Effects of *Aspergillus oryzae* Fermentation Extract on *In Situ* Degradation of Feedstuffs

P. W. S. Chiou*, C. Chen and B. Yu
Department of Animal Science, National Chung-Hsing University, Taichung, Taiwan, ROC

ABSTRACT : The aim of this study was to evaluate the effect of *Aspergillus oryzae* fermentation extract (AFE) on *in situ* degradation of the various concentrates, forages and by-products in Taiwan. The *in situ* trial was conducted to determine the effect of AFE on the rate of ruminal degradation of dry matter (DM), organic matter (OM), neutral detergent fiber (NDF), and acid detergent fiber (ADF) of the various local available feedstuff commonly used for dairy cattle. Two ruminal fistulated cows were arranged into a two by two switchback trial. Two dietary treatments were control without AFE inclusion diet and diet with 3 g of AFE (Amaferm) added daily into the total mixed ration (TMR). Results showed that effect of AFE inclusion on the ruminal degradability of concentrates vary; soybean meal is the most responsive feedstuff, corn is the next, whereas full-fat soybean did not response the AFE inclusion at all. The inclusion of AFE significantly depressed most of the nutrient degradation of the concentrates of soybean meal in the first 12-hour *in situ* incubation. The effect declined in the next 12 hours. Rapeseed meal showed a different trend of response: addition of AFE improved its NDF degradation. The inclusions of AFE significantly improved ADF degradation of roughage after 24 or 48 hours of incubation. However, corn silage and peanut-vines showed a different trend. Effects of AFE inclusion on the by-products degradability were inconsistent. Most of nutrients in rice distillers grain and some in beancurd pomace did show increased degradation by the AFE inclusion. ***(Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 8 : 1076-1083)***

Key Words : *Aspergillus oryzae* Fermentation Extract, *In Situ* Degradation, Forages, By-Products, ADF, NDF

INTRODUCTION

The *Aspergillus oryzae* fermentation extract (AFE) has long been used as a human food. It is a natural safe nonbacterial food product. Since AFE is not a metabolic product, such as antibiotics with a specific quantifiable molecular action, a well defined traceable mode of action is difficult to identify in feeding trials. This leads researchers to suspect the effectiveness of AFE as a feed additive for ruminants. After reviewing nine feeding trials involving AFE inclusion, Newbold (1990) concluded that the mean improvement in milk yield was 4.3% and ranged from 91.0% to 112% depending upon the quality of the AFE, feed composition, ingredient sources and environmental conditions.

Wallace et al. (1990) suggested that the inclusion of probiotics from fungus in ruminant diets increased DM intake using the intake-driven characteristic of the probiotics. Some researchers proposed a theory that AFE inclusion in the ruminant diet would stimulate the growth and metabolism of lactic acid metabolizing bacteria, i.e., *Megasphaera elsderii* and *Selenomonas ruminatium*. This therefore stabilizes ruminal pH by depressing the concentration of lactic acid produced from ruminal fermentation (Waldrip and Martin, 1993; Nisbet and Martin, 1991, 1993). AFE may also provide nutrients that stimulate rapid growth and multiplication of ruminal bacteria, and hence improve the rate of fiber degradation (Harris and Lobo, 1998; Williams et al., 1991). This increase in fiber digestion will decrease gut fill and enhance DM intake. The aim of this study was to evaluate the effect of *Aspergillus oryzae* fermentation extract on *in situ* degradation of the various forages and by-products in Taiwan. The *in situ* trial was conducted to determine the effect of AFE on the rate of ruminal degradation of dry matter (DM), organic matter (OM), neutral detergent fiber (NDF), and acid detergent fiber (ADF) of the various local available feedstuffs commonly used with dairy cattle.

MATERIALS AND METHODS

The experiment was designed in a 2×2 switchback arrangement with two ruminal fistulated dry dairy cows which were fed two different diets. The treatments were a control diet without the inclusion of *Aspergillus oryzae* fermentation extract (AFE) in the basal diet and a treatment diet with 3 g/day of AFE per animal added into the basal diet according to the manufacturer's recommendation. BioZyme Enterprises, Inc., St. Jose, Mo. supplied the AFE (Amaferm).

