A PRELIMINARY STUDY ON THE CHEMICAL COMPOSITION OF AUSTRALIAN COTTONSEED AND THE RELEVANCE OF COTTONSEED AS A FEEDSTUFF FOR RUMINANT AND MONOGASTRIC LIVESTOCK

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INTRODUCTION

Extracted cottonseed meal has long been recognised as a high-protein feedstuff for domestic livestock. However, in the case of monogastric species (ie pigs and poultry), its use in rations is limited due to the presence of gossypol, a secondary plant compound present in the endosperm (kernel). This can be counteracted by the steaming of cottonseed during the oil extraction process, which binds gossypol to protein (Frank 1987). Such drastic heat treatment, however, reduces the efficiency with which cottonseed protein can be utilised by monogastric animals, especially for the amino acid lysine (Batterham et al. 1990).

Because gossypol can be metabolised by rumen micro-organisms, cottonseed meal can readily be fed to ruminant animals. A large part of the protein in processed cottonseed meal escapes rumen fermentation, and is referred to as "by-pass" protein. Hence, cottonseed meal is particularly useful as a supplement to ruminants fed low quality roughage diets, (Lee et al. 1987).

Recent investigations by our group (Terrill et al. 1992) have detected condensed tannins (CT), as a further group of secondary compounds present in commercially

produced cottonseed meal. CT are likely to further reduce protein nutritional value in diets for monogastric animals. Low concentrations (less than 2% DM) are likely to promote increased protein "by-pass" in ruminant diets, with higher concentrations reducing feed intake (Barry 1989).

Thus, whilst only one manufacturing process is currently used for oil extraction and the preparation of cottonseed meal in Australia (Fig.1), it seems that different manufacturing conditions may be needed to produce cottonseed meals that have optimum nutritive value for monogastric and ruminant animals. A three year investigation is being undertaken at Massey University to study the effect of condensed tannins, heat and solvent extraction upon the nutritive value of cottonseed meal for ruminant and monogastric farm animals. This paper describes the project objectives and presents some of the initial results on cottonseed chemical composition.

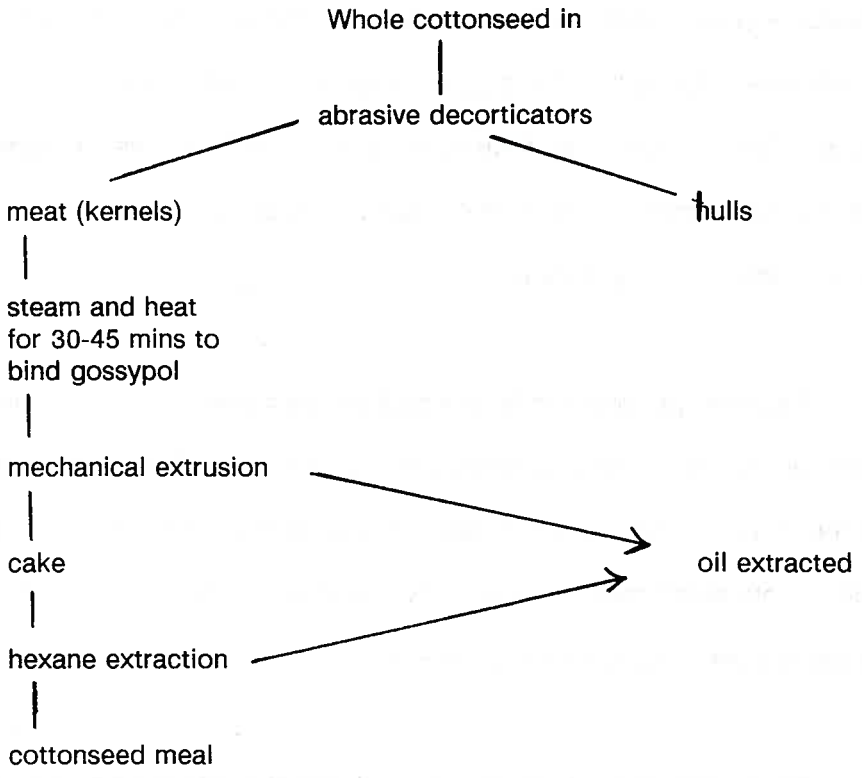

Figure 1. Oil extraction and the production of cottonseed meal.

PLANT COMPOSITION

Nutritive value is very dependent upon plant chemical composition. A scheme showing the various compounds present in plants is shown in Fig. 2. Plant chemical components can be divided into primary and secondary compounds. In the case of cottonseed, oil is the most economically important primary compound, followed by protein.

