THE TOTAL REPLACEMENT OF PROTEIN SUPPLEMENTS BY SYNTHETIC LYSINE IN RATIONS BASED ON SORGHUM GRAIN FOR PIGS OVER 45 kg LIVEWEIGHT

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Summary

In three experiments, various levels of lysine, yeast and soybean meal were used independently as supplements in diets based on sorghum grain plus minerals and vitamins. These diets were given to pigs during growth from 45-90 kg. Growth, feed efficiency and carcass characteristics were improved by supplementation with lysine. and to a similar extent by soybean diets that provided equal or slightly lower calculated amounts of lysine.

I. INTRODUCTION

It is probable that the price of synthetic amino acids will continue to fall and that they will be used increasingly as replacements for conventional protein supplements.

Three experiments were made to investigate various levels of lysine as a sole nitrogenous supplement to sorghum grain. Their main purpose was to test the findings of Jensen, Becker and Harmon (1965) who found that the growth of pigs over 45 kg liveweight on a ration of sorghum plus 0.25% lysine was as good as the growth on maize plus 8% soybean meal.

II. MATERIALS AND METHODS

(a) General

In Experiment 1, twenty-four Large White male castrate pigs with a mean liveweight of 44 kg were divided into three groups of eight on the basis of liveweight. Within groups, eight diets (Table 1) were allocated at random. Pigs were housed in concrete pens and fed individually in stalls once daily with a maximum air-dry allowance of 2.10 kg. Feed was moistened (approximately one part water to two parts feed). Pigs were weighed weekly, and were sent for slaughter when their Iiveweight was 89.8 kg or more. They were fed immediately after the last weighing and slaughtered approximately 26 h later.

In Experiment 2, three groups of six Large White pigs, initially of 45 kg liveweight were used; one group consisted of gilts and two of male castrates. Within groups, six diets (Table 1) were allocated at random. The pigs were kept in bare earthern yards, each provided with a shelter, and were given their rations dry, twice daily, in individual stalls. The air-dry allowance of feed was 1.85

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TABLE 1

Composition** of **diets in Experiments 1, 2 and 3 by weight on air-dry basis

Item	Diet No. 1	2	3	4	5	6	7	8
	%	%	%	%	%	%	%	%
				Experiment 1				
Sorghum	96.77	96.67	96.57	96.47	89.63	89.16	88.75	84.89
Lysine $HCl.2H_2O$	—	0.10	0.20	0.30	—	—	—	—
Torula yeast	—	—		—	7.35	10.92	—	—
Soybean meal	—		—	—	—	—	8.16	12.09
$CaHPO_4.2H_2O$	1.31	1.31	1.31	1.31	1.00	0.86	1.11	1.00
$CaCO_3$	0.42	0.42	0.42	0.42	0.52	0.56	0.48	0.52
Lysine %*	0.26	0.33	0.40	0.46	0.46	0.57	0.46	0.57
Crude protein %	11.32	11.38	11.43	11.49	14.60	16.20	14.35	15.81
				Experiment 2				
Sorghum	98.23	98.11	97.99	97.87	90.50	86.49	—	—
Lysine $HCl.2H_2O$	—	0.12	0.24	0.36	—	—	—	—
Soybean meal	—	—	—	—	7.88	11.91	—	—
$CaHPO_4.2H_2O$	0.17	0.17	0.17	0.17	—	—	—	—
Pulverised limestone	1.10	1.10	1.10	1.10	1.12	1.10	—	—
Lysine %*	0.26	0.34	0.42	0.50	0.46	0.57	—	—
Crude protein %	10.81	10.87	10.93	11.01	13.77	15.28	—	—
				Experiment 3				
Sorghum	98.10	97.86	97.74	91.29	86.31	—	—	—
Lysine $HCl.2H_2O$	—	0.24	0.36		—	—	—	—
Soybean meal	—		—	7.88	11.91	—	—	—
$CaHPO_4.2H_2O$	0.50	0.50	0.50	0.33	0.28	—	—	—
Pulverised limestone	0.90	0.90	0.90	1.00	1.00	—	—	—
Lysine %*	0.26	0.42	0.50	0.46	0.57	—	—	—
Crude protein %	12.16	12.29	12.35	14.80	15.97	—	—	—

All rations contained 0.5% Ca, 0.4% P.

