

The effect of caponization on production indices and carcass and meat characteristics in free-range Extremeña Azul chickens

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Abstract

This paper reports the effect of caponization on production indices and carcass and meat characteristics in free-range Extremeña Azul chickens. At 11 weeks, capon body weight was significantly lower than that of roosters ($p < 0.05$), although it was similar at slaughter. There were no significant differences in the corresponding percentages of abdominal fat and eviscerated carcass. However, the corresponding percentages of wings, breast and butchered portions (thighs + drumsticks + wings + breast) were significantly greater ($p < 0.05$) in capons. However, the corresponding percentages of neck, thighs + drumsticks, and the edible portion of the thighs + drumsticks were greater in roosters ($p < 0.05$). In tests involving 48 consumers, no significant differences were detected in capon and rooster meat organoleptic characteristics.

Key words: capons, roosters.

Resumen

Efecto de la castración sobre índices productivos y características de la canal y de la carne de pollos de la raza Extremeña Azul criados en extensivo

Se realizó un estudio para evaluar el efecto de la castración sobre índices productivos y características de la canal y de la carne de pollos de la raza Extremeña Azul criados en extensivo. La castración disminuyó significativamente el peso vivo de los capones a las 11 semanas de edad ($p < 0,05$). A la edad de sacrificio (228 días) capones y gallos presentaron pesos similares. No hubo diferencias significativas en el porcentaje de grasa abdominal y en el rendimiento de la canal eviscerada. Sin embargo, el porcentaje de alas, de pechuga y el rendimiento del despiece fue significativamente mayor ($p < 0,05$) en los capones, mientras que el porcentaje de cuello, de muslos + contramuslos y de producto consumible de muslos + contramuslos fue mayor en los gallos ($p < 0,05$). No hubo diferencias significativas en las características organolépticas de la carne de capón y de gallo percibidas por 48 consumidores.

Palabras clave: capones, gallos.

Introduction

Extremeña Azul chickens (*Gallus gallus* L.) are capable of living outdoors but show scant body development. Although this breed is not officially recognised, it does have a basic morphological pattern (Orozco, 2000), there is an aviculture association (in Extremadura, Spain) interested in its rearing, and it is in demand as a pet by owners of country houses.

The native breeds of Extremadura are considered part of the region's identity; they therefore enjoy protection and their rearing is encouraged. For this reason, the Research and Technological Development

Dept. of the Extremadura Regional Government (*Servicio de Investigación y Desarrollo Tecnológico de la Junta de Extremadura*) maintains the Valdesequera Farm in Badajoz. This facility has a population of Extremeña Azul chickens, the morphology and productive capacity of which have been the subject of research since the year 2000 (Muriel, 2002). The intention is to encourage the rearing of this breed not only as a leisure activity but as a commercial concern.

Free-range chickens are a production alternative to intensive exploitation (Muriel *et al.*, 1997). However, the market for speciality products such as *poullards*, country chickens, ecological chickens, *picantones* and capons is very small, with peak demand normally at Christmas.

According to CEE regulation no. 1000/96 (OJ, 1996), a capon is a male chicken that has been surgically

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castrated before having reached sexual maturity, and slaughtered at a minimum age of 140 days. Once castrated, capons must be subjected to a minimum fattening period of 77 days.

In capon production, light-weight, middle-weight or heavy-weight chicken breeds or strains can be used. In Spain, the following native breeds are currently used in capon production: *Catalana del Prat* (BOE, 1991), *Penedesenca Negra* (Cubiló *et al.*, 2000a), *Ampurdanesa Roja* (Cubiló and Tor, 1999a), *Mos* (Sánchez *et al.*, 1995, 2000), *Castellana Negra* (Ciria *et al.*, 2002 a and b) and several Andalusian breeds (Villena *et al.*, 2002). This industry contributes to the conservation of chicken genetic resources. Similar use is made of native breeds in France (e.g., of the Bresse or Géline de Loué breeds) and in Hungary (Barna *et al.*, 1995).

Few studies have examined the effects of castration on bird growth and carcass and meat characteristics through the comparison of these variables in capons and roosters. The aim of the present work was to perform such a comparison in free-range Extremeña Azul poultry.

