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Barley feed fractions from integrated ethanol-starch process in diets of pigs

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Abstract. The nutritive value of feed fractions of barley obtained from integrated ethanol-starch production was evaluated in a feeding trial and five digestibility and balance trials with growing pigs. The products examined were barley protein, (375 g CP/kg), barley fibre (166 CP and 653 NDF), barley molasses (298 CP) and distillers solubles (333 CP); their respective digestibilities for OM were 0.895, 0.633, 0.864 and 0.834 and for CP 0.910, 0.577, 0.809 and 0.851. Barley protein fortified with pure lysine gave a nitrogen balance similar to that of the isonitrogenous soybean-barley diet. In the growth trial, one third and two thirds of soybean meal protein were replaced with barley protein and barley was replaced with 200 g/kg barley fibre or processed fibre. There was no significant difference in performance between the control and treatment groups, the mean growth rate being 795 g/d and the feed conversion rate 2.9 FU/kg gain. Carcass quality was inferior ($P < 0.05$) in pigs fed barley protein but higher in pigs receiving barley fibre diets. Hydrothermal or multienzyme treatments of barley fibre did not improve its feed value for growing pigs. The overall results of these experiments indicate that the feed fractions, rich in protein have good potential as protein supplements in pig diets. The satisfactory feed conversion when barley fibre was used as an energy source was in line with the results of the digestibility trial.

Index words: Barley fractions, grain protein, digestibility, pig feeding

Introduction

A new integrated ethanol-starch process, developed by Alko Ltd., is replacing the traditional alcohol process technology in Finland (LEHMUSSAARI and HAM 1987). Barley is used as the main raw material in this process. The starch, which constitutes about half the grain raw material, is utilized in the manufacture of alcohol and starch leaving the remaining constituents of the grain to be used as animal feed (NÄSI 1988 a). In the integrated process the majority of the feed constituents are removed before alcohol manufacturing, thus avoiding many heating steps which impair feed quality. Barley distillers feeds from the traditional ethanol process have been found to have a relatively low nutritive value for pigs, due to their denatured protein and high fibre content (Näsi 1984 a, 1985). The integrated process also enables the fractionation of the barley feedstuffs into specific feed products which meet the needs of different animal species (Näsi 1988 a, Huhtanen et al. 1988, 1989, Ala-Seppälä et al. 1988).

With the present technology, four different feed fractions can be obtained: barley protein, fibre, molasses and distillers solubles. A description of the process and detailed characterisation of the barley feed fractions were presented by Näsi (1988 a). As the supply of barley by-products from the distillery and starch industry increases, more barley feed ingredients will be available for the animal feed industry and for delivery direct to pig producers. The objective of this study was to determine the nutritive value and utilization of barley feed fractions in pig production, especially their use as protein supplements.

Materials and methods

Feed evaluation and nitrogen balance

The evaluation of the barley fractions in pig feeding involved five digestibility and balance trials and one performance trial with growing pigs. The barley feed fractions for the present investigation were obtained from ALKO Ltd, from a pilot-scale starch ethnaol factory in Rajamäki. Details of the products and the process technology have been given by Näsi (1988 a).

The treatments in the digestion trials were as follows: Expt. 1. barley replaced by 200 or 400 g/kg of barley protein, Expt. 2. barley replaced by 200 or 400 g/kg of barley fibre, Expt. 3. barley replaced by 330 g dry matter (DM)/kg of barley molasses and diet compared with isonitrogenous barley-soybean meal (SBM) and barley-barley protein diets, Expt. 4. barley replaced by 250 or 500 g/kg of barley distillers solubles, Experiment 5. consisted of six treatments, the diets being isonitrogenous (160 g crude protein, CP/kg) or having equal lysine levels (7.6 g/kg) with supplements of barley protein and pure lysine or lysine added together with methionine and threonine. The control diet was barley-SBM (870 + 130 g/kg). In one of the treatments, normal barley meal was replaced with hydrothermally and enzymatically processed barley meal manufactured as presented by Inborr and Ogle (1988).