Sodium chloride, 0.5% by weight, was added to all rations.

Minerals and vitamins were added at the following levels per kg of ration: *Experiment 1:* Copper 20 mg as $CuSO_4.5H_2O$; Manganese 40 mg as $MnSO_4.H_2O$; Zinc 50 mg as $ZnSO_4.7H_2O$; Vitamin A 1325 i.u.; Vitamin D_3 220 i.u.; Choline chloride 441 mg; Vitamin B_{12} 22 μg; Butylated hydroxy toluene 100 mg. *Experiments 2 and 3:* Manganese 8 mg as $MnSO_4.H_2O$; Vitamin A 1325 i.u.; Vitamin D_3 265 i.u.; Riboflavin 0.53 mg; Calcium pantothenate 0.70 mg; Vitamin K bisulphite 0.24 mg; Vitamin E 0.46 mg; Vitamin B_{12} 22 μg.

*Calculated from N.A.S. — N.R.C. (1964) Publication 1232 except for yeast where analyses were supplied with the material.

Lysine $HCl.2H_2O$ contains approximately 68% lysine.

Crude protein percentages on an air dry basis in the ration components in Experiments 1, 2 and 3 respectively were: sorghum 11.7, 11.0, 12.4; soybean meal 48.6, 48.4, 44.2; yeast (Experiment 1) 56.0. Moisture content of all components was approximately 10%.

kg for a 45 kg pig rising by 0.03 kg/kg liveweight to a maximum of 2.27 kg. Pigs were withdrawn from trial at approximately 86 kg liveweight. They were fed just prior to final weighing and slaughtered 50 h later.

In Experiment 3, five groups of five Berkshire pigs were used, three groups consisting of gilts and two of male castrates. Within groups, five diets (Table 1)

were allocated at random. Pigs were kept in concrete yards provided with shelters and were given rations moistened as in Experiment 1. Pigs were slaughtered 48 h after the final weighing which was made 24 h after the last feed. Other experimental procedures were as for Experiment 2.

(b) Carcass measurements

Carcasses were held at a temperature of approximately +2°C for 24-82 h and then appraised by the Bostock (1964) system. Dressing percentage was calculated as 97% of the hot dressed weight including the head, divided by the final weight on experiment multiplied by 100.

In Experiment 1, carcass density and chemical composition were measured. As the percentage of internal fat remaining after dressing varied between pigs, this fat and the kidneys were first removed. Carcasses were then split down the midline by handsaw. After removal of the limbs distal to the tarso-metatarsal and carpo-metacarpal joints and the head at the atlanto-occipital joint, the density of the right side was measured by submersion in water at 17°C. The side was then separated into bone, separable lean and separable fat (including skin). The separable lean and fat were analysed by the method for oven-dried sample cuts described by Morris and Moir (1963) and the data bulked to determine total amounts of ether extract, crude protein, water and ash.

III. RESULTS

Results of Experiment 1, and of Experiments 2 and 3 are presented in Tables 2 and 3 respectively. In all experiments, the mean daily feed intake of pigs receiving no nitrogenous supplement was lower than that of pigs on other treatments; refusals increased as time progressed and feed was frequently regurgitated.

(a) Experiment 1

In Experiment 1 daily liveweight gain was significantly ($P < 0.05$) increased by all supplements except 0.1% L-lysine $HCl.2H_2O$. Efficiency of feed conversion was improved ($P < 0.05$) by the addition of 0.1% L-lysine $HCl.2H_2O$, and further improved, although not significantly so, by the higher levels of lysine, and by yeast and soybean meal.

There were significant ($P < 0.05$) treatment effects on density measurements Bostock appraisal and chemical analyses but not on carcass backfat thickness and eye muscle index.

(b) Experiment 2

Mean daily liveweight gain was significantly ($P < 0.05$) increased by supplementation with lysine, but only at the 0.36% level of L-lysine $HCl.2H_2O$ was the daily gain at a level similar to that achieved with the 11.9% soybean meal supplement. Increased gains were accompanied by improvements in feed efficiency. The mean eye muscle index was increased significantly ($P < 0.05$) by soybean supplementation but not by lysine.

