Growth and carcass traits of three Portuguese autochthonous chicken breeds: Amarela, Preta Lusitânia and Pedrês Portuguesa

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Abstract

The purpose of this study was to estimate the growth curve parameters and carcass traits yields of three Portuguese autochthonous chicken breeds, Amarela (AM), Preta Lusitânia (PL) and Pedrês Portuguesa (PP). Birds (198) were individually weighed at pre-established time intervals (6682 records) and the study period lasted 30 months. The growth data were fitted to a mixed nonlinear model based on the Gompertz growth function. Fixed effects were breed, sex, lot, temperature and photoperiod. The adult weight estimated for males (females) were 2851.3 (1951.6) g at 20.7 (17.5) g at 79 (72) days for PL, and 18.1 (16.3) g at 82 (74) days for PP, respectively. The males (females) estimated maximum daily growth were 22.7 (18.1) g at 77 (69) days for AM, 20.7 (17.5) g at 79 (72) days for PL, and 18.1 (16.3) g at 82 (74) days for PP, respectively. Within breed the males were heavier than females at 365 days but with lower maturity rates. Yields of carcass and noble meat pieces were evaluated on data collected from 10 males of each breed, sacrificed at 240 days. Traditionally, these breeds are commercialised whole and again the PP had the heaviest carcass with the highest yield. Growth of these autochthonous breeds after 240 days was minimal and may justify the decrease of the traditional slaughter age of approximately one year, in order to increase profitability. Establishing special market niches will also be a valuable complement for the rural economy of Portugal and an important contribution to the conservation of this genetic heritage.

Introduction

Poultry meat is the world’s second most important source of animal protein in the human diet (FAO, 2013). Years of genetic selection and intensification of production systems, contributed for this status but nevertheless, at the cost of loss of genetic variability, with very few breeds being used in the industry. Only recently, especially due to changes in consumer demands, emerging diseases, global climate changes, etc., a turn back to traditional production systems using adapted autochthonous chicken breeds reappeared giving opportunity to new market niches. This process was also an important incentive for breed conservation and consequently a contribution for the maintenance of the genetic diversity of the species, as preconised by FAO (2007). Portugal has 47 autochthonous breeds with an official genealogical book (DGAV, 2013). Among these, 4 are chicken breeds (Carolino, 2011): Branca, Amarela (AM), Preta Lusitânia (PL) and Pedrês Portuguesa (PP), all of them classified according to the FAO (2007) as rare and particularly endangered. The majority of these chickens are located in the Norwest region of continental Portugal, raised under traditional production systems (pens with open parks and low input) associated with subsistence and small family farms.

There is no reliable phenotypic information about these breeds except their external breed pattern characteristics like type of feathering, color of paws, crest shape, etc., as described on their respective genealogical books (DGAV, 2013). To increase its intrinsic value and contribute for the conservation of these autochthonous chicken breeds, further knowledge is necessary. Therefore, the purpose of this study was to characterise their potential for growth, carcass and noble meat pieces yields (breast and thigh+drumstick) of 3 of these breeds: Amarela, Preta Lusitânia and Pedrês Portuguesa.

Materials and methods

Animals, housing and feeding

The present study was carried out at the facilities of Escola Superior Agrária de Ponte de Lima-Instituto Politécnico de Viana do Castelo, Portugal, between September 2008 and August 2013. These facilities are located in the North of Portugal (41°47’38.64”N and 8°32’22.54”W), where the majority of these autochthonous Portuguese chicken breeds have their origin.

New born birds of the 3 breeds (AM, PL and PP) were provided with one week of age by the National Association of Autochthonous Chicken Breeders (AMIBA). The initial sample size was relatively small emphasising the status of endangered breeds. Table 1 shows the number of individuals per breed and sex that formed the 1st lot for the AM and PL breeds. The initial number of birds of the PP breed was so small that they were to be reproduced in loco before forming their 1st lot and enter the study. This process explains the late start of this breed on the study, as indicated in Table 1.

