**Comparison of Palm Oils, Corn Oil and Beef Tallow on Serum Glucose and Lipid Profile in Rats Fed a High-Fat Diet with these Oils**

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**ABSTRACT**

In this study we investigated the effect of three kinds of palm oil product (refined bleached deodorized palm oil (RBDPO), red palm oil (RPO) and palm kernel oil (PKO)) on the serum glucose and lipids profile of rats in fed high-fat diet, and compare it with beef tallow and corn oil. Growing male SD rats were fed high-fat diet (20% fat) for 13 weeks, divided into 2 groups (with and without AOM). Dietary corn oil showed the lowest serum glucose (*P* < 0.05) both in the AOM and Non-AOM groups. Beef tallow diet caused highest level of serum triglyceride, cholesterol, and LDL followed by RPO/PKO, RBDPO, and corn oil, respectively (*P* < 0.05). Contrary, corn oil diet generated highest level of serum HDL, followed by RBDPO, PKO/RPO, and beef tallow (*P* < 0.05). In general, the serum glucose and lipids profile were not affected by the AOM (azoxymethane) treatment.

**Keywords**: palm oil, beef tallow, corn oil, serum, rat

**INTRODUCTION**

Over the past decades, there are growing health concerns about the effect of dietary fat such as from beef tallow or vegetable oils composition on human body. This is due to the fact that consumption of dietary fat has been associated with several health problems such as several health impact factor e.g. obesity, fatty liver, cardiovascular diseases, mortality (Al-Hayder et al., 2020). The quantity and quality of fat in the diet play a vital role in the development of insulin resistance and associated metabolic disturbances, such as glucose tolerance, hepatic steatosis and dyslipidaemia (Akande et al., 2020). Also, different degrees of saturation in fat (monounsaturated, polyunsaturated or saturated fat) may exert different effects on insulin action and secretion and glycaemic response. In this context, vegetable oil has been demonstrated to show hypolipidemic effect due to its low content of saturated fatty acids and high content of polyunsaturated fatty acids. It was reported that the polyunsaturated fatty acids such as linoleic acid can reduce the alterations in liver me- tabolism and prevent heart diseases. Edible oil is a fatty liquid that is extracted from several plants and some animal tissues used in food preparation, frying and baking (Al-Hayder et al., 2020).

The application of vegetable oils for daily food consumption and manufacturing of health supplement products is increasing recently(Syarifah-Noratiqah et al., 2020). Palm oil (PO) is widely used oil in food processing industry and has become the most important vegetable oil in the world (Kadandale et al., 2019). There are two distinct oils are extracted from palm fruit: PO which obtained from the mesocarp, and palm kernel oil (PKO) is sourced from the kernel or seed (Edem, 2002). The fatty acid composition of PO is quite different from that of other vegetable oil, which mainly composed palmitic acid (44%) dan oleic acid (39%), with total saturated fatty acids and unsaturated fatty acids similar in percentage (49% and 49%) (Mancini et al., 2015). PKO is high in lauric acid (~48%) and myristic acid (~16%), has a sharp melting profile, therefore suitable for confectioneries, edible fats, baked goods, soaps and detergents (Dian et al., 2017; Edem, 2002; Mancini et al., 2015). PO can be used in different forms: red PO, refined PO, or RBD (refined, bleached and deodorized) PO. The composition (and properties) of each one is different, because in the RBDPO most of the antioxidants, carotenoids, tocopherols and tocotrienols are removed during the RBD process (Nagendran et al., 2000). On the other hand, corn oil also one of vegetable oils that have been investigated for its effect in vivo. Previous research showed that linoleic acid as the major of fatty acid in corn oil can give positive effect for health (Pavlisova et al., 2016). A series of experiments have shown the benefits effects of the vegetable oil compare with animal tallow, where the consumption of high amount of beef tallow can cause hyperlipidaemia (Al-Hayder et al., 2020).

