

## Influence of dietary fatty acids composition, level of dietary fat and feeding period on some parameters of androgen metabolism in male rats

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### **SUMMARY**

The aim of the present study was to determine the effect of the composition of dietary fatty acids, the duration of feeding period and dietary fat level on androgen metabolism in male rats. One hundred and twelve Wistar rats were divided into 18 groups which were fed three diets containing different types of fat (rapeseed [R], palm [P] and fish [F] oil) at either normal fat level (w/w; 5%) or high fat level (20%) during one, three or six weeks. Blood plasma level of androgen (testosterone + dihydrotestosterone) and testicular activity of 17 $\beta$ -hydroxysteroid dehydrogenase (17 $\beta$ -HSD) were investigated. In addition, androgen content in cytosol of the heart, the target organ, was measured. Androgen concentration in both blood plasma and heart cytosol extracts was measured by radioimmunoassay. The activity of 17 $\beta$ -HSD was expressed as a conversion of [<sup>3</sup>H]androstendione to [<sup>3</sup>H]testosterone in soluble fraction of gonadal homogenates. Plasma

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androgen concentration was influenced by a type of dietary fat ( $p < 0.05$ ). The highest plasma level of androgen was observed in animals fed R diets rich in unsaturated fatty acids. Significantly lower androgen concentration was demonstrated in rats fed P diets rich in saturated fatty acids. Only the feeding period factor significantly influenced androgen content in cytosol fraction of heart muscle cells ( $p < 0.01$ ). A positive correlation was found between plasma androgen concentration in plasma and cytosol fraction of the heart muscle cells ( $r = 0.63$ ,  $p < 0.001$ ). The feeding period ( $p < 0.001$ ) and dietary fat type ( $p < 0.05$ ) significantly affected the activity of  $17\beta$ -HSD. The least  $17\beta$ -HSD activity was observed in animals consuming the P-20% diet for six weeks. In summary, dietary fat type and feeding period, but not fat level, significantly affected both testosterone production and testosterone uptake by the target organ in male rats. It was found that a rapeseed diet rich in unsaturated fatty acids stimulated the testicular function in rats. *Reproductive Biology* 2002 2 (3): 277-293.

**Key words:** androgen, dihydrotestosterone, dietary fat, heart muscle,  $17\beta$ -hydroxysteroid dehydrogenase, male rats, testosterone, testes

## INTRODUCTION

Results of epidemiological studies on humans as well as those gained during experiments with laboratory animals indicate that there is a connection between fat intake and breast, prostate and large intestinal cancers [7, 14, 30]. This connection may result from the influence of dietary fat on concentrations of sex steroid hormones [28]. A high-fat diet, rich in saturated fatty acids, was found to cause a decrease in sex hormone binding globulin (SHBG), and consequently an increase in the level of free sex steroid hormones [6]. The increases in testosterone and estradiol may promote the development of hormone-dependent cancers. A high-fat diet and high intake of saturated fatty acids can lead to the development of obesity and circulatory diseases [8] whereas an increased intake of polyunsaturated fatty acids lowered plasma cholesterol concentration [2]. Some studies on men and rats revealed that after they were fed a high-fat diet, there was an increase in plasma androgen concentration [4, 6]. In contrast, a reduction of fat intake caused a decrease in plasma testosterone concentration [11, 12, 20].

Besides the amount of fat in the diet, organism functions appear to be influenced by the composition of fatty acids. Polyunsaturated fatty acids

containing 22 carbon atoms were found to be important in testes development and spermatogenesis in rats [24] and these acids increased corticosterone concentration in vivo [31] and in vitro [22]. Diets rich in saturated fatty acids inhibited SHBG binding activity, increased the plasma level of free sex steroid hormones [17] and blocked steroid synthesis in the adrenal gland [9].

There is limited information concerning the effect of fat type and particular fatty acids on androgen metabolism. Thus, the present study was aimed to examine the effect of composition of dietary fatty acids, the feeding period duration and dietary fat level on: 1. blood plasma androgen concentration, 2. testicular activity of 17 $\beta$ -hydroxysteroid dehydrogenase, and 3. androgen content in heart muscle cells in rats.

