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Original Article

Laparoscopic vacuum testectomy technique for castration Royal Project Bresse chickens on highland of Thailand

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Abstract

One hundred and eighty 4-week-old Bresse cockerels were allotted into 6 groups of 3 replications/group according to a 2x3 Factorial in a Completely randomized design. The main factor was traditional vs. custom or developed caponizing tools while the sub-factor was the age of the birds at castration i.e., 4, 6, and 8 weeks of age. All birds were raised on a highland farm in Thailand until 12 weeks old before slaughtering and carcass evaluation. Using the custom tools significantly decreased ($P<0.05$) incision size, caponizing time, mortality rate, and slip. At the same time the birds significantly increased average daily gain and feed intake but no significant differences on feed conversion ratio and carcass quality. Early age castration by the custom tools improved the efficiency and bird performance. In conclusion, the Laparoscopic vacuum testectomy technique can be done at 4 weeks of age. It minimized incision size, shortened caponizing time, and improved the performance of Bresse capon production at a highland farm of the Royal Project Foundation.

Keywords: Bresse, capon, castration, caponizing tool, laparoscopy vacuum testectomy

1. Introduction

Capon is a castrated male chicken that is popular among consumers in many Asian countries such as Thailand, Malaysia, Singapore, and China because the chicken is more tender and juicier, and the meat has a better flavor than uncastrated chickens (Jacob & Mather, 2000). The market price of a capon is around two times higher than a broiler. Castration can be done either by embedding female hormone-like substances, such as diethylstilbestrol, into the lower part of the skull or by completely removing both testes, which produce testosterone, to reduce male behavior (Andrew & Jones, 1992). Castration results in the accumulation of abdominal and muscular fat (Chen, Wu, & Hong, 2000) which provides the preferable flavor and taste. Since 1986 hormone embedding was banned to avoid hormone residues that may be harmful to consumers. Therefore, castration is done by removing the testes which requires high skill and expertise to save time and reduce the loss of chickens. Rikimaru, Takahashi, and Nichlos (2011) have developed more practical and effective equipment which reduces castration time to 1 min per chick. The equipment used in Thailand is still the traditional equipment (Figure 1A) which needs to be performed in chickens at around 8 weeks of age. The risk may be high since a wide wound is needed to remove the larger testes and the testicular tissue is tougher than in younger chicks. Moreover, removing the testes with a dip cup is quite difficult because the testes are located near large blood vessels which may overstress the chicken. Therefore, improvements in the technique and equipment are required for easy implementtation by low skilled farmers and to reduce the loss of chickens.

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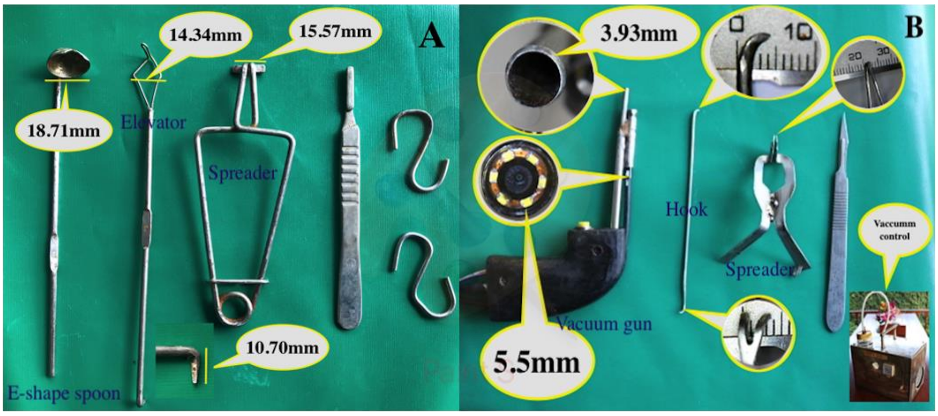

Figure 1. Caponizing tools: (A) Traditional tools; (B) Customized or developed tools.

