ADVANCES IN GRAIN LEGUME UTILIZATION FOR PIG PRODUCTION

R.L. DAVIES*

SUMMARY

In the ten year period to 1988-89 pig numbers in all significant Australian pig producing regions increased similarly. While an expanding variety of grain legumes has contributed to feed protein supplies, production increases have been greatest in Western Australia and least in Queensland and northern New South Wales. In the south eastern region, which accounts for almost 60% of Australian production, increased grain legume production has been an important factor in the industry's continued expansion.

Current information on the utilization and limitations of grain legumes grown in each region is reviewed.

Future development implications are discussed, with emphasis on plant/seed identification and stratification of research effort.

(Key words: grain legumes, pigs)

INTRODUCTION

This paper reviews the changing pattern of grain legume production in Australia and its effects on pig production. It also summarizes current information on grain legume utilization and discusses some future research and development implications.

STATISTICAL DATA

Pig population and feed protein production data are available by State but the more relevant figures, relating to geographic and marketing regions, have to be estimated.

Plant protein crops used in pig production can be broadly described as winter crops which predominate south of about 31 degrees south (northern New South Wales) and summer crops which predominate to the north. Australian pig meat is primarily consumed in local markets centred on the capital cities, with the largest on the eastern seaboard. Pig meat and, to a lesser extent, live animals are traded throughout the eastern market, but the distance between the eastern and western markets and that centred in Perth isolates them. This rationale is the basis for dividing Australia into four regions, the north/south distinction based on climate and the east/west based on markets, to examine the distribution and effects of grain legumes on pig production. Estimates of the pig population and production of major feed proteins in the three significant regions over time are shown in table 1.

The figures in table 1 show some common trends: pig numbers in all regions increased by similar proportions since 1978-79, cyclical changes in sheep and cattle numbers and the development of the pet food industry affected meat meal supplies similarly, and oilseed meal production

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* South Australian Department of Agriculture, GPO Box 1678, Adelaide 5000

approximately doubled in all regions. On the other hand the initial protein distributions and their changes differed widely. In particular, while grain legume production in the north eastern region increased at about the same rate as that of oilseed meals, it increased eight fold in the south eastern region and almost 40 fold in the south western. Grain legume production in southern Australia, predominantly narrow leafed sweet lupins and field peas, is now over 1.5 m t per year compared with 100 000 t 10 years ago.

There is no simple relation between pig numbers and protein supply. This analysis is simplistic in that it ignores grain and imported feed protein and amino acids, and a variety of competing markets for regional proteins. However there is a broad relation between regional feed production, including proteins, and the pig population that can be supported. Increased grain legume production in the south eastern region has been an important factor in maintaining its predominance in the Australian industry over the past ten years. Grain legumes have probably also improved the pig industry's stability by broadening the feed base.

Increased use of grain legumes reflects their economic benefit to the pig industry, but the cross-benefits are often ignored. To the extent that grain legume production has been more profitable than the grain production it generally replaced, some of the benefit has been distributed throughout the farming and regional communities. The market which intensive animal producers provide for grain legumes has been an important step in establishing significant export markets for these crops. Finally the intensive animal industries help to maintain grain legume prices on other markets by absorbing low grade material.

In view of the likely rationalization of world grain markets and other factors, it remains to be seen whether grain legume production is maintained. However, current production levels would enable the pig industry to establish longer term opportunity comparisons against other proteins and to identify changes to existing varieties which would improve their value.

REQUIREMENTS OF GRAIN LEGUMES: THE PIG INDUSTRY ENVIRONMENT

The predominant economic pressures in the pig industry are for high rates of reproduction and fast, lean growth of slaughter pigs. This means that, if they are to be primary rather than peripheral protein supplements for pigs, grain legumes must have digestible and net energy levels compatible with the diet as a whole, provide cost-effective amino acid supplementation and have few or no other components which prevent pigs 'achieving their nutritional potential. The identification and amelioration of inhibitory effects is a difficult area of grain legume evaluation but, like handling, storage and milling characteristics, is part of their overall assessment.

ENERGY, AMINO ACIDS AND INHIBITORY COMPOUNDS IN GRAIN LEGUMES

Typical nutrient levels of the more widely used grain legumes are shown in table 2. Setting aside apparent exceptions such as valine in mung beans and cystine/methionine and tyrosine/phenylalanine in lupins, there is considerable similarity in amino acid levels between species.

