the onset of cardiovascular disease. Low levels of HDL cholesterol in the blood are a risk factor for cardiovascular disease. HDL cholesterol is a lipoprotein that functions to balance excess LDL cholesterol levels in the body, and is responsible for carrying cholesterol from the arterial wall to the liver, where it is broken down for elimination from the body (Wulandari et al., 2020).

Hypercholesterolemia can cause atherosclerosis, leading to increased blood pressure (BP). High levels of LDL cholesterol stick to the walls of blood vessels and cause plaques. Over time, a thicker plaque can tear the lining of the artery wall and a blood clot (thrombus) occurs, blocking blood flow in the artery. The thrombus completely blocks the coronary artery, causing cessation of oxygen supply to the heart muscle and myocardial infarction (Winarsi et al., 2011). High triglyceride levels can lead to lipolysis, causing atherosclerosis and blood vessel inflammation. Triglyceride levels can be influenced by diet, physical activity, genetics, age, and sex (Brahm & Hegele, 2013; Andini & Ardiaria, 2016).

Lipids affect the gut microbiota as substrates for bacterial metabolic processes and as toxic inhibitors of bacterial growth toxins. Gut microbiota influences lipid metabolism and blood lipid levels in humans (Schoeler & Caesar, 2019). Lipid metabolism affects homeostatic processes, including membrane synthesis and the use of lipids such as triglycerides for energy storage. Lipids are transmitted into cells via fatty acid transport or translocase proteins, including Fatty Acid Transport Protein (FATP) and CD36. In the mitochondria, lipids are oxidized to produce acetyl-CoA, which is further used to produce fatty acids. Glucose uptake via glucose transporters contributes pyruvate and acetyl-CoA to support the tricarboxylic acid (TCA) cycle in the mitochondria. Citrate is synthesized during the TCA cycle and exported from the mitochondria for fatty acid and cholesterol synthesis (Yoon et al., 2021; Jia et al., 2020).

The factors contributing to increased hypertriglyceridemia include obesity, metabolic syndrome, increased risk of cardiovascular disease (CVD), insulin resistance, hypertension, diets with a high positive energy intake balance, high glycemic index, alcohol consumption, diabetes mellitus, kidney disease (uremia or glomerulonephritis), pregnancy (especially in the third trimester), paraproteinemia, systemic lupus erythematosus, and medications, including corticosteroids, oral estrogens, tamoxifen, thiazides, non-cardioselective beta-blockers, bile acid sequestrants, cyclophosphamide, antiretroviral drugs, and antipsychotic agents (Brahm & Hegele, 2013).

Combination treatment is necessary for severe hypertriglyceridemia, which is difficult to treat. In general, monotherapy with pharmacological agents should be performed first, followed by dietary adjustments. Fibric acid derivatives, such as gemfibrozil, bezafibrate, and fenofibrate, are treatments for hypertriglyceridemia. This fiber can reduce plasma triglyceride levels by up to 50% and increase plasma HDL-C concentrations by as much as 20%. Statins are inhibitors of 3-hydroxy-3-methylglutaryl-coenzyme A reductase. Newer statins used at higher doses can markedly reduce triglyceride levels. Consuming 3 g per day of niacin (nicotinic acid) can reduce plasma triglyceride levels by 45%, increase plasma HDL-C levels by 25%, and reduce plasma LDL-C levels by 20%. Bile acid-binding resins degrade plasma triglyceride concentrations. This combination of fenofibrate and ezetimibe has been shown to be safe and effective in patients with high triglyceride and LDL-C levels (Yuan et al., 2007).

Bempedoic acid is an adenosine triphosphate (ATP) citrate lyase inhibitor that inhibits cholesterol biosynthesis and increases LDL receptor expression. Ezetimibe is a selective inhibitor of cholesterol absorption. Proprotein convertase subtilisinor kexin type 9 (PCSK9) inhibitors are lipid-lowering drugs such as antisense oligonucleotides, volanesorsen, olezarsen, and ANGPTL3 inhibitors (Merćep et al., 2022). In addition to pharmacological treatment, the efficacy and safety of natural products have shown favorable changes in lipid profiles and reduced CVD risk. Numerous studies have shown the positive and side effects of herbs, as they contain biological components. One example of ginseng plant has antioxidant properties that improve physical performance. These side effects can cause indigestion, diarrhea, insomnia, headaches, heart palpitations, and blood pressure fluctuations (Sellami et al., 2018). Herbal medicines commonly used for lipid reduction include garlic, ginger, ginseng, pepper, spirulina, aloe vera, cumin, and berberies (Adel-Mehraban et al., 2021).

