



Effect of strain and sex of bird on carcass and fat yield of foraging slow-growing chickens

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Free-range systems allow access to an outside area, promoting expression of normal behaviour, thus theoretically improving bird welfare (Ponte *et al.* 2008). This is critical in view of the increasing demand for products that are produced under high welfare standards (Janczak and Riber 2015). In addition to being more natural and better-tasting, such products may carry several health benefits (Midmore *et al.* 2005). Consumers prefer meat with low fat content since excessive fatness is associated with poor dietetic quality (Loh *et al.* 2000). This explains, in part, the preference for chicken meat to beef or pork (Haslinger *et al.* 2005). The poultry industry aims to increase carcass yield and reduce fatness, mainly the abdominal fat pad (AFP) (Fouad and El-Senousey 2014) and the latter is a reliable indicator of carcass fat content (Eits *et al.* 2003). Carcass and portion yield provide useful information to guide farmers as to how strain, sex and slaughter age influence consumer preferences (Faria *et al.* 2010). Slow-growing lines are widely used for production of high quality free-range products (Chabault *et al.* 2012). The Naked Neck (NN), Ovambo (OV) (Mapiye *et al.* 2008) and Potchefstroom Koekoek (PK) chickens are closely associated with rural livelihood in Sub-Saharan Africa where they are used to meet household nutritional and economic needs. Meat and fat yield of these slow-growing chickens have not been examined despite their increasing popularity in recommended modern poultry rearing systems. The objective of the study was, therefore, to assess the effect of strain and sex on carcass and fat yield of NN, OV and PK chickens.

The care, use and bird management in this study were compliant with internationally accepted standards for the welfare of research animals as specifically approved by the University of KwaZulu-Natal Animal Ethics Research Committee.

The study was conducted from January to March, 2015

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at Cedara College of Agriculture, Pietermaritzburg, South Africa (SA). Cedara is located in an upland savanna zone 29.53°S and 30.27°E, 613 m above sea level. The area is characterised by hot wet summers and cool dry winters, with the lowest and highest temperatures occurring from June to July and November to February, respectively.

Day-old chicks of OV, NN and PK strains, with mean body weights of 42.6±2.89 g were obtained from parent flock at the Agricultural Research Council, Irene, Pretoria, SA. These were reared in a standard poultry house as part of a separate study. From d 1 to d 49, chicks of each strain were reared in 2 × 1.5 m pens in a well ventilated poultry house under a deep litter. Infrared lamps of 75 Watt were used for heat and lighting. A commercial broiler starter diet (Table 1) and potable tap water were offered *ad lib.* from standard tube feeders and 4 litre plastic founts, respectively. A Newcastle Disease vaccine was administered at 10 and 35 d of age. For biosecurity, a foot bath with disinfectant was placed at the entrance to the poultry house. From d 50, birds were given a commercial grower meal and both feeds were supplied by Meadow Feeds, SA.

A total of 258 randomly selected PK, OV and NN birds, 20 weeks old and initial average weight 1710±308.8 g were allocated to eight pens in the intensive and extensive system. Birds were allocated to 4 pens each of the two rearing systems. There were 11 males/strain and the same number

Table 1. Chemical composition (label values) of commercial broiler starter and grower feeds

| Composition | Starter | Grower |
|-----------------------------|---------|--------|
| Crude protein (g/kg) | 200.00 | 180.00 |
| Metabolisable energy (MJ/g) | 12.76 | 13.00 |
| ME/CP ratio (MJ/g) | 0.06 | 0.07 |
| Fat (g/kg) | 25.00 | 25.00 |
| Fibre (g/kg) | 50.00 | 60.00 |
| Moisture (g/kg) | 120.00 | 120.00 |
| Calcium (g/kg) | 12.00 | 12.00 |
| Phosphorus (g/kg) | 6.00 | 5.50 |
| Lysine (g/kg) | 12.00 | 10.00 |

of females/strain in each pen on the extensive system. Three pens in the intensive system had 10 birds/strain each while the fourth one had 11 birds of each strain under study. The paddocks with 30 cm tall *Chloris gayana* (Katambora Rhodes grass) as the dominant grass species, measured 900 m² each. Wooden cages, measuring 2.5 × 2 m with slatted wooden floors elevated 1 m above the ground surface, were placed in one corner of each paddock to shelter the birds. A 12 litre plastic drinker was used to provide potable tap water. Drinkers were inspected, washed and replenished twice daily. Similarly, males and females of the three strains were separated by wire mesh in a poultry house measuring 4 × 10 m. Birds were weighed individually on a digital scale.

