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Souza, XR; Faria, PB; Bressan, MC

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# Proximate Composition and Meat Quality of Broilers Reared under Different Production Systems

**■Author(s)**

Souza XR[1]
Faria PB[2]
Bressan MC[3]

[1] IFMT Campus São Vicente. Santo Antonio do Leverger, MT, Brasil.
[2] Departamento de Medicina Veterinária, Universidade Federal de Lavras. Lavras, MG, Brasil.
[3] Instituto Nacional de Investigação Agrária. Vale do Santarém, Portugal.

**■Mail Adress**

PB Faria
Departamento de Medicina Veterinária
Universidade Federal de Lavras
Caixa Postal 3037
37.200-000. Lavras, MG, Brasil.

E-mail: peterbfvet@yahoo.com.br

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## ABSTRACT

In this study, the physical-chemical characteristics and proximate composition of the meat of of two strains of broilers (Paraíso Pedrês and Máster gris plumé – Super Pesadão, utilized for semi-intensive rearing) and Cobb® strain, utilized in intensive rearing systems) were evaluated. Differences related to strain and sex (males and females) were studied. Cobb® broilers were slaughtered at 45 days and the other strains at 85 days. The following characteristics were evaluated in breast and thigh meat: moisture, protein, ether extract, ashes, color (CIEL*a*b*), final pH, cooking loss (CL) and shear force (SF). Bird strain and sex influenced breast color parameters, with Cobb® presenting higher yellowness (b*) and redness (a*) means, whereas females had higher b* values and males, a* values. Paraíso Pedrês had lower SF values. As to proximate composition, there was an interaction between strain and sex, with higher ether extract values in the meat of Super Pesadão males. Cobb® birds presented higher lightness (L*) and b* values, and there was no effect of sex on color parameters. Higher pH and SF values were found in the meat of Super Pesadão birds. There was an interaction between strain and sex for b* and SF values, with higher b* values obtained with Cobb® males, while differences between sex, with superiority for females in the Paraíso Pedrês strain and for males in the Cobb® strain were found. Increased values of SF for males were obtained for Super Pesadão strain. Both Paraíso Pedrês and Super Pesadão strains presented physicochemical and proximate composition characteristics similar to those of Cobb® strain in the cuts breast and thigh so that in a few parameters, no differences between the birds kept in this two rearing systems were found.

## INTRODUCTION

Although genetic improvement has led to higher productivity in domestic species, these advances have only immediate economic importance and disregard long-term issues, such as the sustainability of production systems and the increasing demands of consumers as to the origin of the food they buy. The failure to include meat quality parameters in the selection criteria of domestic animals resulted in the emergence of abnormalities, such as PSE (pale, soft, and exudative meat) and DFD (dark, firm, and dry meat), affecting modern breeds of pigs, broilers, cattle, and turkeys. The development of broiler strains with the purpose of providing birds with features closer to the original breeds to alternative production systems may contribute for the reduction of biochemical meat abnormalities (e.g., PSE) that have been currently shown in studies with broiler strains reared in conventional industrial systems.

The production chain acknowledges the importance of food their purchase (Farmer *et al*., 1997). Therefore, farmers should adopt measures to maintain those attributes or to adopt strategies to develop the desired features in the final product.

The breeds and strains of birds used in alternative systems usually have poor genetic growth potential, are very hardy and well-adapted to extensive farming. The main birds used in alternative systems in Brazil are Colonial 041 (EMBRAPA-CNPSA), Caipirinha da ESALQ (USP), Paraíso Pedrês (Aves do Paraíso farm), Barred Plymouth Rock®, and some strains imported from France (HUBBARD-ISA® and SASSO®), such as Redbro *cou nu* and Redbro *plumé*, also known as pesadão; Gris Barre Plumé, known as carijó; and Master *gris plumé*, also known as Super Pesadão (Souza, 2004).

Free-range broiler production systems are regulated in Brazil by DIPOA (Department of Inspection of Products of Animal Origin – Departamento de Origem de Produtos de Origem Animal) provision number 007/99, which recommends the use of slow-growing strains adapted to the system; minimal slaughter age of 85 days; access to a pasture area with at least 3m$^2$/bird; feeds based exclusively on plant feedstuffs, and the use of antibiotic growth promoters is not allowed.

