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Effects of early castration on production performance, serum lipids, fatty acid profile and desaturation indexes in male chicken broilers fed a diet with increased fat content

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ABSTRACT

This paper analyses the effect of early caponisation, at 18 days, on the production performance, lipid metabolism and fatty acid profile of fattening broilers fed an increased amount of fat. Early castration did not influence growth performance and feed intake in the experimental birds. Feed conversion was significantly improved in castrated birds ($P<0.05$). Triglyceride and total cholesterol values were not significantly influenced ($P>0.05$) by early castration. Glucose values were significantly higher on the 25th ($P<0.05$) and 40th ($P<0.01$) day in sham operated birds in comparison to castrated. Fatty acid composition of the thigh muscle was significantly influenced by castration. The most noticeable difference was in the increased percentage of saturated fatty acids ($P<0.05$) in castrated birds in comparison to uncastrated. Moreover, the saturation index and the thrombogenic index were higher ($P<0.05$) in castrated birds and unsaturated/saturated fatty acid ratio was higher ($P<0.05$) in uncastrated birds.

Key words: castration, serum lipids, fatty acid profile, growth performance

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Introduction

Capons are male chickens with surgically removed testes. The purpose of caponisation is to obtain a traditional product with high market value, because the meat of roosters tends to become coarse, stringy and tough as the birds age. In contrast, capon meat is more tender and succulent than that of entire male birds (MAST et al., 1981). These characteristics are mainly achieved by changes in the metabolism and behaviour of capons.

The most important metabolic effect of castration is an increase in fat content, both intramuscular and abdominal (SEVERIN et al., 2007; CHEN et al., 2000; TOR et al., 2002). Increased fat deposition has been connected to increased hepatic lipogenesis capability, increased blood lipid concentrations (HSIEH et al., 2001) and alterations in lipoprotein transport mechanisms (HSIEH et al., 2001; CHEN et al., 2005). Several authors have found significant changes in the fatty acid profile of poultry edible meat after castration (RIKIMARU et al., 2009; SIRRI et al., 2009; TOR et al., 2005). These differences are interesting mainly because of the nutritional importance of polyunsaturated fatty acids for humans and animals (HORROCKS and YEO, 1999). Therefore, decreasing the level of saturated fatty acids (SFA) and/or increasing monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) content in poultry meat would be beneficial for human health and would be of commercial interest.

Besides metabolic changes, removal of the testes, and the subsequent decrease in male sex hormones, reduces male sex instincts and changes their behaviour (ANDREW and JONES, 1992). Consequently, energy that is normally expended in sexual behaviour is greatly reduced, allowing more efficient conversion of feed into growth and fat deposition (YORK and MITCHELL, 1968). Other effects related to the level of testosterone in castrated poultry are changes in search behaviour (ANDREW, 1972; ANDREW and ROGERS, 1972) and increased distractibility (ANDREW and JONES, 1992).

Several studies about the influence of castration on slow-growing male chickens have been reported (MIGUEL et al., 2008; CHEN et al., 2000). However, only a few trials have investigated the characteristics of early castrated chicken broilers and different feeding regimes. The aim of this study was to evaluate the influence of early castration on performance and lipid metabolism in fattening broilers, fed with an increased amount of fat, and to investigate the differences between capons and sham operated chicken in terms of the fatty acid profile of edible meat.

Materials and methods

Animals, management and body measurements. In all, 30 Ross 308 male broilers were used in the trial. All birds received the same diet with increased fat content and water ad libitum. Before castration, the birds were divided into two experimental groups, each numbering 15 animals. One group was castrated on the 18th day after a 2 day fasting period prior to anesthesia and castration. Castration was performed as described by SEVERIN et al. (2007). Other birds were sham operated at the same age. The birds were housed in two pens with a density of 10 chickens per m^2. All birds were weighed weekly until the end of the trial. On the 55th day all the birds were euthanized and body measurements were taken (Table 3).

