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Xin Huo

Chayapol Meeprom

Wisitiporn Suksombat

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Original Article

Effects of Oleic Acid Enriched Oil Supplemented Diets on Feeding Behaviors in Cross-bred Brahman cattle

Xin Huo[1, 2] Chayapol Meeprom[1] Wisitiporn Suksombat[1,*]

Abstract

Two experiments were conducted to compare feeding behavior in the free choice of 3 kinds of oil supplemented diets, and in 2 kinds of oil supplemented diets in beef cattle. Of the two groups, the first group received approximately 6 kg/d of concentrate as a basal diet, whilst the other was a free choice group which was fed the same quantity of basal diet as the control, but 1 kg basal diet was supplemented with 35 g per meal of corn oil (CO), palm oil (PO), and rice bran oil (RO) respectively by top dressing. The 2nd experiment was conducted using the same animals as in the 1st experiment with the 1st group (control) receiving approximately 3 kg of concentrate per meal as a basal diet together with 0.5 kg of cassava pulp, while the 2nd (RO) and 3rd (PO) groups being fed the same basal diet supplemented with 100 g per meal of RO or PO, respectively. Results of the free choice test showed that the DMI of CO significantly decreased during the final 3 weeks of feeding (p<0.05). The highest percentage of total frequency of the behaviors was eating, followed by switches and visits. In the 2nd experiment, the oil supplemented diets affected the percentage of visits (p<0.01) and drinking (p<0.05). Significant differences in the percentage of jaw activities of the cattle were for eating and ruminating in period 1 (p<0.05). The highest percentage of eating and ruminating were found in the control group and PO groups (p<0.05), respective and the control and RO groups (p<0.05). The highest percentage of idling was shown during observation. In conclusion, the cattle preferred rice bran oil diet. The effects of the oil supplemented diets were not obvious in the frequency of behaviors during the 13-week feeding period. The oil supplemented diets did not affect the dry matter intake, feeding rate, spatial distribution and postures, but it could affect the feeding behavior in the final finishing period and the jaw activities in the beginning and finishing period.

Keywords: choice, Cross-bred Brahman cattle, feeding behavior, oil supplementation

[1]*School of Animal Production Technology, Institute of Agricultural Technology, Suranaree University of Technology, Nakhon Ratchasima 30000, Thailand*

[2]*Program of Agriculture, Faculty of Science and Technology, Nakhon Ratchasima Rajabhat University, Nakhon Ratchasima 30000, Thailand*

***Correspondence:** *wisitpor@sut.ac.th*

Introduction

A choice of feeding tests provides an opportunity to study factors influencing an animal's decision of what to eat and how much to eat under widely controlled conditions (Meier et al., 2012). It gives cattle a chance to choose their own diet so that their rumen can develop and they can be more comfortable (Boga et al., 2009). Vegetable oils are commonly added to ruminant diets to enhance the proportion of desirable unsaturated fatty acids in edible products (Raes et al., 2004). This increases biohydrogenation intermediates available for metabolism by a variety of ruminant animal tissues (Hess et al., 2008). Smith et al. (2006) reviewed that early research demonstrated that the concentration of oleic acid (18:1n-9) in beef is positively correlated with its overall palatability. This may be related to fat softness, because beef lipids enriched with oleic acid have lower melting points.

There are several oleic acid enriched oil supplements such as corn oil, palm oil and rice bran oil (Edem, 2002; Gunstone, 2002; Pavan et al., 2007, Aluyor and Ori-Jesu, 2008). Corn oil supplementation increased the efficiency of energy utilization as fat deposition and increased carcass fat thickness and weight without altering other carcass quality parameters (Pavan et al., 2007). Palm oil supplemented diets can be used to feed beef cattle in order to increase the amount of marbling and subcutaneous adipose tissues without negatively affecting beef fatty acid composition as was found by Smith and Johnson (2012). Moreover, Meeprom and Suksombat (2013) found that oleic acid enriched rice bran oil supplemented diets could decrease cooking loss and increase marbling score without affecting growth performance in a previous study.

Most of the choices of feeding tests in ruminants (Rodriguez et al., 2007; Gorgulu et al., 2008) are given in order to find whether the animals are able to correctly meet their nutrient requirements by selecting a diet corresponding to their physiological status and environmental conditions (Gorgulu et al., 2012). If we decide what animals would prefer to eat, we need to consider the animals' motivation and behavior. Motivation is a process that describes the force and persistence that an individual is willing to devote towards achieving a goal, which may include overcoming internal and external factors (Toates cited by Zobel, 2007). Therefore, it is important to consider the motivational state of the individual, in order to identify individual differences in the behavior of cattle.

