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The evaluation of the field bean (*Vicia Faba* L.) in animal nutrition

By H. E. CLARKE, *R.H.M. Agricultural Research and Advisory Services Ltd.*

The field bean (*Vicia Faba* L.) has been gaining increased popularity in Britain over the last few years. This year's crop of 400 000 acres, according to the estimate of the Ministry of Agriculture, Fisheries and Food (although it may only be 300 000 acres, based on the total sale of seed), exceeds the 240 000 acres of 1968 which itself was a far cry from the 67 000 acres of 1964. Its present popularity is mainly due to its value as a break crop, especially where cereal mono-culture is practised. With the present intensity in agricultural production it is unreasonable to think of a crop's economic value in terms of the increased return of the succeeding crops; rather, the bean should be grown as an economic crop in its own right.

The object of this paper is therefore threefold: firstly to examine the analytical composition of the field bean, secondly to assess its potential as a raw material ingredient in animal feeds, and lastly to bring into perspective its value in the feeds of various farm animals and to see if this sheds any light on the direction in which development ought to proceed. Two bean varieties only are considered, Minor's Tic and Throws M.S., representing spring and winter varieties respectively. These make up 70% to 75% of the total acreage of each of the seasonal varieties.

Composition

Consideration will first be given to those three factors which are required to be declared in animal feeds, namely the crude protein, crude fibre and crude oil. Eden (1968), following a survey of bean crops in 1966 and 1967 in Cambridgeshire and the Isle of Ely, found in the majority of the analytical determinations no difference in the composition of spring and winter beans except in respect of crude protein, crude fibre and hence in nitrogen-free extractives which are obtained by difference. Values obtained in our own laboratory in 1967 and 1968 corroborate Eden's findings: the results are shown in Table 1.

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Table 1. *Crude protein and crude fibre content of field beans (as a percentage of dry matter)*

Type of bean	Source of values*	Mean	Range	SE	Sample size
		Crude protein			
Spring	Eden (1968)	31·4	25·5–35·4	0·20	104
	ARAS	34·1	27·9–36·6		55
Winter	Eden (1968)	26·5	24·3–29·9	0·28	28
	ARAS	26·7	24·1–28·6		25
		True protein			
Spring	Eden (1968)	28·2	22·3–31·7	0·08	104
Winter	Eden (1968)	24·0	22·0–27·0	0·16	28
		Crude fibre			
Spring	Eden (1968)	8·0	6·0–10·6	0·18	104
	ARAS	8·4	6·2–11·0		43
Winter	Eden (1968)	9·0	7·5–10·6	0·24	28
	ARAS	9·0	7·4–10·9		16

*ARAS, RHM Agricultural Research and Advisory Services Ltd.

Compared with other published figures (Evans, 1961; Bolton, 1967), the later results are probably a more reliable reflection of the present position; comparative figures are shown in Table 2.

Table 2. *Dry matter composition of field beans (as a percentage of the dry matter)*

	Evans (1961)*		Bolton	Eden (1968)		ARAS† (1968)	
	A	B	(1967)	Spring	Winter	Spring	Winter
Crude protein	29·6	31·8	32·2	31·4	26·5	34·1	26·7
Ether extract	1·7	1·2	1·5	1·5	1·5	1·6	1·6
Crude fibre	8·3	11·1	62·8 (crude fibre and nitrogen-free extractives)	8·0	9·0	8·4	9·0
Nitrogen-free extractives	56·6	52·4		55·2	59·0		
Total ash	3·7	3·5	3·5	4·0	4·0		

*A, experiments with ruminants; B, experiments with pigs.
†RHM Agricultural Research and Advisory Services Ltd.

The fibre of the winter bean is approximately 1% higher than that of the spring; this is accounted for by the thicker testa. There would appear to be no difference in the crude oil content, 1·5% being a representative figure. The stage of maturity at harvesting has an important bearing on the protein content. Three samples of winter beans were separated into three fractions: green (slightly immature) beans, normal 'olive'-coloured beans, and dark fully ripened beans. The mean protein contents of the fractions were 25·6%, 27·7% and 27·3% of the dry matter respectively.

Table 3 shows the fatty acid composition of the field bean expressed as a percentage of the total fatty acids (RHM Lord Rank Research Centre, 1969) together with the composition of barley and the germ of wheat, maize and oats (Hilditch, 1956). The high content of linoleic acid in beans and barley, so important in its influence on egg size in poultry, is noteworthy.