The major grain legume crop in the north eas tern region of Australia is the soyabean (Glycine max); acknowledged to produce a high quality commercial protein meal and experimental reference protein. Some 5 000 t of

TABLE 1 Australian pig population and feed protein production by region: estimates based on State statistics published by the Australian Bureau of Statistics and the Australian Bureau of Agricultural and Resource Economics

	Region		
	North east	South east	South west
Regional description	Qld, NSW above 31°S	Remainder NSW, Vic, SA, Tas	Southern WA
Pigs ('000)			
1978-79	728	1 267	271
1983-84	822	1 404	300
1988-89	992	1 767	341
Feed protein production ('000 t)			
1978-79	420	361	63
1983-84	421	440	346
1988-89	584	1 008	1 034
Meat meal ('000 t)			
1978-79	197	224	37
1983-84	144	168	31
1988-89	192	219	36
Oilseed meals ('000 t)			
1978-79	164	62	1
1983-84	214	74	-
1988-89	246	119	2
Grain legumes ('000 t):			
Lupins			
1978-79	4	28	24
1983-84	7	56	314
1988-89	14	121	940
Peas			
1978-79	1	41	1
1983-84	2	132	1
1988-89	23	475	55
Chickpeas			
1983-84	-	-	-
1988-89	47	20	1
Soyabean meal			
1978-79	52	6	-
1983-84	48	10	-
1988-89	39	10	-
Faba beans			
1983-84	-	-	-
1988-89	4	42	-
Other (mung and navy beans, cowpeas)			
1978-79	2		-
1983-84	6		-
1988-89	19		-

TABLE 2 Typical nutrient composition of soyabean meal and the more common Australian grain legume seeds (digestible energy as MJ/kg, the remainder as g/kg, air dry)

	Soyabean	Soyabean meal	Chickpea	Mung bean	Sweet lupin	Field pea	Faba bean
Digestible energy	16.9	14.0		15.6	14.2	14.2	13.7
Crude protein	458	379	230	251	239	237	232
Ether extract	174	12	39	13	54	12	13
Crude fibre	53	52	20-100	39	130	75	85
Threonine	15	18	8	8	8	9	8
Valine	18	21	8	15	9	11	10
Cystine	5	6	2	1	5	4	3
Methionine	4	5	2	2	1	2	2
Isoleucine	18	21	10	12	9	9	9
Leucine	30	35	17	18	18	16	16
Tyrosine	14	16	6	6	9	8	8
Phenylalanine	19	22	12	12	9	11	10
Histidine	10	12	6	5	6	6	6
Lysine	23	27	13	17	11	17	14
Arginine	29	34	23	15	24	25	22

Sources: Batterham (1986)
Davies (1984a)
Davies (1986)

soyabean meal are imported into Australia annually to supplement local production.

Extrusion and other forms of heat treatment can be used to minimize inhibitory effects of raw soyabeans and preserve varying amounts of oil as an energy source. Despite the apparently wide limits of trypsin inhibitor and urease activity consistent with minimal effects on pig growth (Hansen *et al.* 1987) American experience has been that at least some soyabeans processed commercially in these ways are inadequately treated (Vandergrift 1985). The same conclusion appears to be developing in Australia.

Recent American work has also examined the potential for raw soyabeans with normal and reduced levels of low molecular weight (Kunitz) trypsin inhibitors (Cook *et al.* 1988). The full implications of selection against trypsin inhibitors which, in a number of species, contain relatively high levels of sulphur amino acids and tryptophan (Sastry and Murray 1987) have not been established. A disconcerting aspect of current work is that it appears to ignore evidence that, at least for some animals, resistance of native soybean proteins to proteolysis is a more serious limitation to protein utilization than inhibitors (Liener and Kakade 1980).

Chickpeas (*Cicer arietinum*) can be divided into two classes: low fibre (kabuli) and high fibre (desi). The difference can be substantial: approximately 20 versus 100 g/kg crude fibre respectively on our limited analysis. The high fibre level of desi types may have significant implications for growing pig diets where energy dilution by protein supplements needs to be minimized. The possibility that fibre or tannins in desi types may affect nutrient utilization does not appear to have been examined. Visitpanich et al. (1985a) reported similar protein quality for one line of each type and soyabean meal for growing pigs. Our results support this conclusion for Opal, a low fibre variety but live growth rate on a diet containing 35% Tyson chickpeas (desi type) was 8% or 50 g/d slower than on the soya diet ($P < 0.001$) (Davies, unpublished data). Tyson's trypsin inhibitor level was five mg/g compared to three for Opal (E.S. Batterham, personal communication).

Limited evidence suggests that untreated mungbeans (Vigna radiata) can replace at least some supplementary protein without substantial effects on growing pig or reproductive performance (Maxwell et al. 1986; Takken and Young 1987; Maxwell et al. 1987). The same is true for lentils (Lens culinaris) (Caste11 1988) and pigeon peas (Cajanus cajan), though autoclaving improves the latter's value (Visitpanich et al. 1985b).

Navy or kidney beans (Phaseolus vulgaris) contain up to about half the trypsin inhibitor activity of untreated soybeans (Hove and King 1979) and lectins or phytohaemagglutinins (Liener 1983), and have to be heated to be acceptable to pigs (Rodriguez and Bayley 1987). Despite the identification of the first lectin, castor bean ricin, a century ago the characterization and elucidation of their structure and effects has been slow, and we have only limited knowledge about their toxic versus inhibitory effects (Bondi and Alumot 1987).

Small amounts of other cull food crops such as cowpeas (Vigna sinensis) and adzuki beans (Vigna angularis) may also be available in north eastern Australia (A. Takken, personal communication). Guidelines are available for their use (Evans 1985) but, in view of the dearth of published information, should be regarded as indicative only.