Laparoscopy is a procedure that uses a laparoscope and a thin tube with a light and camera on the end. Under general anesthesia it is inserted through a small cut or incision (0.5 to 1 cm) into or near the navel. The camera can project images onto an external screen, which allows surgeons to directly visualize the pelvic and abdominal organs. This permits performance of keyhole surgery which uses much smaller surgical tools without the need for large incisions. When laparoscopy is performed, gas is gently pumped into the abdomen to increase the workspace for the camera and tools. Although there is a small risk of damage to the organs, the cut is small, a clear view of the structures is possible, and there is an absence of abdominal bleeding (Ahmad, Baker, Finnerty, Phillips, & Watson, 2019).

Bresse chickens were donated from France to the Royal Project Foundation (RPF), Thailand in 1990. The appearance of the chickens is similar to the French flag, i.e. white feathers, red comb, white beak, and blue legs and shanks. The meat has a tight texture and has a remarkably better flavor than a broiler. It was introduced to the highland farmers as an alternative economic animal due to its higher price than broilers (Tangtaweewipat *et al*., 2014). Castration of Bresse chicken is expected to produce a value-added product of the RPF to serve the high-end market and at the same time provide a better income to farmers.

2. Materials and Methods

The experiment was performed in accordance with the guidelines and rules of care and use of laboratory animal experimentation established by Chiang Mai University, Thailand. The experimental procedure was approved by the Research Committee of Highland Research and Development Institute (Public Organization) and the RPF.

2.1 Birds and experimental design

Two-week-old Bresse cockerels of the RPF, Chiang Mai, Thailand were used as experimental animals. They were raised in an open house within a back-yard of a highland farmer at 800 m above mean sea level. At 4 weeks of age, 180 birds were individually weighed and randomly assigned into 6 groups of 3 replications (rep)/group with 10 chicks/rep according to a 2x3 Factorial in a Completely randomized design. The main factor was traditional vs. custom caponizing tools, while the sub-factor was the age of the birds at castration i.e., 4, 6, and 8 weeks of age. Commercial feed and water were provided *ad libitum* until 12 weeks of age. From week 1 to week 6, the birds were fed 21% crude protein (CP) with 3,200 kcal of metabolizable energy (ME)/kg starter ration. From week 7 to week 12, they were fed 19% CP with 3,200 kcal ME/kg grower ration. The birds were vaccinated according to the RPF vaccine program. The health of the birds was checked daily and the microclimate conditions were also monitored during the whole investigation period.

2.2 Development of the caponizing tools

The customized equipment was comprised of 4 units. (1) The caponizing table consisted of auto lockers for the shanks and wings, chair, tablet holder, and disinfectant cup (Figure 2). The table could be folded for easy moving and could be mechanically locked by pressing down on the front table surface for opening of the loops. After inserting the shanks and the wings into the loops and lifting the table up, the two regions were automatically secured. Then a screw could be loosened to move the shank locker forward or backward by a direct current motor gear (speed 100 rpm) or

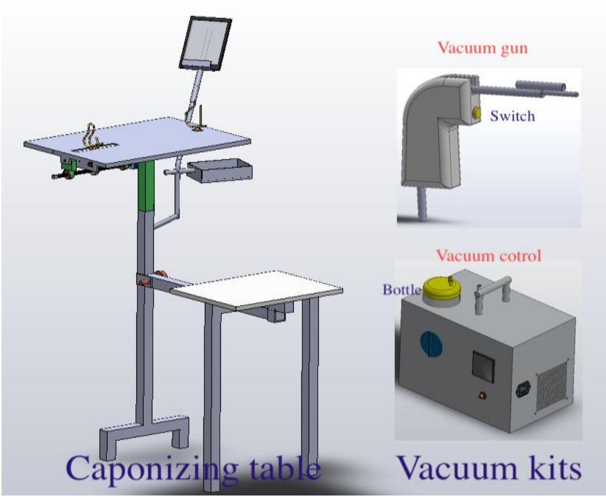

Figure 2. Customized caponizing table and vacuum kits.