(c) Experiment 3

Mean daily liveweight gain of 391 g in the control group was increased significantly ($P < 0.05$) to 497 g with 0.24% L-lysine $HCl.2H_2O$ and to 516 g

TABLE 2

The effect of treatments in Experiment 1 on feed intake, liveweight change, feed efficiency and carcass composition

Item	Diet No. 1	2	3	4	5	6	7	8
Nitrogen supplement (%)		0.1 lysine HCl.2H_2O	0.2 lysine HCl.2H_2O	0.3 lysine HCl.2H_2O	7.3 yeast	10.9 yeast	8.2 soy-bean meal	12.1 soy-bean meal
Number per group	3	3	3	3	3	3	3	3
Initial weight (kg)	42.1	43.4	43.4	47.0	43.5	44.0	43.4	46.5
Final weight (kg)	86.9	90.7	90.3	90.5	90.7	90.8	90.4	91.4
Days on trial	127	108	98	91	98	92	90	79
Mean daily feed intake (g)	1901	1946	2051	1906	2040	2063	2111	2112
Mean daily body-weight gain (g)	347^{a}	443^{ab}	487^{bc}	485^{bc}	517^{bc}	507^{bc}	530^{bc}	568^{c}
Feed efficiency (g feed/g gain)	5.61^{a}	4.32^{b}	4.21^{b}	4.02^{b}	4.23^{b}	4.05^{b}	3.72^{b}	3.58^{b}
Dressing percentage*	79.4^{a}	75.5^{a}	73.7^{a}	77.2^{a}	76.2^{a}	76.0^{a}	77.3^{a}	74.3^{a}
Measurements, right side of carcass								
(a) Separable bone (%)	10.44^{a}	11.46^{a}	12.27^{a}	9.79^{a}	9.73^{a}	10.72^{a}	10.30^{a}	9.89^{a}
(b) Non-bone portion								
Water (%)	23.86^{a}	39.27^{b}	40.71^{bc}	39.25^{b}	40.87^{bc}	42.06^{bc}	41.13^{bc}	46.40^{c}
Crude protein (%)	7.81^{a}	9.98^{a}	10.37^{ab}	11.88^{b}	11.51^{b}	11.11^{b}	10.59^{b}	12.62^{b}
Ether extract (%)	52.52^{a}	38.79^{b}	35.93^{bc}	38.70^{b}	36.60^{bc}	35.61^{bc}	37.24^{b}	30.16^{c}
Ash (%)	0.36	0.49	0.47	0.53	0.48	0.50	0.49	0.58
Density	1.0213^{a}	1.0359^{bc}	1.0374^{bc}	1.0341^{b}	1.0386^{bc}	1.0395^{bc}	1.0453^{c}	1.0458^{c}
Bostock appraisal (pts)	38^{a}	71^{b}	76^{b}	71^{b}	71^{b}	87^{b}	84^{b}	89^{b}
Backfat† (mm)	35^{a}	26^{a}	24^{a}	26^{a}	26^{a}	22^{a}	22^{a}	23^{a}
Eye muscle index (AxB) (mm^2)‡	2772^{a}	3750^{a}	3838^{a}	3999^{a}	3635^{a}	4201^{a}	4237^{a}	4619^{a}

Within comparisons, means not containing a common superscript letter are significantly different ($P < 0.05$). Data with no superscript were not statistically analysed.

*($P = 0.063$).

†Not including skin.

‡Cross-sectional length x width (Bostock 1964).

