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Conference paper

EFFECTS OF EXPANDING ON THE NUTRITIVE VALUE OF BARLEY AND WHEAT BRAN IN PIG DIETS

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Abstract

The apparent nutrient digestibily and protein utilization responses of growing pigs (from 31 to 70 kg) to expanded barley (B) and a wheat bran/wheat middlings - mixture (2:1) (WBM) were studied in two latin squares of 4×4 and 5×5. WBM and hammer milled B were expanded separately by adding 0.0, 3.0 and 6.0% (w/w) steam to the expander. WBM, which contained NDF-fibre 350 and crude protein (CP) 165 g/kg DM, was included in barley-soybean meal (B-SB) diets at three levels: 0, 200 and 400 g/kg. The diets were formulated to have the same CP content (163 g/kg). Both the effects of expanding and the WBM levels (200 vs. 400 g/kg) were measured in exp. 1. The effects of adding steam to the expander were measured in exp. 2. Expanding increased significantly the digestibility of crude fat (CF) (exp. 1. and 2) and decreased the digestibility of dry matter (DM) (exp. 2) and CP (exp. 1). The calculated digestibilities of DM, NDF-fibre, CF and CP in the WBM were 0.720, 0.440, 0.393 and 0.812 and in the expanded WBM 0.699, 0.447, 0.583 and 0.783 respectively. Expanding had no effect on the calculated energy value of WBM. Digestibility of the B-SB diet was superior to that of the B-WBM-SB diets. Expanding had no effect on nitrogen retention in exp. 1 but improved it from 22.5 to 24.2 g/d in exp. 2. Different steam additions during expanding had no effect on either digestibility or protein retention.

Introduction

Wheat bran and wheat middlings are palatable feedstuffs for pigs and they contain more crude protein (CP) and lysing than the whole kernel. Unfortunately, they are also very fibrous and thus their digestibility is low (Fevrier et al. 1992). At little as 100 g/kg of wheat bran has been detrimental to pig performance (Cromwell et al. 1992). Expander processing is thought to modify starch and degrade cell walls thus improving digestibility and

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faciliating a higher addition of fibrous ingredients into the diet without decreasing pig performance (Armstrong 1994). However, expanding (Fadel et al. 1988, Bolduan et al. 1993, Näsi and Partanen 1993) has not significantly improved faecal digestibility of organic matter and CP in previous experiments with growing pigs, but extruding a diet containing wheat middlings has improved the digestibility of gross energy and the feed conversion ration to the same level as steam pelleting in weanling pigs (Skoch et a. 1983). The aims of this study were to evaluate the effects of 1.) expanding barley and wheat bran-wheat middlings - mixture and 2.) the by-product level on faecal digestibility and nitrogen retention.

Table 1. - EXPERIMENTAL DIETS, G/KG AND EXPERIMENTAL ARRANGEMENTS

Experiment 1. The effects of expanding and the WBM level				
Diet	A	B	C	D
WBM	200	400	200	400
Barley	614	437	614	437
Soybean meal	156	135	156	135
Expand., 3% steam add.[a]	-	-	+	+

Experiment 2. The effects of different steam additions and the comparison between WBM substituted diets and barley-soybean diet (the control diet)					
Diet	Control	B	E	D	F
WBM	0	400	400	400	400
Barley	789	437	437	437	437
Soybean meal	177	135	135	135	135
Eypanding[a]	-	-	+	+	+
Steam addition, w/w	-	-	0%, expand. I	3%, expaned. II	6%, expand. III

[a] In expanded diets both barley and WBM were separately expanded with the same steam addition

Material and methods

The apparent nutrient digestibility and protein utilization responses of growing pigs to expanded barley and wheat bran/wheat middlings - mixture (WBM) were studied in two latin squares of 4×4 and 5×5. WBM was compounded by mixing wheat bran and wheat middlings 2:1 on weight basis. Hammer milled barley (2.5 mm sieve) and WBM were each divided into four batches, and three of the batches from each group were expanded separately by adding steam 0,3 and 6% w/w. The experimental diets were formulated to have the same (CP) content (163 g/kg). WBM was included in barley-soybean diets at levels of 0, 200 and 400 g/kg. The effects of expanding and wheat bran level (200 vs. 400 g/kg) were evaluated in experiment 1. The effects of different

steam additions during expanding were studied in experiment 2. WBM substituted diets (400 g/kg) were also compared to barley-soybean diet (control) in experiment 2 (see table 1).