Approximately 8 months after the start of this study (3 months after the beginning of laying), eggs from all breeds were collected and locally incubated using a portable commercial incubator [Covatutto 54 automatic (Novital, Lonate Pozzolo, Italy) equipped with electronic thermostat and ventilation system]. Hatching chicks were used to form the 2nd lot and the data was also collected and added to the study (Table 1).

The birds were kept in a total area of approximately 180 m² divided into 6 paddocks. Each paddock was subdivided into an open area (21 m²) with access to a covered protected area (9 m²) and used to house each lot (2 per breed). The 30 m² of each paddock assured a minimum of 1 m² per adult bird in an attempt to avoid ter-
ritorial problems. All 6 protected areas were equipped with perches, nests, feeders and drinkers. No light programme was used.

On the first 3 weeks of life, chicks of each lot were kept under a brooder lamp in a confined area of 3 m². Between the second and third week of life, all birds were identified by the application of a metal ring on the right wing, with the serial number and breed. Both sexes were raised together during all the study period. In order to maintain the ratio of 1 m² per adult bird, males were randomly culled when necessary. At the end of the study (±30 months) there were 39 AM, 30 PL and 28 PP animals (Table 1).

During the starter phase (3 weeks), birds were provided feed and water ad libitum. The starter meal was commercial with a minimum composition of 19.3% crude protein (CP), 4.2% crude fat, 4.8% crude fibre, 7.7%; Ash and 3946 kcal/kg dry matter (DM) of metabolisable energy (ME) (estimated according to INRA, 1989). After this period, birds were allowed free access to the open area and fed locally produced yellow corn ad libitum, first broken (until 20 weeks of age) and then in grain (CP, 8.0%; crude fat, 4.2%; crude fibre, 2.4%; Ash, 1.5%; ME, 3951 kcal/kg DM; estimated according to INRA, 1989). When available, vegetable scraps from the local garden were also provided. This production system mimics very closely the traditional one, an important pre-condition for the design of the present study. Similarly, no vaccination programme was adopted.

Data

Bird weight records were taken individually using a portable electronic scale (Electro Samson, 25kg x 20 g; Salter Brecknell, Fairmont, MN, USA). These measurements were taken on-pre-established time intervals and always during the morning period: weekly until 6 months of age, biweekly until 1 year old, monthly up to 1.5 years and every 60 days thereafter. This weighing frequency was adopted to minimise the effect of the small sample size and to maximise the accuracy of prediction of the growth curves parameters for each breed. The total number of observations was 6682 weight records (1534 for PL, 2302 for AM, and 2846 for PP) obtained from 198 birds.

For the carcass traits evaluations, the slaughter age of 240 days was used for comparability reasons, as most studies report a range between 210 to 270 days. Samples of 10 males of each breed were randomly selected, weighed (live weight [LW]) and then slaughtered after fasting for 12 hours. The birds were slaughtered by mechanical stunning followed by immediately bleeding (carotid and jugular incision). They were manually plucked after scalded, washed and then weighed [plucked and bled carcass weight (CW1)]. After evisceration and cooling, two other weight measurements were taken corresponding to the eviscerated carcass weight with (CW2) or without head and paws (CW3). Another weight of interest (CW4) is related to popular consumption traditions that includes the carcass (CW2) plus all edible viscera [gizzard, heart, liver and kidneys (EW)]. Corresponding carcass yields were obtained by expressing those weights as percentages of LW (CY1, CY2, CY3 and CY4, respectively). This work also included the analysis of noble meat pieces (breast and thigh-drumstick) in three combinations: with skin and bone (B1 and T1, respectively), without skin (B2 and T2, respectively) and without skin and bone (B3 and T3, respectively). Their yields were obtained as percentages of CW2 and hereafter referred as BY1 to 3 and TY1 to 3, respectively. Yields of the edible viscera (EV) were also expressed as percentage of CW2.