Two Holstein dry dairy cows with a 600-kg live-weight were fistulated in the rumen, and placed into a 50 m^2 pen with a concrete floor and holding stanchion inside. The cows were fed 15 kg total

* Address reprint request to P. W. S. Chiou. Tel: +886-4-2870613, Fax: +886-4-2860265, E-mail: wschiou@dragon.nchu.edu.tw.

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mixed ration Bermuda hay with a 1 to 1 ratio of concentrate on a dry basis. Table 1 presents the diet formulation and chemical analysis of the basal diet. After a 10-day adaptation, the cows were fed every four hours with equal portions of feed every day. The feeding hours were 0400, 0800, 1200, 1600, 2000 and 2400 during the experimental period.

Table 1. Basal diet formulation for the *in situ* ruminal degradation study, g/kg

	Basal diet
Ingredients	
Bermuda hay	500.0
Soybean meal, 44%	122.5
Corn, dent	249.0
Wheat bran	100.0
Limestone	10.0
Dicalcium phosphate	15.0
Common salt	2.5
Premix[1]	1.0
Total	1000.0
Calculated analysis	
Crude protein	154.0
NEL, Mcal/kg	1.40
ADF	453.0
NDF	245.0
Calcium	9.0
Phosphorus	7.0

Premix components (each kg contain): vitamin A, 10,000,000 IU; vitamin E, 70,000; vitamin D, 1,600,000 IU; Fe, 50 g; Zn, 40 g; Co, 0.1 g; Cu, 10 g; I, 0.5 g; Se, 0.1 g.

The 21 of the most commonly used feed ingredients in dairy cattle were collected and oven dried in a 60℃ forced-driven oven for 48 hours. Samples were then ground through a 2 mm mesh screen and stored at -18℃ for *in situ* incubation and chemical analysis.

The procedure for ruminal incubation in this trial followed the method of Oskov and McDonald (1979) modified by Chiou et al. (1995). A feedstuff sample of approximately 8 g was packed and sealed into a 10 ×20 cm polyester bag (Ankom Co. Ltd., Spencerport, N.Y., USA). The pore size of the polyester bag was 53±10 μm. Each sample of 42 replicates for roughage and 30 replicates for other feedstuff with three replications per cow and an additional 6 replicates for 0 hour were prepared into individual nylon bags for the assay. Before being placed into the rumen for incubation, all sample bags were heat sealed, and placed into a 39℃ water bath for a 10 min. presoak. Three replicate sample for each incubation time were placed into the two fistulated cows. Every feed sample of the different replicates, with exception of the 0 h samples, were placed into three ruminal incubation periods, 12, 24, and 48 h for roughage, and two incubation periods 12, 24 h, for the other feedstuffs. The three 0 h incubation sample bags were directly rinsed with water only. The bags were strung onto an iron ring of 450 g. The string ring was then connected to the fistula outside the rumen by a nylon cord. The sample bags were placed into the rumen for different periods and were removed from the rumen simultaneously. After incubation, samples were put on ice to stop ruminal fermentation and then washed with water three times. Samples were then dried in a 60℃ force-driven oven for 48 h. Dried samples of the feedstuff and the incubated samples were determined by proximate analysis according to AOAC (1984). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were also analyzed according to Van Soest et al. (1991).

Analysis of variance was calculated with the general linear model procedure of the Statistical Analysis Systems Institute Inc. (1985). Duncan's new multiple range test was used to compare the treatment means (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Table 2 presents the chemical composition of ingredients that are commonly used in the dairy cattle industry in Taiwan. The feedstuffs include seven concentrates, eight forages and six by-products. Tables 3, 5 and 7 present the effects of AFE supplementation on *in situ* dry matter and organic matter degradation for the concentrates, forages and by-products, respectively. Table 4, 6 and 8 present the effects of *in situ* acid detergent fiber and neutral detergent fiber degradation of the concentrates, forages, and by-products, respectively.