Feed analyses. The chemical composition of the diet is provided in Table 1 and 2. Samples of the feed mixture were collected throughout the experimental period (every week) and average chemical composition is presented. The samples were ground and analysed for dry matter, crude protein, crude fibre, crude fat, Ca, P, lysine, methionine and cystine according to AOAC procedures (AOAC, 1995).

Blood biochemistry. Blood samples were collected on the 25th, 40th and 55th day of experiment by puncture of the jugular vein. The blood plasma was separated by centrifugation and stored at -20 ºC until assayed. Serum glucose, triglyceride and total cholesterol values were assayed by an automatic analyser (SABA 18, AMS, Italy).

Determination of fatty acid profiles and indexes. All the tissue samples were frozen in liquid nitrogen for 90 seconds, individually wrapped in aluminium foil, transported to the laboratory and stored at -80 ºC until analysis. Thigh muscle (*m. iliotibialis cranilais*) total lipid extraction for fatty acid analysis was performed according to HARA and RADIN (1978), using a hexane/isopropanol mixture. The fatty acids were analysed as their methyl esters and transesterification was performed using a 20% solution of boron trifluoride in methanol (RULE, 1997). The prepared samples were then determined using gas chromatography equipped with a flame-ionisation detector (Gas Chromatograph GC 2010 Plus, Shimadzu, Japan) with a capillary column ZB WAX (Phenomenex, USA) and helium as the carrier gas. The quantification was carried out through area normalisation with an external standard mixture of fatty acid methyl esters (Sigma-Aldrich, Germany). Fatty acid composition was calculated as a percentage of each individual fatty acid relative to total fatty acids. The saturation (S/P), atherogenic (AI) and thrombogenic (TI) indexes were calculated according to ULBRICHT and SOUTHGATE (1991) as follows:

$$S/P = (C14{:}0 + C16{:}0 + C18{:}0)/[\Sigma MUFA + \Sigma PUFA]$$

$$AI = (C12{:}0 + 4xC14{:}0 + C16{:}0)\,/[\,\Sigma MUFA + \Sigma n-6) + \Sigma\,(n-3)]$$

$$TI = (C14{:}0 + C16{:}0 + C18{:}0)/[0.5 \times \Sigma MUFA + 0.5 \times \Sigma\,(n-6) + 3 \times \Sigma\,(n-3) + \Sigma\,(n-3)/\Sigma\,(n-6)]$$

where MUFA are monounsaturated fatty acids and PUFA polyunsaturated.

Statistical analyses. All analyses were performed using the Statistica Version 9 program. Statistical significance of the differences was determined by the *t*-test.

Results

The mortality caused by castration and sham operation was 6.6% (2/30). Testicular regeneration was identified visually and later checked after slaughter. All birds with testicular regeneration were excluded from the results (20%, 6/30).

Fig. 1 shows the observed live weights and weight gains of the experimental birds. There were no significant differences in the body weight and weight gain between castrated and sham operated birds.

Table 1. Ingredients and nutrient content of the diets fed during the trial

Ingredients	%
Corn	58.5
Lucerne dehydrated	3.0
Soybean meal	28.5
Sunflower oil	5.0
Mineral and vitamin mixture	5.0
Nutrient content	%
Crude protein (%)	18.10
Crude fat	7.59
Crude fibre	3.41
Calcium	0.99
Phosphorus	0.47
Lysine	1.06
Methionine + cystine (%)	0.56

A comparison of feed intake and feed conversion is shown in Fig. 2 There was no difference in the feed intake between the castrated and sham operated birds. The feed conversion of capons was significantly better ($P<0.05$) in comparison to the sham operated birds.

Table 2. Fatty acid composition (% of total fatty acids) of the diets fed during the trial

Fatty acid	%
C16:0	8.2
C18:0	2.4
C18:1	20.4
C18:2n-6	57.1
C18:3n-3	6.3

Different body measurements are presented in Table 3. Castrated animals had significantly smaller combs and wattles (P<0.01). Heart weight and liver weight were similar between the groups.