Material and Methods

Animals and their management

The starting material consisted of 400 non-sexed Extremeña Azul chicks with a mean birth weight of 37.5 g. Each bird was identified with a metallic band on the wing membrane.

The chicks were raised following European legislation for the production of traditional free-range animals (OJ, 1991), living outside from the age of six weeks. Until this time they lived in a 50 m² henhouse with electrical heating. Continuous lighting was provided during the first week of life, after which natural light was made available.

At six weeks the chicks were sexed and the males transferred to open corrals on the Valdesequera Farm (Badajoz). One hundred were randomly selected for caponization and 84 were left untouched to act as controls. These were separately placed in 500 m² corrals, each with a metal-frame shelter. The birds were raised between March and November of 2002. During the time they lived outside, the maximum and minimum temperatures recorded were 44°C (in June) and 3°C (in October).

At 60-64 days of age, the 75 males still available in the caponization group were surgically castrated by

Table 1. Chemical composition of feeds

	Starter feed	Fattening feed
ME (kcal kg ⁻¹)	3,100	2,900
CP (%)	23.5	18.2
Ash (%)	8.2	5.9
GF (%)	1.8	4.2
EE (%)	4.2	2.3
DM (%)	91.0	92.5

ME: metabolizable energy. CP: crude protein. GF: gross fibre. EE: ether extract. DM: dry matter. All values refer to fresh weight of product.

testicular strangulation (intercostal approach) (Van der Horst, 1997).

The birds were fed *ad libitum*. Until the age of six weeks, a ground feed was provided, but from this moment until slaughter they were fed granulated 70% cereal feed. Table 1 shows the chemical composition of these feeds.

Water was also provided *ad libitum* from manually or automatically-filled troughs. At 228 days of age, 70 capons and 44 roosters were taken to slaughter in Talavera La Real (province of Badajoz). In the preceding week, these birds were fed their normal feed but without coccidiostatic additives. Thirty capons and 30 roosters were reserved for the study of their carcasses while the remainder, prepared as eviscerated carcasses without heads or feet, were destined for test consumption to determine consumer acceptability.

Monitoring of variables

Individual weight and feed consumption were measured every two weeks for the first six weeks. The last body measurements before caponization were taken at eight weeks. From this time on, the birds were weighed and feed consumption determined at 11, 15, 20, 25, 30 and 32 weeks. All measurements were made using a Mettler PM 6000 weighing scale.

Carcass samples were frozen until use. Thawing was performed at refrigeration temperature in the Meat Laboratory at the La Orden Farm (Badajoz).

The metatarsus, head, edible viscera (liver, heart and crop) and body fat of the plucked capons and roosters were removed and weighed. The butchering method of the World Poultry Association European Federation (1984) was used. The legs were dissected, separating the meat from the edible product (lean meat, fat and

skin) (Minor *et al.*, 1964). The testes of the roosters were also extracted, as were those that had regenerated in capons. A Cobos D-4000-CS balance was used to measure all carcass weights.

For the study of the meat, habitual chicken consumers were provided with 40 capon and 14 rooster carcasses plus a questionnaire for evaluating the following sensorial characteristics on a 1-10 scale: tenderness (1 = soft, 5 = mid range, 10 = very hard), juiciness (1 = very dry, 5 = mid range, 10 = very juicy), and flavour (1 = very poor, 5 = acceptable, 10 = excellent). The questionnaire included suggestions on how to prepare the meat. The consumers received no previous training. The number of rooster carcasses tested was only 14 since no more consumers were available for this part of the study. Thirty four completed forms were returned for the capon study, and 14 for the rooster study.

Statistical analysis

The results are presented as means, the standard error of the means, and variation coefficients. To evaluate the effect of caponization on the variables measured, the equation $Y = \mu + C + \epsilon$ was used, where Y is the variable considered, μ the mean of the population, C the effect of caponization and ϵ the residual error. Means were compared using the LSD test. Significance was set at 0.05. All data were analysed using Statistica v.5 software (Statsoft, 2002).