Statistical analysis

To describe and predict animal growth over time, the growth data were fitted to the mixed effects Gompertz growth function as described by Wang and Zuidhof (2004) using the PROC NL MIXED (SAS, 1999).

The application of a mixed, non-linear model to field data on chicken growth where the parameters of the Gompertz growth curve were directly and simultaneously adjusted to the environmental effects (relative humidity, rainfall and solar radiation) were obtained as percentages of CW2. Fixed effects were age (AM, PL and PP), sex, lot, photoperiod, daily average temperature, relative humidity, rainfall and solar radiation, the last five taken at the day of weighing from data provided by the nearest meteorological station (Ponte de Lima). The photoperiod was calculated according to the latitude, longitude and declination of Earth at the day of weighing, according to Cooper (1969). Preliminary analysis revealed that not all fixed effects (relative humidity, rainfall and solar radiation) were significant and, therefore, they were discarded from subsequent analysis. Furthermore, only breed, sex and photoperiod (fp) significantly affected all 3 Gompertz parameters simultaneously: average mature weight (A), relative growth rate at the inflexion point (B) and days in which the growth rate was maximum (C). Temperature (temp) only affected A while lot affected A and C. The criteria to define the best model was the smallest fit statistic AIC. The final model can be written as:

\[ M_i=(A+u_i)exp(-(B2-C)\cdot t)+e_{it} \]

where, \( M_i \) = body weight (g) of the animal i in time t, expressed as a function of A; \( t=\text{age} \) (days); \( u_i = \text{random mature weight of the individual} \) i based on the average mature weight of its breed, assumed \( N=0, \sigma_u^2 \) and independent of \( e_{it}; A=a+\text{breed}+\text{sex}+\text{lot}+fp+\text{temp} = \text{average mature weight} \) (g), adjusted for breed, sex, lot, fp and temp; \( B=b+\text{breed}+\text{sex}+fp = \text{relative growth rate at the inflexion point} \) (g/day/body weight), adjusted for breed, sex and fp; \( C=c+\text{breed}+\text{sex}+\text{lot}+fp = \text{days in which the growth rate was maximum} \), adjusted for breed, sex, lot and fp; \( e_{it} = \text{individual weight residue} \) i in time t, assumed \( N(0, \sigma_{e_i}^2) \).

The absolute growth rate (GR) curve was obtained by taking the first derivative of the model, reflecting weight gain in g/day:

\[ GR=A\cdot B\cdot \left(\frac{1}{(B(t-C)-exp(-B\cdot t))}\right) \]

where the terms have the same definitions as before. The estimated parameters from the

Table 1. Number of birds per breed, lot and sex at the beginning and end of the study.

| Breed+lot | Initial number | Final number | Study period |
|-----------|----------------|--------------|--------------|
|           | Female | Male | Female | Male |                  |
| AM1       | 13     | 2    | 10     | 1    | Nov 2008 to Apr 2011 |
| AM2       | 29     | 27   | 23     | 5    | Jul 2009 to Dec 2011 |
| PL1       | 8      | 9    | 8      | 1    | Set 2008 to Mar 2011 |
| PL2       | 21     | 9    | 17     | 4    | Jul 2009 to Dec 2011 |
| PP1       | 10     | 17   | 8      | 2    | May 2010 to Aug 2012 |
| PP2       | 22     | 31   | 15     | 3    | Mar 2011 to Jul 2013 |

AM1, Amareló, 1st lot; AM2, Amareló, 2nd lot; PL1, Preta Lusitánica, 1st lot; PL2, Preta Lusitánica, 2nd lot; PP1, Pedrês Portuguesa, 1st lot; PP2, Pedrês Portuguesa, 2nd lot.
model also permitted the derivation of weights by sex within breed at specific ages, allowing statistical comparisons between them. For the analysis of the carcass traits, a linear fixed model was used to compare breeds performance using the PROC GLM (SAS, 1999):

\[ y_{ij}=\mu+B_i+e_{ij} \]

where, \( y_{ij} \)=carcass trait (g or %) of the animal \( j \) from breed \( i \); \( \mu \)=overall mean; \( B_i \)=breed \( i \) (AM, PL and PP, respectively); \( e_{ij} \)=random residual error, assumed N~(0, \( \sigma^2_e \)).