The effects of AFE inclusion on the *in situ* nutrient degradation in rumen varied according the specific characteristics of the feedstuff. Among the concentrates, inclusion of AFE significantly depressed the first 12 hours of degradation in DM. OM, ADF, and NDF in soybean meal ($p<0.05$); it however, did not significantly influence the degradability of DM, OM, ADF, and NDF in soybean meal in 24 hours incubation. It showed a significant interaction by AFE inclusion and incubation period on the DM, OM and ADF degradation of soybean meal ($p<0.05$). Inclusion of AFE showed a trend of depressing DM and OM degradation of corn in 24 hours incubation as compared to the control diet. This may be attributed to the starch granular structure of corn. This can also

Table 2. The chemical composition of common feedstuffs in Taiwan, %

Ingredients	IFI number	DM	OM	CP	ADF	NDF
Concentrates						
Corn, dent	4-02-935	89.98	90.57	10.31	3.40	13.16
Corn, flake	4-02-864	90.40	89.24	9.88	4.43	10.80
Wheat	4-05-211	89.83	87.19	17.90	4.49	15.06
Soybean meal, 44%	5-04-612	90.85	93.38	47.12	8.02	14.18
Soybean, full-fat	5-04-608	93.30	91.21	43.15	8.76	11.31
Cottonseed	5-01-614	92.82	94.77	25.00	32.13	37.36
Rapeseed meal	5-08-135	90.76	79.41	44.94	18.13	24.58
Forages						
Alfalfa hay	1-00-050	90.00	82.24	24.36	33.38	39.80
Corn silage	3-02-912	21.99	90.32	8.08	28.84	51.49
Bermuda hay	1-00-713	91.65	84.43	11.34	26.85	60.04
Bermuda straw	1-00-210	91.20	83.19	7.10	31.03	67.43
Oat hay	1-03-	90.46	87.46	9.01	44.01	63.25
Pangola hay	2-03-493	92.65	84.46	8.79	35.94	64.73
Napiergrass	1-08-462	14.00	85.55	10.86	37.59	62.50
Peanut vine	1-03-619	89.93	88.29	13.70	33.40	39.08
By-products						
Wheat middling	4-05-205	89.93	86.85	19.87	8.04	27.92
Brewers grain, wet	5-02-142	23.00	90.80	28.53	22.78	53.41
Sorghum distiller's grain, wet	5-04-374	28.68	89.08	22.34	25.32	42.76
Rice distillers' grain, dried	5-	95.09	94.10	25.08	30.48	48.77
Soy pomace, dried	5-	90.36	87.99	25.79	27.40	36.18
Beancurd pomace, wet	4-	13.06	90.66	19.90	21.21	35.83

Table 3. Effect of *Aspergillus oryzae* fermentation extract supplementation on *in situ* dry matter and organic matter degradation of concentrates, %

	Dry matter				Organic matter			
	Control	AFE	SEM	P-value	Control	AFE	SEM	P-value
Corn yellow dent								
12 h incubation	73.20	73.33	2.76	0.9746	71.75	71.89	2.81	0.9975
24 h incubation	93.91[c]	92.14[d]	0.58	0.0827	93.54[c]	91.75[d]	0.60	0.0885
Corn, flake								
12 h incubation	67.08	64.04	3.43	0.5587	63.18	60.57	3.75	0.6435
24 h incubation	87.58	87.00	3.82	0.9183	86.94	86.01	4.40	0.8868
Wheat								
12 h incubation	91.70	92.25	0.48	0.4540	90.93	91.54	0.53	0.4514
24 h incubation	93.99	94.27	0.15	0.2450	93.44	93.79	0.15	0.1624
Soybean meal, 44%								
12 h incubation	91.65[a]	81.95[b]	1.96	0.0175	91.42[a]	81.05[b]	2.12	0.0180
24 h incubation	96.51	97.66	0.76	0.3345	96.42	97.60	0.78	0.3339
Soybean, full-fat								
12 h incubation	82.96	77.49	3.88	0.3646	81.25	75.93	4.17	0.4079
24 h incubation	87.78	91.98	6.63	0.6732	86.41	91.34	7.34	0.6547
Cottonseed								
12 h incubation	52.34	52.47	1.94	0.9640	43.75	43.72	1.68	0.9911
24 h incubation	58.27	54.97	1.57	0.1963	49.98	46.63	1.53	0.1835
Rapeseed meal								
12 h incubation	59.05	61.21	0.77	0.1052	61.00	55.52	5.78	0.5326
24 h incubation	72.13	71.61	0.60	0.5673	75.73	81.84	4.59	0.3898