Table 3. *Fatty acid composition of field beans (as a percentage of the total fatty acids)*

Fatty acid	Winter beans*	Wheat germ†	Maize germ†	Oat germ†	Barley†
Palmitic ($C_{16:0}$)	13·1	11·8	10·2	10·0	9·0
Stearic ($C_{18:0}$)	2·5	3·0	3·0	—	3·0
Oleic ($C_{18:1}$)	20·5	39·0	49·6	59·0	33·0
Linoleic ($C_{18:2}$)	54·8	30·0	34·3	31·0	54·0
Linolenic ($_{18:3}$)	5·8	6·0	—	—	0·5
Arachidic ($C_{20:0}$)	2·0	—	—	—	—
Behenic ($C_{22:0}$)	0·5	—	—	—	—
Myristic ($C_{14:0}$) and unknown acids	1·0	—	—	—	—

*RHM Lord Rank Research Centre (1969).
†Hilditch (1956).

Table 4 shows the amino acid profile of winter beans; the concentrations of the sulphur amino acids are seen to be particularly low. This will have a significant bearing on the value of beans in poultry rations. On the other hand the concentration of lysine is relatively high, which, as shown later, makes beans useful for inclusion in pig rations. The coefficient of variation of the sulphur amino acids is high and

Table 4. *Amino acid composition of winter-sown (Throws M.S) and of spring-sown (Minor) beans (g/16 g N)*

Amino acid	Winter Mean	Winter CV	Spring Mean
Threonine	3·76	8·5	4·02
Glycine	4·33	4·8	5·57
Valine	4·62	3·9	4·92*
Cystine	0·92	15·2	0·84
Methionine	0·80	16·2	0·73
Isoleucine	4·04	9·9	4·35
Leucine	7·53	6·1	7·87
Tyrosine	3·53	4·2	3·86
Phenylalanine	4·36	4·8	4·63
Lysine	6·80	7·3	6·59
Histidine	2·59	10·0	2·55
Arginine	8·44	4·1	10·30*
Aspartic acid	11·93	†	11·88
Alanine	4·24	†	4·20
Serine	5·21	†	5·48
Glutamic acid	18·48	†	19·68

No. of samples:
Winter beans: 8 (7 from RHM Agricultural Research and Advisory Services Ltd and 1 from Bolton, 1967).
Spring beans: 2 (including 1 from Bolton, 1967).
*Difference between spring and winter means significant at $P<0·05$. All other differences not statistically significant.
†One sample only from Bolton, 1967.

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there is no doubt that this is a reflection of the difficulties experienced in analysis. The coefficient of variation of the other amino acids is not much greater than the expected analytical error.

Only two analyses of the spring variety were available, but its general amino acid pattern is very similar to that of the winter variety, although the concentration of the amino acids tends to be greater in the spring than in the winter variety (Table 4), for the most part in the same proportion as the crude protein. However, these differences, with the exception of those for valine and arginine, were not statistically significant. The concentration of cystine in the two samples of spring beans was 1·11% and 0·56% and it is probable that analytical difficulties are being experienced and that not much significance should be attached to the reported differences between the two varieties in the sulphur amino acid concentrations until further work has been carried out. Bond (1970) reports that the dry-matter lysine content increases as the protein concentration increases, but not at so fast a rate, as in cereals there is a highly significant negative correlation between protein content and g lysine/16 g nitrogen. Further investigation is required before priorities for varietal development are established.

Waring & Shannon (1969) using colostomized laying hens reported that the true digestibility coefficients of the crude protein of spring and winter beans were 84% and 81% respectively, and that the true digestibility coefficients of the amino acids were generally close to those of the crude protein. Soya-bean meal protein had a true digestibility coefficient of 90%.

Bolton (1967) recorded a metabolizable energy value for beans of 3490 kcal/kg. Carpenter & Johnson (1968) estimated by the chick test the metabolizable energy of spring-sown Minor's and winter-sown Throws M.S as 2980 and 2800 kcal/kg respectively; by analysis of the same sample of beans, energy values of 3090 and 2830 were predicted. (All values quoted are on a dry-matter basis.)

More recently Waring (1969) reported an energy content of beans of 3296 kcal/kg; the analysis of 32·2% crude protein (on a DM basis) suggests that they were spring-sown, although this was not specified. C. B. Fairbairn (1968, personal communication) reported an average value of 2880 kcal/kg obtained in the analysis at Starcross of eight spring-sown varieties. Our own analysis of one sample of Minor's beans gave a value of 2739 kcal/kg, and values of 2941 and 3029 kcal/kg for two samples of Throws M.S.

