The effect of supplementation of liquid and crystalline lysine to barley-distillers solids diet on the performance and carcass quality of pigs

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The response to dietary lysine of liquid or crystalline form was examined in pigs fed on cereal protein diets over the range of live weight from 25.0 to 95.0 kg. Forty individually fed growing pigs (20 gilts and 20 castrated males) were allocated to four isonitrogenous diets consisting of barley, undehydrated distillers solids and a mixture of minerals and vitamins with lysine supplementation of 0.9 or 3.2 g pure lysine per kg DM in liquid or crystalline form to provide 7.1 or 9.1 g/FU total lysine, respectively. The pigs were given feed on a restricted scale twice daily.

A high level of lysine supplementation significantly increased the growth rate and improved the feed conversion efficiency ($p<0.001$). A low level of lysine supplementation produced significantly less lean in carcass ($p<0.05$) and a smaller area of eye muscle ($p<0.001$). The loss at slaughter (in relation to live weight) of the pigs on high level of lysine supply was significantly lower than that of the pigs on low level of lysine supply ($p<0.05$).

No significant differences were found in the performance and carcass quality of the pigs between liquid and crystalline form of lysine except that the area of eye muscle of the pigs on liquid lysine diets was larger than that of the pigs on crystalline lysine diets ($p<0.05$). No interaction was found between lysine source and level of supplementation on the performance or carcass quality.

The results of this study showed that both sources of lysine supplementation were equally efficient in improving the performance of the pigs.

Key words: growing pigs, lysine, crystalline, liquid, distillers solids, performance, carcass quality

Introduction

Barley is the main ingredient in pig diets in Finland and it may account for up to 85 percent of the diet depending on the type of feeding. Barley provides most of the dietary energy and half or more of the protein in pig diets. Lysine is generally considered the first limiting amino acid in barley based diets for pigs (FULLER et al. 1979a, 1979b). Therefore, addition of protein to barley diets has the dual objective of increasing the dietary protein and of correcting the imbalances in amino acid composi-

tion of barley protein, especially the lack of lysine.

Barley distillers solids is a cereal protein feed derived through an integrated barley starch-ethanol process, and its amino acid composition reflects the amino acid composition of the whole grain. The level of lysine in distillers solids does not meet the requirement of growing pigs (NÄSI and AIMONEN 1992). An adequate level of amino acids in the diet can be achieved by increasing the total protein content of the diet or by balancing the amino acid composition of the diet with synthetic amino acids. Progressive protein supplementation of the diet always leads to excess of other amino acids which has to be catabolized and excreted with manure. On the contrary, the crude protein content of the pig feeds can be reduced by supplementation of synthetic amino acids to meet better the amino acid requirement of the animal (TAYLOR et al. 1979, NÄSI 1985, VALAJA 1992).

Several experiments have been made to study the utilization of different forms of lysine in pigs. However, in most of reports comparison is being made between free and protein-bound lysine (FULLER et al. 1986, SUSENBETH et al. 1991, MATRE and HOMB 1991), or between protein-bound lysine of different sources (BATTERHAM et al. 1978, 1981, 1990). Only few studies deal with the utilization of different lysine products (GRUHN et al. 1982, LIEBERT and GEBHARDT 1984, NÄSI 1992). The present work was undertaken to study the effect of supplementation of lysine in liquid or crystalline form to barley-distillers solids diets on the performance of growing pigs.

Material and methods

Forty growing Landrace and Yorkshire pigs weighing 25.0 (SE 0.36) kg on average were used in a performance trial. The pigs were allocated to five blocks on the basis of litter origin and sex. Two pigs from each block were assigned at random to one of four experimental diets. One pig was placed in each pen. Each diet was tested on five gilts and five castrated males.

Table 1. Dietary ingredients (g/kg DM) and calculated chemical composition of the experimental diets.

