畜產研究 53(4)：253-265, 2020
DOI：10.6991/JTLR.202012_53(4).0007

# The Effect of caponization on the blood physiological value of Taiwan male native chickens (1)

Cheng-Yung Lin (2)  Jenn-Chung Hsu (3) and Tien-Chun Wan (4) (5)

Received: Apr. 30, 2020; Accepted: Mar. 4, 2021

## Abstract

The purpose of this study was to investigate the effects of caponization on the packed cell volume (PCV), plasma pH, and plasma physiological values of Taiwanese male native chickens at different ages. For the experiment, the rooster of Taiwan Livestock Meat No. 13 was selected. The chickens were castrated at the 10$^{th}$ week of age and were fed with feed during the growth period (10 ~ 18 weeks of age) and the fattening period (19 ~ 28 weeks of age). Caponized or sham male native chickens were selected at the 14$^{th}$ week in this experiment. The treatment groups were divided into a castrated group and a slip group according to the re-development of the comb. After the chickens were fasted for 12 hours, blood samples were collected from individual chickens every two weeks, while 20 chickens from each treatment group were randomly sampled every time. The results showed that the capons (16 ~ 28 weeks old) had the highest plasma inorganic phosphorus, potassium ion and total cholesterol concentration. Besides, the capons (20 ~ 28 weeks old) had the lowest PCV and plasma pH values. The capons had also the lowest testosterone concentration at the 28$^{th}$ week of age, followed by the slip chickens and the sham group, respectively ($P < 0.05$). Capons and slip chickens have significantly higher plasma calcium ions, total protein, albumin, globulin, triglycerides, low-density lipoprotein, high-density lipoprotein, and blood suppression ($P < 0.05$), compared with roosters, however with a significantly lower concentration of plasma uric acid ($P < 0.05$). In addition, the activities of plasma creatine kinase and alkaline phosphatase were significantly higher in capons whereas the sham group had significantly higher concentrations of plasma creatinine and total hydroxyproline ($P < 0.05$). Furthermore, blood PCV value increased in both capons and slip chickens with increasing age, and peaked at the 20$^{th}$ and 26$^{th}$ weeks of age, respectively. In addition, the concentrations of plasma total calcium in sham, slips and capons, peaked at the 18$^{th}$ week of age and declined at the 22$^{th}$ week of age. Moreover, the concentrations of plasma inorganic phosphorus in sham, slips and capons, were reduced significantly with age. In conclusion, the results of these tests revealed that castration will significantly affect the PCV, plasma pH and certain components between 4 and 6 weeks, mainly due to androgen functions, including erythropoiesis, protein, lipid, bone, and connective tissue synthesis.

Key words: Age, Blood parameters, Caponization, Male native chicken, Testosterone.

## Introduction

Capons are male chickens whose testes have been surgically removed. Because of the resultant androgen deficiency, secondary male sexual characteristics (comb, wattle, fighting, mount-bite behavior, and vocalization) are degenerative, and maturity regresses to an immature stage. Capons, commonly known as eunuch chickens, represent a number of locally produced chickens favored by Taiwanese consumers, which use the male Taiwan native chickens or male Taiwan game chickens. In Taiwan, capons are the main source of chicken meat in Hakka residence and have the highest unit price of all chicken species.

(1) Contribution No. 2661 from Livestock Research Institute, Council of Agriculture, Executive Yuan.
(2) Animal Industry Division, COA-LRI, Tainan 71246, Taiwan, R. O. C.
(3) Department of Animal Science, National Chung-Hsing University, Taichung City 402, Taiwan, R. O. C.
(4) Technical Service Division, COA-LRI, Tainan 71246, Taiwan, R. O. C.
(5) Corresponding author, E-mail: tcwan@tlri.gov.tw.

In general, the rearing period of capons is longer (24 ~ 32 weeks) than that of the Taiwan native chicken; and the live weight is also heavier. Capons are divided into heavy type capons (above 3.5 kg of live body weight) and light type capons (below 3.5 kg of live body weight). Taiwanese consumers traditionally prefer heavy types of capons to the broilers and are willing to pay a premium for capons.

Numerous reports have pointed out the influence of surgical caponization on the behavior (Wang, 2001), growth performance (Wang, 2001; Lin and Hsu, 2002; Murawska *et al.*, 2019), comb area, feather scores and rectal temperature (Lin and Hsu, 2003a), organ and carcass part ratios (Lin and Hsu, 2003b), skin and muscle colors (Lin and Hsu, 2003b), muscle compositions (Lin *et al.*, 2011b), ATP related compounds (Lin *et al.*, 2011b), fiber diameter and area (Lin and Hsu, 2003a; Lin *et al.*, 2011b), certain muscle physical properties (Lin and Hsu, 2002; Lin *et al.*, 2011b), taste panel scores (Lin *et al.*, 2011b), and bone traits (Lin and Hsu, 2003a; Chen *et al.*, 2006a, b; Lin et al, 2012). The effects of castration, androgens treatment or testosterone deficiency on blood traits have been reported in other studies (Chen *et al.*, 2006a, b; Lin *et al.*, 2012; Antunes *et al.*, 2019), but these reports are inconsistent and the main focus is related to the blood parameters and on bone and lipid metabolism. However, these studies do not show other blood characteristics. PCV value measures the percentage composition of blood cells relative to other contents. The author further explained that PCV is very useful in assessing normal blood levels in animals (Augustine et al, 2020). There are limited studies comparing capons, slips or sham chickens in blood PCV, plasma pH and certain blood parameters. The aim of the study is to examine the blood PCV, plasma blood biochemical characteristics in the caponization situations.

# Materials and methods

I. Experimental design and animal feeding

Healthy male Taiwan native chicken cockerels (LRI native chicken Taishi meat No. 13.) bred by the Taiwan Livestock Research Institute, were caponized or sham operated at the 10th week of age and were reared in an open-sided broiler house with 22 chickens in each pen (200 cm × 450 cm) for a 4-week adaptation period. Twenty- two male (sham), 22 slips, and 22 caponized (capon, prominent degenerated comb) chickens were selected at the $14^{th}$ week of age for a 14-week feeding experiment. From the $10^{th}$ to $18^{th}$ weeks of age, chickens were fed 19% crude protein and 3,000 kcal/kg metabolizable energy grower rations. From the $19^{th}$ to $28^{th}$ weeks, the chickens were fed 17% crude protein and 2,800 kcal/kg metabolizable energy finisher rations. The chickens received a daily photoperiod of 23 h light and 1 h dark. Feed and water were provided ad libitum (Lin and Hsu, 2003a). The experimental procedures involving animals were performed in accordance with the COA-LRI Guide for Care and Use of Laboratory Animals.

II. Testectomy

The testectomy procedure was performed according to Lin and Hsu (2002). Male chickens were restrained and restricted to feed and water for 24 h before the surgical operation. The incision site was sterilized with iodine-alcohol. A 1-cm lateral incision was made from the last rib. The testes were then removed. Iodine-alcohol was applied again to the incision site for disinfection.

III. Capon and slip distinguished

Capons and slips were distinguished according to Lin and Hsu (2003a). Although, chicken cockerels were caponized in the same way, but some chicken castrations were incomplete, leading to a few testicles remaining in the abdominal cavity. Relics of testicle can be regrown several weeks later, resulting in these chickens redeveloping a comb and wattle, with which caponized chickens can be divided into capon and slip groups. The comb and wattle color were bright red. The size change of the slip was significant, whereas the capons appeared to maintain an atrophy status.