Table 3. Means and standard deviation of selected body measurements in capons and sham operated birds

Parameter (unit)	Castrated (n = 10)	Sham (n = 12)	Significance
Testes (g)	0	0.80 ± 0.4	/
Comb (mm)	38.8 ± 8.6	51.0 ± 2.9	P<0.01
Wattle (mm)	11.4 ± 4.8	19.5 ± 4.8	P<0.05
Heart (g)	17.7 ± 1.9	16.5 ± 1.1	NS
Liver (g)	55.8 ± 13.2	65.3 ± 8.0	NS

Table 4. Means and standard deviation of summarised fatty acid profiles (% total fatty acids) and indices calculated to assess the desaturation of fatty acids of tight muscles

Parameter	Castrated (n = 10)	Sham (n = 12)	P value
Saturated fatty acids (SFA)	39.79	31.15	0.034
Unsaturated fatty acids (UFA)	60.21	68.85	0.034
Monounsaturated fatty acids (MUFA)	22.01	28.83	0.105
Polyunsaturated fatty acids (PUFA)	37.90	39.09	0.440
UFA/SFA	1.51	2.21	0.039
PUFA/SFA	0.95	1.25	0.078
n3	2.84	3.58	0.144
n6	35.36	36.44	0.411
n6/n3	12.44	10.18	0.343
Saturation index (S/P index)	0.61	0.42	0.033
Atherogenic index (AI)	0.49	0.32	0.094
Thrombogenic index (TI)	0.98	0.66	0.020

Blood glucose, triglyceride and total cholesterol values are shown in Fig. 3. Glucose values were significantly higher in the sham group on the 25^{th} (P<0.05) and 40^{th} days (P<0.01) compared to the castrated group. Triglyceride and total cholesterol values were similar in both groups.

Percentages of predominant fatty acids are presented in Fig. 4 and the summarized fatty acid profile of thigh muscle and saturation indexes are presented in Table 4. Capons had a higher percentage of saturated fatty acids (P<0.05), saturation index (P<0.05) and thrombogenic index (P<0.05) and lower unsaturated/saturated fatty acid ratio (P<0.05).

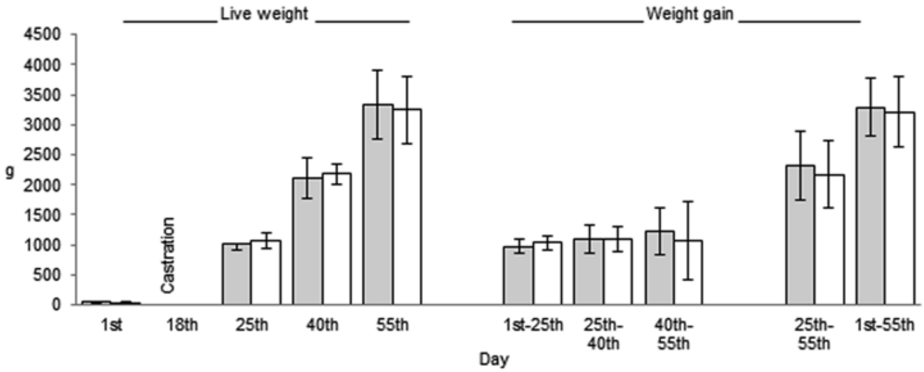

Fig. 1. Live weight and weight gain (means and standard deviation) of capons and sham operated broilers during the experimental period. Castrated (n = 10); Sham (n = 12). All values were not significant (P>0.05).

