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Effect of Different Dietary Sources of Oils on Growth Performance and Profile of Lipid, Testosterone and Fatty Acids in Rabbit Bucks

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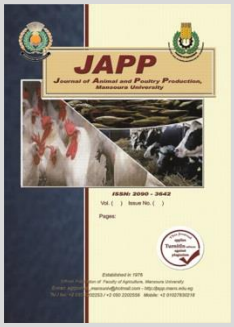

ABSTRACT

The current study aimed to evaluate the effect of dietary supplementation with sunflower oil (SFO), flaxseed oil (FSO) or 1% SFO+1% FSO on growth performance, and lipid, testosterone and fatty acid profiles of California rabbit bucks. Number of 24 California bucks having 5.3-5.5 months of age and weighing 2316-2429 g were divided into four groups (n=6). Bucks in the control group were fed free commercial diet, while those in the 2nd, 3rd and 4th groups were fed the same diet with 2% SFO, 2% FSO, or 1% SFO+1% FSO, respectively. Growth parameters were determined during the experiment (16 wk). Serum lipid, testosterone and fatty acid profiles were determined. Results showed insignificant treatment effect on body weight, feed intake and weight gain during the experiment (0-16 wk). The differences in serum triglycerides and total lipids between treatment groups and control were not significant, but triglycerides increased (P<0.05) in FSO- than SFO-bucks. Phospholipids decreased (P<0.05) only by SFO+FSO, while total cholesterol and LDL increased (P<0.05) by SFO or SFO+FSO, but HDL was not affected. All oil types increased (P<0.05) Non-HDL, being higher (P<0.05) in SFO+FSO than in SFO or FSO. Serum Castelli I and II indices, AST and ALT activity, serum total fatty acids and fatty acid profile were not affected by treatment. In conclusion, balancing the ratio between n-6: n-3 fatty acids is important to be the easiest approach to indicate this would be intake of oils rich in n-3 or n-6 fatty acids, such as sunflower and flaxseed oils, respectively.

Keywords: Rabbit bucks, n-3 and n-6 fatty acids, growth, lipid profile.

INTRODUCTION

Fats and oils are the essential constituents in animal food, and nearly 80 % of these are obtained from plants. The predominant fatty acids present in plant oils are saturated and unsaturated compounds with straight aliphatic chains of carbon atoms and a single carboxyl group. The mono- and poly-unsaturated fatty acids can be denoted as n-3, n-6, or n-9, based on the position of the1st double bond from the methyl (n) end in the acyl chain of fatty acid. Excess consumption of n-6 fatty acids has greatly and unfavorably increased the n-6: n-3 ratio up to 25:1, which is associated with prevalence of many negative health effects (Lunn and Theobald, 2006; Simopoulos, 2008).

In animals, polyunsaturated fatty acids (PUFAs) are naturally present both in the membranes of sperm cells and in seminal plasma (Zaniboni *et al*., 2006). The successful fertilization of spermatozoa depends on the lipids of the spermatozoa membrane (Lenzi *et al*., 2000). The PUFAs n-3 and n-6 are necessary for the body's metabolism, growing, brain development, vision, health, meat quality and reproduction (Zsédely *et al*., 2012; Kolanowski, 2015; Orzołek *et al*., 2016).

The PUFAs are basic and essential constituents of all human cells and are precursors of locally produced hormones, eicosanoids that play essential and multifaceted roles in human reproduction (McGregor *et al*., 2001). Eicosapentaenoic acid (EPA; 20:5 n-3) and docosahexanoic acid (DHA; 22:6 n-3), are long-chain PUFAs of the n-3 series. Decreased DHA and PUFA, and increased n-6/n-3 in spermatozoa may be related to infertility (Aksoy *et al*., 2006).

