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Health benefits of consumption of chicken sausage enhanced with local beetroot powder

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Abstract

Sausage is a community's product, a processed meat product which is wrapped in a casing. Sausages with high-fat content contain high calories and will cause weight gain if consumed excessively. The impact of consuming sausage can be caused if high-fat and high-calorie sausages are consumed continuously for a long time. Increasing public awareness of health demands for sausage products that are safe for consumption. This study aimed to determine the health benefit of consuming sausage enriched with local beetroot powder on the performance and lipid profile of white rats (*Rattus novergicus* L.). This study used white rats Spraque-Dawley strain male, aged between 7-8 months with a weight of 180 to 200 g. This research is equipped with ethical clearance number: 00116/04/LPPT/XII/18. The research material was 25 individuals who were fed AIN 93M and chicken sausage at doses of 1.8, 2.7, and 3.6 g/head/day for 30 days. The results of this study showed that the highest daily body weight gain (ADG) was found in white rats with AIN 93M basal diet of 234.4±3.8 g/head/day while the lowest was found in white rats that consumed chicken sausage enhanced with local beetroot powder at a dose of 2.7 g/head/day was 0.66±0.4 g/head/day. In addition to the achievement of ADG which can be slowed down, it is also necessary to look at the impact on the lipid profile. Tests on the consumption of chicken sausage substituted with 2% local beetroot powder have an effect on increasing HDL, decreasing cholesterol, LDL, triglycerides and glucose if consumed for 3 consecutive weeks. The equivalent dose of white rats into human doses of chicken sausage enhanced with beetroot powder the consumption was 0.33 g/kg BW/day. Based on this, it can be recommended that the consumption of chicken sausage containing 2% local beetroot powder is 0.33 g/kg BW/day with a maximum time limit for regular consumption for 3 weeks.

1. Introduction

In Indonesia, the frozen food market has been performing well following their lifestyle, because frozen food is the solution for consumers striving for nutritional food with extended shelf life and simple choices, especially for a hectic life. Among all, frozen pre-cooked meals became the most popular choice among consumers. Sausage is frozen food which is a kind of comminuted meat or poultry food product prepared from one or more kinds of meat or meat and meat byproducts, or poultry or poultry and poultry byproducts containing various amounts of water and usually seasoned with spices and flavorings ("condimental ingredients"). Any amount of condiment may be used up to the maximum amount needed to impart its normal characteristic flavor. The word "sausage" comes from the Latin word "salsus," which means salted, or preserved by salting. According to the regulation, a fresh sausage formulation may have up to 30 or 50% fat content. Although nutritional stats vary widely Italian sausage has around 200 calories, 16 grams of total fat (of which six are saturated), 50 grams of cholesterol, and 550 mg of sodium.

Overconsumption of any one of the above carbs, calories, fat, cholesterol, and sodium can lead to serious health issues, including obesity and their impacts like heart disease, diabetes, and cancer. Of course, depending

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on your eating habits serving, you may need to double (or triple) portions in a day.

Based on statistical data related to obesity prevalence, there are 57% of overweight or obese women and 66% of obese men caused by lack of physical activity and accompanied by an unbalanced diet. The prevalence of obesity in the Indonesian population in 2018 at the age of >8 years with a male gender of 26.6% and a female of 44.4. This number increased by 2% from 2016, where the obese category is people who have a Body Mass Index (BMI) >25 (Riskesdas, 2018).

Obesity is an excessive accumulation of fat due to energy intake (intake) with energy used (energy expenditure) for a long time in adults, adolescents and children.

It is necessary to prevent the control of non-communicable diseases between diabetes mellitus and metabolic disorders. Based on the above, it is necessary to manufacture frozen food products (sausages) that are safe for consumption and do not cause obesity or obesity comorbidities such as increased cholesterol and blood sugar.