Expt. 1, 2 and 4 were made with four castrates (65—85 kg liveweight) with a switchover experimental design. Expt. 3. had a duplicate 3×3 Latin square design and Expt. 5 was designed as a 6×6 Latin square with pigs weighing 30—65 kg. Each period comprised 5 days of adjustment and 5 days of total collection of faeces and urine. The pigs were fed twice daily according to a restricted feeding regime and their diets were adequately fortified with minerals and vitamins (Salo et al. 1982). The details of the procedure are the same as described by Näsi (1984 b) and the chemical analyses were performed as presented by Näsi (1988 a). The digestibilities of the ingredients were calculated with a regression equation from the quantities of each feed consumed and the digestion coefficients of the diet (Schneider and Flatt 1976).

Performance trial

The pigs used in this trial numbered 144. There were six diets: the control diet and five diets formulated with the intention of achieving a similar concentrations of energy and digestible crude protein (DCP) and lysine. In two diets, one third and two thirds of the barley protein was replaced by barley protein. In three diets, 200 g/kg of barley fibre was substituted for the barley: in one of these diets the barley fibre was processed hydrothermally and in one it was treated hydrothermally and enzymatically (Porzyme, Finn Sugar Ltd.; Inborr et al. 1988). Pure lysine and methionine were added to adjust the amino acid levels in the rations. The composition of the feeds and their nutrient contents are given in Table 6. The pigs were assigned at random to the different feeds, the variations in starting weight between the groups being kept as small as possible. Four pigs were placed in each pen, the gilts and castrates being kept separate, and each diet was tested on three pens of gilts and three pens of castrates. The pigs were fed on a 180 g CP/kg pretest diet during 20 days. At 36 kg weight the pigs were transferred to the test diets containing 165 g CP/kg and were fed according the schedule of SALO et al. (1982). The pigs were weighed every two weeks and the feed consumption was determined for each pen. The individual pigs were slaughtered at an average weight of 100 kg, at which time the carcass weight was recorded and the carcass classified.

Results and discussion

Composition of the barley fractions

The chemical composition of the feed fractions from barley is presented in Table 1. The composition of the various ingredients was similar to that in the previous experiments (NÄSI 1988 a, ALA-SEPPÄLÄ et al. 1988 and HUHTANEN et al. 1988, 1989). The barley fractions mainly deviated from the raw material in their contents of protein and fibre. Barley protein, molasses and distillers solubles contain protein 300—380 g/kg DM, which is three times as high as in the barley grain. They also have a low fibre content, but twice as high fat content as the original material.

Barley fibre, obtained by sieving grain slurry, contains mainly barley kernel cell wall material. The hemicellulose content is high, but little lignified fibre remains. The product contains 150—170 g protein and 100—150 g/kg starch. The amino acid content of the barley feed fractions is almost the same as in the barley grain. The contents of lysine and sulphur containing amino acids is slightly higher in barley molasses than in the other feed fractions and lower in distillers solubles.

Digestibility and feed values

All the barley feed fractions seemed to be palatable to pigs even at the higher levels of inclusion. Barley fibre was an exception when its proportion of the total feed intake was high, 400 g/kg of the diet. The digestibilities of barley protein, molasses and distillers solubles were high, 0.83—0.90 for organic matter (OM) and 0.81—0.91 for CP, but the values for barley fibre were rather poor, 0.63 for

Table 1. Chemical composition of feed fractions from integrated starch-ethanol process and other experimental feeds used in the experiments.

Composition g/kg	Barley protein	Barley fibre	Barley molasses	Distill solubles	Barley meal	Soybean meal
Dry matter	958	959	324	948	875	857
Ash, in DM	38	37	183	165	30	62
Crude protein	375	166	298	333	133	508
Ether extract	59	65	47	67	34	16
Crude fibre	23	148	—	34	72	66
NFE	506	584	472	402	730	349
NDF	30	653	—	53	172	111
ADF	30	168	—	10	41	57
ADL	06	21	—	—	17	10
g/kg protein						
Lysine	32	34	44	24	35	59
Methionine	18	16	21	14	20	19
Cystine	22	27	28	17	27	15
Threonine	34	35	41	32	33	38
Available lysine	31	33	38	23	34	56

OM and 0.58 for CP (Table 2). Barley protein consists of storage protein of the grain endosperm and its starch content is usually 150—300 g/kg, but its cell wall content is very low and its constituents are thus highly digestible (NÄSI 1988 a). Correspondingly, KNAEBE et al. (1989) have shown high ileal (0.88) and faecal (0.92) protein digestibilities of corn gluten feed (590 g/kg CP and 20 g/kg CF), and the barley protein fraction (256 g/kg CP) obtained by finely grinding and air-classifying showed 0.75 apparent and 0.92 true protein digestibility (BELL et al. 1983).

