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The nutritive value of hulled and hulless barley for growing pigs. 1. Determination of energy and protein digestibility with the *in vivo* and *in vitro* method*

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ABSTRACT

An experiment was conducted to determine the digestibility of energy and crude protein (CP) in hulled and hulless barley with the *in vivo* and *in vitro* method. Six barrows were fed six diets according to a 6 × 6 Latin square design. The six diets included 950 g kg^{-1} of four barleys and two mixtures. Diet A: hulled barley, c.v. Harrington I. Diet B: hulled barley, c.v. Harrington II. The origin of c.v. Harrington in diet B was different from that in diet A, and therefore referred to as c.v. Harrington II. Diet C: hulless barley, c.v. CDC Buck. Diet D: hulless barley, c.v. CDC Richard. Diet E: mixture of c.v. Harrington I and c.v. CDC Buck (50:50, wt/wt). Diet F: mixture of c.v. Harrington II and c.v. CDC Richard (50:50, wt/wt). The mixtures were created in order to establish linear regression equations between *in vivo* and *in vitro* methods. Chromic oxide was used as the digestibility marker. The barrows were fed twice daily, at 08.00 and 20.00 h. Each experimental period consisted of an 8-d adaptation period followed by a 2-d collection period of faeces. The initial and final average body weights of the barrows were 40 and 90 kg, respectively. The *in vivo* energy digestibilities were higher ($P < 0.05$) in the hulless (81.4 to 84.7%) than in the hulled barleys (76.9 to 77.6%). The digestible energy contents in the hulless barleys ranged from 14.01 to 14.60 MJ kg^{-1} while the contents in the hulled barleys ranged from 13.05 to 13.16 MJ kg^{-1} (as-fed). The average digestible CP contents in the hulled and hulless barleys were nearly similar and were 88.0 and 89.7 g kg^{-1} (as-fed), respectively. The *in vivo* energy and CP digestibilities in the barleys and their mixtures can be accurately predicted by *in vitro* values, as these were very high correlations between these methods for energy ($r^2 = 0.93$) and CP ($r^2 = 0.87$).

KEY WORDS: pigs, digestibility, energy, crude protein, barley

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INTRODUCTION

Today barley ranks fourth after wheat, rice and maize in world cereal production (FAO, 2000). In Canada, barley production ranks second after wheat. It is grown mainly in the prairie provinces of Alberta, Saskatchewan and Manitoba. Barley is usually included in diets for growing and finishing pigs in western Canada. Recent advances in barley breeding have led to the development of hulless barley varieties. Hulless barley varieties have a higher digestible energy and usually a higher crude protein (CP) and amino acid (AA) content than hulled barley. The development of hulless barley varieties will likely result in increased usage in diets for young pigs.

Many factors, including variety, fertilizer application and environmental conditions influence the nutritive value of barley (e.g., Sauer and Ozimek, 1986). Consequently, it is not always appropriate to assign specific values to digestible energy and CP values in barley, as published for example in the NRC (1998).

The feed industry, but also plant breeders would benefit greatly from an *in vitro* method that is rapid and inexpensive and that can accurately predict the *in vivo* digestible energy and CP content in different samples of barley, including hulless barley.

The objectives of these studies were: 1. to determine the energy and CP digestibility values in hulled and hulless barley with the *in vivo* and *in vitro* method, and 2. to establish regression equations to predict the *in vivo* energy and CP digestibility values from the *in vitro* method.

MATERIAL AND METODS

Animals and diets

Eight barrows (Camborough × Canabrid), average initial body weight (BW) 40 kg, were obtained from the Swine Research Unit of the University of Alberta and housed individually in stainless steel metabolism crates in a temperature-controlled barn (22 ± 1°C). Four days later, the barrows were fitted with a simple T-cannula at the proximal duodenum according to procedures described by Sauer et al. (1983). The cannulas were modified according to De Lange et al. (1989). A detailed description of pre- and post-operative care was previously presented by Li et al. (1994). During the 4-d adaptation period to the crates and the 14-d recuperation period, the pigs were given a 160 g CP kg^{-1} grower diet (Sauer et al., 1983). Water was freely available from a low-pressure drinking nipple. At the conclusion of the experiment, the barrows, average BW 90 kg, were sacrificed and dissected to determine whether cannulation had caused intestinal adhesions or other abnormalities.