Results

Table 2 shows the change in live weight from eight weeks (last measurement before caponization) until

Table 2. Change in live weight (g) (mean \pm standard error) of Extremera Azul capons and roosters

Age (weeks)	Capons	Roosters	Level of significance
8	748.40 \pm 14.04	739.29 \pm 12.02	NS
11	1,152.93 \pm 24.42	1,213.65 \pm 21.26	*
15	1,770.85 \pm 25.79	1,729.13 \pm 25.44	NS
20	2,171.37 \pm 30.00	1,909.48 \pm 27.43	***
25	2,352.29 \pm 31.52	2,145.56 \pm 32.29	***
30	2,553.40 \pm 36.68	2,394.63 \pm 36.65	*
32 + 4 days	2,575.67 \pm 36.80	2,491.96 \pm 37.59	NS

NS: not significant. * $p < 0.05$. *** $p < 0.001$.

slaughter. At 11 weeks (the first weighing after caponization), the capons were significantly lighter than the roosters ($p < 0.05$), but at 15 weeks their weights had equalled. At 20, 25 and 30 weeks, the capons had become significantly heavier than the roosters. At slaughter, capon weight was only slightly greater than rooster weight (not significant).

The feed conversion index was slightly higher for the capons (7.83 compared to 7.32 for the roosters) since their feed consumption was greater (19.86 compared to 17.97) but the weights eventually reached by both types of bird were very similar. As a consequence, the cost of feed per kg live weight produced is somewhat higher for capons (1.87 eur compared to 1.75 eur).

As expected, significant differences ($p < 0.001$) were seen with respect to the effect of caponization on testicular weight. Sixty percent of the capons showed no signs of testicular remains. However, in the majority of the remaining 40%, regeneration of small testes were seen, although these were much lighter than normal rooster testes. The mean capon testicular weight was 2.88 g (mean of 30 birds: 18 with no testicular remains, 5 with remains of one testis, and 7 with remains of 2 testes), while that of roosters was 17.79 g.

Tables 3 and 4 show the effects of caponization on the carcass variables measured. Table 3 shows that capon metatarsus, wing and breast weights were significantly

Table 3. Effect of caponization on carcass variables

Weight (g)	Capons	Roosters
At slaughter	2,613.23 \pm 54.12	2,522.74 \pm 45.17
Metatarsus	110.00 \pm 3.45 ^a	97.29 \pm 2.63 ^b
Head	70.36 \pm 3.12 ^b	82.91 \pm 1.67 ^a
Edible viscera	75.72 \pm 1.58	78.92 \pm 1.57
Abdominal fat	37.00 \pm 4.92	23.88 \pm 4.55
Eviscerated carcass	1,908.58 \pm 44.06	1,829.53 \pm 33.17
Neck	130.36 \pm 3.68	136.53 \pm 3.52
Thighs and drumsticks	687.72 \pm 17.77	681.32 \pm 14.24
Wings	213.47 \pm 4.84 ^a	195.39 \pm 4.03 ^b
Breast	401.90 \pm 11.36 ^a	348.25 \pm 7.97 ^b
Rest of carcass	464.40 \pm 9.84	461.73 \pm 11.05
<i>Dissected thighs and drumsticks</i>		
Edible product	601.37 \pm 15.79	602.21 \pm 12.49
Bone	80.44 \pm 2.62	71.58 \pm 2.01

Figures with different letters in the same row are significantly different ($p < 0.05$).

Table 4. Effect of caponization on carcass and leg dissection variables

Percentage (%)	Capons	Roosters
Abdominal fat ¹	1.43 ± 0.19	0.94 ± 0.18
Eviscerated carcass ¹	72.95 ± 0.28	72.54 ± 0.31
Neck ²	6.84 ± 0.12 ^b	7.46 ± 0.13 ^a
Thighs + drumsticks ²	35.99 ± 0.21 ^b	37.20 ± 0.24 ^a
Wings ²	11.19 ± 0.07 ^a	10.67 ± 0.07 ^b
Breast ²	21.01 ± 0.31 ^a	19.05 ± 0.29 ^b
Rest of the carcass ²	24.40 ± 0.25	25.25 ± 0.41
Butchered portions ³	68.19 ± 0.29 ^a	66.92 ± 0.40 ^b
<i>Dissected thighs and drumsticks⁴</i>		
Edible product	88.20 ± 0.23 ^b	89.40 ± 0.15 ^a
Bone	11.80 ± 0.23 ^a	10.60 ± 0.15 ^b

¹ With respect to live weight at slaughter. ² With respect to the weight of the eviscerated carcass. ³ Sum of % (thighs + drumsticks) + % wings + % breast. ⁴ With respect to the weight of the thighs + drumsticks. Figures with different letters in the same row are significantly different ($p < 0.05$).

greater than those of roosters ($p < 0.05$), while rooster heads were heavier than those of capons ($p < 0.05$). All other variables were similar.

