Animal Feed Science and Technology, 13 (1985) 183—190
Elsevier Science Publishers B.V., Amsterdam — Printed in The Netherlands

FEEDING VALUE OF HYDROPONICALLY SPROUTED BARLEY FOR POULTRY AND PIGS

D.J. PEER and S. LEESON

Department of Animal and Poultry Sciences, University of Guelph, Guelph, Ontario N1G 2W1 (Canada)

(Received 7 November 1983; accepted for publication 25 April 1985)

ABSTRACT

Peer, D.J. and Leeson, S., 1985. Feeding value of hydroponically sprouted barley for poultry and pigs. *Anim. Feed Sci. Technol.*, 13: 183—190.

Barley was sprouted hydroponically for 1—7 days under controlled conditions. Metabolizable energy (ME) concentration of dried barley sprouts was determined with mature White Leghorn cockerels. There was a significant linear decrease ($P < 0.05$) in ME of the sprouts with increased sprouting time.

Digestibility of dry matter (DDM), protein (DP) and energy (DE) of raw 4-day sprouts was determined with pigs, as were the weight gain and feed efficiency of the animals. Day 4 sprouts were significantly ($P < 0.05$) lower in DDM, DP and DE than ground barley, but were superior in these characteristics ($P < 0.05$) to whole barley. Young pigs (18 kg live weight) fed on 4-day sprouts gained significantly ($P < 0.05$) less weight than pigs fed on ground barley, although feed efficiency was the same for both barley types.

Results from the above experiments suggest that digestibility decreases as sprouting time increases. It would appear that drying and grinding the sprouts improves their digestibility.

INTRODUCTION

Limited research has been conducted on the feeding value of sprouted grain. Early workers found lower weight gains when pigs were fed on 10-day sprouted maize relative to ground maize (Leitch, 1939). Schmidt et al. (1937), as cited by Leitch (1939), found similar results when pigs were fed on sprouted or ground barley.

Several researchers have investigated the feeding value of field-sprouted grain for poultry. Bull and Peterson (1969), Farlin et al. (1971), Rowland et al. (1978) and Sibbald et al. (1962) found no difference in performance of birds fed on sprouted or non-sprouted grain. In contrast Falen and Peterson (1969) reported an increase in metabolizable energy content of Gaines wheat when the diet contained a combination of sprouted and non-sprouted grain.

These trials were conducted to gain information on the feeding value of

0377-8401/85/$03.30

hydroponically-sprouted barley and the possibility of relating such results to the feeding value of field-sprouted grain.

MATERIALS AND METHODS

The methods of hydroponic cultivation and chemical analyses of the sprouted grain used in these trials have been described previously (Peer and Leeson, 1985).

Experiment 1

The apparent metabolizable energy concentration of sprouted and unsprouted barley seed was determined with cockerels. Samples of 1—7 day hydroponically-sprouted barley, with a germination rate of 60—65%, were freeze-dried and ground through a 1-mm screen. Samples were dried since cockerels refused to eat all samples of freshly-sprouted grain. Nine diets were used: (1) Basal (B) (Table I); (2) B + ground, unsprouted barley; (3—9) B + barley sprouted for 1—7 days, respectively. The test ingredients constituted 25% of the diet. Mature White Leghorn cockerels were randomly assigned to metabolism cages maintained in a controlled environment room. Diets were assigned such that no two adjacent birds were consuming the same diet. Owing to the limited number of birds and cages available at a given time, the nine diets were tested over three consecutive test periods; seven birds were used for Diet 2, six birds per diet were used for Diets 1, 3, 4, 7 and 8 and

TABLE I

Basal diet for determination of metabolizable energy in poultry

Ingredient	% of diet
Maize	57.12
Soya bean meal (49% CP)	35.07
Fat (animal—vegetable blend)	3.00
Limestone ($CaCO_3$)	1.25
Calcium phosphate (20% P)	2.00
Iodized NaCl	0.25
Bone meal	0.50
Vitamin mix[a]	0.50
Mineral mix[b]	0.25
DL methionine	0.06