The production of broilers in free-range systems is may provide determined meat traits sought by consumers of chicken meat. The main differences in meat quality attributes between free-range and conventionally-reared chickens are related to color, flavor, and texture "(Castellini *et al*., 2002a; Castellini *et al*., 2002b; Castellini, 2005; Rizzi, 2007). These differences may be related to sex, due to the different growth and muscle development potential between males and females (Le Bihan-Duval, 2004; Farmer *et al*., 1997; Santos *et al*., 2005; Toldrá, 2003; Touraille *et al*., 1981). However, the effects of different genetic strains on meat quality characteristics are not well known, particularly in slow-growing strains.

The objective of the present study was to evaluate the quality and the physical-chemical characteristics of the meat of two strains developed for free-range production systems (Paraíso Pedrês and Super Pesadão) and to compare them to a strain (Cobb®) developed for conventional rearing systems according to sex (males or females).

## MATERIAL AND METHODS

The experiment was conducted at the Federal Institute of Education, Science and Technology of

72 birds was used, with 24 males and females of two free-range broiler strains (Super Pesadão and Paraíso Pedrês) and one conventional broiler strain (Cobb®). Free-range chickens were slaughtered at 85 days of age, and the conventional broilers were slaughtered at 45 days.

A completely randomized experimental design was applied, using a 3 x 2 x 4 factorial arrangement with three strains (Super Pesadão, Paraíso Pedrês, and Cobb®), two sexes (males and females), and four replicates per treatment, totaling 72 experimental units. One experimental unit consisted of three birds.

Diet was formulated for two growing phases (Table 1). The starter diet was fed for the first 28 days and the finisher diet from day 29 up to slaughter. Free-range birds were reared from 1 to 28 days in pens, with free access to feed and water, and from 29 to 85 days in a shed with access to a grazing area at a density of more than 3m$^2$/bird.

Birds were humanely slaughtered by mechanical stunning (contusion at the region of the occipital and atlas bones), followed by cutting of the blood vessels (carotid artery and jugular vein). After evisceration, carcasses were packed, identified, and chilled to 0 °C. Cuts were deboned 24 hours *post mortem*, packed, identified, frozen, and stored at -18 °C. Meat physical-chemical analyses were performed after cuts were thawed at 4 °C for 24h.

Final pH was determined using a DIGIMED DM-20 pHmeter coupled to a probe placed in incisions made with the tip of a knife in the cranial right side of the breast and in the upper front side of the right thigh.

Color was determined using a MINOLTA CR 200b colorimeter (Osaka, Japan), operating in the CIEL*a*b* system with D65 illuminant. Readings were made at three different areas of the internal face of the cranial position of the left *pectoralis major* muscle in the breast and of the internal face the *fibular longus* muscle in the thighs (Souza, 2004). Meat samples were exposed to light for 30 minutes before readings. The values of the color components used for statistical analyses were the averages of the three readings performed per cut per bird in each experimental unit.

Cooking loss (CL) was determined in breast and thigh samples used for color determination. Samples were weighed in semi-analytical scales (METTLER M P1210, Toledo, Brazil), involved in aluminum foil, and cooked on an electric griddle at 150ºC. When meat temperature reached 72ºC, samples were removed from the griddle, let to cool to room temperature, *al*., 2004; Souza, 2004; Faria, 2009). Averages values of the weight difference before and after cooking of breast and thigh samples per experimental unit were converted in percentages and submitted to statistical analysis.

**Table 1** – Ingredients and calculated and analyzed composition of starter and finisher diets fed to free-range and conventional chickens.

| Ingredients | Starter diet (%) | Finisher diet (%) |
|---|---|---|
| Ground corn | 63.00 | 70.00 |
| Soybean meal (45%) | 33.70 | 27.00 |
| Dicalcium phosphate | 2.00 | 1.80 |
| Calcitic limestone | 0.85 | 0.75 |
| Salt (NaCl) | 0.30 | 0.25 |
| Vitamin and mineral supplement | 0.35 | 0.20 |
| **Calculated values** | | |
| True metabolizable energy (kcal/kg) | 2,896 | 2,972 |
| Methionine + cystine (%) | 0.70 | 0.64 |
| Lysine (%) | 1.13 | 0.97 |
| Methionine (%) | 0.34 | 0.30 |
| **Analyzed values (%)** | | |
| Moisture | 13.90 | 13.95 |
| Crude protein | 21.50 | 18.25 |
| Ether extract | 4.02 | 3.64 |
| Ashes | 4.98 | 4.72 |
| Crude fiber | 3.42 | 3.12 |
| NDF (Neutral detergent fiber) | 15.60 | 16.80 |
| ADF (Acid detergent fiber) | 7.20 | 7.80 |
| Nitrogen-free extract | 52.32 | 56.66 |
| Calcium | 1.22 | 1.36 |
| Phosphorus | 0.66 | 0.63 |
| Magnesium | 0.17 | 0.18 |