Resistant starch, a prebiotic, is starch that is not digested in the small intestine but is fermented in the large intestine by microorganisms in healthy people. It produces short-chain fatty acids (SCFA) that are associated with several metabolic effects. Resistant starch can lower postprandial blood glucose and lipid metabolism, and reduce fat accumulation, gut health, and weight loss. and insulin sensitivity (Bojarczuk et al., 2022). Increasing fiber intake causes satiety, reduces energy intake, and increases the release of the hormones cholecystokinin, glucagon-like peptide-1 (GLP 1), ghrelin, and peptide YY (PYY); therefore, this study is very important for further research (Abutair et al., 2016).

Mangpis cookies are cookies made from mangrove fruit flour (*Bruguiera gymnorhiza*) and kepok banana flour (*Musa paradisiaca l*). Mangrove fruit is a high-fiber fruit found in the coastal areas of Indonesia. This fruit has been widely processed into flour and other processed products, such as biscuits, cookies, crackers, plates, cakes, analog rice, brownies, lunkheads containing tannin, and cyanide acid, which are safe for consumption (Rosulva et al., 2022). Mangrove fruit is commonly used in traditional medicine for treating asthma, bleeding, coughing, heat reduction, bleeding, intestinal parasites, hemorrhoids, sprains, swelling, and ulcers. Mangrove fruit contains fiber and bioactive compounds that can be used as antioxidants and antimicrobials (Budiyanto et al., 2022).). The nutritional content of mangrove flour in 100 grams is 3,17% water content, 0,64% fat, 4,86% protein, 89,71% carbohydrates, 1,64% ash content, 23,43% dietary fiber (Amalia et al., 2022). In contrast, 100 g of banana flour contains 9,64% water content, 0,5% fat, 3,1% protein, 84,96% carbohydrates, 1,8% ash content, 1,8% fiber (Rosalina et al., 2018).

Bananas are considered good prebiotics. Kepok bananas are a type of plantain that contains inulin, resistant starch and high fiber. The starch content of Kepok bananas ranges from 61-73% (Pertanian, 2013). Nutrient-rich bananas contain macronutrients, micronutrients (provitamin A, vitamin C, magnesium, copper, iron, potassium, calcium, sodium, zinc, and manganese), and phytonutrients that have highly effective pharmacological activities, such as anti-inflammatory, anticancer, antidiabetic, and bioactive compounds as antioxidants in reducing the risk of disease (Afzal et al., 2022).). Banana flour contains high levels of total starch (70.0%), resistant starch (17,5%), and dietary fiber (14,5%)(Malindi, 2021). This study showed that the content of dietary fiber and resistant starch in *mangpis* cookies had an effect on lipid profiles, especially TG levels. Previous studies have not combined mangrove and kepok banana flours. This study aims to identify dietary fiber and resistant starch in *mangpis* cookies and analyze the effect of *mangpis* cookies on reducing lipid profiles in humans.

Methods

This study used a pre-experimental design to determine the effect of mangpis cookie consumption on reducing lipid profiles. A pre-test and post-test design was used to measure the decrease in lipid profile after being given mangpis cookies as a result of the intervention. Mangpis cookies were prepared by preparing mangrove flour and kepok banana flour, analyzing the fiber and resistant starch of mangpis cookies, and testing the effect of mangpis cookies consumption on lowering the lipid profiles in 16 obese subjects in the Gorontalo Ministry of Health Polytechnic area, from February to March 2023.

Sample calculation using G power 3,1 application. The sampling technique was based on purposive sampling that met the inclusion and exclusion criteria. This study was approved by the ethics committee of NUMBER 149/EC/KEPK/FK-UNDIP/IV/2023, issued by the KEPK for Health Research, Faculty of Medicine, Diponegoro University, Semarang/DR KARIADI Hospital, Semarang City.

The tools needed for making cookies in this study are a cabinet dryer (Getra, Indonesia), oven, Miyako brand blender, Miyako brand mixer, stainless steel basin, spoon, fork, knife, spatula, 60 mesh sieve pan, food scale, cookie mold. The materials needed include mangrove flour, kepok banana flour, margarine, powdered milk, powdered sugar, chicken eggs, maezena flour. The tools needed for sample analysis were a 3 ml dispo, green EDTA tube, handscun, label, cotton, alcohol swap, and tourniquet. The manufacture of Mangrove Flour and Kepok Banana Flour was carried out at the Food Preparation Laboratory of the Nutrition Department, Health Polytechnic of the Ministry of Health, Gorontalo and the Culinary Laboratory of the Nutrition Science Study Program, Diponegoro University, Semarang.