IV. Sample collection and analysis

Twenty chickens in each group were bled between the 14 and 28 weeks of age at 2-week intervals. After 12 h of feed deprivation, the blood samples were collected from the brachial vein using a syringe pre-rinsed with a solution 0.15 M NaCl containing 1,000 IU/mL of heparin-Li. Then, samples were placed into a tube containing 50 μL of a 1,000 IU/mL heparin-Li solution per milliliter of blood. The blood samples were kept on ice, centrifuged (1,500 × *g* for 30

min) at 5℃ and the recovered plasma was placed into three vessels. One of these vessel samples were held at 0 ~ 4℃ for determining plasma ion contents. The remaining vessels were frozen at -20℃ as plasma for other blood parameters analysis. PCV (packed cell volume) was measured by centrifuging, at 13,362 × *g* for 5 minutes (Kubota KN70, Japan). The plasma sodium, potassium and chloride concentration were analyzed using a kit (Bayer, UK) and automatic analyzer (634 ISE $Na^+/K^+/Cl^-$ Analyzer, Ciba Corning, England) within 72 h of blood sampling. The plasma pH and ionized calcium concentration were determined using a kit (Bayer, UK) and automatic analyzer (644 ISE $Ca^{2+}$/pH Analyzer, Ciba Corning, England). The plasma sodium, potassium and chloride concentration were analyzed using a kit (Bayer, UK) and automatic analyzer (634 ISE $Na^+/K^+/Cl^-$ Analyzer, Ciba Corning, England) within 72 h of blood sampling. Assays for the activities of plasma creatine kinase, alkaline phosphatase and concentrations of plasma total calcium, inorganic phosphorus, magnesium, total protein, albumin, globulin, uric acid, urea nitrogen, triglyceride, total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), creatinine and lactic acid were determined with different kits (Wako, Japan) and automatic analyzers (Hitachi 7050, Japan). The total hydroxyproline and free hydroxyproline concentrations in plasma were measured according to the method of Bannister and Burns (1970). Determination of the concentrations of plasma testosterone, calcitonin and parathyroid hormone were carried out with an ELISA microtiter reader (Mrx Dynex Technologies, USA), using different ELISA kits (Neogen Testosterone ELISA kit, Active Calcitonin ELISA kit, DSL-10-7700 and Active Parathyroid hormone ELISA kit, DSL-10-8000).

V. Statistical analysis

Analysis of variance among treatment groups (sham, slips, and capons) were calculated using the General Linear Models (GLM) procedure of SAS (SAS Institute Inc., 2006). The physiological values of different experimental animals at the same age and the physiological values of the same experimental animals at different ages are statistically compared. When significant differences were detected ($P < 0.05$), means were used Least Squares Means (LSMeans).

# Results and discussion

I. Blood PCV, plasma pH, and concentrations of plasma $Na^+$, $K^+$ and $Cl^-$

The blood PCV, plasma pH, and concentrations of plasma sodium, potassium, and chloride data are summarized in Table 1. Results showed that the sham group had the highest ($P < 0.05$) PCV at the 14 weeks of age (after 4 weeks of caponized treatment), followed by slips and capons. The PCV in sham and slips increased significantly with the advance of age, and the peak occurred at the $20^{th}$ and $24^{th}$ weeks of age ($P < 0.05$). This is in agreement with the finding of Lin and Hsu (2011a), who reported male chickens had significantly higher PCV than those of capons. Peh *et al.* (2000) found similar findings that male chickens had significantly higher PCV than that of female chickens. In addition, Griggs *et al.* (1989) also indicated that groups administered testosterone had greater PCV than those of controls. However, Lin *et al.* (2012) also indicated that the plasma testosterone concentration was significantly lower in capons at the 12th week of age than that of the intact males. In addition, Lin and Hsu (2003a) found that intact chickens had the highest concentration of testosterone followed by slips and capons. Accordingly, the blood PCV in male chickens and slips may have been caused by the effect of higher androgen increasing the bodily erythropoiesis and greater PCV than that of capons as suggested by Lin and Hsu (2011a).

The sham group had the highest plasma pH at the $16^{th}$ week of age followed by slips and capons ($P < 0.05$), which was consistent with the results of Lin and Hsu (2011a), who showed capons had lower plasma pH than male birds. However, Peh *et al.* (2000) showed that there were no significant differences between sexes in their serum pH. The results for plasma pH in this study were inconsistent with these results. Reasons of capons with lower plasma pH are presently unclear. It may be due to a reduced plasma testosterone concentration. In animals exposed to androgens, there is an alteration of fiber type profiles and muscle metabolism. Castration causes an increase in white fiber numbers, muscle glycogen contents and glycolytic enzymes activity, resulting in enhanced pyruvate or lactate deposition and reduced plasma pH, as shown by Judge *et al.* (1988).

The results of this study for the concentration of plasma sodium were inconsistent at different weeks of age among sham, slips and capons. However, slips had significantly lower mean plasma sodium concentrations than sham and

capons ($P < 0.05$), but there was no significant difference between sham and capons. Similarly, Peh *et al.* (2000) and Lin and Hsu (2011a) have reported that no effects on plasma sodium concentration between the male and female chickens or capons were found.

The capons had the highest concentration of plasma potassium at the 16th week of age, followed by slips and sham ($P < 0.05$). These results agree with Lin and Hsu (2011a), who indicated that male chickens had a lower concentration of plasma potassium than capons. Similarly, Peh *et al.* (2000) also found that female Silkie bantams had a higher concentration of plasma potassium than that of male birds. The testosterone is anabolic in normal adult subjects and is considerable evidence for positive nitrogen, potassium, and phosphorus balance. An increase in muscle mass is reflected by increasing total body potassium content (Griggs *et al.*, 1989). Therefore, the observed higher plasma potassium values for capons in this study were associated with a lower plasma testosterone concentration, which may have been due to decreased muscle protein synthesis, as resulted by Lin and Hsu (2013).

The results of the present study for the concentration of plasma chloride were inconsistent at different weeks of age among sham, slips and capons. However, slips had significantly higher mean than that of the sham and capons ($P < 0.05$), but the plasma chloride concentration did not significantly differ between sham and capons. Lin and Hsu (2011a) found no difference in the concentrations of plasma chloride between capon and male chicken. In contrast, Peh *et al.* (2000) indicated plasma chloride concentrations were higher in female Silkie bantams than that in male birds.

II. Concentrations of plasma ionized calcium, total calcium, inorganic phosphorus, magnesium, and activity of plasma alkaline phosphatase

The concentrations of plasma ionized calcium, total calcium, inorganic phosphorus, magnesium, and activity of plasma alkaline phosphatase results in this experiment are presented in Table 2. The capons had the highest concentrations of plasma ionized calcium at the 14th week of age ($P < 0.05$), followed by slips and sham. However, the concentrations of plasma total calcium were not affected by the treatments. Further, the concentrations of plasma total calcium in sham, slips and capons peaked at the 18th week of age, and declined at the 22th week of age. Lin and Hsu (2003a), Chen *et al.* (2007), and Lin *et al.* (2012) had the same results, attributing this difference to increased bone calcium loss by the capons or slips that favored bone loss over bone formation. In contrast, Peh *et al.* (2000) also found that male Silkie bantams had significantly higher concentrations of serum ionized calcium than female chickens. Chen *et al.* (2006a) showed that caponization increased the blood total calcium concentration. Moreover, Mauras *et al.* (1999) also demonstrated that orchidectomized rats or hypogonadism men showed no serum ionized calcium concentration change. In the present study, capons have a higher plasma ionized calcium concentration, associated with higher plasma calcitonin concentration, as shown by Stepan and Lachman (1989). These results showed the plasma calcitonin concentrations in the capons were significantly higher than in the sham (Table 5). These results support the current findings that ionized calcium showed a better response than total calcium in terms of the analyses on blood calcium concentration.

