Food Research 8 (2) : 343 - 353 (April 2024)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

RESEARCH PAPER

The effects of creamy and skimmed dairy products (milk, yoghurt and cheese) on lipid profile of healthy rats

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Article history:
Received: 16 May 2022
Received in revised form: 19 July 2022
Accepted: 2 September 2023
Available Online: 10 April 2024

Keywords:
Yoghurt,
Cheese,
Liver and renal function,
Cholesterol,
Triglycerides,
Andatherogenic indexes

DOI:
https://doi.org/10.26656/fr.2017.8(2).039

Abstract

Milk and dairy products contain saturated fatty acids that have different effects on human health status and are risk factors for many diseases including cardiovascular disease and diabetes mellitus. The present study aimed to evaluate the impact of creamy and skimmed milk administration and certain dairy products (yoghurt and cheese) on healthy rats. A total of forty-nine healthy male Sprague Dawley rats were divided to seven groups. The treatment diet includes creamy and skimmed milk, creamy and skimmed yoghurt, creamy and skimmed cheese. After 60 days of consumption, body weight (BW) and lipids profile were measured. The final BW was higher in rats fed with creamy milk (256.40±23.81), and rats fed with creamy yoghurt (262.71±25.41) and creamy cheese (266.57±22.71). A significant elevation in the liver (aspartate aminotransferase and serum alanine) and kidney functions (urea, creatinine, and uric acid) have been observed in rats fed with fresh creamy whole milk and skimmed milk groups. The measured lipid profile has increased, especially rats fed with creamy milk, creamy, and skimmed cheese. In which, the total cholesterol has reached 159.70, 170.11 and 160.11. Meanwhile, the triglycerides increased to 125.51, 117.35 and 110.41. The low-density lipoprotein and the very low-density lipoprotein have also elevated with their atherogenic indexes at 5.2±0.55, 5.74±0.68 and 5.31±0.44 respectively. On the other hand, notable decreases were seen in the high-density lipoprotein cholesterol and liver glycogen compared to rats fed with control diet. In conclusion, both skimmed and creamy yoghurt indicated healthy nutritional properties, especially with lipid and atherogenic indexes by means of healthy liver and renal functions. Thus, yoghurt (creamy or skimmed) improved the healthy rats' lipid profile while creamy milk additions increased the BW. However, cheese (creamy or skimmed) is suggested to be avoided due to hyperlipidemic conditions in rats.

1. Introduction

Milk and dairy products have the most nutrients needed for a balanced diet because of their vital content of several significant minerals, including Ca, K, P, and Mg, many different vitamins especially those soluble in fat, including vitamin A, vitamin D, vitamin E, and vitamin K, and macronutrients that are essential for growth and tissue maintenance (protein; consist of whey and caseins) (Visioli and Strata, 2014; Kapaj and Deci, 2017; Burke *et al*., 2018).

Routine life and maladaptive diet are the principal underlying causes of many diseases mainly metabolic disease and systemic inflammation (Lordan and Zabetakis, 2017). The dietary factors identification has the supreme potential for diminishing obesity, heart disease and diabetes (Mozaffarian *et al*., 2013). Milk and dairy products contain saturated fatty acids which can increase serum LDL cholesterol level accompanied by

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eISSN: 2550-2166 / © 2023 The Authors.
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raising the likelihood of coronary heart disease, diabetes, and certain cancers (Ohlsson, 2010).

Recent findings indicated that dairy products contain both saturated and unsaturated fat that affect lipoprotein metabolism and contribute significant quantities of many nutrients such as phospholipids, protein, and calcium which modify metabolic, and heart disease (Huth and Park, 2012; Guo *et al*., 2017). It is believed that restricting whole milk and dairy products would reduce the risk of diabetes because they have high content of energy and saturated fat. However, recent evidence supports that reducing fat consumption increases the tendency to be replaced by sugar or carbohydrates, which has negative impact on insulin level and the risk of diabetes. (Mozaffarian *et al*., 2011). Moreover, some countries such as Australia recommend eating such fatty dairy products such as cream or butter and shown that they are maybe beneficial to cardiovascular health. However, it is recommended to operate randomized controlled studies that examine postprandial lipemia, vascular stiffness and function, and inflammatory indicators (Markey *et al*., 2014).