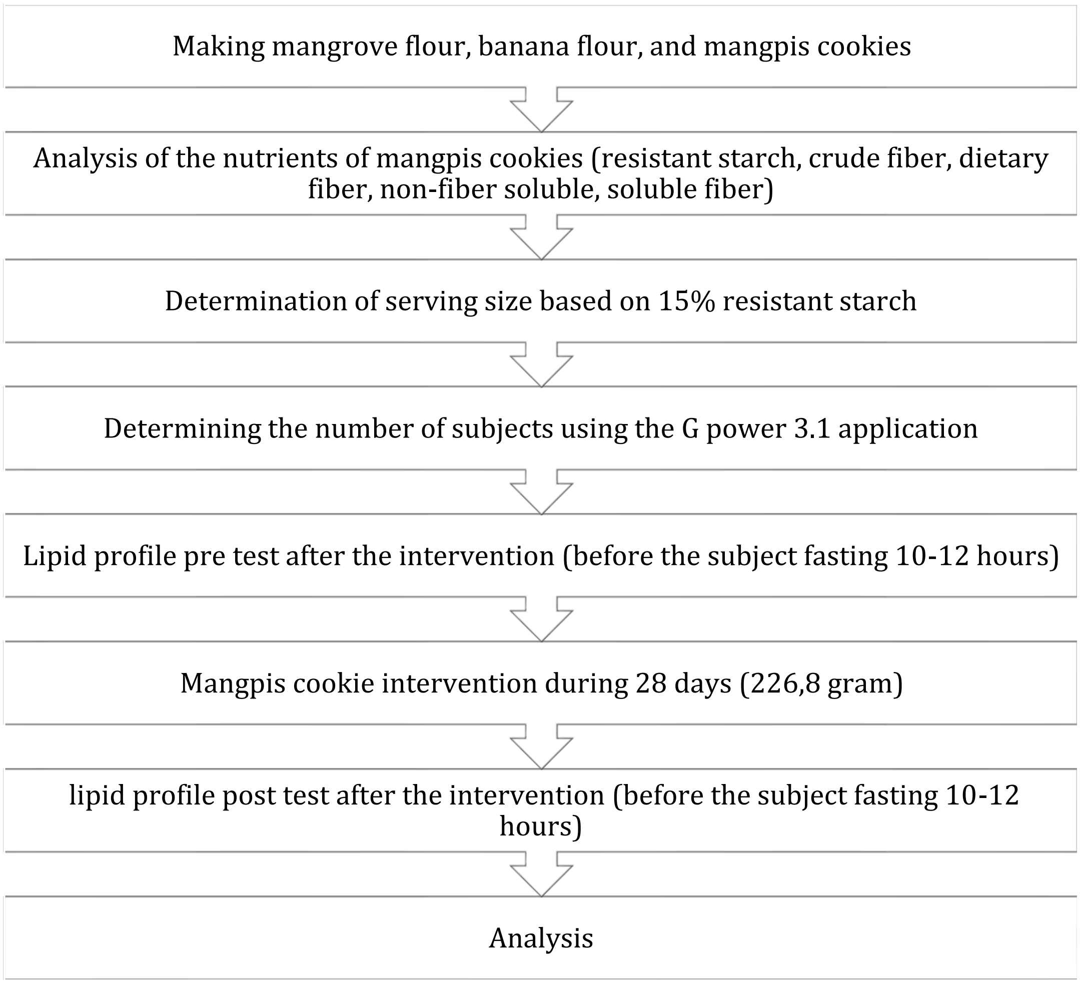

Chart 1. Research flow

Preparation of mangrove flour. Mangroves with dark green and purplish color characteristics, cylindrical shape, 15-30 cm long and 1-2 cm wide, were sorted, peeled, washed, and thinly sliced 0,5-1 cm in a size. The samples were then soaked in 30% rice-husk ash for 24 h at a ratio of 1:4. After soaking, the mangrove fruits were rinsed with water and boiled for 30 min. Mangrove fruit that had been boiled was dried using sunlight three times for 24 hours. After drying, it was mashed with a grinder and sieved through a 60 mesh sieve with a diameter of 0,250 mm. The process of making banana flour is sorted, peeled, thinly sliced to a size of 0,5-1 cm. The banana fruits were then dried using a cabinet dryer at 70°C for 12 h. After drying, it was mashed with a grinder and sieved through a 60 mesh sieve with a diameter of 0,250 mm.

