Feeding of *Aspergillus oryzae* Fermentation Culture (AOFC) to Growing Sheep: 2. Growth Rate and Feed Efficiency

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ABSTRAK

LUBIS, D., B. HARYANTO, E. WINA dan T. SUHARGIYANTATMO. 2002. Pemberian kultur fermentasi *Aspergillus oryzae* pada domba bertumbuh: 2. Laju pertumbuhan dan efisiensi penggunaan ransum. *JITV* 7(4): 214-219.

Penggunaan ragi dan atau jamur berfilamen sebagai pakan tambahan untuk ternak ruminansia telah menarik perhatian sejak akhir tahun 1980-an. Dua spesies jamur telah diproduksi secara komersial di Amerika Serikat, (1) Yea-Sacc® yang mengandung sel hidup *Saccharomyces cerevisiae* dan (2) Amaferm® berupa ekstrak fermentasi *Aspergillus oryzae*. Kultur jamur dapat mempercepat perkembangan dan fungsi rumen ternak muda. Makalah ini mencakup penggunaan kultur fermentasi *Aspergillus oryzae* (AOFC) sebagai pakan tambahan untuk domba Garut jantan muda fase pertumbuhan. *A. oryzae* dibiakkan pada suatu media yang dibuat dari tepung onggok yang diperkaya dengan campuran mineral. AOFC dipersiapkan dengan menginkubasikan jamur tersebut secara bertahap pada suhu ruang (26 – 30^{0}C) selama 5 hari, lalu dikeringkan pada suhu 40^{0}C dan digiling. AOFC ditambahkan ke dalam konsentrat komersial (GT-03) sebanyak 0, 5 dan 10% dari berat konsentrat (selanjutnya masing-masing disebut sebagai C_0 atau kontrol, C_1, dan C_2). Digunakan 15 domba Garut bertumbuh dan alokasi perlakuan pakan konsentrat dilakukan berdasarkan rancangan acak kelompok. Air minum tersedia setiap saat. Jumlah pakan yang diberikan (cacahan rumput Raja dan konsentrat) dan pakan yang tersisa ditimbang setiap hari, sedangkan domba ditimbang seminggu sekali pada pagi hari. Feses dikumpulkan dan ditimbang setiap hari selama 10 hari terakhir dari 14 minggu periode penelitian. Semua contoh pakan dan feses dianalisa untuk kandungan bahan kering, bahan organik, protein kasar, total serat (NDF), dan abu. Penambahan AOFC menghasilkan peningkatan pertambahan berat badan harian sebesar 94,81; 122,08; dan 140,52 g/h masing-masing untuk perlakuan C_0, C_1, dan C_2 ($P<0,05$). Konsumsi bahan kering, bahan organik maupun protein ransum juga meningkat dengan pemberian AOFC dalam pakan konsentrat ($P<0,05$). Peningkatan konsumsi nutrien tersebut berasal dari pakan konsentrat dan tidak ada perbedaan asupan nutrien dari rumput Raja, akan tetapi tidak didapatkan pengaruh dari pemberian AOFC terhadap efisiensi penggunaan ransum.

Kata kunci: *A. oryzae*, domba, pertambahan berat, efisiensi

ABSTRACT

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Utilization of yeast and or filamentous fungi as feed additive to ruminants has been of interest since the late 1980's. Two fungi species have been commercially produced in the United States, (1) Yea-Sacc® containing living cells of *Saccharomyces cerevisiae* and (2) Amaferm® bearing *Aspergillus oryzae* fermentation extract. It has been demonstrated and proven that the cultures can enhance rumen development and function in young ruminants. This paper concerns the use of *Aspergillus oryzae* fermentation culture (AOFC) as feed additive for young-growing male 'Garut' sheep. The *A. oryzae* was cultured in a media made of mineral-enriched 'onggok' flour, a material of tapioca processing waste. The AOFC was prepared gradually by incubating the fungus at room temperature (26 – 30^{0}C) for 5 days, dried at 40^{0}C and ground. The AOFC was added to a commercial concentrate (GT-03) at 0, 5 and 10% (w/w) levels, as treatment C_0 (control), C_1, and C_2, respectively. Fifteen growing 'Garut' sheep were used and the concentrate feed treatments were randomly allotted based on a randomized block design. Drinking water was available at all time. The amount of feed offered (chopped King grass and concentrates) and their refusals were weighed daily and live-weight of sheep was measured once a week in the morning. Daily feces was collected and weighed in the last 10 days of the 14-week experimental period. All feed and fecal samples were analyzed for dry matter, crude protein, total fiber (NDF), and ash. AOFC supplementation resulted in higher weight gains ($P<0.05$), which were 94.81; 122.08; and 140.52 g/d for C_0, C_1, and C_2 treatments, respectively. Dry and organic matter, as well as protein intake was also significantly increased by inclusion of AOFC into concentrate diet ($P<0.05$). The increment in nutrient intake was from increased consumption of concentrates, and not from King grass, however, there was no effect of AOFC supplementation on feed efficiency.