Diet	1	2	3	4
Ingredient:				
Barley	818.6	822.4	812.1	798.9
Distillers solids	142.0	135.3	142.0	135.3
Liquid lysine	–	–	7.6	27.8
Crystalline lysine	1.1	4.1	–	–
Mineral + vitamin mixture[1]	38.3	38.2	38.2	38.0
Chemical composition:				
Crude protein, g/FU	156	156	158	164
Digestible crude protein, g/FU	135	135	136	140
Lysine, g/FU	7.1	9.1	7.1	9.1
Threonine, g/FU	6.9	6.8	6.8	6.7
Methionine + Cystine, g/FU	6.8	6.7	6.8	6.7
Feed unit (FU/kg DM)[2]	1.12	1.12	1.12	1.11

[1] Supplied per kg DM:

Ca	g	200
P	"	75
NaCl	"	103
Vitamin A	1000 IU	3500
Vitamin D	"	57.2
Vitamin E	mg	1200
Se	"	4

[2] Feed unit (FU) = 0.7 kg starch equivalent

The four experimental diets were isonitrogenous and consisted of barley meal, barley distillers solids and an adequate amount of minerals and vitamins to meet the nutritional requirements of growing pigs (SALO et al. 1990) (Table 1). Lysine was supplemented to the diets either in a liquid or crystalline form. The liquid lysine was a product derived through fermentation of beet molasses by *Brevibacterium flavum*, strain V-5 (BEKER et al. 1971). It was sterilized and dehydrated in a vacuum-vapour evaporator up to a DM content of 500 g/kg and stabilized by adding hydrochloric acid up to pH 5.1. Commercially produced L-lysine monohydrochloride (Eurolysine) was used as the crystalline lysine. The level of lysine supplementation to the diets was 0.9 and 3.2 g pure lysine/kg DM. Distillers solids were obtained by centrifugation of distillers sol-

Table 2. Average chemical composition of the experimental feeds.

Feed	Barley	Distillers solids			Liquid lysine	Crystalline lysine
		Mean	Min.	Max.		
No. of observations	1	8			1	1
Dry matter, g/kg	887	198	140	236	520	990
Crude protein, g/kg DM	119	530	432	592	497	ND
Ether extract, "	20	79	70	89	10	ND
Crude fibre, "	62	19	10	25	–	ND
N-free extract, "	776	340	263	442	240	ND
Ash, "	23	67	46	100	150	ND
Amino acids	g/160 g N	g/160 g N			g/kg DM	g/kg DM
Lysine	40	45	37	56	117	790
Threonine	39	40	36	44	8	
Methionine	14	23	21	25	4	
Cystine	ND	35	25	42	–	
Histidine	43	18	13	22	–	
Leucine	66	75	69	84	12	
Isoleucine	35	51	43	59	8	
Phenylalanine	51	59	53	70	7	
Arginine	60	45	36	52	7	

ND = not determined

ubles from the Alko Ltd. Koskenkorva factory employing an integrated starch-ethanol process and using barley as raw material. The detailed description of the integrated starch-ethanol production process has been presented by NÄSI (1988). Undehydrated distillers solids were preserved with sodium benzoate 3 g/kg and were delivered from the Koskenkorva factory weekly during the experiment. At the research station distillers solids were stored in a 1500 litre glass fibre container, with a propeller mixing the contents of the container for 15 minutes every two hours. The feed ingredients were analyzed by standard methods (AOAC 1984) and the amino acid composition was determined by high-performance liquid chromatography (HPLC). Feed values were calculated using feed table values for barley (SALO et al. 1990) and digestibility coefficients reported by NÄSI and AIMONEN (1992) for distillers solids. The chemical composition of the feed ingredients is presented in Table 2.

The pigs were housed in partially slatted pens with concrete floors and free access to water. Feeding was restricted to 1.3 - 3.0 FU/day/animal. Two basal feeds were compounded from barley, a mixture of minerals and vitamins and crystalline lysine for diets 1 and 2 and two basal feeds from barley and a mixture of minerals and vitamins for diets 3 and 4. The daily allowances of the basal feed and distillers solids (diets 1 and 2) or basal feed, distillers solids and liquid lysine (treatment 3 and 4) were weighed separately and mixed in a trough. Because of the variation in dry matter content of distillers solids the daily amount was adjusted weekly according to the dry matter analysis of each batch. The pigs were fed twice a day. They were weighed at two week intervals and feed consumption was recorded daily. The pigs were slaughtered at an average weight of 95.0 kg. At slaughter the carcass weight was recorded and backfat and sidefat thickness, area of eye muscle, lean in carcass and in valuable cuts were measured (Kantakoe-eläinten...1979).

Table 3. Performance and carcass quality of the pigs (LS means of the treatments are presented).

