Estimation of the Composition of Broiler Carcasses from their Specific Gravity

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ABSTRACT

An experiment was conducted to quantify the relationships between broiler carcass specific gravity and chemical composition (percentage moisture, percentage lipid, percentage protein). Carcasses of widely varying compositions were produced by feeding several dietary protein and energy combinations (52 to 64% moisture, 0.6 to 2.5% ash, 1.6 to 11.7% lipid, and 4.9 to 8.0% nitrogen). Very strong relationships were found between percentage moisture and percentage lipid (r = ±0.969) and percentage moisture and percentage N (r = 0.968). Strong relationships were found between specific gravity and percentage lipid (r = -0.872) and specific gravity and percentage N (r = 0.857). Specific gravity is recommended as a means to estimate carcass fat in broiler chickens.

(Key words: broiler, carcass fat, carcass nitrogen, carcass specific gravity)

INTRODUCTION

It is possible to make large changes in the protein and lipid contents of broiler chicken carcasses (Fraps, 1943; Donaldson et al., 1956; Edwards et al., 1973). Increasing the dietary protein concentration increases the proportion of carcass lean, and increasing dietary energy concentration increases the proportion of carcass lipid. Carcass composition may also change with environmental temperature, because cool birds use more of their dietary energy to keep warm and deposit less in their bodies (Kubena et al., 1972). Carcass composition itself is difficult, tedious, and expensive to measure: carcasses have to be ground, dried, and extracted with hazardous chemicals to determine lipid content, and digested to liberate ammonia to estimate crude protein content. Therefore, it would be advantageous if a simple means of estimating carcass composition from a physical characteristic, such as its specific gravity, could be developed to give acceptable estimates.

Becker et al. (1981:2045) concluded that “specific gravity is not recommended as a means to estimate carcass fat in broiler chickens” based on low correlation coefficients between carcass fat and specific gravity (−0.31 to −0.69). Similarly, Chambers and Fortin (1984) found low R² values (0.36) for the relationship between specific gravity and ether extract of the chilled carcass.

As pointed out by Chambers and Fortin (1984), the low coefficients could have been due to the narrow range in carcass composition in these studies. The objective of this study was to use carcasses with a broad range of carcass compositions to develop equations relating both carcass lipid and protein to carcass specific gravity or carcass moisture.

MATERIALS AND METHODS

Fifty broiler carcasses with a wide variety of carcass moisture, lipid, and nitrogen contents were produced by feeding female broilers five diets from 15 to 46 d of age. The diets were made by mixing a basal diet (10.0% crude protein, 3.50 kcal ME/g) and a summit diet (30.0% crude protein, 2.50 kcal ME/g) in proportions of 100:0, 75:25, 50:50, 25:75, and 0:100. When the birds were 46 d old, they were deprived of feed overnight and killed, scalded, and picked using standard processing techniques. The carcasses were eviscerated, washed, dried, and weighed to the nearest 0.1 g. They were then weighed in water by suspending them with a 500-g weight from a top-loading scale (nearest 0.1 g) into approximately 160 L of water. The mass of the line and 500 g weight in water were subtracted to give the weight of the carcass in water. Specific gravity = dry carcass weight/(dry carcass weight – carcass weight in water). The carcasses were frozen at −10 C, cut into approximately 2-cm cubes with a band saw, and ground to a fine paste with a K115Q Cutter Slicer. The percentage moisture content was determined by freeze drying. Carcass lipid was determined by the method of Folch et al. (1957) and nitrogen was determined by the
method of AOAC (1970). The relationships between various carcass parameters were investigated using SAS® (1985) PROC CORR and PROC GLM procedures.

**RESULTS AND DISCUSSION**

The diets employed produced a high degree of variation for each carcass parameter measured (Table 1). Differences between the minimum and maximum values were 1.05-fold for specific gravity to 2.3-fold for live weight to 2.6-fold for percentage carcass nitrogen, to 15.1-fold for percentage carcass lipid. There were strong relationships between live weight and carcass weight and percentage nitrogen \( (P < 0.05) \) but not live weight and percentage moisture, percentage lipid, or specific gravity \( (P > 0.11) \). Very close relationships were found between percentage carcass moisture, percentage lipid, percentage nitrogen, and specific gravity \( (P < 0.001) \). The relationships between these parameters are illustrated in Figures 1, 2, and 3.

Linear relationships between the energy to protein ratio of the diet and carcass parameters were first illustrated by Donaldson *et al.* (1956). The data in Tables 1 and 2 essentially confirm and extend the results of Donaldson *et al.* (1956) and subsequent research (Edwards *et al.*, 1973; Summers *et al.*, 1965; Coon *et al.*, 1981) that these parameters vary together. Barton (1983) found a relationship between carcass lipids and specific gravity [ready to cook (RTC) fat = \( 482.637 - 445.1086 \times \text{SG} \)]. This result is very similar to the relationship reported in the present study (Table 3).