Red beet is one of the most potent vegetables with respect to antioxidant activity. The consumption of red beet, which is rich in phenolic acids and has a high antioxidant capacity, can help protect against age-related diseases (Ravichandran *et al*., 2013). The phenolic compounds present in red beet decrease the level of oxidation of lipids and also consumption of red local beetroot powder can improve antioxidant status in humans. Due to their high phenolic compound content provide a good alternative to conventional natural antioxidants, and can serve as a source of natural antioxidants for meat products (Karre *et al*., 2013). Developing processing meat products using natural antioxidants had benefits in chemical and physical in chicken sausage (Swastike *et al,* 2020; Swastike *et al.,* 2021).

To determine the effect of sausage consumption, it is necessary to evaluate sausage as a frozen food product on white rats (*Rattus novergicus* L.) so that it can be seen that chicken sausage products enhanced with local beetroot powder and also made from lean chicken meat have benefits and can also be proven to be safe, do not cause obesity or increase the level of fat and fat profiles also, blood sugar so that it can be categorized as a functional food.

2. Materials and methods

2.1 Materials

This study used white rats (*Rattus novergicus* L.) Spraque-Dawley strain male, aged between 7-8 months with a weight of 180 to 200 g. This research is equipped with ethical clearance number: 00116/04/LPPT/XII/18. The research material was 25 individuals who were fed AIN 93M and chicken sausage at doses of 1.8, 2.7, and 3.6 g/head/day for 30 days.

The standard type of feed given is the American Institute of Nutrition (AIN) standard 93 M. The feed formulation is AIN 93 M, with a carbohydrate content of 76%, protein 16% and fat 6% with a composition of corn, sucrose, casein, L-cystin, Soybean oil, fiber, minerals, vitamins and choline of 583.5, 106, 140, 3, 70, 50, 35, 10 and 2.5 g/kg, respectively.

As many as 25 white rats were kept in individual cages during the experiment. The cage temperature was 27°C with humidity ranging from 40-70%. The light in the cage is 12 hours bright and 12 hours dark. Cage cleaning is done every day. Feeding is given in the morning and evening. Weighing of the rest of the feed is done every morning. Sausage feeding is done by sonde and given in the morning. Weighing was carried out at the beginning of the treatment and carried out every 1 week.

2.2 Treatment grouping

The treatment groups were: treatment group 1 with AIN 93M feed, treatment group 2 with AIN 93M feed plus chicken sausage enhanced with local beetroot powder at a dose of 1.8 g/head/day, treatment group 3 with AIN 93M feed plus chicken sausage enhance with local beetroot powder at a dose of 2.7 g/head/day, and treatment group 4 with AIN 93M feed plus chicken sausage enhance with local beetroot powder at a dose of 3.6 g/head/day. The treatment was carried out for 5 weeks, with 1 week of adaptation.

The standard type of feed given is the American Institute of Nutrition (AIN) standard 93 M. The feed formulation is AIN 93 M, with a carbohydrate content of 76%, protein 16% and fat 6% with a composition of corn, sucrose, casein, L-cystin, soybean oil, fiber, minerals, vitamins and cholin of 583.5, 106, 140, 3, 70, 50, 35, 10 and 2.5 g/kg, respectively (Reeves *et al.,* 1993).

2.3 The performance aspect

The performance of white rats including body weight, body weight gain and feed consumption was observed for 5 weeks. White rats were weighed every

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week and carried out during the study. Feed consumption was calculated by weighing the remaining feed to determine the white rat's appetite. Weighing was carried out every week to determine changes in the body weight of white rats.

2.4 Blood lipid profile

The body lipid profile including cholesterol, low-density lipoprotein (LDL), high-density lipoprotein (HDL), and triglycerides of the rats was observed at weeks 1, 3 and 5. The rats' blood samples were taken using microhematocrit through the retroorbital vein or around the eye Herck *et al.* (2000), with modification. Approximately 1.5 mL of blood is centrifuged at 2500 rpm for 15 mins.