Each experimental period comparised 5 days of adjustement and 5 days of total collection of faeces and urine. Analysis were performed according to AOAC (1984). CP was calculated as Kjejdahl N * 6.25. Ether extract (EE) was determined after hydrolysis in 4 N Hcl. NDF- and ADF-fibre were analysied acording to Robertson and van Soest (1981). Soluble and insoluble dietary fibre (SDF and IDF, respectively) were determined enzymatically (ASP et al. 1983). Total dietary fibre TDF) was calculated as the sum of SDF and IDF. The data were subjected to a least square analysis of variance and the degree of freedom for treatment effects were further partitioned into single degrees of freedom by orthogonal contrasts.

Table 2. - THE CHEMICAL COMPOSITION OF THE EXPERIMENTAL FEEDS, G/KG DM

	Unexpand barley 1	Expand barley 1	Expand barley 2	Expand barley 3	Unexpand WBM	Expand WBM 1	Expand WBM 2	Expand WBM 3	Soybean meal
Organic matter	973	973	973	967	950	948	949	948	938
Crude protein	130	136	132	137	157	166	167	170	476
Ether extract	34	35	33	42	44	56	57	58	56
NDF-fibre	195	205	209	208	327	358	358	369	104
ADF-fibre	41	41	39	47	83	92	91	95	59
Starch	511	531	545	521	333	278	272	266	23
Free sugars	16	14	11	12	46	59	55	59	123
TDF	214	220	232	217	346	408	378	412	222
SDF	47	50	62	43	33	50	33	43	65
IDF	167	170	170	174	313	358	345	369	157

TDF=total dietary fibre, SDF=soluble dietary fibre, IDF=insoluble dietary fibre

Results and discussion

Digestibility of diets

The gross chemical composition of barley remained the same despite different expanding treatments, but the analyzed starch content of WBM slightly decreased with a corresponding increase in total dietary fibre (table 2). Expanding has not had any effect on the gross chemical composition of barley (Näsi 1992) or wheat bran (Bolduan et al. 1993, Näsi and Partanen 1993). A harder processing method, extrusion, has increased SDF in the expance of IDF in wheat bran (Wang and Klopfenstein 1993), but it may also produce more Klason lignin (Fadel et al. 1988) and dietary fibre (Björk et al. 1984).

The expander processing increased the digestibility of EE and decreased the digestibility of crude carbohydrates (CHH = organic matter - CP and EE) thereby decreasing the digestibility of organic matter (OM) in both experiments, though non-significantly in experiment 1 ($p<0.11$) (tables 3 and 4). Expanding increased the analyzed TDF contend of WBM and diigestibility decreased with increasing fibre content. However, fibre formed during extruding has been completely degraded in the intestines of rat (Björk et al. 1984) and growing pig (Fadel et al. 1988). Also Näsi (1992) found that the expanding of barley (Fadel et al. 1988) and expanding of wheat bran (Bolduan et al. 1993, Näsi and Partanen 1993) has had no effect on faecal digestibility of dry matter or OM. Extruding of diet containing wheat middlings has also improved the feacal digestibility od DM, but only to the same level as pelleting (Skoch et al. 1983). Expanding did not improve digestibility of energy (tables 3 and 4), which is consistent with earlier results (van der Poel et al. 1989, Fadel et al. 1988 and Bolduan et al. 1993). The expander processing had no effect on the calculated (as regression in experiment 1) digestibilities of the nutrients in WBM, excluding EE which improved by 0.196 units (table 5). The EE content of WBM was low and therefore the calculated feed value of unprocessed and expanded WBM was the same. Digestibility of EE improved linearly with increasing steam addition, but the other component digestibilities remained at the same level (experiment 2). However, EE intake was higher (58 vs. 63 g/d) on expanded diets, which may have affected the results in these experiments.