Based on feed intake and BW, six barrows were selected and fed six experimental diets according to a 6 × 6 Latin square design. The pigs were fed twice daily, equal amounts each meal, at 08.00 and 20.00 h. During the first experimental period, the daily dietary allowance was provided at a rate of 5% (wt/wt) of the average BW determined at the initiation of the experiment. Thereafter, the daily allowance was increased by 100 g at each successive experimental period.

The six experimental diets (Table 1) contained 950 g barley kg^{-1}. Diet A: hulled barley, c.v. Harrington I. Diet B: hulled barley, c.v. Harrington II. The origin of c.v. Harrington in diet B was different from that in diet A, and therefore referred to as c.v. Harrington II. Diet C: hulless barley, c.v. CDC Buck. Diet D: hulless barley, c.v. CDC Richard. Diet E: mixture of c.v. Harrington I and c.v. CDC Buck (50:50, wt/wt). Diet F: mixture of c.v. Harrington II and c.v. CDC Richard (50: 50, wt/wt). The aforementioned barleys are grown commercially. The mixtures of hulled and hulless barley were created in order to establish regression equations between *in vivo* and *in vitro* measurements. Canola oil was included in all diets at a level of 30 g kg^{-1} to reduce the dustiness of the diets. Vitamins and minerals were supplemented to meet or exceed NRC (1998) standards. Chromic oxide (2.5 g kg^{-1}) was included in the diet as the digestibility marker. Prior to incorporation into the diets, barley was finely ground through a 2 mm mesh screen.

TABLE 1

Formulation of the experimental diets, g kg^{-1}as-fed basis

Ingredients	Diets					
	A	B	C	D	E	F
Hulled barley (Harrington I)	947.8	-	-	-	474.3	-
Hulled barley (Harrington II)	-	947.8	-	-	-	474.3
Hulless barley (CDC Buck)	-	-	947.8	-	474.3	-
Hulless barley (CDC Richard)	-	-	-	947.8	-	474.3
Canola oil	30.0	30.0	30.0	30.0	30.0	30.0
Biophos [1]	5.2	5.2	2.7	2.7	3.1	3.1
Calcium carbonate	9.2	9.2	11.7	11.7	10.4	10.4
Trace-mineralized salt [2]	3.0	3.0	3.0	3.0	3.0	3.0
Choline chloride [3]	0.3	0.3	0.3	0.3	0.3	0.3
Vitamin-mineral Premix [4]	2.0	2.0	2.0	2.0	2.0	2.0
Chromic oxide	2.5	2.5	2.5	2.5	2.5	2.5

[1] contained P 180 g kg^{-1} and Ca 240 g kg^{-1}; supplied by Continental Lime Ltd., Exshaw, AB

[2] provided the following (g kg^{-1} diet): NaCl, 2.9 g; ZnO, 12.0 mg; $FeCO_3$, 4.8 mg; MnO, 3.6 mg; CuO, 1.0 mg; $Ca(IO_3)_2$, 0.2 mg; CaO, 0.1 mg. Supplied by Windsor Salt Co., Toronto, ON

[3] contained 600 g kg^{-1} choline chloride. Supplied by Champion Feed Service Ltd., Westlock, AB

[4] provided the following (g kg^{-1} diet): vit. A, 10,000 IU; vit. D_3, 1,000 IU; vit. E, 80 IU; vit. K_3, 2.0 mg; vit. B_{12}, 0.03 mg; riboflavin, 12 mg; niacin, 40 mg; d-pantothenic acid, 25 mg; d-biotin, 0.25 mg; folic acid, 1.6 mg; thiamine, 3.0 mg; ethoxyquin, 5.0 mg; pyridoxine, 2.25 mg; Fe, 150 mg; Zn, 150 mg; Cu, 125 mg; I, .21 mg; Se, 0.3 mg. Supplied by Champion Feed Service Ltd., Westlock, AB

Each experimental period consisted of an 8 d adaptation period followed by a 2 d collection of faeces. Faeces were collected at 08.00, 14.00 and 20.00 h. Thereafter, faeces were immediately frozen at -20°C, then freeze-dried and ground through a 1-mm mesh screen. Faeces were pooled within pig and period before analyses.

