The Grain Sorghum Ferris Wheel

Introduction
Amy Moss

A Luke Witt, @alukewitt
instagram
Presently, 628 million broilers processed

An increasing annual requirement of over 3 million tonnes of rations, in the order of 2 million tonnes of feed grains, to grow broiler chickens out to 5-7 weeks.
A review of the nutritive value of sorghum for broilers (WL Bryden)
Steam-pelleting temperatures of sorghum-based broiler diets (PH Selle)
Evaluation of sodium bisulphite in sorghum-based broiler diets (PH Selle)
The factors influencing sorghum starch digestibility in broiler diets (PH Selle)
RIRDC Chicken-meat reports


Book chapter

Invited conference paper

Reviews


**Research papers**


Truong HH, Cadogan DJ, Liu SY, Selle PH (2015) Addition of sodium metabisulphite and microbial phytase individually and in combination, to a sorghum-based diet for broiler chickens from 7 to 28 days post-hatch. *Animal Production Science* dx.doi.org/10.1071/AN14841

Truong HH, Neilson KA, McInerney BV, Khoddami A, Roberts TH, Liu SY, Selle PH (2015) Performance of broiler chickens offered nutritionally-equivalent diets based on two red grain sorghums with quantified kafirin concentrations as intact pellets or reground mash following steam-pelleting at 65 or 97°C conditioning temperatures. *Animal Nutrition* (article in press).

Sorghum: An enigmatic grain
Ha Truong
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1 Introduction
This first sorghum TechNote, is derived from an invited text-book chapter, "Sorghum: an enigmatic grain for chicken-meat production" by my colleagues Peter Selle, Sonia Liu and Aaron Cowie. All references mentioned below are listed in this publication (Selle et al., 2013). A number of the issues raised in this introductory sorghum TechNote will be considered in more detail in subsequent editions.

While wheat is the dominant grain, sorghum makes up approximately one-third of the cereal base of Australian broiler diets. Both sorghum per se or as wheat-sorghum blends. The Australian annual sorghum harvest averaged 2.236 billion tonnes from 2008 to 2012 inclusive, and the entire crop could be utilised as an animal feedstuff, primarily for pigs, poultry and feedlot cattle. However, up to 500,000 tonnes of sorghum may be exported annually, which indicates that these livestock industries are somewhat reluctant to incorporate sorghum into their diets despite the fact that sorghum is usually available at a discounted price relative to wheat.

In Australia, if not other countries, sorghum is an enigmatic grain for chicken-meat production because the performance of broiler chickens on sorghum-based diets is considered to be either exacerbated or markedly inferior to those offered wheat-based diets. Broiler performance on sorghum-based diets has been described as "sub-optimal". However, our view is that "non-optimal" is probably a better description. For example, in a recently completed Poultry Research Foundation feeding study, sorghum-based diets supported significantly better performance than wheat and numerically-outperformed maize-based diets.

Red versus white sorghums Part 1
Is white sorghum really better than red?
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425 Werribee Road Cardsen NSW 2750

The majority of grain sorghum harvested in Australia, perhaps 95%, possess red pericaps while the minority (Liberty) have white pericaps. This appears to reflect an acceptance of the proposal that red-sorghum varieties are more agronomically viable. However, despite the predominance of red sorghum, the perception amongst pig and poultry nutritionists in 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.

Cullenin and Fette (2010) compared a 6.0% 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 0.15 MJ (14.87 versus 14.28 MJ/kg, as-is), than Buster. Overall, Liberty supported a higher average daily gain (8.16 versus 9.73 g/day), feed intake (4.18 versus 4.57 g/day), similar feed conversion ratios (1.418 versus 1.410) and higher DE values (14.87 versus 14.47 MJ/kg, as-is) than Buster in non-supplemented and protease-supplemented diets in the 21 days post-weaning period.

Digestive dynamics of starch and protein
Factors influencing digestive dynamics in sorghum-based broiler diets
Sonia Liu, Ha Truong and Peter Selle
Poultry Research Foundation, The University of Sydney
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Introduction
As discussed in TechNote 4, digestive dynamics of starch and protein embrace the digestion of nutrients in the gut lumen, absorption of end-products into the gut mucosa, and their entry into the systemic circulation. It is a combination of the rate, site and extent of nutrient digestion, in sorghum-based broiler diets, digestive dynamics is more relevant to feed conversion efficiency than individual assessment of apparent digestibility coefficients (Liu et al., 2013).