Table 3. - THE EFFECT OF THE EXPANDER AND THE WBM LEVEL ON THE DIGESTIBILITY AND NITROGEN UTILIZATION OF DIETS (EXP. 1)

	Diet A[a]	Diet B	Diet C	Diet D	SEM[b]	C1	C2
Organic matter	0.822	0.801	0.813	0.792	0.0052	**	NS
Crude protein	0.826	0.815	0.804	0.792	0.0062	NS	*
Ether extract	0.475	0.463	0.504	0.537	0.0169	NS	*
Crude carbohydrates	0.840	0.816	0.833	0.806	0.0046	**	NS
NDF-fibre	0.517	0.492	0.515	0.495	0.0157	NS	NS
ADF-fibre	0.148	0.170	0.137	0.175	0.0246	NS	NS
GE digestibility	0.796	0.774	0.787	0.767	0.0057	*	NS
N retained, g/d	22.7	21.6	21.7	21.4	0.365	NS	NS
- of intake	0.496	0.495	0.489	0.483	0.0080	NS	NS
- of absorption	0.600	0.608	0.607	0.603	0.0079	NS	NS

[a] For diets, see table 1. [b] SEM = standard error of mean. Constrsts: C1 = the level of WBM; 200 g/kg vs. 400 g/kg, C2=unexpanded vs. expanded barley and WBM. Statistical significances: NS = non - significant, * = P < 0.05, ** = P < 0.01, *** = P < 0.001.

Table 4. - THE EFFECT OF PROCESSING CONDITONS ON THE UTILIZATION OF DIETS AND THE CONTROL DIET COMPARED TO THE WBM (400 G/KG) DIETS (EXP. 2)

	Control[a]	Diet B	Diet E	Diet D	Diet F	SEM[b]	C1	C2	C3
Organic matter	0.852	0.797	0.790	0.788	0.784	0.0042	***	o	NS
Crude protein	0.837	0.797	0.800	0.794	0.796	0.0074	***	NS	NS
Ether extract	0.521	0.473	0.541	0.549	0.572	0.0100	NS	***	*
Crude carbohydrates	0.873	0.816	0.804	0.802	0.796	0.0041	***	**	NS
NDF-fibre	0.533	0.493	0.506	0.506	0.508	0.0120	*	NS	NS
ADF-fibre	0.165	0.172	0.164	0.178	0.214	0.0263	NS	NS	NS
GE digestibility	0.830	0.770	0.766	0.764	0.761	0.0046	***	NS	NS
N retained, g/d	24.3	22.5	24.4	23.8	24.3	0.340	NS	**	NS
- of inake	0.522	0.489	0.511	0.505	0.507	0.0062	*	*	NS
- of absorption	0.624	0.613	0.640	0.637	0.638	0.0082	NS	*	NS

[a] For diets, see table 1. [b] SEM = standard error of mean. Constrasts: C1 = control vs. WBM diets, C2 = unexpanded vs. expanded barley and WBM, C3 = linear effect of steam addition. Statistical significances: NS = non - significant, o = P<0.01, * = P < 0.05, ** = P < 0.01, *** = P < 0.001.

Table 5. - THE DIGESTIBILITY COEFFICENTS OF (BARLEY + SOYBEAN + MINERALS), (EXPANDED BARLEY + SOYBEAN + MINERALS), WBM AND EXPANDED WBM (CALCULATED AS REGRESSION IN EXPERIMENT 1)

	Unexpand. barley + soy.	SE[a]	Expand. barley + soy.	SE	Unexpand. WBM	SE	Expand. WBM	SE
Dry matter	0.831	0.0081	0.827	0.0123	0.720	0.0180	0.699	0.0275
Crude protein	0.836	0.0207	0.827	0.0257	0.812	0.0578	0.783	0.0678
Ether extract	0.504	0.0319	0.495	0.0412	0.393	0.0594	0.589	0.0584
Crude carbohydrates	0.868	0.0063	0.868	0.0098	0.748	0.0129	0.714	0.0208
NDF-fibre	0.562	0.0349	0.560	0.0426	0.440	0.0398	0.447	0.0471
ADF-fibre	0.139	0.0307	0.136	0.0766	0.188	0.0348	0.178	0.0781
FU/kgDM[b]	-		-		0.94		0.94	

[a]SE = standard error, [b]FU = feed unit according to SALO et al. (1990)

Digestibility of the barley-soybean diet was superior to that of WBM substituted diets excluding the digestibility of EE, which was unfacted. Higher WBM content led to lower digestibility of OM and energy, which is consistent with the results of Chabeautiet al. (1991).