These values suggest considerable variation within the winter-sown and spring-sown varieties, but there is no reason to suppose that this is greater than that found in any other raw material used in animal feeds, although the need for the regular analysis of consignments of raw materials is evident. In determining the economic value of beans, discussed later, a value of 2816 kcal/kg DM (or 1100 kcal/lb on an air-dry basis) has been arbitrarily selected.

Eden (1968) found that there were no differences in mineral composition between winter-sown and spring-sown varieties (Table 5). Our own values confirm the phosphorus contents quoted by Bolton (1967) and Eden (1968) and the latter's comment that the value quoted by Evans (1961) of 0·44% is too low. The manganese

Table 5. *Mineral composition of spring-sown (Minors) and winter-sown (Throws M.S) beans (in terms of dry weight) (Eden, 1968)*

	Spring-sown Mean	Winter-sown Mean
Siliceous matter (%)	<0·1	<0·1
Calcium (%)	0·16	0·19
Phosphorus (%)	0·66	0·68
Chlorine (%)	Trace	Trace
Magnesium (%)	0·13	0·13
Potassium (%)	1·17	1·22
Sodium (%)	<0·01	0·02
Manganese (μg/g)	14	14
Iron (μg/g)		64*
Zinc (μg/g)		54*
Cobalt (μg/g)		<0·01*

*Values from RHM Agricultural Research and Advisory Services Ltd.

content is low, requiring extra supplementation should a diet contain a large proportion of beans.

Little information is available on the vitamin content of beans (Table 6).

Table 6. *Vitamin content of the field bean (on a dry-matter basis)*

	Bolton (1967)*	ARAS† (1969)
α-Tocopherol (mg/100 g)	0·10	—
Choline (mg/g)	1·11	—
Riboflavine (μg/g)	3·1	—
Nicotinic acid (μg/g)	29	11·9
Pantothenic acid (μg/g)	—	11·7
Thiamine (μg/g)	—	15·0

*Variety unspecified.
†RHM Agricultural Research and Advisory Services Ltd; winter-sown variety.

Fractionation of winter beans, involving the separation of the testa from the cotyledons and germ, showed that the testa accounted for 14·3% by weight of the whole bean; 96·5% of the total crude oil and 97·5% of the total crude protein were to be found in the dehulled fraction and 84·5% of the total crude fibre in the testa, resulting in a metabolizable energy level of 3416 kcal/kg in the dehulled fraction (Table 7). Separation of the bean into these two fractions suggests a possible method of up-grading a home-produced protein. Although a mechanical separation

Table 7. *Dry-matter composition of refined fractions of winter beans (Throws M.S)*

	Testa	Cotyledons	Whole sample (by calculation)
Crude oil (%)	0·35	1·53	1·36
Crude protein (%)	4·71	31·2	27·47
Crude fibre (%)	54·1	1·65	9·14
Metabolizable energy (kcal/kg)	532	3416	3029

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on a large scale would not produce such clearly divided fractions, a food with a lower fibre and enhanced protein and energy content would be of greater nutritional value to pigs and poultry, leaving the fibrous fraction for ruminants.

Potential for animal feeding

Although much of the experimental work in the feeding of beans did not attempt to achieve parity of nutritional constraints between the experimental diets and the controls, reliable information indicates that beans are a satisfactory raw material in animal diets.

Blair & Bolton (1968) reported that nutritionally balanced diets for chickens containing 0, 10, 20 and 30% field beans, duplicated for both spring and winter beans, showed that live-weight gains, amounts of food eaten, and food conversions were not influenced by the level of inclusion. Supplementation with synthetic methionine was found necessary to maintain the requirements suggested by the Agricultural Research Council (1963). Whereas Brisson, Nikolaiczuk & Maw (1950) had reported better feathering and better growth when choline was added, Blair & Bolton detected no adverse effects on growth of feathering when the diet contained 30% beans.

J. R. Luscombe (1969, personal communication) compared the effects of the partial and complete replacement of soya-bean meal by beans in pig rations, where the nutritional constraints were at parity. When fed to pigs from 32 to 91 kg live weight the differences in growth rate and food conversion were not significant. Luscombe also found that methionine supplementation produced no response compared with the control rations. Beans when fed on our own farm at a level of 5% inclusion to turkeys from 12 to 16 weeks of age, produced live-weight gains and food conversions similar to those obtained with the control diet.