The capons had the highest ($P < 0.05$) concentrations of plasma inorganic phosphorus at the 14th week of age (caponized treatment after 4 weeks), followed by slips and sham. The concentrations of plasma inorganic phosphorus in sham, slips and capons reduced significantly with the advance of age ($P < 0.05$), which agreed with Lin and Hsu (2003a), Chen *et al.* (2006a), and Lin *et al.* (2012). However, Mauras *et al.* (1999) reported the reverse results. Orchidectomized rats or hypogonadism men had significantly lower serum phosphorus concentrations. On the other hand, Bogin (1992) indicated that hypoparathyroidism causes an increment in the plasma phosphorus concentration. In addition, Vanderchuersen and Bouillion (1995) found that androgens increased marrow cell or osteoblast sensitivity to the parathyroid hormone. Besides, the increased concentrations of plasma inorganic phosphorus in capons are probably due to reduced concentrations of plasma testosterone, leading to reduction in marrow cell or osteoblast sensitivity to the parathyroid hormone.

The concentrations of plasma magnesium did not significantly differ among treated groups, but the sham, slips and capons before the 16th week of age had a lower plasma magnesium concentration than after the 18th week of age, which was consistent with the results of Lin and Hsu (2003a) and Lin *et al.* (2012). Plasma alkaline phosphatase activity was as high as in capons over the slips and sham, and as expected showed a significant difference at the 18th and 28th weeks of age. The results are in agreement with previous reports (Chen *et al.*, 2007; Lin *et al.*, 2012). However, the increased blood

alkaline phosphatase activity damages bone cells and their cell numbers increase in bone remodeling (Bogin, 1992). In general, castration causes an increase in bone calcium loss (Lin and Hsu, 2003a; Chen *et al.*, 2006b; Lin *et al.*, 2012). Phosphate calcium and carbonate calcium account for the largest part of the cortical bone. In this study, it is reasonable to expect capons to have a higher plasma ionized calcium, inorganic phosphorus and alkaline phosphatase concentration, associated with lower plasma testosterone concentrations, as discussed by Lin *et al.* (2012).

III. Activity of plasma creatine kinase and concentrations of plasma creatinine, uric acid, triglyceride, total cholesterol, and total protein

Table 3 shows the activity of plasma creatine kinase and concentrations of plasma creatinine, uric acid, triglyceride, total cholesterol, and total protein results. Plasma creatine kinase activity in capons was higher than that in the sham group at 16 weeks of age, and showed a significant difference at the $20^{th}$ week of age and mean activity of age. The results in this study agreed with those of Lin and Hsu (2011a), who found that caponization increased blood creatine kinase activity. In contrast, Griggs *et al.* (1989) found a significant increase in creatine kinase activity during testosterone administration in men. Blood creatine kinase activity, indicating striated muscle and heart muscle healthy state, lean mass and psychological state, has been reported in another study (Griggs *et al.*, 1989; Bogin, 1992). The capons showed higher activities of plasma creatine kinase are presently unclear, but it is probably due to castration leading to reduced concentrations of plasma testosterone and an altered temperament, increasing timidity and sensitivity, as suggested by Wang (2001). Bogin (1992) demonstrated that the blood creatine kinase activity increased, which reflected animals under stress.

Plasma creatinine concentrations in the sham group were higher than those in the capons between the $14^{th}$ and $28^{th}$ weeks of age, showing significant differences of mean concentration at the $16^{th}$, $18^{th}$, $24^{th}$ and $26^{th}$ weeks. Besides, the concentrations of plasma creatinine in the sham group reduced significantly with the increment of age ($P < 0.05$). Similarly, Griggs *et al.* (1989) showed that there was significant increment in serum creatinine concentration during testosterone administration. However, increases in muscle mass as reflected by increasing urinary creatinine excretion content and serum creatinine concentration have been shown in other studies (Bogin, 1992). The observed lower plasma creatinine concentrations for capons in this study are associated with lower plasma testosterone concentration, which may be due to decreased muscle protein synthesis (Lin and Hsu, 2013).

The capons had significantly higher concentrations of plasma uric acid at the $14^{th}$ week of age ($P < 0.05$), whereas the capons had significantly lower concentrations of plasma uric acid than the sham group after 18 weeks of age ($P < 0.05$). Lin and Hsu (2011a) also had similar results. Accordingly, it seems reasonable to conclude the observed lower plasma uric acid concentrations for capons in this study are associated with an improved feed conversion after 18 weeks of age, which may be due to decreased plasma testosterone concentration leading to less aggression and sexual (mount-bite) behavior, as has been suggested by Wang (2001) and Lin and Hsu (2002).

The capons had the highest concentration of plasma total cholesterol at the $16^{th}$ week of age ($P < 0.05$), followed by slips and sham, which were consistent with the results of Chen *et al.* (2005) and Lin and Hsu (2011a). In contrast, Griggs *et al.* (1989) showed that there was no significant change in serum total cholesterol concentration during testosterone administration. Further, the capons or slips had higher concentrations of plasma triglyceride at the $16^{th}$ week of age, and a significant difference at the $16^{th}$, $18^{th}$, $26^{th}$ and $28^{th}$ week of age and mean concentration of age. Lin and Hsu (2011a) also had similar results, but the reverse was shown by the results of Griggs *et al.* (1989) with no significant change in serum triglyceride concentration during testosterone administration. Moreover, the reduced plasma total cholesterol and triglyceride concentration in the sham may be attributed to the effects of androgen decrease in lipogenic enzyme activity (Chen *et al.*, 2005). On the other hand, the enhanced plasma total cholesterol and triglyceride concentrations in the capons and slips are likely due to castration, which resulted in less activity (Wang, 2001), higher intake of feed (Lin and Hsu, 2002), and a higher fat content (Lin *et al.*, 2011b). Compared with other groups, the sham group had significantly lower concentrations of plasma total protein at the $14^{th}$ weeks of age ($P < 0.05$). These results are in agreement with the findings of Lin and Hsu (2011a), who reported intact birds were lower in plasma total protein concentration than capons and slips. In contrast, Peh *et al.* (2000) found no significant differences between sexes in serum total protein concentration. Therefore, it is reasonable to expect the capons had high concentrations of plasma total protein associated with higher plasma albumin and globulin concentration (Table 4).

IV. Concentrations of plasma albumin, globulin, urea nitrogen, total hydroxyproline, free hydroxyproline, LDL, HDL, and lactic acid

The concentrations of plasma albumin, globulin, urea nitrogen, total hydroxyproline, free hydroxyproline, LDL, HDL, and lactic acid in this study are displayed in Table 4. Compared with the sham group, slips and capons had significantly lower concentrations of plasma albumin and globulin at the 28$^{th}$ week of age ($P < 0.05$). However, caponized treatment had no effects on the concentration of plasma urea nitrogen. Lin and Hsu (2011a) had similar results, but in contrast, Vaelimaeki *et al.* (1999) demonstrated that concentrations of serum testosterone decreased, resulting in a concomitant drop in serum albumin. Preston *et al.* (1995) indicated that the anabolic steroids and growth hormone-releasing factors were additive, decreasing plasma urea nitrogen concentration in feedlot steers. The results of the concentration of plasma urea nitrogen in this study are not completely consistent with these reports. The reasons for such discrepancy could be due to the different kinds of animal chosen. Moreover, the reduced plasma globulin concentration in the sham group is probably due to increased blood testosterone concentration, leading to inhibited immune organs development and immune response, as discussed by Vojtiskova *et al.* (1976) and Fennel and Scanes (1992). On the other hand, capons have high concentrations of plasma albumin, which is associated with increased lipid synthesis (higher plasma triglyceride and total cholesterol concentration), and causes increased albumin in the blood for transport lipid.