manually until the bird's body was stretched out to its full length to expose the rib cage area. (2) The vacuum kit was comprised of a vacuum gun and vacuum pump controller. The vacuum gun had a stainless nozzle with outer and inner diameters of 6.30 and 4.70 mm. A smaller stainless nozzle with outer and inner diameters of 3.93 and 2.92 mm and 20 mm long was connected to the larger nozzle (Figure 1B). The smaller nozzle was smaller than a testes remover (spoon) (3.93 vs. 18.71 mm) and elevator (3.93 vs. 14.34 mm) in the traditional caponizing kits (Figure 1A). The camera end of a 5.5 mm universal serial bus connector endoscope was attached to the top of the large nozzle. The endoscope had 6 LED light sources and a light intensity adjustment gave a large and clear view on a smart phone or tablet during surgery. In addition, a smaller hook and forceps spreader were also developed (Figure 1B).

2.3 Caponizing methods

The cockerels were caponized in order to compare the efficiency of traditional tools to the custom made caponizing tools. By using the traditional castration tools illustrated in Figure 1A, the bird's legs and wings were fastened to a work surface by a rope or rubber band. Feathers on both sides of the last two ribs were removed and the incision was done using a scalpel (No. 24) along the anterior border of the last rib. Both testes were removed using a grooved round spoon or elevator instrument (iron loop). The testicle was thread through the eye of the elevator or spoon groove and twisted until free from its connective tissue**.** In the customized method, the bird's legs and wings were fastened to the new caponizing table. Surgery was done using a scalpel (No. 11), a new spreader, hook, and vacuum kit (Figure 1B). Testectomy was done by touching the tip of the nozzle onto the testes and then pressing the switch of the gun to activate the vacuum pump (flow rate 120 L/min) until the testes were completely sucked into the bottle (Figure 2). Both testes were removed from the single incision. After surgery the incision was not stitched but the wound was disinfected with a 10% wt/vol povidone-iodine solution. The air puff problem which occurred in some birds was released by repeat insertion of a sharp pointed knife into the wound. The castration methods using the traditional vs. custom tools are shown in Figure 3.

2.4 Surgical size, caponizing time, mortality rate, and carcass composition

The time required for castration, i.e. from fastening the bird to a work surface until the testes were removed, as well as surgical size and body weight (BW) of all experimental birds were individually recorded. The surgical size was measured along the anterior border of the last rib using a Vernier caliper (Mitutoyo-500; Mitutoyo Thailand). The mortality rate was calculated on the basis of bird death between the time of surgery and 2 days later. Beyond 2 days no mortality occurred in this experiment. The BWs of the chicks were measured at 4, 6, 8, and 12 weeks of age. Incomplete castration (slip) was identified visually and checked after slaughtering all birds at 12 weeks of age in the RPF slaughter house. For carcass evaluation, the replicate was the average of 2 birds (selected at random) per pen. Carcass percentage was calculated from the weight of the cleaned capons compared with the live capons.

Figure 3. Caponizing methods: (A) Using traditional tools; (B) Using customized tools.

2.5 Statistical analysis

Surgical size, caponizing time, mortality rate, BW gain, feed intake (FI), feed conversion ratio (FCR), and carcass composition were subjected to 2-way ANOVA in which caponizing tools and the age at castration were the main effects. Duncan's new multiple range test was performed when significant differences were found (SAS University Edition software).

3. Results and Discussion

3.1 Castration efficiency

The results of incision size, caponizing time, mortality rate, and slip rate of the 6 groups are shown in Table 1. The incision size of the 8-week group with either the traditional or customized caponizing tools was larger than the 4- and the 6-week groups ($P<0.05$). This occurred because the 8-week-old birds had larger testes as well as larger ribs and body cavity than the younger birds. Therefore, a larger incision was necessary to insert the tools to remove the testes. However, no significant difference was found between the 4-week and 6-week groups. It was found that the custom made tools could significantly reduce the average incision size of all age groups by 46.49% (11.97±0.04 vs. 22.37±0.22 mm, $P<0.01$). This occurred because of the Laparoscopic vacuum testectomy technique. In addition, the size of the vacuum nozzle tip with the camera (3.93+5.50 mm) was much smaller

Table 1. Effects of caponized tools and age on castration efficiency in Bresse chickens.