Table 4 shows that all the variables, except for the percentage of live body weight made up by the abdominal fat and the eviscerated carcass, and the rest of the carcass as a percentage of the eviscerated carcass, were significantly influenced by caponization.

The percentage of eviscerated carcass weight made up by the wings, breast, and butchered portions (thighs + drumsticks + wings + breast) was significantly greater ($p < 0.05$) in the capons. The percentage of the eviscerated carcass weight made up by the neck and

the thighs + drumsticks, however, was significantly greater ($p < 0.05$) in the roosters.

The differences in the dissected parts of the thighs + drumsticks, expressed as a percentage of the overall weight of these pieces, shows the percentage edible product to be greater ($p < 0.05$) in the roosters. With respect to these pieces, roosters therefore have proportionally less bone than do capons ($p < 0.05$).

Table 5 shows the results for the meat sensorial characteristics tested. No differences were found between capons and roosters. Tenderness, juiciness and flavour were judged to be favourable in both: both products were acceptable.

Discussion

Once the stress of the surgical procedure has been overcome, caponization seemed to have no negative effect on growth. Several authors have shown that for the same slaughter age, capon live weights are either similar (Zanusso *et al.*, 2001) or greater than those of roosters (Mast *et al.*, 1981; Tor *et al.*, 1999; Cubiló *et al.*, 2000b). In the present study, caponization only led to significantly inferior body weights at 11 weeks. This can be attributed to the pre-castration fast and the resulting stress caused by the procedure. The fact that the capons were significantly heavier at 20, 25 and 30 weeks might be due to the fact that the roosters were more aggressive at this stage (which actually led to their greater mortality). This was also observed by Zanusso *et al.* (2001).

Although in the present study the accumulated feed conversion index for the capons was only slightly higher than that of the roosters, it would appear that

Table 5. Sensorial characteristics of capon and rooster meat

	Sensorial characteristics			
	Tenderness	Juiciness	Flavour	General acceptance
<i>Capons</i>				
Mean	5.68 ± 0.24	7.29 ± 0.30	8.29 ± 0.24	7.71 ± 0.24
cv (%)	24.82	24.01	17.25	18.55
<i>Roosters</i>				
Mean	6.58 ± 0.40	7.50 ± 0.47	8.25 ± 0.37	7.83 ± 0.41
cv (%)	20.97	21.60	15.64	17.88
Significance	NS	NS	NS	NS

cv: coefficient of variation. NS: not significant.

castration improves this variable once castration stress has been overcome (Mast *et al.*, 1981; Van der Horst, 1997; Francesch *et al.*, 1998). However, if capons deposit more fat (which is generally considered to be the norm), it is difficult to see how the efficiency of feed utilisation is not altered by castration (Etches, 1996). In the present study, the greater feed consumption and reduction in utilisation efficiency in capons might be explained by the greater energy cost of fat deposition.

The caponization procedure is not always successful and the testes regenerate in some animals. Cubiló and Tor (1999a) indicate that 8-9 weeks after castration, some capons show a reddening of the crest and wattle and make attempts to crow. The same authors (1999b) report that testicular regeneration is usually due to deficient surgery (perhaps because of operator inexperience), a deficient pre-surgery fast, performing the operation too quickly, or pre-operative dehydration. In the present study, the authors had no prior experience of performing castration by the technique used, and a high percentage of birds showed signs of regeneration. There were failures to extract at least one testis whole in some birds; rather, these testes were extracted in fragments and some remnants could have remained. Improving our expertise in this technique is an objective of future work.

With respect to the weight and percentage of abdominal fat, the present results are in agreement with those of Zanusso *et al.* (2001) who worked with an experimental line of chickens, but they do not agree with those of Francesch *et al.* (1998) or Cubiló and Tor (1999b). These authors indicate that, for native breeds, capons show a greater deposition of abdominal fat. This could be due to the interaction between genetics and nutrition.

