Evaluation of Protein and Energy Values of OAC Wintri Triticale Using Cannulated Pigs

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Protein and energy digestibilities in two samples of OAC Wintri triticale (triticale B and triticale C) were determined with pigs fitted with ileal cannulae and compared with corn. Apparent total tract dry matter digestibilities of corn and triticale C were similar and higher ($P < 0.05$) than that of triticale B. Apparent gross energy digestibility was higher ($P < 0.05$) for triticale C than for corn or triticale B. Digestibilities determined at the end of the ileum of dry matter, nitrogen, and gross energy were lower ($P < 0.01$) than the respective total tract digestibilities for the three grains. True ileal available protein for corn, triticale B, and triticale C were 8.86, 8.46, and 9.77 g/100 g of dry matter, respectively. Digestible energy values determined for corn, triticale B, and triticale C were 4.04, 3.87, and 4.13 kcal/g, respectively, while metabolizable energy corrected for nitrogen retention for the respective grains were 3.83, 3.74, and 3.85 kcal/g.

OAC Wintri triticale is a high-yielding and winter-hardy variety of triticale with good resistance to mildew, leaf rust, and septoria (Poysa et al., 1981). This variety was developed at the University of Guelph and is the first winter hexaploid triticale (×*Triticosecale* Wittmack) licensed for sale in Canada. Earlier studies in this laboratory (Adeola et al., 1986) indicated that the protein and energy digestibilities differ between two OAC Wintri samples harvested in different years and vary widely in protein content.

In view of the limited information available on the nutritive value of OAC Wintri triticale and the move to express nutrient requirements of pigs on the basis of available nutrients, this experiment was conducted to compare the protein quality and energy values of two samples of OAC Wintri triticale and corn.

MATERIALS AND METHODS

The two samples of OAC triticale (triticale B and triticale C) were harvested in 1984 and 1985, respectively. Both the corn and triticale samples were hammer-milled (4.8-mm screen), incorporated into diets containing 0.3% chromic oxide, and pelleted (Table I). Digestibility studies were undertaken using six Yorkshire-Landrace crossbred barrows surgically fitted with simple T-cannulae (3-mm wall thickness, 10-mm internal diameter, and 65-mm barrel length) that were located about 8 cm cranial to the ileocecal junction and exteriorized at the right flank.

The experiment was conducted as 3 × 3 Latin square in a crossover design with three experimental diets (Table I) and three periods. Each of the three experimental periods comprised 5 days of adjustment to diet followed by 4 days of total, but separate, collection of feces and urine and 1 day of ileal digesta collection. The pigs averaged approximately 30 kg at the start of the trial and were offered 1 kg of diet/day in two equal amounts.

Feeding and management of experimental animals postsurgey and during the balance trial; urine, fecal, and ileal digesta collections; and preservation and preparation of samples for chemical analyses were identical with the procedures outlined by Adeola et al. (1986).

After ileal digesta were collected for the third experimental period, the barrows were fed a nitrogen-free diet (Table I), and the collection procedure was repeated to determine metabolic fecal and ileal nitrogen loss for the estimation of true digestibility values for proteins.

Table I. Composition of Diets

ingredient	corn	triticale B	triticale C	N-free
corn	96.15			
triticale B[a]		96.15		
triticale C[b]			96.15	
salt[c]	0.50	0.50	0.50	0.50
limestone (38% Ca)	1.20	1.20	1.20	0.60
calcium phosphate (18.5% Ca, 20.5% P)	1.20	1.20	1.20	2.50
vitamin premix[d]	0.50	0.50	0.50	0.50
trace mineral premix[e]	0.10	0.10	0.10	0.10
Se–vitamin E premix (200 mg Se; 1100 IU vitamin E/kg)	0.05	0.05	0.05	0.05
corn oil				3.00
α-floc				5.00
dextrose				30.00
corn starch				57.25
chromic oxide	0.30	0.30	0.30	0.30
total	100.00	100.00	100.00	100.00