Key words: *A. oryzae*, sheep, gain, efficiency

INTRODUCTION

Feeding a probiotic to animals, especially ruminants, was primarily intended to improve the efficiency to convert feedstuffs consumed to produce meat or milk. Utilization of products based on yeast and/or filamentous fungi (analogues to probiotics) has enormously received increased interest since the late 1980's. It has been demonstrated and proven to enhance foregut development and function (WALLACE and NEWBOLD, 1992). BEHARKA *et al*. (1991) reported that the development of the rumen of young calves was stimulated by feeding *A. oryzae* fermentation extract, characterized by higher total bacterial counts, including amylolytic, pectinolytic, cellulolytic, and hemicellulolytic bacteria, from the second week of life onwards. To date, at least two fungi species have been commercially produced as feed additives, i.e. Yea-Sacc® containing living cells of *Saccharomyces cerevisiae* and Amaferm® bearing *Aspergillus oryzae* fermentation extract.

While many experimental results indicate positive effects of feeding probiotics to ruminant productivity, most studies were concerned with lactating dairy cows and its digestive physiology. One of the living microorganisms that has been used is *Aspergillus oryzae*. Research on the use of *A. oryzae* culture as a feed additive feed for lactating cows, beef cattle, and sheep indicated variable response. HARRIS *et al*. (1983) reported that feeding *A. oryzae* fermentation culture at 56 g/d to lactating dairy cows fed on corn silage as basal diet, resulted in increased milk production and milk fat content, but was not found in cows fed cottonseed hulls. HUBER *et al*. (1985) found that adding 90 d/g of *A. oryzae* culture increased milk production from 18.5 kg/d to 20.2 kg/d. Other researchers reported that the effect of feeding *A. oryzae* on milk production was more significant in early lactation period from 1 to 90 days (WALLENTINE *et al*., 1986; KELLEMS *et al*., 1987; 1988).

Feeding *A. oryzae* culture in a ration containing more non-fibrous carbohydrates gave better results than in rations containing less non-fibrous carbohydrates (SIEVERT and SHAVER, 1993). The finding suggests that the effect of *A. oryzae* as a feed additive was more realized in high-energy or less fiber diets. Most recently, CHIOU *et al*. (2002) in an experiment with lactating dairy cows found that feeding corn silage supplemented with *A. oryzae* fermentation extract ('Amaferm') in hot season increased dry matter consumption and milk production, however, increased milk production was more significant in cold season, but not accompanied by increased dry matter intake. Cows may need less protein and energy in cold season with Amaferm supplementation or more efficient use of nutrients.

In this experiment, feeding a commercial concentrate substituted with *Aspergillus oryzae* fermentation culture (AOFC) and chopped fresh King grass as a basal diet was conducted with growing 'Garut' sheep.

MATERIALS AND METHODS

As reported in the previous paper (LUBIS *et al*., 2002), the animals used in the present experiment were 15 male growing 'Garut' sheep having initial live-weight range from 13.7 to 20.0 kg. *Aspergillus oryzae* fermentation culture (AOFC) was prepared using tapioca processing waste ('onggok') flour as media. The fungus *A. oryzae* (derived from the previous experiment dealing with *in vitro* digestion test on fibrous feeds) was *A. oryzae* SP_{66} (AO). AO grown in mineral-enriched cooked rice was used as *inoculum* for the production of AOFC based on mineral-enriched 'onggok' within two months before the study. Three concentrate feeds were prepared: (C_0) a commercial concentrate (GT-03, Indofeed Co., Ltd.) as control, (C_1) GT-03 supplemented with 5% (w/w) AOFC, and (C_2) GT-03 supplemented with 10% (w/w) AOFC (Table 1). The GT-03 (label) contains 16% crude protein (12% digestible protein), 4% ether extractibles (crude fat), 7% crude fiber, and 8% ash, with 68% total digestible nutrients.

