濃厚飼料多給下の褐毛和種肥育牛の成長に及ぼす活性炭給与の効果

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Growth Performance of Japanese Brown Cattle Fed Concentrate-Based Diets with and without Activated Charcoal in Practical Beef Operations

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A simultaneous feeding trials with beef cattle under 4 practical beef operations in Kumamoto Prefecture were carried out to evaluate the effects of activated charcoal (AC) on fattening cattle fed concentrate-based diets. In experiment 1, the incorporation of 0.3% AC in diet showed an improvement in the daily gain (DG) of animals for Farms A, B and C compared to the reference animals by 28.6%, 16.0% and 14.8%, respectively. However, little effect on DG was noted in Farm D. The marked improvement on feed conversion ratio in Farms A and C were indicated to be 31.2% and 28.6%, respectively. In experiment 2, however, the addition of 0.3% AC to diet in Farms A and B was found to be not different in DG of animals from that of the reference diet. However, a marked improvement on DG was noticed in 0.3% AC diet in Farm C which was 33.6%. In trials 1 and 2 of Farm D, the growth performance of animals were slightly improved by the incorporation of 0.3% AC in the diet.

Introduction

The previous researches conducted on beef cattle under scientific and practical feeding conditions have shown that the incorporation of 0.3% AC in diet improved the growth performance of Japanese Brown cattle (7). Nevertheless, the previous studies on the effect of AC on the growth performance of sheep have shown either no effect or tendency to improve especially during the first 2-week period of feeding concentrate-based diets (Garillo *et al.*, unpublished data). The positive results obtained in beef cattle have not been properly answered nor documented although considerable trials have already been carried out. However, it is possible that the changes in rumen fermentation might be involved due to the enormous surface area of AC which results in higher adsorbance capacity of inorganic and organic compounds. In addition, it seems that AC have the buffering capacity in the rumen as observed by Garillo *et al.* (2, unpublished data) which was evidenced by the increase tendency of ruminal pH in mature goats 4 hours after feeding AC diet.

This study is concerned principally about the effect of AC on the growth of Japanese Brown cattle to further substantiate the positive results obtained by the authors especially under institutional (unpublished) and practical feeding conditions of beef farmers.

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Materials and Methods

Experiment 1. A total of 36 Japanese Brown cattle of about 9 to 20 months of age were used involving 4 beef cattle farms. The animals in each farm were divided into two groups, one for reference and the other for treatment with AC diet. During the experimental phase, the body weight of the animals was measured every 2 to 3 months depending on the

availability of the farmer. The feed intake of animals was taken on a monthly basis and feed conversion ratio (FCR) was calculated. The AC (Nacalai Tesque Co., Kyoto, Japan) was incorporated at a rate of 0.3% of feed dry matter (DM) offered just before feeding. Feed was given once a day in Farm A, while in Farms B, C and D it was offered twice a day. The chemical composition of feed offered in 4 farms were different.

For Farm A, the feed was a mixture of flaked soybean, formula feed, Alfalfa pellet, bagasse and rice straw. During the final stage of fattening, an amount of 50 grams of flaked barley per head was supplemented. Diets offered by Farm B were formula feed, fermented feed (Jyanbori, Zennou), rice straw plus small amount of bagasse. The diets in Farm C were formula feed, fermented feed (Dairy Power, Futaba Feed Inc.) plus rice straw, and for Farm D, a mixture of formula feed, fermented feed (Dairy Power) and small amount of flaked soybean and Alfalfa pellet or straw. The experiment was undertaken from September 9 to January 16 on Farm A, September 18 to January 17 on Farm B, October 7 to January 17 on Farm C, respectively, while for Farm D it was performed from October 7 to February 17.

For the chemical analysis of diets, pooled feed samples were oven dried at 55°C for about 48-72 hours. Proximate analysis was performed by the AOAC (1984) standard procedures. The components measured were crude ash (CA), crude protein (CP), acid detergent fiber (ADF) and gross energy (GE). Growth performance data of animals in Farms A and C were analyzed using single factorial design, while in Farms B and D the data were analyzed using single factorial design with an equal replicates in complete randomized design (6).

