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Study of Nutritional Effects of Rapeseed and Sunflower Oils on Ponderal and Biochemical Parameters in Wistar Rats

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Abstract Oilseeds are rich in mono-unsaturated (MUFAs) and poly-unsaturated fatty acids (PUFAs) as omega-3 and omega-6. These nutrients showed preventive and protective properties against obesity and cardiovascular diseases. This study aimed to assess the nutritional effects of rapeseed oil and sunflower oil on ponderal and biochemical parameters in rats. The experiments were carried out on 15 two months old rats, with a mean body weight of 55 g. The experiment lasted 4 weeks. Animals were assigned into 3 groups: group 1 (control), group 2 (fed with rapeseed oil) and group 3 (fed with sunflower oil). Weight gain was daily measured and biochemical parameters were weekly determined. The results showed a insignificant decrease in weight gain in animals of group 2 fed with rapeseed oil (32.12 ± 12.77 g), a significant reduction of serum HDL-cholesterol in group 3 fed with sunflower oil (0.83 ± 0.26 mMol / L), although serum total-triglycerides in groups 2 and 3 were not significantly lower than controls (2.63 ± 0.15 and 3.19 ± 0.61 *vs* 3.1 ± 0.58 mMol / L respectively). However rapeseed oil had showed lowering effects on the higher blood cholesterol and triglyceride levels.

Keywords Poly-unsaturated fatty acids, Cardiovascular diseases, Rapeseed oil, Sunflower Oil, Cholesterol, Triglyceride

1. Introduction

Further genetic and environnemental factors, nutrition substantially contributes to the occurrence and prevention of various diseases. Nutritional approaches could serve as a natural protective factor in case of dietary deficiencies and metabolic disorders such as diabetes, cardiovascular disease, osteoporosis and cancer [1]. According to the epidemiological studies, it is recommended to eat less fat in order to maintain an improved health status. It is obvious that the fats increase the risk of cardiovascular diseases, although they play an important role in human nutrition as a part of a balanced diet [2]. Lipids are contained in different foods and they contribute in flavor and taste, as well as in the transport of fat-soluble vitamins and energy [3]. The last decades, qualitative analysis of vegetable oils provides new insights. Oilseeds, such as rapeseed, sunflower, nuts and flax, are rich in essential fatty acids (EFAs), like ω-3 and ω-6 that human or animal body is unable to produce and are received by the diet or through supplements [4]. The hypercholesterolemic effects of the long chain saturated fatty acids (SFAs) on LDL-cholesterol but also HDL-cholesterol blood-levels are well established. Polyunsaturated fatty acids (PUFAs) of ω-3 and ω-6 series are involved in physiological processes such as the constitution and integrity of cell membranes, cardiovascular, brain, hormonal and inflammatory functions. These micronutrients cover the daily nutrient requirements and maintain balance between ω-3 and ω-6 [4]. The present experiment aims to assess the effect of supplementation either with rapeseed oil or sunflower oil on the body weight and lipid parameters in rats.

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2. Material and Methods

2.1. Rapeseed Oil and Sunflower Oil

Rapeseed oil (Brassica *napus*) and sunflower oil (Helianthus *annuus*), used in the present study, were purchased from shops in France, after the implementation of physicochemical and compositional analysis, which revealed their high content in MUFAs and PUFAs (Table 1).

The determination of the acidity was performed according to ISO No. 660.1990. The iodine value is calculated according to the method described in NF T 60-231. Fatty acid compositions of the oils were carried out by gas chromatography Hewlett-Packard type (6890) coupled to a mass spectrometer (HP 5973). These instruments were

connected to a computer system managing a mass spectral database (NIST 98) and driven by software "HP ChemStation" allowing to follow the evolution of chromatographic analyzes.