The cookies were prepared by mixing margarine, milk, powdered sugar, and eggs, according to the recipe formulation shown in Table 1. After mixing, the dough was round and flattened at 16,2 grams per piece with a 5 cm diameter, and then baked in an oven at 150 °C for

40 min. The finished cookies were then analyzed for resistant starch, crude fiber, dietary fiber, soluble fiber, and insoluble fiber content using the enzymatic gravimetric method (AOAC 2005).

Table 1. Mangpis cookies formulation

Ingredient	Weight (grams)	%
Wheat flour	0	0
Mangrove fruit flour	25	14,3
Kepok banana flour	25	14,3
Margarine	20	11,4
Full cream powder milk	10	5,7
Refined sugar	25	14,3
Eggs	60	34,3
Maezena Flour	10	5,7
Total	175	100

The research subjects in this experimental stage were selected using purposive sampling, namely, 16 obese people in the Gorontalo Ministry of Health Polytechnic area. The inclusion criteria were as follows: research subjects, aged 18-45 years, obese nutritional status (indicated by BMI ≥ 25 kg/m^2), not pregnant, no history of DM, no smoking, no history of allergies to ingredients used in the product, and not on a weight loss diet. The exclusion criteria were as follows: not following the research procedures, resigning in the middle of the study, not taking drugs for less than 24 h, fasting for more than 14 h, and strenuous physical activity 12 h before blood collection.

The lipid profile was measured using blood tests performed by health workers at the Prodia Gorontalo Laboratory. Blood was collected twice, 2 h before intervention and 12 h after the *mangpis* cookie intervention. The intervention lasted for 28 days. The blood collection procedure starts with filling out informed consent, then the subject will fast for 10-12 hours, then 5 ml of blood will be taken from the vein (pre-test) and put into a tube with a green cap. This tube contained a gel separator with lithium heparin anticoagulant. Blood plasma was at the top after mixing. The subjects were then given cookies for 28 days and blood sampling was continued again (post-test) using the same procedure.

Data from the lipid profile test were then analyzed using the paired T-test and Wilcoxon test, which was first carried out as a normality test, and then continued with univariate tests and bivariate tests with a confidence level of 95% CI to see the differences in lipid profiles before and after the intervention.

Result and Discussion

Yield is an important factor in flour production. The yield was obtained by dividing the weight of flour produced by the weight of the mangrove fruit or kepok banana fruit. The yield values of mangrove flour and Kepok banana flour are shown in Table 2.

These two ingredients (Table 2) were made into *mangpis* cake by nutritional analysis, as shown in Table 3.

Table 2. Yield of mangrove flour and kepok banana flour

Various of Flour	Yield value (%)
Mangrove	18,89
Kepok Banana	18,47

$$\text{Yield value} = \frac{flour\ weight\ (gram)}{Initial\ weight(gram)} x\ 100$$

Table 3. Nutritional content of *mangpis* cookies

Paramater	Mean±SD
Resistant starch (%)	6,65±0,01
Crude fiber (%)	6,32±0,08
Dietary Fiber (%)	7,86±0,04
Insoluble Fiber (%)	7,43±0,04
Soluble fiber (%)	0,43±0,00

SD= Standard deviation

The results of the analysis of the nutritional content of cookies (Table 3) show that the average resistant starch of *mangpis* cookies was 6,65% with a standard deviation of 0,01, the average crude fiber is 6,32% with a standard deviation of 0,08, the average dietary fiber is 7,86 % with a standard deviation of 0,04, the average of insoluble fiber is 7,43% with a standard deviation of 0,04 and the average of soluble fiber is 0,43% with a standard deviation of 0,00. Resistant starch categories are divided into 5 groups, namely very low <1%, low 1-2,5%, medium 2,5-5%, high 5-15%, very high above 15% (Afifah et al., 2020). Resistant starch and fiber contained in *mangpis* cookies were classified in the high category. Previous research has shown that mangrove flour type Bruguiera gymnorrhiza can reduce lipid profiles in rats. Fiber content and antioxidants in the form of saponins, flavonoids, and tannins are thought to cause a decrease in lipid profiles (Jariyah et al., 2019). Resistant starch has an effect on the lipid profile when administered for 4 weeks. Resistant starch reduces fat accumulation and increases antioxidant enzyme activity and lipid metabolism (Eshghi et al. 2019). The fiber, resistant starch, and flavonoids in banana flour have the potential to regulate cholesterol in the body, increase HDL levels and antioxidant capacity, and reduce total and LDL cholesterol levels. Resistant starch in banana flour affects lipid metabolism through short-chain fatty acid (SCFA) fermentation in the intestine (Agustin et al., 2019).