[a,b] Means in the same row followed by different letters are significantly different ($p<0.05$).
[c,d] Means in the same row followed by different letters are significantly different ($p<0.10$).

Table 4. Effect of *Aspergillus oryzae* fermentation extract supplementation on *in situ* acid detergent fiber and neutral detergent fiber degradation of concentrates, %

	Acid detergent fiber				Neutral detergent fiber			
	Control	AFE	SEM	P-value	Control	AFE	SEM	P-value
Corn, yellow dent								
12 h incubation	50.92	34.08	11.05	0.3305	44.49	50.04	6.40	0.5670
24 h incubation	68.46	66.04	6.84	0.8037	71.43	68.19	3.83	0.5754
Corn, flake								
12 h incubation	55.52[a]	44.26[b]	2.77	0.0349	18.45	6.88	11.13	0.4954
24 h incubation	73.91	23.47	27.35	0.2490	61.62	41.88	10.65	0.2471
Wheat								
12 h incubation	46.27	52.67	2.40	0.1171	66.79	64.35	2.37	0.4992
24 h incubation	53.36	56.60	2.97	0.4768	67.76	69.47	0.68	0.1370
Soybean meal, 44%								
12 h incubation	66.56[a]	42.50[b]	4.39	0.0117	70.61[a]	55.18[b]	2.93	0.0136
24 h incubation	82.07	88.76	5.63	0.4385	84.18	90.10	3.63	0.3009
Soybean, full-fat								
12 h incubation	46.30	44.84	9.43	0.9168	37.18	25.37	14.64	0.5930
24 h incubation	31.76	85.72	37.83	0.3595	34.71	85.73	33.16	0.3263
Cottonseed								
12 h incubation	5.06	0.03	3.93	0.4066	-5.12	-2.75	1.98	0.4368
24 h incubation	10.18	3.53	2.71	0.1437	5.83	-1.24	4.35	0.3027
Rapeseed meal								
12 h incubation	19.68	24.69	5.18	0.5244	27.57[b]	41.87[a]	2.37	0.0079
24 h incubation	39.61	37.09	1.44	0.2705	49.97	53.97	2.63	0.4067

[a,b] Means in the same row followed by different letters are significantly different ($p<0.05$).
[c,d] Means in the same row followed by different letters are significantly different ($p<0.10$).

be explained from the different degradation rates of different fractions of carbohydrate in rumen (NRC, 1996; Nocek and Russell, 1988). This can also be proven from the depressing effect that AFE inclusion had on the ruminal degradation of corn flakes in which the starch grains were ruptured and partially gelatinized through the steam flake process (NRC, 1996). On the other hand, inclusion of AFE promotes NDF degradation in rapeseed meal in rumen ($p<0.05$).

It appears that the effects of AFE inclusion on the ruminal degradability of concentrates vary; soybean meal is the most responsive feedstuff, corn is the next, whereas full-fat soybean did not response to AFE inclusion at all. The inclusion of AFE significantly depressed degradation of most nutrients in the concentrates, especially soybean meal during the first 12 hour *in situ* incubation; this effect declined during 12 to 24 hour period. Rapeseed meal showed a different trend of response; addition of AFE improved its NDF degradation.