The capons and slips showed significantly higher concentrations of plasma LDL and HDL than those of the sham group at the 28$^{th}$ week of age ($P < 0.05$), which was consistent with the results of study of Chen *et al.* (2005) and Lin and Hsu (2011a). Thus, capons and slips had high concentrations of plasma LDL and HDL, which was associated with higher plasma total cholesterol concentration. Compared with the sham group, capons and slips had a significantly lower concentration of plasma total hydroxyproline ($P < 0.05$), but the plasma free hydroxyproline concentration was unaffected among the sham, slips and capons at the 28$^{th}$ week of age. These results agree with the report of Lin and Hsu (2011a), who indicated that plasma total hydroxyproline concentrations were higher in capons than in intact chickens, but the plasma free hydroxyproline concentration was unaffected by the caponization treatment. Similarly, Gerrard *et al.* (1987) found the serum hydroxyproline and testosterone concentrations in bulls were higher than that in steers. A significant increase in connective tissue content during testosterone administration in men has been demonstrated (Griggs *et al.*, 1989). Moreover, Stepan and Lachman (1989) indicated increased urinary hydroxyproline excretion in castration males. However, no treatment differences were associated with concentrations of plasma lactic acid among the sham, slips and capons. Lin and Hsu (2011a) showed similar results.

V. Concentrations of plasma testosterone, parathyroid hormone and calcitonin

Some blood hormone parameters data are summarized in Table 5. The sham group had the highest concentrations of plasma testosterone at the 28$^{th}$ week of age ($P < 0.05$), followed by slips and capons, which was consistent with the results of Lin and Hsu (2003a) and Chen *et al.* (2005). In addition, Mashaly (1984) reported that 3-week-old cockerels subjected to orchiectomy treatment after 2 weeks caused a reduction in the serum testosterone concentration, but the serum dihydrotestosterone concentration after 12 weeks orchiectomy treatment was also reduced. Moreover, Lin *et al.* (2012) also demonstrated 8-week-old cockerels at orchiectomy treatment after 4 weeks caused a reduction in the serum testosterone concentration.

The plasma parathyroid hormone concentration could be as much as 11.5% in capons over the sham at the 28$^{th}$ week of age. However, this is not enough to conclude that there is a resulting difference among the treated groups. Lin and Hsu (2011a) also had similar results. Similarly, Mauras *et al.* (1999) showed that hypogonadism men showed unchanged serum parathyroid hormone concentration between the baseline and 10 weeks later. In normal physiology, parathyroid hormone secretion over the basal level occurred in response to decreased extracellular ionized calcium concentration, resulting in a close inverse relationship between the blood parathyroid hormone and calcium concentration (Marcus, 1989). Thus, it is reasonable to expect capons have a higher plasma parathyroid hormone concentration, which is associated with higher ionized calcium concentration. Vanderchuersen and Bouillion (1995) found that androgens could have increased marrow cell or osteoblast sensitivity to the parathyroid hormone. The parathyroid hormone has a wide range of biological actions primarily related to the prevention of hypocalcemia. Kao *et al.* (1992) showed that these reactions included enhancement of bone reabsorption, stimulation of distal renal tubular calcium reabsorption, inhibition of proximal renal tubular phosphate reabsorption, and stimulation of renal 1 $\alpha$ -hydroxylation of 25-OH vitamin D.

Compared with the sham, capon and slip groups had a significantly higher concentration of plasma calcitonin at the 28th week of age ($P < 0.05$). These results agree with the results of Stepan and Lachman (1989) and Lin and Hsu (2011a), who stated castrated men or cockerels showed an increase in blood calcitonin concentration. In contrast, Mauras *et al.* (1999) showed hypogonadism men did not have altered the serum calcitonin concentration between the baseline and 10 weeks later. However, Copp (1992) found that the major action of calcitonin was to lower plasma calcium concentration. Relatively small increments in extracellular calcium concentration had been indicated to stimulate calcitonin secretion. Calcitonin secretion had been also regulated by gastrointestinal peptide, estrogen, and vitamin D.

The gonads are related to the accumulation of calcium in the bones. After the testicle is castrated, the calcium dissolving power of the bone increases, which affects the calcium metabolism. This is the feedback pathway of calcium after the testicle is removed. Calcitonin apparently acts by inhibiting osteoclast activity, resulting in decreased mobilization of calcium from bones. Thus, the results from the observed higher plasma calcitonin concentration in capons and slips are associated with higher plasma ionized calcium concentration. This study discovered the caponization of male chickens could reflect blood content and body states. Therefore, the study would point out the influence of muscle protein and lipid synthesis, connective tissues growth and bone formation on male chickens.

# Conclusion

The test studied the effect of age and caponization on blood biochemical parameters of male native chickens. These findings of blood biochemical parameters can directly reflect body states in this study. The caponization caused a significant decrease in blood PCV, plasma pH, and some characteristics after 4 to 6 weeks post treatment, which showed androgen could directly influence erythropoiesis, muscle protein and lipid synthesis, connective tissues growth and bone formation in male native chickens.

# References

Antunes, I. C., M. A. G. Quaresma, M. F. Ribeiro, S. P. Alves, P. Martins da Costa and R. J. B. Bessa. 2019. Effect of immunocastration and caponization on fatty acid composition of male chicken meat. Poult. Sci. 98: 2823-2829.

Augustine, C., J. U. Igwebuike, I. D. Kwari, S. B. Adamu, T. John, A. Zakaria, M. U. Ardo, J. G. Katsala, L. U. Obidah, A. J. Maspalma, M. P. Shall and S. Ahmed 2020. Haematological and biochemical parameters of broiler chickens fed processed or raw tropical Sickle Pod (Senna obtusifolia) seed meal-based diets. Life Sci. J. 17: 80-89.

Bannister, D. W. and A. B. Burns. 1970. Adaptation of the Bergman and Loxley technique for hydroxyproline determination to the autoanalyzer and its use in determining plasma hydroxyproline in domestic fowl. Analyst 95: 596-600.

Bogin, E. 1992. Handbook for Veterinary Clinical Chemistry. New York, Kodak Publ. USA.

Chen, K. L., W. T. Chi and P. W. S. Chiou. 2005. Caponization and testosterone implantation effects on blood lipid and lipoprotein profile in male chickens. Poult. Sci. 84: 547-552.

Chen, K. L., S. M. Tsay, T. Y. Lee and P. W. S. Chiou. 2006a. Effects of caponization and different exogenous androgen on the bone characteristics of male chickens. Poult. Sci. 85: 1975-1979.

Chen, K. L., M. H. Chang, S. M. Tsay, H. Y. Hurng and P. W. S. Chiou. 2006b. Effects of caponization on bone characteristics and histological structure in chickens. Asian-Aus. J. Anim. Sci. 19: 245-251.

Chen, K. L., S. M. Tsay, D. Y. Lo and P. W. S. Chiou. 2007. Effects of caponization and testosterone on bone and blood parameters of SCWL male chickens. Asian-Aus. J. Anim. Sci. 20: 706-710.

Copp, D. H. 1992. Remembrance: calcitonin: discovery and early development. Endocrinol. 131: 1007-1008.

Fennel, M. J. and C. G. Scanes. 1992. Effect of androgen (testosterone, 5α-dihydrotesterone, and 19-nortestosterone) administration on growth in turkey. Poult. Sci. 71: 539-547.

Gerrard, D. E., S. J. Jones, E. D. Aberle, R. P. Lemenager, M. A. Diekman and M. D. Judge. 1987. Collagen stability, testosterone secretion and meat tenderness in growing bulls and steers. J. Anim. Sci. 65: 1236-1242.