## MATERIALS AND METHODS

### Experimental design

Male Wistar rats (tribe Isz:BOA) were obtained from the Institute of Animal Physiology and Nutrition in Jabłonna (n = 112). The initial body weight ranged from 230 – 250 g. Animals were housed in individual stainless steel cages in standard environmental conditions: 23°C and 12h: 12h light-dark cycle and they were given free access to water and forage. During the experiment's first week (adaptation period) animals were fed a standard pelleted rat diet (Altromin Standard Diet type 1310N, Germany). The rats were then divided into 18 groups which were fed one of three semisynthetic diets containing different fat types (rapeseed [R], palm [P] and fish [F] oil) at one of two levels (w/w): normal (5%) or high-fat (20%) for one, three or six weeks. Compositions of experimental and standard diets are shown in tab. 1.

Dietary fats were selected so that differentiation of fatty acids composition was obtained. The rapeseed oil contained 63% of monounsaturated fatty acids (MUFA; mostly oleic acid:18:1), 30 % of polyunsaturated fatty acids (PUFA) and 7% of saturated fatty acids (SFA). The palm oil contained 43% of MUFA, 4 % of PUFA and 52% of SFA (mostly palmitic acid 16:0). The fish oil contained 55% of MUFA, 22% of PUFA (mostly docosahexaenoic acid 22:6) and 23% of SFA. The PUFA/SFA ratio differed between diets and was 4.43, 0.08, and 0.96 for R, P and F diets, respectively. The daily food intake was measured for each animal and body weight of the rats was monitored every three days.

Rats from six groups ( $n = 37$ , five groups:  $n= 6$ , one group:  $n=7$ ) were sacrificed after one week of being fed the experimental diet; another six groups ( $n = 38$ , four groups:  $n= 6$ , two groups:  $n= 7$ ) after three weeks and the remaining six groups ( $n = 37$ , five groups:  $n=6$ , one group:  $n=7$ ) after six weeks. All animals were anaesthetized with diethyl ether and blood was taken by cardiac puncture. Testes and hearts - an important target tissue for steroid hormones - were then dissected, rinsed, weighed, immediately frozen in liquid nitrogen and stored at  $-80^{\circ}\text{C}$  until the examinations. Blood plasma was stored at  $-23^{\circ}\text{C}$  until assayed for androgen concentrations.

All procedures involving animals were approved by the III Local Animal Care and Use Committee in Warsaw.

### Biochemical analyses

The testes and hearts were homogenized (1g/1 ml) in a phosphate buffer (0.05 M,  $\text{pH}=7.4$ ) with 1% (w/v) bovine serum albumin (Sigma-Aldrich). Homogenates were centrifuged at  $4^{\circ}\text{C}$  for 60 min at 105 000 g and supernatants were collected and frozen at  $-80^{\circ}\text{C}$  until assayed.

Tab. 1. Composition of diets (g/kg) according to Gronowska-Senger et al. [10].

Component	5% of dietary fat	20% of dietary fat	Standard diet
casein	220	220	225
cornstarch	640	490	610
potato starch	45.8	45.8	45
Fat	50.0	200	50
mineral mix	30	30	30
vitamin mix	10	10	30
l-methionine	2.2	2.2	4
choline chloride	2	2	6

Mineral mix contained in 1kg: 735g  $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$ , 81g  $\text{K}_2\text{HPO}_4$ , 68g  $\text{K}_2\text{SO}_4$ , 30.6g NaCl, 21g  $\text{CaCO}_3$ , 21.4g  $\text{Na}_2\text{HPO}_4 \cdot 2\text{H}_2\text{O}$ , 25g MGO and 18g microelement mix (in 100g: 31g  $\text{C}_3\text{H}_4(\text{OH})(\text{COO})_2\text{Fe}$ , 4.5g  $\text{ZnCO}_3$ , 23.4g  $\text{MnCO}_3$ , 1.85g  $\text{CuCO}_3$ , 39.2g  $\text{C}_3\text{H}_4\text{OH}(\text{COOH})_3$ , 0.04g KJ.

Vitamin mix contained in 1kg: 2 mln i.u. vit. A, 200 000 i.u. vit. D3, 10000 i.u. vit. E, 0.5g vit. K, 4g niacin, 4g calcium pantothenate, 0.5g vit. B1, 0.8g vit. B2, 0.5g vit. B6, 0.2g folic acid, 0.04g biotin, 0.003g vit. B12, 10g para-aminobenzoic acid, 10g inositol, 769.5g starch.