There are different types of dietary dairy sectors globally with different nutritional values including many foods such as liquid/powders milk, cheese, butter, yoghurt, and ice cream and each has a vital role in the dietary guidelines. For instance, yoghurt is a fermented dairy product that has many positive effects on intestinal microbiota as it is considered the main source of living probiotic organisms in addition to all human health; it has been recommended with the previously published data from the diabetic models (Khalil *et al*., 2021). Additionally, another dairy product is cheese which has numerous nutritional values within the human diet (Shori *et al*., 2012). It is the highest source of cholesterol and saturated fat according to used milk type (whole, reduced -fat, or skimmed milk). Cheese made from whole milk is higher in saturated fat and cholesterol than that made with low-fat milk or skimmed milk. It also contains less calcium due to loss of whey which gives it an important role in maintaining and preventing many health problems. For example, it has anti-hypertensive peptides that can help reduce hypertension incidence (Shori *et al*., 2012; Park *et al*., 2016; Shori *et al*., 2018)

Skimmed milk and milk products have a potential effect in preventing inflammatory properties and may modify the effect of certain proinflammatory cytokines in the liver and kidney that are related to vitamin D and calcium. Milk also contains bioactive peptides which inhibit inflammatory responses (da Silva and Rudkowska, 2015). Additionally, caseins and whey proteins of milk work in concert with other ingredients including calcium, magnesium, and potassium in recovering inflammation (McGregor and Poppitt, 2013). However, full-fat varieties of dairy products increase likelihood of weight gain and hypercholesterolemia associated with fatty liver. Excessive consumption of whole milk and dairy products can provide significant amounts of saturated fat and cholesterol through diet which can raise heart disease incidence. Eating fermented skimmed dairy products (yoghurt and cheeses) could lower cholesterol because the fermentation of non-digestible carbohydrates by gut microflora reduces the production of cholesterol and obstructs the flow into the liver (Steinmetz *et al*., 1994; Yeh and Brunt, 2014). It is unclear how much milk and dairy products add to diet quality. On the optimistic side, dairy products contribute a substantial quantity of everyday nutrient needs from protein, minerals, and vitamins. However, they may have some side effects such as the ones related to allergies to milk protein and lactose intolerance besides the saturated fat and cholesterol, especially within whole milk products. Therefore, the present study targeted to assess the impacts of the administration of milk, both creamy and skimmed dairy products (yoghurt and cheese) on lipids profile between healthy rats.

2. Materials and methods

2.1 Materials

Commercial milk, yoghurt, and cheese either creamy or skimmed were obtained from local markets. Table 1 illustrates chemical composition of creamy or skimmed product of milk and yoghurt. It shows that creamy milk is composed of fat, protein, and carbohydrates at 3% while skimmed milk is composed of 0.25% fat, 3% protein and 3% carbohydrates. Creamy yoghurt is composed of 3% fat, 3% protein and 5% carbohydrates while skimmed yoghurt is composed of 1.5% fat, 3.2% protein and 6% carbohydrates. The creamy cheese used was made from pasteurized milk, palm oil, 5% skimmed milk powder, salt, and fat /dry matter is not less than 60%. Skimmed cheese made from pasteurized milk, palm oil, 5% skimmed milk powder, salt, and fat /dry matter from 20 to 30%. Healthy Sprague Dawley albino rats, weighing 135±7 g, were obtained from specialized farm (Helwan Farm for Laboratory Animals, Cairo, Egypt). All reagents and chemicals were obtained from the single source (Sigma, St. Louis, USA).

Table 1. The percentages of chemical compositions within used milk (creamy and/or skimmed) in addition to used yoghurt (creamy and/or skimmed).

	Chemical Composition %			
	Milk		Yoghurt	
	Creamy	Skimmed	Creamy	Skimmed
Fat	3	0.25	3	1.5
Protein	3	3	3	3.2
Carbohydrates	3	3	5	6

https://doi.org/10.26656/fr.2017.8(2).039

2.2 Animal study

The study was conducted in accordance with ethical principles for animal management, and approval was granted from the Menoufiya University ethical committee (MUFHE/F/NFS/2/22). The experiment was carried out at the School of Home Economics, Menoufia University, Egypt. Rats had free access to food and water. After a week of adaptation, blood samples were obtained from the orbital venous plexus of each rat's left eye. The samples were then centrifuged and kept at –20° C for additional examination.

