Improvement of Feeding Value of Barley by Enzyme Supplementation

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Recently, the production of barley for feed usage has been increased year by year. However, the feeding value of barley is much lower than that of corn or milo, mainly due to lower energy level and poor palatability which may limit its use in poultry rations. The usage of barley for poultry rations could be increased by the improvement of its energy value.

It was indicated that the nutritive value of barley could be increased by some enzyme supplements in several experiments with chicks conducted in the United States of America.[1-3,5,6,8-11] In Japan, about 20 years ago, Morimoto et al.[7] showed that no significant improvement was obtained by adding any enzyme supplement to barley diets of chicks.

Chemical composition and varieties of barley

In Japan, over 40 varieties of barley have been cultivated in recent years. The author collected 9 varieties of barley which are produced in relatively large amounts. The varieties and their growing locations are shown in Table 1. Of the 9 varieties, four varieties are 2-row type, four are 6-row type and one is naked barley. The chemical compositions of these barley are also shown in Table 1. Some variation in the contents of crude protein and nitrogen free extract (NFE) was observed among the varieties. Naked barley contained lower crude fiber and higher NFE than those of 2-row and 6-row types of barley.

Influence of barley varieties on effectiveness of enzyme supplementation

Three experiments were conducted with White Leghorn male chicks to investigate the influence of barley varieties on the effectiveness of enzyme supplementation to barley diets. In Experiment 1 and 2, four varieties of barley, namely Hoshimasari, Daisengold, Katorimugi and Kikaihadaka and in Experiment 3, five varieties, namely Kawahonami, Seijo-17, Saikaikawa-9, Sanada-

Table 1. Variety, growing location and chemical composition of barley

Variety	Growing location	Chemical composition (%)					
		Moisture	C. protein	C. fat	N.F.E.	C.fiber	C. ash
(Two-row types)							
Hoshimasari	Hokkaido	13.92	11.18	2.13	65.37	4.78	2.62
Kawahonami	Ohita	12.37	9.65	2.01	69.35	4.17	3.45
Seijo-17	Ohita	10.97	10.84	2.12	69.25	4.32	2.50
Daisengold	Ohita	11.44	9.47	2.15	70.08	4.32	2.54
(Six-row types)							
Saikaikawa-9	Gunma	13.03	8.66	1.87	68.44	5.41	2.59
Katorimugi	Chiba	12.23	11.93	2.00	67.02	4.53	2.29
Sanadamugi	Nagano	11.31	8.85	1.98	69.68	5.38	2.80
Minorimugi	Nagano	12.31	8.07	2.01	71.39	3.68	2.54
(Naked barley)							
Kikaihadaka	Hyogo	11.75	9.30	1.69	73.61	1.67	1.98

mugi and Minorimugi were used. Barley was ground with a grinding mill to pass through 1.0 mm screen. Compositions of the experimental diets are shown in Table 2. Barley was included at the rate of 60% as an only grain source in the barley diets. All the experimental diets were prepared to meet the Japanese Feeding Standard for starting chicks. To evaluate ME of barley, glucose-soybean meal diet (substitution by glucose for barley in the barley diet) was used. Commercial cellulase (Cellulase Onozuka for Feed Analysis, 1500 U/g) was added to barley diets at 0.1% (enzyme-supplemented diets), or not added (control diet). White Leghorn male chicks were fed experimental diets during 14 days from 7 to 21 days of age. In each experiment, excreta was collected for 48 hours at 24-hr intervals, and ME of the barley and glucose diets was determined by the Cr_2O_3 index method. ME of barley was calculated by using the method of Hill et al.[4]

Table 2. Composition of experimental diets (%)

	Barley diet	Glucose-soybean meal diet
Barley	60.0	—
Glucose (anhydrous)	—	60.0
Soybean meal	18.5	18.5
Fish meal	8.0	8.0
Defatted rice bran	4.5	4.5
Alfalfa meal	3.0	3.0
Soybean oil	3.5	3.5
Sodium chloride	0.4	0.4
Calcium carbonate	1.0	1.0
Dicalcium phosphate	0.7	0.7
Trace mineral supplement	0.05	0.05
Vitamin ADE supplement	0.10	0.10
Vitamin B supplement	0.15	0.15
Chromic oxide	0.10	0.10

Body weight gain of chicks was significantly increased by adding the cellulase to barley diets, except those prepared from Saikaikawa-9 and Katorimugi (Table 3). The greatest increase in body weight gain was obtained for Kikaihadaka diet, in which the cellulase supplementation increased the gain by 17%. In Hoshimasari and Minorimugi diets, the cellulase addition resulted in over 10% increase of weight gain. In Daisengold, Sanadamugi and Kawahonami diets, the cellulase also improved weight gain over 5%.