One ml of soluble fractions of heart tissue was double extracted with diethyl ether. The organic phases were then evaporated under nitrogen and resuspended in 0.5 ml of 0.05 M phosphate buffer (pH=7.4) with 1% (w/v) gelatine (Sigma-Aldrich). Recovery after extraction was 83%. Androgen concentration was measured by radioimmunoassay in 0.1 ml of heart cytosol fraction extracts or directly without extraction in 50 ml of plasma [27]. The androgen concentration was determined by using a single highly specific rabbit antibody (R.7) supplied by the Institute of Animal Physiology and Nutrition. The antibody cross-reacts only with testosterone (100%), dihydrotestosterone (100%) and androstenedione (0.01%). Assay sensitivity was 10.0 pg/ml for tissue cytosol extracts and 12.5 pg/ml for blood plasma. Intra-assay and inter-assay coefficients of variation were 12.5% and 4.9%, respectively. Androgen cytosol content was expressed as ng/500 mg of fresh tissue weight and the plasma androgen level was expressed as ng/ml of plasma.

Five isoenzymes of 17 $\beta$ -hydroxysteroid dehydrogenase (17 $\beta$ -HSD) seem to control the last stage in the formation of all androgens and estrogens. Type 3 of 17 $\beta$ -HSD (microsomal isozyme with NADP as a cofactor) catalyzes in mammal testis the formation of testosterone from androstendione [15]. Enzyme activity is considered as the best indicator of testosterone biosynthesis in male gonads.

The activity of the steroidogenic enzyme was expressed as a percentage of androstendione converted to testosterone per 500 mg of fresh rat testes. This conversion was measured by incubating testicular homogenate soluble fraction with a tritiated substrate followed by separation of incubation products by thin layer chromatography (TLC, [19]). Homogenates were incubated at 37°C for 10 minutes in a total volume of 1 ml containing 5 mM NADP, 0.25 M sacharose and 0.07 mCi of <sup>3</sup>H-androstendione (androst-4-ene-3,17-dione [1,2,6,7]<sup>3</sup>H, 74.0 Ci/mmol, NEN Life Science Products Inc., Boston, USA). At the end of incubation 2.5 ml of diethyl ether was added. The organic phases were then evaporated under nitrogen and separated on TLC aluminium-backed silica gel sheets (Silica gel 60 F<sub>254</sub>, Merck) using a 97:3 mixture of chloroform and methanol (Sigma-Aldrich). The R<sub>f</sub> values of androstendione and testosterone in this system were 0.71 and 0.46 respectively. Radioactivity associated with each steroid was measured in a scintillation counter (Tri Cab Canberra Packard) and corrected for recovery losses.

## **Statistical analysis**

To determine the effects of fat type, fat level and feeding period on examined parameters, data on plasma and cytosol androgens concentration and 17 $\beta$ -hydroxysteroid dehydrogenase activity in gonadal soluble fraction were subjected to ANOVA followed by Fisher's least significant differences (LSD) test. The means differed significantly when  $p < 0.05$ . Simple regression analysis was applied to examine associations between androgen concentration, gonadal enzyme activity, fatty acid intake and final body weight. All statistical analysis was performed by computer program STATGRAPHICS Plus version 4.1. All data were expressed as means  $\pm$  SEM.

## **RESULTS**

### **Final body weight**

Differences in final body weights (tab. 2) among the groups depended significantly on fat level in the diet ( $p < 0.001$ ), length of feeding period ( $p < 0.0001$ ) and type of dietary fat ( $p < 0.01$ ). The final body weight increased with the fat level in the diet and the length of the feeding period. Dietary fat type affected significantly body weight only in groups fed 5% fat level diets for one week and those fed 20% fat level diets for three and six weeks. Simple regression analysis showed significant positive correlation between final body weight and PUFA intake ( $r = 0.51$ ,  $p < 0.0001$ ).

### **Food consumption**

Total food consumption during the 42-day experiment was influenced by feeding period and fat level ( $p < 0.0001$ ). Animals fed the 5% fat diets consumed significantly more food than rats receiving the 20% fat diets (125.9 $\pm$ 7.32 and 114.9 $\pm$ 6.78 g/100 g bw, respectively). Groups which were fed the experimental diet for six weeks consumed more than groups fed for one week (170.8 $\pm$ 1.88 and 52.1 $\pm$ 1.51 g/100 g bw, respectively). Fat type, however, did not significantly affect food consumption (120.4 $\pm$ 8.78, 123.0 $\pm$ 8.43 and 117.9 $\pm$ 8.95 g/100 g bw in animals fed R, P and F diets, respectively). In addition, fat level, fat type and feeding period duration significantly influenced consumption of some fatty acids (tables 3, 4 and 5).