As mentioned previously, the barrows were fitted with a simple T-cannula in the duodenum for the purpose of studies with the mobile nylon bag techniques. The results of these studies, in which many new lines of hulless barley were evaluated, will be presented in a later communication. It is generally accepted that the placement of a simple T-cannula in the small intestine of the pig does not affect the measurement of the digestibility values of energy and CP.

The animals used in this experiment were cared for in accordance with the guidelines established by the CCAC (1993) and approved by the Faculty of Agriculture, Forestry and Home Economics Animal Care Committee of the University of Alberta.

In vitro studies

The dry matter (DM), energy and CP digestibility values of the same sources of barley and mixtures used in the *in vivo* studies were determined according to the method described by Boisen (1991), but modified as follows: one gram of barley (or mixture), finely ground through a 1.0 mm mesh screen, was weighed into a 125 mL conical flask that contained 25 mL phosphate buffer (0.1 M, pH 6.0) and 10 mL 0.2 M HCl solution. The pH was adjusted to 2 with 1 M HCl or 1 M NaOH solutions. Following, 1 mL freshly prepared pepsin (10 mg/mL, Fisher ChemAlert, Fair Lawn, NJ) and 0.5 mL chloramphenicol solutions (0.5 g/100 mL ethanol) were added. The flasks were closed with a rubber stopper and incubated in an Environ-Shaker (Lab-line Instruments, Inc., Melrose Park, Ill) at an oscillatory rate of 120 at 39°C for 6 h. Thereafter, 10 mL phosphate buffer (0.2 M, pH 6.8) and 5 mL 0.6 M NaOH solution were added and pH adjusted to 6.8 with 1 M HCl or 1 M NaOH solutions. The contents of the flask were mixed with 3 mL freshly prepared pancreatin solution (50 mg/mL, Sigma chemical, St. Louis, MO) and incubated in the Environ-Shaker at an oscillatory rate of 120 at 39°C for 18 h. To simulate fermentation by the microflora in the large intestine, 20 mL of a freshly prepared cellulase solution (3 units/mL, Trichoderma Viride, Sigma-C9422) was mixed with the contents in the flask and incubated in the Environ-Shaker at an oscillatory rate of 120 at 40°C for 24 h. Then, 5 mL of 20% sulphosalicylic acid solution was added to precipitate the soluble protein for 30 min. After incubation the precipitate was separated from the solution by filtration using pre-weighed glass filter crucibles (diameter 3 cm; pore size 40 - 90 μm). Any precipitate remaining was rinsed with 1% sulphosalicylic acid and filtered. The precipitate was

then dried at 80º C for 18 h. The weight of the residue was determined by difference. The DM, energy and CP contents in the residues were determined.

Chemical analyses

Samples of dietary ingredients, diets, faeces, and residues remaining after *in vitro* incubation were ground through a 0.5 mm mesh screen before analyses. Analyses for DM, crude fat and ash were carried out according to AOAC (1990). Gross energy and CP was determined using a Leco AC-300 Automatic Calorimeter and a Leco FP-428 Nitrogen Analyzer (Leco Corporation, St. Joseph, MT), respectively. The chromic oxide contents in diets and faeces were measured according to Fenton and Fenton (1979). Neutral detergent fibre, acid detergent fibre and lignin were analysed according to principles outlined by Goering and van Soest (1970). β-glucans in the barleys and their mixtures were analysed according to principles outlined by McCleary and Glennie-Holmes (1985) by aid of a Megazyme kit (Megazyme, Bray Business Park, Bray, Co. Wicklow, Ireland). The sources of barley and mixtures were finely ground through a 0.5 mm mesh screen and approximately 0.5 g was weighed into polypropylene tubes. One mL of aqueous ethanol solution (50% vol/vol) was added to each tube to aid the subsequent dispersion of the sample. Then, 5 mL of sodium phosphate buffer (20 mM, pH 6.5) was added and the tubes were stirred on a vortex mixer. The tubes were incubated in a boiling water bath for approximately 2 min and then stirred again. After heating the tubes for a further 3 min in the boiling water bath and then cooling to 40°C, 0.2 mL of lichenase solution was added into each tube and incubated at 40°C for 1 h after capping and stirring the tubes. The contents in each tube were made up to 30 mL of volume with distilled water, mixed thoroughly and centrifuged at approximately 1,000 × g for 10 min. Three samples, 0.1 mL each, were obtained from the supernatant of each tube and carefully transferred to three test tubes. To one of the three test tubes, 0.1 mL of acetate buffer (50 mM, pH 4.0) was added. To the other two test tubes, 0.1 mL β-glucanase in 50 mM acetate buffer (pH 4.0) was added. All test tubes were incubated for 15 min at 40°C. After adding 3.0 mL of glucose oxidase/peroxide reagent, the test tubes were incubated for 20 min at 40°C again. The absorbance of the solution of each sample after incubation was measured at the wavelength of 510 nm.