The feeding trial was carried out from early August till mid November 2001 at the sheep research station of the Indonesia Research Institute for Animal Production (IRIAP) in Bogor. Valbazen® was given to all sheep at a week before the study was commenced to control digestive tract worms. The animals were grouped into 5 blocks based on live-weight, and dietary treatments were allotted to sheep in a randomized block design with five replicates (MONTGOMERY, 1984). The first two weeks of the feeding experiment was an adaptation period to adjust the amount of feed offered. Chopped fresh King grass was fed in the morning (at 07:00) as much as 2 – 3 kg/h/d, and the concentrates were fed at 10:00 – 11:00 at the rate of 500 g/h/d. Drinking water was available during the experimental period. Feed refusals were weighed the next morning before feed offered. The sheep were weighed every Monday morning before feeding.

Feces of the sheep was collected and weighed daily over the last 10 days of experimental period. All feed and fecal samples were analyzed for dry matter, crude protein, total fiber (NDF), and ash. Parameters recorded were feed intake, weight gain, and feed efficiency. Analysis of variance of data recorded were run using general linear model according to Statistical Analysis Systems (SAS, 1996).

Table 1. Nutrient composition (in dry matter) of concentrate diets and King grass fed to sheep

Nutrient	King grass	Concentrates		
		C_0	C_1	C_2
Dry matter, %	28.40	83.41	88.02	87.39
Gross energy, Mcal/kg	3.131	3.744	4.004	4.287
Crude protein, %	7.97	14.27	14.99	15.16
Total fiber (NDF), %	82.52	40.35	39.40	36.81
Ash, %	11.54	8.87	8.02	8.50

* C_0: control (GT-03); C_1: GT-03 with 5% AOFC; C_2: GT-03 with 10% AOFC

Duncan's multiple range tests was applied to determine differences in mean values of parameters measured between dietary treatments.

RESULTS AND DISCUSSION

Supplementation of AOFC at 10% in the concentrate diet increased feed consumption and body weight-gain of sheep, but no effect on feed efficiency. The average daily gain of sheep fed with 10% AOFC supplementation was 48% above that of control sheep.

Feed consumption

Total dry matter consumption varied between 593 to 971 g/d and analysis of variance indicated differences between treatments ($P<0.05$). On average, total dry matter intake increased 18% of sheep fed the concentrate diet with 5% AOFC supplementation and 16% of sheep fed the concentrate with 10% AOFC supplementation (Table 2), however, dry matter intake of sheep fed on AOFC treatments was similar. Forage dry matter intake of sheep given the three dietary treatments was similar ($P>0.05$).

Increased concentrate intake with the presence of AOFC was probably due to increased palatability. The concentrate feed containing 5% (C_1) and 10% (C_2) AOFC smelled better than the control concentrate (C_0).

Another possibility is due to increased digesta flow from the rumen as fiber and protein digestibility were significantly higher in sheep fed on concentrate with AOFC supplementation (LUBIS *et al*., 2002). VAN SOEST (1983) stated that better rumen digestion will make ingested feed finer and more available while the

Table 2. Nutrient consumption (g/d) of sheep fed a concentrate supplemented with AOFC