[a] OAC Wintri triticale harvested in 1984: analytical dry matter, 86.21%; protein (dry-matter basis), 10.02%. [b] OAC Wintri triticale harvested in 1985: analytical dry matter, 87.79%; protein (dry-matter basis), 11.16%. [c] Cobalt-iodized salt with 40 mg/kg Co, 70 mg/kg I, and 99% NaCl. [d] Vitamin premix provided the following per kilogram of diet: 3300 IU vitamin A; 700 IU vitamin D3; 15 IU vitamin E; 2 mg of menadione sodium bisulfate; 4 mg of riboflavin; 20 mg of niacin; 10 mg of calcium *d*-panthothenate; 20 μg of vitamin B_{12}; 100 mg of choline chloride. [e] Trace mineral premix provided the following per kilogram diet: 60 mg of Mn; 70 mg of Fe; 10 mg of Cu; 100 mg of Zn.

The proximate composition of feeds and nitrogen contents of feces, urine, and ileal digesta were determined according to standard procedures outlined by the AOAC (1980). The gross energy values of feeds, feces, urine, and ileal digesta were determined by adiabatic bomb calorimetry (Parr, 1982). Feeds, feces, and ileal digesta were also analyzed for chromic oxide content (Fenton and Fenton, 1979). Digestibilities were calculated by the same procedures as Adeola et al. (1986).

The data for each response criterion were analyzed as a crossover 3 × 3 Latin square using the General Linear Models procedure of SAS (1985). Newman-Keul's multiple-range test were used to identify differences among treatment means.

RESULTS AND DISCUSSION

The diet containing triticale C had the highest crude protein (12.79%) and ash (5.34%) (Table II). This protein value is intermediate among the three OAC Wintri samples

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0021-8561/88/1436-1233$01.50/0

Table II. Proximate Composition of Diet (Dry-Matter Basis)[a]

item	diet			
	corn	triticale B	triticale C	N-free
dry matter, %	88.49	90.13	89.88	94.23
crude protein, %	10.62	11.43	12.79	0.74
ether extract, %	3.48	2.27	1.87	2.84
crude fiber, %	3.28	3.55	3.39	3.75
NDF, %	17.02	16.83	14.57	6.19
ADF, %	3.88	4.71	4.10	5.69
ash, %	4.07	4.99	5.34	3.08
calcium, %	0.67	0.73	0.80	0.66
phosphorus, %	0.60	0.70	0.81	0.29
gross energy, kcal/g	4.53	4.36	4.42	4.00

[a] Mean of duplicate analysis.

Table III. Comparative Apparent Total Tract and Terminal Ileum Digestibilities of Dry-Matter Nitrogen and Gross Energy in Corn and Triticale Samples Using Chromic Oxide as Digestibility Index[a]

item	diet			
	corn	triticale B	triticale C	EMS[b]
dry matter				
total tract	89.47^d	86.93^e	90.66^d	0.92*
terminal ileum	83.56^d	74.65^e	77.74^e	7.35**
difference[c]	5.91^e	12.28^d	12.91^d	9.24*
nitrogen				
total tract	81.20	79.52	84.24	6.10^{NS}
terminal ileum	75.75	67.37	69.58	30.72^{NS}
difference[c]	5.44	12.14	14.66	38.27^{NS}
gross energy				
total tract	89.27^e	86.75^f	89.90^d	0.72*
terminal ileum	82.69^d	73.57^e	80.16^d	12.63*
difference	6.57	13.18	9.73	13.85 ($P < 0.10$)

[a] Least-squares means of six observations for triticale C and five observations each for corn and triticale B (see Table IV). [d-f] Means on the same line with different superscripts differ ($P < 0.05$). Key: *, $P < 0.05$; **, $P < 0.01$. NS = not significant ($P > 0.05$). [b] Error mean squares. [c] Total tract digestibility minus terminal ileal digestibility.