[a]Vitamin mix supplies the following per kg of diet: vitamin A, 8000 IU; vitamin D, 1600 IU; vitamin E, 11.0 IU; vitamin K (hetrezeen), 1.5 mg; riboflavin, 9.0 mg; d calcium pantothenate, 11.0 mg; vitamin B_{12}, 13.0 μg; niacin, 26.0 mg; choline Cl (50%) (74% choline), 900 mg; folic acid, 1.5 mg; biotin (2%), 0.20 mg; santoquin (25%), 125 mg.
[b]Mineral mix supplies the following per kg of diet: manganese oxide, 31 mg; selenium, 0.1 mg; zinc, 40 mg; copper, 1.0 mg; iron (69.94% Fe), 21 mg.

five birds per diet were used for Diets 5, 6 and 9. Collection trays were lined with pre-weighed foil. During each day of the collection period, the excreta were removed and placed in pre-weighed foil pans and stored at 4°C. This procedure was found to minimize contamination of faeces with scale and feathers and also prevented mould growth.

Birds were allowed a four-day feed adjustment period with excreta collected over the subsequent 4 days. Feed refused was weighed back each day during the collection period. The excreta were frozen prior to subsequent freeze-drying and grinding to a fine particle size. Nitrogen and energy content of the feed and excreta were determined by a macro-Kjeldahl technique and adiabatic bomb calorimetry according to the Association of Official Analytical Chemists (A.O.A.C.) (1975).

The ME values of the sprouts were calculated according to the following equation:

$$\text{Barley sprout ME (test ingredient)} = \text{basal diet ME} - \left(\frac{\text{basal diet ME} - \text{test diet ME}}{\text{\% of sprouts substituted for the basal diet}}\right)$$

Statistical analysis

The relationships between sprouting period of 1—7 days and the quantity of metabolizable energy (ME) was determined using linear regression (Steel and Torrie, 1980). The 5% level of probability was assumed to be the maximum value for significance.

Experiment 2

Digestibility of dry matter (DDM) and protein (DP) and digestible energy (DE) of whole barley, ground barley and sprouted barley was determined with growing pigs. Four test diets were used: (1) Basal (Table II); (2) Basal + whole barley; (3) Basal + sprouted barley; (4) Basal + ground barley. Barley constituted 30% of the test diet by weight. For the sprouted-grain treatment, the daily feed contribution of barley per pig was sprouted on individual trays within the hydroponic unit. The sprouted grain was subsequently mixed fresh with the remaining diet ingredients to provide the daily feed allocation for each pig. Barley was sprouted for 4 days in the hydroponic system described previously (Peer and Leeson, 1985). In order to ensure the required proportional consumption of sprouts (which could be selected out by the pig) all test diets were given at 80% of maximal intake. Each diet was given to six barrows (average 32 kg live weight), each receiving one diet per test period of 8 days, so that each pig consumed all four diets in turn. Pigs were given a 4-day adjustment period between diets. Faeces were collected over a 4-day period, weighed and 300—600-g samples taken for subsequent freeze-drying and chemical analysis. Protein and gross energy were determined by a standard macro-Kjeldahl technique and adiabatic bomb calorimetry (A.O.A.C., 1975). Digestible energy, DDM and DP of the sprouts were calculated according to principles previously outlined for ME.