It is said that beans should not be fed in the same year as harvesting; this perhaps dates from pre-war years when beans were cut, slightly immature, with a binder, standing in stooks until they had dried. Digestive upsets might be expected if immature beans are threshed and fed soon after harvesting: compare this situation with the care that is exercised when new crop cereals are first available for feed mixing. However, when beans are harvested with a combine harvester they have reached a greater degree of maturity than in pre-war days. We have fed newly harvested and dried mature beans at an inclusion rate of 10% of the diet to pregnant and lactating sows; no digestive upsets were experienced by the sows, nor were the litters adversely affected. Luscombe (1969, personal communication) reported that he had fed freshly cut beans in the pod to piglets of 50 lb live weight without any visual effect on health.

Jensen (1964) commented on the detrimental effect beans had on the taste and smell of chicken meat. This observation has not been confirmed. Clausen & Hansen (1968) fed bacon pigs diets containing up to 30% of beans and reported that raising the level of beans had no effect on the taste or consistency of the meat. The iodine counts were normal.

Comparative value as animal feed

When judging economically the value of beans in mixed feeds it must be accepted that there are two basic categories of beans, spring and winter, of different protein levels and therefore of different cash values, and also two basic sites of feed manufacture, on the farm and in the compound merchants mill, and with the latter the cost of hauling the beans from the farm to the mill must be taken into account.

Figs. 1–4 show the value of winter and spring beans both in farm mixings and in the merchants compounding plant; it is evident that beans have a varying value according to which class of livestock is being fed with them and also according to the nutrient density of the particular ration. The value of beans was determined on an analogue computer used in least cost formulations. The values shown are on an 'on the farm' basis, i.e. the beans were evaluated as a raw material on a 'ready for the mixer' basis minus grinding and haulage charges.

In a milk production ration containing 18% crude protein (Fig. 1) the value of beans declines as the energy of the ration increases. Both in the farm mixes and the merchants' mixes spring beans are worth £3 per ton more than winter beans, and the extra value to the farm mix is approximately the haulage difference. At a starch equivalent of over 72% the value rapidly declines for the merchant, but for the farmer it was not possible to formulate a ration at 74% containing beans, assuming that fat cannot be added to farm mixings.

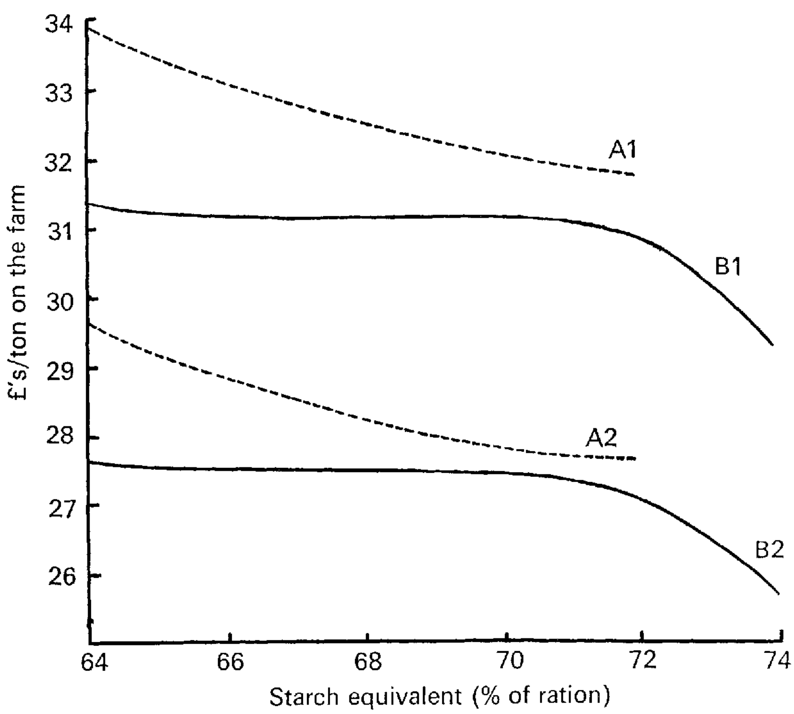

Fig. 1. Evaluation of winter and spring beans in an 18% protein milk production ration of varying energy density. Spring (A1) and winter (A2) beans in farm mix; spring (B1) and winter (B2) beans in merchants mix.

In a 16% protein dairy ration (Fig. 2) the difference in value between spring and winter beans is approximately £4 per ton and, whereas the value to the merchant is more or less constant over a range of energy values of the compound ration, the value to the farmer decreases as the energy of the ration increases. This is because the farmer would need to use a more expensive cereal, i.e. flaked maize, to balance the beans, and it would be more economic to use an oilcake with rolled barley.