Impact of ingestion of diets containing polyunsaturated fatty acids (PUFAs) was evaluated in horses supplemented with flaxseed oil (Schmid-Lausigk and Aurich, 2014), rabbits with canola oil (Andreazzi *et al*., 2004) and sunflower oil (Rodenas *et al*., 2005). The positive effects of PUFAs in the diet have been described in relation to semen production (Castellano *et al*., 2010; Schmid-Lausigk and Aurich, 2014). Several authors indicated positive impact of n-3 and –6 fatty acid treatment on semen quality of dogs (Risso *et al*., 2016; Rodrigues *et al*., 2017), boars supplemented with shark oil (Mitre *et al*., 2004), sheep with fish oil (Esmaeili *et al*., 2012), stallions administrated by fatty acids of n-3 or n-6, L-carnitine or selenium and in Holstein bulls fed a docosahexaenoic acid-enriched nutriceutical (Gholami *et al*., 2010). In rabbits fed a diet containing canola oil, which is rich in n-3, improvement in semen quality was reported (Andreazzi *et al*., 2004).

Effect of PUFAs as n-3 or n-6 on lipid profile was studied by several authors on different species. Usage PUFAs as a food supplement to increase semen quality or to treat testicular degeneration has not been fully elucidated

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in rabbits, although it has been reported in other species (Attaman *et al*., 2012; Esmaeili *et al*., 2012; Schmid-Lausigk and Aurich, 2014). Results of Benson and Devi (2009) suggested a protective role against LPO in normal and stress conditions in rats treated with mustard oil as n-3 rich. The findings signify that not just PUFA, but type of PUFA present in dietary oil used is important.

Formulated animal feeds usually have a very high n-6: n-3 fatty acid ratio. Recent work has highlighted some potential benefits of n-3 fatty acid supplementation for the health and productivity of the animal. For example, supplementation of sows with fish oil during pregnancy increased both the n-3 fatty acids content and the weight of the piglet brain (Rooke *et al*. 2001). However, deleterious health effects of increased dietary n-6/n-3 fatty acid ratios have been documented by Buckley *et al*. (2010). For animal reproduction, supplementation with omegas has been used to increase the reproductive efficiency and conception rate, but few studies have been conducted on rabbit bucks.

The aim of this study was to evaluate the effects of daily dietary supplementation with n-3 fatty acids (2% sunflower oil), n–6 fatty acids (2% flaxseed oil) or their combination 1% sunflower oil+1% flaxseed oil) on growth performance, lipid, testosterone and fatty acid profiles of California rabbit bucks.

MATERIALS AND METHODS

This study was carried out at Rabbit Farm Unit, belonging to Station of Agricultural Researches and Experiments in Faculty of Agriculture, Mansoura University, during the period from March to July 2018.

Animals:

California rabbit bucks (n=24) having 5.3-5.5 months old and 2316-2429 g live body weight (LBW) were disturbed according to body weight into four experimental groups (n=6 in each). All bucks were kept under the same conditions of management. Rabbits were individually housed in galvanized wire cages (35 × 40 × 50 cm) under similar hygienic conditions. Feed and clean water were offered *ad libitum* during an experimental period of 16 weeks.

Climatic conditions:

The rabbitry was semi-closed with electric exhausted fans. Indoor ambient temperature (AT) and relative humidity (RH %) were weekly recorded inside the rabbitry using electronic digital thermo-hygrometer. Average of maximum and minimum values of AT, RH and calculated thermal-humidity index (THI) during the experimental period were 26.3-36.7^{o}C, 55.3-81.4% and 24.8-32.6, respectively. The THI was calculated according to the equation of Marai *et al.* (2001) as following:

$$\mathbf{THI = db\ ^{o}C - [(0.31 - 0.31 \times RH) \times (db\ ^{o}C - 14.4)].}$$

Where

db ^{o}C = dry bulb temperature. Values of THI <27.8 = absence of heat stress, 27.8 to 28.8 = moderate heat stress, 28.9 to 29.9 = severe heat stress, while >30.0 = very severe heat stress.

Experimental design:

All the experimental diets used in feeding bucks in all groups formulated to be similar in digestible energy (DE) and ether extract. Bucks were fed on a commercial diet (CD) without supplements in the first group (Control), CD supplemented with 2% sunflower oil in the 2nd group (2% SFO), CD supplemented with 2% flaxseed oil in the 3rd group (2% FSO), or CD supplemented with 1% SFO+1% FSO in in the 4th group.