Barley molasses and distillers solubles consist of the soluble cereal material. Evaporation was used to increase the dry matter content of these products and, in spite of their high contents of soluble protein and carbohydrates, the dehydration treatment did not reduce the nutrient digestibilities, as was the case with barley distillers grain with solubles (NÄSI 1984 a, 1985). Similarly, the values for grain distillery spent wash (296 g CP and 41 g/kg CF) in pigs were 0.87 for OM and 0.73 for CP (PEERS et al. 1978).

Since barley fibre is mainly composed of cell wall constituents, its digestibility in pigs is low, due to the limited capacity of their lower digestive tract. LONGLAND et al. (1988) and GRAHAM et al. (1986, 1988) have, however, shown that substantial quantities of non-starch polysaccharides (NSP) can be fermented in the small intestine of pigs. The nature of the NSP affects digestion; those of vegetable origin and β-glucans are highly fermentable, but the digestibility of, for example, wheat bran is rather low (FADEL et al. 1988, GRAHAM et al. 1988, LONGLAND et al. 1988). The endosperm cell walls of barley consist mostly of β-glucan and arabinoxylans (FINCHER 1975, ÅMAN et al. 1988). Dietary fibre (neutral detergent fibre, NDF) is most efficiently digested in pigs consuming grain-soybean meal diets containing up to 100—130 g/kg NDF, but in diets containing more than 150 g/kg NDF the digestibility of the additional fibre is minimal and NDF appears to depress the digestibility of other dietary energy components (CROMWELL and STAHLY 1986). This was also seen in the present diets at the barley fibre inclusion levels of 200 and 400 g/kg, when the NDF contents of the diets were 268 and 363 g/kg; the diet OM digestibilities were, respectively, 0.83 and 0.78, and the corresponding CP values were 0.82 and 0.77.

Multienzyme treatment (Diet 6) did not improve the digestibility of any of the diet nutrients ($P > 0.05$), compared with the unsupplemented diets 2, 3 and 4 in Expt. 5. Enzymatic processing did not increase the nutritive value of barley fibre in the growth trial either (Table 7). This agrees with the obser-

Table 2. Digestibility of nutrients and calculated feed values of barley fractions fed to growing pigs.

Barley fraction	Protein Expt. 1	Protein Expt. 5	Fibre	Molasses	Distill. solubles
Digestibility					
Org. matter	0.892	0.898	0.633	0.864	0.834
Crude protein	0.897	0.914	0.577	0.809	0.851
Ether extract	0.634	0.674	0.163	0.756	0.740
Crude fibre	0.192	0.245	0.498	—	0.355
NFE	0.928	0.941	0.741	0.946	0.876
Feed values					
FU/kg DM	1.13	1.16	0.80	1.01	0.95
kg/FU	0.92	0.92	1.30	3.06	1.11
DCP, g/kg	335	343	96	241	283
DCP g/FU	297	295	119	239	298
ME, MJ/kg DM	16.82	17.09	11.13	14.17	14.19
NE, MJ/kg DM	10.74	10.94	6.47	8.75	8.76
NE, FU/kg DM	1.39	1.42	0.84	1.13	1.13

vations of Inborr et al. (1988), who did not find differences in nutrient digestibilities between enzymatically treated barley and normal barley. Näsi (1988 a) showed that enzymatic processing increased the OM and CP digestibility of SBM but not in the case of rapeseed meal. Graham et al. (1988) concluded that supplementation with appropriate enzymes can lead to a partial degradation of endosperm cell walls in feeds, thus increasing the proportion of the diet digested in the small intestine.