Total cholesterol and HDL cholesterol levels were analyzed using the CHOD-PAP (Cholesterol oxidase-p-aminophenazone) method. Triglyceride levels were analyzed using GPO-PAP (Glyserol-3-phosphate oxidase -p-aminophenazone). LDL calculation is done mathematically. Blood chemistry tests were also carried out to take glucose and malondialdehyde (MDA), parameters. The rat's blood was taken at 1.3 and 5 weeks during the study.

This bioassay study on white rats was carried out for 5 weeks. Feeding white rats in the form of AIN 93 M for 5 weeks with 1 week at the beginning as an adaptation period. Feeding chicken sausage which was substituted with beetroot powder was given through sonde with feed treatment divided into 5 treatments. Sausage that has been mashed in liquid form is given using an oral probe. The oral probe is attached to the roof of the mouth, then slowly inserted into the esophagus and the sausage feed is inserted.

2.5 Data analysis

Data on body weight, basal feed consumption, chicken sausage consumption, blood glucose levels, triglycerides, LDL, HDL and MDA, were analyzed using one-way ANOVA and the differences between means were tested with Duncan's New Multiple Ranges Test (DMRT).

3. Results and discussion

The biological and physiological status of white rats used in this research was normal conditions (Ghasemi *et al.,* 2021). The body temperature range was 36.0 to 37.0℃, respiratory rate 80 to 100/min and heart rate of 250 to 400/min, showing that their condition was in the normal ranges.

Performance data (mean initial body weight, mean final body weight, daily body weight gain (ADG) and feed consumption in white rats fed chicken sausage substituted with local beetroot powder can be seen in Table 1.

The mean initial weight of the white rats showed a significant difference. The mean initial body weight ranged from 179.0±2.6 - 182.6±3.9 g/head. The mean average daily body weight gain (ADG) of white rats was significantly different ($p<0.05$) (Table 1). The highest increase in ADG was found in white rats with AIN 93M basal diet of 234.4±0.8 g/head/day, while the lowest ADG was 0.66±0.4 g/head/day found in white rats consuming chicken sausage substituted with local beetroot powder at a dose of 2.7 g/day

The initial body weight of white rats for each treatment was not significantly different ($p>0.05$) between treatments. This was due to the fact that at the beginning of maintenance, all treatments received the same basal feed, AIN 93M. The response of the average body weight for 5 weeks showed a significant difference between treatments. During the research, the average body weight was obtained from lowest to highest respectively, white rats were treated with sausage at a dose of 2.7 g, a dose of 1.8 g, a dose of 3.6 g, and white rats without sausage. This is because chicken sausage substituted with local beetroot powder contains dietary fiber (Table 1), and also contains antioxidants so that it can help the thermoregulation process in the body and minimize fat accumulation, even white rats consumed chicken sausage regularly during 5 weeks.

White rats that only consumed AIN 93M basal feed had an increasing body weight gain with an ADG of 1.53±0.89 g/head/day. The ADG white rats consuming chicken sausage enhanced with local beetroot powder at increasing doses also increased the ADG. This is because the nutrient content of chicken sausage substituted with local beetroot powder (Table 1) also contains 14.65±0.01 - 14.77±0.02% protein. However, the ADG of white rats that consumed chicken sausage substituted with local beetroot powder had a relatively slow rate of increased weight compared to white rats that only consumed fed AIN 93M.

The mechanism that occurs is thought to be more on the utilization of nutrients through changes in thermogenesis in the utilization of energy content in food used for the formation of body heat. Mechanisms controlling adipogenesis can result in variations in the characteristics of adipose tissue between individuals. This can indicate that consuming research sausages in research phase 2 with low fat, calorie, and fiber content and substituted with bioactive compounds from beetroot powder can slow down the rate of ADG.

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Table 1. The performance of the white rats consumed chicken sausage enhanced with local beetroot powder.