Experiment 2. A total of 48 Japanese Brown cattle of about 9 to 19 months of age in 4 beef farms were used in this study. The animals in each farm were divided into two groups, one for reference and the other for treatment with AC diet. During the experimental phase, the body weight of the animals was measured every 2 to 3 months depending on the availability of the farmer. The AC (Nacalai Tesque Co., Kyoto, Japan) was incorporated at a rate of 0.3% of feed DM offered just before feeding. The feed intake of animals was taken on a monthly basis and FCR was calculated. In farms A and B the feed was offered once a day, while in farms C and D feed was offered twice a day. Fermented feed used in Farms A and B was Jyanbori, while the fermented feed offered in Farms C and D was Dairy Power which have a high content of DM than Jyanbori. Feed intake of the experimental animals was measured monthly. The duration of the study ranged from April 27 to December 1 for Farm A, from April 27 to January 25 for Farm B, October 7 to December 2 and October 11 to January 17 for Farm C, respectively, while for trial 1 of Farm D it did from October 7 to July 30 and for trial 2 from October 7 to February 17. Monthly pooled feed samples for chemical analyses were taken and analyzed following the procedures described previously in experiment 1.

All pertinent data for Farms A, B and C were recorded and analyzed using single factorial design, while for farm D it was analyzed using single factorial design with unequal replicates in complete randomized design (6).

Results

Table 1 presents the chemical composition of feed offered to animals in Farms A, B, C and D in experiment 1. The composition of the feedstuffs analyzed were in normal ranges. The DM intake of the animals in 4 different farms as well as the nutrient intake for the whole experimental period is presented in Table 2. There was no difference of feed intake between treatments because the amounts of feed offered was restricted, depending on the amount of feed refusals.

Table 3 indicates the effect of AC on daily gain (DG) and FCR of the animals. In farm A, the DG was noted to be higher by 28.6% and the FCR was improved by 31.2% for the inclusion of 0.3% AC. The DG and FCR in Farm B were both improved by the incorporation of 0.3% AC being 16.0% and 6.0%, respectively, as compared to the reference diet. Moreover, in Farm C an almost similar improvement was observed to that of Farm B in terms of DG. Further, a marked improvement on

FCR was noted in Farm C by 29.0% and the result was concurrent with that of the data obtained in Farm A being 31.2% as compared to the reference diet. However, comparing to the FCR obtained in Farms A and C, the values obtained in Farm D were quite different where the animal fed on reference diet showed slight improvement of FCR by 6.0% as compared to the 0.3% AC diet.

Table 4 indicates the chemical composition of the diets offered in experiment 2. The CP contents of feed in B and D farms were very high. The effect of AC on DM intake is presented in Table 5.

Table 1. Chemical composition of the feed offered in Experiment 1

Farm	Period	g/100g DM			GE
		CA	CP	ADF	Mcal/kg
A	Oct	4.93	13.87	6.87	4.38
	Nov	5.17	13.00	16.54	4.40
	Dec	5.43	14.29	13.51	4.48
	Jan	4.72	14.15	12.74	4.49
B	Oct	7.66	14.71	27.44	4.59
	Nov	5.77	15.09	27.03	4.74
	Dec	7.13	17.12	24.38	4.54
	Jan	6.73	15.19	25.87	4.68
C	Oct	7.92	15.54	18.62	4.47
	Nov	5.52	18.83	15.75	4.66
	Dec	6.32	18.95	14.95	4.60
	Jan	4.98	17.11	15.71	4.61
D	Oct	6.64	15.08	18.58	4.46
	Nov	6.00	14.71	20.49	4.52
	Dec	7.05	14.76	16.82	4.30
	Jan	6.69	15.49	17.78	4.50

Table 3. Effect of AC on growth of the animals in Experiment 1

Farm	Diet	No of Animal	Body Weight, kg		DG, kg/day	FCR*
			Initial	Final		
A	Reference	4	550.0	663.5	0.56	11.91
	0.3% AC	4	590.5	675.5	0.72	9.08
B	Reference	5	547.2	631.5	0.66	9.67
	0.3% AC	4	581.0	673.0	0.76	9.13
C	Reference	4	286.8	416.8	1.28	5.26
	0.3% AC	4	281.5	431.5	1.47	4.08
D	Reference	6	504.2	614.2	1.08	10.44
	0.3% AC	5	436.6	550.2	1.11	11.09