At the end of the trial, chickens were fasted overnight before slaughter. Two birds per strain were randomly selected per paddock and weighed individually. Thus, eight birds per strain were randomly selected from the paddocks. The same number was sampled from the intensive system to give a grand total of 48 birds with equal representation of each strain. Body weights (BW) were measured on a digital scale. Birds were euthanized by cervical dislocation and slaughtered by exsanguination. Carcasses were immersed in water at 60°C for 63 sec and plucked manually. Heads and feet were removed before weighing on a digital scale (±1 g sensitivity) to determine carcass weight. After evisceration, the AFP was removed with the aid of a scalpel and weighed. It comprised leaf fat surrounding the cloaca and abdominal muscles excluding fat around the gizzard. The eviscerated carcass was cut into prime cuts including shanks, thighs and drumsticks. Giblets and gut organ weights were also measured individually and weights were expressed as a percentage of the eviscerated carcass weight.

All data were tested for normality using the Shapiro-wilk test and log₁₀-transformed wherever the data were not normal. Data were subjected to ANOVA with strain and sex of bird as the main effects, using proc GLM of SAS version 9.3 (SAS 2010). Least square (LS) means were generated by the LSMEANS and separated using the PDIF options of SAS at the 5% level of significance. The model $Y_{ijk} = \mu + S_i + T_j + (S \times T)_{ij} + \epsilon_{ijk}$ was applied where Y_{ijkl} was the response variable (BW, DW, portion and giblet weights); μ , the general mean; S_i , effect of the i^{th} strain of bird ($i = \text{NN, OV, PK}$); T_j , effect of the j^{th} sex of bird ($j = \text{M, F}$); $(S \times T)_{ij}$, interaction effects of sex and strain of bird and ϵ_{ijk} , the random residual error term.

Strain had no effect ($P > 0.05$) on BW while males were significantly heavier ($P < 0.05$; Tables 2 and 3) than females in this study. All other factors did not influence BW and no interaction effects ($P > 0.05$) were observed. Strain and sex did not influence DW ($P > 0.05$).

Management, environment and genetics all influence an animal's actual performance (Miszta and Lovendahl 2012). Chickens normally kept by farmers under extensive conditions in SSA are largely unimproved and slow-growing. The observation that sex of bird influenced BW in this study agrees with earlier studies (Chabault *et al.* 2012, Zhao *et al.* 2015) where males were heavier than females.

Male chickens were 15–20% heavier than females at slaughter age (Mignon-Grasteau *et al.* 1998). Similar sexual dimorphism was reported by Remesj and Sze'kely (2010). Sexual dimorphism in relation to BW can be ascribed to differences in feed intake as well as hormonal influence on tissue accretion. Growth in both sexes depends on the concentration of growth hormone (GH) and growth factors, however, growth is modified between males and females because of the sex-specific patterns of synthesis and secretion of the hormones. It is also thought that differences may have resulted from sex-specific selection pressures and targets e.g. where selection was aimed to improve male traits for cock fighting (Remesj and Sze'kely 2010). The observation that strain did not influence BW is contrary to a report by Chikumba and Chimonyo (2014) but agrees with findings of Zhao *et al.* (2015). We hypothesize that the absence of differences could be linked to small genetic differences among strains. The NN and OV strains developed over time through random mating while the PK is a dual-purpose composite strain from the crossing of Black Australorp cockerels with White Leghorn hens and the Plymouth Rock (Grobbelaar *et al.* 2010).