1 - Guaranteed levels per kg product: calcium 212g; phosphorus 74.7g; sodium 40g; selenium 6.8mg; nicotinic acid 866mg; copper 3125mg; calcium panthotenate 237.5mg; biotin 4mg; manganese 1906mg; DL-methionine (minimum) 42.5g; iodine 32.5mg; coccidiostat 2750mg; antioxidant 100mg; choline 15g; growth promoter 1250mg; Vit. A 175,000IU; Vit. B1 44.5mg; Vit. B2 240mg; Vit. B6 86.6mg; Vit. B12 250mcg; Vit. D3 7500IU; Vit. E 625mg; Vit. K 24.5mg; Zinc 2281mg; Fluorine (max.) 747mg. 2 - Guaranteed levels per kg product: calcium 212g; phosphorus 65g; sodium 40g; selenium 6.8mg; nicotinic acid 866mg; copper 3125mg; calcium panthotenate 237.5mg; biotin 4mg; manganese 1906mg; DL-methionine (minimum) 33.7g; iodine 32.5mg; coccidiostat 2750mg; antioxidant 100mg; choline 15g; growth promoter 1250mg; Vit. A 175,000IU; Vit. B1 44.5mg; Vit. B2 240mg; Vit. B6 86.6mg; Vit. B12 250mcg; Vit. D3 7500IU; Vit. E 625mg; Vit. K 24.5mg; Zinc 2281mg; Fluorine (max.) 747mg.

Samples used for CL determination were prepared for shear force (SF) or tenderness evaluation. The pieces, with the longest length lengthwise to the muscle fibers, according to the methodology of Froning & Uijttenboogarte (1988) and Castellini *et al*., 2002. Samples were cut transversally to the muscle fibers using a Warner-Bratzler apparatus coupled to a texturometer (model TA XT-2) calibrated to a cutting speed of 2mm/s, sensitivity of 0.250N and in kg/cm² units.

Skin and aponeuroses were removed from breast and thigh samples, which were then homogenized and submitted proximate analysis. Moisture, protein, ether extract, and ash were analyzed in triplicate and carried out according to Horwitz (1990).

Data were analyzed using SISVAR software program (Ferreira, 2000). Means were compared by the test of Tukey at 5% significance level.

## RESULT AND DISCUSSION

Breast lightness (L*) values were not influenced by genetic strain or sex. However, redness (a*) and yellowness (b*) in Cobb® meat samples were higher than in Super Pesadão and Paraíso Pedrês meat, and males presented higher redness and lower yellowness values as compared to females. According to Qiao *et al*. (2002), pre-slaughter management and genetic predisposition are the main factors that influence meat color. The effect of pre-slaughter management on meat color is related to pH, which directly influences the capacity of myoglobin to express the red color and to bind to water (Castelinni *et al*., 2002). In the present study, pH values were very similar among the treatments, resulting in similar lightness (L*) values among treatments. The differences in redness (a*) values among strains, taking into account the absence of pH difference, can be ascribed to the genetic traits.

Average breast pH values were not affected by genetic strain or sex. The breast is composed of glycolytic muscles, which are not often used in movements performed by the bird during the pre-slaughter period. In addition, the experimental birds did not suffer transportation stress and were submitted to the same pre-slaughter management conditions. These conditions possibly influenced the uniformity of the pH values found among the treatments in the present study. Literature reports results that are consistent with the findings of the present study (Lonergan *et al*., 2003; Quentin *et al*., 2003 and Santos *et al*., 2005).

Mean breast CL was not influenced by genetic strain and sex. CL values may be influenced by pH and lipid

2004). In the present study, differences in pH and lipid content were not sufficient to influence CL values.

SF values were affected by genetic strain, with Paraíso Pedrês presenting the lowest SF (Table 2). Chicken breast meat tenderness can suffer the phenomenon of PSE (Bressan, 1998). The uniformity of pH values rules out the possibility of PSE occurrence in the evaluated treatments, which possibly accounts for the small differences among the shear force values found in the present study.