2.2.*1 The experimental study design*

Forty-nine healthy Sprague Dawley albino male rats, weighing 135±7 g, were purchased from the Vaccine and Immunity Organization under the Ministry of Health supervision has been placed in Helwan Farm, Cairo, Egypt. All of them have been kept in regular, healthy laboratory circumstances, with free access to water and a temperature adjustment of 25±2^o C and roughly 12 hours of light and dark. Also, they all were fed one week adaptation prior to a basal diet before starting the experimental and that diet was evolved in accordance with Reeves *et al*. (1993) as followed within our recently published study (Aljutaily *et al*., 2022).

Then, rats were split into the following seven groups randomly:

Group 1 (G1): Control group fed with basal diet only.

Group 2 (G2): Fed 20% fresh creamy whole milk of their basal diet.

Group 3 (G3): Fed 20% fresh skimmed milk of their basal diet.

Group 4 (G4): Fed 20% creamy yoghurt of their basal diet.

Group 5 (G5): Fed 20% skimmed yoghurt of their basal diet.

Group 6 (G6): Fed 20% creamy cheese of their basal diet.

Group 7 (G7): Fed 20% skimmed cheese of their basal diet.

Each day, the amount of food consumed, and the rats' weight were reported. An estimate of the feed efficiency ratio (FER) was made (overall weight of feed divided by the net production, ending weight minus initial weight). Rats were fasted for an overnight period and then exterminated when the 60-day experiment was over. Their blood samples were obtained for further blood analysis. Urea and creatinine were evaluated as described by Henry *et al*. (1974). Additionally, a kidney histopathological examination was performed as described below.

2.3 Biochemical analyses

2.3.1 Liver functions

Hepatic functions were evaluated by estimation of serum alanine (ALT) according to Clinica Acta (1980) alkaline phosphatase (ALP) enzymes, and aspartate aminotransferase (AST) according to Hafkenscheid (1979). All the following methods were applied as followed within our previous recently published research (Khalil *et al*., 2021).

2.3.2 Kidney functions

Kidney functions have been determined using enzymatic colorimetric methods mainly urea, creatinine, and uric acid in accordance with the methods of Henry (1974) and Patton and Crouch (1977). These all were followed as described within our recently published data (Aljutaily *et al*., 2022).

2.3.3 Serum lipid profile

Serum lipids have been used to measure the effects of the used material on the experimental animal models' health.

2.3.3.1 Total cholesterol

Total cholesterol was measured in accordance with the method of Lewis *et al*. (1995). In which, an enzymatic method was used to hydrolyze cholesterol ester into free cholesterol by using cholesterol ester hydrolase. The free cholesterol was oxidized into cholest -4-en-3-one by using cholesterol oxidase. The cholest-4-en-3-one was coupled with 4-aminoantipyrine and phenol in the presence of peroxidase. The mixture was then read under spectrophotometer at a wavelength of 500 nm.

2.3.3.2 Triglycerides

Triglycerides (TG) were measured in accordance with the method of Fossati and Prencipe (1982). The triglycerides sample was hydrolyzed by using lipase and produce glycerol. Glycerol kinase and L-alpha-glycerol phosphate oxidase were then added into the sample which then produces hydrogen peroxide. The hydrogen peroxide was determined under the existence of horseradish peroxidase and 3,5-dichloro-2-hydroxybenzenesulfonic acid/4-aminophenazone. After 15 mins incubation sample (ratio 1:150) was then read at 510 nm.

2.3.3.3 High-density lipoprotein cholesterol

High-density lipoprotein cholesterol (HDLc) was measured in accordance with the method of Allain *et al*.

https://doi.org/10.26656/fr.2017.8(2).039

(1974). Isolation of HDLc was accomplished by precipitation with dextran sulfate (0.05%) and $MnCl_2$ (0.05 M). The LDLc and VLDLc will then be precipitated and then removed through centrifugation at 10 mins, 6000×*g*. Dissolving the precipitation and washing by centrifugation was repeated, then further removed by dialysis process. The LDLc and VLDLc free supernatant are then added with 0.65% dextran sulfate and 0.2 M $MnCl_2$, then centrifuged at 20,000×*g* for 30 mins. The washing procedure was performed using Tris HCL NaCl buffer containing 0.1% dextram sulfate and 0.2 M $MnCl_2$. The HDL was then recovered using ultracentrifugation as described in Burstein *et al.* (1970).

2.3.3.4 Low-density lipoprotein cholesterol

Low-density lipoprotein cholesterol (LDLc) was calculated in mg/dl based on the method of Lee and Nieman (1996) as follows: LDL (mg/dl) = Total CHO – (HDL+VLDL) and very low-density lipoprotein cholesterol (VLDLc) was determined as VLDLc (mg/dl) = TG / 5.