However, there is no research which has focused specifically on the choice of feeding tests or feeding behavior in cross-bred Brahman cattle in Thailand. Therefore, the objectives of this research were to compare free choices of feeding of three different types of oil supplement in a three-week feeding period in beef cattle and various feeding behavior in different oil supplemented diet treatments in a thirteen-week feeding period in beef cattle. We hypothesized that the feeding choices of cattle might be different because of the different oil flavors, therefore the frequency and percentage of behavior of cattle in the free choice group and in the different oil supplemented diets group might be different from the control group.

Materials and Methods

Free choice test: Cross-bred Brahman male cattle (n=12) of two years of age with an initial BW of 304 ± 42 kg were used. The experiment was conducted according to a repeated measures completely randomized design and assigned to two indoor treatment groups. One group (control, n=3) received approximately 6 kg of concentrate (Table 1) per day as a basal diet, while the other (free choice, n=9) was fed the same basal diet concentrate (total 6 kg/d) as the control group, but 1 kg basal diet was supplemented with 35 g per meal of corn oil (CO), palm oil (PO) and rice bran oil (RO) by top-dressing. All feeds were delivered at 07:30 and 15:30 h daily. The cattle also received *ad libitum* rice straw, were housed in a free stall unit, and were individually fed according to the treatments. The study lasted for four weeks including a week of adaptation, followed by a three-week period of feeding. Data collection was conducted three times per week during the feeding period. BW, body weight gain (BWG) and ADG were measured between days 1 and 21 of the study. Animal cares followed the guidelines of the Committee on Care and Use of Laboratory Animal Resources, National Research Council of Thailand. Procedure of the experiment was performed with the advice of the Institutional Animal Care and Use Committee, Suranaree University of Technology, Nakhon Ratchasima, Thailand.

Visual observations were made (using a video camera) over 24 h to collect and store the animal behavior data. The feeding behavior of the animals was analyzed as previously described by Moya et al. (2011). The feed offered was recorded daily (total DMI) for each pen during the entire experiment. Time to measure feed

Table 1 Chemical composition of the feeds used in the experiment (Mean ± SD)

Composition	Concentrate	Rice straw	Cassava pulp
Dry matter (%)	**93.33**	**92.08 ± 0.01**	**91.14**
	----------% Dry matter----------		
Crude protein	11.80 ± 0.07	1.32 ± 0.02	1.87 ± 0.10
Crude fat	4.51 ± 0.15	1.52 ± 0.11	0.22 ± 0.03
Ash	6.59 ± 0.08	15.86 ± 0.24	4.10 ± 0.21
Crude fiber	13.45 ± 0.52	34.94 ± 0.21	18.56 ± 0.42
NDF	47.34 ± 1.89	73.58 ± 0.28	33.29 ± 0.23
ADF	32.16 ± 156.	59.15 ± 0.15	23.15 ± 0.18
ADL	3.58 ± 0.05	10.41 ± 0.03	3.79 ± 0.20
NDIN	0.12 ± 0.01	0.14 ± 0.01	0.10 ± 0.05
NDICP	0.75 ± 0.01	0.88 ± 0.01	0.63 ± 0.01
ADIN	0.17 ± 0.02	0.16 ± 0.01	0.93 ± 0.04
ADICP	1.06 ± 0.02	1.00 ± 0.01	5.81 ± 0.01
*dg*DM	48.30	17.80	46.30
*dg*CP	45.00	-	42.30

NDF = Neutral detergent fiber, NDIN = Neutral detergent insoluble nitrogen, NDICP = Neutral detergent insoluble crude protein, ADF = Acid detergent fiber, ADIN = Acid detergent insoluble nitrogen, ADICP = Acid detergent insoluble crude protein, ADL = Acid detergent lignin

feed intake of each oil supplemented diet in the free choice test was limited to 30 min/meal, and then the orts of three feeding buckets were weighed for DM determination. Therefore, DMI was determined for each diet per pen as DM offered minus DM refused within 30 min. After the measurement of DMI, the orts were returned to the cattle to continue feeding.

Frequency of switches between the feeds on offer was recorded (Ginane et al., 2002). Frequency of visits was calculated as the number of feeding visits per meal within 30 min. Frequency of eating, self-grooming, drinking, and disturbance from neighbors was recorded within 30 min/meal per day. An observation was defined as eating when the cattle ate from the feed buckets with their muzzles in the feed buckets or chewed or swallowed feed with their heads over the buckets. Self-grooming was self-licking any part of the body or scratching the body against fixtures of the stall. An observation was recorded as drinking when the cattle held their muzzles in the water bowl or swallowed water. Disturbance from neighbors was when at least one of the neighbors had its muzzle inside the stall of the experimental cattle (Herskin and Munksgaard, 2000; Robles et al., 2007). All data were expressed by percentages. Total behavioral frequency was summed by the data in the morning and afternoon.