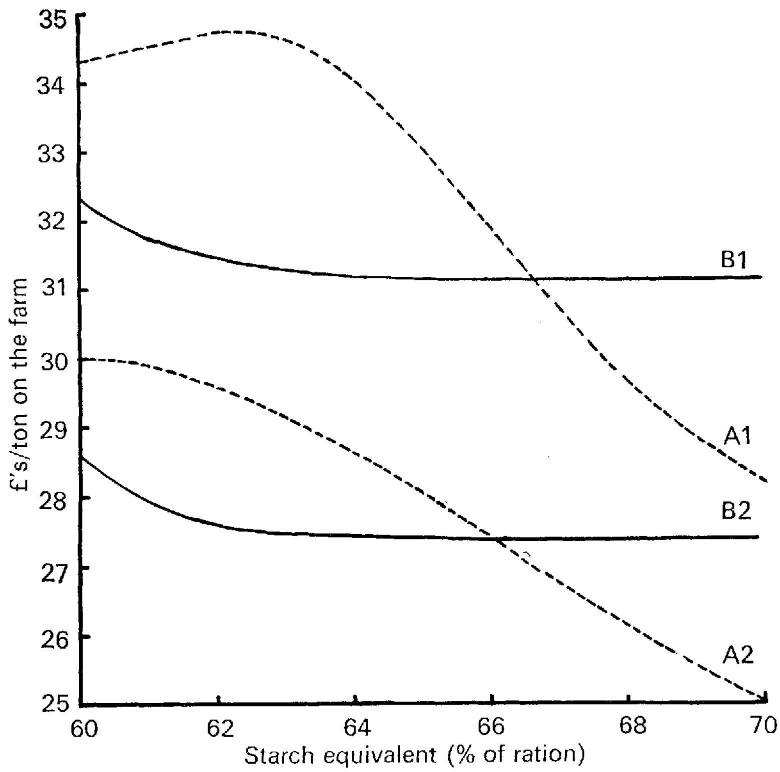

Fig. 2. Evaluation of winter and spring beans in a 16% protein milk production ration of varying energy density. Spring (A1) and winter (A2) beans in farm mix; spring (B1) and winter (B2) beans in merchants mix.

In a 14% cattle ration the situation is similar to the 16% dairy ration; the value of the beans in the farm mix decreases by £5 per ton over the energy range 60% to 68% starch equivalent.

In poultry rations, a nominal energy content of 1100 kcal/lb has been attributed to beans on an air-dried basis, and even at this level beans are not a particularly attractive raw material. Fig. 3 shows the values of beans in layers rations varying from a metabolizable energy content of 1220 to 1320 kcal/lb. At each energy level the ratios of protein, amino acids and minerals were balanced for efficient production. Whereas the value of the beans is relatively constant in the farm mix, the value to the merchant rises to a higher peak. This higher peak can be explained by the greater variety of raw materials available to the merchant, the farm mix containing relatively

