

Letters to the Editors

Ileal digestibility and availability of lysine in protein concentrates for pigs

The availability of lysine in protein concentrates for pigs and the relationship between ileal digestibility and availability have been investigated in two separate research projects: Dr Jane Leibholz of the University of Sydney, with weaner pigs, and myself at the Wollongbar Agricultural Institute, using grower pigs. The findings have been published in two separate series of papers in the *British Journal of Nutrition*. The results and conclusions have been diametrically opposed; Dr Leibholz found that ileal digestibility and availability were similar, we found that ileal digestibility overestimated availability in heat-damaged meals.

In her latest paper Dr Leibholz (1992) offers explanations for these differences and why her results differ from mine. I would like to offer readers alternative explanations.

The major differences in our findings are summarized in Table 1, using soya-bean meal and cottonseed meal as examples of high- and low-quality meals. They indicate: (1) both centres found similar values for the ileal digestibility of lysine in cottonseed meal (0.56–0.74) and soya-bean meal (0.88–0.92); (2) Dr Leibholz found the availability of lysine was similar to the ileal digestibility, we found the availability of lysine was similar to the ileal digestibility for soya-bean meal, but only about half the ileal digestibility for cottonseed meal; (3) Dr Leibholz reported high estimated retentions of absorbed lysine from cottonseed meal (0.94) which suggest that all the absorbed lysine was available, we found much lower retention (0.36), which indicates it wasn't!; (4) Dr Leibholz also reported high retentions of absorbed methionine from soya-bean meal (0.98), again we found much lower retention (0.45); (5) both centres conducted experiments which they claimed validated their values.

The results described were the basis for Dr Leibholz concluding that the ileal digestibility of amino acids reflected availability. We concluded that the ileal digestibility assay overestimated availability in heat-processed meals. Clearly both conclusions can't be right!

Table 1. Comparison of ileal digestibility and availability of lysine and retention of amino acids in cottonseed meal and soya-bean meal as assessed by Leibholz and Batterham (From Batterham *et al.* 1979, 1984, 1990*a, b*; Leibholz 1985*a, b*, 1986, 1992)

	Leibholz		Batterham	
	Cottonseed	Soya-bean	Cottonseed	Soya-bean
Ileal digestibility	0.61–0.73	0.92	0.56–0.74	0.88–0.89
Availability of lysine	0.69–0.75	0.95–0.99	0.27–0.43	0.87–0.98
Retention of ileal-digestible lysine	0.94	—	0.36	0.75
Retention of ileal-digestible methionine	—	0.98	0.38	0.45
Testing of values	Gain/d different Digestible dry matter intake/gain (g/d) similar		No differences in gain/d, FCE or lysine retained/available lysine intake	

FCE, Food conversion efficiency.

These differences are unlikely to be due to differences in sample as at one stage we both worked on the same samples (with different results!). The differences are most probably due to differences in methodologies.

REASONS FOR DIFFERENCES IN ESTIMATES OF AVAILABILITY

There were two major differences in the way the availability estimates were derived.

1. Criterion of response

Both centres used different indices of response when assessing availability.

We used food conversion efficiency (FCE) on a carcass basis to assess response. FCE has the advantage over weight gain in that it makes some allowance for differences in feed intake. Expressing the results on a carcass rather than a live-weight basis eliminates overestimation of results due to gutfill. This occurs as fibrous materials such as cottonseed, sunflower or lupin-seed meal are incorporated into the diet at the expense of highly digestible wheat starch.

This higher dietary fibre content results in increases in gut fill in pigs given these diets which can considerably inflate the estimate of availability. This is illustrated below (from Batterham *et al.* 1979):

Criterion	Cottonseed meal	Soya-bean meal	Skim-milk powder
Live-wt gain	0.62	0.93	0.88
Carcass gain	0.39	0.87	0.88

Leibholz (1986, 1992) expressed her results on a live-weight basis and this could have led to an over-estimation in availability figures for fibrous vegetable proteins.

2. Statistical analysis

Both centres used different statistical analyses to analyse the availability values.

We analysed our results by the slope-ratio analysis as described by Finney (1964). This has tests to try to ensure that the responses are to the lysine in the test protein, and are not influenced by other factors contributed by the protein concentrates. Leibholz's (1986) work failed this analysis, as many of the assay values were fundamentally invalid (the slopes of the responses to protein concentrates failed to pass through a common intercept, which indicates that other factors contributed by the test proteins were most probably influencing the results).

Because in general her results failed this test, Leibholz (1986) deemed the slope-ratio assay 'inappropriate' and calculated the ratios without any statistical safeguards. It is highly probable that the responses were not to lysine alone and were being influenced by factors such as differences in digestible energy or fibre contents, which inflated the values for cottonseed meal.

In the assay reported by Leibholz (1992) the regression lines were constrained to have a common intercept. Again this removes the test for lack of intersection and removes this safeguard from the assay.

Thus, the higher availability value for cottonseed meal reported by Leibholz (1986) may well be due to other dietary factors influencing the results.

VALIDATING ASSAY VALUES

Both centres conducted experiments to validate their availability values. However, each centre has reservations about the validity of the other centres' findings!

Leibholz (1992) conducted an experiment to evaluate her availability values for cottonseed, sunflower and soya-bean meals. In that experiment piglet performance was substantially lower on the diets containing sunflower and cottonseed meal, relative to soya-bean meal.