Hyperlipidaemia, referring to a metabolism disorder, is abnormally high levels of total cholesterol (TC) and/or triglyceride (TG) in the blood, has been regarded as the crucial risk factor of cardiovascular disease (CVD) (Nie & Luo, 2021). High-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C), together with TC and TG, are four lipid associated particles that play an important role as CVD-related biomarkers (Syarifah-Noratiqah et al., 2020). Recent studies reported the possibly association between serum lipid levels with colorectal cancer (CRC) risk (Brantley et al., 2020; Fang et al., 2021). Multiple studies have demonstrated that higher risk of CRC associated with lower levels of HDL, higher levels of LDL and higher levels of TG (Tian et al., 2015; Yao & Tian, 2015; Zhang et al., 2014). However, the exact role of dislipidemia in CRC remain unknown and the association between serum lipids and CRC risk have been conflicting (Brantley et al., 2020; Fang et al., 2021).

The health benefit of vegetable oils such as palm oil in animal and human studies have been reviewed, these including improvement cardioprotective effects in ischemic heart disease, antiatherogenic, antihemorrhagic, antihypertensive, and anticancer properties (Loganathan et al., 2017). However, there are several considerable controversies on their effects to the development of CVD specifically several serum lipid parameter (TC, TG, HDL-C, LDL-C, glucose) (Syarifah-Noratiqah et al., 2020; Szulczewska-Remi et al., 2019b). The aim of our present study was to measure the effects of beef tallow, corn oil, RPO, RBDPO and PKO-containing diet on glucose (Glu), TC (Total Cholesterol), HDL-C, LDL-C, TG (Tryglyceride) concentrations in male Sprague-Dawley rats treated with and without azoxymethane (AOM). AOM is a derivative of dimethylhydrazine, falls in the category of a direct inducer drug that being considered a good colorectal carcinogen (Jucáa et al., 2014).

**MATERIALS AND METHODS**

**Material**

The vegetable oils such as RPO, RBDPO, and PKO were obtained from The Indonesian Oil Palm Research Institute, Medan, Indonesia. The corn oil and beef tallow was obtained from the market in Yogyakarta, Indonesia. All chemical reagents are chemical grade. The kit from DiSys Diagnostic System was used for the determination of Serum Glucose, Triglycerides, Total Cholesterol, HDL, and LDL cholesterol Level (Germany).

**Methods**

*a. Animal and experimental protocols*.

Male Sprague Dawley rats (3 weeks old) were obtained from The Center for Food and Nutrition Studies Laboratory Animal Center Universitas Gadjah Mada and housed in individual cages in a room at 25-26°C and 50-60% relative humidity, with a 12 h light-dark cycle. The rats were fed a pellet diet for 1 week before the commencement of the experimental diet and were assigned randomly to one of five groups (Table 1). Animal care is maintained according to the “Guide for the Care and Use of Laboratory Animals” established by Universitas Gadjah Mada and approved by the Medical and Health Research Ethics Committee of the same university.

Table 1. Compositions of the diets

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ingredient (w/w *%*) | Beef Tallow | Corn Oil | RBDPO | RPO | PKO |
| Casein | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 |
| Corn starch | 39.95 | 39.95 | 39.95 | 39.95 | 39.95 |
| AIN-93 vitamins | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| AIN-93 minerals | 3.50 | 3.50 | 3.50 | 3.50 | 3.50 |
| Cellulose | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Sucrose | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| L-Cystine | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| Choline | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Beef tallow | 20.00 | - | - | - | - |
| Corn Oil | - | 20.00 | - | - | - |
| RBDPO | - | - | 20.00 | - | - |
| RPO | - | - | - | 20.00 | - |
| PKO | - | - | - | - | 20.00 |

Abbreviations used: RBDPO, refined bleached deodorized palm oil; RPO, red palm oil; PKO, palm kernel oil.

*b. Determination of Serum Glucose*

Serum glucose level was also determined according to the manufacturer’s manual (DiaSys Diagnostic Systems GmbH, Germany). The method employed uses the enzymatic colorimetric glucose-oxidase/GOD-PAP to determine glucose level by Trinder’s reaction.

*c. Determination of Triglyceride*

Serum triglyceride level was also determined according to the manufacturer’s manual (DiaSys Diagnostic Systems GmbH, Germany). Colorimetric enzymatic test using glycerol-3-phosphate-oxidase (GPO).

*d. Determination of Total Cholesterol*

The total cholesterol level was also determined according to the manufacturer’s manual (DiaSys Diagnostic Systems GmbH, Germany). The colorimetric indicator is quinoneimine which is generated from 4-aminoantipyrine and phenol by hydrogen peroxide under the catalytic action of peroxidase (Trinder’s reaction) (DiaSys Diagnostic Systems GmbH, Germany).