Strain influenced back, pancreas, gizzard, neck and AFP weight. Sex of bird affected shank, back, thigh, drumstick ($P < 0.05$) but not breast, wing and neck weights ($P > 0.05$). Shank, back, thigh, drumstick, pancreas and gizzard were heavier ($P < 0.05$) in males while AFP yield was higher in females. Strain and sex also affected ($P < 0.05$) pancreas and gizzard weights (Table 2). There was no interaction between sex and strain on cut weight. Strain × sex interaction ($P < 0.05$) was observed on AFP yield. There was some

Table 2. Body weight (BW), selected cut and giblet weights in foraging Naked Neck (NN), Ovambo (OV) and Potchefstroom Koekoek (PK) chickens

| Parameter | Sex | | SE | P-value |
|----------------|---------------------|---------------------|-------|---------|
| | Male | Female | | |
| Body weight | 2269.3 ^a | 1476.1 ^b | 96.71 | 0.0410 |
| Back | 357.4 ^a | 193.6 ^b | 6.83 | 0.0051 |
| Drumstick | 135.9 ^a | 56.7 ^b | 6.11 | 0.0171 |
| Shank | 274.3 ^a | 145.2 ^b | 9.96 | 0.0171 |
| Thigh | 138.4 ^a | 88.4 ^b | 6.67 | 0.0486 |
| Wing | 94.1 ^a | 59.8 ^a | 5.09 | 0.0576 |
| Breast | 345.4 ^a | 269.5 ^a | 18.17 | 0.1351 |
| Neck | 94.4 ^a | 66.0 ^a | 4.01 | 0.0541 |
| Gizzard | 61.4 ^b | 66.2 ^a | 1.92 | 0.0269 |
| AFP | 17.9 ^b | 18.6 ^a | 0.40 | 0.0091 |
| Crop | 13.6 ^a | 12.0 ^a | 0.66 | 0.1178 |
| Pancreas | 3.6 ^a | 3.4 ^a | 0.47 | 0.8833 |
| Intestines | 130.0 ^a | 136.7 ^a | 11.86 | 0.7742 |
| Liver | 33.2 ^a | 31.0 ^a | 3.00 | 0.7108 |
| Heart | 13.9 ^a | 6.6 ^a | 2.97 | 0.2919 |
| Spleen | 4.6 ^a | 1.7 ^a | 2.81 | 0.6188 |
| Proventriculus | 5.6 ^a | 9.8 ^a | 1.31 | 0.1973 |

^{a,b}Values in the same row with different superscripts differ significantly ($P < 0.05$); SE, Standard error; AFP, Abdominal fat pad.

evidence of pancreatic atrophy among birds raised in paddocks with the effects being most severe in NN chickens. While deliberate selection over time has led to development of chickens with higher breast yield for fast-growing birds, slower-growing strains have largely been neglected in that regard. The observation that strain influenced yield of some portions is consistent with findings of Fanatico *et al.* (2005). They reported that fast-growing birds show higher breast yield compared to slow-growing strains.

The observation on heavier shank, back, thigh, drumstick and gizzards in males in the current study is similar to findings of Takahashi *et al.* (2006). Larger portions in males could be related to hormonal influence as described earlier. However, larger gizzards in males perhaps indicate the need to process more food in this sex where there is greater demand for energy. Our results also largely agree with Hrněár *et al.* (2010) except for back weight which was higher in females in the other study. Males yielded less abdominal fat than females as was expected. Similar observations were made by other workers (Hrněár *et al.* 2010). The fact that the NN strain was affected more may suggest poor or slow adaptive capacity on the part of this strain. A peculiarity about the OV is the gizzard and pancreas weight. The OV has the highest body and pancreas weights but the smallest gizzard (Table 3).

Differences in pancreas, gizzard and crop weight in relation to BW present an interesting observation, given that these differences did not translate to differences in actual BW. This may suggest crop and gizzard muscle hypertrophy and pancreatic atrophy in foraging birds. Gizzard muscle hypertrophy may have occurred in response to the need to accommodate large volumes of forage. This would be accompanied by a concomitant increase in crop volume in order to increase capacity for temporary storage of forage. The crop receives hunger signals and empties into the proventriculus. Large volumes of forage emanate from diet nutrient density which directly affects the amount of feed that has to pass through the gastrointestinal tract for a given amount of energy and protein to be extracted.