Table 1. Physicochemical and composition analysis of Rapeseed and Sunflower oil (per 100g)

Parameters	Rapeseed oil	Sunflower oil
Saponification index (mg/g)	167-174	188-194
Iodine index (mg/g)	97-100	125-144
Refrecative index at 50 °C (η^{20})	1.462	1.466-1.468
T° fusion (°C)	-10 / -2	-15
Density (g/ml)	0.916	0.948
Satured fatty acids (%)	7.36	10.3
Mono-unsatured fatty acids (%)	63.27	19.5
Poly-unsaturated fatty acids (%)	28.14	65.7
Oleic acid (g)	61.744	19.5
Linoleic acid ω-6 (g)	19.005	65.7
Alpha-linolenic acid ω-3(g)	9.137	-
Vitamin E (mg)	45.8	41.08
Vitamin K (µg)	71.3	5.4

2.2. Animals and Treatments

Fifteen male Wistar rats (Rattus norvegicus var. albinus), aged 2 months old with an average body weight of 55 ± 10 g, were obtained from the Department of Biology at the University of Saida, Algeria. The animals were kept under standard environmental conditions (22±2°C; 12:12 h dark/light cycle). Water and commercial feed, obtained from the National Office of Feed for Cattle (NOFC, Algeria), were available *ad libitum.* The composition of control diet rat is showed in table 2. The experimental protocol was approved by the Animal Experimentation Ethics Committee of the UFPE (Process no. 012974) in accordance with the National Institute of Health Guidelines for the Care and Use of Laboratory Animals.

Table 2. Composition of the maintenance regime NOFC (standard diet)

Composition	Amount (%)
Vegetable protein	14.5
Lipids	7.5
Carbohydrates	55.8
Cellulose	5.4
Humidity	11
Mineral materials	9.5
Energy (kJ / g)	14.6

2.3. Distribution of Animals in Groups

The fifteen rats were randomly allocated into three groups (n = 5 /group):

Group 1 (Normal control rats): each rat received daily 100 g diet and water is supplied ad- libitum.

Group 2 (experimental animals): each rat received daily 100 g diet and orally 1.5 ml rapeseed oil.

Group 3 (experimental animals): each rat received daily 100 g diet and orally 1.5 ml sunflower oil.

Body weight gain was daily evaluated during the whole experimental period (4 weeks). After 28 days of treatment, animals were anesthetized (sodium pentobarbital 40 mg/kg b.w.), blood samples were collected , remained for 20 min in laboratory temperature and then centrifuged for 10 min at 1500 *g* for serum separation [5].

2.4. Serum Assay of Lipids

Determination of serum lipid levels (total-cholesterol, triglyceride, HDL-cholesterol and LDL-cholesterol) has been performed by an enzymatic colorimetric method as described by **Kamelska *et al.* (2015)** using SPINREACT commercial kits [6].

2.5. Statistical Analysis

Data are expressed as means ± SD (standard deviation). The values were analyzed by one way analysis of variance (ANOVA) test on SigmaPlot software *version 11.0*. Differences at $p<0.05$ were considered statistically significant.

3. Results and Discussion

Weight gain values were not significantly different among the experimental groups; 31 ± 19.93; 32.12 ± 12.77 and 34.75 ± 20.64 g for group 1, 2 and 3, respectively (Table 3; p = 0.95). In **Figure 1,** values for during the whole experimental period are presented. Rats of group 2 (Rapeseed oil) showed a decrease in body weight between the 3rd and 4th week of experimentation but during the 4th week, an increase in weight was observed. These results are closely related to the amount of feed ingested. On the other hand, rats of group 1 and 3 showed a continuous increase of their body weight.

Serum total-cholesterol levels were also not significantly different among the experimental groups (3.8 ± 0.57, 3.11 ± 0.38 and 3.28 ± 0.2 mMol / L for group 1, 2 and 3, respectively) (Table 3; p = 0.10). No differences were observed with time, as it is shown in Figure 2.

The mean values of serum HDL-Cholesterol concentration in the different groups of rats are shown in Table 3. Figure 3 showed values of serum HDL-Cholesterol levels were significantly different among the groups of rats ($p^* = 0,04$). Serum HDL-Cholesterol levels, among animals of group 3 (fed sunflower oil), were significantly lower than that of control rats and less and more than group 2 (fed with rapeseed oil). Effects of sunflower oil showed, particularly in the 3rd week of experiments, significantly difference between groups 2, 3 and controls with lower blood HDL-CH level that were respectively 0,83 ± 0,26*;* 1,09 ± 0,31 and 1,36 ± 0,09 mMol / L.