This concept was discussed during the early acceptance of synthetic amino acid in 1970s. Initially methionine and subsequently lysine was introduced, however, nutritionists were reluctant to include lysine in diets at more than 0.5 kg per tonne (Kidd and Tillman, 2012). The early research into lysine monomethylketone provides an invaluable insight into the gravity with which digestive dynamics can influence pig performance (Rattenbury, 1974, Rattenbury and O'Neill, 1975).

Rattenbury (1974) investigated the effect of frequency of feeding on the utilisation of free lysine in growing pigs and found that in conventional diets, not supplemented with free amino acids, feeding frequency
Sorhghum TechNotes – Feed Grain Partnership

1 Sorghum: An enigmatic grain.
Ha Truong

2 Phytate in sorghum Why are responses to phytase as modest as they appear?
Peter Selle, Ha Truong and Sonia Liu

3 Red versus white sorghums Part I Is white sorghum really better then red?
Sonia Liu, Ha Truong and Peter Selle

4 Digestive dynamics of starch and protein Why it is important in sorghum-based broiler diets?
Sonia Liu, Ha Truong and Peter Selle

5 Digestive dynamics of starch and protein Factors influencing digestive dynamics in sorghum-based broiler diets
Sonia Liu, Ha Truong and Peter Selle
6 Kafirin in sorghum Just how big a villain is this protein fraction?
Peter H Selle, Ha H Truong and Sonia Yun Liu

7 An assessment of three grain sorghums by ‘contour plots’
Sonia Liu, Ha Truong and Peter Selle

8 Additions of the reducing agent sodium metabisulphite in sorghum-based broiler diets based on eight different varieties
Ha H Truong, Amy F Moss, Sonia Yun Liu and Peter H Selle

9 Red versus white sorghums Part II The digestion of amino acids in broiler diets based on red and white sorghums
Sonia Liu, Ali Khoddami, Ha Truong, Amy Moss and Peter Selle

10 Sorghum A feed grain with issues for chicken-meat production
Peter Selle, Sonia Liu, Ha Truong, Amy Moss and Ali Khoddami
Dr Karlie Neilsen – quantification of kafirin in sorghum and definition of its amino acid profile

Mr Ali Khoddami – quantification of polyphenolics, free, conjugated and bound phenolic acids in sorghum, RVA pasting profiles of sorghum starch, Clorox beach tests for presence of pigmented testas and condensed tannin
### Amino acid profile of kafirin in MP sorghum and HP sorghum (mean values - APAF data) in comparison to average values of three data-sets reported by Xiao *et al* (2015)

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>APAF (g/100g protein)</th>
<th>Xiao <em>et al</em> 2015</th>
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<tr>
<td>Arg</td>
<td>2.2</td>
<td>2.1</td>
</tr>
<tr>
<td>His</td>
<td>1.9</td>
<td>1.2</td>
</tr>
<tr>
<td>Ile</td>
<td>4.1</td>
<td>3.7</td>
</tr>
<tr>
<td>Leu</td>
<td>15.8</td>
<td>16.9</td>
</tr>
<tr>
<td>Lys</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Met</td>
<td>1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Phe</td>
<td>5.7</td>
<td>5.4</td>
</tr>
<tr>
<td>Thr</td>
<td>2.7</td>
<td>2.5</td>
</tr>
<tr>
<td>Val</td>
<td>4.8</td>
<td>4.2</td>
</tr>
<tr>
<td>Ala</td>
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<td>Asp</td>
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<td>6.0</td>
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<tr>
<td>Glu</td>
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<tr>
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<tr>
<td>Ser</td>
<td>4.2</td>
<td>3.7</td>
</tr>
<tr>
<td>Tyr</td>
<td>4.7</td>
<td>4.4</td>
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RVA starch pasting profiles of the six Liverpool Plains sorghums
Sorghum: a feed grain with issues for chicken-meat production

Reducing agents in sorghum-based diets
RVA starch profiles and Promatest protein solubilities of grain sorghum

Bilateral bioavailability of starch and protein and the nutritional geometry of grain sorghum
Sorghum: An enigmatic grain for chicken-meat production
Peter H Selle
Sorghum: A sub-optimal or a maligned feed grain for chicken-meat production?