Tab. 2. Final body weight (mean  $\pm$  SEM) of experimental rats (g)

Fat level	Period of feeding (week)					
	1 week		3 weeks		6 weeks	
	5%	20%	5%	20%	5%	20%
Fat type						
R	273.8 $\pm$ 2.39 <sup>aA</sup>	283.2 $\pm$ 4.50 <sup>aA</sup>	345.3 $\pm$ 4.80 <sup>bA</sup>	372.2 $\pm$ 3.21 <sup>bB</sup>	393.3 $\pm$ 6.94 <sup>dA</sup>	401.5 $\pm$ 7.39 <sup>dB</sup>
P	269.3 $\pm$ 6.11 <sup>aA</sup>	293.2 $\pm$ 2.77 <sup>bA</sup>	336.0 $\pm$ 8.42 <sup>cA</sup>	349.7 $\pm$ 4.43 <sup>cdA</sup>	389.3 $\pm$ 4.43 <sup>eA</sup>	382.0 $\pm$ 3.62 <sup>eA</sup>
F	305.0 $\pm$ 4.72 <sup>bB</sup>	284.3 $\pm$ 3.31 <sup>aA</sup>	340.0 $\pm$ 4.72 <sup>cA</sup>	374.0 $\pm$ 6.07 <sup>dB</sup>	385.7 $\pm$ 4.76 <sup>deA</sup>	398.0 $\pm$ 7.32 <sup>dB</sup>

Diets with rapeseed oil – R, palm oil – P, fish oil – F.

Lower case letters designate significant differences within one row; capital letters designate significant differences within column ( $p < 0.05$ )Tab. 3. Dietary saturated fatty acids (SFA) consumption (mean  $\pm$  SEM) during experiment (g/100 g bw)

Fat level	Period of feeding (week)					
	1 week		3 weeks		6 weeks	
	5%	20%	5%	20%	5%	20%
Fat type						
R	0.15 $\pm$ 0.00 <sup>aA</sup>	0.77 $\pm$ 0.01 <sup>bA</sup>	0.46 $\pm$ 0.01 <sup>abA</sup>	1.68 $\pm$ 0.05 <sup>cA</sup>	0.61 $\pm$ 0.02 <sup>abA</sup>	2.23 $\pm$ 0.04 <sup>dA</sup>
P	1.74 $\pm$ 0.06 <sup>aB</sup>	5.18 $\pm$ 0.11 <sup>dC</sup>	3.73 $\pm$ 0.09 <sup>bC</sup>	14.51 $\pm$ 0.57 <sup>eC</sup>	4.58 $\pm$ 0.08 <sup>cC</sup>	17.57 $\pm$ 0.26 <sup>fC</sup>
F	0.56 $\pm$ 0.02 <sup>aA</sup>	1.97 $\pm$ 0.09 <sup>bB</sup>	1.80 $\pm$ 0.05 <sup>bB</sup>	6.15 $\pm$ 0.21 <sup>eB</sup>	1.99 $\pm$ 0.03 <sup>bB</sup>	7.13 $\pm$ 0.15 <sup>fB</sup>

Diets with; rapeseed oil – R, palm oil – P, fish oil – F.

Lower case letters designate significant differences within one row; capital letters designate significant differences within column ( $p < 0.05$ )

Tab. 4. Dietary monosaturated fatty acids (MUFA) consumption (mean  $\pm$  SEM) during experiment (g/100 g bw)