Table 3. Ponderal and biochemical parameters in rats

Parameters	Statistical data	Controls	Rapeseed oil	Sunflower oil	*p-value*
Weight Gain (g)	Mean ± SD CI (95 %) of mean Median Min-Max	31 ± 19.93 31.71 34 5 – 51	32.12 ± 12.77 20.31 35 15 – 43.5	34.75 ± 20.64 32.85 39,5 8 - 52	*p = 0.95*
Serum Total-Cholesterol (mMol / L)	Mean ± SD CI (95 %) of mean Median Min-Max	3.8 ± 0.57 0.90 3.75 3.2 – 4.5	*3.11 ± 0.38 0.61 3.18 2.6 – 3.5	3.28 ± 0.2 0.32 3.3 3.05 – 3,5	*p = 0.10*
HDL-Cholesterol (mMol / L)	Mean ± SD CI (95 %) of mean Median Min-Max	1.36 ± 0.09 0.15 1.32 1.3 – 1.5	1.09 ± 0.31 0.5 1.23 0.62 – 1.27	0.83* ± 0.26 0.41 0.74 0.65 – 1.22	*P* = 0.04*
LDL-Cholesterol (mMol / L)	Mean ± SD CI (95 %) of mean Median Min-Max	1.8 ± 0.21 0.33 1.76 1.6 – 2.1	1.84 ± 0.28 0.45 1.88 1.48 – 2.15	2.02 ± 0.33 0.53 2.02 1.66 – 2.4	*p = 0.52*
Total-Triglycerides (mMol / L)	Mean ± SD CI (95 %) of mean Median Min-Max	3.1 ± 0.58 0.93 3.1 2.5 – 3.7	**2.63 ± 0.15 0.24 2.58 2.5 – 2.85	3.19 ± 0.61 0.98 3.22 2.45 – 3.9	*p = 0.48*

SD: standard deviation, CI: confidence interval, Min: minimum, Max : maximum, HDL : high density lipoprotein, LDL : low density lipoprotein.
P*: < 0.05

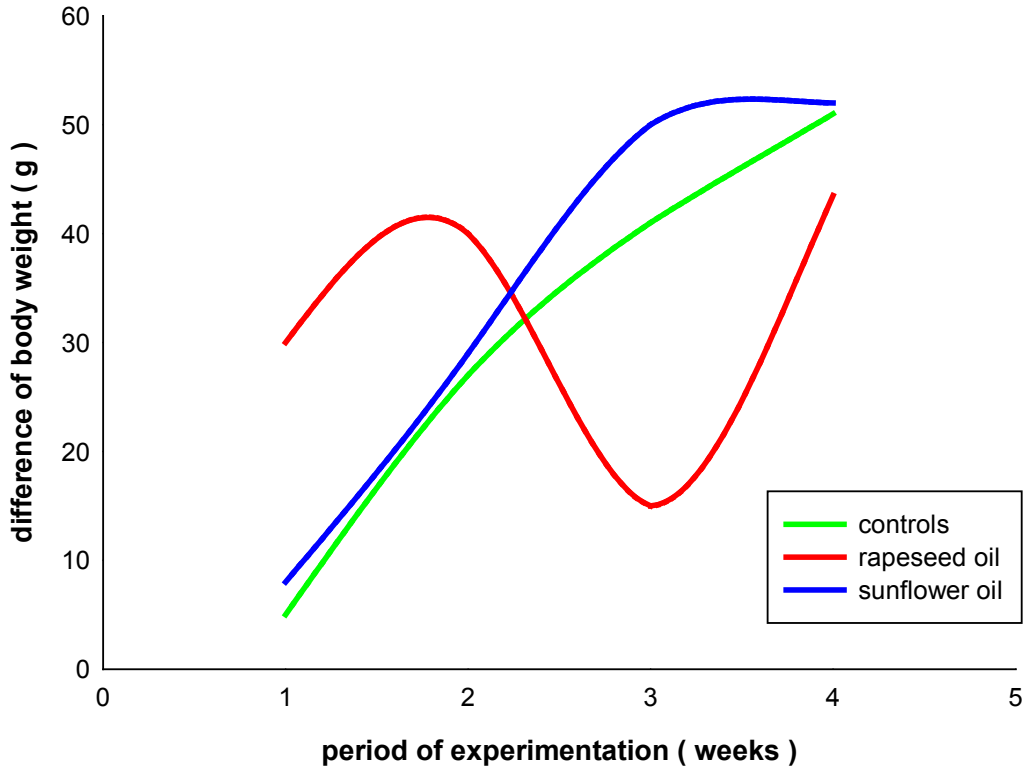

Figure 1. Weight gain per week (g) in groups of rats during the whole experimental period