*e. Determination of HDL-cholesterol*

The HLD-cholesterol level was also determined according to the manufacturer’s manual (DiaSys Diagnostic Systems GmbH, Germany). The determinations were performed by time-consuming precipitation methods . HDL-C Immuno FS is a homogeneous method for HDL-cholesterol measurement without centrifugation steps. Antibodies against human lipoproteins are used to form antigen-antibody complexes with LDL, VLDL, and chylomicrons in a way that only HDL-cholesterol is selectively determined by an enzymatic cholesterol measurement.

*f. Determination of LDL-cholesterol*

The LDL-cholesterol level was also determined according to the manufacturer’s manual (DiaSys Diagnostic Systems GmbH, Germany). The determination of LDL-cholesterol was performed indirectly by calculation from the combined results of total cholesterol, HDL cholesterol, and triglycerides using the Friedewald equation. LDL-C Select FS is a homogeneous method without centrifugation steps for the direct measurement of LDL-cholesterol. In the first step, LDL is selectively protected while non-LDL-lipoproteins are processed enzymatically. In the second step, LDL is released and LDL-cholesterol is selectively determined in a color-producing enzymatic reaction.

*g. Statistical analysis*.

Values are expressed as mean ± standard error of mean (SEM). To compare mean values, one-way ANOVA was used. The Tukey-Kramer post hoc test was conducted when a significant effect was found by one-way ANOVA. Data analysis was performed using SPSS Statistics for Mac (version 26.0; IBM SPSS Statistics). Differences were considered as differently significant at *P*<0.05.

**RESULT AND DISCUSSION**

Serum glucose was highest in the rats fed with beef tallow diet than in those fed corn oil and palm oils (*P* < 0.05), both in AOM and Non-AOM group (Table 2). Serum glucose did not differ between corn oil and RBDPO groups of rats (p >0.05). The level of serum glucose in the RPO and PKO diet groups were significantly higher than in the corn oil and RBDPO group (*P* < 0.05). Treatment with AOM did not showed any significant different for the serum glucose in all groups (p > 0.05). Similarly, certain dietary bioactive compounds may have beneficial effects for optimizing glycemic control by measuring the glucose level. Therefore, identifying potential dietary factors that influence glycemic control is vital for both the management and prevention of non communicable diseases such as diabetes.

Table 2. The levels of glucose (mg/dl) in blood serum at the end of study

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Groups | Beef Tallow | Corn Oil | RBDPO | RPO | PKO |
| AOM | 130.5±2.8a | 81.3±0.8c | 87.6±2.0c | 101.9±0.7b | 101.0±0.8b |
| Non-AOM | 126.1±3.1a | 82.5±1.7d | 89.1±0.6cd | 98.2±2.9bc | 101.4±1.1b |

Data are expressed as means ± S.E.M., *n* = 3. a,b,c,d Values in a row not sharing a superscript are significantly different at *P* < 0.05.

Consumption of the corn oil diet showed the lowest serum triglyceride, both in AOM and Non-AOM group (Table 3). Corn oil is composed mainly (99% of the refined or 96% of the crude oil) of cylglycerols (mono-, di- and primarily tri-), and has 59% poly-unsaturated (PUFA), 24% monounsaturated (MUFA) and 13% saturated fatty acid (SFA). The PUFA to SFA ratio (P/S) is about 4.6. The primary PUFA is linoleic acid (C18:2n−6), with a small amount of linolenic acid (C18:3n−3) giving a n−6/n−3 ratio of 83. Corn oil contains a significant amount of ubiquinone and high amounts of gamma-tocopherols (vitamin E), These high contents of PUFA and vitamin E may contribute to the health benefits of corn oil consumption especially reducing the tryglycerides (Si et al., 2014). On the other hand, palm oil-based diets (RBDPO, RPO and PKO) results in a decrease level of serum triglyceride compared to beef tallow diet (*P* < 0.05).

Table 3. The levels of triglyceride (mg/dl) in blood serum at the end of study

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Groups | Beef Tallow | Corn Oil | RBDPO | RPO | PKO |
| AOM | 121.6±1.7a | 87.3±0.7c | 95.4±1.7b | 100.8±0.4b | 100.1±0.7b |
| Non-AOM | 124.4±1.0a | 88.3±0.4d | 96.2±0.8c | 101.5±1.0b | 101.8±1.2b |

Data are expressed as means ± S.E.M., *n* = 3. a,b,c,d Values in a row not sharing a superscript are significantly different at *P* < 0.05.