Table IV. Nitrogen Balance Values of Corn and Triticale Samples for Pigs[a]

item	diet			
	corn	triticale B	triticale C	EMS[b]
daily N intake, g	12.24^f	14.51^d	13.93^e	0.004**
app N digestibility, %				
total tract	81.20	79.52	84.24	6.101^{NS}
terminal ileum	75.75	67.37	69.58	30.719^{NS}
true N digestibility, %				
total tract	90.02	87.13	92.10	6.101^{NS}
terminal ileum	83.46	74.02	76.44	30.715^{NS}
daily absorbed N, g	9.31^e	11.26	11.74^d	0.054**
daily N retained, g	3.93	5.03	5.76	0.760^{NS}
net protein utilization, %				
total tract	32.55	33.98	43.84	49.732^{NS}
terminal ileum	32.55	33.98	43.84	49.732^{NS}
biological value, %				
total tract	40.52	44.15	49.12	59.327^{NS}
terminal ileum	42.90	61.54	63.20	42.962
number of pigs[d]	5	5	6	($P < 0.09$)

[a] Analyzed with dry-matter intake as a covariate. [d-f] Means in the same line with different superscripts differ ($P < 0.05$). Key: *, $P < 0.05$; **, $P < 0.01$. NS = not significant ($P > 0.05$). [b] Error mean square. [c] Calculated as described by Adeola et al. (1986). [d] One pig each from the groups fed corn and triticale B were removed from trial in period 3 because of displaced cannulae.

evaluated in our laboratory. The protein contents of the three samples harvested in 1982, 1984 (Adeola et al., 1986), and 1985 ranged between 10.02 and 15.48% on a dry-matter basis. Wide variations in protein content and amino acid profiles of different varieties of triticale have been reported (Radcliffe et al., 1983). However, wide variation in nutrient composition of the same variety may be associated in part to soil fertility, agronomic practice, and the year they were harvested.

Results of the apparent dry-matter, nitrogen and energy digestibilities (Table III) indicate that total tract (TT) matter digestibility of corn and triticale C were similar and higher ($P < 0.05$) than that of triticale B. Although a similar trend was observed in TT nitrogen digestibility, the values for corn and the two triticale samples were not different ($P > 0.05$). TT gross energy digestibility was higher ($P < 0.05$) for triticale C than corn or triticale B, while triticale B had a lower gross energy digestibility than corn. That triticale B has lower digestibilities of major nutrients when compared to corn is consistent with an earlier report from our laboratory (Adeola et al., 1986).

Digestibility measured at the end of the ileum (ileal digestibility) for dry matter, nitrogen, and gross energy of the three grains followed a trend similar to TT digestibility values. However, ileal digestibilities of dry matter, nitrogen, and gross energy were lower ($P < 0.05$) than the respective TT digestibilities for all the grains. Consistent observations of a net disappearance of nutrients in the hindgut had been reported (Holmes et al., 1974; Owsley et al., 1981; Taverner et al., 1981; Adeola et al., 1986) due to flora or microbial degradation of amino acids into ammonia or amines that are absorbed and excreted in urine (Sauer et al., 1977; Just et al., 1981).

The difference between the TT and ileal digestibilities represents the net disappearance of nutrients in the hindgut. Greater ($P < 0.05$) net disappearance of nitrogen and energy were observed in pigs fed the triticale samples, indicating greater overestimation of the amount of energy and protein absorbed from the samples. Ileal digestibilities of the nutrients also indicate that the corn had nonsignificant higher ileal nitrogen digestibility than triticale C (75.75 vs 69.58) in contrast to the higher TT nitrogen digestibility observed in the latter. The increased sensitivity of ileal digestibility in evaluating protein digestibility in pigs had been reported (Taverner et al., 1981; Adeola et al., 1986).

True TT and ileal nitrogen digestibilities (Table IV) gave trends similar to apparent digestibility values. While the apparent TT-digestible protein values for corn, triticale B, and triticale C were 8.62, 9.09, and 10.77 g/100 g of dry matter, respectively, the corresponding apparent available protein values at the ileum were 8.04, 7.70, and 8.87 g/100 g of dry matter, representing overestimation of digestible protein by 0.58, 1.39, and 1.99 g/100 g of dry matter of corn, triticale B, and triticale C, respectively, when TT digestibility was used as an index. The corresponding true TT-digestible protein values were 9.56, 9.95, and 11.77 g/100 g of dry matter of corn, triticale B, and triticale C, respectively, while the true ileal available protein values for the three samples were 8.86, 8.46, and 9.77 g/100 g of dry matter.