Variable	(week)	Dosage consumption of chicken sausage (g)				Average
		0 g	1.8 g	2.7 g	3.6 g	
Sausage consumption (g/d)	1	0	0	0	0	0^{p}
	2	0^{a}	$1.55±0.05^{b}$	$2.47±0.05^{c}$	$3.32±0.19^{d}$	$1.84±0.05^{q}$
	3	0^{a}	$1.62±0.05^{b}$	$2.55±0.07^{c}$	$3.43±0.2^{d}$	$1.9±0.05^{r}$
	4	0^{a}	$1.67±0.06^{b}$	$2.62±0.08^{c}$	$3.55±0.2^{d}$	$1.96±0.05^{s}$
	5	0^{a}	$1.73±0.05^{b}$	$2.71±0.09^{c}$	$3.66±0.2^{d}$	$2.03±0.05^{t}$
	Average	0^{a}	$1.31±0.67^{a}$	$2.07±1.07^{c}$	$2.78±1.4^{d}$	1.54±1.40
Basal consumption AIN (g/d)	1	$9.3±1.35^{a}$	$7.5±1.46^{a}$	$8.0±1.2^{a}$	$9.6±5.43^{a}$	$8.6±2.87^{p}$
	2	$9.23±0.65^{a,b}$	$8.3±1.35^{a}$	$8.66±1.15^{a}$	$11.94±0.46^{b}$	$9.52±1.17^{p,q}$
	3	$10.43±1.71^{a}$	$9.34±1.4^{a}$	$10.37±1.43^{a}$	$12.94±0.87^{b}$	$10.77±1.97^{q,r}$
	4	$10.08±1.13^{a}$	$9.85±1.38^{a}$	$8.99±1.45^{a}$	$12.0±1.07^{b}$	$10.23±1.62^{q,r}$
	5	$9.4±1.51^{a}$	$8.94±1.36^{a}$	$9.4±1.4^{b}$	$12.52±0.05^{c}$	$10.06±1.87^{q,r}$
	Average	$9.69±1.3^{b}$	$8.78±1.63^{a}$	$9.08±1.48^{a}$	$11.8±2.58^{a}$	9.84±2.15
Body Weight (g)	1	$181.00±2.24^{a}$	$180.8±0.8^{a}$	$179.0±2.6^{a}$	$182.6±3.9^{a}$	$180.85±2.78^{p}$
	2	$190.8±3.01^{b}$	$188.6±1.67^{b}$	$184.0±1.87^{a}$	$190.4±1.67^{b}$	$188.45±3.39^{q}$
	3	$205.4±4.4^{d}$	$194.0±1.87^{b}$	$189.2±1.9^{a}$	$198.2±2.38^{c}$	$196.7±6.63^{r}$
	4	$218.8±2.8^{c}$	$199.8±1.43^{a}$	$194.8±0.84^{a}$	$206.4±2.6^{b}$	$20495±9.42^{s}$
	5	$234.4±3.8^{d}$	$205.4±1.14^{b}$	$202.0±1.22^{a}$	$214.8±193^{c}$	$214.15±13.01^{t}$
	Average	$206.08±19.74^{d}$	$193.72±8.83^{b}$	$189.8±8.8^{a}$	$198.48±11.85^{c}$	197.02±14.2
Average daily gain (g/each/day)	1	0	0	0	0	0^{p}
	2	$1.39±0.24^{b}$	$1.12±0.26^{b}$	$0.71±0.2^{a}$	$11.11±0.34^{b}$	$1.09±0.34^{q}$
	3	$2.08±0.46^{c}$	$0.77±0.08^{a}$	$0.74±0.06^{a}$	$1.11±0.34^{b}$	$1.18±0.6^{q,r}$
	4	$1.91±0.48^{b}$	$0.83±0.29^{a}$	$0.79±0.22^{a}$	$1.17±0.06^{b}$	$1.18±0.5^{r}$
	5	$2.23±0.43^{c}$	$0.8±0.08^{a}$	$1.03±0.25^{a,b}$	$1.03±0,25^{b}$	$1.32±0.6^{r}$
	Average	$1.53±0.89^{c}$	$0.70±0.5^{a}$	$0.66±0.4^{a}$	$0.92±0.5^{b}$	0.95±0.7

Values are presented as mean±SD. Values with different superscripts (a, b, c and d) within the same row are statistically significantly different. Values with different superscripts (p, q, r and s) within the same column are statistically significantly different.