Response to AFE inclusion in the diet on nutrient degradation in the forages was most marked in corn silage, napier grass and peanut vine; Bermuda straw showed a modest response, and Bermuda hay the least response. Inclusion of AFE influenced ruminal degradation of most nutrients in corn silage; it depressed degradation of DM, OM, ADF, and NDF in both 12 and 24 h incubation. However, it increased degradation of ADF and NDF in the 48 h incubation. Napier grass showed a similar response in most of the nutrients except NDF. Most of the depressing effect of AFE inclusion on nutrient degradation became evident by 24 h incubation, with the exception of ADF degradation which showed a trend to increase with the inlusion. Inclusion of AFE showed an increased response of DM, OM, ADF, and NDF degradation in peanut-vine. Inclusion of AFE significantly increased DM and OM degradation ($p<0.05$) in peanut-vine during the first 12 hours, and showed only a trend towards increase during the second 12 hours ($p<0.10$) of ruminal incubation. The ADF and NDF however, showed significantly increased degradation by the AFE inclusion with the 24 hours incubation ($p<0.05$). Bermuda straw, on the other hand, did not significantly respond in increased OM, ADF, and NDF degradation until 24 hours incubation.

It appears that inclusion of AFE in the diet promoted ADF degradation in forage, but it normally

Table 5. Effect of *Aspergillus oryzae* fermentation extract supplementation on *in situ* dry matter and organic matter degradation of forages the in Taiwan, %

	Dry matter				Organic matter			
	Control	AFE	SEM	P-value	Control	AFE	SEM	P-value
Alfalfa hay								
12 h incubation	64.35	62.87	1.54	0.5252	55.00	54.00	2.03	0.6541
24 h incubation	74.52	75.77	1.25	0.5116	68.13	69.91	1.58	0.4633
48 h incubation	80.02	79.74	0.37	0.6088	74.93	74.69	0.45	0.7218
Corn silage								
12 h incubation	53.31^{a}	47.23^{b}	1.01	0.0079	52.82^{a}	46.53^{b}	1.04	0.0080
24 h incubation	65.37^{a}	59.78^{b}	1.36	0.0336	63.67^{a}	59.45^{b}	0.77	0.0118
48 h incubation	72.40	72.74	0.24	0.3697	72.26	72.99	0.33	0.1762
Bermuda hay								
12 h incubation	48.30	52.90	4.69	0.5192	42.33	47.42	5.15	0.5162
24 h incubation	62.64	60.57	4.55	0.7604	48.37	56.63	7.56	0.4749
48 h incubation	70.02	70.45	1.29	0.8211	66.80	67.55	1.38	0.7193
Bermuda straw								
12 h incubation	41.37	41.50	0.82	0.9319	33.25	34.01	1.13	0.6507
24 h incubation	52.31	53.37	2.11	0.7374	46.44^{b}	52.75^{a}	1.38	0.0231
48 h incubation	64.45	63.56	1.04	0.5731	60.44	59.38	1.14	0.5393
Oat hay								
12 h incubation	43.48	42.87	2.13	0.8476	39.17	38.44	2.34	0.8331
24 h incubation	52.87	53.17	2.69	0.9390	49.32	50.42	3.07	0.8097
48 h incubation	62.13	62.62	1.57	0.8364	60.02	60.18	1.78	0.9519
Pangola hay								
12 h incubation	48.78	46.34	2.19	0.4661	41.69	38.30	2.85	0.4385
24 h incubation	55.23	59.07	2.71	0.3620	49.38	53.01	3.44	0.4887
48 h incubation	66.49	67.49	1.31	0.6136	62.27	63.27	1.66	0.6889
Napier grass								
12 h incubation	35.59	39.13	2.30	0.3264	31.43	35.10	2.50	0.3474
24 h incubation	60.89^{c}	45.75^{d}	4.32	0.0884	59.41^{c}	42.46^{d}	4.89	0.0879
48 h incubation	55.35	57.94	2.88	0.5542	52.52	55.89	3.10	0.4987
Peanut vine								
12 h incubation	76.04^{b}	82.44^{a}	0.48	0.0002	74.14^{b}	81.06^{a}	0.51	0.0002
24 h incubation	80.99^{d}	83.20^{c}	0.74	0.0882	79.37^{d}	81.81^{c}	0.81	0.0872
48 h incubation	82.12	85.77	1.21	0.2675	80.66	84.62	2.22	0.2641

^{a,b} Means in the same row followed by different letters are significantly different ($p<0.05$).