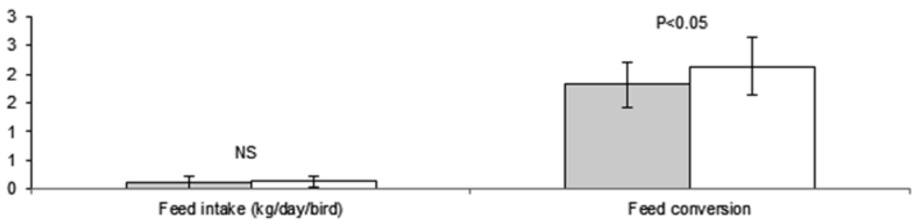

Fig. 2. Feed intake and feed conversion values for capons and sham operated broilers during the experimental period. Castrated (n = 10); Sham (n = 12)

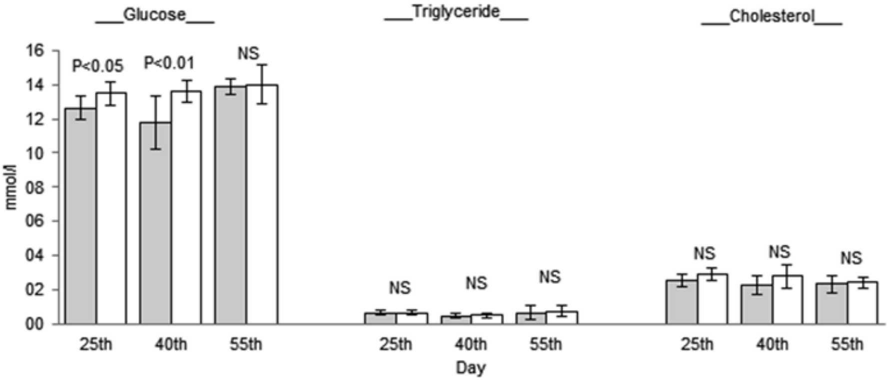

Fig. 3. Serum glucose and triglyceride values (means and standard deviation) in capons and sham operated broilers during the experimental period. Castrated (n = 10); Sham (n = 12)

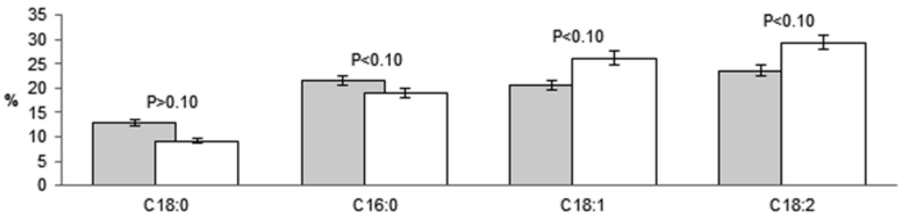

Fig. 4. Predominant fatty acids in tight muscle in capons and sham operated broilers during the experimental period. Castrated (n = 10); Sham (n = 12).

Discussion

Growth performance. The effects of castration on the growth performance of male birds described in literature are inconsistent. Several authors reported no difference between castrated and uncastrated birds (CHEN et al., 2005; SEVERIN et al., 2007; MIGUEL et al., 2008) which is consistent with our results. On the contrary, other authors found different growth patterns: some author reported higher values in uncastrated birds (SEVERIN et al., 2006; SHAO et al., 2009), while others reported higher values in castrated birds (LIN and HSU, 2002; CHEN et al., 2007). It is evident that the growth patterns and final live weight of capons are strongly influenced primarily by the time of castration and strain, although other factors could not be ruled out. SHAO et al. (2009) summarized the reasons for discrepancies as: differences in surgical age, slaughter age, species or strain, nutritional level, or husbandry methods and conditions. An additional important fact that could lead to misinterpretation of data is the presence or absence of sham operation. In this sense, SHAO et al. (2009) did not find significant differences in body weight between the three treatments (intact, sham and capons) after early castration at 6 weeks of age. Nevertheless, the same authors found a significant difference in body weight after late castration at 18 weeks of age, but only between capons and intact birds. Moreover, in some trials, a sudden drop in body weight of capons, when compared with cockerels, immediately after caponisation was noticed, which could be explained by the absence of or an inadequate sham operation. If that drop in body weight after castration is pronounced enough, it could influence the whole growth curve and final body weight. In our trial, the birds were sham operated and the decrease in body weight as a consequence of the operation was similar between the groups and this could be, at least in part, the explanation of the similar final live body weights and weight gains. The feed intake was similar between the groups as was also noted by SHAO et al. (2009), but in our trial, feed conversion was improved in the castrated group.