Barley protein had a high energy value, 1.15 FU and 17.0 MJ ME / kg DM, owing to its low cell wall contents and high nutrient digestibilities. Barley molasses and distillers solubles had slightly lower values, 0.95—1.01 FU and 14.2 MJ ME / kg DM, due to their rather high ash content (16.5—18.3 % in DM). Barley fibre had a low FU value, 0.80 and 11.1 MJ ME / kg DM. Edwards et al. (1985) reported that maize gluten feed contained 11.7 MJ ME / kg. The digestible protein concentrations expressed per FU were high, 240—300 g, for barley protein, molasses and distillers solubles.

Protein utilization

Data on the nitrogen balance and protein utilization are presented in Tables 3—5. In Expt. 1—4, the protein contents of the diets varied and thus comparisons between treatments are difficult. A higher protein supply

Table 3. Nitrogen balance and protein utilization in pigs fed diets containing various barley fractions.

	Expt. 1		Expt. 2		Expt. 4	
Barley fraction	Barley protein		Barley fibre		Distill. solubles	
Level in diet, g/kg	200	400	200	400	250	500
N intake, g/d	61.6	84.6	54.2	45.3	62.4	85.0
N excreted in faeces	10.3	11.7	10.0	10.5	15.7	18.2
N absorbed	51.3	72.9	44.2	34.8	46.7	66.7
Apparent digestibil.	0.84	0.85	0.82	0.77	0.75	0.78
N excreted in urine	33.1	48.1	30.3	27.4	29.0	30.2
N retained, g/d	18.2	24.9	14.0	7.4	17.7	36.5
of intake	0.29	0.29	0.24	0.17	0.27	0.43
of absorption	0.35	0.34	0.30	0.22	0.37	0.54
g/kg $W^{0.75}$	0.62	0.85	0.53	0.29	0.88	1.78
Biological value	44.9	40.9	39.9	33.9	44.6	59.3

Table 4. Nitrogen balance and protein utilization in pigs fed diets containing various barley fractions, Experiment 3.

Supplement Level in diet, g DM/kg	Contr. SBM 120	Barley molass. 330	Barley protein 170	SEM	Level of signif
N intake, g/d	51.8	58.6	53.0	1.23	*
N excreted in faeces	8.6	10.4	7.4	15.7	*
N absorbed	43.3	48.2	45.7	46.7	NS
Apparent digestibil.	0.832	0.820	0.863	0.014	NS
N excreted in urine	20.5	20.0	21.6	1.09	NS
N retained, g/d	22.8	28.2	24.1	1.92	NS
of intake	0.44	0.48	0.45	0.027	NS
of absorption	0.53	0.58	0.52	0.026	NS
g/kg $W^{0.75}$	1.14	1.41	1.19	0.092	NS
Urea excretion, g/d	23.6	20.6	23.9	2.07	NS
g/kg $W^{0.75}$	1.20	1.03	1.22	0.106	NS
Biological value	59.9	64.4	58.9	5.37	NS

SEM = standard error of the means; significance: NS (non-significant), * P(<0.05), ** (P<0.01)

Table 5. Nitrogen balance and protein utilization in pigs fed diets with different contents of barley protein, Experiment 5.

Diet no	1	2	3	4	5	6	SEM	Level of signif.
Level in diet, g/kg	130	174	174	174	428	174		
Crude protein, g/kg	160	160	160	160	222	160		
Lysine, g/kg	7.6	5.8	7.6	7.6	7.6	7.6		
N intake, g/d	50.0	52.4	54.3	53.0	72.5	53.5	1.07	**
N excreted in faeces	10.2	9.7	10.2	10.7	10.0	10.0	0.44	NS
N absorbed	39.8	42.7	44.1	42.4	62.6	43.4	0.90	**
Apparent digestibil.	0.793	0.814	0.811	0.798	0.861	0.810	0.008	**
N excreted in urine	19.1	24.9	22.3	23.7	38.1	21.2	1.10	**
N retained, g/d	20.7	17.8	21.8	18.7	24.5	22.2	1.05	**
of intake	0.41	0.34	0.41	0.35	0.34	0.42	0.019	NS
of absorption	0.52	0.41	0.50	0.44	0.40	0.52	0.021	**
g/kg $W^{0.75}$	1.12	0.97	1.18	1.01	1.32	1.23	0.06	**
Urea excreted, g/d	44.5	62.1	48.2	50.0	88.2	52.6	4.20	**
g/kg $W^{0.75}$	2.3	3.4	2.5	2.7	4.8	2.9	0.25	**
Biological value	59.4	48.8	56.9	51.8	45.0	58.3	1.92	**
Daily gain, g/d	775	653	758	762	801	738	13.1	

SEM = standard error of the means; significance: NS (non-significant), * P(<0.05), ** (P<0.01)

Table 6. Components and composition of the experimental diets fed to growing pigs.