Fat level	Period of feeding (week)					
	1 week		3 weeks		6 weeks	
	5%	20%	5%	20%	5%	20%
Fat type						
R	1.46 $\pm$ 0.03 <sup>aA</sup>	7.33 $\pm$ 0.07 <sup>dB</sup>	4.35 $\pm$ 0.05 <sup>BB</sup>	15.94 $\pm$ 0.45 <sup>eC</sup>	5.78 $\pm$ 0.05 <sup>cC</sup>	21.14 $\pm$ 0.40 <sup>fC</sup>
P	1.45 $\pm$ 0.04 <sup>aA</sup>	4.32 $\pm$ 0.09 <sup>eA</sup>	3.11 $\pm$ 0.08 <sup>bA</sup>	12.11 $\pm$ 0.47 <sup>dA</sup>	3.82 $\pm$ 0.06 <sup>eA</sup>	14.66 $\pm$ 0.21 <sup>eA</sup>
F	1.33 $\pm$ 0.06 <sup>aA</sup>	4.71 $\pm$ 0.22 <sup>bA</sup>	4.31 $\pm$ 0.11 <sup>BB</sup>	14.70 $\pm$ 0.50 <sup>eB</sup>	4.74 $\pm$ 0.07 <sup>BB</sup>	17.02 $\pm$ 0.36 <sup>dB</sup>

Diets with; rapeseed oil – R, palm oil – P, fish oil – F.

Lower case letters designate significant differences within one row; capital letters designate significant differences within column ( $p < 0.05$ )

Tab. 5. Dietary polyunsaturated fatty acids (PUFA) consumption (mean  $\pm$  SEM) during experiment (g/100 g bw)

Fat level	Period of feeding (week)					
	1 week		3 weeks		6 weeks	
	5%	20%	5%	20%	5%	20%
Fat type						
R	0.71 $\pm$ 0.02 <sup>aC</sup>	3.56 $\pm$ 0.03 <sup>dC</sup>	2.12 $\pm$ 0.02 <sup>bC</sup>	7.74 $\pm$ 0.22 <sup>eC</sup>	2.81 $\pm$ 0.03 <sup>cC</sup>	10.27 $\pm$ 0.20 <sup>fC</sup>
P	0.14 $\pm$ 0.00 <sup>bA</sup>	0.41 $\pm$ 0.01 <sup>aA</sup>	0.29 $\pm$ 0.01 <sup>aA</sup>	1.14 $\pm$ 0.04 <sup>bA</sup>	0.36 $\pm$ 0.00 <sup>aA</sup>	1.38 $\pm$ 0.02 <sup>bA</sup>
F	0.53 $\pm$ 0.02 <sup>aB</sup>	1.87 $\pm$ 0.09 <sup>bB</sup>	1.71 $\pm$ 0.04 <sup>BB</sup>	5.82 $\pm$ 0.20 <sup>eB</sup>	1.88 $\pm$ 0.03 <sup>BB</sup>	6.75 $\pm$ 0.14 <sup>dB</sup>

Diets with; rapeseed oil – R, palm oil – P, fish oil – F.

Lower case letters designate significant differences within one row; capital letters designate significant differences within column ( $p < 0.05$ )

Total intake of saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids was significantly ( $p < 0.0001$ ) affected by fat type, fat level and feeding period.

The highest SFA intake was in animals consuming the P diets in comparison to those fed F and R diets. On the other hand the highest intake of MUFA and PUFA occurred in groups fed R diets. It was observed that as the feeding period and the fat level increased, fatty acids intake rose as well.

Simple regression analysis showed a highly significant positive correlation between dietary fatty acids intake and final body weight. Calculated correlation coefficients were  $r = 0.30$  ( $p < 0.01$ ),  $r = 0.61$  ( $p < 0.0001$ ) and  $r = 0.51$  ( $p < 0.0001$ ) for SFA, MUFA and PUFA, respectively.