Giving *mangpis* cookies an appropriate serving size and 15% resistant starch can provide benefits in changing lipid profiles. The serving size of cookies is the number of cookies consumed per day during the intervention, which is expressed in grams or household measurements (URT) of cookies. The determination of serving size is based on the resistant starch content that provides an effect of 15 g/day on obesity and overweight (Maki et al., 2012). The weight of *mangpis* cookies given was 226,8 g which was divided into 2 times. This amount of cookies was equivalent to 15,1% resistant starch and 17,8% dietary fiber (Table 4). The weight of the *mangpis* cookies was 15% resistant starch. One piece of cookie weighs 16,2 g with a total of 14 pieces consumed in a day. Food starch can be grouped into slow-digestible starch, fast-digestible starch, or resistant starch. Resistant starch is a partition of starch that is not digested in the small intestine and is fermented in the large intestine by microorganisms, resulting in the formation of short-chain fatty acids (SCFA), which are associated with several metabolic effects (Bojarczuk et al., 2022).

Table 4. Determination of the Serving Amount of Cookies

Cookies	*Mangpis*
Serving size (gram)	226,8
Resistant starch (%)	15,1
Crude fiber (%)	14,3
Dietary Fiber (%)	17,8
Insoluble Fiber (%)	16,9
Soluble fiber (%)	0,98

Based on Perka BPOM 2016, solid products are said to be high in fiber if they contain 6 g of dietary fiber in 100 g, so that the dietary fiber in *mangpis* cookies can be categorized as high in fiber (Badan Pengawasan Obat dan Makanan, 2016). Dietary fiber is an edible part of plants that is composed of carbohydrates and is resistant to digestion and absorption in the small intestine (Santoso, 2011).

The results of the lipid profile examination before and after *mangpis* cookie intervention are shown in Table 5. Based on Table 5, it can be seen that the triglyceride lipid profile of 16 people, TG decreased by 16 people. The total cholesterol lipid profile examination decreased by 12 people and increased by 4 people. LDL lipid profile examination decreased by 9 people and increased by 7 people, while HDL lipid profile examination decreased by 15 people and 1 person did not experience an increase; thus, it can be concluded that the *mangpis* cookie intervention had an effect on reducing the lipid profiles, especially TG 24,8 % but had no effect on total cholesterol, LDL, and HDL. TG is a simple lipid consisting of fatty acids and glycerol (Putri & Anggraini, 2015). Excess TG in the body leads to coronary heart disease and stroke, blood pressure, risk of diabetes mellitus, and causes the formation of arteriosclerosis (Hidayati et al., 2017; Agung, 2021).

Obesity and saturated fat intake can the trigger activation of Jun N Terminal Kinase (JNK). Increased fat accumulation in adipocytes in obesity leads to the production of pro-inflammatory cytokines, including Tumor Necrosis Factor Alpha (TNF-α) and Interleukin-6 (IL-6), which activate the JNK and NF-kB signaling pathways. The activation of NF-kB in obesity further enhances the inflammatory response, which increases insulin resistance (Sah et al., 2016). Genetic factors and excessive food intake influence elevated triglyceride (TG) levels or hypertriglyceridemia caused by carbohydrates, fat, protein, and alcohol. Elevated levels of TG in the blood are caused by low activity of the Lipoprotein Lipase (LPL) enzyme which plays a role in hydrolyzing TG into fatty acids and glycerol (Nadia et al., 2020). In this study, total cholesterol, LDL, and systolic blood pressure showed no significant differences, which were influenced by several factors, such as the use of granulated sugar, margarine, and high calories, but the dietary fiber and resistant starch in *mangpis* cookies were also high.

The mean and standard deviation of the lipid profile before the intervention (Table 5) were as follows: TG, 92 ± 31,5, total cholesterol KT of 172,1 ± 22,0, LDL of 108,8 ± 21,6, HDL 48,6 ± 7,7. After the intervention, TG was 69,1 ± 20,6, KT was 163,8 ± 22,1, LDL was 107,2 ± 20,2 and HDL levels were 43,5 ± 7,3. Based on the p-value of the Paired T-test of TG and the Wilcoxon HDL test, which is 0,001, it can be seen that there are differences in the lipid profile of TG and HDL lipid profiles before and after the intervention of *mangpis* cookies. Therefore, it can be concluded that *mangpis* cookie intervention has an effect and can reduce TG and HDL, but has no effect on total cholesterol and LDL.