Diet no.	1	2	3	4	5	6
Supplement	CONT	BP1/3	BP2/3	BF 200	BF 200 Proc.	BF 200 Proc + Enz.
Ingredients, g/kg						
Barley	670	649	627	505	505	505
Oats	50	50	50	50	50	50
Molasses	20	20	20	20	20	20
Soybean meal	202	138	75	157	157	157
Barley protein	—	89	178	—	—	—
Barley fibre	—	—	—	200	200	200
Fat mixture	15	10	6	25	25	25
Dicalcium phosphate	22	22	18	22	22	22
Calcium carbonate	5	5	8	5	5	5
Sodium chloride	3	3	3	3	3	3
L-lysine	1.2	2.0	2.7	1.4	1.4	1.4
DL-methionine	0.4	0.4	0.6	0.4	0.4	0.4
Min. Vit. premix.	1.7	1.7	1.7	1.7	1.7	1.7
Serla Bondex	10	10	10	10	10	10
Calculated nutrients:						
Dry matter, g/kg	877	882	888	896	896	896
Dig. crude protein	141	142	143	135	135	135
NDF	150	143	135	234	234	234
FU/kg feed	0.98	0.98	0.98	0.96	0.96	0.96
Lysine, g/kg	9.4	9.4	9.3	8.9	8.9	8.9
Meth. + Cyst.	6.0	6.3	6.6	6.1	6.1	6.1
Ca	9.2	9.1	9.1	9.1	9.1	9.1
P	7.5	7.7	7.2	7.2	7.2	7.2
Analysed composition, g/kg DM						
Dry matter	863	872	871	886	878	889
Ash	65	61	59	63	59	59
Crude protein	185	189	187	188	188	192
Ether extract	42	39	40	55	55	53
Crude fibre	67	57	59	79	79	69
N F E	641	654	615	619	619	627

promoted nitrogen retention in Expt. 1 and 3. Barley molasses as protein supplement tended to give a higher nitrogen balance than the control barley-SBM (P>0.05). Barley molasses had a favourable amino acid composition compared with the other barley fractions. Lysine supplementation, to give the same level in the barley protein diet as in the control diet based on barley-SBM, gave a higher nitrogen balance than in the control (21.8 vs 20.7 g/d) and a significantly (P<0.01) higher balance than in the isonitrogenous barley protein — barley diet (Table 5). Further supplementation with methionine and threonine did not evoke any response. The barley protein — barley diet formulated to have the same lysine level as the control barley-SBM diet had a significantly (P<0.01) higher nitrogen balance than the control one. Urinary urea excretion also indicated fairly good protein utilization in Expt. 5, but, diet 6 deviated statistically significantly (P<0.01) from the others. The storage proteins of barley endosperm are mainly hordeins and glutelins, which are rich in proline and glutamic acid, but low in essential amino acids, such as lysine (BACH KNUDSEN 1982). The quality of barley protein can thus be improved by amino acid supplementation.

Table 7. Performance of pigs on diets supplemented with barley protein or barley fibre.