Meat proximate composition was not influenced by genetic strain; however, ash content was affected by sex, with the highest values obtained in males (Table 2). Ashes indicate muscle mineral content. These minerals are associated to the organic compounds involved in the muscle contraction process, and its values increase as the animal grows (Prändl *et al*., 1994). Males present higher ash content as their muscle tissue percentage values is higher as compared to females.

Breast ether extract was affected by the interaction between sex and genetic strain (p<0.05), with Super Pesadão males presenting the highest values (Table 3). On the other hand, Lonergan *et al*. (2003) reported higher ether extract values in females as influenced by the interaction between sex and genetic group. In the present study, it was not expected that the breast meat of males presented higher ether extract content. Taking into account the high coefficients of variation of ether extract data (Table 2), further studies are required to determine if that difference can be truly ascribed to the effect of the treatment.

**Table 3** - Mean ether extract values of chicken breasts as a function of genetic strain and sex.

| Strains | Sex | |
|---|---|---|
| | Males | Females |
| Super Pesadão | 0.90[aA] | 0.57[bA] |
| Paraíso Pedrês | 0.62[aB] | 0.74[aA] |
| Cobb® | 0.72[aB] | 0.63[aA] |

Means followed by different capital letters in the same column and different small letters in the same row are different by the test of Tukey (p<0.05).

In thigh meat, color parameters were affected by genetic strain, with Cobb® birds presenting higher L* and b* value and lower a* values (Table 4). Low pH values affect meat protein biochemistry, resulting in higher lightness and redness and lower yellowness (Castelinni *et al*., 2002). This was confirmed by the relation between pH and color parameters in Cobb® and Super Pesadão strains; however, despite presenting pH values similar to Cobb®, Paraíso Pedrês had different color values. Genetic factors possibly have higher influence on color parameters than pH in Paraíso Pedrês meat. The effect of genotype on color parameters was reported by several authors, including Berri *et al*. (2005), Castellini *et al*. (2002b), Grashorn & Clostermann (2002), and Quentin *et al*. (2003). When tissues (breast and thighs) were compared as to redness (a*), it was found that Cobb® birds presented higher a* values in the breast as compared to the free-range strains (Table 2). On the other hand, higher a*values were found in the thighs of free-range birds (Paraíso Pedrês and Super Pesadão). This apparent inconsistency may be due to bird movement, as birds reared in free-range systems graze and perform more exercises, changing muscle metabolism, with higher development of red muscle fibers (Erickson, 1996).

The analysis of thigh pH values showed differences among strains, with higher values for Super Pesadão birds as compared to Paraíso Pedrês and Cobb®. Broiler strains reared in alternative systems are more adapted to movement, and therefore, present higher capacity of reacting to pre-slaughter management. This may have lead to higher glycogen muscle consumption during the pre-slaughter period, reducing meat acidifying capacity. The differences found between Cobb® and Super Pesadão strains are consistent

**Table 2** – Mean meat quality trait values and proximate composition chicken breast as a function of genetic strain and sex.

| Color | Strains | | | Sex | | CV (%) |
|---|---|---|---|---|---|---|
| | Super Pesadão | Paraíso Pedrês | Cobb | Male | Female | |
| L* | 46.62[a] | 46.75[a] | 46.76[a] | 46.46[a] | 46.96[a] | 4.58 |
| a* | 4.76[b] | 4.16[b] | 6.12[a] | 5.38[a] | 4.64[b] | 13.50 |
| b* | 6.69[b] | 6.33[b] | 7.87[a] | 6.62[b] | 7.31[a] | 11.55 |
| pH | 5.78[a] | 5.70[a] | 5.80[a] | 5.76[a] | 5.76[a] | 1.62 |
| CL[1] | 30.18[a] | 29.28[a] | 29.63[a] | 29.69[a] | 29.70[a] | 4.77 |
| SF[2] | 2.12[a] | 1.92[b] | 2.09[a] | 2.08[a] | 2.00[a] | 6.02 |
| **Proximate composition** | | | | | | |
| Moisture | 75.26[a] | 75.62[a] | 75.57[a] | 75.60[a] | 75.37[a] | 0.74 |
| Protein | 22.61[a] | 22.48[a] | 22.49[a] | 22.35[a] | 22.70[a] | 2.38 |
| Ether extract | 0.73[a] | 0.68[a] | 0.67[a] | 0.75[a] | 0.65[a] | 18.26 |
| Ashes | 0.95[a] | 1.00[a] | 0.96[a] | 1.01[a] | 0.93[b] | 8.49 |

Means followed by different small letters in the same row are different by the test of Tukey