Treatment	1	2	3	4		Sex			Significance		
Lysine form	Crystalline		Liquid		SEM	Gilts	Castrated males	SEM	Lysine Form	Lysine Level	Sex
Lysine level, g/FU	7.1	9.1	7.1	9.1							
No. of animals	10	10	10	9		19	20				
Initial weight, kg	24.9	24.9	25.0	25.0	0.362	24.7	25.2	0.512	NS	NS	NS
Final weight (corr.), kg	93.8	95.4	94.4	95.7	0.938	95.2	94.4	1.327	NS	NS	NS
Carcass weight, kg	69.4	70.6	69.9	70.8	0.694	70.4	69.9	0.981	NS	NS	NS
Loss at slaughter, %	27.0	25.5	26.1	25.4	0.397	25.6	26.4	0.561	NS	*	o
Daily gain, g	732	832	754	852	16.63	776	807	23.52	NS	***	o
Days in experiment	94.6	85.5	92.5	82.8	2.203	91.8	86.2	3.115	NS	***	*
Feed consumption, kg DM/animal	197.6	176.6	194.9	176.4	3.698	190.6	182.1	2.615	NS	***	*
FU/animal	222.0	198.3	218.5	195.6	4.149	213.6	204.0	5.868	NS	***	*
kg DM/animal/day	2.09	2.07	2.11	2.11	0.020	2.08	2.11	0.014	NS	NS	NS
FU/animal/day	2.35	2.32	2.37	2.36	0.022	2.33	2.36	0.031	NS	NS	NS
FCE, kg DM/kg gain	2.87	2.51	2.81	2.50	0.047	2.71	2.63	0.033	NS	***	o
", FU/kg gain	3.22	2.82	3.15	2.77	0.053	3.04	2.95	0.075	NS	***	o
Back fat thickness, mm	24.1	23.1	24.8	24.7	1.200	23.3	25.0	1.697	NS	NS	NS
Side fat thickness, mm	17.5	16.0	18.0	17.2	1.111	16.6	17.6	1.571	NS	NS	NS
Eye muscle area, cm^2	36.5	38.7	37.4	41.0	0.701	39.2	37.6	0.991	*	***	*
Lean in valuable cuts, %	80.3	81.6	80.0	80.7	0.569	81.6	79.8	0.805	NS	o	**
Carcass lean, %	54.2	55.3	53.8	54.6	0.473	55.0	54.0	0.669	NS	*	*

Significance of lysine level (treatment 1 and 3 vs. 2 and 4); Significance of lysine form (treatment 1 and 2 vs. 3 and 4).
Significance: NS = non-significant, o = $p<0.10$, * = $p<0.05$, ** = $p<0.01$, *** = $p<0.001$.
SEM = standard error of means.
FCE = feed conversion efficiency.

The data were analyzed by the GLM procedure of SAS (1985). The model used to analyse the data was:

$$y_{ijklm} = \mu + a_i + b_j + c_k + d_l + (bc)_{jk} + (bd)_{jl} + (cd)_{kl} + e_{ijklm}$$

where y_{ijklm} is the dependent variable; μ is the overall mean; a_i is the effect of block; b_j is the effect of lysine source; c_k is the effect of the level of lysine supplementation and d_l is the effect of sex. e_{ijklm} is a normally distributed random variable. Interactions between lysine source, lysine level and sex were considered in the model.

Results

Variation in the composition of distillers solids between different batches was found during the experiment (Table 2). The range of the dry matter, crude protein and lysine content varied between 140-236 g/kg, 432-592 g/kg DM and 37-56 g/160 g N, respectively. Because the daily allowance of distillers solids was adjusted according to dry matter content, its effect on the results was eliminated. As the changes in protein and lysine content of distillers solids could not be eliminated from the results, they were included in the experimental error. The palatability of distillers solids was satis-

factory. One gilt from diet 4 was excluded from the trial for a reason not related to the treatment and the missing values were fitted for this pig. Otherwise the pigs completed the experiment successfully. The overall results of the experiment are given in Table 3.