^{c,d} Means in the same row followed by different letters are significantly different ($p<0.10$).

took a longer incubation period to respond. The response of AFE inclusion in nutrient degradation in corn silage and peanut-vine was different. This may attributed to the different ratio of carbohydrate fractions in the feedstuff. Corn silage contains all starch in 37.2% of nonstructural CHO and 44.6% structural CHO with 35.0% slow degradable CHO (B_2) and 9.6% unavailable CHO (C) (Sniffer et al., 1992). Peanut-vine contains 39.9% non-structural CHO with 38.1% sugar (A) and 1.8% starch, and 35.3% structural CHO with 19.4% slow degradable CHO and 16.0% unavailable CHO (Chiou, unpublished data). Most of the non-structural CHO in peanut-vine is soluble CHO and starch in corn silage, while both feedstuffs contain about same amount of non-structural CHO. These fast degradable carbohydrates in peanut-vine may have enhanced rumen fermentation, which resulted in faster response of AFE in nutrient degradation as compared to the intermediate degradable carbohydrate in corn silage.

The most responsive by-products on *in situ* nutrient degradation in rumen is rice distillers grains; wheat

Table 6. Effect of *Aspergillus oryzae* fermentation extract supplementation on *in situ* acid detergent fiber and neutral detergent fiber degradation of forages in Taiwan, %

	Acid detergent fiber				Neutral detergent fiber			
	Control	AFE	SEM	P-value	Control	AFE	SEM	P-value
Alfalfa hay								
12 h incubation	31.83	28.63	3.41	0.5367	26.31	24.62	2.48	0.6514
24 h incubation	37.78[d]	56.53[c]	6.30	0.0895	44.69	47.62	2.44	0.4349
48 h incubation	55.73	54.46	1.58	0.5943	56.16	59.19	1.77	0.2803
Corn silage								
12 h incubation	26.32[a]	16.80[b]	1.82	0.0141	30.78[a]	20.88[b]	1.90	0.0142
24 h incubation	42.51[a]	33.71[b]	1.27	0.0045	46.33[a]	39.94[b]	1.26	0.0158
48 h incubation	56.32[d]	59.22[c]	0.89	0.0689	59.21[b]	61.23[a]	0.60	0.0637
Bermuda hay								
12 h incubation	32.12	35.63	6.49	0.7176	35.16	40.56	5.65	0.5292
24 h incubation	49.49	47.90	5.42	0.8434	53.62	51.40	5.92	0.8015
48 h incubation	54.14	63.95	3.98	0.1415	62.94	65.52	1.76	0.3488
Bermuda straw								
12 h incubation	26.03	27.47	0.99	0.3501	31.89	32.04	1.62	0.9502
24 h incubation	41.17[b]	49.68[a]	1.98	0.0287	45.41[b]	51.97[a]	1.42	0.0220
48 h incubation	57.03	56.53	2.02	0.8688	59.97	59.51	1.61	0.8493
Oat hay								
12 h incubation	32.48	32.68	2.82	0.9607	27.70	27.34	2.56	0.8680
24 h incubation	47.25	48.35	2.98	0.8034	40.93	41.01	3.66	0.9874
48 h incubation	56.18	59.84	1.81	0.2115	52.32	54.24	1.98	0.5228
Pangola hay								
12 h incubation	28.12	19.53	5.59	0.3263	33.50	31.15	6.25	0.6512
24 h incubation	34.01	40.30	4.82	0.3982	43.26	48.46	4.39	0.4407
48 h incubation	49.65	55.65	3.11	0.2307	58.44	59.74	1.87	0.6426
Napier grass								
12 h incubation	15.46	23.26	2.17	0.0517	20.56	25.77	2.98	0.2706
24 h incubation	48.07	26.32	7.35	0.1311	52.02[c]	35.25[d]	4.69	0.0851
48 h incubation	42.53	45.63	4.28	0.6700	45.50	49.08	3.69	0.4693
Peanut vine								
12 h incubation	51.78[b]	66.88[a]	1.21	0.0003	51.11[b]	65.77[a]	1.68	0.0016
24 h incubation	61.24[b]	66.15[a]	1.25	0.0394	60.05[b]	65.76[a]	1.30	0.0268
48 h incubation	63.62	70.67	4.17	0.2849	62.66	70.84	4.60	0.3917

[a,b] Means in the same row followed by different letters are significantly different ($p<0.05$).