TABLE II

Basal diet composition for pig digestibility trials (%)

Ingredients	Experiment 3	Experiment 4
Maize	77.79	70.2
Soya-bean meal (48.5% CP)	16.81	25.3
Salt	0.70	0.60
Calcium phosphate	2.0	1.9
Limestone	1.5	1.3
Vitamin—mineral premix	1.2[1]	0.7[2]
Nutrient composition (calculated)		
Dry matter	90.0	90.0
Digestible energy (MJ kg^{-1})	14.19	14.45
Crude protein	15.0	18.4
Lysine	0.72	0.97
Methionine and cystine	0.55	0.64
Calcium	0.99	0.93
Phosphorus	0.74	0.70

[1]Provides per kg of diet: vitamin A, 35 200 IU; vitamin D, 3600 IU; vitamin E, 100 IU; vitamin K, 8.8 mg; thiamin, 6 mg; riboflavin, 16 mg; niacin, 100 mg; pantothenic acid, 64 mg; folic acid, 4 mg; pyridoxine, 6.0 mg; biotin, 0.8 mg; vitamin B_{12}, 60 μg; choline, 1200 mg; selenium, 1.2 mg; manganese 43 mg; iron, 490 mg; copper, 32 mg; zinc, 128 mg; calcium, 294 mg.

[2]Provides per kg of diet: vitamin A, 21 120 IU; vitamin D, 2160 IU; vitamin E, 60 IU; vitamin K, 5.28 mg; thiamin, 3.6 mg; riboflavin, 60 mg; niacin, 60 mg; pantothenic acid, 38.4 mg; folic acid, 2.4 mg; pyridoxine, 3.6 mg; biotin, 0.48 mg; vitamin B_{12}, 36 μg; selenium, 0.72 mg; choline, 720 mg; manganese, 22 mg; iron, 245 mg; copper, 16 mg; zinc, 64 mg; calcium, 147 mg.

Statistical analysis

Data were subjected to analysis of variance and Duncan's multiple-range test (Steel and Torrie, 1980).

Experiment 3

This experiment was conducted to determine the effect of giving 4-day barley sprouts on weight gain and feed efficiency of young growing pigs. Two diets were used: (1) Basal (Table II) + sprouted barley; (2) Basal + ground barley. Inclusion level of barley in the test diets was 20% by weight. The barley for the sprouted diet was weighed into individual trays, 1 tray per pen per day on a dry-weight basis, in order to keep the inclusion level of barley constant between the two diets. Barley was sprouted for 4 days in the hydroponic unit mentioned earlier (Peer and Leeson, 1985), and given fresh. Both diets were given once daily at 90% of maximal intake to guarantee total consumption of the sprouts, so that the inclusion levels of barley would remain constant for the two diets.

Forty, 18-kg gilts and boars were weighed and randomly assigned to 10 consecutive pens in an environmentally controlled room, such that each sex was evenly distributed among the 10 pens. Five pens were assigned to each test diet. The trial lasted 29 days. Pigs were weighed on Days 10, 18 and 29.

Statistical analysis

Total weight gain was subjected to covariance analysis using initial weight as the covariate. Feed-to-gain data were subjected to analysis of variance and least-square means calculated according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

Experiment 1

The metabolizable energy value for Day 0 unsprouted barley was substantially less than that recorded for Day 1 sprouts (Table III). This large difference of some 4 MJ kg^{-1} is difficult to reconcile with previous observations of changes in nutrient profile with sprouting (Peer and Leeson, 1985). It is also observed that this ME value for regular unsprouted barley is somewhat less than that previously reported for this ingredient (Summers and Leeson, 1976). For this reason, the ME value for Day 0 sprouts was not included in subsequent regression analyses. Regression analysis showed a significant linear relationship between ME and sprouting time. The regression equation is $y = 16.15 - 1.46x$ where y = ME (MJ kg^{-1}), and x = sprouting time (days). Previous experimentation (Peer and Leeson, 1985), has shown that the amounts of starch and energy of barley sprouts decrease, while the amount

TABLE III

Metabolizable energy concentration of sprouted barley determined with adult cockerels (Experiment 1)

Day	Metabolizable energy (MJ kg^{-1} DM)	S.E. of mean
0	11.3	±0.79
1	14.8	±1.41
2	13.8	±0.20
3	11.4	±0.74
4	8.7	±1.36
5	9.8	±0.36
6	6.8	±0.69
7	6.6	±0.59

Day 0 = unsprouted barley; not included in regression equation.
Regression coefficient = $-1.46x$; regression constant = 16.15; residual standard deviation = 2.188; $R^2 = 0.65$ and $P < 0.0001$.

of fibre increases with increased sprouting time. As poultry have a limited ability to digest fibre (Moran, 1982), the gain in fibre coupled with the loss of starch explain the observed decrease in ME of the sprouts.