Ingredients and chemical composition of the experimental diet are presented in Tables (1). Before starting the experiment, dietary samples from the experimental diets were taken for chemical analysis. Diets were analyzed for dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE) and ash based on the official methods of AOAC (2012). However, nitrogen free extract (NFE) was calculated. Bucks were left for 2 weeks as adaptation period at the beginning of the experiment.

Table 1. Ingredients and chemical analyses of the experimental diet.

Item	Control diet	SFO diet	FSO diet	SFO+FSO diet
Ingredient (%):				
Yellow corn	17	15	15	15
Soybean meal 44%	17	17	17	17
Wheat bran	28	28	28	28
Alfalfa hay	25	25	25	25
Olive meal	5	5	5	5
Caraway straw	5	5	5	5
Flaxseed oil	0	0	2	1
Sunflower oil	0	2	0	1
Di-calcium P.	1.3	1.3	1.3	1.3
Lime stone	1.0	1.0	1.0	1.0
Salt	0.3	0.3	0.3	0.3
Premix	0.3	0.3	0.3	0.3
Yeast	0.1	0.1	0.1	0.1
Total	100	100	100	100
Chemical analysis (%. As fed)				
Dray matter	93.5	93.0	93.0	92.2
Ash	13.5	13.0	10.5	13.5
Crude protein	17.0	16.8	17.3	17.1
Crude fat (Ether extract)	4.0	6.0	6.0	6.0
Crude fiber	14.0	13.0	13.5	15.0
Nitrogen free extract	45.0	44.2	45.7	40.6
Digestible energy (Kcal/Kg)	2840	2980	3060	2856

Experimental procedures:

During the experimental period (16 wk), LBW and feed intake were weekly recorded, then feed intake and total weight gain were calculated at 0-4, 4-8, 8-12, 12-16 and 0-16 weeks of the experimental period.

Blood sampling:

Blood samples were taken from the marginal veins of the ears from each bucks in each group at the end of experiment. Blood samples were collected into test tube without anticoagulant, centrifuged at 3500 rpm for 15 min, and then blood serum was separated and stored (-20 ^{o}C) for assaying lipid, testosterone and fatty acid profiles in blood serum.

Lipid Profile:

Lipid profile, including concentration of total lipids, triglycerides, phospholipids, total cholesterol, low density lipoprotein and high density lipoprotein were analyzed in blood serum. In this respect, commercial kits (Biodiagnostic, Egypt) and Spectro-photometer (Spectro UV-VIS Auto, UV-2602, Labomed, USA) were used. All procedures were carried out according to the manufacturers' instructions.

Some lipid profile indices were measured according to Zibaeenezhad *et al*. (2017**)** by following formulas:

Castelli I (Cholesterol ratio) Index = Total cholesterol/HDL,
Castelli II Index = LDL/HDL
Non-HDL cholesterol = Total Cholesterol-HDL

Fatty acids profile:

Fatty acids profile was determined in blood serum after extraction and methylation of lipids, and then fatty acids profile was chromatographically analyzed by Hewlett Packard 6890 Gas Chromatography Device.

Testosterone assay:

Serum testosterone concentration was estimated by radioimmunoassay (RIA) using commercial kit (Biosource-Europe S.A. 8, rue de L'Lndustrie.B-1400 Nivelles, Belgium) according to the manufacturer information.

Statistical analysis

The obtained data were statistically analyzed by a randomized complete design using the General Linear Model procedures of SAS (2004). The significant differences between means were tested using Multiple Range Test (Duncan, 1955**)** and set at P<0.05.

RESULTS AND DISCUSSION

Growth performance of rabbit bucks:

Live body weight:

Effect of dietary oil supplementation on live body weight (LBW) of rabbit bucks at each week was not significant, but rabbit bucks fed FSO diet tended to be the heaviest at different age weeks as compared to control and other treatment groups (Table 2).

In comparable the results of rabbits fed 2% SFO diet, Elsetiha (2019) found that LBW at 13 wk of age was similar in growing rabbits (NZW) fed diets contained 0, 1, 2 and 3% SFO. Rabbits fed diet containing 1% SFO were significantly (P<0.05) heavier than those fed diets containing 2 or 3% SFO.