Available lysine (g/kg) ...	Sunflower meal 9.3	Cottonseed meal 9.3	Soya-bean meal 9.3	SEM
Wt gain (g/d)	227	270	323	19.3

This clearly shows that the values were overestimating availability in the sunflower and cottonseed meals.

However, Leibholz (1992) divided digestible dry matter intake by gain (g/d) to produce a ratio which was similar for all three diets, and used these values to validate the availability values. It is difficult to see the nutritional basis for such a correction. In order for the experiment to be valid the diets needed to be formulated to similar digestible energy and available lysine contents. If the diets varied in digestible energy then the comparison was invalid.

Interestingly, if the digestible energies were incorrect in these diets then they were most probably incorrect in the diets for the slope-ratio assay. This may well be the reason for the lack of intersection experienced by Leibholz (1986) in the slope-ratio assay.

Batterham *et al.* (1990*b*) reported similar growth, FCE and lysine retained:available lysine intakes for pigs given diets formulated to similar digestible energy and available lysine contents, with the test lysine supplied from cottonseed or soya-bean meals. Leibholz (1992) interpreted the reason for the similar performance reported in our work as possibly due to only one lysine level being used, and a smaller supplement could have given the same result. This is unlikely as the efficiency of lysine retention would have been different if a surplus of lysine had been given in any one diet.

EXPLANATION FOR DIFFERENCES

In order to explain the differences in availabilities for cottonseed meal, Leibholz (1992) conducted an experiment determining the availability of lysine in cottonseed meal where the diets were maintained isonitrogenous and isoenergetic. The response to free lysine was linear for weight gain and non-linear for FCR. For cottonseed meal the responses were non-linear for both weight gain and FCR. Leibholz (1992) suggested that a factor other than lysine was influencing the response and that the availability of cottonseed meal was 100% in the lower part of the curve and lower at the higher part of the curve.

Leibholz (1992) also suggested that the growth responses of piglets in her experiments corresponded to the lower part of the curve, where availability of cottonseed meal was high, whilst the growth responses in our experiments corresponded to the upper part of the curve, where the responses were curvilinear, and this was the reason for our lower availabilities.

It is difficult to follow this argument. In any experiment it is necessary to have a control as performance varies between experiments. One cannot take growth data from grower pigs

given diets containing from say 40 to 160 g/kg cottonseed meal and fit them to a part of a plot of results of weaner pigs given diets containing up to 420 g/kg cottonseed meal.

The curvilinear results could well be due to the effect of the high inclusion levels of cottonseed meal. Leibholz (1992) added graded levels of cottonseed meal, up to 420 g/kg, without any correction for differences in fibre content, protection against gossypol contributed by the cottonseed meal, differences in the other amino acids, etc. Thus, it is not surprising that non-linear responses were recorded with weaner pigs.

Leibholz (1986) also explained the differences in values for lupin-seed meal (0.9, Leibholz (1986), 0.57, Batterham *et al.* (1984)) as due to the low methionine status of lupin-seed meal. This is unlikely. The linear response to free lysine in that assay indicated that lysine was the limiting amino acid. No contribution of methionine from lupin-seed meal was required. An alternative explanation is that the value determined by Leibholz (1986) was inflated by gut fill contributed by the lupin-seed meal. We found values for lysine availability were about 0.25 units higher on a live-weight basis, compared with a carcass basis, as lupin-seed meal accumulates in the hindgut of pigs.

RETENTION OF ILEAL DIGESTIBLE LYSINE AND METHIONINE

The differences in lysine and methionine retentions (high in Leibholz's work, low in our studies) are most probably due to the fact that Leibholz did not determine these, but used values from piglets used in other experiments. In contrast, we determined the contents of the amino acids in the pigs given the test diets. For lysine, protein deposition per d, the protein content in the empty body and the concentration of lysine in the protein were all influenced by the lysine status of the diets. In the methionine retentions, Leibholz (1985*b*) calculated retentions using estimated values for methionine of about 2.0 g methionine/16 g N, which was determined in piglets given methionine-adequate diets. In our work the methionine contents of the pigs were affected by the methionine status of the diets (1.5 for deficient diets, 1.6–1.8 for supplemented diets). Thus, it is not surprising if Leibholz (1985*a, b*) overestimated lysine and methionine retentions for pigs given diets containing cottonseed meal.

These findings indicate the importance of actually determining amino acid retentions when examining responses to amino acids.

SUMMARY OF REASONS FOR DIFFERENCES

It is most probable that the higher estimates for lysine availability recorded by Leibholz (1986, 1992) were due to the use of diets where the response to lysine was influenced by other factors. This in turn was confounded by the use of live weight as the criteria of response, and the removal of statistical safeguards designed to protect the validity of assay values.

Similarly, the higher estimated retentions of ileal digestible lysine and methionine recorded by Leibholz (1985*a, b*) may well be due to the fact that the actual contents of these amino acids in the piglets given the test diets were not determined.

OVERALL CONCLUSIONS

The ileal digestibility assay is a good indicator of lysine availability for meals of high availability. However, in severely heat-processed meals, such as cottonseed meal, ileal digestibility overestimates availability. Accordingly, the ileal digestibility assay is not suitable for measuring the availability of lysine in heat-damaged meals.

Our conclusion that the ileal digestibility assay overestimates availability is supported by recent findings of Bellaver & Easter (1989), Moughan *et al.* (1991) and Wiseman *et al.* (1991).

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