Diet no Supplement	1 CONT	2 BP1/3	3 BP2/3	SEM	Statistical significance of effect[1] Protein		Sex
No. of pigs in expt.	24	24	23				
Weight at start I, kg	23.1	23.1	23.0	0.38	NS		NS
Weight at start II, kg	36.2	36.3	35.6	0.58	NS		NS
Final liveweight, kg	104.5	105.0	106.4	1.29	NS		NS
Days on test I	20	20	20				
Days on test II	84.3	84.6	84.0	1.52	NS		*
Daily gain, g I	656	658	633	19.9	NS		NS
Daily gain, g II	817	818	848	20.8	NS		*
Daily gain, g	786	787	806	20.9	NS		NS
Feed intake, kg/d	2.18	2.24	2.22	0.026	NS		**
FU/gain, II	3.06	3.14	3.00	0.057	NS		NS
FU/gain	2.85	2.91	2.82	0.047	NS		NS
Dressing %	73.1	73.2	72.8	0.36	NS		**
Carcass points	3.91	3.46	3.43	0.147	*		***
Diet no Supplement, g/kg	**4 BF 200**	**5 BF 200 Proc.**	**6 BF 200 Proc+Enz.**	**SEM**	**Statistical significance of effect Fibre**	**Proc.**	**Sex**
No. of pigs in expt.	24	24	24				
Weight at start I, kg	23.1	23.1	23.1	0.35	NS	NS	NS
Weight at start II, kg	35.6	36.1	36.2	0.59	NS	NS	NS
Final liveweight, kg	105	102.2	104.2	1.16	NS	NS	NS
Days on test I	20	20	20				
Days on test II	83.7	80.8	81.8	1.54	NS	NS	*
Daily gain, g I	644	650	651	21.7	NS	NS	NS
Daily gain, g II	830	826	840	22.4	NS	NS	*
Daily gain, g	793	791	800	18.2	NS	NS	NS
Feed intake, kg/d	2.22	2.23	2.26	0.037	NS	NS	**
FU/gain, II	3.12	3.16	3.20	0.092	NS	NS	NS
FU/gain	2.91	2.95	2.96	0.077	NS	NS	NS
Dressing %	72.3	70.6	71.4	0.43	**	*	NS
Carcass points	3.46	3.88	3.83	0.147	*	*	**

[1] Linear effect of barley protein
SEM = standard error of the means; significance: NS (non-significant), * P(<0.05), ** (P<0.01)

The water-soluble proteins in barley molasses are higher in lysine and other amino acids (Briggs 1978).

Performance of pigs fed barley fractions

The average daily gain in the experiment was 0.79 kg and the feed conversion was 2.9 FU/kg gain. There were no statistically significant differences in performance between the control group and the animals given barley protein or barley replaced by barley fibre (Table 7). Gilts had a lower daily gain than castrates, 804 vs. 853 g/d ($P<0.05$). The dressing percentage was significantly ($P<0.01$) higher in gilts receiving barley protein than in the controls (73.8 vs 72.3), but lower in the pigs fed on barley fibre ($P<0.01$). The processing of the barley fibre decreased the dressing percentage still further ($P<0.05$). The differences probably indicate variability in the gut fill. The carcass quality assessed on side fat thickness (points 5—1) was significantly lower ($P<0.05$) in pigs fed on barley protein than in the control group, but significantly higher in the animals fed on barley fibre ($P<0.05$). Pigs fed on processed barley fibre also showed improved carcass quality ($P<0.05$). Correspondingly, Edwards et al. (1985) found that carcass backfat thickness was reduced with increasing maize gluten feed.

It appeared from these performance data that barley protein fortified with lysine could be substituted for a major proportion of the protein of SBM, over 0.50, in barley-soy bean pig diets, without an adverse effect on production. This is in agreement with the nitrogen balance experiments (Expt. 3 and 5). The present observations are in line with the results showing that a considerable saving of soybean meal was achieved with the use of high-protein barleys in diets for growing pigs (Thomke et al. 1978, Newman et al. 1978). Distillery spent wash at a level of 540 g/kg diet DM has given a similar performance in pigs to that obtained with an equal nutrient supply from a barley-soybean diet (Peers et al. 1978). A slightly poorer carcass quality in pigs fed barley protein may indicate some deficiency in the protein quality, although the lysine contents were the same. This is not, however, supported by the results of the nitrogen balance trial, in which supplementation with methionine and threonine gave no improvement. An explanation of the slightly greater side fat thickness could be that the energy value of barley protein is higher than that based on the digestible nutrients, since the feed conversion was equal.

An equivalent performance was achieved with the test animals when 200 g/kg of barley was replaced by barley fibre. This is in agreement with the results of Edwards et al. (1985), which showed that maize gluten feed at inclusion rates of up to 300 g/kg did not influence pig performance or carcass characteristics adversely. Similar results were obtained by Yen et al. (1971) when substituting corn gluten feed as an energy source. However, increasing levels of gluten feed also increased the levels of linoleic acid, which indicated that progressively softer fat would be produced (Edwards et al. 1985). Erickson et al. (1985) reported depressed gains and feed efficiency when pigs were fed diets in which maize was replaced with more than 200 g/kg wheat middlings, rather similar in composition to the present barley fibre.