The effect of the consumption of chicken sausage enhanced with local beetroot powder also has a direct or indirect mechanism. The mechanism is directly by suppressing appetite, with the presence of soluble fiber in the tuber. The indirect mechanism can be seen molecularly in the flavonoid group as in the research conducted by Kumar and Pandey (2013). Indirect mechanisms include having a role in the body's thermoregulation process so that it is able to regulate body heat stability through the role of brown adipose tissue (BAT). The role of BAT is very important in controlling the increasing body weight gain that causes obesity, that mechanism is through the body's thermoregulator process through the role of uncoupling protein (UCP1). Through the expression of the UCP1 gene, it can increase energy expenditure (Cannon and Nedergaard, 2004). The mechanism for activating UCP expression in BAT and the liver can also significantly affect body weight loss, so the presence of BAT can be used to determine thermoregulation conditions as a result of consumption in rats and also in a human (Wu *et al.,* 2012).

3.1 Lipid profile and metabolism

Lipid profile can be characterized by cholesterol levels, high-density lipoprotein (HDL), low-density lipoprotein (LDL) and very low-density lipoprotein (VLDL). Lipoproteins have each function in the body. VLDL functions to carry triglycerides and other lipids made in the liver to the body's cells for use. LDL serves to transport cholesterol and other lipids into body tissues. HDL functions to carry cholesterol from body cells to the liver to be recirculated as VLDL or as a precursor for bile acid synthesis (Mayes, 1996).

LDL is made from VLDL, VLDL is so large that it cannot supply the peripheral tissues with triglycerides. Therefore, it must first be converted into VLDL and then converted into LDL. LDL is a complex macromolecule that accounts for nearly 50% of the total cholesterol in plasma. LDL supplies peripheral tissues with cholesterol and triglycerides (Mayes, 1996). LDL is called bad cholesterol because it is easily attached to blood vessels and causes fat accumulation which over time hardens (forms plaque) and clogs blood vessels, which is called atherosclerosis.

HDL is the lipoprotein with the highest density compared to other lipoproteins. However, it has a smaller size than other lipoproteins. HDL consists of 50% protein, 20% phospholipids and 20% cholesterol. The role of HDL in the blood is to transport excess cholesterol from the tissues to the liver which is then degraded or converted into bile acids. Increased plasma HDL concentrations may protect arterial walls against plaque development, which is facilitated by the reverse mechanism of cholesterol transport by removing cholesterol from peripheral tissues to the liver. The difference in density of HDL and LDL is influenced by differences in the ratio of protein: lipid. LDL is richer in lipid content so it is bigger and heavier while HDL is richer in protein so it is lighter and smaller. The total blood concentration of white rats increased by 20%, it can be categorized that the white rats had hypercholesterolemia.

Increased plasma cholesterol is also influenced by the type of fat present in the diet. This can be related to various studies on diet related to cholesterolemia which have stated that saturated fat will increase cholesterol while unsaturated fat will decrease it. Unsaturated fatty acids (ALT) are fatty acids that have one or more double bonds, while saturated fatty acids are fatty acids that do not have double bonds. This unsaturation of fatty acids should be considered because the intake of these types of fatty acids in the body is related to health aspects (Briggs *et al.,* 2017). Saturated fatty acids can increase the level of total cholesterol and LDL cholesterol (low density lipoprotein) and increase the incidence of heart disease.