2.3.4 Atherogenic indexes

Atherogenic indexes were also calculated (cholesterol/HDLc and LDLc/HDLc) in addition to the liver cholesterol, total lipids, and glycogen were estimated enzymatically based on the method of McPherson and Pincus (2017). It has been established as well as followed within the recently published study from our group (Khalil *et al*., 2021).

2.4 Statistical analysis

ANOVA was applied on the data. Duncan's multiple range test was used to compare means at the significance level of 0.05, complemented at significance levels of 0.05 using the Kruskal-Wallis correlation approach to examine correlations between parameters (Elliott and Hynan, 2011).

3. Results

3.1 The impact of creamy and skimmed (milk, yoghurt, and cheese) on body weight gain between used healthy rats.

Table 2 reveals the impact of eating creamy, skimmed milk, and other dairy products (i.e., yoghurt and cheese) on body weight gain of healthy animal models. Table 2 also illustrates the food consumption and food efficiency ratio (FER) of animal models. After 60 days of consumption, final body weight and FER tended to be higher in the whole milk-fed group (256.40±23.81 and 0.104±0.002, respectively). While final body weight gain and FER were significantly greater in both groups fed creamy yoghurt (262.71±25.41 and 0.107±0.3, respectively) and creamy cheese (266.57±22.71 and 0.111±0.003, respectively). Also, food consumption levels were not significant among all experimental groups, however, the FER was significantly greater in the skimmed cheese rat group (0.103±0.004) compared to the rats fed with the basal diet (control group; 0.089±0.01). Final weight, body weight gain, and food consumption were within normal control values in rats administered with skimmed yoghurt and skimmed cheese.

3.2 The effects of creamy and skimmed (milk, yoghurt, and cheese) on kidney and liver functions between used healthy rats.

Table 3 demonstrates that a significant elevation in both kidney and liver measured indicators (AST, ALP, urea, creatinine, and uric acid). It could be observed that rats administered with creamy milk and creamy cheese compared to the control rat group increased significantly. Meanwhile, rats administered with skimmed milk showed a significant elevation of ALP, creatinine, and uric acid. Additionally, rats administered with creamy yoghurt and skimmed cheese showed a significant elevation of AST, ALP and uric acid compared to the control rat group. Thus, liver and kidney function significantly improved between group rats who consumed creamy cheese. Surprisingly, the rats

Table 2. The effects of creamy and/or skimmed (milk, yoghurt and cheese) on the body weight gain, food intake and food efficiency ratio between healthy rats.

Group	Initial weight (Day 0)	Final weight (Day 60)	Body weight gain	Food intake	Food efficiency ratio
G1	$135.77±5.61^{a}$	$231.55±21.75^{c}$	$95.78±8.96^{bc}$	$17.80±1.18^{ab}$	$0.089±0.01^{d}$
G2	$136.80±4.99^{a}$	$256.40±23.81^{ab}$	$119.60±10.35^{ab}$	$19.05±1.57^{a}$	$0.104±0.002^{bc}$
G3	$135.40±5.77^{a}$	$229.97±21.11^{bc}$	$94.51±9.61^{bc}$	$17.75±1.22^{ab}$	$0.088±0.001^{d}$
G4	$137.11±5.41^{a}$	$262.71±25.41^{a}$	$125.60±13.11^{a}$	$19.40±1.33^{a}$	$0.107±0.3^{b}$
G5	$136.50±5.11^{a}$	$229.94±23.11^{c}$	$93.44±9.66^{bc}$	$17.70±1.17^{ab}$	$0.087±0.001^{d}$
G6	$135.96±6.07^{a}$	$266.57±22.71^{a}$	$130.61±12.33^{a}$	$19.44±1.95^{a}$	$0.111±0.003^{a}$
G7	$137.50±5.22^{a}$	$238.83±20.41^{c}$	$101.33±8.77^{b}$	$18.25±1.81^{a}$	$0.103±0.004^{bc}$

Values are presented as mean±SD, n = 7. Values with different superscripts within each column are statistically significantly different (*P*<0.05).

https://doi.org/10.26656/fr.2017.8(2).039

Table 3. Measured liver and kidney function parameters in rats fed with creamy and/or skimmed (milk, yoghurt and cheese).