### **Blood plasma androgens concentration**

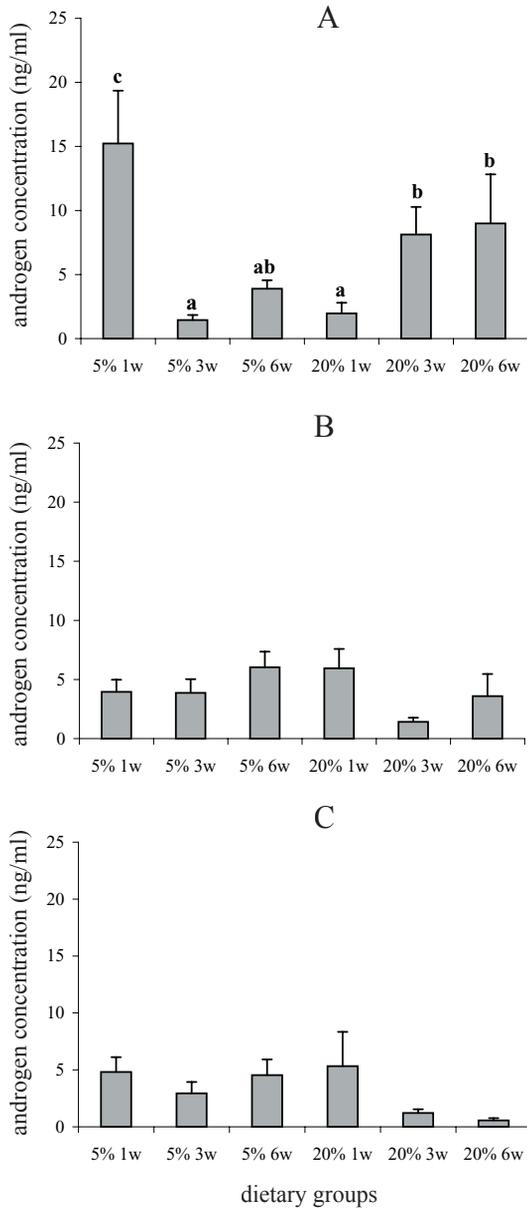
Changes in blood plasma androgen concentration are depicted in fig. 1. The concentration was significantly influenced by fat type ( $p < 0.05$ ). The mean androgen concentration was significantly higher in rats fed R diets compared with those fed the P and F diets.

The highest androgen concentration was found in rats fed the R diets for one week ( $15.23 \pm 4.12$  ng/ml) then it diminished and remained low to the end of experiment. In groups fed the R diets with 20% of fat, androgen plasma concentration increased together with the length of the feeding period whilst the concentration tended to decrease in animals fed the F diet with a similar fat level. There was no statistically significant changes in rats consuming P and F diets.

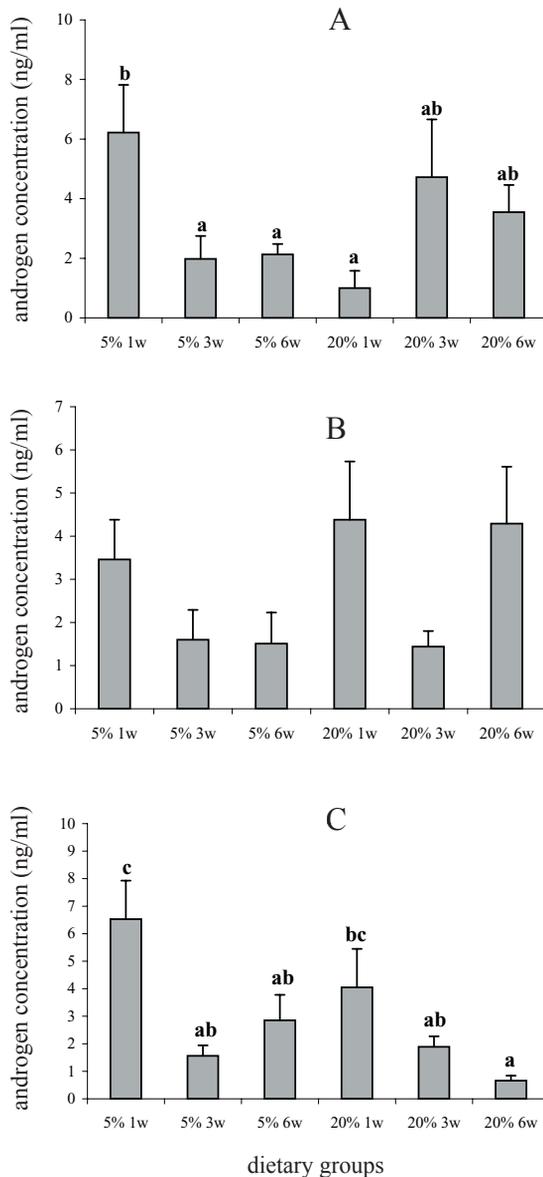
Simple regression analysis showed a significant positive correlation between androgen concentration in blood plasma and heart cytosol fraction ( $r = 0.63$ ,  $p < 0.0001$ ) and negative correlation between plasma androgen level and SFA intake ( $r = -0.21$ ,  $p < 0.05$ ).