Feeding test: Two-year-old Cross-bred Brahman steers (n=12) with an initial BW of 322 ± 12 kg were used. The experiment was conducted according to a repeated measures Latin-square design, and assigned to three indoor treatment groups. The 1st group (control, n=4) received approximately 3 kg of concentrate (Table 1) per meal as a basal diet and 0.5 kg of cassava was added per meal. The 2nd group (rice bran oil (RO), n=4) and 3rd group (palm oil (PO), n=4) were fed the same basal diet (3 kg) as the control, but the basal diet was supplemented with 100 g per meal each of RO and PO, respectively. All feeds were delivered at 07:30 and 15:30 h daily. The cattle also received *ad libitum* rice straw, had free stall units and were individually fed according to the treatments. The study lasted for 14 wk including a week as an adaptation period, followed by a 13 wk period for feeding.

The method of measuring DMI was the same as in the 1st experiment. The authors conducted data collection three times during the 13 wk feeding period, was divided into three periods, namely, period 1 (days 26, 27), period 2 (days 54, 55), and period 3 (days 89, 90) of study. The feeding rate of each oil supplemented diet was determined as DMI divided by feeding time (g of DM/30 min).

The method for the feeding test within 30 min was the same as the 1st experiment. Total behavioral frequency was summed by the data in the morning and afternoon. The data were collected at period 1 (days 26, 27), period 2 (days 54, 55) and period 3 of the study (days 89, 90).

General behavioral observation was carried out for approximately 24 h during which a video was recorded. The observation periods were from 07:00 to 19:00 h at period 1 (days 25, 26, 27), period 2 (days 53, 54, 55), and period 3 of the study (days 88, 89, 90). Every hour in integral point the following data were recorded for each cattle (modified from Charlton et al., 2011): 1) Spatial distribution of cattle in each pen. The space of each pen was divided into three areas, namely, the feeding area, the center area and the drinking area; 2) Posture of cattle: lying, standing or walking; 3) Jaw activity: eating, ruminating, drinking or idling (i.e. neither eating, drinking nor ruminating); 4) Other: self-grooming and social interaction (non self-grooming).

The experimental unit considered was the pen. Data analysis was performed using SPSS, version 16.0 (SPSS). The period (or week) and treatments were considered to fixed effects. The data were subjected to the independent sample T-test and the General Linear Model (GLM) repeated measures procedure was used. Means were compared using Duncan's multiple-range test and significance was determined at $p<0.05$.

Results

Free choice test: There was no significant difference in BW, BWG, and ADG of cattle between the control and the free choice group (Table 2). The results showed that there was no significant difference among DMI of PO and RO from wk 1 to wk 3. The DMI of CO was significantly decreased whilst the feeding lasted three weeks ($p<0.05$), but the DMI of CO between wk 1 and wk 2 was similar (Table 3). According to the results of 30 min DMI in wk 1, the cattle preferred the feed supplemented with RO and CO rather than PO ($p<0.05$). Therefore, for the last three weeks of the feeding test, the DMI of RO was higher than that of CO ($p<0.05$), but there was no statistically significant difference between the DMI of PO and RO.

According to the behavioral observation, the highest percentage of total frequency of behavior was eating, followed by switches and visits. The percentage of self-grooming, drinking, and disturbance from neighbors was quite low during observation (Table 4). Moreover, there was no significant difference between those percentages of behavioral frequencies between the control and the free choice group.

Table 2 Body weight and body weight gain of cattle

Group	BW d1 (kg)	BW d21 (kg)	BWG (kg)	ADG (g)
Control	296.33±11.29	306.33±15.83	19.67±2.73	702.40±97.44
Free choice	316.00±13.86	324.00±15.05	17.67±2.67	631.00±95.05

Values are presented as Mean ± Standard error (SE).

Table 3 Dry matter intake (g) of three kinds of oil supplemented diets in 30 min free choice test from week 1 to week 3

Week	Treatment[1]		
	PO	RO	CO
1	1049.30 ± 96.39[a]	1475.30 ± 54.12[b]	1462.90 ± 57.28[bB]
2	1287.60 ± 116.19	1486.50 ± 98.46	1294.30 ± 93.77[B]
3	1103.60 ± 156.21[b]	1493.80 ± 114.69[b]	1056.50 ± 143.22[aA]

[1]Values are presented as Mean ± SE;
PO: Palm oil; RO: rice bran oil; CO: corn oil;
[a, b] significant difference within the same row ($p<0.05$)
[A, B] significant difference within the same column ($p<0.05$)

Table 4 Percentage of total frequency of behavior patterns of cattle during feeding periods