TABLE 3

The effect of treatments in Experiments 2 and 3 on feed intake, liveweight change, feed efficiency and linear body measurements

Item	Experiment 2						Experiment 3				
	Diet No.						Diet No.				
	1	2	3	4	5	6	1	2	3	4	5
Nitrogen supplement (%)	—	0.12 lysine $HCl.2H_2O$	0.24 lysine $HCl.2H_2O$	0.36 lysine $HCl.2H_2O$	7.9 soybean meal	11.9 soybean meal	—	0.24 lysine $HCl.2H_2O$	0.36 lysine $HCl.2H_2O$	7.9 soybean meal	11.9 soybean meal
Number per group	3	3	3	3	3	3	5	5	5	5	5
Initial weight (kg)	45.8	45.3	45.3	45.3	45.3	45.3	45.7	45.5	44.9	45.7	45.5
Final weight (kg)	81.4	88.8	87.3	88.0	87.2	87.4	82.3	86.5	87.0	87.8	88.4
Days on trial	135	99	78	76	73	78	94	83	82	77	73
Mean daily feed intake (g)	1814	2165	2165	2176	2176	2159	1873	1957	1952	1964	1961
Mean daily liveweight gain (g)	267^{a}	441^{b}	541^{c}	563^{cd}	575^{cd}	616^{d}	391^{a}	497^{b}	516^{bc}	545^{c}	590^{d}
Feed efficiency (g feed/g gain)	6.82^{a}	4.92^{b}	4.02^{c}	3.87^{c}	3.79^{c}	3.52^{c}	4.84^{a}	3.94^{b}	3.81^{bc}	3.59^{cd}	3.33^{d}
Dressing percentage	78.8^{a}	74.6^{b}	74.1^{b}	74.0^{b}	73.8^{b}	74.8^{b}	78.3^{a}	78.7^{a}	75.2^{a}	77.0^{a}	77.3^{a}
Bostock appraisal (pts)	54^{a}	55^{a}	58^{a}	68^{a}	73^{a}	73^{a}	41^{a}	53^{a}	55^{a}	53^{a}	59^{a}
Backfat (mm)*	25^{a}	24^{a}	22^{a}	21^{a}	22^{a}	22^{a}	27^{a}	28^{a}	25^{a}	28^{a}	24^{a}
Eye muscle index (AxB) (mm^2)†	2635^{a}	3013^{ab}	2845^{a}	3089^{ab}	3400^{b}	3568^{b}	2777^{a}	3391^{bc}	3307^{bc}	3287^{b}	3697^{c}

Within comparisons, means not containing a common superscript letter are significantly different ($P < 0.05$). Data with no superscripts were not statistically analysed.

*Not including skin.

†Cross-sectional length x width (Bostock 1964).

with 0.3 6% L-lysine $HCl.2H_2O$. Mean daily liveweight gain rose to 545 g with a 7.9% soybean meal supplement and significantly ($P < 0.05$) further to 590 g with the 11.9% level of soybean meal. Feed efficiency showed a response similar to that of bodyweight gains.

IV. DISCUSSION

In these experiments, increasing levels of lysine supplementation improved growth rate and feed efficiency, but in Experiment 3 the maximum growth and efficiency were significantly less ($P < 0.05$) than values obtained with the highest level (11.9 %) of soybean meal. Trends similar to these results were obtained in the other two -experiments. The possibility that an adequate lysine level had not been reached is supported by the results of Ericson, Larsson and Ostholm (1962) who found that pigs grew faster from weaning to bacon weight on a wheat-barley ration supplemented with 1 .0% L-lysine HCl than one supplemented with 0.34% L-lysine HCl. Thus the optimum dietary lysine level would appear to be greater than the estimated (N.A.S.-N.R.C. 1964) 0.7 % in the latter ration. The lack of response to methionine in addition to 0.25% lysine with a sorghum ration reported by Jensen, Becker and Harmon (1965) would indicate that at this level of supplementation lysine was still the primary limiting amino acid, although threonine might have been a better choice to test as the second limiting amino acid (Pond, Hillier and Benton 1958). However, if lysine is the primary limiting amino acid to a level of 0.7% or more in the complete ration, the better growth produced by the 12% soybean meal ration in Experiment 3 than by the ration containing 0.36% L-lysine $HCl.2H_2O$ would be difficult to explain, as both these rations had approximately the same estimated lysine content of 0.50 to 0.57%. It appears that the change from the first limiting amino acid to the next may be a gradual one.

No explanation can be offered for the trend towards poorer performance in Experiment 1 of the pigs receiving yeast compared with those receiving soybean meal, particularly in view of the similarity of the amino acid profile of these two products. (N.A.S.-N.R.C. 1964).

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