*FCR—feed conversion ratio

Table 2. Effect of AC on feed intake of the animals in Experiment 1

Farm	Period	DMI, kg/hd/day			kg/hd/day		GE
		*CONC	*ROUGH	Total	CP	ADF	Mcal/hd/day
A	Oct—Nov	5.73	0.91	6.64	0.89	0.78	29.13
	Dec—Jan	5.64	0.76	6.40	0.91	0.84	28.59
B	Oct—Nov	6.50	1.36	7.86	1.17	2.14	36.66
	Dec—Jan	6.01	1.71	7.72	1.28	1.94	35.56
C	Oct—Nov	5.68	0.81	6.49	1.11	1.12	29.59
	Dec—Dec	6.03	0.43	6.46	1.17	0.99	—
D	Oct—Nov	8.73	2.46	11.18	1.67	2.18	53.20
	Dec—Jan	9.16	1.40	10.56	1.60	1.83	—

*CONC and ROUGH mean concentrates and roughage, respectively.

Table 4. Chemical composition of the feed offered in Experiment 2

Farm	Period	g/100g DM		
		CA	CP	ADF
A	Apr to Jun	8.08	18.68	15.64
	Jul to Sep	7.58	18.66	15.73
B	Apr to Jun	12.39	26.58	31.40
	Jul to Sep	12.78	26.05	33.49
	Oct to Dec	12.11	28.35	36.44
C	Mar	5.61	19.10	14.54
	Apr to Jun	6.69	18.91	15.97
	Jul to Sep	6.20	18.41	15.62
	Sep to Nov	5.89	18.38	13.88
D	Mar-to Aug	8.13	22.52	21.96
	Sep to Nov	11.68	23.47	31.29
	Nov	10.38	20.98	29.17

So far no treatment differences were noted in terms of DM intake between the reference and 0.3% AC diets in Farms A and B. However, in Farm C during the period from September 11 to November 15, the DM intake was noted to be increased on the reference diet as compared to the 0.3% AC diet. Likewise, in farm D, the animal on reference diet showed slightly higher intake from September to January. However, during the months of October to November and January to March, the DM intake for 0.3% AC diet was observed to be slightly higher as compared to that of the reference diet. Table 6 presents the growth performance of the animals in experiment 2. It can be noted that the DG of animals that received 0.3% AC diet in Farms A and B were found to be not different from that of reference diet. In Farm C, however, a marked improvement on DG was noticed on 0.3% AC diet being 36.6%. In Farm D, both trials showed the slight improvement by the addition of 0.3% AC in the diet. On the other hand,

Table 5. Effect of AC on dry matter intake of the animals in Experiment 2

Farm	Period	Reference diet, kg/hd/day			AC diet, kg/hd/day		
		CONC	ROUGH	Total	CONC	ROUGH	Total
A	28 Apr - 13 Jul	8.08	0.86	8.94	8.08	0.86	8.94
	13 Jul - 21 Sep	7.68	0.87	8.55	7.68	0.87	8.55
	21 Sep - 15 Nov	—	—	—	7.49	0.87	8.36
B	27 Apr - 13 Jul	6.75	1.43	8.18	6.75	1.43	8.18
	13 Jul - 21 Sep	6.80	1.42	8.22	6.80	1.42	8.22
	21 Sep - 15 Nov	6.42	1.42	7.84	6.42	1.42	7.84
C	7 Oct - 21 Nov	5.34	0.94	6.28	5.72	0.93	6.65
	21 Nov - 17 Jan	5.52	0.63	6.15	5.46	0.59	6.05
	17 Jan - 27 Mar	7.48	0.87	8.35	7.55	0.81	8.36
	27 Mar - 30 Jun	7.57	0.86	8.43	7.64	0.81	8.45
	30 Jun - 11 Sep	7.90	0.64	8.54	7.90	0.58	8.48
	11 Sep - 15 Nov	8.78	0.73	9.51	7.58	0.57	8.15
D	7 Oct - 21 Nov	9.42	1.42	10.84	8.18	3.48	11.66
	21 Nov - 17 Jan	9.32	1.39	10.71	9.04	1.76	10.81
	17 Jan - 27 Mar	8.02	1.19	9.21	9.23	1.36	10.59
	27 Mar - 30 Jun	—	—	—	6.77	0.73	7.50
	11 Sep - 15 Nov	5.98	2.47	8.45	4.70	2.47	7.17
	15 Nov - 25 Jan	7.64	2.64	10.27	6.37	2.63	9.00