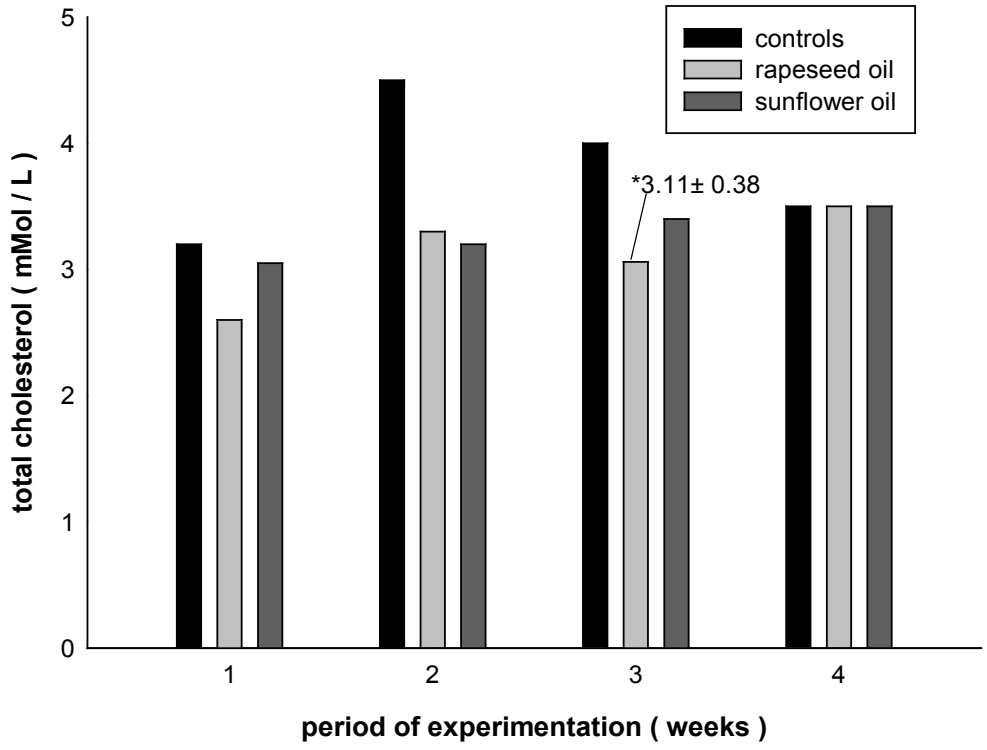

Figure 2. Serum total cholesterol in groups of rats during the whole experimental period