3.1.1 High-density lipoprotein levels

The provision of sausage substituted with local beetroot powder showed a significant difference ($p<0.05$) in the first week to the fifth week, in the blood HDL levels of white rats (Table 2). The level of chicken sausage enhanced with local beetroot powder at a dose of 2.7 g/head/day had a similar effect with a dose of 3.6 g/head/day. The higher the dose of chicken sausage substituted with beetroot powder can increase blood HDL so that HDL can function as protection against other blood profiles. The role of HDL in lowering cholesterol is by transporting excess cholesterol from the tissues to the day which is then converted into bile acids.

3.1.2 Low-density lipoprotein levels

The provision of sausage substituted with local beetroot powder showed a significant difference ($p<0.05$) in the first week to the fifth week in the blood LDL levels of white rats (Table 2). The lowest LDL level was found at the level of chicken sausage enhanced with local beetroot powder at a dose of 3.6 g/head/day and the highest was given without sausage. The higher the dose and the longer the consumption of chicken sausage substituted with beetroot powder can lower blood LDL compared to white rats with 93M AIN feed.

3.1.3 Triglyceride levels

The content of triglycerides in the blood is positively correlated with lowering abdominal fat and vice versa. According to Murray *et al*. (2003), the main fat stored in

Table 2. The lipid profile of the white rats that consumed chicken sausage enhanced with red local beetroot powder.

Variable (mg/dL)	Weeks	Dosage consumption of chicken sausage (g)				Average
		0 g	1.8 g	0 g	1.8 g	
Cholesterol	1^{ns}	67.66±1.84	66.16±1.9	66.79±1.73	68.78±1.68’	$68.1±1.93^{p}$
	3	$141.43±7.22^{c}$	$83.21±2.28^{b}$	$78.65±2.01^{a,b}$	$74.43±1.52^{a}$	$94.43±1.73^{q}$
	5	$164.37±4.54^{d}$	$97.52±3.29^{c}$	$82.48±1.9^{b}$	$77.64±2.16^{a}$	$105.5±35.79^{r}$
	Average	$124.49±42.93^{d}$	$83.29±12.22^{c}$	$75.97±1.73^{b}$	$73.63±2.16^{a}$	105.51±35.8
HDL	1^{ns}	77.89±3.86	75.6±2.34	74.06±3.07	74.45±3.34	$75.5±3.31^{r}$
	3	$60.24±3.6^{a}$	$69.38±3.16^{b}$	$72.16±3.14^{b}$	$73.79±3.49^{b}$	$68.89±6.19^{q}$
	5	$39.85±2.77^{a}$	$62.05±2.19^{b}$	$72.16±3.14^{c}$	$73.79±3.49^{c}$	$60.68±3.34^{p}$
	Average	$59.32±16.4^{a}$	$69.01±6.21^{b}$	$71.66±3.59^{c}$	$73.45±3.25^{c}$	68.36±10.43
LDL	1^{ns}	23.16±1.3	23.29±3.07	24.11±2.09	23.57±1.06	$23.53±1.92^{p}$
	3	$63.07±0^{c}$	$63.32±0^{b}$	$32.04±1.27^{a}$	$29.06±0.22^{a}$	$39.89±14.10^{q}$
	5	$82.78±0.78^{c}$	$48.6±0.45^{b}$	$39.23±0.27^{a}$	$36.46±0.51^{a}$	$51.82±1.06^{r}$
	Average	$56.34±25.74^{d}$	$35.82±10.86^{c}$	$31.65±6.85^{b}$	$29.85±5.8^{a}$	38.42±17.83
TG	1	$60.73±0,03^{b}$	$56.03±1.81^{a}$	$56.68±1.81^{a}$	$61.05±2.49^{b}$	$58.62±3.03^{p}$
	3	$87.07±2.97^{c}$	$65.02±1.6^{b}$	$61.34±1.68^{a}$	$62.89±2.49^{a,b}$	$69.08±2.49^{q}$
	5	$104.14±0^{c}$	$63.14±0.39^{b}$	$63.14±0.54^{a}$	$64.77±0.39^{a,b}$	$74.83±17.5^{r}$
	Average	$83.97±18.6^{c}$	$62.74±5.28^{b}$	$60.49±3.14^{a}$	$62.83±2.64^{b}$	$67.51±13.65^{a}$

Values are presented as mean±SD. Values with different superscripts (a, b, c and d) within the same row are statistically significantly different. Values with different superscripts (p, q, r and s) within the same column are statistically significantly different.