[c,d] Means in the same row followed by different letters are significantly different ($p<0.10$).

middlings, beancurd pomace and sorghum distillers grains are the next responsive, whereas brewers' grains respond least to the AFE inclusion. Inclusion of AFE increased DM and NDF of rice distillers grain in 12 hours and 24 hours incubation; OM degradation increased in 12 hours incubation and ADF in 24 hours incubation. The DM and OM degradation were increased by the AFE inclusion in 12 hours incubation ($p<0.05$). The response of AFE inclusion on wheat middling and sorghum distillers grain was inconsistent.

In general, effects of AFE inclusion on by-products degradability were inconsistent. Most of nutrients in rice distillers grain and some in beancurd pomace did show increased degradation by the AFE inclusion.

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Table 7. Effect of *Aspergillus oryzae* fermentation extract supplementation on *in situ* dry matter and organic matter degradation of by-products in Taiwan, %

	Dry matter				Organic matter			
	Control	AFE	SEM	P-value	Control	AFE	SEM	P-value
Wheat middlings								
12 h incubation	83.59	81.81	1.28	0.3704	82.01	79.74	1.28	0.2664
24 h incubation	87.42	87.25	0.56	0.8408	86.16	86.15	0.57	0.9865
Brewers grains, wet								
12 h incubation	57.03	53.75	1.87	0.2681	54.55	53.52	3.12	0.8256
24 h incubation	65.87	67.02	1.44	0.5987	63.68	65.52	1.51	0.4277
Sorghum distillers grain, wet								
12 h incubation	63.49	68.96	4.25	0.4052	57.25	65.90	6.87	0.4148
24 h incubation	78.78	76.90	2.42	0.6072	76.86	75.14	2.52	0.6504
Rice distillers grain, dried								
12 h incubation	38.23[a]	45.35[a]	0.96	0.0033	35.18[b]	41.10[a]	0.85	0.0044
24 h incubation	49.23[b]	60.89[a]	2.22	0.0139	47.72	68.90	8.50	0.1385
Soy pomace, dried								
12 h incubation	79.01	77.34	0.22	0.6220	77.73	75.92	2.30	0.6020
24 h incubation	87.62	85.33	1.46	0.3184	86.68	84.34	1.56	0.3182
Beancurd pomace, wet								
12 h incubation	49.70[b]	51.12[a]	0.35	0.0359	46.76[b]	48.35[a]	0.41	0.0396
24 h incubation	87.59	85.76	3.13	0.6975	86.92	85.04	3.33	0.7063

[a,b] Means in the same row followed by different letters are significantly different ($p<0.05$).
[c,d] Means in the same row followed by different letters are significantly different ($p<0.10$).

Table 8. Effect of *Aspergillus oryzae* fermentation extract supplementation on *in situ* and acid detergent fiber and neutral detergent degradation of by-products in Taiwan, %

	Acid detergent fiber				Neutral detergent fiber			
	Control	AFE	SEM	P-value	Control	AFE	SEM	P-value
Wheat middlings								
12 h incubation	38.56[a]	30.56[b]	2.02	0.0429	58.12[c]	48.31	3.42	0.0985
24 h incubation	45.60	47.43	2.76	0.6586	63.85	66.40	1.05	0.1458
Brewer's grains, wet								
12 h incubation	32.42	29.67	2.01	0.3778	37.44	35.55	2.32	0.5879
24 h incubation	43.50[c]	29.86[d]	4.04	0.0627	48.67	51.20	1.82	0.3688
Sorghum distillers' grain, wet								
12 h incubation	29.91	44.23	10.55	0.3809	42.10	39.58	13.08	0.8969
24 h incubation	55.20	53.80	3.07	0.7600	68.30	65.22	3.26	0.5323
Rice distillers grain, dried								
12 h incubation	27.11	34.53	2.67	0.1016	31.33[b]	38.13[a]	1.76	0.0408
24 h incubation	33.75[b]	50.80[a]	2.95	0.0094	41.04[b]	53.95	2.67	0.0189
Soy pomace, dried								
12 h incubation	65.46	64.42	4.77	0.8840	62.33	55.19	5.82	0.4250
24 h incubation	79.74	77.65	2.10	0.5134	73.74	69.78	3.44	0.4520
Beancurd pomace, wet								
12 h incubation	21.91	15.84	3.31	0.2506	29.95	28.83[a]	3.78	0.8423
24 h incubation	65.78	72.82	6.34	0.4681	75.65	75.29	5.58	0.9649