Nitrogen utilization

The expander processing decreased the digestibility of CP without any effect on protein retention in experiment 1 (table 3), but improved protein retention with no effect on digestibility of CP in experiment 2 (table 4). Nitrogen intake was higher on expanded diets than on unprocessed ones (46.0 vs. 47.5 g/d) in experiment 2, which may explain the improved nitrogen utilizatin. However, nitrogen retention did not improve linearly with increasing nitrogen intake. Nitrogen retention remained the same despite different steam additions. Thus, expanding neither improved nor impaired nitrogen utilization, though hot and dry processing conditions favour Maillard reaction. The expanding of barley (Näsi 1992) or of whean bran (Näsi and Partanen 1993) has had no effect on nitrogen retention in growing pigs in previous experiments either.

The increased WBM level from 200 to 400 g/kg had no effect on nitrogen digestibility of utilization, though a higher by-product level has decreased crude protein digestibility (Chabeauti et al. 1991, Näsi and Partanen 1993). Nitrogen digestibility, retention of intake and urea excretion were higher on barley-soybean diet than on WBM diets. The WBM level had no effect on the utilization of digested N in either experiment, which is consistent with the results of Näsi and Partanen (1993).

Conclusions

The expander processing did not improve apparent feacal digestibility of nutrients in barley or WBM, excluding digestibility of EE in WBM which was improved. However, expanding had no effect on the digestible energy of diets. Neither was the calculated feed value of WBM altered. Moreover, nitrogen utilization remained the same despite expanding and different steam additions during processing. Digestibilities of the barley-soybean diet were superior to those of WBM substituted diets. Also nitrogen retention of intake was higher on the barley-soybean diet, but the utilization of digested nitrogen remained unchanged.

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DJELOVANJE BUBRENJA (EXPANDING) NA HRANIDBENU VRIJEDNOST JEČMA I POSIJA PŠENICE U OBROCIMA SVINJA

Sažetak

Očito reagiranje svinja u rastu (od 31 do 71 kg) na probavljivost hranjivih tvari i iskorištavanje bjelančevina na nabubreni ječam (B) i smjesu pšenične posije / grubo mljevena pšenica (2:1) (WBM) proučavani su u dva latinska kvadrata od 4×4 i 5×5. WBM i batom tučen B bubreni su posebno, dodatkom 0.0, 3.0 i 6.0% (w/w) pare. WBM, što je sadržavao vlakno NDF 350 i sirove bjelančevine (CP) 165 g/kg DM, uključen je u obroke brašna, ječma i soje (B-SB) na tri razine: 0, 200 i 400 g/kg. Obroci su sastavljeni tako da imaju isti sadržaj CP (163 g/kg). Djelovanje bubrenja i razine WBM (200 nasuprot 400 g/kg) mjereno je u pokusu 1. Djelovanje dodatka pare mjereno je u pokusu 2.

Bubrenje je značajno povećalo probavljivost sirove masti (CF) (pokusi 1 i 2) i smanjilo probavljivost suhe tvari (DM) (pokus 2) i CP (pokus 1). Izračunata probavljivost DM, NDF tkiva, CF i CP u WBM iznosila je 0.720, 0.440, 0.393 i 0.812, a u nabubrenom WBM 0.699, 0.447, 0.583 i 0.783. Bubrenje nije djelovalo na izračunatu energetsku vrijednost WBM-a. Probavljivost B-SB obroka bila je bolja od obroka B-WBM-SB. Bubrenje nije djelovalo na retenciju dušika u pokusu 1 ali ju je poboljšalo od 22.5 do 24.2 g/d u pokusu 2. Različito dodavanje pare za vrijeme bubrenja nije djelovalo niti na probavljivost niti na retenciju bjelančevina.

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