Item	Group[1]	Week[2]		
		1	2	3
Switching	C	20.84 ± 3.54	18.50 ± 4.57	16.32 ± 4.46
	FC	18.96 ± 1.89	15.78 ± 1.99	12.26 ± 1.59
Visits	C	13.40 ± 1.02	8.30 ± 0.92	7.98 ± 0.48
	FC	14.42 ± 1.68	11.86 ± 1.56	11.70 ± 1.19
Eating	C	53.83 ± 3.41	63.06 ± 1.97	60.77 ± 0.77
	FC	56.27 ± 2.74	61.35 ± 3.28	61.35 ± 3.28
Self-grooming	C	6.33 ± 2.39	5.55 ± 1.85	8.98 ± 4.71
	FC	7.24 ± 1.25	9.18 ± 1.88	11.14 ± 2.55
Drinking	C	3.66 ± 1.58	1.56 ± 0.46	3.17 ± 1.78
	FC	2.27 ± 0.77	0.97 ± 0.23	2.02 ± 0.72
Disturbance from neighbors	C	1.93 ± 1.13	3.03 ± 1.63	2.79 ± 2.46
	FC	0.84 ± 0.39	2.11 ± 1.03	1.54 ± 0.97

[1]C: Control; FC: Free choice
[2]Values are presented as Mean ± SE.

Table 5 Dry matter intake (kg) of oil supplemented diets in 30 min

Period		Treatment[1]		
		Control	RO	PO
1	M	1.91 ± 0.14[b]	2.27 ± 0.32	1.77 ± 0.37
	A	2.62 ± 0.22[a]	2.37 ± 0.39	2.64 ± 0.21
2	M	2.46 ± 0.36	2.02 ± 0.30[b]	2.40 ± 0.21
	A	3.07 ± 0.00	2.92 ± 0.12[a]	2.64 ± 0.26
3	M	2.37 ± 0.24[b]	2.40 ± 0.28	2.61 ± 0.26
	A	2.94 ± 0.07[a]	2.54 ± 0.32	2.54 ± 0.31

[1]Values are presented as Mean ± SE; PO: Palm oil; RO: rice bran oil; CO: corn oil; M: morning; A: afternoon
[a, b] means within the same column and within the same period with different superscripts were significantly different at $p<0.05$

Table 6 Feeding rate (g/min) of cattle in feeding test

Period	Meal	Treatment[1]		
		Control	RO	PO
1	M	63.81 ± 4.60	75.81 ± 10.62	59.05 ± 12.43
	A	87.40 ± 7.19	78.85 ± 13.15	87.84 ± 7.03
2	M	82.00 ± 11.86[b]	67.24 ± 9.96	80.14 ± 7.07
	A	102.28 ± 0.00[a]	97.24 ± 3.92	87.89 ± 8.69
3	M	79.14 ± 8.06[b]	80.11 ± 9.45	87.03 ± 8.68
	A	97.92 ± 2.18[a]	84.53 ± 10.80	84.82 ± 10.37

[1]Values are presented as Mean ± SE; PO: Palm oil; RO: rice bran oil; CO: corn oil; M: morning; A: afternoon
[a, b] means within the same column and within the same period with different superscripts were significantly different at $p<0.05$

Feeding test: The results for the DMI are reported in Table 5. There was no significant difference among the DMI of the control group, the RO group or the PO group within period 1, 2 and 3, respectively. It was found that the DMI of the control group in periods 1 and 3 ($p<0.05$) and RO group in period 2 ($p<0.05$) in the afternoon was significantly higher than that in the morning. The results for the feeding rate of cattle are reported in Table 6. There was no significant difference among treatments within periods 1, 2 and 3. The feeding rate of cattle in the morning was significantly higher than that in the afternoon, especially in the control group in periods 2 and 3 ($p<0.05$).

Table 7 shows the percentage of total frequency of behavior of the cattle during the feeding periods of 30 min from periods 1 to 3. The highest frequency of behavior was eating during the feeding test, and the cattle showed other sorts of behavior such as visits, self-grooming, drinking, disturbing neighbors and social interaction as well, although these sorts of behavior were rare events.

With an increase in the age of cattle, an increase in the tendency of the total percentage of frequency of visits of the cattle was found ($p<0.01$). The lowest percentage of visits was found in period 1, while the highest was in period 3. There was a similar percentage of visits between period 2 and period 1, and period 2 and period 3. Moreover, the different oil supplemented diets affected the behavior of the cattle, for example, the percentage of visits ($p<0.01$) and drinking ($p<0.05$). The percentage of visits of those cattle fed on RO was higher than those in the control and PO groups ($p<0.05$). However, the percentage of visits of cattle in the control group was similar to that of the PO group.