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the tissue is triglycerides, of which 95% of triglycerides come from the food consumed and 5% from body synthesis. Hence, the lower the triglyceride content in the blood, the lower the tissue fat content and abdominal fat content. The provision of sausage enhanced with local beetroot powder had a significant effect on blood triglyceride levels ($p<0.05$). The larger the dose of sausage substituted with local beetroot powder in white rats the decrease in triglycerides. The lowest triglyceride levels were found in white rats with chicken sausage at a dose of 2.7 g/head/day, which was 60.49±3.14 mg/dL (Table 2). These implications are to any extent related to α- lipoic acid and antioxidant content of beetroot or other factors involved (Brown *et al.,* 2018).

3.2 Glucose levels

The provision of sausage enhances with local beetroot powder with different doses significantly affected blood glucose levels ($p<0.05$) (Table 3). The carbohydrate content in beets which is feared will cause an increase in blood sugar actually makes glucose levels decrease compared to white rats that are not given chicken sausage. The sugar contained in beets is simple sugar so that it is easily broken down by the body into a source of energy, this state almost has the same mechanism that consumption of beetroot juice effectively postpones the postprandial glycemic response and decreases the blood glucose peak and also Significant reduction of blood glucose level and the positive impact on the glycemic and insulin responses (Mirmiran *et al.,* 2020).

3.3 Malondialdehyde levels

MDA levels in the blood indicate oxidative stress conditions in white rats caused by consumption. The provision of sausage substituted with local beetroot powder with different doses had a significant effect on blood MDA levels ($p<0.05$). The higher the dose given, the lower the MDA blood level. The lowest MDA levels were found in white rats given chicken sausage at a dose of 2.7 g/head/day, which was 2.23±0.74 nmol/ml (Table 3). This shows that giving sausage has a positive effect on white rats by decreasing levels of free radicals in the body. MDA is the end product of fat peroxidation and an indicator of the presence of free radicals in the body. Unsaturated fatty acids will undergo peroxidation to produce MDA products. The MDA product can be measured as an indirect index of oxidative damage (Morales and Munne-Bosch, 2019).

The chicken sausage consumption enhanced with local beetroot powder as a functional food product can be seen from the pre-clinical stage. Tests on the consumption of chicken sausage, doses of chicken sausage were given as much as 1.8, 2.7 and 3.6 g/head/ day for each rat. The mean initial body weight ranged from 179.0±2.6 - 182.6±3.9 g/head. The highest increase in daily body weight (ADG) was found in white rats with AIN 93M basal diet of 234.4±3.8 g/head/day, while the lowest was found in white rats consuming chicken sausage substituted with local beetroot powder at a dose of 2.7 g/day. head/day of 0.66±0.4 g/head/day. In addition to the achievement of ADG which can be slowed down the rate of increase also needs to be seen the impact on the lipid profile. Tests on the consumption of chicken sausage substituted with 2% local beetroot powder have an effect on increasing HDL and decreasing cholesterol, LDL, triglycerides and glucose. Giving chicken sausage containing 2% local beetroot powder at a dose of 2.7 g/head/day will be effective for increasing HDL when consumed for 3 consecutive weeks. The higher the dose of sausage consumed, the lower the blood MDA level, which was 2.23±0.74. This shows that giving sausage has a positive effect on white rats by decreasing levels of free radicals in the body. MDA is the end product of fat peroxidation and an indicator of the presence of free radicals in the body.