Table 2. Effect of dietary oil supplementation on live body weight of rabbit bucks during the experimental period.

Week	Control group	Treatment group			±SEM	P-value
		2% SFO	2% FSO	1%SFO+1%FSO		
0	2332	2316	2349	2429	96.52	0.830
4	2636	2602	2776	2551	57.95	0.075
8	2808	2832	3033	2756	69.78	0.060
12	2799	2919	3019	2822	69.21	0.135
16	2789	3044	2971	2894	76.67	0.150

These results may indicate beneficial effects of SFO diet on maintain LBW of rabbits as compared to those fed 2% FSO or 1% SFO+1% FSO diets. Improvement body weight of rabbit bucks may be attributed to increasing nutrient digestibility coefficients of diets containing oils (Iftikhar *et al.*, 2015).

Feed consumption:

The effect of dietary oil supplementation on feed intake by rabbit bucks at 4-8, 8-12 and 0-16 wk intervals was not significant. However, this effect was significant (P<0.05) at 0-4, 12-16 wk intervals, being the lowest at 0-4 wk, and the highest at 12-16 wk for rabbits fed SFO+FO diet. These results reflected insignificant differences in feed intake by rabbit bucks fed the experimental diets during the whole experimental period (0-16 wk), although there was a tendency of higher feed intake of rabbits fed the supplemented diets in comparing with those fed control diet (Table 3).

Table 3. Effect of dietary oil supplementation on total feed intake (g) of rabbit bucks at experimental week intervals.

Week interval	Control group	Treatment group			±SEM	P-value
		SFO	FSO	SFO+FSO		
0~4	3602.40^{ab}	3883.60^{a}	3928.40^{a}	3239.20^{b}	169.80	0.040*
4~8	2860.00	3472.60	3345.00	3139.20	187.28	0.148
8~12	2499.40	3004.20	2827.20	3032.20	208.47	0.284
12~16	2583.40^{b}	2884.40^{ab}	2785.60^{ab}	3146.40^{a}	121.05	0.032*
0~16	11545.2	12692.8	12886.2	12557.0	441.82	0.181

a and b: Significant group differences at P<0.05.

The observed tendency of increasing feed intake of rabbits fed the oil supplemented diets as compared to those fed the control diet was reported by Elsetiha (2019) on growing rabbits fed 2 and 3% SFO diet. Interestingly to observe that some of rabbit bucks in each group showed marked reduction in their feed intake by advancing the experimental period, whereas all rabbit bucks were kept under sever heat stress condition. The rate of reduction in feed intake was more pronounced in rabbits fed the control diets than in those fed the supplemented diets. The significant decrease in feed consumption of rabbits fed SFO+FSO diet at the first interval may be related to the palatability of diets supplemented with the oils combination.

Total weight gain:

The effect of dietary treatment on body weight gain of rabbit bucks at 4-8 and 0-16 wk intervals was not significant. However, this effect was significant (P<0.05) at 0-4, 8-12 and 12-16 wk intervals, being the lowest for SFO+FO diets at 0-4 wk, the highest for FSO or SFO+FSO diets at 8-12 wk and for FSO diet at 12-16 wk, reflecting insignificant differences in weight gain of rabbit bucks fed the experimental diets during the whole experimental period (0-16 wk). Generally, rabbit bucks fed SFO or FSO diet tended to have higher body weight gain than those fed control or SFO+FSO diets (Table 4). It is worthy noting that some rabbit bucks fed control or FSO diet showed negative body weight gain at 8-12 wk interval,

being in association with pronounced sharp reduction in their feed intake under sever heat stress during this interval. However, those fed SFO or SFO+FSO diet showed less reduction in their feed intake (Table 3).