Groups	Liver functions (units/L)			Kidney Functions (units/L)		
	Aspartate aminotransferase	Serum alanine	Alkaline phosphatase	Urea	Creatinine	Uric acid
G1	40.11± 3.44^{c}	48.69±5.66^{bc}	29.41±3.11^{c}	44.66±4.11^{b}	0.66±0.13^{c}	3.66±0.29^{b}
G2	49.33± 4.77^{ab}	55.11±4.99^{ab}	37.21±3.31^{a}	49.33±5.11^{a}	0.78±0.16^{ab}	4.11±0.58^{a}
G3	43.30± 4.27^{bc}	52.11±5.31^{ab}	35.11±3.07^{ab}	45.60±4.96^{ab}	0.70±0.15^{b}	4.21±0.55^{a}
G4	46.11±4.90^{b}	53.20±5.18^{ab}	39.59±4.11^{ab}	46.10±4.81^{ab}	0.68±0.10^{bc}	4.33±0.44^{a}
G5	39.66±3.90^{c}	45.11±5.17^{bc}	28.64±2.66^{c}	43.21±4.22^{b}	0.55±0.12^{d}	3.51±0.39^{b}
G6	53.70±5.61^{a}	59.11±6.03^{a}	39.91±3.60^{a}	48.71±5.11^{a}	0.86±0.11^{a}	4.59±0.41^{a}
G7	49.98±4.66^{ab}	50.77±5.71^{b}	34.99±3.22^{b}	46.11±3.99^{ab}	0.60±0.15^{cd}	4.31±0.39^{a}

Values are presented as mean±SD, n = 7. Values with different superscripts within each column are statistically significantly different (*P*<0.05).

administered with skimmed yoghurt showed a non-significant difference in liver and renal functions measured parameters except for the reduction of creatinine value compared to the control rat group.

3.3 The impact of creamy and skimmed (milk, yoghurt, and cheese) on the lipid profile between used healthy rats.

At the beginning of the experiment (day 0; the start time point), the values of cholesterol, triglyceride and HDLc were non-significant among all experimental groups. After 60 days of feeding the used different treatments (creamy milk, creamy cheese, and skimmed cheese) in the basal diet, the levels of serum total cholesterol and triglycerides levels were significantly elevated by 22–30% and 12–27%, respectively. However, HDLc significantly decreased (19–22%) compared to the control rat group. Additionally, skimmed milk supplementation among the rat group significantly increased the levels of triglycerides while decreasing the HDLc levels by 12% and 14%, respectively compared with the results of the control rat group. Moreover, administration of creamy and skimmed yoghurt in a basal diet could keep the values of serum total cholesterol, triglycerides, and HDLc, appearing within the values of the control rat group as presented in Table 4. Again, on Day 0 of the experiment, all values of LDLc and VLDLc were non-significant compared to the values of the control group. However, at the end of the experimental time (60 days), the LDLc and VLDLc increased after the scheduled consumption of the dairy products. In which, healthy models consuming creamy milk have LDLc and VLDLc levels of 103.89±12.55 and 25.10±2.25. Meanwhile, LCLc and VLDLc level of the healthy models given with a diet of skimmed milk is 85.48±8.11 and 22.12±2.15. The healthy models consuming creamy cheese in their diet have a LDLc and VLDLc level of 117.03±12.61 and 23.47±2.17. The healthy models fed with the diet with skimmed cheese have a LDLc and VLDLc level of 107.88±1.22 and 22.08±2.14. All these models revealed an increased LCLc and VLDLc level when compared to control group with LCLc and VLDLc levels of 72.76±6.41 and 19.74±1.88. The values of LDLc appeared obviously in creamy cheese and skimmed cheese while the levels between rats fed with yoghurt either creamy or skimmed showed similarity within the values of control rat group (Table 4).

3.4 The effects of creamy and skimmed (milk, yoghurt, and cheese) on the atherogenic indexes between used healthy rats.

The atherogenic indexes (cholesterol/HDLc and LDLc/HDLc) were non-significant in experimental rat groups compared with control rat group at day 0 of experiment. Administration of creamy milk, creamy cheese, and skimmed cheese for 60 days could increase both atherogenic indexes, while administration of skimmed milk, creamy yoghurt, and skimmed yoghurt showed normal values of atherogenic indexes compared to control group (Table 5). Additionally, the effect of the administration of creamy and skimmed milk and dairy products on cholesterol, total lipids and glycogen in the liver is presented in Table 6. The results have shown that the concentrations of liver cholesterol and total lipids were significantly higher, but glycogen was significantly lower in rat groups that administered creamy milk, creamy cheese, and skimmed cheese in basal diets compared to control group at day 60 of experiment. However, rats administered skimmed milk in basal diets displayed a significant rise in liver cholesterol and non-significant value of liver total lipids and glycogen compared to control group. Administration of creamy and skimmed yoghurt could maintain the levels of liver cholesterol, total lipids, and glycogen close to control levels.