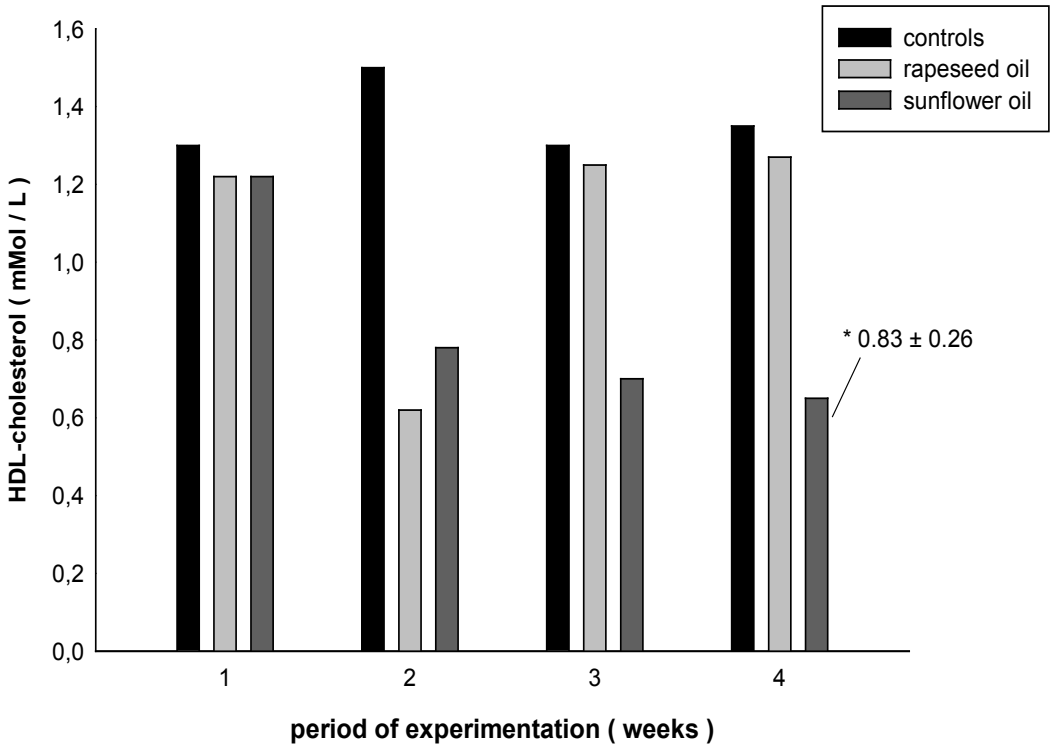

Figure 3. Serum HDL-Cholesterol in groups of rats during the whole experimental period

Serum LDL-Cholesterol levels were not significantly different among the experimental groups (1.8 ± 0.21; 1.84 ± 0.28 and 2.02 ± 0.33 mMol / L for group 1, 2 and 3, respectively) (Table 3; p = 0,52). Serum LDL-Cholesterol values did not vary with time (Figure 4).

Serum total-triglyceride levels in group 2 (fed with rapeseed oil) and 3 (fed with sunflower oil) were not significantly higher than that of control animals (group 1) (3.1 ± 0.58, 2.63 ± 0.15 *vs* 3.19 ± 0.61 mMol / L, respectively) (**Table 3;** p = 0,48). No variation was alo observed with time (Figure 5).

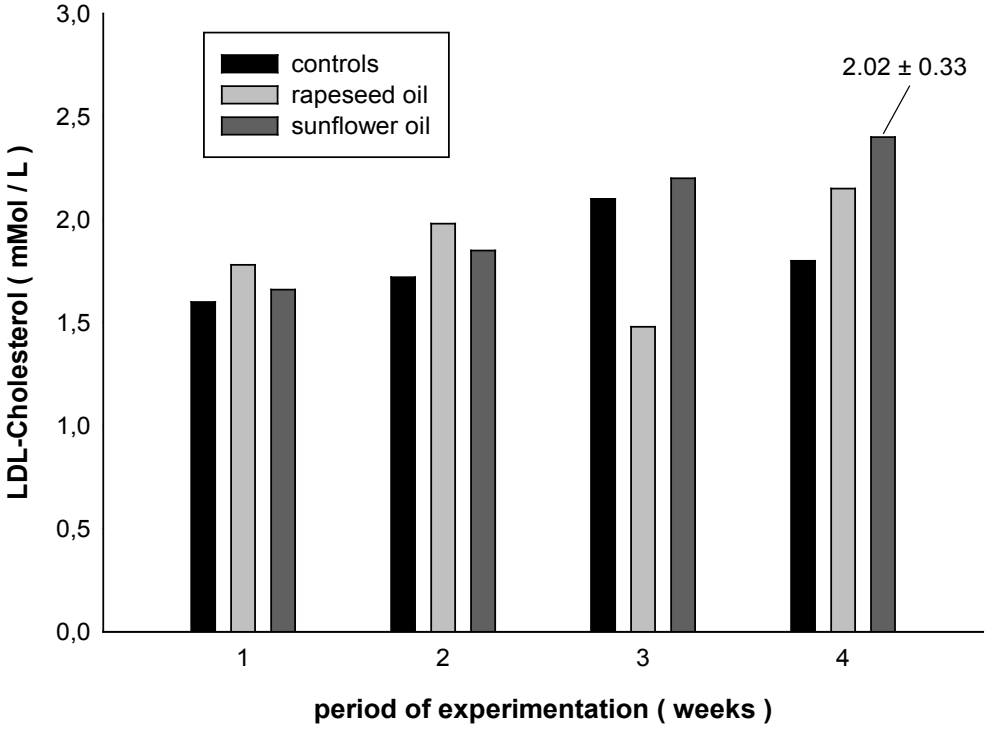

Figure 4. Serum LDL-Cholesterol in groups of rats during the whole experimental period