Performance

The dietary level of lysine clearly influenced the performance of the pigs. The pigs on high lysine diet grew significantly faster than those on low lysine diet ($p< 0.001$) (843 vs. 739 g/day). Therefore it took on average 9.1 days longer for the pigs on low lysine diets to reach the final weight of 95 kg compared to the pigs on high lysine diets. The difference was highly significant ($p<0.001$). Also total feed consumption during the experiment was significantly higher for the pigs on low lysine diets compared to the pigs on high lysine diet ($p<0.001$). Because of faster gain and lower total feed consumption the feed conversion efficiency of the pigs on high lysine diets was significantly better than that of the pigs on low lysine diets (2.80 vs. 3.19 FU/kg gain) ($p<0.001$).

Dietary lysine of crystalline or liquid form did not affect the performance of the pigs. No significant differences were found in daily gain nor in feed conversion efficiency between the different lysine sources ($p>0.10$). No interactions were found between lysine level and form of supplementation in the performance of the pigs.

Regression equations were calculated for daily gain and feed conversion efficiency as a function of lysine level in the diets based on the assumption of linear response of lysine between the two levels. Because no differences were found in the performance of the pigs between the lysine sources, pooled data was used in the calculation. The regression equation for daily gain (g/d) (Y) as a function of lysine level in the diet (g/FU) (X) was

$$Y = 409\ (SE\ 77.5) + 46.9\ (SE\ 9.53) * X,\ R^2=0.40.$$

The regression equation for feed conversion efficiency (FU/kg gain) (Y) as a function of lysine level (g/FU) (X) was

$$Y = 4.54\ (SE\ 0.238) - 0.19\ (SE\ 0.029) * X,\ R^2=0.53.$$

Sex also had a significant influence on the performance of the pigs. There was a tendency to higher growth rate for castrated males compared to gilts (807 vs. 776 g/day) ($p<0.10$). Consequently, castrated males finished the experiment 5.5 days earlier than gilts ($p<0.05$). The total feed consumption of gilts was significantly higher than that of castrated males (213.6 vs. 204.0 FU/pig) ($p<0.05$), and a tendency to better feed conversion in castrated males was noticed ($p<0.10$).

Carcass quality

The carcass trait results showed that the pigs on low lysine diets deposited more fat and less lean compared to the pigs on high lysine diets. The eye muscle area of the high lysine pigs was significantly larger than that of low lysine pigs ($p<0.001$). Significant differences were found also in the lean content of carcass ($p<0.05$) and in the loss at slaughter (in relation to live weight) ($p<0.01$) between the low and high lysine diets. There was also a tendency to higher content of lean in valuable cuts for the pigs on high lysine diets compared to those on low lysine diets ($p<0.10$). However, no significant differences were detected in side fat or back fat thickness between the high lysine and low lysine diets ($p>0.10$). This was partly due to high coefficients of variation for both measurements (0.17 and 0.24 for side fat and back fat thickness, respectively).

There were no significant differences in thickness of back fat and side fat, lean in valuable cuts or lean in whole carcass between the pigs fed on crystalline or liquid lysine ($p>0.10$). Neither were any interactions found between lysine level and form of supplementation in carcass trait measurements.

However, the eye muscle area of the pigs given lysine in liquid form was significantly larger ($p<0.05$) than that of pigs given lysine in crystalline form.

There were significant differences between the sexes also in the area of eye muscle ($p<0.05$), portion of lean in valuable cuts ($p<0.01$) and in whole carcass ($p<0.05$) (Table 3.). In all these measurements the gilts were superior to castrated males.

Discussion

The main purpose of this work was to investigate whether supplementation of lysine in the form of liquid compared to crystalline has any effect on the performance and the carcass quality of the pigs. In order to establish the full effect of the different lysine sources, two levels of supplementation were used (0.9 and 3.2 g pure lysine per kg DM). The performance results clearly showed that the pigs responded similarly to both forms of lysine and they confirm the earlier results of NÄSI (1992) who found no differences in nitrogen retention of the pigs fed on diets supplemented either with liquid or crystalline lysine.

GRUHN et al. (1982) observed no differences in the protein utilization between microbially produced lysine concentrate and crystalline lysine. In contrats to this, LIEBERT and GEBHARDT (1984) reported that microbially produced lysine might have better utilization than crystalline lysine due to a complexity of composition which causes longer absorption time from the small intestine. In the carcass quality measurements of the present study the liquid lysine yielded a significantly larger area of eye muscle compared to crystalline lysine. However, the other carcass measurements did not confirm the hypothesis of better utilization of microbially produced lysine.