With an increase in the age of the cattle, an increase in the drinking of the cattle was found ($p<0.05$). The lowest percentage of drinking was found in period 1, while the highest was in period 2 ($p<0.05$). There were similar percentages of visits between period 3 and period 1, and period 3 and period 2. It was found that the percentage of drinking of the cattle fed on RO was higher than that of those fed on PO ($p<0.05$). However, the percentage of drinking of cattle in the control group was similar to that in the RO and PO groups.

With an increase in the age of cattle, no significant difference was found in the percentage of eating. The percentage of eating in the control group was significantly higher than that in the RO group ($p<0.05$) in period 3. No difference was found between the control and PO groups, or the RO and PO groups in period 3.

The percentage of disturbance from neighbors increased from period 1 to period 3 ($p<0.01$). No difference was found between this behavior in period 1 and 2. The oil supplemented diets did not affect the percentage of disturbance from neighbors. The percentage of the cattle that showed social interaction decreased from period 1 to period 3 ($p<0.05$). The cattle did not show social interaction during the observation of period 3. No difference was found between social interaction in period 1 and 2. The oil supplemented diets did not affect this behavior.

Table 8 shows all results on spatial distribution. There was no significant difference among the groups in the feeding, center, and drinking area distribution in periods 1, 2 and 3, except that significant results were found in the percentage of spatial distribution in the drinking area in period 1. The highest percentage of spatial distribution in the drinking area was found in the RO group ($p<0.05$) compared to the control and PO groups. No difference was detected between the control and PO groups.

With an increase in the age of cattle, the linear tendency of spatial distribution was found in the feeding and center areas. The percentage of spatial distribution in the feeding area decreased ($p<0.05$), and it was significantly different among the periods ($p<0.05$). The percentage of spatial distribution in the center area increased ($p<0.05$), with the highest in period 3, but there was no difference between in periods 1 and 2.

Table 7 The percentage of total frequency of behavior patterns of cattle during feeding periods (Values are presented as Mean ± SE.)

Item	Group	Period		
		1	2	3
Visits	Control	9.26 ± 0.84	10.86±2.33	12.56±2.52^{b}
	RO	9.97 ± 1.22^{A}	16.28±3.13^{AB}	21.87±5.74^{aB}
	PO	8.01 ± 1.08	9.55±1.52	12.36±1.64^{b}
Eating	Control	70.49 ± 4.95	71.15±7.13	78.96±2.49^{b}
	RO	78.59 ± 2.50	60.56±5.54	57.57±5.81^{a}
	PO	76.97 ± 6.76	73.75±5.99	72.11±5.29^{ab}
Self grooming	Control	7.01 ± 1.83	8.67±2.51	2.14±1.23
	RO	3.87 ± 1.10	9.49±2.77	5.81±3.16
	PO	12.09 ± 5.32	10.93±4.49	7.93±3.91
Drinking	Control	2.48 ± 1.75	5.72±2.14	1.97±1.07^{ab}
	RO	3.33 ± 0.94^{B}	6.54±2.27^{A}	6.68±0.71^{bA}
	PO	0.89 ± 0.89	3.40±1.11	1.12±0.61^{a}
Disturbance from neighbors	Control	5.15 ± 2.58	0	4.37±2.09
	RO	0.46 ± 0.46^{B}	0^{B}	8.08±3.73^{A}
	PO	0.75 ± 0.50	0.20±0.19	6.47±3.71
Social interaction	Control	5.60 ± 2.19	3.61±2.92	0
	RO	3.78 ± 1.47^{B}	7.14±1.92^{A}	0^{B}
	PO	1.28 ± 0.67	2.18±1.26	0

RO: rice bran oil; PO: palm oil.
$^{a, b}$ means within the same column with different superscripts were significantly different at p<0.05;
$^{A, B}$ means within the same row with different superscripts were significantly different at p<0.05.

Table 8 The percentage of spatial distribution of cattle (Values are presented as Mean ± SE.)

Item	Group	Period		
		1	2	3
Feeding area	Control	60.26 ± 4.42^{A}	44.87 ± 3.99^{B}	23.72 ± 4.18^{C}
	RO	50.00 ± 3.85	42.95 ± 6.73	23.08 ± 3.41
	PO	51.92 ± 5.45	41.03 ± 6.16	26.28 ± 5.05
Center area	Control	31.41 ± 4.17^{B}	37.18 ± 4.42^{B}	56.41 ± 6.01^{A}
	RO	30.13 ± 3.96	44.87 ± 6.27	64.10 ± 3.71
	PO	37.82 ± 5.14	30.13 ± 5.80	56.41 ± 4.37
Drinking area	Control	8.33 ± 1.76^{b}	17.95 ± 3.83	19.87 ± 4.07
	RO	19.87 ± 3.83^{a}	12.18 ± 2.41	12.82 ± 1.73
	PO	10.26 ± 2.19^{b}	20.51 ± 6.09	17.31 ± 4.93

RO: rice bran oil; PO: palm oil.
$^{a, b}$ means within the same column with different superscripts were significantly different at p<0.05;
$^{A, B, C}$ means within the same row with different superscripts were significantly different at p<0.05.