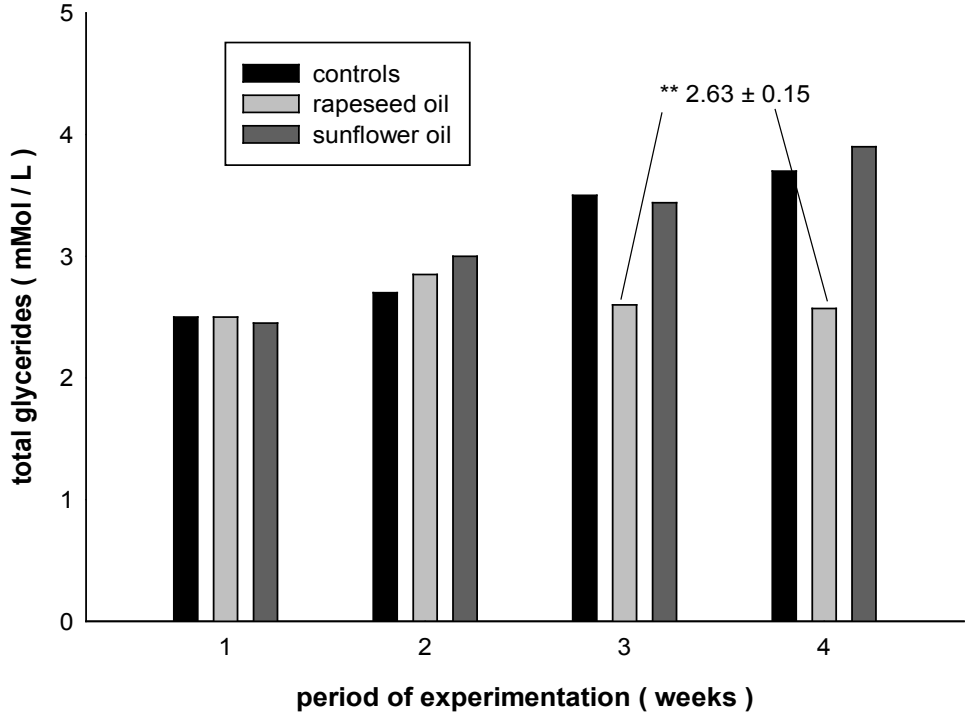

Figure 5. Serum total triglycerides in groups of rats during the whole experimental period

Increased dietary fat intake is normally related with high serum-cholesterol levels and obesity. Qualitative changes, made in recent decades in the fatty acid composition of the diet, are not fully known. However, previous studies have shown that all the fatty acids do not play the same role. Saturated and mono-unsaturated fatty acids (SFAs and MUFAs) are more adipogenic than poly-unsaturated fatty acids (PUFAs) [7]. Our study aims to assess the effects of rapeseed and sunflower oils supplementation on ponderal and biochemical parameters in rats. Experimental animals did not show a real significant weight gain in all groups. Rapeseed and sunflower oil supplementation reduce appetite of animals and even the total number of feed calories ingested [8]. Experiments with animals have also shown that SFAs and MUFAs were more effective than the PUFAs to induce weight gain [9]. The fatty acid composition of the food considerably contributes in regulating body weight. Studies, both in animal models and humans, showed that PUFAs are more used as energy source, while SFAs are accumulated in the adipose tissue [10]. In our study, a decrease of serum total-cholesterol levels in animals fed with rapeseed and sunflower oils, although it was not statistically significant, coincides with the results of some previous studies [11]. The results of the present study suggested that sunflower oil reduces HDL-cholesterol levels unlike rats fed rapeseed oil (Table 3). The reduction of serum total-cholesterol was explained by its elimination from the blood and deposition in the liver tissue. Rapeseed oil prevents the accumulation of cholesterol in liver tissues [12]. ω-3 PUFAs, present in vegetable oils, reduce serum total-triglyceride levels deriving from carbohydrate transfromations [13]. On the other hand,a diet rich in SFAs induces an increase in plasma triglyceride levels and their accumulation in liver tissue [14].

Alpha-linolenic acid (ALA), present in both oils, reduced hepatic synthesis of fatty acids which consequently reduces plasma triglyceride levels [15]. Recent works showed that the ingestion of PUFAs (ω-3 and ω-6), present in vegetable oils, is inversely proportional to the incidence of heart disease and results in a reduction of blood cholesterol and triglyceride levels [16].

4. Conclusions

As it is shown in the present study, supplementation with rapeseed oil and sunflower oil did not significantly affect growth performance and lipid parameters. Biochemical analysis showed that sunflower oil contributes to the reduction of HDL-cholesterol, while rapeseed oil did not have an effect on serum HDL-cholesterol levels.

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