From this present experiment, it would appear that the ME content of grain is influenced by the duration of sprouting time. Sprout-damaged grain in which the radicle is visible as a white tip may be similar to Day 1 sprouts (Peer and Leeson, 1985), while grain that has sprouted enough to have shoot and root visible may be similar to Day 2—Day 5 sprouts with respect to ME. This difference in degree of sprouting may explain why Falen and Petersen (1969) reported an increase in the ME content of sprouted wheat while others (Sibbald et al., 1962; Bull and Petersen, 1969; Farlin et al., 1971; Rowland et al., 1978), reported no change in animal performance. It would, therefore, appear that if the degree of sprouting (i.e., the length of shoot and root) of field-sprouted grain was known, its feeding value could be estimated from comparison with the feeding value of the hydroponically-sprouted grain showing the same degree of development.

Experiment 2

Digestibility of dry matter (DDM), protein (DP) and digestible energy (DE) was significantly lower with sprouted barley than ground barley but was superior to that recorded for whole barley (Table IV). The significant increase in fibre content of 4-day sprouts, (Peer and Leeson, 1985), could account for the decrease in DDM since digestibility of a feedstuff decreases with increasing fibre content for pigs (Church, 1977; Whittemore and Elsley, 1977).

The DDM could also be influenced by the proportion of germinated barley

TABLE IV

Digestibility of dry matter and protein and digestible energy content of 4-day barley sprouts, whole and ground barley as determined with pigs

Diet	Dry matter digestibility (%)	Digestible energy (MJ kg^{-1} DM)	Protein digestibility (%)
Ground barley	85.0^{a}	15.9^{a}	83.5^{a}
S.E.	±1.73	±0.37	±2.99
Sprouted barley	68.8^{b}	13.3^{b}	66.0^{b}
S.E.	±4.60	±1.02	±4.46
Whole barley	32.3^{c}	4.95^{c}	31.0^{c}
S.E.	±3.09	±0.425	±2.86

Means within columns followed by different superscripts are significantly different ($P < 0.05$).

kernels. With the low germination reported herein, 35—40% of the barley assumed to be given as "sprouted" kernels would actually be unsprouted intact kernels with such grain being poorly digested by swine (Whittemore and Elsley, 1977). The presence of whole barley kernels in the faeces of pigs fed on sprouts verifies the above statement.

Experiment 3

The germination of the barley in this trial was only 50%, a decrease of 17—23 percentage units from the germination obtained in previous trials, and could have been due to the more prolonged grain storage (Cook, 1962). This decrease in germination should result in less dry-matter loss with sprouting as fewer kernels would use their starch reserves in respiration. The dry-matter loss (DML) of Day 4 sprouts at 50% germination was 4.48% as compared with 12% DML at 65% germination, mentioned previously (Peer and Leeson, 1985).

Pigs fed on Diet 1 (basal + sprouts) gained significantly ($P < 0.05$) less than did pigs fed on diet 2 (basal + ground barley). Feed:gain (F:G) ratios for the two diets were not significantly different ($P < 0.05$) (Table V), although F:G was slightly poorer for the sprout-fed pigs. The digestion trial demonstrated that sprouted barley and ground barley had digestible energy concentrations of 12.5 and 15.9 MJ kg^{-1}, respectively. From these values, the DE of Diets 1 and 2 would be calculated as 14.0 and 14.7 MJ kg^{-1}, correspondingly. The dry-matter intakes of pigs on both diets were calculated on a dry barley (unsprouted) basis. As the sprouts lost 4.48% dry matter during sprouting, sprout-fed pigs would have consumed less feed at a lower energy content, thus explaining their lower weight gain.