The corn oil and RBDPO diets showed the lowest serum cholesterol, both in AOM and Non-AOM group (Table 4). Our results are in line with these previous studies that corn oil lowers total cholesterol. This effect may be due to the high PUFA of corn oil, which is supported by evidence that corn oil can give positive effect in lowering cholesterol. Corn oil has a plant sterol content of 128 mg/1000 kcal vs. 66 mg/1000 kcal for olive oil, and these plant sterols can reduce cholesterol absorption from the gut which in turn lowers body pools and enhances synthesis rate through de-suppression of cellular hydroxy- methylglutaryl-CoA reductase activity which give positive effect in lowering cholesterol (Si et al., 2014). On the other hand, serum cholesterol was highest in the rats fed with beef tallow diet followed by PKO and RPO (*P* < 0.05).

Table 4. The levels of cholesterol (mg/dl) in blood serum at the end of study

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Groups | Beef Tallow | Corn Oil | RBDPO | RPO | PKO |
| AOM | 158.4±2.7a | 107.5±1.1c | 108.7±2.3c | 130.1±1.8b | 131.7±1.5b |
| Non-AOM | 154.1±2.6a | 106.8±2.2c | 107.2±1.1c | 128.3±1.1b | 128.6±0.6b |

Data are expressed as means ± S.E.M., *n* = 3. a,b,c,d Values in a row not sharing a superscript are significantly different at *P* < 0.05.

The blood serum of rats fed with corn oil diet contain the highest HDL followed by RBDPO, PKO, RPO, and beef tallow diets, respectively (Table 5). While the level of HDL from RPO significantly higher than beef tallow in the AOM group, this was not seen in the Non-AOM group (*P* < 0.05).

Table 5. The levels of HDL (mg/dl) in blood serum at the end of study

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Groups | Beef Tallow | Corn Oil | RBDPO | RPO | PKO |
| AOM | 34.5±0.9d | 72.5±2.3a | 60.5±1.7b | 48.8±1.0c | 48.1±3.1c |
| Non-AOM | 34.8±1.4d | 70.7±1.5a | 59.0±2.4b | 44.2±0.9cd | 49.8±2.8bc |

Data are expressed as means ± S.E.M., *n* = 3. a,b,c,d Values in a row not sharing a superscript are significantly different at *P* < 0.05.

Beef tallow diet gives the highest level of serum LDL followed by RPO, PKO, RBDPO, and corn oil diets, respectively (Table 6). There were no significant different between RPO and PKO diets, while the other diet groups showed significant different (*P* < 0.05). Several fatty acid profiles of vegetables oils compared to the beef tallow can be seen in Table 7.

Table 6. The levels of LDL (mg/dl) in blood serum at the end of study

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Groups | Beef Tallow | Corn Oil | RBDPO | RPO | PKO |
| AOM | 62.8±0.8a | 28.6±1.2d | 35.5±1.4c | 43.0±1.7b | 41.5±1.0b |
| Non-AOM | 65.3±0.4a | 28.5±1.0d | 35.4±1.0c | 42.2±0.8b | 40.6±0.8b |

Data are expressed as means ± S.E.M., *n* = 3. a,b,c,d Values in a row not sharing a superscript are significantly different at *P* < 0.05.

Table 7, Fatty acid profile of vegetable oils (palm oil and corn oil) compare to beef tallow

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| No | Sample | Saturated Fatty Acid | Unsaturated fatty Acid | Bioactive compound | Reference |
| 1 | RBDPO | • Palmitic acid  • Stearic acid  • Arachidic acid | • Oleic acid  • Linoleic acid |  | (Absalome et al., 2020; Dian et al., 2017) |
| 2 | RPO | • Palmitic acid  • Stearic acid  • Arachidic acid | • Oleic acid  • Linoleic acid | • Beta carotene • Tokotrienols | (Absalome et al., 2020; Edem, 2002) |
| 3 | PKO | • Lauric acid  • Myristic acid  • Palmitic acid  • Stearic acid | • Oleic acid  • Linoleic acid |  | (Dian et al., 2017) |
| 4 | Corn Oil | • Palmitic acid  • Stearic acid | • Oleic acid  • Linoleic acid  • Linolenic acid |  | (Orsavova et al., 2015; Pavlisova et al., 2016) |
| 5 | Beef tallow | • Palmitic acid  • Stearic acid  • Myristic acid  • Arachidic acid | • Oleic acid |  | (García-Morales et al., 2022) |