### **Androgen content in the heart muscle**

Figure 2 presents the mean androgen content in a soluble heart muscle fraction in all experimental groups. Among the examined factors only the feeding period significantly affected ( $p < 0.01$ ) androgen level in heart muscle cytosol fraction. Changes of androgen concentration in plasma and the heart muscle showed a similar pattern in R diet groups.



*Fig. 1.* Androgen concentration (mean  $\pm$  SEM) in blood plasma of rats fed diets containing rapeseed oil (A), palm oil (B), or fish oil (C). Additionally, the fat type groups were divided into subgroups and fed diets containing different fat levels (5% and 20%) for three various feeding periods: one week (1w), three weeks (3w) or six weeks (6w). Bars with different letters are significantly different ( $p < 0.05$ ).



*Fig. 2.* Androgen content (mean  $\pm$  SEM) in soluble fraction of the heart muscle (ng/500mg fresh weight tissue) in rats fed diets containing rapeseed oil (A), palm oil (B), or fish oil (C). Additionally, the fat type groups were divided into subgroups and fed diets containing different fat levels (5% and 20%) for three various feeding periods: one week (1w), three weeks (3w) or six weeks (6w). Bars with different letters are significantly different ( $p < 0.05$ ).

In rats fed the R diet containing 5% fat, heart muscle androgen content decreased as the feeding period became longer. In contrast, in animals fed a R diet containing 20% fat, heart androgen content tended to be higher after 3 and 6 weeks of feeding period. In animals fed the F diets, heart androgen content dropped significantly after 3 and 6 weeks of treatment. There was no statistically significant changes in rats consuming P diets. Figure 2 shows that each dietary fat type group (R, P, F) with 20% fat had a different pattern of changes in androgen content. No significant correlation was found between heart muscle androgen content and weight of testes or a particular fatty acid intake.

### **Activity of 17 $\beta$ -hydroxysteroid dehydrogenase in male gonads**

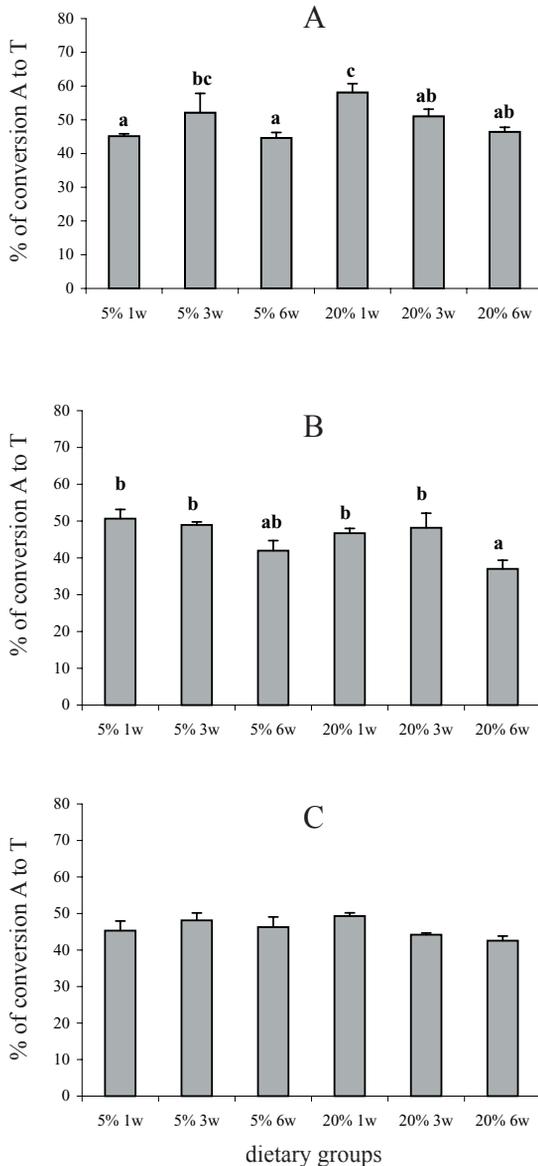
Feeding period ( $p < 0.001$ ) and type of dietary fat ( $p < 0.05$ ) significantly affected 17 $\beta$ -hydroxysteroid dehydrogenase activity in rat testes. A significant decrease in enzyme activity was found in animals fed the R and P diets with 20% fat for six weeks (fig. 3). A similar pattern was observed in P diet groups with 5% fat level. In contrast, enzyme activity increased after a three week feeding period in R-5% fat groups and then lowered after 6 weeks of treatment. There was no statistically significant changes in rats consuming F diets.

