

[Sorghum TechNote PRF 3-14A]

## **Red versus white sorghums Part I** *Is white sorghum really better than red?*

**Sonia Liu, Ha Truong and Peter Selle**  
Poultry Research Foundation, The University of Sydney  
425 Werombi Road Camden NSW 2570

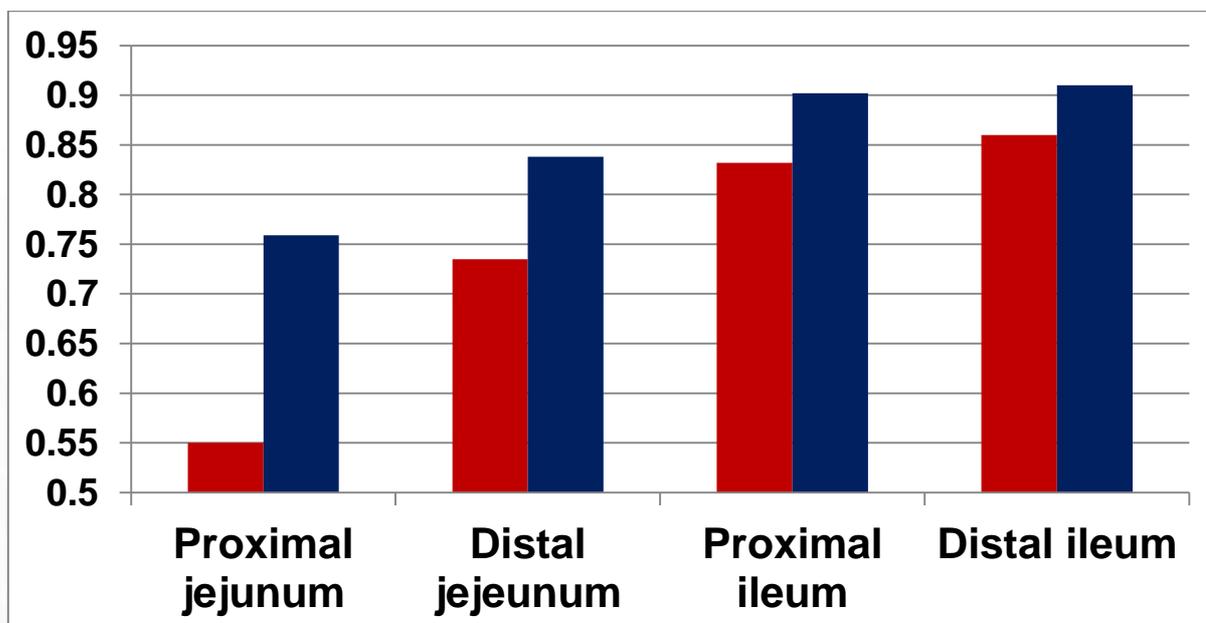


The majority of grain sorghum harvested in Australia, perhaps 95%, possess red pericarps while the minority (Liberty) have white pericarps. This appears to reflect an acceptance of the proposal that red sorghums varieties are more agronomically viable. However, despite the predominance of red sorghums, the perception amongst pig and poultry nutritionists is that white sorghum is the better feedstuff and this view is probably more strongly held by the pork industry. The first task is to assess the validity of this perception and, if considered valid, the second task is to identify the underlying factors contributing to the superiority of white sorghum.

Cadogan and Finn (2010) compared a 9.0 % protein white sorghum (Liberty) with a 11.5% protein red sorghum (Buster) in weaner pigs, with and without exogenous protease. In non-supplemented diets, the digestible energy (DE) content of Liberty was significantly higher, by 0.59 MJ (14.87 versus 14.28 MJ/kg, as-is), than Buster. Overall, Liberty supported higher average daily gains (416 versus 397 g/day), feed intakes (416 versus 397 g/day), similar feed conversion ratios (1.418 versus 1.410) and higher DE values (14.80 versus 14.47 MJ/kg, as-is) than Buster in non-supplemented and protease-supplemented diets in the 21 days post-weaning period.