The digestibility values obtained for triticale B in this study compared favorably with the results of an earlier study (Adeola et al., 1986) while TT nitrogen digestibility for triticale C was similar to that for triticale of the winter cultivar Grace (84.24 vs 84) reported by Hanrahan (1986).

Daily absorption of nitrogen (Table IV) was similar in triticales B and C and higher ($P < 0.05$) in the two samples than corn. Although nitrogen retention and other protein quality indices, viz. net protein utilization and biological value, were not statistically different among grains, triticale samples B and C tended to exhibit higher TT and ileal net protein utilization and biological values than corn (Table

Table V. Comparative Energy Values of Corn and Triticale Samples for Pigs[a]

item	diet corn	triticale B	triticale C	EMS[b]
daily gross energy intake, kcal	3357.50	3277.09	3318.11	1983.03 ($P < 0.11$)
energy digestibility, %	89.27[e]	86.75[f]	89.90[d]	3.58*
daily absorbed energy, kcal	2986.37	2814.74	2984.43	503.02 ($P < 0.06$)
digestible energy, kcal/g	4.04[f]	3.87[e]	4.13[d]	0.001**
metabolizable energy, % of gross energy (GE)	85.69	85.19	84.52	7.72[NS]
metabolizable energy, kcal/g	3.90[d]	3.72[e]	3.94[d]	0.004*
corrected metabolizable energy, kcal/g	3.83	3.74	3.85	0.019[NS]
corrected metabolizable energy, % of GE	84.74	83.79	83.86	9.50[NS]
number of pigs[d]	5	5	6	

[a] Analyzed with dry-matter intake as a covariate. [d-f] Means on the same line with different superscripts differ ($P < 0.05$). Key: *, $P < 0.05$; **, $P < 0.01$. NS = not significant. [b] Error mean square. [c] Metabolizable energy corrected for nitrogen (Diggs et al., 1965). [d] As in Table IV.

IV). Rao et al. (1980) reported that the net protein utilization and biological value of triticale were superior to corn when rats were used to assay the grains. The values of the protein quality indices reported in the present study for corn and the two samples of triticale compare favorably with the results of a previous study (Adeola et al., 1986). The logistics of calculating the net utilization of nitrogen absorbed in the small intestine has been described (Adeola et al., 1986). All the nitrogen absorbed in the hindgut was assumed to be excreted by the kidney. TT net protein utilization values in the present study were similar to ileal net protein utilization values (Table IV), which did not support data presented by Adeola et al. (1986).

Daily absorption of energy was not different ($P > 0.05$) among the grains (Table V). The digestible energy values of the three grains were different ($P < 0.05$) and were greater ($P < 0.05$) for triticale C than corn while triticale B had a lower ($P < 0.01$) digestible energy. Metabolizable energy values of triticale C and corn were similar and greater ($P < 0.05$) than those of triticale B. Metabolizable energy values corrected for nitrogen retention were not different ($P > 0.05$) between grains. The uncorrected metabolizable energy values averaged 96.53, 96.12, and 95.39% of the digestible energy for corn, triticale B, and triticale C, respectively, while the metabolizable energy values corrected for nitrogen retention were 94.80, 96.64, and 93.20% of digestible energy for corn, triticale B, and triticale C, respectively. A comparison of the energy values for the two OAC Wintri triticale samples for pigs reported here with those published by Erickson et al. (1978) and by Adeola et al. (1986) on some winter varieties of triticale reveals that the values obtained in the present study are slightly higher. The ME values of these grains were determined with each grain as the only source of protein and energy and may not represent the true values when fed in a balanced diet.

On the basis of these and previous reports from this laboratory, OAC Wintri triticale can be a good alternative to corn as a source of protein and energy in pig diets.

Registry No. Nitrogen, 7727-37-9.

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Received for review February 17, 1987. Accepted April 13, 1988. The study was supported by the Ontario Ministry of Agriculture and Food and the Ontario Pork Producers' Marketing Board.