In addition, a significant negative correlation was found between 17 $\beta$ -hydroxysteroid dehydrogenase activity and SFA intake ( $r = -0.32$ ,  $p < 0.001$ ).

## **DISCUSSION**

In this study dietary fat type, fat level and feeding period significantly affected the final body weight of rats, which resembles the results reported by Cha and Jones [3]. In our experiment the highest weight gain was in rats fed rapeseed and fish oils. In contrast, dietary fatty acid composition did not exert any influence on weight gain, body composition and lipid metabolism in adipose tissue in rats fed fish oil and safflower oil [1]. In another experiment body weight gain was lower in rats fed a beef tallow diet than those with a safflower oil diet [26]. It suggests that a dietary fat rich in SFAs (i.e. palm oil or beef tallow) may have some inhibitory effects on final body weight in rats.

As found in epidemiological studies on humans, the intake of animal fat with higher a SFA level, was positively associated with body weight



*Fig. 3.* Activity of  $17\beta$ -hydroxysteroid dehydrogenase (mean  $\pm$  SEM) in testes [% of androstenedione (A) conversion to testosterone (T) of rats fed diets containing rapeseed oil (A), palm oil (B), or fish oil (C)]. Additionally, the fat type groups were divided into subgroups and fed diets containing different fat levels (5% and 20%) for three various feeding periods: one week (1w), three weeks (3w) or six weeks (6w). Bars with different letters are significantly different ( $p < 0.05$ ).

gain. This contrasted with the intake of vegetable fat with more unsaturated fatty acids which produced a negative association with gain weight [5]. Wilson et al. [32] demonstrated that a high-fat diets ( $\geq 25\%$  energy provided as fat) suppressed hepatic lipogenesis in rats. This was even more evident when sunflower oil substituted beef tallow as a diet component. These findings point to the different properties of animal and vegetable fats affecting weight gain and fat accumulation [25].

We demonstrated that the type of dietary fat affected testicular steroidogenesis and plasma androgen level, and that both plasma androgen concentration and heart androgen content were affected by the feeding period. In this study the type of dietary fat significantly influenced plasma testosterone concentration and activity of  $17\beta$ -hydroxysteroid dehydrogenase – the most important key-enzyme in the testosterone synthesis pathway in male rat gonads [16]. These parameters were higher in animals receiving rapeseed oil diets as a fat source than in groups fed a palm oil diet. This may suggest that monounsaturated fatty acids stimulate enzyme activity and androgen secretion into blood. In contrast, saturated fatty acids may inhibit testes  $17\beta$ -hydroxysteroid dehydrogenase activity and lower plasma androgens level. This observation was confirmed by a significant negative correlation between SFA intake and  $17\beta$ -HSD activity or androgen plasma level. Sebokova et al. [24] also observed that feeding rats with a diet rich in fish oil caused an increase in testosterone synthesis in testes. These authors suggested that dietary fat affected phospholipid composition in plasma membranes of testes which altered the availability of gonadotropin receptors and influenced the rate of steroidogenesis [23]. According to Meikle et al. [18], such influence on steroidogenesis occurs at an early stage of conversion of cholesterol to pregnenolone, and saturated fatty acids (linolenic, stearic and palmitic acids) demonstrated the strongest inhibitory effect at this time. In another experiment, the stimulatory *in vitro* effect of arachidonic acid (AA) on testosterone synthesis was observed in rat testes [21]. It is not presently understood what is the testicular mechanism of AA action, however, it is known that the steroid hormone receptors also bind fatty acids. Such binding results in allosteric modification of receptor and a change of its function [29]. These fatty acids may also induce gene expression in hepatocytes [13] which changes capability of these cells to synthesise hormones.

In summary, dietary fat level did not change  $17\beta$ -dehydrogenase activity in testes, plasma androgens concentration and their uptake by cardiac mus-

cle cells. On the other hand these parameters were significantly influenced by the type of dietary fat as well as feeding period. Activity of testicular 17 $\beta$ -dehydrogenase and plasma androgen concentration were higher in groups fed diets rich in unsaturated fatty acids (i.e. rapeseed oil). Androgen uptake by cardiac muscle cells were influenced only by the feeding period.

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