The Poultry Research Foundation (Selle *et al.*, 2013; Liu *et al.*, 2013b) also compared Liberty (98 g/kg protein) and Buster (121 g/kg protein) sorghum varieties in broiler chickens. In this comparison, sorghums were hammer-milled through a 3.2 mm screen prior to being incorporated into diets that were steam-pelleted at a conditioning temperature of 95°C. Liberty supported 4.69% better weight gains (1540 versus 1471 g/bird;  $P < 0.03$ ) and 2.88% better feed conversion ratios (1.485 versus 1.529;  $P < 0.05$ ) from 7 to 28 days post-hatch. These improvements in growth performance were associated with significantly higher starch digestibility coefficients in four small intestinal segments, higher starch digestion rates, a higher predicted glycaemic response and a greater quantity of potentially digestible starch. In this comparison, Liberty contained less total phenolic compounds (2.02 versus 4.13 GAE/g), less phytate (6.74 versus 9.22 g/kg) and almost certainly contained less kafirin than Buster.

The superiority of white over red sorghum in terms of starch digestibility is illustrated in Figure 1 where it is most evident in the two jejunal segments. Digestion of starch is followed by absorption of glucose, which can be assessed by the predicted glycaemic response. The importance of starch digestion and glucose absorption in relation to feed efficiency is illustrated in Figure 2 where there is a significant linear relationship between predicted glycaemic responses and feed conversion ratios (FCR) in broiler chickens offered coarsely-ground sorghum-based diets (Liu *et al.*, 2013a). Interestingly, in both pig and poultry, there is the suggestion that energy utilisation of Liberty is better than Buster and the majority of energy is derived from the starch component of sorghum. These ‘one-on-one’ comparisons are instructive but they need not be representative of the bigger picture. However, Perez-Maldonado and Rodrigues (2009) offered broiler chickens, diets that were based on 31 different sorghums harvested in 2004 and 2005 in a RIRDC Chicken-meat project. Seventeen 2004 sorghums were assessed of which two were white (Liberty) and fourteen 2005 sorghums were assessed of which one was a white sorghum. The sorghum varieties investigated are tabulated (Table 1) where Pacific MR 43 and Pacific Buster were the most common varieties. Thus this data permits a retrospective comparison between white (3) and red (28) sorghum varieties to test the validity of the empirical assertion that white sorghum is a superior feedstuff to red sorghum.



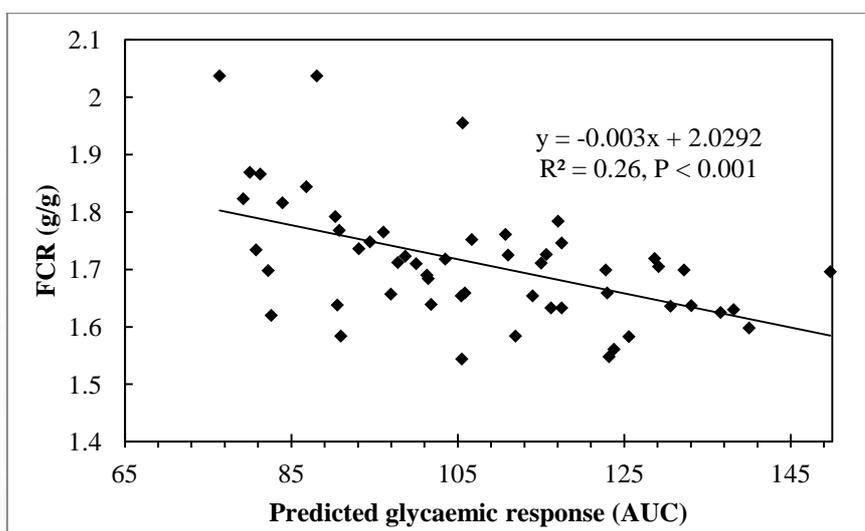
**Figure 1** Apparent starch digestibility coefficients in four small intestinal segments in broilers offered steam-pelleted diets based on a red (Buster) or white (Liberty) sorghum (Selle *et al.*, 2103)

**Table 1** Number of sorghum varieties assessed by Perez-Maldonado and Rodrigues (2009) in their report on the “Nutritional characteristics of sorghums from Queensland and New South Wales for chicken meat production”.

| Sorghum variety       | 2004 harvest | 2005 harvest | Combined harvests |
|-----------------------|--------------|--------------|-------------------|
| Pacific MR 43         | 7            | 3            | 10                |
| Pacific Buster        | 5            | 5            | 10                |
| Hylan Liberty (white) | 2            | 1            | 3                 |
| Balance <sup>1</sup>  | 3            | 5            | 8                 |
| Total                 | 17           | 14           | 31                |

<sup>1</sup>Balance consisted of Hylan Dominator, Pioneer Bonus (2), Pioneer 85G83, Pioneer 86G87, Pioneer Bounty (2), Pacific MR 44.