As affected by n-6 fatty acids, Elsetiha (2019) found that body weight gain of NZW growing rabbits fed diet supplemented with 1, 2 and 3% SFO was similar to controls. They was similar to the controls, but was significantly (P<0.05) lower in rabbits fed 2 or 3% SFO diet than in those fed 1% SFO diet. Sunflower oil has the higher percentage of linoleic acid (C18: 2, n-6), as n-6 fatty acids. This plant oil has the lower n-3 to n-6 fatty acid ratio in comparison to soybean oils (Jalali *et al*., 2015). The recorded improved ADG might be due to the presence of poly-unsaturated fatty acids (PUFA) in vegetable oils (El-Sayed *et al*., 2013). Including the PUFA may increase the retention time of the digesta within the gastrointestinal tract and consequently increased absorption of nutrients. This may led to improving the nutrient digestibility coefficients, and consequently improving live body weight and total weight gain (Sultan *et al.*, 2015; Awaad *et al*., 2016).

These results may reveal beneficial effects of SFO diet on maintain higher body weight gain of rabbits as compared to those fed 2% FSO or 1% SFO+1% FSO diet under heat stress condition.

Table 4. Total weight gain (g) of rabbit bucks fed different dietary oil sources at experimental week intervals.

Week interval	Control group	Treatment group			±SEM	P-value
		SFO	FSO	SFO+FSO		
0~4	304^{ab}	286^{ab}	427^{a}	122^{b}	66.27	0.043*
4~8	172	230	257	205	64.28	0.812
8~12	-9^{b}	87^{b}	-14^{a}	66^{a}	18.16	0.001***
12~16	-10^{b}	125^{b}	-48^{a}	72^{ab}	38.91	0.025*
0~16	457	728	622	465	116.92	0.249

a and b: Significant group differences at P<0.05.

Lipid profile in blood serum:

Data in Table 5 showed that the differences in triglycerides and total lipids concentrations between treatment groups and control one were not significant, but triglycerides level was significantly (P<0.05) higher by FSO than SFO diet. However, phospholipids concentration was significantly (P<0.05) lower in SFO+FSO than in control and other treatment groups.

Concerning other lipid profiles, dietary oil supplementation significantly (P<0.05) increased total cholesterol and LDL concentrations with SFO and with SFO+FSO compared to control, respectively, but HDL level was not affected significantly by oil supplementation (Table 5).

The significant effect of oil supplementation on cholesterol and LDL levels, reflected significant (P<0.05) increase in non-HDL with dietary supplementation of all oil types as compared to control diet, being significantly (P<0.05) higher in SFO+FSO than in either SFO or FSO alone. However, the insignificant effect of oil supplementation reflected nearly similar Castelli I and II indices (Table 5).

Table 5. Effect of dietary oil supplementation on serum lipid profile of rabbit bucks at the end of experimental period.

Lipid parameter	Control group	Treatment group			±SEM	P-value
		SFO	FSO	SFO+FSO		
Triglycerides (mg/dl)	72.41^{ab}	64.94^{b}	84.43^{a}	73.93^{ab}	4.15	0.041
Total lipids (mg/dl)	135.33	125.00	119.84	116.74	9.47	0.548
Phospholipids (mg/dl)	42.53^{a}	39.12^{a}	40.34^{a}	30.55^{b}	2.51	0.0001
Total cholesterol (mg/dl)	32.51^{c}	39.26^{b}	37.19^{cb}	46.83^{a}	1.81	0.001
LDL (mg/dl)	12.40^{c}	21.06^{ab}	15.39^{bc}	25.04^{a}	2.20	0.006
HDL (mg/dl)	5.63	5.21	4.92	7.01	0.78	0.293
Non HDL cholesterol (mg/dl)	26.88^{c}	34.05^{b}	32.27^{b}	39.82^{a}	1.32	0.0462
Castelli I index	5.77	7.54	7.56	6.68	1.01	0.145
Castelli II index	2.20	4.04	3.13	3.57	1.46	0.102

a and b: Significant group differences at P<0.05.
Castelli I index = Total cholesterol/HDL ratio. Castelli II index = LDL/HDL ratio.
Non HDL cholesterol = Total cholesterol-HDL