Body measurement. The comb, wattle and testes were underdeveloped in the castrated birds. As we excluded castrated birds with testicular regeneration, there were no chickens with intermediate values, or so called slips. Heart weight was similar in castrated and sham operated birds, although several authors have found higher heart weights in the intact group (SHAO et al., 2009; MIGUEL et al., 2008; SEVERIN et al., 2007). Liver weight was only numerically higher in uncastrated birds, while for MIGUEL et al. (2008) these values were significant. In contrast, SHAO et al. (2009) reported higher liver weights in castrated birds and concluded that these values are closely related to fat deposition. Nevertheless, it should be noted that growth in our trial was much faster than in these studies and the liver weights were much higher.

Lipid metabolism. CHEN et al. (2005) did not find significant differences between cockerels and capons in blood glucose values. Nevertheless, some authors found higher glucose values in the sham operated group and an increase in glucose values after testosterone implantation, which reflects the effects of testosterone on glucose concentration. Similarly, in our investigation, blood glucose values were higher in the sham operated group. Triglyceride and cholesterol values in our trial were very variable and the differences between treatments were not significant. In contrast, some other studies showed a significant increase in blood triglyceride (CHEN et al., 2005; SHAO et al., 2009; MAŠEK et al., 2010) and cholesterol (SHAO et al. 2009) values after caponisation. Blood triglyceride values in our trial were much lower in comparison to these trials, which may be attributable to the strain used, with lower lipogenesis capability and blood concentrations.

Fatty acid composition. Linoleic acid was the predominant fatty acid in castrated and sham operated birds, which was expected, because linoleic acid is always the predominant fatty acid in birds fed sunflower oil (CRESPO and ESTEVE-GARCIA, 2001). A significantly increased percentage of saturated fatty acids in castrated chicken was also observed by SINANOGLOU et al. (2011). Nevertheless, other authors did not find significant differences in saturated/unsaturated fatty acids ratio (SIRRI et al., 2009) or even found a lower percentage of saturated fatty acids in castrated birds (TOR et al., 2005). SINANOGLOU et al. (2011) also found, similar to our results, a higher thrombogenic index in castrated chickens. It is evident that sex hormones influence Δ desaturase activity (CINCI et al., 2000), but these influences are complex and further investigations are needed to completely elucidate the interaction between sex hormones, species and nutrition.

Conclusions

In conclusion, early caponisation modified lipid metabolism in fattening chicken fed an increased amount of fat. Even if the main fatty acids were not individually strongly affected by caponisation, it was observed that caponisation increased the saturated fatty acid percentage. Further studies should be carried out to elucidate the role of sex hormones on fatty acid profile in fast growing chicken broilers.

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SAŽETAK

Članak analizira učinke rane kastracije s 18 dana starosti na proizvodne rezultate, metabolizam lipida i masnokiselinski profil u tovnih pilića hranjenih povišenom razinom masti. Rana kastracija nije značajno utjecala na rast i unose hrane pokusne peradi. Konverzija hrane je bila značajno bolja kod kastriranih pilića ($P<0,05$). Razina triglicerida i ukupnog kolesterola nije se značajno promijenila nakon rane kastracije ($P>0,05$). Razina glukoze bila je značajno povišena 25. ($P<0,05$) i 40. ($P<0,01$) dana kod nekastriranih pilića u usporedbi s kastriranima. Masnokiselinski sastav mišića batka značajno se promijenio uslijed kastracije. Najočitija razlika bila je u povećavaju razine zasićenih masnih kiselina ($P<0,05$) kod kastriranih pilića u odnosu na nekastrirane. Dodatno, indeksi zasićenosti i trombogenosti bili su značajno viši ($P<0,05$) kod kastriranih pilića, dok je odnos nezasićene/zasićene masne kiseline bio značajno viši kod nekastriranih pilića.

Ključne riječi: kastracija, lipidi seruma, masnokiselinski profil, proizvodni rezultati

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