The most important grain legume in the south eastern Australian region is the field pea (Pisum sativum). Some reports show that peas provide relatively high levels of digestible energy and essential amino acids, with few inhibitory or other complications, especially for growing and finishing pigs (Bell and Wilson 1970; Davies 1984b; Grosjean and Gatel 1986: Leitgeb et al. 1986). Other reports show varying, though normally modest, depression of digestibility and performance, especially when peas are used as the main or sole protein supplement (Henry and Bourdon 1977; Grosjean and Gatel 1986; Edwards et al. 1987). Limited work on the effects of peas in dry sow and lactation diets has given differing results (Ogle and Hakansson 1988; Gate1 et al. 1988). While peas may contain trypsin inhibitor, lectin, tannin and cyanogenetic glycoside activity (Ogle and Hakansson 1988) as well as a zinc chelating factor (Liener 1983), there is little unequivocal evidence of the detriment, if any, that each causes.

The status of the faba bean (Vicia faba) is similar, though the literature suggests a generally more conservative approach than with peas (Simpson 1984; Thacker and Bowland 1985). In our own experience growing and finishing pigs fed faba beans (var. Fiord) perform as well as those fed peas if differences in nutrient levels are taken into account (Davies 1986).

The common vetch (Vicia sativa var. Languedoc) may have agronomic potential as a fodder and grain crop in low-rainfall areas of southern , Australia. Preliminary evaluation suggests that, while the intake of growing pigs fed 350 g/kg was comparable to that of pigs fed soyabean meal, performance was marginally but significantly reduced (Davies, unpublished data).

There are also temperate counterparts to the damaging summer grain legumes. Wooly pod vetch (Vicia villosa subsp. dasycarpa var. Namoi) is a useful pasture plant but persists and can be harvested with subsequent grain crops. In an experiment to measure the growing pig's tolerance to Namoi, intake was significantly depressed above about 10 g/kg in the diet. In continuing work to identify the cause we have established that neither trypsin inhibitors nor Namoi's high canavanine level are responsible. Purple vetch (Vicia venghalensis var. Popany) had an almost identical effect to wooly pod vetch on the intake of growing pigs and, while the effects of narbon bean (Vicia narbonensis) were less severe, this potential low-rainfall grain legume appears to have very limited commercial promise for pigs as harvested (Davies, unpublished data).

Low alkaloid (sweet) varieties of narrow leafed lupin (Lupinus ongustifolius) are by far the most important grain legume in south western Australia. Despite their introduction to commercial agriculture over 15 years ago and widespread use, lupins still present an enigma. Ileal digestibility data shows lupin protein to be well digested (Taverner et al. 1983) but by slope ratio assay the availability of lysine for growth is low (Batterham et al. 1984). Apparent digestibility of energy is high, despite high fibre, but carbohydrates are predominantly fermented in the large intestine rather than being digested before the terminal ileum (Taverner et al. 1983) . Whether this has implications for net as compared with digestible energy or is part of the explanation for the ileal digestibility/slope ratio disparity is unknown. Abnormal growing conditions can increase the alkaloid level and substantially reduce feed intake in pigs (Godfrey et al. 1985). Lupins are more difficult to mill than other grain legumes.

The white lupin (Lupinus albus) contains significantly more fat than the narrow leafed lupin (Green and Oram 1983) and potentially toxic levels of manganese (Hung et al. 1987). On the limited evidence available (Batterham 1979; Kemm et al. 1987) they should be used with caution.

FUTURE PROSPECTS

An increasing variety of grain legumes will contribute to the Australian pig industry. Genetic engineering will be combined with conventional selection to increase the rate at which potentially improved lines can be developed. At present new species and varieties usually first appear from late, pre-release agronomic experiments or in limited commercial quantities; and with considerable pressure for at least preliminary animal evaluation by the next harvest or sowing. Novel feeds often generate a great deal more interest than their potential warrants, and many literature reports are essentially preliminary evaluations done with limited material and time.

However, to the extent that these generate the initial perception and influence future work, it is important to adopt some basic guidelines. First, the identity of the material should be established as unequivocally as possible. The literature contains a plethora of common and botanical names apparently describing the same plant, and proper identification of novel and unregistered material is often difficult. Second, if the evaluation involves animal experiments in which growth rate, feed conversion or body composition are parameters it is essential that the nutritional status of the test and control diets is compatible, or that the differences are recognized. At the least this means determining the digestible energy level of ingredients, preferably using the pig, and amino acid composition. Third, a relatively wide set of associated analyses should be done, especially if the literature has identified potential inhibitor or other compounds likely to affect utilization.

A more difficult problem arises if preliminary results indicate sub-optimal utilization. Beyond confirming original results or identifying where the constraint to utilization operates, the tendency has been to identify the constraint by correlated responses. Correlated responses between performance and a small number of measured and potentially detrimental components generally provide unconvincing evidence of cause and effect. Because most alternate approaches involve extensive segregation of identified components, they are frequently discarded as impractical or unaffordable. Despite their difficulty and cost we should recognize that a more factorial approach will ultimately have to be used to answer many of the questions which correlated responses pose about grain legumes. The need for more detailed and expensive methods highlights the importance of careful choice of grain legumes to be evaluated beyond the preliminary stage.

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