The Perez-Maldonado and Rodrigues (2009) report contain an immense amount of data but an essential comparison of red versus white sorghums can be encapsulated in one figure. As shown in Figure 3, the mean apparent metabolisable energy (AME) of white sorghum was 0.45 MJ higher (15.87 versus 15.42 MJ/kg DM) than red sorghum and the nitrogen (N) corrected AME (AMEn) was 0.39 MJ higher (15.33 versus 14.94 MJ/kg DM) across both harvest years. A larger number of white sorghum samples would have been preferable; nevertheless, the differences in AME ( $P < 0.125$ ) and AMEn ( $P < 0.05$ ) either approach or are statistically valid. Thus the implication is that the energy/starch component of white sorghum is better utilised than red sorghums.



**Figure 2** The linear relationship between predicted glycaemic responses and feed conversion ratios (FCR) in broiler chickens offered coarsely-ground sorghum-based diets (Liu *et al.*, 2103a)

**Table 2** Key characteristics of the sorghum varieties from 2004 and 2005 harvests assessed by Perez-Maldonado and Rodrigues (2009)

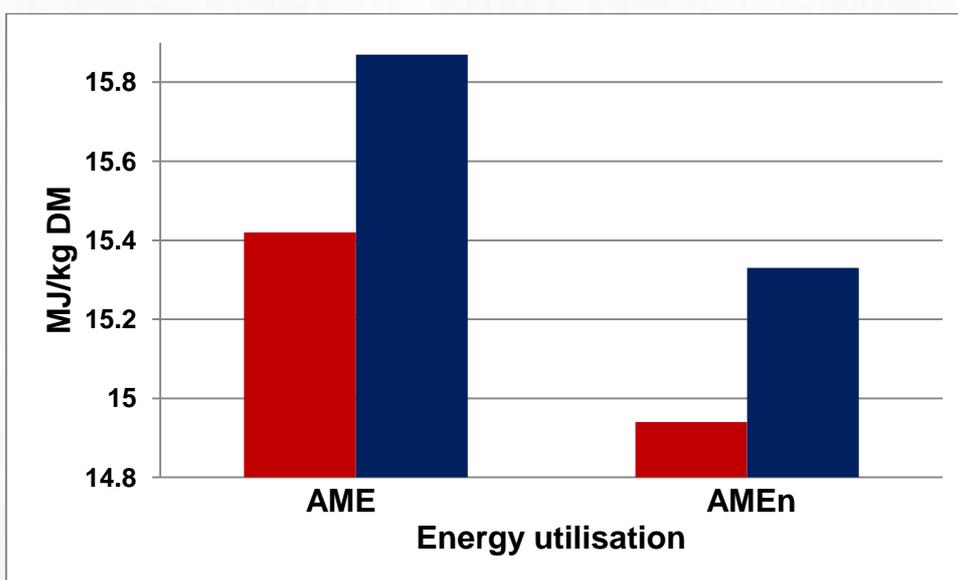
| Parameter                           | Red sorghums<br>(n = 28) | White sorghums<br>(n = 3) |
|-------------------------------------|--------------------------|---------------------------|
| Starch (g/kg)                       | 637                      | 656                       |
| Protein (g/kg)                      | 117                      | 105                       |
| Kafirin index <sup>1</sup>          | 5.48                     | 4.27                      |
| Phytate (g/kg)                      | 7.37                     | 6.27                      |
| “Phenolic compounds”                | 6.99                     | 1.53                      |
| Apparent ileal starch digestibility | 0.881                    | 0.908                     |
| Apparent metabolisable energy (AME) | 15.42 MJ/kg              | 15.87 MJ/kg               |
| [Range]                             | [14.3 – 16.2]            | [15.6 – 16.1]             |
| N-corrected AME (AMEn)              | 14.94 MJ/kg              | 15.33 MJ/kg               |
| [Range]                             | [14.0 – 15.2]            | [15.2 – 15.5]             |