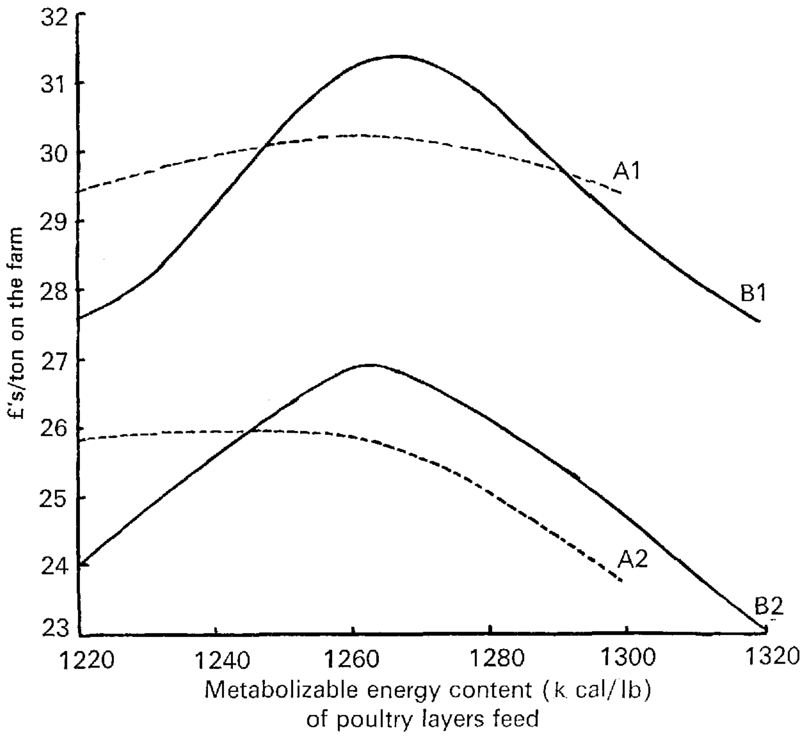

Fig. 3. Evaluation of winter and spring beans in balanced poultry layers rations of varying energy density. Spring (A1) and winter (A2) beans in farm mix; spring (B1) and winter (B2) beans in merchants mix.

few. The difference in value between spring and winter beans is approximately £3 10*s*. 0*d*. per ton. Dehulled beans in poultry feeds are worth considerably more than whole beans, but without figures for processing cost it is not possible to express a value on the same basis as for whole beans.

While beans in cattle and poultry feeds are scarcely economically attractive, in pig rations they can be economically included, at rates varying from 4 to 10% (Fig. 4). If the inclusion rate is increased above the least cost maximum inclusion then the value will decrease. Again the graph shows a difference in value of £4 per ton between spring and winter beans in favour of the former, and the difference between merchant and farm mix is still approximately that of haulage. Although Fig. 4 refers to rations for growing and fattening pigs, beans are also economic in sow rations at inclusion rates varying from 5 to 10%.

It would appear, therefore, that the field bean should be able to stand as a crop in its own right. At present it is economic when used in pig rations chiefly because of its relatively high lysine content. The higher protein of the spring-sown variety would command a premium, but this would be difficult to implement because of the variation between and within varieties. Development perhaps ought to be aimed at increasing the energy content of beans, either by breeding and selection or by mechanical refining, or by the combination of both methods.

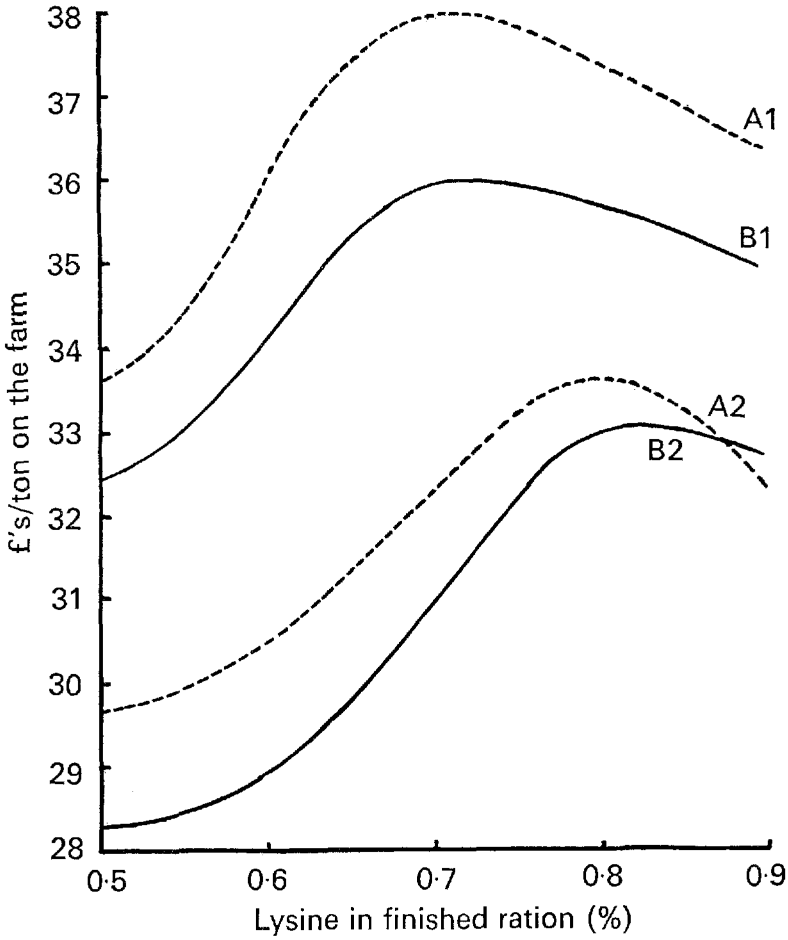

Fig. 4. Evaluation of winter and spring beans in balanced pig rations of varying lysine density. Spring (A1) and winter (A2) beans in farm mix; spring (B1) and winter (B2) beans in merchants mix.

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