The improvement of body weight gain caused by adding cellulase to barley diets appeared to be large for the varieties showing lower body weight gain in the absence of cellulase. Therefore, body weight gain of chicks fed the diets with supplemented cellulase showed lower variation than those fed the diets without supplemented cellulase.

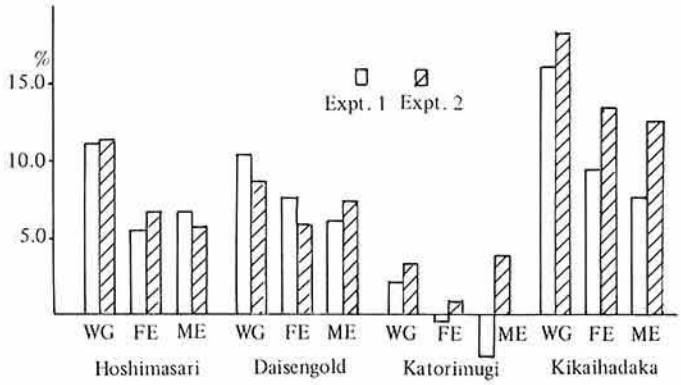
The increase of feed consumption by adding the cellulase to barley diets was less than the increase of body weight gain (Table 3). Only four varieties (Hoshimasari, Kikaihadaka, Minorimugi and Sanadamugi) of barley showed the significant increase in feed consumption by the cellulase supplementation, and the rate of increase was about 5%.

Feed efficiency (body weight gain/feed) was also significantly increased by adding cellulase to barley diets prepared from seven varieties out

Table 3. Effect of adding cellulase to barley diets prepared from different barley varieties on growth and feed efficiency of chicks, and metabolizable energy of barley

Variety	Weight gain			Feed consumption			Feed efficiency			ME of barley		
	Control	C+Enz.	Inc.	Control	C+Enz.	Inc.	Control	C+Enz.	Inc.	Control	C+Enz.	Inc.
	g	g	%	g	g	%			%	kcal/g		%
Hoshimasari	135	150	11.3**	275	289	5.3*	0.491	0.521	6.1**	2.61	2.77	6.1*
Kawahonami	150	158	5.4*	302	308	1.9	0.497	0.514	3.4*	2.66	2.96	11.3**
Seijo-17	154	161	4.3*	304	303	−0.1	0.508	0.531	4.5*	2.89	2.95	2.1*
Daisengold	133	146	9.5**	274	283	3.3	0.487	0.516	6.0**	2.71	2.89	6.6*
Saikaikawa-9	150	154	2.5	311	313	0.9	0.484	0.492	1.7	2.55	2.59	1.6
Katorimugi	142	146	2.5	279	286	2.5	0.509	0.509	0.0	2.67	2.68	0.4
Sanadamugi	146	157	7.5**	300	311	3.5*	0.487	0.505	3.7*	2.60	2.70	3.8*
Minorimugi	143	158	10.4**	298	313	5.0*	0.479	0.504	5.2**	2.59	2.92	12.7**
Kikaihadaka	123	144	17.3**	270	284	5.2*	0.455	0.506	11.2**	2.66	2.93	10.2**

*, **: Significantly different ($P<0.05$), and ($P<0.01$), respectively from control (enzyme unsupplemented).