As shown in Table 2, starch and protein concentrations in the two sorghum categories were reasonably similar. The Kafirin Index<sup>1</sup> is a coarse estimate of the kafirin content of sorghum and is calculated by subtracting the sum concentrations of basic amino acids from that of leucine.

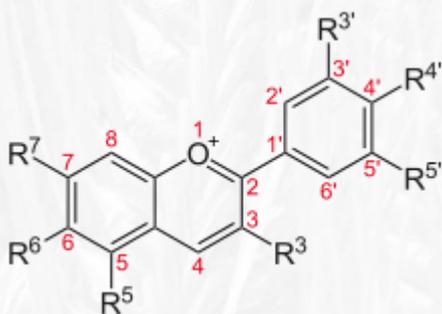
$$\text{Kafirin Index} = \text{leucine}_{(g/kg)} - [\text{arginine} + \text{histidine} + \text{lysine}]_{(g/kg)}$$

This suggests that red sorghums contained somewhat more kafirin, which is in keeping with their higher protein contents, and they also contained somewhat more phytate. However, the biggest discrepancy was in the reported concentrations of phenolic compounds where red exceeded white sorghum by a 4.6-fold factor.

The phenolic compounds analysed by Perez-Maldonado and Rodrigues (2009) were described as free and bound tannins, expressed as g/kg. For example, in the 2004 harvest 15 red sorghums were reported to contain an average of 7.58 g/kg of free and bound, or total tannin. Thus, the implication is that these 15 red sorghums contained 7.58 g/kg condensed tannin; however, it seems extremely unlikely that this would have been the case. Nevertheless, it is probable that the “total tannin” levels reported are reflective of total phenolic concentrations. Given this interpretation, the finding that white sorghum contained substantially less phenolic compounds than red sorghum is a highly predictable outcome. This is because the red colour of sorghums is due to the presence of pigments (anthocyanins, anthocyanidins, Figure 4) that are, in fact, polyphenolic compounds (Taylor, 2005). Thus it is almost axiomatic that red sorghums will contain more phenolic compounds than white sorghums. The implications of this will be discussed in another TechNote.