Cromwell and Stahly (1986) reported that diets containing 100—200 g/kg dried distillers grains with solubles were utilized fairly efficiently by growing pigs, whereas diets containing 300 or 400 g/kg DDGS resulted in depressed feed efficiency. They concluded that dietary levels of NDF exceeding 150 g/kg had an adverse effect on the digestibility of fibre and other dietary components. In the present experiment, the diets with barley fibre had NDF 234 g/kg and the control diet 150 g/kg. The feed conversion in pigs on diets containing barley fibre was equal to that in the control group, which indicates that the energy value for barley fibre obtained in the digestion trial was valid. Hydrothermal or multienzyme treatments of barley fibre did not improve its feed value for growing pigs. The fibre polysaccharides of barley fibre are probably degraded during the manufacturing, so that no further improvement could be seen after the present treatments. Other feeding trials with pigs have shown only small and often insignificant increases in growth rate on addition of enzyme (Näsi 1988 b, Inborr and Ogle 1988).

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SELOSTUS

Integroidusta alkoholi-tärkkelystuotannosta saatavat ohrarehujakeet lihasikojen rehuna

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Tutkimuksessa selvitettiin yhdistetystä alkoholi- ja tärkkelystuotannosta saatavien ohrarehujakeiden rehuarvoa ja käyttömahdollisuuksia lihasikojen ruokinnassa. Tutkittavina rehuina olivat ohravalkuaisrehu (375 g/kg raakavalkuaista RV), ohrarehu (166 g/kg RV ja 653 g NDF), ohramelassi (298 g/kg RV) ja kuivattu ohratärkkelysrakki (333 g/kg RV).

Ohrarehujakeiden ravintoaineiden sulavuutta ja valkuaisen hyväksikäyttöä tutkittiin viidessä sikojen sulavuus- ja typpitasekokeessa. Ohravalkuaisen, -melassin ja -tärkkelysrankin sulavuudet olivat korkeita, orgaaninen aine (OA) 0.83—0.89 ja RV 0.81—0.91. Ohrarehu sitävastoin suli huonommin, OA 0.63 ja RV 0.57, korkeasta kuitupitoisuudesta johtuen. Ohravalkuaisrehun rehuyksikköarvoksi saatiin 1.15/kg KA sekä -melassin ja tärkkelysrankin vähän alemmat arvot johtuen niiden korkeahkosta tuhkapitoisuudesta (0.95—1.01). Ohrarehun energia-arvo oli edellisiä alempi, 0.80 RY/kg KA.

Ohravalkuainen täydennettynä puhtaalla lysiinillä vastasi typpitaseen perusteella ohrajauhodieetissä soijavalkuaistäydennystä. Metioniini ja treoniinitäydennys ei parantanut typen pidättymistä.

Lihasikojen tuotantokokeessa käytetystä soijavalkuaisesta korvattiin ohravalkuaisella 0.33 tai 0.67. Samoin ohrasta korvattiin 200 g/kg ohrarehulla tai prosessoidulla ohrarehulla. Rehuseosten aminohappotasot ja energiaväkevyys pidettiin samoina. Ohravalkuaisryhmät ja ohrarehuryhmät kasvoivat yhtä hyvin kuin vertailuryhmä (keskimäärin 795 g/d) ja rehunkäyttö lisäkasvukiloa kohti oli yhtä tehokasta (2.9 RY/kg lisäkasvua). Prosessointi ei parantanut ohrarehun rehuarvoa. Ohravalkuaista saaneilla ryhmillä sikojen teurasluokitus oli vähän heikompi kuin vertailuryhmällä.

Yhteenvetona tuloksista voidaan esittää, että ohrarehujakeet ovat sopivia käytettäväksi sikojen ruokinnassa. Ohravalkuaisella pystyttiin korvaamaan huomattava osa soijarouhetta kun rehuseosta täydennettiin puhtaalla lysiinillä. Ohrarehu vastasi tuotantotulosten perusteella sulavuuskokeessa saatua rehuarvoa.