[a,b] Means in the same row followed by different letters are significantly different ($p<0.05$).
[c,d] Means in the same row followed by different letters are significantly different ($p<0.10$).

REFERENCES

AOAC. 1984. Official Methods of Analysis (14th Ed.). Association of Official Analytical Chemists, Washington, DC.

Chiou, P. W. S., K. J. Chen, K. S. Chen, J. C. Hsu and B.

Yu. 1995. Study on the protein degradabilitites of feedstuff in Taiwan. Anim. Feed Sci. Technol. 55:215-226.

Harris, B. and R. Lobo. 1998. Feeding yeast culture to lactating dairy cows. J. Dairy Sci. 77(Suppl. 1):276 (Abstr)

National Research Council. 1996. Nutrient Requirements of Beef Cattle, 7th ed., Washington, DC., Natl Acad. Sci.

National Research Council. 1989. Nutrient Requirements of Dairy Cattle, 7th ed., Washington, DC., Natl Acad. Sci.

Newbold, C. J. 1990. Probiotics as feed additives in ruminant diets. 51st Minn. Nutr. Conf. p. 102.

Nisbet, D. J. and S. A. Martin. 1991. Effect of a *Saccharomyces cerevisiae* culture on lactate utilization by the ruminal bacterium *Selenomonas ruminantium*. J. Anim. Sci. 69:4628-4633.

Nisbet, D. J. and S. A. Martin. 1993. Effects of fumarate, L-malate and an *Aspergillus oryzae* fermentation extract on D-lactate utilization by the ruminal bacterium *Selenomonas ruminantium*. Curr. Microbiol. 26:133-136.

Nocek, J. and J. B. Russell. 1988. Protein and carbohydrate as an intergrate system. Relationship of ruminal availability to microbial synthesis and milk production. J. Dairy Sci. 71:2070-2107.

Oskov, E. R. and I. McDonald. 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. J. Agric. Sci. (Camb.). 92:499-503.

Sniffer, C. J., J. D. OConnor, P. J. Van Soest, D. G. Fox and J. B. Russell. 1992. A net carbohydrate and protein system for evaluating cattle diets: II. Carbohydrate and protein availability. J. Anim. Sci. 70:3562-3577.

Statistical Analysis System Institute Inc. 1985. SAS Users Guide, version 5 edn. SAS Institute Inc., Cary, NC.

Steel, R. G. D. and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill, New York.

Van Soest, P. J., J. B. Robbertson and B. A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides on relation to animal nutrition. J. Dairy Sci. 74:3583-3597.

Waldrip, H. M. and S. A. Martin. 1993. Effects of an *Aspergillus oryzae* fermentation extract and other factors on lactate utilization by the ruminal bacterium *Megasphaera elsdenii*. J. Anim. Sci. 71:2770-2776.

Wallace, R. J., C. J. Newbold and N. McKain. 1990. Influence of ionophore and energy inhibitors on peptide metabolism by rumen bacteria. J. Agric. Sci. (Cambridge) 115:285-290.

Williams, P. E. V., C. A. G. Tale, G. M. Innes and C. J. Newbold. 1991. Effects of the inclusion of yeast culture (Saccharomyces cerevisiae plus growth medium) in the diet of dairy cows on milk yield and forage degradation and fermentation patterns in the rumen of steers. J. Anim. Sci. 69:3016-3026.