Table 5. Effect of consuming *mangpis* cookies on reducing lipid profiles

Examination	n	Min	Maks	Mean	Median	SD	p-value
Triglyceride (mg/dL)							
Pre test	16	48	175	92	84	31,5	0,001*
Post tes	16	32	112	69,1	68	20,6	
Δ Triglyceride	16	-82	-1	-22,9	-17	20,8	
Total cholesterol (mg/dL)							
Pre test	16	145	224	172,1	165	22,0	0,77*
Post tes	16	121	192	163,8	171,5	22,1	
Δ Total cholesterol	16	-47	28	-8,3	-6,5	17,5	
LDL (mg/dL)							
Pre test	16	73	151	108,8	108	21,6	0,877**
Post tes	16	75	133	107,2	112	20,2	
Δ LDL	16	-35	21	-1,6	0,5	15,8	
HDL (mg/dL)							
Pre test	16	38	65	48,6	46,5	7,71	0,01**
Post tes	16	32	61	43,5	41,5	7,3	
Δ HDL	16	-16	0.0	-5,1	-3,5	4,7	
Systolic Blood Pressure (SBP)(mmHg)							
Pre test	16	94	169	122,4	120,5	17,4	0,867*
Post tes	16	90	160	121,7	123,5	21,9	
Δ SBP	16	-20	50	-0,75	-0,5	17,6	
Diastolic Blood Pressure DBP (mmHg)							
Pre test	16	65	121	84,9	87	14,8	0,020*
Post tes	16	60	100	77,5	80	12,9	
Δ DBP	16	-41	25	-7,5	-8	18,5	

n = Total subject, SD= Standard deviation LDL= Low Density Lipoprotein, HDL= High Density Lipoprotein,
Δ= Delta *Paired T Test, **Wilcoxon test

In this study, there are limitations, namely the use of granulated sugar in making *mangpis* cookies, the need for direct supervision when consuming *mangpis* cookies, and not controlling the food intake of obese people.

Conclusion

Mangpis cookies have potential as a snack food that can reduce TG levels due to their high fiber and resistant starch content, and have an impact on the metabolism of the body. Mangrove flour can be used as a substitute for wheat flour, which can be utilized in coastal areas and is very good for consumption in reducing the problems experienced by people with obesity. Further research on insulin resistance should be conducted.

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References

Abutair, A. S., Naser, I. A., & Hamed, A. T. (2016). Soluble fibers from psyllium improve glycemic response and body weight among diabetes type 2 patients (randomized control trial). *Nutrition Journal, 15*(1), 1–7. https://doi.org/10.1186/s12937-016-0207-4

Adel-Mehraban, M. S., Tabatabaei-Malazy, O., Rahimi, R., Daniali, M., Khashayar, P., & Larijani, B. (2021). Targeting dyslipidemia by herbal medicines: A systematic review of meta-analyses. *Journal of Ethnopharmacology, 280*(May), 1–33. https://doi.org/10.1016/j.jep.2021.114407

Afifah, D. N., Sari, L. N. I., Sari, D. R., Probosari, E., Wijayanti, H. S., & Anjani, G. (2020). Analisis kandungan zat gizi, pati resisten, indeks glikemik, beban glikemik dan daya terima cookies tepung pisang kepok (Musa paradisiaca) termodifikasi enzimatis dan tepung kacang hijau (Vigna radiate). *Jurnal Aplikasi Teknologi Pangan*, *9*(3), 101–107. https://doi.org/10.17728/jatp.8148

Afzal, M. F., Khalid, W., Akram, S., Khalid, M. A., Zubair, M., Kauser, S., Abdelsamea Mohamedahmed, K., Aziz, A., & Anusha Siddiqui, S. (2022). Bioactive profile and functional food applications of banana in food sectors and health: a review. *International Journal of Food Properties, 25*(1), 2286–2300. https://doi.org/10.1080/10942912.2022.2130940

Agung, L. R. (2021). Pengaruh daun salam (Syzygium polyanthum) terhadap kadar trigliserida dan kolesterol total darah pada penderita dislipidemia. *Jurnal Ilmiah Kesehatan Sandi Husada*, *10*(2), 408–412. https://doi.org/10.35816/jiskh.v10i2.617

Agustin, F., Febriyatna, A., Damayati, R. P., Hermawan, H., Faiziah, N., Santoso, R. D., & Wulandari, R. D. (2019). Effect of Unripe berlin banana flour on lipid profile of dyslipidemia rats. *Majalah Kedokteran Bandung*, *51*(2), 70–74. https://doi.org/10.15395/mkb.v51n2.1630

Amalia, R., Pramono, A., Nur, D., Ratna, E., & Cahyo, A. (2022). Mangrove fruit (Bruguiera gymnorhiza) increases circulating GLP-1 and PYY , modulates lipid pro fi les , and reduces systemic in fl ammation by improving SCFA levels in obese wistar rats. *Heliyon, 8*(September), 1–10. https://doi.org/10.1016/j.heliyon.2022.e10887

Andini, A. N., & Ardiaria, M. (2016). Pengaruh pemberian kombinasi minyak rami dengan minyak wijen terhadap kadar trigliserida pada tikus sprague dawley dislipidemia. *Journal of Nutrition College*, *5*(4), 555–564. https://doi.org/https:10.14710/jnc.v5i4.16472.