Items	Caponizing tools	Age at castration (week)			Mean[1]
		4	6	8	
BW at castration (g)	Traditional	299.10	710.17	1,117.13	708.80±38.36
	developed	295.07	715.00	1,117.27	709.11±45.15
	mean[1]	297.09^{x}±33.88	712.59^{y}±27.33	1,117.20^{z}±64.06	
Caponizing time (min)	Traditional	6.98^{a}	6.12^{b}	5.01^{c}	6.04^{m}±0.45
	developed	1.79^{e}	2.99^{d}	3.38^{d}	2.72^{n} ±0.17
	mean	4.39±0.14	4.46±0.42	4.20±0.37	
Incision size (mm)	Traditional	22.11	22.36	22.65	22.37^{m}±0.22
	developed	11.22	11.48	13.22	11.97^{n}±0.04
	mean	16.67^{x}±0.48	16.92^{x}±0.71	17.94^{y}±0.54	
Mortality (%)	Traditional	30.00^{a}	16.67^{b}	3.33^{c}	16.67^{m}±7.18
	developed	3.33^{c}	3.33^{c}	0.00^{c}	2.22^{n} ±3.85
	mean	16.67^{x}±7.89	10.00^{x}±5.77	1.67^{y}±2.89	
Slip (%)	Traditional	80.00^{a}	30.00^{b}	13.33^{c}	41.11^{m}±8.59
	developed	6.67^{c}	6.67^{c}	10.00^{c}	7.78^{n}±9.11
	mean	43.34^{x}±7.89	18.34^{y}±10.77	11.67^{y}±7.89	

P-value:

Source	Age at castration	Caponizing tools	Age x Caponizing tools
BW at castration	<0.0001	0.9886	0.9855
Caponizing time	0.2729	<0.0001	<0.0001
Incision size	0.0177	<0.0001	0.1488
Mortality	0.0046	0.0004	0.0226
Slip	0.0001	<0.0001	<0.0001

$^{a-e, m-n, x-z}$ Values with no common superscript differs significantly when tested with Duncan's New Multiple Range Test following Analysis of Variance

[1]Mean=main effects mean±SDM

BW=body weight

than the grooved round spoon and the elevator of the traditional model which were 18.71 and 14.34 mm, respectively.

Caponizing time was recorded from fastening the bird to the work surface until the testes were removed. The customized tool method also required significantly less time for all ages of birds (2.72±0.17 vs. 6.04±0.45 min, P<0.01) compared with the traditional tools. It gave a clear view of the body cavity on external screens for easy cutting and removing of the testes from the body cavity which indicated the efficiency of the customized tools.

There was a significant relationship between the caponizing tools and the age of the birds on caponizing time (P<0.01). Castration with the traditional tools in the 4-week group required significantly more time than the 6- and the 8-week groups (6.98 vs. 6.12 vs. 5.01 min). This was possibly due to the smaller incision size of the smaller younger birds which caused difficulty in removing the testes. In contrast, the customized tools required significantly less time in the 4-week-old group than the 6- and the 8-week groups (1.79 vs. 2.99 vs. 3.38 min). This was possible because the younger birds had softer connective tissue and smaller testes than the older birds. This result agreed with Rikimaru *et al*. (2011) who reported that early castration at 2 and 4 weeks of age in the Hinai-jidori chicken by small loop forceps (12 mm) needed less caponizing time than the spoon forceps (19 mm) at 8 weeks of age. In addition the tunica albuginea of the testes becomes hard as the birds become older which makes testicular removal more difficult and time consuming (Rikimaru, Yasuda, Komastu & Ishizuku, 2009).