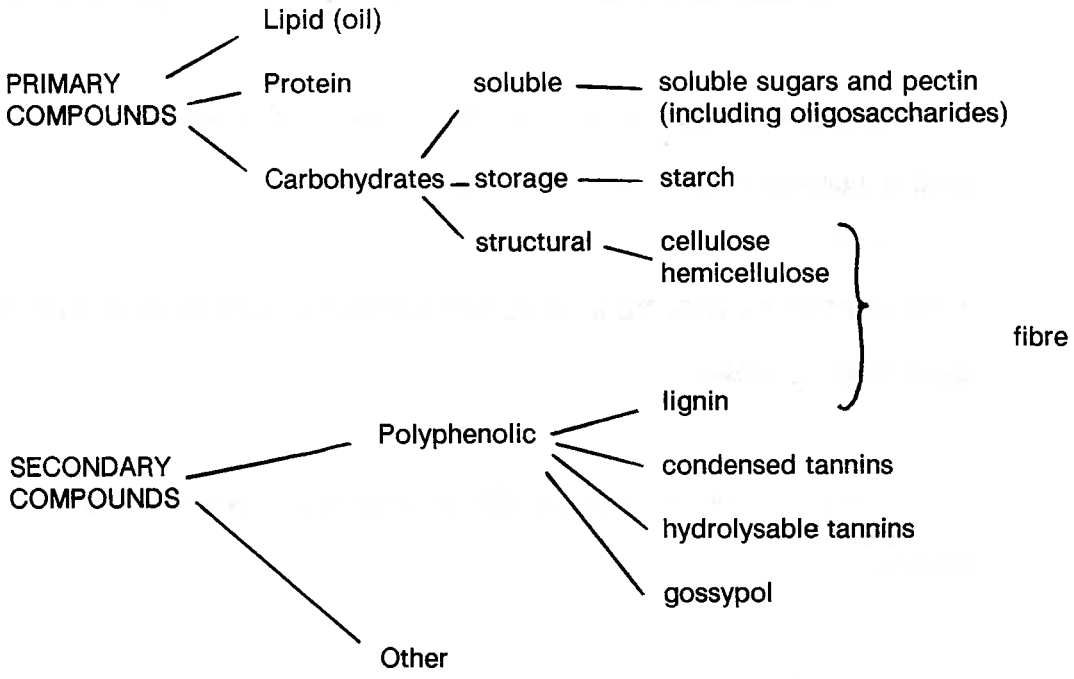

Figure 2. Classification of plant components.

Cottonseed contains polyphenolic secondary plant compounds, including both gossypol and condensed tannins, and also lignin which contributes to the fibre content of the cottonseed. It is, however, of some interest to reflect on the evolutionary role of these secondary compounds, which is thought to be to defend the plant against attack by pathogenic bacteria and fungi, insects and against being eaten by herbivores. In the wild state, plants may have evolved these chemical defences in this order to ensure

protection (Barry 1989). While this has contributed to survival of the plants, it leads to two problems for modern agriculture:

1. producing secondary compounds is energetically expensive and plants with high concentrations of these compounds are invariably slow growing and low yielding.
2. high concentrations of secondary compounds can reduce the nutritive value of plant tissues for animals. This is certainly true for gossypol and CT.

Thus selection for nutritive value should not occur in isolation and effects upon yield and disease control will also have to be considered.

THE PROPOSED THREE-YEAR STUDY OF THE NUTRITIVE VALUE OF AUSTRALIAN COTTONSEED MEAL

The study to be undertaken at Massey University is divided into three stages, as follows:

Stage 1. A study of the gross chemical composition of Australian processed cottonseed meals and of the seeds of experimental varieties available in Australia will be undertaken.

Stage 2. A study of the effects of heat, solvent extraction and CT content upon the solubility and degradabilty of cottonseed protein by micro-organisms, and upon the digestion and absorption of protein by monogastric animals (using the rat as a model) will be studied. Experimental batches of cottonseed meal will be made using 16 different methods, and the methods giving rise to the highest protein nutritional value for ruminant and monogastric animals will be identified.

Stage 3. Cottonseed meal prepared using the optimal methods will then be formulated into complete rations, and given to ruminant and monogastric animals in production trials, with the control being cottonseed processed by the standard method. Beef feedlotting for the Japanese market will be used for ruminant feeding and pig production for monogastric feeding.