Calculations and statistical analyses

Canola oil was included in the diets at a level of 30 g kg^{-1}. For the calculations of the energy digestibilities in the barley and mixtures it was assumed, based on NRC (1988), that the digestible energy content in canola oil was 36.6 MJ kg^{-1}.

The results were subjected to analysis of variance by using the General Linear Model procedure of SAS (1990). The main effects of diets (n = 6), pigs (n = 6) and

periods (n = 6) were included in the model. The means of diets were compared using the Student-Newman Keul's multiple range procedure and the statistical significance level was claimed at $P < 0.05$. Correlation coefficients of digestibility values with the *in vivo* and the *in vitro* method were established with the procedure of Regression Analysis of SAS (1990), and regression equations were established if correlations were significant at $P < 0.05$.

RESULTS AND DISCUSSION

The pigs remained healthy throughout the experiment and readily consumed their meal allowances. Postmortem examinations at the conclusion of the experiment revealed no adhesions or other intestinal abnormalities.

The chemical composition of the barleys and mixtures, and diets are presented in Tables 2 and 3, respectively. The contents of β-glucans in the diets were calculated from the analysed values in barley. The analysed values of all other parameters measured in the diets (Table 3) were very close to the calculated values based on the analysed values in the barley sources and mixtures. The values of the parameters measured were within the range of values reported by the NRC (1998) and Jaikaran et al. (1998). Hulless barley is usually higher in CP content than hulled barley (Jaikaran et al., 1998) but this was not the case in one instance in this study. The contents of CP in both hulless barleys were 12.3%, in the hulled barleys 11.4 and 12.4%. As was reported by Newman et al. (1989), the contents of β-glucans are usually higher in hulless than in hulled barley. They reported values ranging from 4.5 to 7% in hulless barley and from 3.5 to 4.5% in hulled barley. In this study, only the content of β-glucans in hulless barley c.v. CDC Richard was higher than in the hulled barleys (Table 2).

The digestibility values of DM, energy, and CP in the barleys and their mixtures determined with the *in vivo* and *in vitro* method are presented in Table 4. The *in vivo* energy digestibility values ranged from 76.9 to 84.7% and were higher in hulless than in hulled barley and intermediate in the mixtures. Beames et al. (1996) also reported higher energy digestibility values in hulless than in hulled barleys. In their study, the energy digestibilities in hulless barleys ranged from 86.6 to 88.8% (n=6); in hulled barleys from 76.7 to 81.4% (n = 12). The higher energy digestibility in hulless compared to hulled barley is a reflection of the lower fibre content in hulless barley (Table 2). In this context, Beames et al. (1996) reported a negative correlation coefficient of -0.96 between energy digestibility and total dietary fibre content in studies with growing pigs fed 18 barley samples, including six samples of hulless barley.