Griggs, R. C., W. Kingston, R. F. Jozefowicz, B. E. Herr, G. Forbes and D. Halliday. 1989. Effect of testosterone muscle

mass and muscle protein synthesis. J. Appl. Physiol. 66: 498-503.
Judge, M. D., E. D. Aberle, J. C. Forrest, H. B. Hedrick and R. A. Merkel. 1988. Principles of Meat Science. pp. 44-47. Second ed. Kendall/Hunt Publishing Company.
Kao, P. C., J. A. van Heerden, C. S. Grant, G. G. Klee and S. Khosla. 1992. Clinical performance of parathyroid hormone immunometric assays. Mayo. Clin. Proc. 67: 637-645.
Lin, C. Y. and J. C. Hsu. 2002. Effects of surgical caponization on growth performance, fiber diameter and some physical properties of muscles in Taiwan country chicken cockerels. Asian-Aust. J. Anim. Sci. 15: 401-405.
Lin, C. Y. and J. C. Hsu. 2003a. Comparison of some selected growth, physiological and bone characteristics of capon, slip and intact birds in Taiwan country chicken cockerels. Asian-Aust. J. Anim. Sci. 16:50-56.
Lin, C. Y. and J. C. Hsu. 2003b. Influence of surgical caponization on the carcass characteristics in Taiwan country chicken cockerels. Asian-Aust. J. Anim. Sci. 16: 575-580.
Lin, C. Y. and J. C. Hsu. 2011a. Effects of surgical caponization on blood characteristics of male Taiwan country chickens. J. Taiwan Livestock Res. 42: 25-37. (in Chinese)
Lin, C. Y., L. C. Lin and J. C. Hsu. 2011b. Effect of caponization on muscle composition, shear value, ATP related compounds and taste appraisal in Taiwan country chicken cockerels. Asian-Aust. J. Anim. Sci. 24: 1026-1030.
Lin, C. Y., J. C. Hsu and T. C. Wan. 2012. Effect of age and caponization on blood parameters and bone development of male Taiwan native chickens. Asian-Aust. J. Anim. Sci. 25: 994-1002.
Lin, C. Y., L. C. Lin and J. C. Hsu. 2013. Comparison of skin and muscle color, muscle composition and sensory panel score of capon, slip and intact birds in Taiwan country chicken cockerels. J. Taiwan Livestock Res. 44: 187-194. (in Chinese)
Marcus, R. 1989. Laboratory diagnosis of primary hyperparathyroidism. Endocrinol. Metab. Clin. North Am. 18: 647-658.
Mashaly, M. M. 1984. Effect of caponization on cell-mediated immunity of immature cockerels. Poult. Sci. 63: 369-372.
Mauras, N., V. Y. Hayes, N. E. Vieira, A. L. Yergey and K. O. O'Brien. 1999. Profound hypogonadism has significant negative effects on calcium balance in males: A calcium kinetic study. J. Bone Miner. Res. 14: 577-582.
Murawska, D., M. Gesek and D. Witkowska. 2019. Suitability of layer-type male chicks for capon production. Poult. Sci. 98: 3345-3361.
Peh, H. C., S. Chiou and D. C. Liu. 2000. Studies on the blood constituents in black bone chickens (Silkie bantams). J. Chin. Soc. Anim. Sci. 29: 51-64. (in Chinese)
Preston, R. L., S. J. Bartle, T. R. Kasser, J. W. Day, J. J. Veenhuizen and C. A. Baile. 1995. Comparative effectiveness of somatotropin and anabolic steroids in feedlot steers. J. Anim. Sci. 73: 1038-1047.
SAS. 2006. The SAS system for Windows (Release 9.1). SAS Inst. Inc., Cary, NC, USA.
Stepan, J. J. and M. Lachman. 1989. Castrated men with bone loss: effects of calcitonin treatment on biochemical indices of bone remodeling. J. Clin. Endocrinol. Metab. 69: 523-527.
Vaelimaeki, M. J., K. Kinnunen, R. Taehtelae, E. Löyttyniemi, K. Laitinen, P. Maekelae, P. Keto and M. Nieminen. 1999. A prospective study of bone loss and turnover after cardiac transplantation: effect of calcium supplementation with or without calcitonin. Osteoporosis Int. 10: 128-136.
Vanderschueren, D. and R. Bouillon. 1995. Androgens and bone. Calcif. Tissue Int. 56: 341-346.
Vojtiskova, M., M. Polackova and V. Viklicky. 1976. Effect of antiandrogen on the lymphoid system. Experientia 32: 1202-1203.
Wang, H. T. 2001. Effects of surgical caponization and administration of estradiol to chicken embryos on daily activity, agonistic behavior, growth performance, carcass traits and sensory evaluation of males Taiwan country chickens. Master thesis. Department of Animal Science, National Chung Hsing University, Taiwan. (in Chinese)

Table 1. Effect of age on the blood PCV, plasma pH, sodium, potassium, and chloride of native chickens