The level and source of fats in the diet have important effects on lipid profile in blood of different animal species. This rule is evident in this study which shows that, dietary sunflower oil caused significant effect on lipid profile examined in blood serum of rabbit bucks. Several authors indicated that high fat-fed rabbits showed an increase in blood levels of total cholesterol and triglycerides as well as visceral adipose tissue accumulation (Zheng *et al*., 2009; Tuncer *et al*., 2009). In agreement with the obtained results of FSO as a source of n-3 fatty acids, Shams (2019) found insignificant effect of dietary olive oil supplementation (0.2, 0.4 and 0.6%) on concentration of total cholesterol, triglycerides, LDL and HDL in blood of growing rabbits. Also, Ashraf *et al.* (2017) found insignificant effect of different dietary sources (olive oil, black seed oil and flaxseed oil) on serum cholesterol, triglycerides and HDL. Moreover, Zibaeenezhad *et al.* (2017) observed that Castelli II index did not change following the feeding on fish oil or fresh fish in human.

The present results of SFO, as a source of n-6 fatty acids are in consistent with Elsetiha (2019), who observed

that total cholesterol and HDL levels in blood plasma of growing rabbits significantly (P<0.05) increased due to dietary supplementation with 2 and 3% SFO. Contrary to the present results, the later author found significant (P<0.05) rise in HDL and triglycerides levels in diets supplemented with 2 and 3% SFO. In accordance with the present results, Pandev and Kumar, 2012) found that the addition of dietary fat from animal and vegetable sources in the diet of rats increased total cholesterol. Also, Elrufai *et al*. (2015) reported significant increase in all lipid profiles in rabbits fed diet modulated of extra 7% sunflower oil. This is due to the fact that SFO is a source of linoleic acid (66% of total fatty acids), which is n-6 fatty acids, whereas FSO is rich in linolenic acid, which is n-3 fatty acids (Abayasekara and Wathes, 1999).

Contrary, data of Zibaeenezhad *et al*. (2017) indicated that, total cholesterol, non-HDL cholesterol, triglycerides (TG) levels, and Castelli I index were reduced significantly, while HDL level increased significantly following the feeding on fish oil or fresh fish in human. Meanwhile LDL level was increased in fish oil group. Benson and Devi (2009) found that SFO treated normal rats significantly reduced triglycerides and HDL, while mustard oil decreased non-HDL level in blood serum.

Polyunsaturated fatty acids, particularly 20:5 n-3 and 22:6 n-3, are powerful regulatory molecules. By interacting with specific transcription factors, they alter the pattern of gene expression in liver ce1ls, profoundly altering the concentrations of key metabolic enzymes (Nakamura *et al*., 2001). These changes increase the β-oxidation of fatty acids and simultaneously inhibit the synthesis of fatty acids and triacylglycerol, thereby reducing lipoprotein secretion.

Enzyme activity in blood serum:

Results presented in Table 6 revealed insignificant effect of dietary oil supplementation on activity of AST and ALT in blood serum. This finding may reflect that all rabbit bucks in treatment groups have lever with normal function. Similar to the obtained results, Shams Eldeen (2019) working on olive oil treatment (0.2, 0.4 and 0.6%), and Elsetiha (2019) found insignificant differences in serum activity of AST and ALT in growing rabbits fed diets supplemented with 1, 2 and 3% SFO. The serum enzyme activity (AST and ALT) of rabbit bucks was studied to evaluate liver malfunctions. Liver enzymes activity is usually raised in acute hepatoxicity, but tend to decrease with prolonged intoxication due to damage to the liver. Activity of ALT increased only in those rats fed palm oil and groundnut oil- based diets compared with the control, while AST levels increased only in those rats administered coconut oil based diet (Obi *et al*., 2004).

Table 6. Effect of dietary oil supplementation on enzyme activity of AST and ALT and testosterone hormone in blood serum of rabbit bucks at the end of experimental period.