**Table 4** – Mean meat quality trait values and proximate composition chicken thighs as a function of genetic strain and sex.

| Color | Strains | | | Sex | | CV (%) |
|---|---|---|---|---|---|---|
| | Super Pesadão | Paraíso Pedrês | Cobb | Male | Female | |
| L* | 43.57[b] | 42.81[b] | 45.77[a] | 44.01[a] | 44.10[a] | 2.16 |
| a* | 12.63[a] | 13.45[a] | 11.78[b] | 12.42[a] | 12.82[a] | 6.43 |
| b* | 8.22[b] | 8.22b | 8.86[a] | 8.46[a] | 8.41[a] | 5.87 |
| pH | 6.14[a] | 5.97b | 5.96[b] | 6.03[a] | 6.02[a] | 1.51 |
| CL[1] | 32.73[a] | 31.82[a] | 34.11[a] | 32.68[a] | 33.09[a] | 5.18 |
| SF[2] | 2.41[a] | 2.20b | 2.17[b] | 2.38[a] | 2.13[b] | 6.57 |
| **Proximate composition** | | | | | | |
| Moisture | 77.15[a] | 77.23[a] | 76.14[b] | 76.86[a] | 76.83[a] | 0.48 |
| Protein | 19.41[a] | 19.79[a] | 19.86[a] | 19.52[a] | 19.85[a] | 2.98 |
| Ether extract | 2.85[a] | 2.65[a] | 2.88[a] | 2.87[a] | 2.72[a] | 13.97 |
| Ashes | 0.95[a] | 0.91[a] | 0.90[a] | 0.92[a] | 0.92[a] | 8.96 |

Means followed by different in the same row are different by the test of Tukey ($p<0.05$). 1 - Cooking loss. 2 - Shear force.

Ultimate pH values in the thigh muscle were high, close to 6.00. High values were reported by Castellini *et al*. (2002a), with means ranging between 6.02 and 6.25 and by Souza (2004), with means varying from 5.93 to 6.22.

There was no effect of genetic strain or sex on CL (Table 4). Weight loss during cooking may vary due to differences in pH and lipid content (Forrest, 1979). Thigh meat pH and lipid content differences observed in the present study possibly were no sufficient to influence CL values. The obtained results are consistent with the findings of Alvarado *et al*. (2005), who did not find any differences in CL in the meat of chickens produced in alternative or conventional systems, but further studies are still required to determine the effect of broiler rearing systems on CL. Santos *et al*. (2005) obtained higher CL values in the meat of conventional chickens relative to those from strains kept in alternative systems. Castellini *et al*. (2002) observed an opposite result, determining higher CL values in organic chicken thigh meat as compared to conventional broilers.

Higher SF values were obtained in Super Pesadão birds, while no differences between Paraíso Pedrês and Cobb® birds were observed. Different results were reported by Castellini *et al*. (2005), who found higher shear force values in breast and thigh meat of two free-range strains with different growth rates (fast and slow) relative to broilers reared in a conventional system. The difference in thigh pH and tenderness observed between Super Pesadão birds and the other two strains is due to the fact that those birds thigh muscles, which leads to a higher development of structures related to the aerobic respiration, such as red muscle fibers, mitochondria, and myoglobin (Erikson, 1996).

The only meat composition parameter influenced by the treatments was moisture, with lower values obtained in Cobb® birds, but there was no effect of sex. The similar meat composition between free-range birds (Super Pesadão and Paraíso Pedrês) and conventional birds (Cobb®) may be related to the feed restriction system adopted in the free-range system. This management possibly leads to higher energy utilization when birds move to seek feed supplementation by grazing, which may explain the increase in slaughter age with no accumulation of lipids in the meat (Tables 2 and 4). Castellini (2005), working with conventional and organic broiler production systems and feeding birds ad libitum, obtained different meat lipid and moisture contents.

## CONCLUSIONS

The meat of birds of Paraíso Pedrês and Super Pesadão strains, recommended for the use in free-range broiler production systems, presented different physical-chemical characteristics as compared to Cobb® broilers reared in a conventional system as to redness and yellowness. Cobb® birds presented higher breast and thigh meat yellowness, whereas Paraíso Pedrês and Super Pesadão birds had higher thigh meat redness, and lower breast meat redness. Meat composition was not influenced by genetic strain or sex. Therefore, under the conditions of the present experiment, there was little influence of genetic strain on the composition and physical-chemical characteristics of breast and thigh meat.

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