4. Discussion

The increase in nutritional values is related to the fat content in dairy products as eating fat tends to improve flavor, digestibility, and absorption of foods that reflect

Table 4. Lipid profile levels (mg/dl) in rats fed with creamy and/or skimmed (milk, yoghurt and cheese).

Group	Total cholesterol		Triglycerides		High-density lipoprotein cholesterol		Low-density lipoprotein cholesterol		Very low-density lipoprotein cholesterol	
	Day 0	Day 60	Day 0	Day 60	Day 0	Day 60	Day 0	Day 60	Day 0	Day 60
G1	122.65±11.17^{a}	130.61 ±12.11^{d}	95.71 ±4.99^{a}	98.71±10.11^{c}	35.96±3.99^{a}	38.11±3.77^{a}	67.55±6.14^{a}	72.76±6.41^{e}	19.14±1.15^{a}	19.74 ±1.88^{c}
G2	120.77±12.55^{a}	159.70 ±15.11^{b}	94.41±5.27^{a}	125.51 ±12.33^{a}	36.70±4.55^{a}	30.71±3.50^{c}	65.19±6.75^{a}	103.89±12.55^{b}	18.88±2.11^{a}	25.10±2.25^{a}
G3	124.30±14.11^{a}	140.31±14.77^{c}	96.11±5.11^{a}	110.61 ±10.17^{b}	35.60±3.11^{a}	32.71±3.71^{bc}	69.48±6.98^{a}	85.48±8.11^{d}	19.22±2.33^{a}	22.12±2.15^{b}
G4	125.11±15.20^{a}	143.11±13.21^{c}	95.41±9.03^{a}	102.71±11.10^{bc}	36.11±3.44^{a}	38.99±4.01^{a}	69.92±7.03^{a}	78.58 ±8.14^{e}	19.08±2.51^{a}	20.54±1.85^{bc}
G5	120.80±16.17^{a}	125.11±12.17^{cd}	93.96±4.11^{a}	91.70±9.68^{c}	35.71±3.22^{a}	40.71±4.33^{a}	66.30±6.55^{a}	66.06±6.22^{e}	18.79±2.71^{a}	18.34±1.99^{c}
G6	123.61±15.22^{a}	170.11±16.11^{a}	95.70±4.03^{a}	117.35±14.21^{ab}	34.71±4.07^{a}	29.61±2.75^{c}	69.76±6.14^{a}	117.03±12.61^{a}	19.14±2.81^{a}	23.47±2.17^{ab}
G7	124.40±12.66^{a}	160.11±15.14^{a}	93.66±4.22^{a}	110.41±12.11^{b}	35.90±3.11^{a}	30.15±3.11^{c}	69.77±6.11^{a}	107.88±1.22b^{c}	18.73±2.70^{a}	22.08±2.14^{b}

Values are presented as mean±SD, n = 7. Values with different superscripts within each column are statistically significantly different (P<0.05).

Table 5. Atherogenic indexes (total cholesterol/HDLc and LDLc/ HDLc) in rats fed with creamy and/or skimmed (milk, yoghurt and cheese).

Group	Total cholesterol/HDLc (mmol/L)		LDLc/HDLc (mmol/L)	
	Day 0	Day 60	Day 0	Day 60
G1	3.41±0.25^{a}	3.42±0.33^{cd}	1.87±0.10^{bc}	1.90±0.20^{c}
G2	3.29±0.24^{ab}	5.2±0.55^{ab}	1.77±0.12^{bc}	3.38±0.44^{ab}
G3	3.49±0.32^{a}	4.28±0.45^{c}	1.95±0.45^{b}	2.61±0.55^{cd}
G4	3.46±0.31^{a}	3.67±0.42^{cd}	1.93±0.54^{b}	2.14±0.65^{cd}
G5	3.38±0.33^{a}	3.07±0.34^{c}	1.85±0.12^{bc}	1.62±0.22^{c}
G6	3.56±0.40^{a}	5.74±0.68^{a}	2.09±0.77^{ab}	3.92±0.18^{a}
G7	3.46±0.35^{a}	5.31±0.44^{ab}	1.94±0.11^{b}	3.57±0.66^{ab}

Values are presented as mean±SD, n = 7. Values with different superscripts within each column are statistically significantly different (P<0.05).