Ration	Dietary treatment			Significance level
	C_0	C_1	C_2	
Dry matter:				
King grass	$355.8^a \pm 110.9$	$457.8^a \pm 70.0$	$452.6^a \pm 57.8$	0.1746
Concentrate	$414.0^a \pm 8.9$	$447.4^b \pm 4.3$	$442.0^b \pm 8.5$	0.0002
Total ration	$769.8^a \pm 106.8$	$905.2^b \pm 74.1$	$894.6^b \pm 58.4$	0.0579
Organic matter:				
King grass	$314.7^a \pm 97.2$	$404.9^a \pm 61.9$	$400.4^a \pm 51.1$	0.1746
Concentrate	$377.3^a \pm 8.1$	$411.5^b \pm 4.0$	$404.4^b \pm 7.7$	0.0001
Total ration	$692.0^a \pm 94.4$	$816.5^b \pm 65.7$	$804.8^b \pm 51.7$	0.0599
Crude protein:				
King grass	$28.36^a \pm 8.84$	$36.5^a \pm 5.58$	$36.06^a \pm 4.61$	0.1743
Concentrate	$59.06^a \pm 1.24$	$67.08^b \pm 0.69$	$67.02^b \pm 1.28$	0.0001
Total ration	$87.42^a \pm 8.28$	$103.58^b \pm 6.24$	$103.08^b \pm 4.79$	0.0091

[a,b]Different superscripts in one row denote and significant difference ($P<0.05$)
*C_0: control (GT-03); C_1: GT-03 with 5% AOFC; C_2: GT-03 with 10% AOFC

increase in rate of passage through the reticular-omasal orifice may reduced regurgitation needed. The combination of higher digestibility and digesta passage will increase feed intake. This physical factor has been determined as an important trigger of feed intake regulation, together with chemostatic-thermostatic regulation (MCDONALD *et al*., 1981). Increased feed intake with *A. oryzae* supplementation was also reported in lactating dairy cows (VAN HORN *et al.*, 1984; HUBER *et al*., 1986; GOMEZ-ALARCON *et al*., 1991; DENIGAN *et al*., 1992; SIEVERT and SHAVER, 1993) and in male calves (BEHARKA *et al*., 1991).

Similar circumstances with organic matter and crude protein intake are found in sheep fed the AOFC supplemented concentrates (Table 2). Increased protein intake follows increased protein digestibility in sheep that consume the AOFC supplemented diets (LUBIS *et al.*, 2002). Protein intake of sheep with 15 – 20 kg live-weight in this study was within the standard requirements (95 – 119 g/d) of tropical sheep to gain 100 g/d (KEARL, 1982).

Weight gain and feed efficiency

The standard deviation of daily weight gain means was wide (Table 3), hence no difference ($P>0.05$) in weight gain of sheep given the concentrates with AOFC supplementation (C_1 and C_2). Weight gain of sheep on treatment C_2 was 48% above ($P<0.05$) that of sheep on control diet (C_0). Daily gain in sheep fed AOFC was in line with significant increase in feed intake. Daily weight gains of sheep fed the 5% AOFC supplementation and control diet were similar ($P>0.05$).

Supplementation of AOFC at 10% in the concentrate diet increased ($P<0.05$) feed consumption and body weight-gain of sheep, but no effect on feed efficiency. The average daily gain was 48% above that of control sheep by 10% AOFC supplementation.

A faster growth rate of the sheep occurred in week-1 through week -4, but probably only a compensatory growth response to better quality diets. Thereafter, weight gain flattened till week-6 and variable increase to week-11, and steadily increase till week-14 (Figure 1).

Improved daily weight gain by feeding *A. oryzae* fermentation extract was also reported with steers by RUSH *et al*. (1990), with young sheep (HERRING *et al*., 1898 (*in* YOON and STERN, 1995), and calves (BEHARKA *et al*., 1991). In addition, BEHARKA *et al*. (1991) reported increased efficiency with male calves.

In the persent experiment, no effect of AOFC supplementation was detected on feed efficiency. Other researchers were also found that feed efficiency was not influenced by *A. oryzae* supplementation (BEHARKA *et al*., 1991; GOMEZ-ALARCON *et al*., 1991). YOON and STERN (1995) in a review on the use of *A. oryzae* supplement in ruminant diets stated that the results in feed efficiency were inconclusive. Diet composition and environmental conditions influence physiological activities of the animals digestion processes.