The *in vivo* CP digestibilities in the barleys and their mixtures ranged from 71.7 to 76.6% (Table 4). The CP digestibility in c.v. CDC Richard was lower ($P < 0.05$) than

TABLE 2

Chemical composition of barleys and their mixtures, g kg^{-1}as-fed basis

Item	Barleys and mixtures [2]					
	A	B	C	D	E	F
Dry matter	891.0	896.0	889.0	887.0	886.0	885.0
Gross energy, MJ kg^{-1}	17.1	17.0	17.2	17.2	17.1	17.1
Crude protein	124.0	114.0	123.0	123.0	124.0	118.0
Crude fat	17.0	17.0	18.0	13.0	17.0	15.0
Neutral detergent fibre	151.0	149.0	110.0	121.0	128.0	131.0
Acid detergent fibre	45.0	39.0	20.0	27.0	32.0	33.0
Lignin	7.0	8.0	6.0	6.0	7.0	6.0
β-glucans	35.1	34.9	34.1	41.0	34.9	38.4
Ash	22.0	20.0	19.0	19.0	20.0	20.0

[1] as-fed basis

[2] A: hulled barley c.v. Harrington I; B: hulled barley c.v. Harrington II; C: hulless barley c.v. CDC Buck; D: hulless barley c.v. CDC Richard; E: mixture of c.v. Harrington I and c.v. CDC Buck (50: 50, wt/wt); F: mixture of c.v. Harrington II and c.v. CDC Richard (50:50, wt/wt)

TABLE 3

Chemical composition of the experimental diets, g kg^{-1}as-fed basis

Item	Diets [1]					
	A	B	C	D	E	F
Dry matter	880.0	881.0	878.0	877.0	880.0	879.0
Gross energy, MJ kg^{-1}	16.9	16.9	16.9	16.9	16.9	16.9
Crude protein	119.0	106.0	116.0	120.0	116.0	109.0
Crude fat	46.0	46.0	47.0	43.0	46.0	45.0
Neutral detergent fibre	141.0	140.0	104.0	117.0	120.0	121.0
Acid detergent fibre	40.0	38.0	17.0	25.0	27.0	32.0
Lignin	5.0	5.0	3.0	4.0	4.0	4.0
β-glucans	33.3	31.2	32.4	39.0	33.2	36.5
Ash	39.0	40.0	39.0	39.0	39.0	39.0

[1] refer to Table 1

TABLE 4

Dry matter, energy and crude protein digestibility values of the barleys and their mixtures with the *in vivo* and *in vitro* methods, %

Item	Barleys and mixtures [1]							SEM [2]
	Method	A	B	C	D	E	F	
Dry matter	*In vivo* (n = 6)	81.2^{d}	80.6^{d}	88.0^{a}	84.8^{b}	84.4^{b}	82.8^{c}	0.96
	In vitro (n = 6)	86.2^{c}	85.3^{c}	91.2^{a}	89.6^{b}	88.1^{bc}	87.6^{c}	1.02
Energy	*In vivo* (n = 6)	77.6^{c}	76.9^{c}	84.7^{a}	81.4^{b}	80.9^{b}	79.3^{b}	1.05
	In vitro (n = 6)	81.3^{c}	80.2^{c}	89.0^{a}	85.6^{b}	82.9^{bc}	81.8^{c}	1.08
Crude protein[c]	*In vivo* (n = 6)	76.6^{a}	75.0^{a}	74.1^{ab}	71.7^{b}	75.3^{ab}	72.9^{ab}	1.07
	In vitro (n = 6)	97.6^{a}	96.7^{ab}	95.2^{c}	94.0^{c}	96.9^{b}	95.8^{bc}	0.52

[1] refer to footnote 2 of Table 2

[2] standard error of the means

[a,b,c,d] means in the same row with different letters differ at $P < 0.05$

in the hulled barleys, ranging from 3.3 to 4.9 percentage units. There were no differences ($P > 0.05$) in CP digestibility between c.v. CDC Buck and the hulled barleys. The lower CP digestibility in c.v. CDC Richard may result from its higher β-glucan content (Table 2). It should be pointed out that the differences in the β-glucan content between the diet containing c.v. CDC Richard and the diets containing hulled barley were relatively small, ranging from 0.57 to 0.78 percentage units. However, it was noticed that faeces from pigs fed the diet containing c.v. CDC Richard was very sticky (compared to faeces from pigs fed the other diets) which was observed when the nylon bags were retrieved from faeces, perhaps reflecting a higher viscosity. It is possible that the higher viscosity of faeces from pigs fed c.v. CDC Richard-containing diet was not only caused by its higher β-glucan content, but perhaps also by the type of β-glucans and distribution in the kernel. As was reviewed in several publications (e.g., Li et al., 1996), β-glucans may have a negative effect on the digestion of protein and AA. This negative effect can be overcome by supplementation of β-glucanase as was shown in studies with growing pigs fed hulless barley-containing diets (Li et al., 1996).