Enzyme	Control group	Treatment group			±SEM	P-value
		SFO	FSO	SFO+FSO		
AST (U/ml)	41.50	43.00	39.00	43.00	2.14	0.5271
ALT (U/ml)	19.75	23.00	21.25	28.75	2.21	0.0633
Testosterone (ng/ml)	6.08	3.14	3.45	4.43	0.77	0.0739

Although serum testosterone concentration was lower in all treatment groups as compared to control one, these differences were not significant (Table 6). Testosterone in males is mainly responsible for normal spermatogenesis (Mclachlau *et al*., 1996; Goeritz *et al*., 2003) and normal function of the reproductive tract (Luke and Coffey, 1994). Androgen deprivation leads to an immediate arrest in meiotic transformation of primary spermatocytes to spermatid resulting in an effective block in sperm production (Suresh *et al*., 1995). It also influences the size and function of epididymis with consequences on maturation and survival of spermatozoa during epididymal transit (Robaire and Viger, 1995, Hinton *et al*., 1996). In general, Rajak *et al*. (2014) mentioned that there were no significant differences in both blood and seminal plasma testosterone concentrations between good and poor crossbred bulls indicating that blood and seminal plasma testosterone profile alone cannot be used to differentiate good and poor bulls.

Fatty acids profile in blood serum:

Results in Table (7) revealed insignificant effect of dietary treatment on concentration of total fatty acids and fatty acid profile in blood serum of rabbit bucks. Concentration of fatty acids decreased in treatment groups as compared to control one, being the lowest in SFO+FSO group, but the differences were not significant. In comparing with the control group, proportion of saturated fatty acids (SFAs) insignificantly decreased by FSO supplementation, while increased by SFO or SFO+FSO supplements. Proportion of mono unsaturated fatty acids (MUFAs) tended to increase in FSO and SFO+FSO groups, however, polyunsaturated fatty acids proportion showed insignificantly marked reduction by all treatments as compared to control. Surprisingly to note that, proportion of n-3 fatty acids markedly decreased in SFO and SFO+FSO, but not found in FSO groups when compare to control, but the differences were not significant. However, proportion of n-6 fatty acids slightly insignificantly decreased in treatment groups, being the lowest in FSO group, reflecting higher ratio of n-3: n-6 fatty acids in SFO and SFO+FSO groups.

Generally, dietary treatment with different oil sources showed an opposite trend on SFAs and MUFAs in different treatment groups and the same effect on PUFAs, n-6 and n-3 fatty acids and total fatty acid concentration in blood serum of rabbit bucks (Table 7).

Animals cannot synthesize n-3 or n-6 fatty acids, and therefore these fatty acids have to be provided in the diet. Still, there is little information about the beneficial effect of n-3/n-6 ratios on male of several species following the consumption of n-3/n-6 on rabbit is available.

Impact of PUFAs in the diet has been described in relation to semen production (Schmid-lausigk and Aurich,

2014). Several authors indicated positive impact of n-3 and –6 fatty acids treatment as n-3 or n-6 PUFAs on lipid profile in different species. In this respect, results of Benson and Devi (2009) suggested a protective role of mustard n-3 against lipid peroxidation (LPO) in normal and stress conditions in rats. The findings signify that not just PUFA, but type of PUFA present in dietary oil used is important. The n-3 fatty acids supplementation results in higher antioxidant activity in human (Safarinejad, 2010).

Table 7. Effect of dietary oil supplementation on fatty acid profile in blood serum of rabbit bucks at the end of experimental period.

Fatty acid profile	Control group	Treatment group			±SEM	P-value
		SFO	FSO	SFO+FSO		
Total fatty acids (mg/dl)	1224.87	827.79	776.11	711.24	203.95	0.173
Frequency distribution of fatty acids (%)						
SFAs (%)	78.94	83.60	74.03	98.76	10.26	0.263
MUFAs (%)	14.80	13.17	23.92	17.22	3.06	0.696
PUFAs (%)	6.27	3.24	2.05	3.34	2.06	0.243
PUFAs n-3 (%)	1.84	0.11	-	0.17	0.73	0.228
PUFAs n-6 (%)	4.42	3.13	2.05	3.17	1.46	0.333
n-3/n-6 ratio	2.40	28.45	-	18.65	-	-

SFA: Saturated fatty acids. MUSFAs: Mono unsaturated fatty acids.
PUSFAs: Poly unsaturated fatty acids.