Feed efficiency determined by observed weight gain and feed intake should include rumen microclimate changes, such as conversion of nutrients into gasses (methane and carbon dioxide). If volume of gasses produced was reduced with the presence of AOFC, more energy will be available to the animals. High concentration of gasses in the rumen will reduce rumen pH since methane and carbon dioxide have acid properties. LUBIS *et al.* (2002) reported as part of this study, that rumen pH in sheep fed with AOFC was close to neutral, thus, more suitable for microbial fermentation process, resulting in increased nutrient digestibility, especially structural carbohydrates like cellulose and hemicellulose (VAN SOEST, 1983). FRUMHOLTZ *et al*. (1989) found that methane production in the rumen was reduced with the addition of *A. oryzae* culture using rumen simulation technique. Such changes have important consequences as a shift in rumen fermentation pattern may affect efficiency of nutrient utilization by the animals (WILLIAMS and NEWBOLD, 1990).

Table 3. Weight gain and feed efficiency of sheep fed AOFC supplemented diets

Parameter	Dietary treatments			Significance level
	C_0	C_1	C_2	
Daily gain (g/d)	$94.81^{a} \pm 30.42$	$122.08^{ab} \pm 18.62$	$140.52^{b} \pm 18.03$	0.0341
Feed efficiency	$0.12^{a} \pm 0.04$	$0.14^{a} \pm 0.03$	$0.16^{a} \pm 0.01$	0.0894

[a,b] Different superscripts in one row denotes significant difference ($P<0.05$)
*C_0: control (GT-03); C_1: GT-03 with 5% AOFC; C_2: GT-03 with 10% AOFC

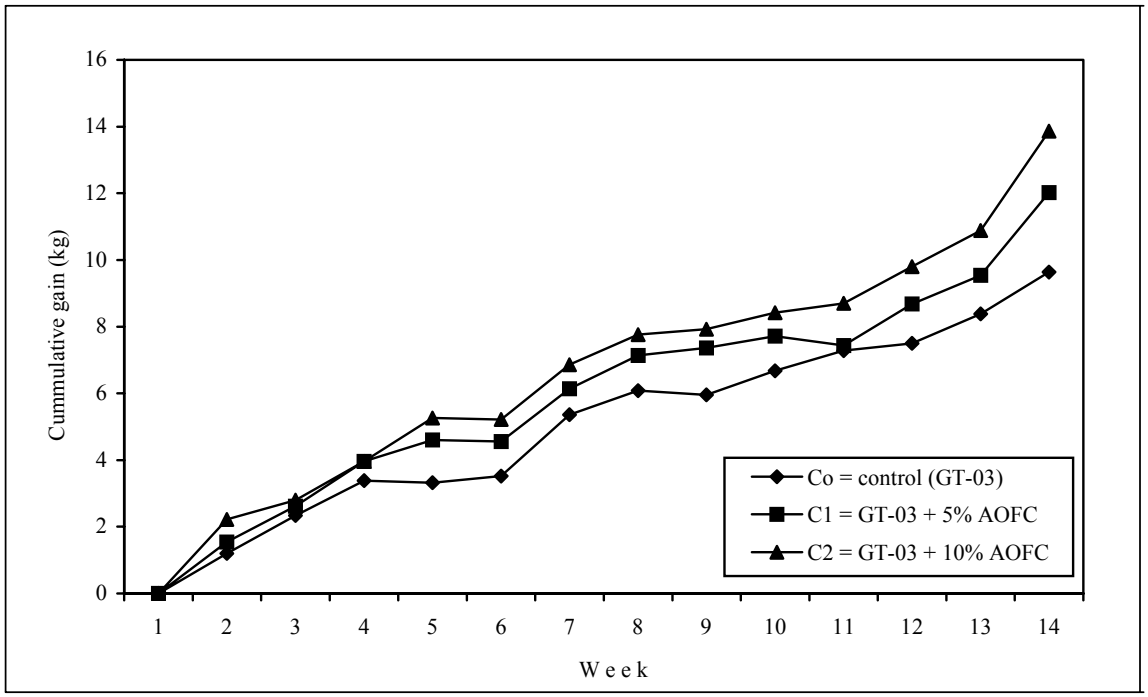

Figure 1. Growth rate of sheep fed concentrates with AOFC supplementation

CONCLUSION

Sheep growth was very responsive to feeding *Aspergillus oryzae* fermentation culture (AOFC) at 10% level in concentrate diet. Total dry matter intake was significantly increased, but no effect on forage (King grass) consumption. Further, feed efficiency was not influenced by AOFC supplementation.

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