Linear contrasts of least squares means were computed from the model to test differences within classes of the breed effect for all traits (P<0.05 was considered the threshold for statistical significance).

**Results and discussion**

**Growth**

Table 2 shows the Gompertz growth function parameters (A, B and C) for each breed and sex, respective maximum growth rate (MGR) at time C and estimates of weights at time C and 365 days of age. All parameter estimates from the model (15 fixed effects and 2 variance components) were significant at P<0.001, suggesting a good fit of the Gompertz function to the data.

Traditionally, breeders sell their birds at one year of age. For that reason, breed and sex comparisons were based on the weight at 365 days, estimated from the model. Differences between sex within breed (895.22 g, 887.26 g and 866.02 g for AM, PL and PP, respectively) were all significant at P<0.001. These differences indicate that sexual dimorphism on weight is a well expressed trait and of about 168.62 to 354.65 g, where PP males were the heaviest breed, followed by AM and 866.02 g for AM, PL and PP, respectively)

Differences within classes of the breed effect for all traits (P<0.05 was considered the threshold for statistical significance).

![Image](image-url)

**Carcass yields**

Adjusted means for the carcass weights of AM, PL and PP breeds, are shown in Table 3.

**Table 2. Gompertz growth function parameter estimates, maximum growth rate, and body weight estimates per breed and sex.**

| Parameters          | AM   | Female | Male | Female | Male | Female |
|---------------------|------|--------|------|--------|------|--------|
| A, g                | 2851.3 | 1951.6 | 3047.5 | 2147.8 | 3243.7 | 2344.0 |
| (13.90)             | (13.84) | (14.01) | (13.94) | (14.12) | (14.05) |
| B, g/day/g body weight | 0.0216 | 0.0253 | 0.0191 | 0.0221 | 0.0152 | 0.0189 |
| (0.0004)            | (0.0004) | (0.0002) | (0.0003) | (0.0002) | (0.0005) |
| C, days             | 76.7  | 69.0   | 79.3  | 71.6   | 81.9   | 74.2   |
| (1.13)              | (1.08) | (0.58) | (0.55) | (0.75) | (0.78) |
| MGR, g/day          | 22.7  | 18.1   | 22.6  | 17.5   | 18.1   | 16.3   |
| (25.33)             | (19.99) | (11.37) | (10.22) | (13.11) | (13.03) |
| BWc, g              | 1048.9 | 718.0  | 1121.1 | 790.1  | 1193.3 | 862.3  |
| (25.33)             | (19.99) | (11.37) | (10.22) | (13.11) | (13.03) |
| BW365c, g           | 2845.7 | 1950.5 | 3031.8 | 2155.5 | 3200.4 | 2334.4 |
| (13.76)             | (13.83) | (13.60) | (13.89) | (13.06) | (13.89) |

AM, Amarela breed; PL, Preta Lusitância breed; PP, Pedrêis Portugaense breed; A, adult body weight; B, relative growth rate at the inflexion point; C, age when the growth rate is maximum; MGR, maximum daily growth rate; BWc=body weight at time C; BW365c=body weight at 365 days. Values in parentheses represent the standard error of mean. Differences between sexes were significant at P<0.001; differences between breeds within sex all significant at P<0.001.
Linear contrasts between these traits revealed significant differences only for the noble meat pieces. The AM breed had the lightest breast weights (P<0.05) for all types (B1, B2 and B3), when compared to the other two breeds which showed no differences between them. For the weights of thigh+drumstick (T1, T2 and T3), only the PP breed showed a significant difference compared to the other breeds, except for T3 where the PP and the AM breeds showed no difference, suggesting a heavier bone structure for the PP. Although with different slaughter ages, reports from other authors indicate approximate weights for the same traits obtained from other autochthonous breeds. For the Mós breed, with 210 and 270 days at the time of slaughter, the LW was 2790 g and 3390 g, respectively (Sánchez et al., 2005). At a slaughter age of 210 days, Miguel et al. (2008b), 2011) reported LW of 2006 g and 1854 g for males of Castellana Negra, respectively for each study, while Sabbioni et al. (2006), obtained 2142 g and 2175 g of LW for the Italian Modenese and Romagnolo breeds, respectively. In another study, Zanetti et al. (2010), working with the Padovana, Ermelintata and Pòpöi, also Italian autochthonous chicken breeds, obtained LW of 2144, 2778 and 1434 g, respectively, at a slaughter age of 190 days.