Table 3. The glucose and MDA profiles of the white rats that consumed chicken sausage enhanced with red local beetroot powder.

Variable (mg/dL)	Weeks	Dosage consumption of chicken sausage (g)				Average
		0 g	1.8 g	0 g	1.8 g	
Glucosa	1^{ns}	$58.32±1.79^{a}$	$59.86±1.5^{a,b}$	$59.3±2.64^{a,b}$	$61.54±1.5^{c}$	$59.75±1.5^{p}$
	3	$77.11±0^{c}$	$100.17±0.02^{b}$	$66.65±0.12^{a}$	$68.64±0.54^{a}$	$71.5±1.5^{q}$
	5	$110.63±0.53^{c}$	$87.9±0.65^{b}$	$73.59±0.05^{a}$	$74.91±0.66^{a}$	$86.48±1.5^{r}$
	Average	$81.82±22.18^{d}$	$73.46±11.8^{c}$	$66.56±6.63^{a}$	$68.47±5.87^{b}$	$72.58±14.28^{c}$
MDA	1^{ns}	$1.73±0.01^{a}$	$1.56±0.23^{a}$	$1.61±0.27^{a}$	$1.4±0.37^{a}$	$1.57±0.28^{p}$
	3	$5.53±0.28^{c}$	$5.97±0.13^{b}$	$2.23±0.12^{a}$	$1.82±0.1^{a}$	$3.17±1.56^{q}$
	5	$7.63±0.22^{c}$	$4.19±0.18^{b}$	$3.04±0.06^{a}$	$2.41±0.1^{a}$	$4.33±2.07^{r}$
	Average	$4.89±2.53^{d}$	$3.09±1.27^{c}$	$2.23±0.74^{b}$	$4.33±2.07^{a}$	$3.03±1.87^{a}$

Values are presented as mean±SD. Values with different superscripts (a, b, c and d) within the same row are statistically significantly different. Values with different superscripts (p, q, r and s) within the same column are statistically significantly different.

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Unsaturated fatty acids initiate peroxidation to produce MDA products. The MDA product can be measured as an indirect index of oxidative damage. Consuming a dose of 2.7 g/head/day with an average consumption of chicken sausage enhanced with local beetroot powder as much as 2.07±1.07 g/head/day in white rats with an average weight of 189.8±8.8 g/head that was equivalent to a consumption dose of 0.33 g/kgBW/day. The average size (weight/pcs) of research chicken sausages and/or commercial chicken sausages is in the range of 12-15 g/pcs. Based on this, it can be recommended that the consumption of chicken sausage enhanced with 2% local beetroot powder is 0.33 g/kgBB/day with a maximum time limit of 21 days of consumption regularly.

The characterization of local beetroot powder contains secondary metabolites, namely flavonoids, phenols and alkaloids. Local beetroot powder produced by non-blanching preparations and freeze dryer drying has higher levels of secondary metabolites, antioxidant activity and color. Comparison of filler substitution of tapioca flour: local beetroot powder 16:2 resulted in the best chemical, physical and sensory qualities of chicken sausage. White rats fed chicken sausage enhanced with local beetroot powder at a dose of 2.7 g/head/day could improve lipid profile by increasing HDL and preventing an increase in LDL cholesterol, triglycerides and MDA in rat blood.

4. Conclusion

Body weight and ADG of white rats fed with chicken sausage which was enhanced with local beetroot powder were lower. Chicken sausage enhanced with local beetroot powder increased HDL levels but decreased cholesterol levels, LDL levels, and blood triglyceride levels in white rats. Concerns about the consumption of chicken sausage which can cause an increase in body weight and lipid profile can be prevented if an antioxidant source from local beetroot powder is added as a substitute for tapioca flour by 2%. Consumption of chicken sausage substituted with local beetroot powder as a source of antioxidants can be safely consumed every day in a row for a maximum of 21 days (3 weeks).

Conflict of interest

The authors declare no conflict of interest.

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