Peter Selle¹, Sonia Liu¹, Ha Truong¹, Amy Moss¹ and Ali Khoddami²,
¹Poultry Research Foundation, The University of Sydney
²Department of Plant and Food Sciences, Faculty of Agriculture and Environment,
The University of Sydney, NSW 2006, Australia

Sorghum is the second feed grain to wheat as the basis of diets for broiler chickens in Australia and there has been a considerable R&D focus on sorghum initiated by the RIRDC reports of Perez-Maldonado and Rodrigues (2009) and Bryden et al. (2009b). The perception is that sorghum is routinely inferior to wheat or ‘sub-optimal’ but our impression is that this is not necessarily the case. Nevertheless, it should be conceded that broilers offered wheat-based diets are advantaged by better pellet quality given the lower starch gelatinisation temperature of wheat and are far more likely to respond to feed enzymes, especially NSP-degrading enzymes. Sorghum, almost certainly, still suffers from the stigma of condensed tannin (CT), a potent polyphenolic anti-nutritive factor associated with ‘bird-proof’ sorghums. In a quite recent local survey of ‘coal-face’, pig and poultry nutritionists, the majority believed that sorghum contained some CT and a minority thought CT was present in sufficient concentrations to compromise animal performance. This group has found that more than 60 sorghum samples did not possess a pigmented testa with the quanatal Chlorox bleach test which indicates that they do not contain CT. This has been confirmed
In contrast, (to wheat and barley) sorghum is generally regarded as a relative consistent source of energy. However, this may not always be the case, as anecdotal evidence from the field suggests that some commercial flocks respond poorly to sorghum-based diets.
Finally, proteins in general appear to behave differently in sorghum than in maize or rice by forming extensive extended web-like or sheet-like structures during cooking. This could impact functional properties and quality of sorghum products, as well as could affect nutritional properties.

Liu *et al.* (2014)
Growth performance from 7 to 27 days post-hatch of broilers offered equivalent diets containing 560 g/kg feed grain
Sorghum: 82.4 g/kg protein, 614 g/kg starch

<table>
<thead>
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<th>Feed grain</th>
<th>Gain</th>
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<th>FCR</th>
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<td>Maize</td>
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<td>Sorghum</td>
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<td>1939</td>
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<tr>
<td>Wheat</td>
<td>1226</td>
<td>1879</td>
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<tr>
<td>Wheat</td>
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<td>1.532</td>
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Control

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<th>Feed grain</th>
<th>Gain</th>
<th>Feed intake</th>
<th>FCR</th>
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<tbody>
<tr>
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<td>Sorghum</td>
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<td>1993</td>
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<tr>
<td>Wheat</td>
<td>1281</td>
<td>1946</td>
<td>1.520</td>
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1,000 FTU/kg phytase
**Selle et al. (2010)**

Growth performance at 42 days post-hatch and AME of broilers offered equivalent sorghum- and wheat-based diets

<table>
<thead>
<tr>
<th></th>
<th>Grain</th>
<th>Gain</th>
<th>Feed intake</th>
<th>FCR</th>
<th>AME</th>
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<tr>
<td>Sorghum</td>
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<td>1.845</td>
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<tr>
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<td>4752</td>
<td></td>
<td>1.929</td>
<td>13.55</td>
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<tr>
<td><strong>Xylanase</strong></td>
<td></td>
<td></td>
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<tr>
<td>Sorghum</td>
<td>2626</td>
<td>4883</td>
<td></td>
<td>1.860</td>
<td>13.95</td>
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<tr>
<td>Wheat</td>
<td>2549</td>
<td>4566</td>
<td></td>
<td>1.792</td>
<td>14.76</td>
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</tbody>
</table>
Sorghum-based broiler diets are not very responsive to feed enzymes Phytase AND Xylanase

Pellet quality is an issue (high starch gelatinisation temperatures)

Broiler chicks on sorghum-based diets often perform better than ‘the perception’

But sorghum has an Achilles’ heel and that is relatively poor starch/energy utilisation

Stigma of condensed tannin persists