From Figures 1 and 2, it may be concluded that (under the conditions of this study) carcass percentage lipid and percentage nitrogen can be predicted very well from either percentage moisture or specific gravity. The determination of either percentage lipid or percentage nitrogen are complex chemical procedures, much more complicated than just drying the ground carcass as in the percentage moisture determination. It would seem that there is not a great deal of new information to be gathered from knowing more than percentage moisture. If it is known that percentage moisture increases, then it can be predicted quantitatively with some high degree of certainty that percentage carcass nitrogen also increases, and percentage lipid decreases. This relationship has been discussed in great detail by Velu *et al.* (1972), Sibbald and Wolynetz (1986), and Wolynetz and Sibbald (1990). Wolynetz and Sibbald (1990) concluded

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**TABLE 1.** Descriptive statistics of broiler carcasses produced by feeding different levels of protein and energy

<table>
<thead>
<tr>
<th>Variable</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live weight, g</td>
<td>1,124</td>
<td>2,575</td>
<td>1,763</td>
<td>301</td>
</tr>
<tr>
<td>Carcass weight, g</td>
<td>680.3</td>
<td>1,789.9</td>
<td>1,205.2</td>
<td>236.3</td>
</tr>
<tr>
<td>Percentage moisture</td>
<td>51.7</td>
<td>76.19</td>
<td>63.90</td>
<td>6.39</td>
</tr>
<tr>
<td>Percentage ash</td>
<td>0.58</td>
<td>3.81</td>
<td>2.49</td>
<td>0.62</td>
</tr>
<tr>
<td>Percentage lipid</td>
<td>1.58</td>
<td>23.84</td>
<td>11.71</td>
<td>5.79</td>
</tr>
<tr>
<td>Percentage nitrogen</td>
<td>4.90</td>
<td>12.65</td>
<td>8.00</td>
<td>2.02</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>1.0193</td>
<td>1.0675</td>
<td>1.0434</td>
<td>0.0134</td>
</tr>
</tbody>
</table>

**FIGURE 1.** The carcass composition of broilers with various carcass moisture contents.

**FIGURE 2.** The carcass composition of broilers with various carcass specific gravities.

**FIGURE 3.** The relationship between percentage lipid and percentage nitrogen in ready-to-cook broiler carcasses.
TABLE 2. Pearson correlation coefficients (upper right) and probabilities that the coefficients are equal to zero (lower left)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Live weight</th>
<th>Carcass weight</th>
<th>Percentage moisture</th>
<th>Percentage lipid</th>
<th>Percentage nitrogen</th>
<th>Specific gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live weight</td>
<td>0.984 ±0.224</td>
<td>0.915 ±0.305</td>
<td>-0.224</td>
<td>0.915</td>
<td>-0.305</td>
<td>-0.240</td>
</tr>
<tr>
<td>Carcass weight</td>
<td>&lt;0.001</td>
<td>0.308</td>
<td>-0.341</td>
<td>0.968</td>
<td>-0.415</td>
<td>-0.351</td>
</tr>
<tr>
<td>Percentage moisture</td>
<td>0.131</td>
<td>0.308</td>
<td>0.841</td>
<td>-0.969</td>
<td>0.948</td>
<td>-0.900</td>
</tr>
<tr>
<td>Percentage lipid</td>
<td>0.189</td>
<td>0.035</td>
<td>0.001</td>
<td>&lt;0.001</td>
<td>-0.948</td>
<td>-0.872</td>
</tr>
<tr>
<td>Percentage nitrogen</td>
<td>0.037</td>
<td>0.004</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>-0.948</td>
<td>-0.857</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>0.104</td>
<td>0.015</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

that even though each observation may not be known accurately, by prediction equations, differences in dietary effects on carcass composition can be accurately assessed statistically.

Hunt (1965) demonstrated that both sex and strain should be included in models using body water and age to predict body nitrogen. Therefore, to be entirely accurate in each experiment, a few carcasses of very high and low moistures or specific gravities could be assayed for lipids and nitrogen to calibrate the prediction lines (Figures 1 and 2). Without such calibrations, relative differences should be detected, but exactly how big the differences are would not be known.

The relationship between specific gravity and carcass composition found in our experiment (Tables 2 and 3) is much stronger than those found by Becker et al. (1981) or Chambers and Fortin (1984). The r values for specific gravity vs percentage lipid in Table 2 are -0.872 vs -0.31 to -0.69 in the Becker et al. (1981) study; and the R^2 values in Table 3 for carcass lipid = f (specific gravity) are 0.76 vs 0.36 in the Chambers and Fortin (1984) study. One possible reason for the improvement in predictability in the present study is surely our introduction of variability in carcass composition by feeding our birds different protein and energy levels to produce some very fat and lean carcasses. Another reason is probably our use of very accurate electronic weighing devices. Although the type of weighing device used in the earlier studies is not known, affordable electronic weighing devices were just becoming available in the early 1980s. Before that time, true balances were used for weighing: It would have taken much extra time for adding weights and sliding slides as the balance came to equilibrium, especially with the carcass hanging in water. With electronic weighing devices we have to be careful not to disturb the water any more than absolutely necessary to speed up the process. The electronic devices certainly make the specific gravity measurements very easy to perform.

The determination of carcass percentage moisture is much more difficult than determining carcass specific gravity. Determining carcass percentage moisture involves grinding the carcass, but specific gravity involves only weighing the carcass in and out of water. The relationships of carcass percentage lipid or percentage moisture with specific gravity are not as strong as they are with percentage moisture. However, specific gravity is much quicker and easier to determine than percentage nitrogen or percentage lipid. Therefore, many more observations can be done for specific gravity when looking for changes in treatment means or trends over time. Taking more specific gravity measurements will allow for the same or greater confidence in treatment means than from grinding carcasses, with a smaller investment in labor and materials.

Another big advantage of using specific gravity to estimate carcass composition is that it is nondestructive. The method could be used in poultry processing plants to monitor changes in carcass lipids over time or from different breeds or diet regimens. All that is necessary is an accurate weighing device, a frame for weighing hanging objects, and a tank of water (a 30-gal garbage can works nicely).

In conclusion, there is a strong relationship between carcass moisture and specific gravity. This relationship can be used to estimate carcass composition from data that are very easy to obtain with modern electronic balances. The method is nondestructive and can be used to monitor changes in carcass composition.
REFERENCES