Table 6. Levels of liver cholesterol, total lipids and glycogen in rats fed with creamy and/or skimmed (milk, yoghurt and cheese).

Group	Cholesterol (mg/g)	Total lipids (mg/g)	Glycogen (mg/100 g)
G1	4.60±0.30^{c}	38.55±3.22^{bc}	6.90±0.66^{a}
G2	5.41±0.33^{a}	55.11±4.96^{a}	4.56±0.55^{c}
G3	5.13±0.25^{b}	40.11±4.01^{bc}	5.91±0.44^{ab}
G4	5.03±0.22^{bc}	40.25±3.10^{bc}	5.55±0.39^{ab}
G5	4.13±0.21^{c}	37.41±2.41^{bc}	6.44±0.71^{a}
G6	5.99±0.41^{a}	49.41±3.96^{a}	4.51±0.51^{c}
G7	5.11±0.40^{ab}	56.71±3.11^{a}	4.94±0.43^{c}

Values are presented as mean±SD, n = 7. Values with different superscripts within each column are statistically significantly different (P<0.05).

https://doi.org/10.26656/fr.2017.8(2).039

on values of final weight, weight gain and FER. Creamy milk, creamy yoghurt, and creamy or skimmed cheese have a better level of FER that is not exactly in line with those of high-fat dairy products that are more fulfilling, naturally eating less. Recently, healthy fats and fat-soluble vitamins have been found mainly in high-fat milk and dairy products. However, reduced-fat dairy products are usually overloaded with sugar to obtain the desired flavor (Kapaj and Deci, 2017). Nevertheless, dairy products have a wide range of fats, proteins, minerals (potassium, calcium, phosphorus, iodine, magnesium, and zinc) and vitamins (A, B6, B12, D and K). Conjugated linoleic acids, *cis* and *trans* palmitoleic acids, butyric acid, phytanic acid, and alpha-linolenic acids are among fatty acids found in dairy products fat. Previous studies in laboratory animals showed that *trans*-palmitoleate (trans 16:1 n-7) in dairy fat is a *trans* fatty acid, and its blood phospholipid concentrations are related to reduced incidence of diabetes by reduce insulin resistance and enhance lipid profile. Also, the intake of vaccenic acid in dairy fat has positive effects on immune function and cardiometabolic risk factors (Mozaffarian *et al*., 2010; Jacome-Sosa *et al*., 2014). Eating dairy products has a beneficial impact on body weight and body fatness as reported by Wade *et al*. (2017).

Notably, low concentrations of HDL cholesterol along with increased levels of triglyceride and total cholesterol are predictors of cardiovascular disease and related to fat deposition in the liver. Milk consumption has a neutral effect on cardiometabolic risk factors. Contrarily, Drouin-Chartier *et al*. (2015) and Rosqvist *et al*. (2015) reported that dairy-saturated fatty acids had a non-significant effect on small LDL particles and elevated large LDL particles. Drinking four cups of skimmed milk (containing 2% fat) for six weeks did not affect cardiometabolic risk factors and markers of inflammation and vascular function in postmenopausal women (Drouin-Chartier *et al*., 2015).

Currently, the results obtained showed a positive health effect of either creamy or skimmed yoghurts as they contain casein and whey protein that led to hypocholesterolemia. The presence of calcium fermented milk could enhance the defecation of fat by lowering fat absorption and improving fecal fat excretion. Administration of lactic acid bacteria (yoghurt) showed an improve in the production of bile acid and a decrease in the recycling of bile acids within the enterohepatic circulation (Nakajima *et al*., 1992; Hjerpsted *et al*., 2011).