Based on the results of fatty acid profile, increasing n-6 fatty acids intake in SFO or in SFO+FSO group increased the ratio of n-6/n-3 up to 28.45 or 18.65, respectively, which is associated with prevalence of many improving performance and positive health effects on rabbit bucks, because the n-3 fatty acids are the precursors for synthesis of anti-inflammatory eicosanoids (Lunn and Theobald, 2006; Simopoulos, 2008).

In conclusion, balancing the ratio between n-6: n-3fatty acids is important to be the easiest approach to indicate this would be intake of oils rich in n-3 or n-6 fatty acids, such as sunflower and flaxseed oils, respectively

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تأثير إضافة مصادر مختلفة من الزيوت الغذائية على أداء النمو وصورة الدهون، التيستيستيرون والأحماض الدهنية فى ذكور أرانب الكاليفورنيا.

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إستهدفت هذه الدراسة تقييم تأثير المكملات الغذائية اليومية باوميجا 6 (2 % زيت عباد الشمس)، اوميجا 3 (2 % زيت بذرة الكتان)، أو خليط منهما (1 % زيت عباد الشمس + 1% زيت بذرة الكتان) علي كل من أداء النمو، صورة الدهون، هرمون التستيسترون والاحماض الدهنية فى ذكور أرانب الكاليفورنيا. تم تقسيم 24 من ذكور أرانب الكاليفورنيا بعمر حوالي 5.3-5.5 شهر ووزن حي 2316-2429 جرام الي 4 مجموعات (6 أرانب في كل مجموعة). تم تغذية الذكور في المجموعة الاولي (القياسية) علي عليقة تجارية بدون أي إضافات، بينما في المجموعة الثانية والثالثة والرابعة تم التغذية علي نفس العليقة مضاف إليها 2% زيت عباد الشمس و 2% زيت بذرة الكتان و 1% زيت عباد الشمس + 1% زيت بذرة الكتان على التوالى. تم حساب متوسط الزيادة في الوزن اليومي المكتسب خلال فترة التجربة (16أسبوع). تم قياس كل من صورة الدهون،هرمون التستيرون و الأحماض الدهنية في سيرم الدم. أظهرت النتائج أن تأثير إضافات الزيوت الغذائية علي وزن الجسم الحي وكمية الغذاء المأكول والوزن المكتسب لم يكن معنويا خلال فترة التجربة (0- 16 أسبوع). لم تكن الاختلافات في تركيزات الجليسريدات الثلاثية والدهون الكلية في سيرم الدم بين المجموعات المعاملة والمجموعة القياسية معنوية، ولكن زادت الجليسريدات الثلاثية بشكل معنوي في مجموعة زيت بذرة الكتان بالمقارنة بمجموعة زيت عباد الشمس، إنخفض تركيز الفوسفوليبيدات فقط في مجموعة الخليط بينما زادت نسبة الكوليسترول الكلي والكوليسترول منخفض الكثافة في مجموعة زيت عباد الشمس ومجموعة الخليط، ولكن لم يتأثر تركيز الكوليستيرول مرتفع الكثافة معنويا. زاد الكوليستيرول غير عالى الكثافة مع كل إضافات الزيوت الغذائية حيث كان أعلى معنوياً فى المجموعة المضاف إليها خليط زيت عباد الشمس وبذرة الكتان مقارنة بالمجموعة المضاف إليها زيت عباد الشمس أو زيت بذرة الكتان كلاً بمفرده. كان تأثير إضافات الزيوت الغذائية علي مؤشرات كاستبلي الأول والثاني غير معنوي. كذلك لم تتأثر إنزيمات الكبد فى سيرم الدم بالمعاملة الغذائية معنوياً.لم يكن تاثير الإضافات علي تركيز الأحماض الدهنية الكلية وصورة الأحماض الدهنية الدهنية في سيرم الدم لذكور الأرانب معنوياً. الخلاصة: يعتبر التوازن بين نسبة كل من أوميجا6 : أوميجا 3 أمراً حيوياً، وأيسرنهج لتحقيق ذلك سيكون من خلال إستهلاك الزيوت الغنية بالأحماض الدهنية أوميجا 6 أو أوميجا 3 مثل زيت عباد الشمس وزيت بذرة الكتان طبقاً لهذة الدراسة.