Yields of carcass and noble meat pieces are important traits for the characterisation of autochthonous breeds. In this study, eleven traits describing yields of the AM, PL and PP breeds are reported in Table 4. For the four traits representing carcass yields (CY1-4), the PP showed the best performance with significant differences when compared to the other breeds, except for CY1 and CY3 where the PP and the AM breeds showed no difference. Traditionally, the Portuguese autochthonous breeds are commercialised whole (carcass with head, paws and edible viscera, CY4) and again, the PP had the heavier carcass with the highest yield, suggesting a marketing advantage for this breed. When comparing CY4 with CY3 (the usual market presentation of the industrial broiler), there is a yield decrease of 12 to 16%, which may impact negatively on the profit of the product and justifying the traditional market presentation for these breeds.

The eviscerated carcass yield, not including edible viscera (CY2), ranged between 77 to 81% and was comparable to other autochthonous breeds: 77% for the Penedesencra Negra, 74% for the Empordana Roja (Miguel et al., 2008b), 76% for the Castellana Negra (Miguel et al., 2011), and 75% for the Mós (Sánchez et al., 2005). For this last breed, Franco et al. (2012) also found a CY2 of 82%, but with an older bird (slaughtertime of 300 days).

Yields of the noble pieces were calculated as percentages of CW2. The AM breed had the smaller breast yields (P<0.05) for all types (BY1, BY2 and BY3), when compared to the other two breeds which showed no differences between them. For yields of thigh+drumstick (TY1, TY2 and TY3), the AM breed continued to have the smaller yields, but only when compared to the PP breed the difference was significant (P<0.05). The exception to this trend was the TY3, where the three breeds did not differ. Most studies indicate the breast and thigh+drumstick with bone and without skin (BY2 and TY2, respectively), as the most relevant noble pieces. In Spanish breeds, Miguel et al. (2008b) reported a BY2 (TY2) of 16% (29%) for the Penedesencra Negra, 16% (30%) for the Empordana Roja and 17% (30%) for the Castellana Negra, while Sánchez et al. (2005) and Franco et al. (2012) found the same yields of 16% (33%) for the Mós breed. The Italian breeds of Modenese and Romagnolo had similar performances of 15% for BY2 and 34% for TY2 (Sabbioni et al., 2006). The Padovana, Ermelintata and Pòpöi, also from Italy, performed similarly for these parameters (Zanetti et al., 2010). The corresponding yields obtained in the present study were in the same range.

### Table 3. Least square means±standard error of mean for yields on carcass traits, edible viscera, breast and thigh+drumstick for males of Amarela, Preta Lusitânica and Pedrês Portuguesa autochthonous chicken breeds.