| Items | Weeks of age | | | | | | | | | S.E. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | Mean | |
| PCV, % | | | | | | | | | | |
| Sham (n = 20) | 33.4$^{d,x}$ | 35.5$^{c,x}$ | 37.9$^{b,x}$ | 40.3$^{a,x}$ | 40.1$^{a,x}$ | 40.6$^{a,x}$ | 41.4$^{a,x}$ | 41.6$^{a,x}$ | 38.9$^{x}$ | 0.23 |
| Slip (n = 20) | 30.1$^{c,y}$ | 30.8$^{bc,y}$ | 31.2$^{bc,y}$ | 33.6$^{ab,y}$ | 34.2$^{a,y}$ | 32.9$^{abc,y}$ | 35.4$^{a,y}$ | 34.8$^{a,y}$ | 32.9$^{y}$ | 0.33 |
| Capon (n = 20) | 28.2$^{b,y}$ | 29.5$^{ab,y}$ | 28.7$^{ab,z}$ | 30.4$^{a,z}$ | 29.9$^{ab,z}$ | 29.1$^{ab,z}$ | 30.4$^{a,z}$ | 29.0$^{ab,z}$ | 29.4$^{z}$ | 0.19 |
| S.E. | 0.29 | 0.30 | 0.37 | 0.39 | 0.44 | 0.46 | 0.52 | 0.46 | 0.17 | |
| pH | | | | | | | | | | |
| Sham (n = 20) | 7.64$^{ab}$ | 7.66$^{a,x}$ | 7.65$^{ab,x}$ | 7.51$^{d,x}$ | 7.66$^{a,x}$ | 7.60$^{bc}$ | 7.56$^{cd}$ | 7.67$^{a,x}$ | 7.62$^{x}$ | 0.006 |
| Slip (n = 20) | 7.61$^{a}$ | 7.59$^{ab,y}$ | 7.51$^{c,y}$ | 7.45$^{d,y}$ | 7.65$^{bc,x}$ | 7.57$^{ab}$ | 7.55$^{bc}$ | 7.60$^{bc,y}$ | 7.57$^{y}$ | 0.006 |
| Capon (n = 20) | 7.61$^{ab}$ | 7.55$^{cd,y}$ | 7.52$^{d,y}$ | 7.44$^{e,y}$ | 7.55$^{a,y}$ | 7.57$^{bc}$ | 7.54$^{cd}$ | 7.55$^{bc,y}$ | 7.54$^{z}$ | 0.006 |
| S.E. | 0.010 | 0.011 | 0.009 | 0.008 | 0.008 | 0.009 | 0.007 | 0.011 | 0.004 | |
| $Na^+$, mmol/L | | | | | | | | | | |
| Sham (n = 20) | 148.6$^{cd}$ | 150.0$^{cd}$ | 148.1$^{d}$ | 153.4$^{b}$ | 150.6$^{c,y}$ | 156.2$^{a,x}$ | 153.7$^{b,x}$ | 150.4$^{c,x}$ | 151.4$^{x}$ | 0.24 |
| Slip (n = 20) | 150.1$^{bc}$ | 150.4$^{bc}$ | 147.6$^{d}$ | 152.9$^{a}$ | 150.6$^{bc,y}$ | 151.2$^{ab,y}$ | 151.3$^{ab,y}$ | 148.6$^{cd,y}$ | 150.3$^{y}$ | 0.24 |
| Capon (n = 20) | 149.0$^{cd}$ | 150.9$^{bc}$ | 149.5$^{cd}$ | 152.1$^{ab}$ | 153.9$^{a,x}$ | 153.0$^{ab,y}$ | 152.9$^{ab,xy}$ | 148.3$^{d,y}$ | 151.2$^{x}$ | 0.24 |
| S.E. | 0.43 | 0.48 | 0.45 | 0.39 | 0.42 | 0.55 | 0.36 | 0.46 | 0.18 | |
| $K^+$, mmol/L | | | | | | | | | | |
| Sham (n = 20) | 4.45$^{a}$ | 3.85$^{bc,y}$ | 3.57$^{cd,y}$ | 4.57$^{a,y}$ | 4.04$^{b,y}$ | 3.40$^{d,z}$ | 3.57$^{cd,y}$ | 3.82$^{bc,y}$ | 3.91$^{z}$ | 0.041 |
| Slip (n = 20) | 4.36$^{bc}$ | 4.44$^{ab,x}$ | 4.29$^{bc,x}$ | 4.74$^{a,xy}$ | 4.47$^{ab,xy}$ | 4.05$^{cd,y}$ | 3.74$^{d,y}$ | 3.88$^{d,xy}$ | 4.25$^{y}$ | 0.041 |
| Capon (n = 20) | 4.81$^{ab}$ | 4.51$^{bc,x}$ | 4.42$^{cd,x}$ | 5.11$^{a,x}$ | 4.73$^{bc,x}$ | 4.51$^{bc,x}$ | 4.06$^{e,x}$ | 4.13$^{de,x}$ | 4.55$^{x}$ | 0.039 |
| S.E. | 0.048 | 0.052 | 0.084 | 0.079 | 0.061 | 0.059 | 0.067 | 0.056 | 0.028 | |
| $Cl^-$, mmol/L | | | | | | | | | | |
| Sham (n = 20) | 110.4$^{de,x}$ | 109.0$^{e}$ | 114.0$^{ab}$ | 115.5$^{a}$ | 111.6$^{cd,y}$ | 112.7$^{bc,y}$ | 113.4$^{bc}$ | 109.1$^{e}$ | 112.0$^{y}$ | 0.22 |
| Slip (n = 20) | 110.9$^{c,x}$ | 110.2$^{c}$ | 113.7$^{b}$ | 115.2$^{ab}$ | 114.4$^{ab,x}$ | 116.7$^{a,x}$ | 114.2$^{b}$ | 107.4$^{d}$ | 112.8$^{x}$ | 0.20 |
| Capon (n = 20) | 105.8$^{d,y}$ | 109.3$^{bc}$ | 115.0$^{a}$ | 114.7$^{a}$ | 115.3$^{a,x}$ | 113.2$^{a,y}$ | 114.2$^{a}$ | 108.0$^{c}$ | 111.9$^{y}$ | 0.19 |
| S.E. | 0.37 | 0.36 | 0.41 | 0.28 | 0.26 | 0.40 | 0.25 | 0.51 | 0.18 | |

$^{a, b, c, d, e}$ Means within the same row without the same superscripts differ ($P < 0.05$).

$^{x, y, z}$ Means within the same column without the same superscripts differ ($P < 0.05$).

Table 2. Effect of age on the concentrations of plasma ionized calcium, total calcium, inorganic phosphorus, magnesium, and activity of alkaline phosphatase of native chickens

| Items | Weeks of age | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | Mean | S.E. |
| $Ca^{2+}$, mmol/L | | | | | | | | | | |
| Sham (n = 20) | $1.13^{d,y}$ | $1.14^{d,y}$ | $1.27^{y,c}$ | $1.47^{ab,y}$ | $1.42^{ab,y}$ | $1.41^{b,y}$ | $1.40^{b,y}$ | $1.49^{a,y}$ | $1.34^{y}$ | 0.009 |
| Slip (n = 20) | $1.24^{de,x}$ | $1.22^{e,x}$ | $1.29^{xy,d}$ | $1.51^{b,x}$ | $1.59^{a,x}$ | $1.40^{c,y}$ | $1.57^{a,x}$ | $1.58^{a,x}$ | $1.43^{x}$ | 0.007 |
| Capon (n = 20) | $1.26^{e,x}$ | $1.24^{e,x}$ | $1.35^{x,d}$ | $1.51^{c,x}$ | $1.62^{ab,x}$ | $1.51^{c,x}$ | $1.55^{bc,x}$ | $1.64^{x,a}$ | $1.46^{x}$ | 0.010 |
| S.E. | 0.011 | 0.013 | 0.010 | 0.007 | 0.007 | 0.006 | 0.011 | 0.016 | 0.014 | |
| Total calcium, mg/dL | | | | | | | | | | |
| Sham (n = 20) | $11.45^{a}$ | $11.38^{a}$ | $11.58^{a}$ | $10.96^{ab}$ | $10.56^{bc}$ | $10.28^{bc}$ | $10.08^{c}$ | $10.55^{bc}$ | 10.86 | 0.234 |
| Slip (n = 20) | $11.42^{ab}$ | $11.54^{a}$ | $12.10^{a}$ | $10.69^{bc}$ | $10.34^{c}$ | $10.64^{bc}$ | $10.12^{c}$ | $10.36^{c}$ | 10.90 | 0.246 |
| Capon (n = 20) | $11.38^{ab}$ | $11.97^{a}$ | $12.02^{a}$ | $11.59^{ab}$ | $10.77^{bc}$ | $10.56^{c}$ | $10.27^{c}$ | $10.57^{c}$ | 11.14 | 0.242 |
| S.E. | 0.246 | 0.286 | 0.342 | 0.314 | 0.272 | 0.249 | 0.234 | 0.194 | 0.230 | |
| Inorganic phosphorus, mg/dL | | | | | | | | | | |
| Sham (n = 20) | $5.42^{a,y}$ | $5.06^{a,z}$ | $4.23^{b,z}$ | $3.87^{bc,z}$ | $3.55^{c,z}$ | $3.57^{c,y}$ | $3.28^{c,z}$ | $3.51^{c,y}$ | $4.06^{z}$ | 0.062 |
| Slip (n = 20) | $5.82^{a,y}$ | $5.81^{a,y}$ | $5.04^{b,y}$ | $4.69^{bc,y}$ | $4.43^{cd,y}$ | $4.06^{de,xy}$ | $3.67^{ef,y}$ | $3.48^{f,y}$ | $4.63^{y}$ | 0.077 |
| Capon (n = 20) | $6.18^{a,x}$ | $6.27^{a,x}$ | $5.89^{a,x}$ | $5.35^{bc,x}$ | $4.93^{c,x}$ | $4.44^{d,x}$ | $4.07^{d,x}$ | $4.33^{d,x}$ | $5.18^{x}$ | 0.057 |
| S.E. | 0.114 | 0.094 | 0.092 | 0.111 | 0.089 | 0.103 | 0.084 | 0.072 | 0.059 | |
| Magnesium, mg/dL | | | | | | | | | | |
| Sham (n = 20) | $2.04^{b}$ | $2.03^{b}$ | $2.36^{a}$ | $2.33^{a}$ | $2.20^{ab}$ | $2.17^{ab}$ | $2.18^{ab}$ | $2.38^{a}$ | 2.21 | 0.073 |
| Slip (n = 20) | $2.02^{b}$ | $2.01^{b}$ | $2.24^{ab}$ | $2.18^{ab}$ | $2.24^{ab}$ | $2.28^{ab}$ | $2.44^{a}$ | $2.38^{a}$ | 2.22 | 0.063 |
| Capon (n = 20) | $2.03^{b}$ | $2.00^{b}$ | $2.17^{ab}$ | $2.14^{ab}$ | $2.35^{a}$ | $2.32^{a}$ | $2.21^{ab}$ | $2.44^{a}$ | 2.21 | 0.060 |
| S.E. | 0.111 | 0.108 | 0.208 | 0.068 | 0.075 | 0.092 | 0.067 | 0.068 | 0.142 | |
| Alkaline phosphatase, U/L | | | | | | | | | | |
| Sham (n = 20) | $1,386.4^{ab}$ | $1,348.6^{ab}$ | $1,424.6^{a,y}$ | $1,277.2^{ab}$ | $1,120.6^{ab}$ | $953.2^{ab}$ | $784.2^{ab}$ | $363.8^{b,y}$ | $1,082.3^{y}$ | 313.48 |
| Slip (n = 20) | $1,936.6^{c}$ | $1,989.2^{ab}$ | $2,113.7^{a,xy}$ | $1,548.3^{ab}$ | $1,184.4^{ab}$ | $1,065.7^{ab}$ | $527.5^{ab}$ | $303.6^{b,y}$ | $1,333.6^{xy}$ | 432.13 |
| Capon (n = 20) | $2,107.2^{abc}$ | $2,353.4^{ab}$ | $2,599.7^{a,x}$ | $1,896.3^{abc}$ | $1,202.6^{abc}$ | $1,052.4^{abc}$ | $916.3^{bc}$ | $467.5^{c,x}$ | $1,574.4^{x}$ | 508.64 |
| S.E. | 531.78 | 543.06 | 533.78 | 381.46 | 183.48 | 188.78 | 184.25 | 45.69 | 150.44 | |