Table 6. Effect of AC on growth of the animals in Experiment 2

Farm	Diet	No of Animal	Body Weight, kg		DG, kg/day	FCR kg DM/kg gain
			Initial	Final		
A	Reference	4	564.6	698.5	0.92	9.66
	0.3% AC	4	525.5	664.0	0.89	10.00
B	Reference	5	339.0	664.4	0.99	8.12
	0.3% AC	5	389.2	646.4	0.94	8.57
C	Reference	4	286.8	728.0	1.10	8.40
	0.3% AC	4	281.5	431.5	1.47	6.95
D	Reference	6	504.2	679.0	1.02	9.96
	0.3% AC	5	436.6	627.8	1.12	9.87
	Reference	5	375.6	511.0	0.99	9.45
	0.3% AC	6	322.8	475.2	1.12	7.26

the FCR of animals in Farms C and D of trial 2 for the AC diet were 6.95 and 7.26, being 8.40 and 9.45 in the reference diet, respectively. In farms A, B and D of trial 1, the FCR were very similar between diets.

Discussion

In experiment 1, it can be noted that the DM intake of the animals on reference and 0.3% AC diets in Farms A, B and C were almost similar except in Farm D where the animals that received 0.3% AC diet showed higher DM intake than that of reference diet. In the previous experiment, Garillo *et al.* (unpublished data) noted that the incorporation of 0.5% and 1.0% AC in the diets of growing sheep fed concentrate-based diets did not show any significant effect on DM intake of the animals.

The positive results obtained on the effect of 0.3% AC on DG and FCR in experiment 1 was synonymous to the results observed by Tobioka *et al.* (7, unpublished data), who reported that Japanese Brown growing heifers and steers fed diets fortified with 0.3% AC had higher DG being 22.0% and 44.6% and improved FCR by 11.0% and 23.0%, respectively, as compared to those on the reference diet. Likewise, a marked effect of 0.3% AC diet was noted on the DG and feed efficiency of Japanese Brown cattle as compared to the reference diet during the cool and warm seasons as noted by Tobioka *et al.* (7).

The AC was shown to have some buffering capacity as evidenced by slight increase of ruminal pH after feeding in mature goats and growing sheep (2, unpublished data). Moreover, Trenkle (9) showed that the addition of 0.4% sodium bicarbonate to a diet of heifers resulted in a slight increase of DG (1.26 vs. 1.17 kg/day) and an 8.0% improvement of feed efficiency compared with the unsupplemented diet. Wilson and Brigstocke (11) indicated a marked response of feedlot cattle to sodium bicarbonate supplementation during the first months of the fattening period. Also, Tobioka *et al.* (7) observed that Japanese Brown cattle at middle stage of growth tended to improve the DG and FCR during the first month of feeding AC diet.

The incorporation of 0.5% and 1.0% AC into two treatment diets in growing sheep fed concentrate-based diets did not show significant effect on DG and FCR of the animals, however, a marked effect of AC on DG was noted during the first 2-week period of the experiment (Garillo *et al.* unpublished data).

This observation is in agreement with the findings of Huntington *et al.* (3) who indicated that the advantages derived from buffering materials could occur only during the period of adaptation to high concentrate diets. Further, Wheeler (10) has indicated that during the stage of introduction of animal to the feedlot, supplementation of sodium bicarbonate was especially useful in helping cattle adjust to the high concentrate ration.