Table 9 The percentage of postures of cattle (Values are presented as Mean ± SE.)

Item	Group	Period		
		1	2	3
Lying	Control	46.15 ± 3.41^{B}	48.72 ± 3.19^{B}	58.33 ± 4.87^{A}
	RO	51.92 ± 3.30	46.79 ± 3.60	53.85 ± 2.84
	PO	43.59 ± 5.04	42.95 ± 5.39	53.21 ± 3.21
Standing	Control	53.85 ± 3.41^{A}	50.64 ± 3.06^{AB}	41.03 ± 4.77^{B}
	RO	48.08 ± 3.30	52.56 ± 3.52	46.15 ± 2.84
	PO	56.41 ± 5.04	48.72 ± 5.39	45.51 ± 2.92
Walking	Control	0	6.64 ± 0.64	0.64 ± 0.64
	RO	0	0.64 ± 0.64	0
	PO	0	0	1.28 ± 0.86

RO: rice bran oil; PO: palm oil.
$^{A, B}$ means within the same row with different superscripts were significant difference at p<0.05.

With an increase in the age of cattle, there was a linear tendency for the percentage of postures of cattle that were found lying or standing (Table 9). However, no significant difference was found among each group. The highest percentage of lying was in period 3 (p<0.05), but there was no difference between periods 1 and 2. The percentage of standing in period 1 was significantly higher than that in period 3 (p<0.05). Similar results were found between those in periods 1 and 2, and those in periods 2 and 3. However, walking behavior was a rare event found during the observation.

Significant differences in the percentage of jaw activities of cattle among the treatment groups were in eating and ruminating in period 1 (p<0.05) (Table 10). The highest percentage of eating was in the control and PO groups (p<0.05) compared with the RO group. Similar results were found between the control and PO groups. The highest percentage of ruminating was found in the control and RO groups (p<0.05) compared with the PO group. Similar results were found between the

Table 10 The percentage of jaw activities of cattle (Values are presented as Mean ± SE.)

Item	Group	Period		
		1	2	3
Eating	Control	35.90 ± 3.59^{aA}	24.36 ± 3.12^{B}	15.38 ± 2.84^{B}
	RO	25.00 ± 2.70^{b}	20.51 ± 2.89	18.59 ± 3.34
	PO	34.62 ± 3.35^{a}	19.23 ± 3.21	20.51 ± 3.71
Ruminating	Control	13.46 ± 3.80^{abB}	26.28 ± 4.28^{A}	12.82 ± 2.38^{B}
	RO	21.79 ± 4.22^{a}	33.97 ± 3.60	13.46 ± 3.92
	PO	10.26 ± 3.04^{b}	30.13 ± 4.39	13.46 ± 3.80
Drinking	Control	1.92 ± 1.00	0.64 ± 0.64	0
	RO	0	0	1.92 ± 1.04
	PO	1.28 ± 0.86	0.64 ± 0.64	0.64 ± 0.64
Idling	Control	48.72 ± 5.22^{B}	48.72 ± 5.47^{B}	71.79 ± 3.71^{A}
	RO	52.56 ± 5.34	45.51 ± 4.68	66.03 ± 3.47
	PO	53.85 ± 3.14	41.67 ± 6.10	64.74 ± 4.28

RO: rice bran oil; PO: palm oil.

$^{a, b}$ means within the same column with different superscripts were significantly different at $p<0.05$;

$^{A, B}$ means within the same row with different superscripts were significantly different at $p<0.05$.

control and RO groups. Drinking behavior was a rare event. The highest percentage of ruminating was in period 2 ($p<0.05$), the highest percentage of idling was found during the observation in period 3 ($p<0.05$). With an increase in the age of cattle, a linear tendency for the percentage of jaw activities of the cattle was found.

Discussion

In general, beef cattle diets should not exceed 6 % fat on a dry matter basis (NRC, 2001), feeding a higher concentration of oils than this level could result in reduced rumen microbial activities, accompanied by reduced nutrient digestibility and dry matter intake (Shingfield et al., cited by Lunsin et al., 2012). In this study, the supplemented oil was lower than the recommended standard. The results which were in accordance with the supplemental lipid to feedlot cattle diets did not affect animal performance (Gillis et al., 2004).