Capons come to market with different weights depending on their genetic background and type of rearing. The weight of the present eviscerated carcasses is of the same order as those sold under the name «Caponcito de Villalba» (Anonymous, 1998) or «Petit Capon de Loué» (Anonymous, 1999).

Caponization led to a significant improvement in some carcass variables expressed both in absolute (grams) and relative terms (percentages). The most interesting were those expressed in percentages since these show that the differences found were not simply due to the birds achieving greater weight but to intrinsic differences. Most noticeable is the greater percentage of breast possessed by capons. This is

important since this is one of the most highly valued pieces of the chicken. The same has been reported by other authors (Francesch *et al.*, 1998; Tor *et al.*, 1999; Cubiló *et al.*, 2000a). It may be that, through a lack of sex hormones, castration causes changes in metabolism that lead to earlier development of the breast in capons – similar to the growth pattern seen in hens (Muriel, 1998). The effect of castration on the breast, plus its effect on the wings, explains why the values recorded for the butchered portions are so high, as suggested by Francesch *et al.* (1998) and Tor *et al.* (1999).

The interest attached to the complete dissection of the thighs + drumsticks is that it provides an idea of the ratio between the weight of the edible products and the bones, which gives a good picture of carcass quality as a whole (Ricard, 1972). The significantly higher percentage of edible product on rooster thighs + drumsticks is probably due to the fact that the proportion of muscle, in both parts of the leg, was significantly lower in capons (Tor *et al.*, 1999).

The absence of any effect of castration on the sensorial characteristics of the final meat has also been reported by Zanusso *et al.* (2001). This author used a panel of trained tasters who tried breast and thigh meat. However, Mast *et al.* (1981), who used a panel of 12 tasters who evaluated meat samples from the *pectoralis major*, *pectoralis minor* and *biceps femoris*, reported capon meat to be more tender – though differences were not always significant. Our survey of the consumers showed there to be great differences of opinion, meaning that consumers do not all evaluate products with the same characteristics in the same way.

Further studies are needed to confirm the results of this work, and it is our intention to complement them with a more detailed analysis of the final product in order to distinguish differences with respect to adipose tissue, muscular tissue and skin. This will allow us to establish whether fat is responsible for some of the differences found between capons and roosters.