Based on our results, we attempted to explore the effects of consuming several types of fat to several biochemical parameter such as serum glucose, trygliceride, total cholesterol, HDL and LDL cholesterol. Based on the results of beef tallows intake seems to impair the postprandial rise in serum glucose. The mechanisms leading to the changes in the glycemic parameters involve an impairment in insulin metabolism due to its inability to adapt to the damage caused by the HFD-induced high calorie intake from beef tallow, which subsequently deteriorates insulin activity and leads to insulin resistance (N’guessan et al., 2022). Furthermore, other fat intake can be beneficial, but rather detrimental, for long-term glycemic control can more maintaining the serum glucose level (Dhanasekara et al., 2022). A high‐fat diet increases the accumulation of lipids in the muscles, which in turn disrupts the metabolism of glucose— both its oxidation and glycogen deposition. The results also indicate that plasma glucose was significantly reduced after consuming a diet fortified with palm oil because tocotrienols lower the blood glucose level acting as peroxisome proliferator‐activated receptor (PPAR) modulators and regulate the expression of numerous genes related to the energy metabolism (Szulczewska-Remi et al., 2019b). Although dietary fatty acids have been linked to affect glucose metabolism and insulin sensitivity, the association of palm oil consumption on biomarkers of glucose metabolism still limited (Zulkiply et al., 2019).

The increase of serum TG as a result of beef tallow intake has been noted previously. The high levels of TG can give an effect on the endothelial cells, causing non communicable diseases such as cardiovascular diseases. It was also demonstrated that the dietary fat caused an increase in the levels of TG due to lipoprotein lipase triacylglycerol hydrolysis and then resulting in increased TG concentration in the liver part. Furthermore, they were reported that the dietary fat can also increase the biosynthesis of phospholipids by reducing the phospholipase activity or increasing phospholipid turnover because of starting the inflammatory process (Al-Hayder et al., 2020). On the contrary, it was demonstrated that intake of polyunsaturated fatty acids and several bioactive compounds such as carotenoids and tocpherols which are found in vegetable oils can reduce incidence of cardiac diseases by lowering the levels of TG (Al-Hayder et al., 2020; Syarifah-Noratiqah et al., 2020). Previous research also showed positive effect of consumption of palm oil for reducing TG. The elevation of serum or plasma TG concentration above a normal range will lead to hypertriglyceridemia, which will eventually increase the risk to CVD such as myocardial infarction and atherosclerosis (Mancini et al., 2015). Previous studies supported the safe consumption of PO and palm olein through the significant reduction of TG, which reflects the potential of this oil in treating hypertriglyceridemia (Syarifah-Noratiqah et al., 2020). Levels of serum triglycerides is one of important markers for the assessment of deposition of fatty acids in adipose tissue and the liver (N’guessan et al., 2022).

The high levels of cholesterol in rats beef tallow diet may be ascribed to the presence of saturated and monounsaturated fatty acid in beef tallow(Al-Hayder et al., 2020). On the contrary, it was demonstrated that intake of polyunsaturated fatty acids which are found in vegetable oils such as PKO and RPO can reduce incidence of cardiac diseases by lowering the levels of cholesterol (Al-Hayder et al., 2020). No significant different was observed in the level of cholesterol between corn oil and RBDPO diets group. RBDPO rich in saturated long‐chain fatty acids, including palmitic acid, and also carotenoids are thought to counter arteriosclerosis, inhibits cholesterol biosynthesis, platelet aggregation, and blood pressure reduction (Szulczewska-Remi et al., 2019b). Scientists have confirmed the effect of palm oil on TC reduction as well as specified an important source of beta‐carotene and alpha‐tocopherols (Syarifah-Noratiqah et al., 2020; Szulczewska-Remi et al., 2019b). Previous research showed that palm oil reduces the blood levels of total cholesterol, triglycerides, LDL-cholesterol, thrombotic eicosanoids (oxygenated metabolites of arachidonic acid and eicosapentaenoic acid) implicated in several pathophysiological processes of the cardiovascular system. Palm oil is beneficial by reducing blood pressure and thrombotic tendency of platelets while offering protection against oxidative damage of the liver and other Palm oil reduces the blood levels of total cholesterol, triglycerides, LDL-cholesterol, thrombotic eicosanoids (oxygenated metabolites of arachidonic acid and eicosapentaenoic acid) implicated in several pathophysiological processes of the cardiovascular system. Palm oil is beneficial by reducing blood pressure and thrombotic tendency of platelets while offering protection against oxidative damage of the liver (Edem, 2002).