| Traits, g | AM | PL | PP |
|-----------|----|----|----|
| LW        | 2713.8±121.33 | 2718.9±114.39 | 2833.0±108.52 |
| CY1       | 2467.5±114.64 | 2460.0±108.08 | 2009.9±102.54 |
| CY2       | 2083.8±81.84 | 2086.7±80.59 | 2284.0±82.14 |
| CY3       | 1806.2±88.19 | 1779.9±83.15 | 2006.0±78.88 |
| CY4       | 2197.2±95.15 | 2263.1±89.71 | 2400.2±85.11 |
| EW        | 113.9±5.04 | 116.4±4.75 | 116.2±4.51 |
| B1        | 365.3±30.66 | 492.6±28.90 | 521.2±27.42 |
| B2        | 336.5±26.11 | 451.1±24.62 | 446.7±23.36 |
| B3        | 293.8±19.97 | 365.8±18.83 | 372.1±17.96 |
| T1        | 619.4±32.51 | 638.0±30.65 | 728.7±29.07 |
| T2        | 548.6±29.59 | 572.4±27.90 | 655.3±26.47 |
| T3        | 449.9±26.95 | 446.3±25.41 | 521.5±24.10 |

### Table 4. Least square means±standard error of mean for yields on carcass traits, edible viscera, breast and thigh+drumstick for males of Amarela, Preta Lusitânica and Pedrês Portuguesa autochthonous chicken breeds.

| Trait, % | AM | PL | PP |
|----------|----|----|----|
| CY1      | 90.83±0.58 | 90.45±0.55 | 92.08±0.52 |
| CY2      | 76.80±0.81 | 76.80±0.76 | 80.70±0.72 |
| CY3      | 68.73±1.10 | 65.38±1.04 | 70.80±0.99 |
| CY4      | 81.04±0.79 | 81.11±0.74 | 84.79±0.70 |
| EW       | 4.24±0.14 | 4.31±0.13 | 4.09±0.12 |
| BY1      | 17.59±0.98 | 23.46±0.92 | 22.81±0.88 |
| BY2      | 16.14±0.82 | 21.50±0.77 | 19.57±0.72 |
| BY3      | 14.09±0.57 | 17.41±0.54 | 16.32±0.51 |
| TY1      | 29.73±0.59 | 30.58±0.56 | 31.83±0.53 |
| TY2      | 26.32±0.58 | 27.44±0.54 | 28.61±0.52 |
| TY3      | 21.58±0.73 | 21.39±0.68 | 22.75±0.65 |

AM, Amarela breed; PL, Preta Lusitânica breed; PP, Pedrês Portuguesa breed; LW, live weight at slaughter age of 42 days; CY1, bled and plucked carcass weight; CW2, eviscerated carcass, with head and feet weight; CW3, eviscerated carcass, without head and feet weight; CY4, eviscerated carcass with head, feet and edible viscera weight; EW, edible viscera weight (gizzard, heart, liver and kidneys); B1, breast, with skin and bone weight; B2, breast, without skin weight; B3, breast, without skin and bone weight; T1, thigh+drumstick with skin and bone weight; T2, thigh+drumstick without skin and bone weight; T3, thigh+drumstick with skin and bone weight. Different letters in the same row indicate significant differences (P<0.05).
Conclusions

Autochthonous chicken breeds are in general animals of slow growth and late maturity, especially when reared in low input systems. This study has showed that the three Portuguese chicken breeds – *Amarela*, *Preta Lusitântica* and *Pedrês Portuguesa* – raised in a traditional production system with very low inputs, had growth performances and carcass yields comparable to other European autochthonous chickens raised under similar production systems. These findings may be used as incentives to the conservation of these breeds and as an important stimulus for potential breeders. Among the three breeds, the *Pedrês Portuguesa* was the one having the best aptitude for meat production, with higher 365 days live weight, although a lower maturity rate, *i.e.*, it needed more days to reach the maximum daily growth rate. Within breed, the same trend was observed between males and females. The *Amarela* breed had the smallest breast and thigh+drumstick yields when compared to the other two breeds which showed no differences between them. Diminishing production costs should be a priority for slow growth chicken breeds. Growth of these autochthonous breeds after 240 days was minimal and may be a justification to decrease of the traditional slaughter age of approximately one year, in order to increase profitability. Further research is necessary to evaluate these assumptions. The establishments of special market niches, with designation and biological label will also be a valuable complement for the rural economy of Portugal and an important contribution to the conservation of this important genetic heritage.

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