The birds castrated with traditional tools at a younger age had a significantly higher mortality rate than the older birds. There was also a higher percentage of slip. In contrast, the customized tools had no significant effects on these two parameters among the different groups of castration age. The customized tools in all age groups significantly reduced mortality by 86.68% (2.22±3.85 vs. 16.67±7.18%, P<0.01) and slip by 81.08% (7.78±9.11 vs. 41.11±8.59%, P<0.01) compared with the traditional tools. This was likely due partially to greater injury caused by the larger size and inconvenient use of the traditional, large grooved round spoon which caused more difficulty in castration of the smaller birds compared to the customized tools. Mašek *et al*. (2013) and Rikimaru *et al*. (2011) reported that, in general, caponizing losses are estimated to range from 5 to 20% and slip is around 10% of the birds (Sirri, Bianchi, Petracci, & Meluzzi, 2009). The mortality rate of the birds castrated with the traditional tools at a young age, especially at 4 weeks in this experiment, indicated that the traditional tools are not appropriate for younger birds. This is in agreement with the general recommendation that the birds should be castrated at 8 weeks of age.

3.2 Growth performance

The initial BWs at 4 weeks of all groups and their performances are shown in Table 2. At 12 weeks of age, there was a significant relationship (P<0.05) between caponizing tools and the age of the birds on BW and average daily gain (ADG). The traditional tools showed no significant differences among the different castration ages in these parameters. However, use of the customized tools decreased BW and ADG in the 8-week-old castration group. The BW and ADG of the birds castrated with the customized tools at 4 weeks of age were significantly higher than the 8-week-old group (1,874.84 vs. 1,719.67 g BW and 28.21 vs. 25.36 g ADG). Rikimaru *et al.* (2011) also found similar results in birds castrated at 2 and 4 weeks old with 12 mm loop forceps of a new type of tool compared to the group castrated at 8 weeks with 19 mm spoon forceps of the traditional type of tools. This possibly occurred because of more surgical stress in the older age group. In addition, the 8-week group was probably approaching sexual maturity which may have also negatively influenced growth (Shao, Wu, & Zhao, 2009).

The birds castrated with the customized tools had significantly higher BW and ADG at 12 weeks of age compared to the traditional tools. On average, the customized tools improved the BW at 12 weeks old by 6.14% (1,802.10±34.84 vs. 1,697.88±64.68 g, P<0.01) and ADG by 7.39% (26.89±0.80 vs. 25.04±0.99 g, P<0.01). This was possibly due to the lower FI of the traditional tool groups (92.62±4.16 vs. 97.06±1.93 grams/bird/day, P<0.05) which was possibly caused by greater surgical stress at caponizing comparing to the customized equipment. However, no significant difference on FCR was found among the groups.

3.3 Carcass quality

At 12 weeks of age, 6 capons/group were randomly selected for slaughtering. The carcass compositions are shown in Table 3. There were no significant differences between the types of castration equipment on the percentages of carcass, breast, thighs, drumsticks, and abdominal fat. These results indicated no influence of the castration methods on these parameters. However, the results of this work confirmed the effect of caponization on abdominal fat deposition compared with the carcasses of Bresse capons at 12 weeks of age in this experiment with the uncastrated chicks of the same age reported by Tangtaweewipat, Cheva-Isarakul, Puakcharoen, Sonloy, and Thantharuk (2015). It was found that abdominal fat composition in the capons was twice as high as the uncastrated chicks (1.97–2.03 vs. 1.07%), while the ratio of other carcass compositions were in the same range, i.e. breast 11.62–12.33 vs. 11.23%, thighs 11.46–12.02 vs. 11.55%, and drumsticks 8.40–8.56 vs. 8.38%. This possibly resulted from androgen deficiency which accelerates abdominal fat accumulation (Chen, Chen, Lin, & Chiou, 2007; Guo *et al*., 2015).

Table 2. Effects of caponized tools and age of birds at castration on performance of Bresse chickens.