Other researchers (Bostock, 1937 and Fishwick, 1937, both as cited by Leitch, 1939) found depressed weight gains when pigs were fed on sprouted maize. Schmidt et al. (1937, as cited by Leitch, 1939) conducted several experiments investigating the feeding value of sprouted barley for pigs. The

TABLE V

Weight gain and feed efficiency of young growing pigs fed on diets containing 4-day barley sprouts or ground barley

Diet	Weight gain (kg per pen)	Feed:gain
Sprouted barley	69.0	2.10
S.E.	±1.15	±0.027
Ground barley	74.6	1.99
S.E.	±1.15	±0.039

Means with different superscripts are significantly different ($P < 0.05$).

growth period of the barley used in these trials was not stated. Pigs fed on sprouted grain and control groups gained weight equally in trials in which the basal diet was given ad libitum. However, groups fed on sprouts gained less weight than did control groups in trials in which the basal diet was given at a specific level. These observations would suggest that sprouted barley is inferior to regular barley in feed value, which agrees with the results from the feeding trial reported herein.

Results from these trials indicate few positive effects due to sprouting of barley. The problem with the use of fresh sprouts stems from the fact that not all kernels germinate and ungerminated whole grains are not well utilized by the pig. Drying and grinding the sprouts would probably be uneconomical, while grinding of the fresh material would produce mechanical problems related to the high moisture content of the sprouts. If field-sprouted grains are necessarily given to animals it seems as though no detrimental effects will occur, other than loss of dry matter and associated nutrients as previously detailed by Peer and Leeson (1985).

ACKNOWLEDGEMENT

This work was sponsored by the Ontario Ministry of Agriculture and Food.

REFERENCES

Association of Official Analytical Chemists, 1975. Official Methods of Analysis, 12th edn. A.O.A.C., Washington, D.C.

Bull, R.C. and Peterson, C.F., 1969. Nutritive value of sprouted wheat for swine and poultry. J. Anim. Sci., 28: 856.

Church, D.C., 1977. Livestock Feeds and Feeding. O. and B. Books, Corvallis, Oregon.

Falen, L.F. and Peterson, C.F., 1969. Comparison of sprouted versus normal wheat when fed to white leghorn cockerel chicks. Poult. Sci., 45: 1772—1775.

Farlin, S.D., Dahmen, J.J. and Bell, T.D., 1971. Effect of sprouting on nutritional value of wheat in cattle diets. Can. J. Anim. Sci., 51: 147—151.

Leitch, I., 1939. Sprouted fodder and germinated grain in stock feeding. Commonw. Bur. Anim. Nutr. Tech. Commun., 11, pp. 3—63.

Moran, E.T., Jr., 1982. Comparative nutrition of fowl and swine — the gastrointestinal systems. University of Guelph, Guelph, Ontario.

Peer, D.J. and Leeson, S., 1985. Nutrient content of hydroponically sprouted barley. Anim. Feed. Sci. Technol., 13: 191—202.

Pollock, J.R.A., 1962. The nature of the malting process. In: A.H. Cook (Editor), Barley and Malt: Biology, Biochemistry and Technology, Chap. 8. Academic Press, New York.

Rowland, L.O., Jr., Plyler, J.E. and Bradley, J.W., 1978. The feeding value of weather-damaged grain sorghum for poultry. Poult. Sci., 57(1): 180—185.

Sibbald, I.R., Slinger, S.J. and Pepper, W.F., 1962. Sprouted, frozen and moldy wheats as sources of nutrients for chicks. Poult. Sci., 41(1): 1003—1004.

Steel, R.G.D. and Torrie, J.H., 1980. Principles and Procedures of Statistics. McGraw Hill, New York.

Summers, J.D. and Leeson, S., 1976. Poultry Nutrition Handbook. Ontario Minist. Agric. and Food, Toronto.

Whittemore, C.T. and Elsley, F.W.H., 1977. Practical Pig Nutrition. Farming Press, Suffolk.