Badan Pengawasan Obat dan Makanan, R. I. (2016). *Peraturan Kepala Badan Pengawas Obat dan Makanan Republik Indonesia Tentang Pengawasan Klaim Pada Label dan Iklan Pangan Olahan* (Vol. 3, Issue 1). https://standarpangan.pom.go.id/dokumen/peraturan/2016/PerKa_BPOM_No_13_Tahun_2016_tentang_Klaim_pada_Label_dan_Iklan_Pangan_Olahan.pdf

Bojarczuk, A., Skąpska, S., Mousavi Khaneghah, A., & Marszałek, K. (2022). Health benefits of resistant starch: A review of the literature. *Journal of Functional Foods, 93*(January), 1–11. https://doi.org/10.1016/j.jff.2022.105094

Brahm, A., & Hegele, R. A. (2013). Hypertriglyceridemia. *Nutrients, 5*(3), 981–1001. https://doi.org/10.3390/nu5030981

Budiyanto, F., Alhomaidi, E. A., Mohammed, A. E., Ghandourah, M. A., Alorfi, H. S., Bawakid, N. O., & Alarif, W. M. (2022). Exploring the Mangrove Fruit: From the phytochemicals to functional food development and the current progress in the middle east. *Marine Drugs, 20*(5), 1–55. https://doi.org/10.3390/md20050303

Eshghi, F., Bakhshimoghaddam, F., Rasmi, Y., & Alizadeh, M. (2019). Effects of resistant starch supplementation on glucose metabolism, lipid profile, lipid peroxidation marker, and oxidative stress in overweight and obese adults: randomized, double-blind, crossover trial. *Clinical Nutrition Research*, *8*(4), 318–328. https://doi.org/10.7762/cnr.2019.8.4.318

Hidayati, D. R., Yuliati, Y., & Pratiwi, K. R. (2017).

Hubungan asupan lemak dengan kadar trigliserida dan indeks massa tubuh sivitas akademika uny. *Jurnal Prodi Biologi*, *6*(1), 25–33. http://journal.student.uny.ac.id/ojs/index.php/biologi/article/view/6055

Jariyah, Yektiningsih, E., & Sarofa, U. (2019). Evaluation of antidiabetic and anticholesterol properties of biscuit product with mangrove fruit flour (MFF) substitution. *Carpathian Journal of Food Science and Technology, 11*(4), 141–152. https://doi.org/10.34302/2019.11.4.13

Jia, Q. fang, Yang, H. xue, Zhuang, N. nan, Yin, X. yuan, Zhu, Z. hua, Yuan, Y., Yin, X. li, Wang, Y., Cheung, E. F. C., Chan, R. C. K., & Hui, L. (2020). The role of lipoprotein profile in depression and cognitive performance: a network analysis. *Scientific Reports*, *10*(1), 1–7. https://doi.org/10.1038/s41598-020-77782-9

Maki, K. C., Pelkman, C. L., Finocchiaro, E. T., Kelley, K. M., Lawless, A. L., Schild, A. L., & Rains, T. M. (2012). Resistant starch from high-amylose maize increases insulin sensitivity in overweight and obese men. *Journal of Nutrition, 142*(4), 717–723. https://doi.org/10.3945/jn.111.152975

Malindi, T. (2021). *Studies In The Application Pf Green Banana Flour Composite From 10 Banana Cultivars In Gluten-Sugar_Free Banana Flour Based Biscuit*. https://doi.org/https://hdl.handle.net/10500/28340

Merćep, I., Strikić, D., Slišković, A. M., & Reiner, Ž. (2022). New therapeutic approaches in treatment of dyslipidaemia—a narrative review. *Pharmaceuticals, 15*(7), 1–13. https://doi.org/10.3390/ph15070839

Nadia, F.S Wati, D.A, Isnawati, M Afifah, D. N. (2020). The effect of processed Tempeh Gembus to triglycerides levels and insulin. *Food Research, 4*(4), 1000–1010. https://doi.org/doi.org/10.26656/fr.2017.4(4).415