Items	Caponizing tools	Age at castration (week)			Mean[1]
		4	6	8	
Initial wt. at 4-week old (g)	Traditional	299.10	291.70	296.80	295.87±14.24
	Developed	295.07	294.30	299.47	296.28±17.50
	Mean[1]	297.09±33.88	293.00±3.79	298.14±9.94	
Final wt. at 12 weeks old (g)	Traditional	1,688.74^{c}	1,697.90^{c}	1,707.00^{c}	1,697.88^{n}±64.68
	Developed	1,874.84^{a}	1,811.78^{ab}	1,719.67^{bc}	1,802.10^{m}±34.84
	Mean	1,781.79±50.92	1,754.84±52.14	1,713.34±46.42	
ADG (g)	Traditional	24.82^{c}	25.11^{c}	25.18^{c}	25.04^{n}±0.99
	Developed	28.21^{a}	27.10^{ab}	25.36^{bc}	26.89^{m}±0.80
	Mean	26.52±0.90	26.10±0.96	25.27±0.83	
FI (g/b/d)	Traditional	86.18	91.95	99.72	92.62^{n}±4.16
	Developed	94.89	95.69	100.60	97.06^{m}±1.93
	Mean	90.54^{y}±2.99	93.82^{y}±3.61	100.16^{x}±2.53	
FCR	Traditional	3.47	3.66	3.96	3.70±0.15
	Developed	3.37	3.53	3.97	3.62±0.08
	Mean	3.42^{z}±0.15	3.60^{y}±0.09	3.97^{x}±0.11	

P-value:

Source	Age at castration	Caponizing tools	Age x Caponizing tools
Initial wt. at 4-week-old	<0.0001	0.3664	0.5148
Final wt. at 12-week-old	0.1258	0.0014	0.0480
ADG	0.1304	0.0020	0.0490
FI	0.0018	0.0219	0.2028
FCR	<0.0001	0.2133	0.6269

$^{a-c,\ m-n,\ x-z}$ Values with no common superscript differs significantly when tested with Duncan's New Multiple Range Test following Analysis of Variance
[1]Mean = main effects mean±SDM
ADG=average daily gain, FI=feed intake, g/b/d=grams/bird/day, FCR=feed conversion ratio.

Table 3. Body weight and percentage of carcass composition of Bresse capons at 12 weeks of age.

Items	Caponizing tools	Age at castration (week)			Mean[1]
		4	6	8	
Body weight[2] (g)	Traditional	1,823.50	1,825.33	1,822.67	1,823.83±52.63
	developed	1,841.33	1,821.67	1,820.00	1,827.67±50.49
	mean[1]	1,832.42±34.98	1,823.50±68.97	1,821.34±50.73	
Carcass (%)	Traditional	77.53	80.74	77.59	78.62±1.97
	developed	77.86	78.38	78.35	78.20±0.42
	mean	77.70±0.58	79.56±1.96	77.97±1.06	
Breast (%)	Traditional	11.63	11.73	11.51	11.62±0.74
	developed	12.75	11.76	12.49	12.33±0.89
	mean	12.19±1.14	11.75±0.60	12.00±0.72	
Thighs (%)	Traditional	11.91	11.23	11.25	11.46±0.95
	developed	11.94	11.71	12.40	12.02±0.67
	mean	11.93±0.46	11.47±1.02	11.83±0.94	
Drumsticks (%)	Traditional	8.54	7.89	8.76	8.40±0.43
	developed	8.58	8.73	8.36	8.56±0.29
	mean	8.56±0.09	8.31±0.51	8.56±0.48	
Abdominal fat (%)	Traditional	2.26	1.93	1.72	1.97±0.74
	developed	2.09	2.20	1.80	2.03±0.89
	mean	2.18±1.14	2.07±0.60	1.76±0.72	

P-value: Source	Age at castration	Caponizing tools	Age x Caponizing tools
Body weight	0.9421	0.8922	0.9384
Carcass	0.1865	0.6219	0.2897
Breast	0.6989	0.1169	0.5330
Thighs	0.6668	0.2203	0.5699
Drumsticks	0.5304	0.4272	0.0678
Abdominal fat	0.1008	0.6895	0.5010

[1] Mean = main effects mean±SDM
[2] From 2 randomly selected capons/replication (6 capons/treatment)

4. Conclusions

The results of this study showed the possibility of using the Laparoscopic vacuum testectomy technique of customized caponizing tools for castration of cockerels. It helps to save time, lower the mortality and slip rates, as well as reduce surgical stress that was indicated by the lower FI. In addition it also improved growth performance of the birds compared to the traditional tools. High castration efficiency can be performed at the age of 4 weeks. This shows that the customized caponizing tools can be used for capon production and the procedure should be applied in practice on a wider scale.

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