Free lysine is absorbed very rapidly from the small intestine and this causes reduced utilization when fed only once daily compared to frequent feeding (six times per day) (BATTERHAM (1974). PARTRIDGE et al. (1985) also reported that the utilization of free lysine measured as N-balance increased from once to twice daily feeding, but no further response was found to increases in frequency of feeding from twice daily. Thus, the twice daily feeding regime in the present study should have been sufficient for the effective utilization of free lysine. The recent reports of the comparisons of protein-bound lysine to crystalline lysine indicate that the utilization of crystalline lysine might be less than 100 % (MATRE and HOMB 1991, SUSENBETH et al. 1991). FULLER et al. (1986) found that addition of protein-bound lysine (soybean meal) to the diet induced a greater increase in daily live weight gain compared to lysine added in the free form, but the difference in terms of carcass gain was not apparent because of the differences in gut fill. There is variation in the digestibility or availability of lysine in different feedstuffs (BATTERHAM et al. 1978, SAUER and OZIMEK 1986). In the work of BATTERHAM et al. (1978) the comparison of eight protein concentrates on a total lysine basis in lysine-deficient diets for pigs showed that with fish meal, skim milk powder, rapeseed meal and soybean meal growth rates and feed conversion efficiencies were similar and superior to those produced with cottonseed meal, meat meal and sunflower meal. BATTERHAM et al. (1981) also found that the availability of lysine measured by a slope-ratio assay was the highest for rapeseed meal (0.87) and the lowest for sunflower meal (0.59), being intermediate for lupinseed meal (0.74). The low estimates for available lysine in sunflower meal presumably reflects processing damage (BATTERHAM et al. 1981).

The growth and carcass characteristics of growing pigs responded linearly to increasing lysine intake until a maximum was attained at which the response levelled off (TAYLOR et al. 1979, YEN et al. 1986a, 1986b). In this study the response of pigs to lysine between two levels of supplementation was assumed to be linear because the inflection point for pigs with high genetic potential is at a higher content of lysine than used in this experi-

ment (HANRAHAN 1989, MADSEN et al. 1991). The linear regression coefficients calculated for daily gain and feed conversion ratio as a function of level of lysine in the diet were in agreement with the results of YEN et al. (1986b). The regression coefficient for daily gain in this experiment was close to the value for gilts (46.74) and the coefficient for feed conversion efficiency was close to the value for boars (-0.199) calculated by YEN et al. (1986b) from 50 to 90 kg live weight, and they show the high genetic potential of the pigs in the present experiment. The regression coefficients calculated from the early period of growth from 25 to 55 kg live weight (YEN et al. 1986a) were generally steeper than the coefficients from the later period of growth (YEN et al. 1986b), indicating that the actual response to lysine is curvilinear over the whole period of growth. In the study of BATTERHAM et al. (1985) the pigs showed linear response to lysine from 20 to 50 kg and a curvilinear response from 50 to 85 kg live weight.

The results from the comparisons between sexes were rather surprising. The castrated males tended to show higher performance than the gilts, but at the same time deposited more fat and less lean meat than the gilts. As lean meat deposition has a lower associated energy cost than fat deposition, a high rate of fat deposition would normally be accompanied by a reduction in growth performance as was indicated by the lysine levels in the present experiment. YEN et al. (1986b) observed that boars showed better growth and feed utilization than gilts, but gilts were superior to castrated males. In contrast to this, TAYLOR et al. (1979) and FULLER et al. (1986) found no significant differences in growth rate or feed:gain ratio between gilts and castrated males. CAMPBELL et al. (1988) reported that between 20 and 40 kg live weight no differences were found in growth performance between gilts and entire males, but at higher live weights entire males grew faster and more efficiently than gilts. However, the carcass quality of the gilts has been better than that of castrated males in earlier experiments (TAYLOR et al. 1979, FULLER et al. 1986, YEN et al. 1986b), which is in agreement with this study.

In conclusion, the liquid form of lysine is as effective as the crystalline form in improving the performance of growing pigs. It is very useful in practical wet feeding systems in combination with undehydrated distillers solids and it improves the quality of the protein in distillers solids.

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References

AOAC 1984. Official methods of analysis. 14th edition. Association of Official Analytical Chemist. Arlington, Virginia.