On the other hand, the β-carotene of palm oil may be important to correct vitamin A deficiency (a public health problem of many developing countries) in addition to protecting against certain forms of cancer. From the foregoing, it can be seen that palm oil (at moderate levels) is completely safe and non-toxic, easily digestible, efficiently utilized and well absorbed; a very stable and good quality oil which does not contain trans fatty acids. In addition to reducing the risk of CVD, it is a rich source of β-carotene, which can prevent nutritionally caused blindness and is protective against carcinogens. The tocotrienols, which are present more in palm oil than in many other oils, inhibit cholesterol biosynthesis, platelet aggregation and lengthens the life-span of cancerous animals. Many of the properties and effects attributed to palm oil are believed to be mediated through its major triglyceride and minor non-glyceride components, but also by the peculiar stereochemical configuration or fatty acid isomeric position. Therefore, palm oil is a completely safe and nutritive edible oil with nutritionally beneficial properties (Edem, 2002).

Previous studies have been demonstrated the relationship between dyslipidaemia and low level of HDL cholesterol. HDL cholesterol is known as good cholesterol because it can help to remove and recycle cholesterol by transporting it to the liver. Therefore, HDL cholesterol keeps the walls of inner blood vessels healthy and can reduce the non communicable disease such as dyslipidemia (Al-Hayder et al., 2020). The positive effect of palm oil seen in our study consistent with the results of previous report (Amini et al., 2017) and recent meta-analysis (Wang et al., 2019) that palm oil consumption results in the elevation of HDL concentration.

LDL cholesterol transfer cholesterol from the liver to the arteries, therefore an elevation of LDL levels can cause cholesterol deposition in the arteries and aorta and thereby leads to reducing the artery diameter. Hence LDL cholesterol is associated with a direct risk of cardiovascular diseases therefore this type of lipoprotein is often called bad cholesterol (Al-Hayder et al., 2020). Furthermore, the dietary lard increased the non-HDL cholesterol concentration in which the LDL fraction, a well-known CVD risk factor, was also included. This agrees with the literature where saturated fat is recognised as increasing LDL cholesterolaemia effect. Another important marker for cardiovascular health is the atherogenic index of plasma, whose values are inversely correlated with those of the lipoprotein particle size, thereby predicting atherogenicity in human (Jurgoński et al., 2014). Tocotrienols present in palm oil reduce total and LDL cholesterol through their ability to suppress 3-hydroxy-3-methylglutaryl-coenzyme A (HMG-CoA) reductase, the hepatic enzyme responsible for the synthesis of cholesterol through a post-translational mechanism (Szulczewska-Remi et al., 2019a). Our result aligned with previous studies suggested, that palm oil presence in the diet maintain the desired level of cholesterol, high-density lipoprotein (HDL), triacylglycerols (TAG), and total cholesterol (TC) in humans as compared with other vegetable oils (Dian et al., 2017; Nagendran et al., 2000; Syarifah-Noratiqah et al., 2020).

**CONCLUSION**

Taken together, the present findings indicate that beef tallow as a highly saturated fatty acid, can affect serum glucose and lipid levels. However, vegetable oils such as corn oil, RPO, PKO, RBDPO that contain unsaturated fatty acid and bioactive compounds, were found to be well metabolized serum glucose and lipid levels. Therefore, we can conclude that the type of fat source can impacts the serum glucose and lipid profile. Further studies, including human researches or clinical trials are needed to clarify the mechanisms and relative effects of the compositions of fats on cholesterol and lipoprotein levels.

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**CONFLICT OF INTEREST**

There is no conflict of interest for the publication of the manuscript

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