On the other hand, Beames et al. (1996) reported higher CP digestibility values in hulless (88.1 to 88.8%) than in hulled barleys (79.3 to 83.6%). This can likely be attributed to the higher CP content in the hulless (15.5 to 16.6%) than in the hulled barleys (11.7 to 14.0%) in the aforementioned studies. In the present studies, the differences in CP content between hulless and hulled barleys was very small (Table 2). As was shown by Buraczewska et al. (1987), the higher the CP content in barley, the higher the CP digestibility, which results from the decrease in the relative proportion of endogenous protein as the dietary CP content increases.

Although the measurement of faecal CP digestibility is of value, a more detailed assessment of protein digestion in hulled compared to hulless barley will be obtained by measurement of ileal AA digestibility values (e.g., Żebrowska, 1978). Differences in ileal AA digestibility values between hulled and hulless barley are presented in a following publication (Huang et al., 2003).

Following the completion of the *in vivo* studies, *in vitro* studies were carried out to determine the DM, energy, and CP digestibility values in the barleys and their mixtures.

The *in vitro* DM and energy digestibility values of the barleys and their mixtures are presented in Table 4. The *in vitro* values were higher than the *in vivo* values. For energy, the differences ranged from 2.0 to 4.3 percentage units. The differences may be attributed, in part, to the fact that samples for *in vitro* analyses were more finely ground (1-mm mesh screen) than the barley used in the diets (2-mm mesh screen) for the *in vivo* studies. As was shown by Wünsche et al. (1987), fineness of grinding of barley has a considerable effect on energy digestibility; the organic matter digestibility values (energy digestibility was not determined) were 75.0, 77.7, and 80.4% in coarsely, medium, and finely ground barley, respectively.

Furthermore, energy digestibility values determined with the *in vitro* method represent true (which does not include energy of endogenous origin) rather than apparent digestibility values. As shown in Table 5, there were very high correlations between the *in vivo* and *in vitro* values for DM ($r^2 = 0.96$) and energy ($r^2 = 0.93$) digestibilities. Beames et al. (1996) reported a correlation coefficient of 0.99 between *in vivo* and *in vitro* values for DM digestibility (energy digestibility was not determined) in 18 samples of barley, including six samples of hulless barley.

TABLE 5

The linear relationships of digestibility values of dry matter, energy, and crude protein between the *in vivo* and *in vitro* method

Item	Regression equation[a,b]	R^2	P value[c]
Dry matter digestibility	$Y_{in\ vivo}=1.23X_{in\ vitro}-24.3$	0.96	0.0006
Energy digestibility	$Y_{in\ vivo}=0.84X_{in\ vitro}+10.1$	0.93	0.0020
Crude protein digestibility	$Y_{in\ vivo}=1.26X_{in\ vitro}-46.3$	0.87	0.0070

[a] Y= digestibility values with the *in vivo* method, %

[b] X= digestibility values with the *in vivo* method, %

[c] the probability of significance for the slope of the regression equation at $P < 0.05$ ($n = 6$)

The *in vitro* values for CP digestibility of the barleys and mixtures were considerably higher than the *in vivo* values (Table 4). The differences ranged from 21.0 to 22.9 percentage units. Crude protein digestibility values determined with the *in vitro* method represent true rather than apparent digestibility values and do not account for CP of endogenous origin which includes sloughed epithelial cells, mucin and bacterial protein. A small proportion of the differences between the *in vivo* and *in vitro* CP digestibility values may also be attributed to fineness of grinding, as samples for *in vitro* analyses were ground more finely. The CP digestibility values were 69.5, 77.8, and 82.0% in coarsely, medium, and finely ground barley, respectively (Wünsche et al., 1987). As shown in Table 5, there was a very high correlation ($r^2 = 0.87$) between the *in vivo* and *in vitro* CP digestibility values.