The project is currently at stage 1, though some results on chemical composition are available:

THE CHEMICAL COMPOSITION OF COTTONSEED

Cottonseed hulls, which are removed by decorticators in the first stage of cottonseed meal manufacture, consist almost entirely of fibre (see Tables 1 and 2). The practice of adding some fibre (ie hulls) back to the meat at Narrabri to allow efficient passage through the extruder may account for the higher fibre and lower protein contents in these meats than in those sampled from a Brisbane plant.

Table 1. The contents (% DM) of oil, crude protein, fibre and lignin in Siokra cottonseed, and in industrial cottonseed meal produced from the Narrabri and Brisbane processing plants.

	Oil	Crude Protein	Fibre[1]	Lignin
Siokra cottonseed				
Whole cottonseed	25.5	25.1	45.8	9.9
Meat	38.7	36.0	19.8	3.7
Hulls	0.9	3.3	88.6	20.9
Industrial cottonseed meal				
Narrabri	3.6	42.9	26.9	5.8
Brisbane	10.4	46.8	23.7	5.4

[1] Neutral detergent fibre (including lignin)

There was little difference in the protein contents of meats made from a range of experimental cottonseeds (Table 2), with the meat of glandless cotton containing a higher concentration of oil than the meats from other varieties, as also found by Lawhon *et al* (1977). All varieties had similar yields of meats (mean 63% seed weight). Meats made from three multiple host plant resistant varieties had notably lower contents of total fibre and lignin than meats made from the other varieties. Also, meats from the high tannin varieties tended to be high in lignin, which is explained by lignin and CT being produced by related biochemical pathways (Barry 1989).

Table 2. The contents (% DM) of oil, crude protein, fibre and lignin in delinted samples of experimental cottonseed.

Type of cottonseed	Source	Oil	Crude Protein	Fibre[1]	Lignin
		MEATS (kernel)			
Commercially grown					
Siokra 14	Australia	33.7	34.9	25.2	2.5
Sicala 33	Australia	34.2	37.0	20.8	1.7
DP 90	Mississippi	34.2	36.3	21.2	4.7
Multiple Hostplant Resistant					
No's 10,11 & 17	Mississippi[2]	35.9	34.7	15.3	1.1
High gossypol					
No's 660,065 & 063	Louisiana[2]	34.5	34.4	23.8	2.2
High tannin					
No's 51S, 51H & 143	Texas[2]	34.3	33.6	25.1	4.0
Glandless					
DP16	Texas	39.2	32.6	25.8	2.8
			HULLS		
All varieties[3]		1.2	3.7	89.3	23.7

[1] Neutral detergent fibre (including lignin).
[2] Mean values presented for 3 varieties.
[3] Mean values for all 13 varieties.

Hulls of Siokra cottonseed contained approximately 5% DM as CT (Table 3), whilst CT was detectable at only trace amounts in the meats. Cottonseed meal produced at the Narrabri plant contained higher concentrations of CT than cottonseed meal produced at the Brisbane plant, probably due to the practice of adding some fibre (ie hulls) back to the meats in the manufacturing process at Narrabri. Extractable CT (the normal method of CT analysis) detected by only a small proportion of total CT in these cottonseed products, and total CT could only be reliably measured using a bound CT method. Analyses for CT in the samples of experimental cottonseed (from Table 2) are in progress.

Table 3. The condensed tannin content (% DM) in Siokra cottonseed, and in industrial cottonseed meal produced from the Narrabri and Brisbane processing plants[1].

	Extractable	Protein-bound	Fibre-bound	Total
Siokra cottonseed				
Whole cottonseed	0.30	1.14	0.29	1.73
Meat	0.11	0.07	0.05	0.23
Hulls	1.25	2.87	1.00	5.12
Industrial cottonseed meal				
Narrabri	0.21	0.76	0.54	1.51
Brisbane	0.01	0.49	0.29	0.79

[1] Determined by the butanol/HCl method of Terrill et al. (1992).

CONCLUSION

One finding of interest based on our preliminary investigation of the chemical composition of cottonseed meal is the lower fibre and lignin concentrations in the meats from multiple host plant resistant varieties, which should mean improved digestion in monogastric animals. This aspect, and the contents of secondary compounds in these

meats will be evaluated in further studies. Because of their lower need for insecticide use, multiple host plant resistance is likely to be a very desirable trait in cotton, and improved cottonseed nutritive value may be a useful bonus.

The present initial investigation has confirmed the finding of Terrill *et al* (1992) that Australian industrial cottonseed contains CT. Studies in progress will determine if this differs between cottonseed varieties, and how the concentration of CT, heat and solvent extraction effect the nutritive value of cottonseed meal for ruminant and monogastric animals.

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