[a, b, c, d, e, f] Means within the same row without the same superscripts differ ($P < 0.05$).

[x, y, z] Means within the same column without the same superscripts differ ($P < 0.05$).

Table 3. Effect of age on the activity of plasma creatine kinase, plasma creatinine, uric acid, triglyceride, total cholesterol, and total protein of native chickens

| Items | Weeks of age | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | Mean | S.E. |
| Creatine kinase, U/L | | | | | | | | | | |
| Sham (n = 20) | 173.7$^{ab}$ | 199.6$^{a}$ | 167.3$^{ab}$ | 171.4$^{ab,y}$ | 145.6$^{b}$ | 161.5$^{ab}$ | 139.2$^{b}$ | 202.0$^{a}$ | 170.0$^{y}$ | 4.30 |
| Slip ( n= 20) | 165.4$^{bc}$ | 204.9$^{ab}$ | 158.5$^{c}$ | 154.0$^{c,y}$ | 152.0$^{c}$ | 159.6$^{c}$ | 164.1$^{bc}$ | 225.2$^{a}$ | 173.0$^{y}$ | 5.05 |
| Capon (n = 20) | 159.9$^{ab}$ | 211.4$^{ab}$ | 173.7$^{ab}$ | 212.4$^{ab,x}$ | 175.9$^{ab}$ | 200.8$^{ab}$ | 154.6$^{b}$ | 215.6$^{a}$ | 188.0$^{x}$ | 5.86 |
| S.E. | 8.23 | 7.46 | 6.85 | 8.00 | 7.85 | 9.90 | 9.87 | 12.82 | 3.26 | |
| Creatinine, mg/dL | | | | | | | | | | |
| Sham (n = 20) | 0.470$^{a,x}$ | 0.450$^{ab,x}$ | 0.440$^{ab,x}$ | 0.430$^{ab}$ | 0.420$^{ab}$ | 0.410$^{ab,x}$ | 0.410$^{ab,x}$ | 0.400$^{b}$ | 0.429$^{x}$ | 0.0057 |
| Slip ( n= 20) | 0.420$^{abc,y}$ | 0.460$^{a,x}$ | 0.440$^{ab,x}$ | 0.410$^{abc}$ | 0.430$^{abc}$ | 0.370$^{c,xy}$ | 0.410$^{abc,x}$ | 0.400$^{bc}$ | 0.414$^{xy}$ | 0.0060 |
| Capon (n = 20) | 0.450$^{ab,xy}$ | 0.410$^{bcd,y}$ | 0.400$^{bcd,y}$ | 0.420$^{bc}$ | 0.400$^{bcd}$ | 0.356$^{d,y}$ | 0.370$^{cd,y}$ | 0.390$^{cd}$ | 0.399$^{y}$ | 0.0061 |
| S.E. | 0.0012 | 0.0098 | 0.0096 | 0.0011 | 0.0013 | 0.0097 | 0.0098 | 0.0014 | 0.0038 | |
| Uric acid, mg/dL | | | | | | | | | | |
| Sham (n = 20) | 3.24$^{c,y}$ | 4.42$^{c}$ | 6.72$^{a,x}$ | 6.28$^{ab,x}$ | 7.73$^{ac,x}$ | 7.56$^{a,x}$ | 7.56$^{a,x}$ | 6.46$^{ab,x}$ | 6.25$^{x}$ | 0.183 |
| Slip (n = 20) | 3.76$^{b,xy}$ | 4.31$^{ab}$ | 5.49$^{ab,y}$ | 4.27$^{ab,y}$ | 4.30$^{ab,y}$ | 4.59$^{ab,y}$ | 5.45$^{ab,y}$ | 5.92$^{a,xy}$ | 4.76$^{y}$ | 0.208 |
| Capon (n = 20) | 4.21$^{x}$ | 4.03 | 3.51$^{z}$ | 3.88$^{y}$ | 4.09$^{y}$ | 3.68$^{z}$ | 4.64$^{z}$ | 4.78$^{y}$ | 4.10$^{y}$ | 0.206 |
| S.E. | 0.231 | 0.218 | 0.410 | 0.321 | 0.421 | 0.429 | 0.441 | 0.381 | 0.169 | |
| Total cholesterol, mg/dL | | | | | | | | | | |
| Sham (n = 20) | 113.0$^{a}$ | 98.9$^{abc,y}$ | 106.7$^{ab,y}$ | 102.7$^{ab,y}$ | 87.6$^{cd,z}$ | 94.8$^{bcd,y}$ | 82.6$^{d,z}$ | 84.9$^{cd,z}$ | 96.4$^{z}$ | 1.49 |
| Slip (n = 20) | 123.4$^{a}$ | 109.6$^{b,xy}$ | 102.6$^{bcd,y}$ | 107.2$^{bc,y}$ | 105.9$^{bcd,y}$ | 109.8$^{b,y}$ | 94.3$^{d,y}$ | 97.2$^{cd,y}$ | 106.3$^{y}$ | 1.33 |
| Capon ( n= 20) | 118.7 | 116.7$^{x}$ | 122.7$^{x}$ | 126.9$^{x}$ | 123.6$^{x}$ | 129.2$^{b,x}$ | 127.6$^{x}$ | 128.1$^{x}$ | 124.2$^{x}$ | 1.23 |
| S.E. | 2.58 | 2.36 | 2.54 | 2.80 | 2.85 | 3.49 | 2.26 | 2.20 | 0.99 | |
| Triglyceride, mg/dL | | | | | | | | | | |
| Sham (n = 20) | 22.2 | 18.4$^{y}$ | 21.1$^{y}$ | 20.7 | 22.7 | 22.9 | 23.2$^{y}$ | 24.1$^{y}$ | 21.6$^{y}$ | 0.85 |
| Slip (n = 20) | 22.8$^{c}$ | 25.6$^{bc,x}$ | 29.3$^{b,x}$ | 25.2$^{bc}$ | 24.4$^{bc}$ | 26.5$^{bc}$ | 28.3$^{b,x}$ | 33.3$^{a,y}$ | 26.9$^{x}$ | 0.63 |
| Capon (n = 20) | 23.2$^{b}$ | 26.9$^{b,x}$ | 24.5$^{b,xy}$ | 26.8$^{b}$ | 27.7$^{b}$ | 27.1$^{b}$ | 30.5$^{b,x}$ | 41.2$^{a,x}$ | 28.5$^{x}$ | 0.96 |
| S.E. | 1.54 | 1.57 | 1.56 | 1.39 | 1.26 | 1.24 | 1.58 | 1.67 | 0.72 | |
| Total protein, g/dL | | | | | | | | | | |
| Sham (n = 20) | 3.80$^{c,y}$ | 3.93$^{bc,y}$ | 4.07$^{abc,y}$ | 4.38$^{ab,y}$ | 4.53$^{a}$ | 4.30$^{ab,y}$ | 4.40$^{ab,y}$ | 4.22$^{abc,y}$ | 4.20$^{y}$ | 0.048 |
| Slip ( n= 20) | 4.04$^{c,xy}$ | 4.22$^{bc,xy}$ | 4.14$^{c,xy}$ | 4.51$^{ab,xy}$ | 4.48$^{ab}$ | 4.65$^{a,xy}$ | 4.77$^{a,x}$ | 4.59$^{a,xy}$ | 4.42$^{x}$ | 0.035 |
| Capon (n = 20) | 4.20$^{c,x}$ | 4.33$^{bc,x}$ | 4.46$^{bc,x}$ | 4.68$^{abc,x}$ | 4.73$^{abc}$ | 4.73$^{abc,x}$ | 5.04$^{a,x}$ | 4.86$^{ab,x}$ | 4.63$^{x}$ | 0.057 |
| S.E. | 0.069 | 0.071 | 0.088 | 0.068 | 0.073 | 0.089 | 0.072 | 0.181 | 0.033 | |