Although there was no related report on whether cattle could identify the flavors of oils or not, the palatability of RO and CO was better than PO for cattle in the week 1 feeding test. Those results for the palatability of the oil supplemented diets indicate that it was probably because of the unique flavor of PO compared with RO and CO. Due to the decreased DMI of CO from week 1 to week 3 in the free choice test experiment, the authors did not feed CO to the cattle in the feeding test experiment. Preference testing is a commonly used technique that enables animals to choose between options for resources or environments that are important to them (Dawkins, 1990; Fraser and Matthew, 1997; Kirkden and Pajor, 2006). Morand-Fehr (2003) claimed that preference tests on goats would be more sensitive and feasible than on cows. Although the behavioral activities did not show any differences between the control and free choice groups from week 1 to week 3, the frequency of switches showed that the beef cattle could choose the diets alternately during feeding periods.

In the feeding test experiment, the feeding rates ranged between 59.05 and 87.03 g/min in the morning and 78.85 and 102.28 g/min in the afternoon, which was lower than those of the finishing heifers (Kelly et al., 2010) and steers (Moya et al., 2011; Schwartzkopf-Genswein et al., 2011) fed in a group. This is possible because of the competition for food (Forbes, 2007). A high percentage of visits during the feeding periods in the feeding test experiment indicated that the feeding behavior of cattle was interrupted by other types of behavior such as drinking, taking a break, turning around, grooming themselves, or fighting (Marie-France Bouissou et al., 2001), and then they visited the feeder again. The low percentage of visits during the feeding periods indicated that the cattle always continued to feed without any interruption.

As a whole, the high percentage of visits in the RO group showed that when the cattle ate the RO supplemented diets they might need to drink more water than the cattle in the PO group, because the percentage of drinking was higher in the RO group than in the PO group. In period 3, the percentage of eating in the RO group was not lower than that in the PO group, although the difference was not statistically significant. During the final period, the percentage of eating clearly decreased. As a result, the percentage of visits increased at the same time. Although the results of DMI within 30 min did not show any significant difference, we found differences in behavior; perhaps we can conclude from this that a high percentage of visits means low palatability of feed. An interesting phenomenon was that the cattle disturbed their neighbors, although it was a rare event during the feeding periods, we do not have any clear explanation for this. The authors wondered whether it was a form of playing during feeding; therefore, further research is necessary.

DeVries and von Keyserlingk (2005) found that the delivery of fresh feed could stimulate feeding behavior. Therefore, as a result of the feeding motivation, there was a high frequency of eating during the 30 min feeding observation (Herskin and Munksgaard, 2000). In this study, the cattle were fattened separately in individual pens, and they showed increasing percentages of lying, and decreasing percentages of standing with an increase in feeding periods. Only feeding and drinking in the general behavior of the cattle were affected by the feeding of different oil supplemented diets in the feeding test experiment. However, the feeding periods had an effect on the percentage of spatial distribution, postures, and jaw activities of the cattle. During the initial period of feeding,

the cattle preferred to stay in the feeding area. But the cattle preferred to stay in the central center area when the feeding time was increased.

Direct visual observation is the most traditional and direct technique in determining animal behavior. Therefore, by using video recording it is possible to observe animals in groups, the individual animals can be recognized and continued monitoring of jaw movements is possible (Forbes, 2007). Oil supplemented diet had effects on jaw activities only at the beginning of feeding period 1. With an increase in the feeding periods, eating and ruminating were replaced by idling, which might be related to the slow digestion of cattle or its appearance of under eating (Forbes, 2007).

In conclusion, the feeding choices of the Cross-bred Brahman cattle tested were affected by different oil supplements. The cattle preferred the rice bran oil supplemented diet during the three-week feeding test. The effects of oil supplemented diets were not obvious in the frequency of different types of behavior in the free choice test. The oil supplemented diets did not affect the dry matter intake, feeding rate, spatial distribution or postures, but it could affect the feeding behavior in the final finishing period and the jaw activities in the beginning and finishing period.

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บทคัดย่อ

ผลของการเสริมน้ำมันต่อพฤติกรรมการกินอาหารของโคลูกผสมบราห์มัน

ฮั่ว ซิน [1,2] ***ชยพล มีพร้อม***[1] ***วิศิษฐิพร สุขสมบัติ***[1*]