BATTERHAM, E.S. 1974. The effect of frequency of feeding on the utilization of free lysine by growing pigs. Br. J. Nutr. 31: 237-242.

— , MURISON, R.D. & LEWIS, C.E. 1978. An evaluation of total lysine as a predictor of lysine status in protein concentrates for growing pigs. Br. J. Nutr. 40: 23-28.

— , MURISON, R.D. & LOWE, R.F. 1981. Availability of lysine in vegetable protein concentrates as determined by the sloperatio assay with growing pigs and rats and by chemical techniques. Br. J. Nutr.45: 401-410.

— , GILES, L.R. & DETTMANN, E.B. 1985. Amino acid and energy interactions in growing pigs. 1. Effects of food intake, sex and live weight on the responses of growing pigs to lysine concentration. Anim. Prod. 40: 331-343.

— , ANDERSEN, L.M., BAIGENT, D.R., DARNELL, R.E. & TAVERNER, M.R. 1990. A comparison of the availability and ileal digestibility of lysine in cottonseed and soya-bean meals for grower-finisher pigs. Br. J. Nutr. 64: 663-677.

BEKER, M.E., WIESTUR, U.E., LATSARS, A.A., MEZHINYA, G.R. & PABERZS, A.O. 1971. Verfahren zur Herstellung des Futterkonzentrates von L-Lysin. Institut Mikrobiologii imeni A. Kirhensteina Akademii Nauk Latvijskoi SSR. Pat. 93704.

CAMPBELL, R.G., TAVERNER, M.R. & CURIC, D.M. 1988. The effects of sex and live weight on the growing pig's response to dietary protein. Anim. Prod. 46: 123-130.

FULLER, M.F., LIVINGSTONE, R.M., BAIRD, B.A. & ATKINSON, T. 1979a. The optimal amino acid supplementation of barley for growing pig. 1. Response of nitrogen metabolism to progressive supplementation. Br. J. Nutr. 41: 321-331.

— , MENNIE, I. & CROFTS, R.M.J. 1979b. The optimal amino acid supplementation of barley for growing pigs. 2. Optimal additions of lysine and threonine for growth. Br. J. Nutr. 41: 333-340.

— , WOOD, J., BREWER, A.C., PENNIE, K. & MACWILLIAM, R. 1986. The responses of growing pigs to dietary lysine, as free lysine hydrochloride or in soya-bean meal, and the influence of food intake. Anim. Prod. 43: 477-484.

GRUHN, K., LÜDKE, H., SCHÖNE, A., HENNING, A. & CHEMNITIUS, K.-H. 1982. Einfluss des L-lysinmonohydrochlorids bzw. eines Lysinfutterkonzentrates auf die Verdaulichkeit des Rohproteins und der basischen Aminosäuren, sowie Ergebnisse der N-Bilanz bei Mastschweinen und kolostomierten Hennen. Arch. Tierernährung 32: 477-482.

HANRAHAN, T.J. 1989. The response of growing pigs to lysine. The Feed Compounder No 7: 32-39.

Kantakoe-eläinten teurasarvostelu ja paloittelu. 1979. Sika 9, 2: 34-35.

LIEBERT, F. & GEBHARDT, G. 1984. Untersuchungen zum N-Umsatz wachsender Schweine unter besonderer Beachtung der Lysinwirksamkeit unterschiedlicher Lysinquellen. Arch. Tierernähr. 34: 379-385.

MADSEN, A., PETERSEN, J., MORTENSEN, H.P., BEJERHOLM, C. & BARTON, P. 1991. Protein til han- og sogrise. Stigende mangder sojaskrå. Statens Husdyrbrugsforsog. Meddelelse 795. 6 p.

MATRE, T. & HOMB, T. 1991. Syntetic amino acids as supplements to a barley/oat/soyabean based ration for growing pigs. Proc. 6th Int. Symp. Protein Metabolism and Nutrition, Herning, Denmark. p.265-267.

NÄSI, M. 1985. Replacing protein supplements in barley-based diets for growing pigs with free lysine and methionine. J. Agric. Sci. Finl. 57: 245-253.

— 1989. Barley feed fractions from integrated ethanol-starch process in diets of pigs. J. Agric. Sci. Finl. 61: 441-450.