Skimmed cheese consumption could improve serum lipid metabolism, specifically in comparison to butter consumption between humans. Additionally, the intake of cheese reduces LDLc although there is no evidence of a consistent cheese effect on serum cholesterol (Cormier *et al*., 2016). Also, atherogenic index estimation is a prediction of artery sclerosis and is linked with fat accumulation in the liver. The collected results showed that excessive cheese consumption could increase liver lipids and atherogenic indexes which may be due to increased calcium supplements and saturated fatty acids, which are linked with a higher likelihood of coronary artery calcification. Taking whole milk and dairy products would be associated with hyperlipidemia or cardioprotective effects of dietary fatty acids are arbitrated via gene expression control (Khodadadi *et al*., 2008; Pereira, 2014). The current observations agreed with results found by Elwood *et al.* (2010) and Abargouei *et al*. (2012). Consuming dairy products can reduce metabolic syndrome symptoms like insulin resistance, elevated blood pressure, dyslipidemia, and abdominal obesity. It also has an inverse relationship with the incidence of cardiovascular illnesses. Moreover, there was an unclear role of dairy product intake on weight management. Praagman *et al.* (2015) and Kurt *et al*. (2018) showed that yoghurt intake could help to achieve more nutrient absorption, decrease levels of circulating triglycerides and glucose, regulate insulin, and modulate the blood lipid profile. The lactic acid bacteria-containing yoghurts contain probiotics, which may cling to bile acids and promote their elimination while decreasing bile acid recycling in the hepatic circulation system. A probiotic lactic acid bacterium can interrupt the absorption of lipids in the intestine of rats by binding directly to cholesterol and fatty acids (St-Onge *et al*., 2000; Kadooka *et al*., 2010). A report published showed a good correlation effect of probiotic consumption (mainly yoghurt) on lipid profile between diabetic animal models (Khalil *et al*., 2021).

The results obtained concurred with results obtained by various researchers (Sun *et al*., 2007; Warensjö *et al*., 2010; Chowdhury *et al*., 2014; Abdullah *et al*., 2015), who reported that milk contains essential fatty acids primarily C15:0 and C17:0. Also, plasma and erythrocytes have three different fatty acids (i.e., the C15:0, C17:0, and trans C16-1) that assessed dairy fat. Whereby, plasma C15:0 is linked to the ischemic heart disease incidence. Conversely, an inverse relationship was found between relative risks and higher levels of the other fatty acids such as Trans C16:1 in plasma and erythrocytes, or C17:0 in erythrocytes, in women only. The content of trans-16:1n−7 in dairy products differs extensively based on dairy animals, the metabolically phenotypes and poor measure of actual intakes (Salvini *et al*., 1989; Kratz *et al*., 2013). Phytanic acid is a minor fatty acid, a potent agonist of peroxisome proliferator that activates hepatic receptor α-a transcription factor

https://doi.org/10.26656/fr.2017.8(2).039

that regulates liver fat oxidation. Together, trans-16:1n−7 and phytanic promote hepatic β-oxidation, prevent de novo lipogenesis, and enhance insulin sensitivity. Dairy fat could decrease liver fat glucose tolerance in parallel with improving hepatic and systemic insulin sensitivity (Hellgren, 2010; Kratz *et al*., 2014).

Excess fatty acid flows from adipose tissue to the liver, and hepatic fat accumulates when lipogenesis and lipid oxidation are out of balance (Donnelly *et al*., 2005). Higurashi *et al.* (2016) found that the liver of rats given cheese with a high-fat diet had less buildup of triglycerides and cholesterol, that the serum lipoprotein profile had improved, and that the amount of fat excreted in the feces had increased. The results obtained showed an elevation of lipids markers and atherogenic indexes when rats consumed cheese either skimmed or creamy may be due to the addition of palm oil found in the cheese. Palm oil is cheap and highly saturated in nature and is mainly introduced in the commercial food industry because it keeps a solid shape when the temperature is ambient and substitutes for butter. However, palm oil contains an equal amount of saturation (44% palmitic acid, 5% stearic acid), 40% oleic acid (monounsaturated), 10% linoleic acid and 0.4% α-linoleic acid (polyunsaturated). Therefore, elevated consumption of palm oil-derived saturated fat leads to a greater rise in plasma concentrations of low-density lipoproteins and total cholesterol. Before having an impact on serum cholesterol levels, palm oil may cause disruption in the liver's lipid metabolism.

In conclusion, creamy or skimmed milk and/or some dairy products have beneficial effects on serum lipid patterns. However, the consumption of yoghurt shows more positive effects than cheese. This might be related to the yoghurt probiotic properties that showed a good correlation to the colonic microbiota. Also, the current treatments represented positive impacts on the liver and kidney functions, suggesting further investigations of different hyperlipidemic components and additives of commercial cheese.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

We would like to thank the School of Home Economics, Menoufia University, Egypt for hosting our experiment within safety guidelines and conditions.

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