The results are summarized in Table 6. Regardless which method was used, the digestible energy content was higher in hulless than in hulled barley. Based on the *in vivo* method, the digestible energy content of the hulless barleys ranged from 14.01 to 14.60 MJ kg^{-1}, in hulled barley from 13.05 to 13.16 MJ kg^{-1}. The NRC (1998) reported values of 14.05 and 12.76 MJ kg^{-1} for hulless and hulled barley, respectively. The average *in vivo* digestible CP content of the hulless barleys was nearly similar to that of the hulled barleys. The rankings of the sources of barley for the digestible energy and also digestible protein content were nearly similar when these were based on *in vivo* or *in vitro* measurements.

TABLE 6

Digestible contents of energy and crude protein determined with the *in vivo* and *in vitro* method, and relative values in hulled and hulless barley, as-fed

Item	Barleys[1]				
	Method	A	B	C	D
Energy, MJ kg^{-1}	*In vivo*	13.27 (100)[2]	13.05 (99)	14.60 (111)	14.01 (107)
	In vitro	13.93 (100)	13.64 (98)	15.35 (110)	14.72 (106)
Crude protein, g kg^{-1}	*In vivo*	95.0 (100)	85.5 (90)	91.1 (96)	88.2 (93)
	In vitro	121.0 (100)	110.2 (91)	117.0 (97)	115.5 (95)

[1] refer to footnote in Table 2

[2] relative values in parentheses (A = 100)

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STRESZCZENIE

Wartość pokarmowa jęczmienia zwyczajnego i bezłuskowego dla rosnących świń. 1. Strawność energii i białka oznaczona metodą *in vivo* i *in vitro*

Doświadczenie przeprowadzono na 6 wieprzkach, żywionych sześcioma dietami, w układzie kwadratu łacińskiego 6 × 6. Średnia m.c. zwierząt na początku i końcu doświadczenia wynosiła 40 i 90 kg, odpowiednio. Każda z 6 diet zawierała 950 g kg^{-1} jednej z czterech partii jęczmienia i dwóch mieszanek. Dieta A: jęczmień zwyczajny, odm. Harrington I; dieta B: odm. Harrington I i II, które różniły się pochodzeniem; dieta C - jęczmień bezłuskowy, odm. CDC Buck; dieta D: jęczmień bezłuskowy, odm. CDC Richard; dieta E: mieszanka odmian Harrington I i odm. CDC Buck (50:50 wt/wt); dieta F: mieszanka odmian Harrington II i CDC Richard (50:50 wt/wt). Diety ułożono w ten sposób, aby można było określić regresję liniową pomiędzy metodami *in vivo* i *in vitro*. Jako wskaźnik do oznaczania strawności zastosowano Cr_2O_3. Świnie żywiono dwa razy dziennie, o 8.00 i 20.00. Każdy okres doświadczalny składał się z 8-miu dni okresu adaptacyjnego i 2 dni kolekcji kału.

Strawność energii jęczmienia bezłuskowego oznaczona metodą *in vivo* była większa ($P < 0,05$; 81,4 do 84,7%) niż zwyczajnego (76,9 do 77,6%), a jej zawartość w jęczmieniu bezłuskowym wynosiła 14,01 do 14,60 MJ kg^{-1}, podczas gdy w jęczmieniu zwyczajnym 13,05 do 13,16 MJ kg^{-1} (w naturalnej s.m.). Średnia zawartość białka ogólnego w obydwóch rodzajach jęczmienia była zbliżona i wynosiła 88,0 i 89,7 g kg^{-1}, odpowiednio w zwyczajnym i bezłuskowym

Strawność energii i białka ogólnego jęczmienia i jego mieszanki może być wystarczająco dokładnie określona metodą *in vitro*, otrzymano bowiem bardzo wysoką korelację między porównywanymi metodami, wynoszącą $r^2 = 0,93$ dla energii i $r^2 = 0,87$ dla białka ogólnego.