ได้ทำการทดลอง 2 การทดลองในโคเนื้อ เพื่อเปรียบเทียบพฤติกรรมการกินได้อย่างอิสระของอาหารที่ได้รับการเสริมน้ำมัน 3 ชนิด (ระยะเวลา 3 สัปดาห์) และอาหารที่ได้รับการเสริมน้ำมันต่างชนิดกัน (ระยะเวลา 13 สัปดาห์) การทดลอง free choice test ใช้โค 2 กลุ่มการทดลอง ที่เลี้ยงดูภายในโรงเรือน กลุ่มการทดลองแรกได้รับอาหารข้นพื้นฐานวันละ 6 กิโลกรัม ในขณะที่อีกกลุ่มการทดลองที่ได้รับอาหารอย่างอิสระ เป็นอาหารข้นพื้นฐาน 6 กิโลกรัมต่อวันเช่นเดียวกับกลุ่มการทดลองแรก แต่แบ่งเป็น 3 ส่วนๆละ 1 กิโลกรัม แต่ละส่วนจะเสริมน้ำมันข้าวโพด (corn oil; CO) น้ำมันปาล์ม (palm, oil; PO) หรือน้ำมันรำข้าว (rice bran oil; RO) อย่างละ 35 กรัมต่อมื้อ โดยการเติมน้ำมันลงบนอาหารข้นที่บรรจุอยู่ในกะละมังพลาสติก ตามลำดับ ส่วนการทดลองที่ 2 ทำการทดลองโดยใช้โคชุดเดียวกันกับการทดลองที่ 1 โดยกลุ่มการทดลองที่ 1 เป็นกลุ่มควบคุม ได้รับอาหารข้น 3 กิโลกรัมต่อมื้อ เป็นอาหารพื้นฐาน และเสริมด้วยกากมันสำปะหลัง 0.5 กิโลกรัมต่อมื้อ ในขณะที่กลุ่มการทดลองที่ 2 (RO) และ 3 (PO) ได้รับอาหารพื้นฐานเช่นเดียวกับกลุ่มการทดลองที่ 1 แต่เสริมด้วยน้ำมันรำข้าว (RO) หรือ น้ำมันปาล์ม (PO) 100 กรัมต่อมื้อ ตามลำดับ ผลการทดลอง free choice feeding แสดงให้เห็นว่า การกินได้ของวัตถุแห้งของโคในกลุ่มที่ได้รับน้ำมันข้าวโพด (CO) ลดลงอย่างมีนัยสำคัญทางสถิติในช่วง 3 สัปดาห์สุดท้ายของการทดลอง (p<0.05) ร้อยละของความถี่ของพฤติกรรมที่สูงที่สุดคือ การกินอาหาร (eating) รองลงมาได้แก่ การเปลี่ยนการเลือกกินอาหาร (switches) และ การเข้ากินอาหาร (visits) ในการทดลอง feeding test การเสริมน้ำมันที่แตกต่างกันมีผลกระทบต่อร้อยละของการเข้ากินอาหาร (p<0.01) และการกินน้ำ (drinking; p<0.05) ของโคทดลอง ความแตกต่างอย่างมีนัยสำคัญทางสถิติของร้อยละของกิจกรรมการใช้ขากรรไกรของโคระหว่างกลุ่มการทดลองคือการกินอาหารและการเคี้ยวเอื้องในช่วงทดลองที่ 1 (p<0.05) ร้อยละที่สูงที่สุดของการกินอาหารพบในกลุ่มควบคุมและกลุ่มที่ได้รับการเสริมน้ำมันปาล์ม (PO) (p<0.05) ร้อยละที่สูงที่สุดของการเคี้ยวเอื้องพบในกลุ่มควบคุมและกลุ่มที่ได้รับการเสริมรำข้าว (RO) (p<0.05) ร้อยละที่สูงที่สุดของการอยู่นิ่งเฉย (idling) พบในระหว่างช่วงที่ทำการสังเกต สรุปได้ว่าการทดสอบการให้โคได้รับอาหารอย่างอิสระ (feeding choice) ถูกกระทบโดยการเสริมน้ำมันที่แตกต่างกัน โดยโคชอบที่จะกินอาหารที่เสริมด้วยน้ำมันรำข้าวตลอดช่วงการทดลอง 3 สัปดาห์ ส่วนผลของการเสริมน้ำมันในอาหารไม่พบความแตกต่างของความถี่ของพฤติกรรมโคตลอดช่วงการทดลอง 13 สัปดาห์ การเสริมน้ำมันในอาหารไม่มีผลกระทบต่อการกินได้ของวัตถุแห้ง อัตราการกินอาหาร การเคลื่อนที่ภายในคอก และการเคลื่อนไหวร่างกาย แต่มีผลกระทบต่อพฤติกรรมการกินอาหารและกิจกรรมของขากรรไกร

คำสำคัญ: การเลือกกินอาหาร โคลูกผสมบราห์มัน พฤติกรรมการกินอาหาร การเสริมน้ำมัน

[1]สาขาวิชาเทคโนโลยีการผลิตสัตว์ สำนักวิชาเทคโนโลยีการเกษตร มหาวิทยาลัยเทคโนโลยีสุรนารี นครราชสีมา 30000

[2]โปรแกรมการเกษตร คณะวิทยาศาสตร์และเทคโนโลยี มหาวิทยาลัยราชภัฏนครราชสีมา นครราชสีมา 30000

****ผู้รับผิดชอบบทความ Email:** visitpor@sut.ac.th*