The either no effect or tendency to improve DG and FCR with use of AC were also noted by Garillo *et al.* (unpublished data) in sheep. Likewise, Tobioka *et al.* (7) have also observed similar situation on growth performance of beef cattle. Furthermore, Marija *et al.* (4) evaluated the effects of bentonite supplementation on DG of fattening cattle, and they found no significant differences among the groups of bentonite, benural (42% urea, 3% sulfur + sodium bentonite) and the control, but the trend was in favor of the bentonite group.

In experiment 2, the positive effect of 0.3% AC on DG in Farm C could be attributed by improved or favorable rumen conditions wherein the efficiency of concentrate utilization was maximized due to the developed porous structure of the AC once activated through steaming. In addition, Garillo *et al.* (2) observed the increased tendency of ruminal pH in goats fed concentrate-based diets 4 hours after feeding with AC. The observed positive effect of AC on growth performance of cattle in the experiment was further substantiated. by the preliminary findings obtained by Tobioka *et al.* (8) who revealed that AC addition at a rate of 0.3% increased the pH and protozoa number in forestomach of hamsters. Similar observations were noted by Tobioka *et al.* (unpublished data) in growing heifers and castrated cattle fed concentrate-based diet with AC. Other possible contributing factor of the positive response of animals to AC diets could be due to other ruminal characteristics like decreased tendency of ruminal ammonia-nitrogen and increased tendency of propionate and acetate to propionate molar ratio as observed by Garillo *et al.* (2) in goats fed concentrate-based diets with 0.6% AC 4 hours after feeding. The similar results obtained between with and without AC diet in terms of DG to farms A and B were also noted by Nicholson and Cunningham (5) who reported that the addition of 5.7% sodium bicarbonate to the all-concentrate ration did not improve DG, feed efficiency or carcass grades. Likewise, Wise *et al.* (12) demonstrated that the rate of weight gain and feed intake were not affected by the addition of 1.14 kg of hay, but were decreased by the addition of 11.0% of sodium and potassium bicarbonate or 5% sodium and potassium acetate to the all-concentrate ration of 230 kg beef calves. The variability obtained in terms of DM intake between the reference and 0.3% AC diets in the study were also observed by Garillo *et al.* (2) who reported that feed intakes of goats fed concentrate-based diets were slightly lower in the 0.3% and 0.6% AC diets than in the reference diet. While Tobioka *et al.* (8) reported that AC addition at a rate of 0.3% AC increased the feed intake of the golden hamsters.

On the basis of data presented, it indicates that the fortification of 0.3% AC in the diet improved the DG of the 3 beef farms in experiment 1 by 19.8%, and the FCR of the 2 beef farms by 29.9%, both on the average values. In experiment 2, a similar trend was noted in the 2 beef farms with a mean improvement of 22.6% on DG of animals. Taking into account of the number of feeding trials conducted in this experiment, the improvement on growth performance was observed in the AC diet among 67% of trials. Therefore, the data obtained in this study substantiated the previous positive data of our study on the effect of AC on growth performance of beef cattle fattened under practical feeding condition. However, with the series of feeding trials in beef cattle, it was observed that in younger animals, the effect of AC was far improved in terms of growth performance.

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濃厚飼料多給下の褐毛和種肥育牛の成長に及ぼす活性炭給与の効果

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濃厚飼料多給下の肥育牛に活性炭を投与した場合の効果を，熊本県下の４戸の肥育農家で調査した．

第一試験で，飼料中に0.3％の活性炭を添加した場合，A，B，Cの３戸の農家では日増体量が対照区に比べてそれぞれ28.6％，16.0％，14.8％改善された．同様にA，C農家の飼料要求率は，それぞれ31.2％，28.6％改善された．しかし，D農家の日増体量は活性炭添加によってほとんど影響をうけなかった．

試験２では，A，B農家における活性炭添加区の家畜の増体は対照区と同様であった．しかし，C農家の日増体量は対照区に比べて33.6％大きかった．D農家の２回の試験では，活性炭の添加は家畜の成長を若干改善した．