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References

- ANONYMOUS, 1998. El sabor de lo auténtico. *Mundo Sada* 14, 12-13.
- ANONYMOUS, 1999. Le petit chapon de Loué au XIII^e trophée coq St Honoré. *Filières Avicoles* 1, 6.
- BARNA J., SZALAY I., BARTA I., LENNERT L., 1995. Genetic basis of capon and hen meat production in Hungary. Proc. of XII European Symposium on the quality of poultry meat, Zaragoza, Spain, 25-29 September, pp. 201-205.
- BOE, 1991. Reglamento de la denominación específica «Pollo y capón de la raza Prat». *Boletín Oficial del Estado*, 15-2-1991.
- CIRIA J., ASENJO B., MIGUEL J.A., CALVO J.L., ANDRÉS J., 2002a. Instrumental meat quality in non-castrated and castrated males of the Castellana Negra breed. Proc. of 48th ICoMST, Roma, Italy, 25-30 August, pp. 252-253.
- CIRIA J., MIGUEL J.A., ASENJO B., DE CASA C., SANZ C.A., 2002b. Étude des acides gras des mâles entiers et des mâles castrés de la race autochtone des poules Noires Castellaines. Proc. of 9^{èmes} Journées des Sciences du muscle et technologies de la viande, France, pp. 137-138.
- CUBILO M.D., TOR M., 1999a. La castración precoz en la producción de capones. *Nuestra Cabaña sep.-oct.*, 72-74.
- CUBILO M.D., TOR M., 1999b. Regeneración testicular en los capones. *Mundo Ganad* 12, 53-55.
- CUBILO M.D., FRANCESCH A., TOR M., 2000a. Caponization effects on some meat quality traits in chickens. Proc. of XXI World Poultry Congress, Montreal, Canada.
- CUBILO M.D., VILLALBA D., ESTANY J., FRANCESCH A., TOR M., 2000b. Efecto de la castración sobre el crecimiento de los gallos de la raza penedesenca negra. Proc. of Congreso Internacional de Producción y Sanidad Animal, Barcelona, 7-10 November, pp.167-170.
- ETCHES R.J., 1996. Reproducción aviar. Editorial Acribia, Zaragoza, 339 pp.
- FRANCESCH A., FORTUNY M.R., FARRAN M., GARCÍA-MARTÍN E., 1998. Extensive breeding and castration effects on the productivity and carcass quality of local breeds of chickens. Proc. of the International Symposium on basis of the quality of typical Mediterranean animal products. EAAP Publication no. 90 (Flamant, Gabiña and Espejo eds.), Wageningen (Holland), pp. 487-492.
- MAST M.G., JORDAN H.C., MACNEIL J.H., 1981. The effect of partial and complete caponization on growth rate, yield and selected physical and sensory attributes of cockerels. *Poultry Sci* 60, 1827-1833.
- MINOR L.J., DAWSON L.E., PEARSON A.M., 1964. Cooked meat yields from roasters and heavy and light hens. *Food Technol* 18, 153-156.
- MURIEL A., 1998. Efecto de la relación energía/proteína del pienso y del sistema de explotación (confinamiento o libertad) sobre índices productivos y características de la canal y de la carne de pollos. Doctoral Thesis. University of Extremadura, Cáceres, Spain.
- MURIEL A., 2002. Situación actual de la raza de gallinas Extremeña Azul. *El Arca* 1(5), 84.
- MURIEL A., SOLANA J., CANCHO M., 1997. Resultados productivos, rendimiento y composición de la canal de dos cruces de pollos de carne criados en libertad. *Arch Zootec* 46, 239-247.
- OJ, 1991. Reglamento (CEE) n° 1538/91 de la Comisión de 5 de junio de 1991 que establece las disposiciones de aplicación del Reglamento (CEE) n° 1906/90 por el que se establecen normas de comercialización aplicables a las aves de corral. *Official Journal of the European Union L* 143, pp.11-22.
- OJ, 1996. Reglamento (CEE) n° 1000/96 de la Comisión, de 4 de junio de 1996, por el que se modifica el Reglamento (CEE) n° 1538/91, que establece las disposiciones de aplicación del Reglamento (CEE) n° 1906/90 por el que se establecen normas de comercialización aplicables a las aves de corral. *Official Journal of the European Union L* 134, 5-6-1996.
- OROZCO F., 2000. La raza de gallinas Extremeña Azul. *Arte avícola* 37, 24-28.
- RICARD F.H., 1972. Étude de la composition anatomique du poulet. IV- Possibilités d'estimation des pourcentages de viande, d'os et de peau à partir d'une dissection simplifiée des membres. *Ann Zootech* 21, 49-57.
- SÁNCHEZ B., FERNÁNDEZ A., SÁNCHEZ L., 1995. La gallina de raza Mos en la producción de carne de calidad. *Feagas* 7, 26-32.
- SÁNCHEZ L., SÁNCHEZ B., FERNÁNDEZ B., 2000. Programa de preservación de la gallina de raza Mos en Galicia. *Arch Zootec* 49, 77-80.
- STATSOFT INC., 2002. Electronic statistics textbook (on line). Available in <http://www.statsoft.com> [December 2002].
- TOR M., CUBILO M.D., PÉREZ V., FRANCESCH A., 1999. Composición tisular de la canal en gallos y capones de la raza penedesenca negra. Proc. of VIII Jornadas sobre Producción Animal, Zaragoza, 11-13 May, Book I, pp. 188-190.
- VAN DER HORST F., 1997. La production du chapon. ITAVI, Paris, France, 52 pp.
- VILLENA A., CUBERO S., CABELLO A., LANCHO G., CAMACHO M.E., MAGALLANES M., 2002. Programa de recuperación, conservación y mejora genética de las razas autóctonas de gallinas andaluzas. *El Arca* 1(5), 46.
- WORLD'S POULTRY SCIENCE ASSOCIATION EUROPEAN FEDERATION, 1984. Method of dissection of broiler carcasses and description of parts. Ed. J. Fris Jensen, Denmark, 32 pp.
- ZANUSSO J., REMIGNON H., AUVERGNE A., MOLETTE C., MANSE H., BABILE R., 2001. Performance characteristics and quality of chicken meat: comparisons between males, females and capons. *Brit Poultry Sci* 42(Suppl), S42-S43.