— 1992. Protein utilization responses of growing pigs to supplemental lysine as liquid versus crystalline form in barley-barley protein diet. Agric. Sci. Finl. 1: 215-223.

— & AIMONEN, E. 1992. Evaluation of undehydrated barley feed fractions and dried oat feed fractions from integrated starch-ethanol process in diets of growing pigs. Agric. Sci. Finl. 1: 291-301.

PARTRIDGE, I.G., LOW, A.G. & KEAL, H.D. 1985. A note on the effect of feeding frequency on nitrogen use in growing boars given diets with varying levels of free lysine. Anim. Prod. 40: 375-377.

SALO, M.-L., TUORI, M. & KIISKINEN, T. 1990. Rehutaulukot ja ruokintanormit. 70 p. Helsinki.

SAS 1985. SAS User's Guide: Statistics. 956 p. 5 th Ed. SAS Institute Inc, Cary, NC, USA.

SAUER, W.C. & OZIMEK, L. 1986. Digestibility of amino acids in swine: results and their practical applications. A review. 15: 367-388.

SUSENBETH, A., SCHNEIDER, R. & MENKE, K.H. 1991. The effect of protein-bound lysine versus free lysine on protein retention in growing pigs. Proc. 6th Int. Symp. Protein Metabolism and Nutrition, Herning, Denmark. p.18-20.

TAYLOR, A.J., COLE, D.J.A. & LEWIS, D. 1979. Amino acid requirements of growing pigs. 1. Effects of reducing protein level in diets containing high levels of lysine. Anim. Prod. 29: 327-338.

VALAJA, J. 1992. Puhtaiden aminohappojen avulla ympäristöystävällisempiä sianrehuja. Sika 22, 2: 25-26.

YEN, H.T., COLE, D.J.A. & LEWIS, D. 1986a. Amino acid requirements of growing pigs. 7. The response of pigs from 25 to 55 kg live weight to dietary ideal protein. Anim. Prod. 43: 141-154.

— , COLE, D.J.A. & LEWIS, D. 1986b. Amino acid requirements of growing pigs. 8. The response of pigs from 50 to 90 kg live weight to dietary ideal protein. Anim. Prod. 43: 155-165.

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SELOSTUS

Nestemäinen tai kiteinen lysiini lihasikojen ohratärkkelysrankkiruokinnan täydentäjänä

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Maatalouden tutkimuskeskus

Kasvatuskokeessa selvitettiin kiteisen tai nestemäisen lysiinilisäyksen vaikutusta ohra-tärkkelysrankkidieetillä ruokittujen lihasikojen tuotantotuloksiin sekä teuraslaatuun. Kokeessa oli 40 koe-eläintä, jotka jaettiin neljään kymmenen sian ryhmään ja kasvatettiin yksilöruokinnalla 25 kilon alkupainosta 95 kilon elopainoon. Neljä koerehua sisälsivät saman määrän nestemäistä tärkkelysrankkia ja ohraa ja niihin lisättiin joko nestemäistä tai kiteistä lysiiniä siten, että dieettien kokonaislysiinimääräksi tuli 7,1 tai 9,1 g lysiiniä/ry. Lisätyn puhtaan lysiinin määrä oli 0,9 tai 3,2 g/kg kuiva-ainetta.

Nestemäisen tai kiteisen lysiinilisäyksen välillä ei havaittu eroja sikojen tuotantotuloksissa tai teuraslaadussa. Ainoastaan pitkän selkälihaksen poikkipinta-alassa oli ero kiteistä tai nestemäistä lysiiniä saaneiden eläinten välillä. Dieetin korkea lysiinitaso (9,1 g/ry) paransi selvästi sikojen päiväkasvua, rehuhyötysuhdetta ja teuraslaatua verrattuna matalaan lysiinitasoon (7,1 g/ry). Leikkojen tuotantotulokset olivat hiukan paremmat kuin imisien, mutta imisien teuraslaatu oli kuitenkin selvästi parempi kuin leikkojen.

Koe osoitti, että nestemäinen ja kiteinen lysiini ovat yhtä käyttökelpoisia sikojen ruokinnassa. Nestemäinen lysiini soveltuu hyvin liemiruokintaan täydentämään nestemäisiä viljaperäisiä valkuaisrehuja.