WG : Body weight gain, FE : Feed efficiency, ME : ME of barley

Fig. 1. Reproducibility of the effects of cellulase supplementation to barley diets for chicks

of 9 varieties (Table 3). These seven barley diets showed significant increases in body weight gain and feed efficiency. The percentage increase of feed efficiency by adding cellulase was the highest (11.2%) in Kikaihadaka diet. In Hoshimasari, Daisengold and Minorimugi diets, over 5% increase of feed efficiency was obtained by adding cellulase. While, in Saikaikawa-9 and Katorimugi diets, cellulase supplementation showed no significant effect on feed efficiency and body weight gain.

ME of barley was significantly increased by adding cellulase to barley diets of seven varieties but not those of Saikaikawa-9 and Katorimugi (Table 3). Seven varieties showed significant increases in ME, body weight gain and feed efficiency by cellulase supplementation. While, in two varieties, no significant increases in ME, weight gain and feed efficiency were observed. The percentage increase in ME of barley by adding cellulase was more than 10% in Minorimugi, Kawahonami and Kikaihadaka. In Daisengold and Hoshimasari, over 6% increase of ME was obtained, while, in Saikaikawa-9 and Katorimugi, no significant increase of ME was obtained by adding cellulase.

It was concluded that the response of supplementing cellulase to barley diets for chicks showed a large difference with regard to varieties of barley used. The increased ME of barley by adding the enzyme can be attributed to the increased growth rate and feed efficiency. The cellulase supplementation may be useful to improve the nutritive value of many varieties of barley.

Reproducibility of the effect of cellulase supplementation

The reproducibility of the effect of cellulase supplementation to barley diets was investigated on data of Experiment 1 and 2. Four barley diets (Hoshimasari, Daisengold, Katorimugi and Kikaihadaka) were fed to chicks in both experiments. The only difference between Experiment 1 and 2 was the time of experimentation. Experiment 1 was conducted in winter (February), while, Experiment 2 in summer (June).

The results are shown in Fig. 1. The effects of cellulase supplementation to barley diets on body weight gain, feed efficiency and ME of barley were similar in Experiment 1 and 2. In both experiments, the nutritive values of barley were significantly improved by adding cellulase to barley diets prepared from Hoshimasari, Daisengold and Kikaihadaka, but not so with the diet prepared from Katorimugi.

Comparison of several commercial cellulase supplements

There are several commercial cellulase supplements for feed usage produced in Japan. Eight commercial cellulase supplements were tested to evaluate their effectiveness in improving the

Table 4. Comparison of the effectiveness of several cellulase supplements

Control	Weight gain	Feed consumption	Feed efficiency	ME of barley
	100.0 (140.5 g)	100.0 (295.8 g)	100.0 (0.475)	100.0 (2.81 kcal/g)
C+Enz. A	105.2	100.2	105.1**	107.9**
C+Enz. B	110.7**	104.2	105.7**	110.8**
C+Enz. C	108.6*	104.4	104.0	109.1**
C+Enz. D	106.8	100.9	105.7**	107.7**
C+Enz. E	110.7**	103.9	106.5**	108.7**
C+Enz. F	109.8*	105.0	104.6*	110.1**
C+Enz. G	110.0*	105.0	104.6*	109.7**
C+Enz. H	105.1	101.8	103.4	109.6**

feeding value of barley.

Basal diet was composed mainly of barley and soybean meal. Naked barley (Kikaihadaka) was contained at the rate of 60% as the only grain in the diet. Each cellulase sample was supplemented to the basal diet at the rate of 0.2%, though there was a large difference in cellulase activities among samples. Experimental diets were fed to White Leghorn male chicks for 14 days (7–12 days of age). The effectiveness of cellulase supplements was evaluated by body weight gain, feed efficiency and ME of barley.

The results are shown in Table 4. All cellulase supplements tested significantly improved ME of barley. The rate of improvement was in the range of 8–11%. Any sample of cellulase supplements also improved body weight gain and feed efficiency. The range of increase by adding cellulase was 5–10% in body weight gain and 3–7% in feed efficiency, respectively. Significant increases in body weight gain and feed efficiency were obtained in 5 and 6 samples of 8 cellulase supplements, respectively. Feed consumption was increased slightly, but not significantly by adding cellulase.

It appears that cellulase supplements used in this experiment are similarly effective in improving growth rate, feed efficiency and ME of barley in chicks fed barley-based rations.

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