$^{a, b, c, d}$ Means within the same row without the same superscripts differ ($P < 0.05$).

$^{x, y, z}$ Means within the same column without the same superscripts differ ($P < 0.05$).

Table 4. Comparison on the plasma albumin, globulin, urea nitrogen, lactic acid, total hydroxyproline, free hydroxyproline, low-density lipoprotein, and high-density lipoprotein concentration in Taiwanese native chickens at 28 weeks of age

| Items | Sham (n = 20) | Slips (n = 20) | Capons (n = 20) | S.E. | P |
|---|---|---|---|---|---|
| Albumin, g/dL | 2.8[b] | 3.3[a] | 3.5[a] | 0.16 | < 0.05 |
| Globulin, g/dL | 1.8[b] | 2.1[a] | 2.2[a] | 0.07 | < 0.05 |
| Urea nitrogen, mg/dL | 3.3 | 3.1 | 3.2 | 0.39 | > 0.05 |
| Low-density lipoprotein, mg/dL | 31.8[b] | 41.4[a] | 42.6[a] | 2.64 | < 0.01 |
| High-density lipoprotein, mg/dL | 58.4[b] | 88.2[a] | 91.7[a] | 3.93 | < 0.01 |
| Total hydroxyproline, μg/mL | 11.3[a] | 9.5[b] | 8.8[b] | 0.33 | < 0.05 |
| Free hydroxyproline, μg/mL | 7.2 | 6.7 | 6.3 | 0.25 | > 0.05 |
| Lactic acid, mg/dL | 72.6 | 66.5 | 65.2 | 6.78 | > 0.05 |

[a, b] Means within the same row without the same superscripts differ ($P < 0.05$).

Table 5. Comparison on the plasma testosterone, parathyroid hormone, and calcitonin concentration in Taiwanese native chickens at 28 weeks of age

| Items | Sham (n = 20) | Slips (n = 20) | Capons (n = 20) | S.E. | P |
|---|---|---|---|---|---|
| Testosterone, pg/mL | 1,484.9[a] | 292.9[b] | 43.5[c] | 15.21 | < 0.05 |
| Parathyroid hormone, pg/mL | 13.9 | 14.8 | 15.5 | 1.89 | > 0.05 |
| Calcitonin, pg/mL | 11.0[b] | 15.3[a] | 16.2[a] | 1.04 | < 0.05 |

[a, b, c] Means within the same row without the same superscripts differ ($P < 0.05$).

Taiwan Livestock Res. 53(4)：253-265, 2020
DOI：10.6991/JTLR.202012_53(4).0007

# 去勢對臺灣公土雞血液生理值之影響 (1)

林正鏞 (2)　許振忠 (3)　萬添春 (4)(5)

收件日期：109 年 4 月 30 日；接受日期：110 年 3 月 4 日

## 摘　要

本研究旨在探討年齡對臺灣公土雞、閹公雞及復陽雞 (Slip) 之血液血球容積比 (Packed cell volume, PCV)、血漿 pH 值及血漿生理值之影響。試驗選用畜試土雞臺畜肉十三號公雞，雞隻於 10 週齡去勢，並餵給生長期飼料 ( 10 － 18 週齡 ) 及肥育期飼料 ( 19 － 28 週齡 )。於 14 週齡時再將閹公雞處理組，依雞冠有無再度發育，分為閹公雞組與復陽雞組。試驗雞隻經 12 小時禁食後，每隔二週進行個別雞隻採血，每處理組逢機取樣 20 隻。試驗結果顯示，閹公雞 ( 16 － 28 週齡 ) 具有最高的血漿無機磷、鉀離子及總膽固醇濃度。閹公雞 ( 20 － 28 週齡 ) 具有最低的 PCV、血漿 pH 值；閹公雞於 28 週齡睪固酮濃度最低，復陽雞次之，公雞最高 ($P < 0.05$)。與公雞比較，閹公雞與復陽雞有顯著 ($P < 0.05$) 較高之血漿鈣離子、總蛋白質、白蛋白、球蛋白、三酸甘油酯、低密度脂蛋白、高密度脂蛋白與抑血鈣素濃度，及顯著 ($P < 0.05$) 較低之血漿尿酸濃度。而閹公雞之血漿磷酸激酶和鹼性磷酸酶活性顯著 ($P < 0.05$) 較高，公雞之肌酸酐及總羥脯胺酸顯著 ($P < 0.05$) 較高。血液 PCV 在閹公雞及復陽雞均隨年齡之增加而增加，並分別在 20 及 26 週齡達高峰。而公雞、復陽雞及閹公雞之血漿總鈣濃度在 18 週齡達高峰，22 週齡後降低。公雞、復陽雞及閹公雞之血漿無機磷濃度則隨年齡增加而降低 ($P < 0.05$)。本試驗結果發現，公雞於去勢後 4 至 6 週即會顯著 ($P < 0.05$) 影響 PCV、血漿 pH 值及某些組成，主要與雄性素功能有關，如紅血球生成、蛋白質、脂質、骨骼及結締組織合成。

關鍵詞：年齡、血液生理值、去勢、公雞、睪固酮。

(1) 行政院農業委員會畜產試驗所研究報告第 2661 號。
(2) 行政院農業委員會畜產試驗所產業組。
(3) 國立中興大學動物科學系。
(4) 行政院農業委員會畜產試驗所技術服務組。
(5) 通訊作者，E-mail: tcwan@tlri.gov.tw。