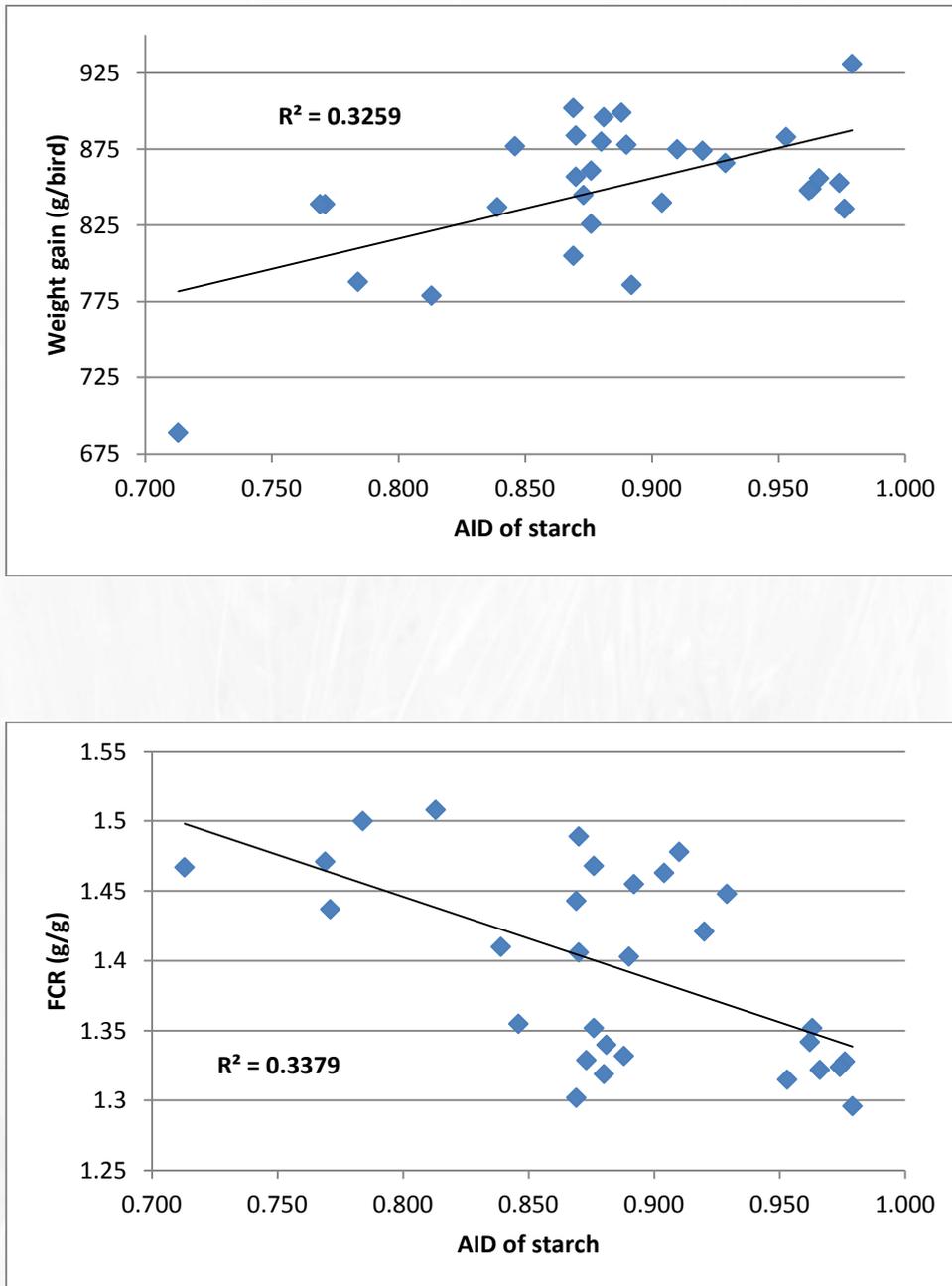
**Figure 3** A comparison of mean energy densities of broiler diets based on **28 red sorghums** and **3 white sorghums** from 2004 and 2005 Australian harvests (adapted from Perez-Maldonado and Rodrigues, 2009)



**Figure 4** The basic chemical structure of anthocyanin, a polyphenolic pigment found in red sorghums

The importance of apparent ileal digestibility coefficients of starch in relation to growth performance (weight gains and feed conversion ratios) of broilers offered sorghum-based diets from

the 2004 and 2005 harvests is illustrated in Figure 5. In the order of one-third of the variation in weight gain and FCR may be attributed to ileal starch digestibility. Overall, ileal starch digestibility in white sorghums (0.908; n = 3) was somewhat higher than red sorghums (0.881; n = 28) but, differences in energy utilisation (AME, AMEn) appear more pronounced than would be suggested by the ileal starch digestibility coefficients.



**Figure 5** Correlations between the apparent ileal digestibility (AID) of starch and weight gains and feed conversion ratios (FCR) from of broilers offered sorghum-based diets from the 2004 and 2005 harvests (adapted from Perez-Maldonado and Rodrigues, 2009)

This outcome is consistent with the proposition of Liu et al. (2014) that digestive dynamics of starch (and protein) are more indicative of broiler performance than static ileal digestibility coefficients. Clearly, in these protein-adequate diets sorghum starch/energy utilisation was a limiting factor on growth performance. In addition to the starch ileal digestibility coefficients, the rate, site and extent of starch digestion along the small intestine would have been very instructive data.

It seems quite reasonable to conclude that the utilisation of energy from white sorghum, which is predominantly derived from starch, is superior to that of red sorghum. This may be the fundamental difference between the two sorghum categories and supports the perception of nutritionists that white sorghum is a better feedstuff than red sorghum for pigs and poultry. Nevertheless, the pressing task is to identify the probable factors that are underlying this difference.

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