Park, J., Sung, S. C., Choi, A. H., Kang, H. K., Myeong, J. Y., Suganami, T., Ogawa, Y., & Jae, B. K. (2006). Increase in glucose-6-phosphate dehydrogenase in adipocytes stimulates oxidative stress and inflammatory signals. *Diabetes*, *55*(11), 2939–2949. https://doi.org/10.2337/db05-1570

Pertanian, B. L. (2013). Yoghurt Sinbiotik - Minuman Fungsional Kaya Serat Berbasis Tepung Pisang. *Badan Litbang Pertanian*, *43(3515)*, 1–8. https://123dok.com/document/zle2mloq-yoghurt-sinbiotik-minuman-fungsional-serat-berbasis-tepung-pisang.html

Putri, S. R., & Anggraini, D. I. (2015). Obesitas sebagai faktor resiko peningkatan kadar trigliserida. *Jurnal Majority*, *4*(9), 78–82. https://juke.kedokteran.unila.ac.id/index.php/majority/article/viewFile/1413/1256.

Rosalina, Y., Susanti, L., Silsia, D., & Setiawan, R. (2018). Characteristics of banana flour from bengkulu local banana varieties. *Industria: Jurnal Teknologi Dan Manajemen Agroindustri*, *7*(3), 153–160. https://doi.org/10.21776/ub.industria.2018.007.03.3

Rosulva, I., Hariyadi, P., Budijanto, S., & Sitanggang, A. B. (2022). Potensi buah mangrove sebagai sumber pangan alternatif potential of mangrove fruit as an alternative food source. *Jurnal Teknologi Hasil Pertanian, 14*(2), 131–150. https://doi.org/10.20961/jthp.v14i2.55509

Sah, S. P., Singh, B., Choudhary, S., & Kumar, A. (2016). Animal models of insulin resistance: A review. *Pharmacological Reports, 68*(6), 1165–1177. https://doi.org/10.1016/j.pharep.2016.07.010

Samuel, Varman, T., Shulman, G. I. (2012). *Integrating mechanisms for insulin resistance. Cell, 148*(5), 852–871. https://doi.org/10.1016/j.cell.2012.02.017.Integrating

Santoso, A. (2011). Serat pangan (*dietetary fiber*) dan manfaat bagi kesehatan. In *Aslib Proceedings* (35–40). https://doi.org/10.1108/eb050265

Schoeler, M., & Caesar, R. (2019). Dietary lipids, gut microbiota and lipid metabolism. *Reviews in Endocrine and Metabolic Disorders*, *20*(4), 461–472. https://doi.org/10.1007/s11154-019-09512-0

Sellami, M., Slimeni, O., Pokrywka, A., Kuvačić, G., Hayes, L. D., Milic, M., & Padulo, J. (2018). Herbal medicine for sports: A review. *Journal of the International Society of*

Sports Nutrition, *15*(1), 1–14. https://doi.org/10.1186/s12970-018-0218-y

Tchernof, A., & Després, J. P. (2013). Pathophysiology of human visceral obesity: An update. *Physiological Reviews*, *93*(1), 359–404. https://doi.org/10.1152/physrev.00033.2011

Winarsi, H., Wijayanti, S. P. M., & Purwanto, A. (2011). Profil Lipid, peroksidasi lipid, dan status inflamatif wanita penderita sindrom metabolik lipid profile, peroxide lipid, and inflammatory status. *Metabolic Syndrome Woman*. *2*(5), 1–6. http://dx.doi.org/10.21109/kesmas.v5i5.129.

Wulandari, D. L., Putriningtyas, N. D., & Wahyuningsih, S. (2020). Potensi yogurt kacang merah terhadap kadar kolesterol HDL pada remaja obesitas (Studi dilakukan pada mahasiswa gizi Universitas Respati Yogyakarta). *Sport and Nutrition Journal*, *2*(1), 10–16. https://doi.org/10.15294/spnj.v2i1.38452

Yoon, H., Shaw, J. L., Haigis, M. C., & Greka, A. (2021). Lipid metabolism in sickness and in health: Emerging regulators of lipotoxicity. *Molecular Cell*, *81*(18), 3708–3730. https://doi.org/10.1016/j.molcel.2021.08.027

Yuan, G., Al-Shali, K. Z., & Hegele, R. A. (2007). Hypertriglyceridemia: Its etiology, effects and treatment. *Canadian Medical Association Journal*, *176*(8), 1113–1120. https://doi.org/10.1503/cmaj.060963