Table 3. Body weight (BW), back, neck, gizzard, pancreas, abdominal fat pad (AFP) and crop weights in foraging Naked Neck (NN), Ovambo (OV) and Potchefstroom Koekoek (PK) chickens

| Parameter | Strain, weight (g) | | |
|-----------|-----------------------------|-----------------------------|---------------------------|
| | NN | OV | PK |
| BW | 1578.0 ± 86.19 ^a | 2036.0 ± 86.19 ^a | 2004 ± 86.19 ^a |
| Back | 241.0 ± 6.08 ^c | 300.5 ± 6.08 ^a | 285.1 ± 6.08 ^b |
| Neck | 62.8 ± 3.57 ^c | 84.7 ± 3.57 ^b | 93.0 ± 3.57 ^a |
| Gizzard | 61.0 ± 1.15 ^b | 53.6 ± 1.15 ^c | 69.5 ± 1.15 ^a |
| Pancreas | 3.3 ± 0.28 ^b | 5.9 ± 0.28 ^a | 4.7 ± 0.28 ^{ab} |
| AFP | 16.1 ± 0.24 ^b | 21.2 ± 0.24 ^a | 19.9 ± 0.24 ^a |
| Crop | 11.6 ± 1.00 ^b | 13.1 ± 1.00 ^a | 13.7 ± 1.00 ^a |

^{a, b, c}Values in the same row with different superscripts differ significantly ($P < 0.05$). NN, Naked Neck; OV, Ovambo; PK, Potchefstroom Koekoek; AFP, Abdominal fat pad.

Birds on paddocks mainly foraged on the Katambora grass albeit with access to various insects. Foraging chickens have to compose their diet unlike housed birds with *ad lib.* access to nutrient-dense diets. The modifications in the nutrient composition and feed structure for housed birds has seen decreases in gizzard size as a consequence of reduced intensity of work. For that reason, minimal hypertrophy was anticipated in housed birds. In addition, the retention time for fibre-rich diets in free-range birds is significantly longer, culminating in the observed modification of gut organs.

Pancreatic atrophy can be caused by various factors. Pancreas functions are influenced by changes in major dietary components and patterns in food intake, among others. It is possible that foraging birds suffered protein-calorie deficiency resulting in weight loss. Pancreatic duct obstruction and selenium deficiency also lead to stunting. Such factors may need further investigation since possible contributions in the current study cannot be ruled out.

The major goal for producers is to increase carcass yield and reduce fatness, mainly the AFP (Fouad and El-Senousey 2014). Excessive fatness is unfavourable for producers and consumers alike. It wastes dietary energy, has low economic value, reduces carcass yield and negatively affects consumer acceptance. For consumers, excessive fat intake is a threat associated with several health conditions, such as atherosclerosis, which predispose consumers to heart problems. Ironically, whether in adipose tissue or muscle, fat plays an important role in meat quality and human health (Wood *et al.* 2008, Peng *et al.* 2015). The farmer, therefore, has to strike a balance since some degree of fatness is essential in quality determination.

In general, absorbed fat, lipogenesis and lipolysis determine body fat deposition and accumulation in an organism. It therefore follows that if the amount of dietary fat is the same, lower body fat deposition may be a consequence of increased fat catabolism, diminished lipogenesis or a combination of the two (Sanz *et al.* 2000). These extrinsic factors interact with the inherent ability of an animal to metabolise fat and it is this interaction that determines ultimate fat content. Sales (2014) observed lower fat concentrations in free-range chickens compared to those without access to a pasture, an observation similar to our findings.

It was concluded that males yielded heavier portions and less fat compared to females. The OV chickens yielded the heaviest portions among the strains. Foraging birds experienced crop and gizzard hypertrophy and pancreatic atrophy, adaptive mechanisms perhaps meant to cope with fibrous diets. Characterisation of fatty acid composition in chicken from free-range systems would help quantify risk associated with the consumption of meat from foraging slow-growing strains.

SUMMARY

Meat and fat yield influence the profitability of modern commercial poultry production. This study sought to

determine the effect of strain and sex on carcass and fat yield of three slow-growing chicken strains reared in open and closed pens. Two hundred and fifty-eight, 20-week old PK, OV and NN chickens, weighing 1710 ± 308.8 g, were allocated to 4 paddocks of *Chloris gayana* and 4 pens in a poultry house. Final body weight (BW), carcass (CW), dressed (DW) weight, cut, abdominal fat pad (AFP) yield and gizzard weights were determined. As a result of this study, strain did not affect BW but influenced back, pancreas, gizzard, neck, crop and AFP weight. Sex of bird influenced BW and males were significantly heavier, yielding heavier cuts and pancreases but lighter AFP than females. It was concluded that foraging males yield heavier cuts and females are fatter than foraging males of the same strain. Evaluating fatty acid composition of meat from foraging birds could help quantify risk associated with consumption of meat from foraging slow-growing chickens.

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