Effect of Potato By-products Based Silage on Growth Performance, Carcass Characteristics and Fatty Acid Composition of Carcass Fats in Holstein Steers

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ABSTRACT : Ten 18.5-month old Holstein steers were allocated into two diet groups of five and fed either concentrates as control group or potato by-products based silage (PBS) as experimental group for six months to investigate the effect of PBS on growth performance, carcass characteristics and fatty acid composition of carcass fats. The PBS diet consisted, in a DM basis, of 74.5% PBS, 16% hay, and 9.5% soybean milk residue (SMR). The control diet consisted, in a DM basis, of 82.5% concentrates and 17.5% hay. There were no significant differences in the overall average daily gain (ADG), dry matter intake (DMI), feed efficiency, yield score and meat quality score of dressed carcass between the two diet groups. There were no statistical differences in DM, crude protein (CP), and ether extract (EE) of beef and melting point of all adipose tissues from steers fed both diets. The PBS-fed steers tended to have lower Warner Bratzler shear (WBS) values than in the concentrate-fed steers (13.0 vs. 17.7 lb, $p<0.1$). At both sampling times 3 and 6 months of feeding period, PBS-fed steers had higher proportions of polyunsaturated fatty acids (PUFA), especially linoleic (C18:2) acids in subcutaneous fat than in control group ($p<0.05$). PBS-fed steers had significantly higher proportions of PUFA, especially C18:2 fatty acids than in concentrate-fed steers in carcass fats ($p<0.05$). In conclusion, feeding PBS to fattening steers has shown to have the same potential as concentrate feeding in terms of effect on the growth performance, feed efficiency, and carcass characteristics. Interestingly, PBS also seems preferable to concentrates because it increased the proportion of C18:2 fatty acid composition of carcass fats which is valuable for beef consumers. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 4 : 490-496)***

Key Words : Potato By-products, Steer, Growth, Carcass Characteristics, Fatty Acids

INTRODUCTION

Agricultural food processing industries in many countries yield a huge amount of by-products which need to be disposed. The potato processing plants in Hokkaido Japan discard about 15% of the total processed potato crop as wastes or by-products during processing. According to Stanhope et al. (1980) about 35% of total processed potato crop in the US was discarded as potato wastes. Disposal of these by-products would be an economical and environmental problem which potato processors have to face. There are some literatures on the utilization of potato-processing residues as animal feed. In the past, potato wastes or by-products were fed to livestock as potato meal or dried pulp which required large expenditures for drying. Thus, the current interest is centered on utilization of wet wastes (Onwubuemeli et al., 1985) or incorporation into silage. Agricultural by-products and forage crop is often the cheapest feedstuffs for cattle production. However, the value of beef produced from these feed resource is often discounted compared with concentrate-fed beef because of perceived differences in meat quality (French et al., 2000).

Ensiling potato by-products may be beneficial to both commercial beef producers and potato processors. Potato by-products based silage (PBS) is produced commercially from potato by-products which include culled potatoes and steamed-peeled potato by-products with some grain by-products, and is used as feed for beef cattle in Hokkaido, Japan. This study was conducted to investigate the effect of feeding PBS on growth performance, carcass characteristics, and fatty acid composition of the carcass fats in Holstein steers.

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MATERIALS AND METHODS

Experimental animals and diets

Ten Holstein steers, initially weighed 598±70 kg, were assigned into two diet groups and fed either concentrates as control group (aged 18.4 mo) or PBS as experimental group (aged 18.6 mo). The PBS used in the experiment were ensiled from, as a fresh basis, 29.6% potato peelings, 29.6% potato scrap, 13.3% potato pulp, 6.7% potato gluten feed, 8.9% corn cob, 8.9% soybean milk residue, and 3.0% beet pulp. Steers in both diet groups were fed in group and were offered 2 kg of hay/head daily plus either concentrates or PBS and soybean milk residue (SMR) as protein supplement. The two experimental diets were formulated to contain 12-13% CP (of DM) and offered at daily growth rate of 1.0 kg/d in accordance with the recommendation of the Japanese feeding standard for beef cattle (AFFRC, 1995). Animals were fed two times at equal amount of feed daily at 8:00 h and 16:00 h. Daily feed offered and residual feed were weighed and recorded daily throughout the

Table 1. Chemical composition of experimental feedstuffs

	Concentrate	PBS[1]	SMR[1]	Hay
DM (%)	86.3	40.6	89.0	87.2
CP (% of DM)	12.4	11.8	29.2	9.9
EE (% of DM)	4.0	1.3	8.9	2.2
NDF (% of DM)	25.0	34.7	21.9	72.8
ADF (% of DM)	6.7	21.5	13.9	42.8
GE (kcal/g DM)	4.4	4.4	5.3	4.3

[1]PBS: potato by-products based silage, SMR = soybean milk residue.

experimental period. Clean drinking water and mineral block were provided freely. The animals were weighed in two-week interval and the amounts of feed offered were adjusted accordingly.

Over the whole experimental period. PBS was sampled weekly and other feedstuffs were sampled every four weeks. The feed samples were dried at 55°C for 48 h in dry oven, air-dried for 24 h, ground to pass 1 mm screen and then stored in air-tight containers until analysis. Samples were analyzed for dry matter (DM), crude protein (CP), and ether extract (EE) according to procedure of AOAC (1990). Neutral detergent fiber and ADF were analyzed according to Van Soest methods (Van Soest, 1967). Gross energy (GE) of feed was analyzed by bomb calorimeter (CA-4P, Shimadzu, Japan) as described by Mwenya et al. (2004).

Carcass data collection and muscle sampling and analysis

Subcutaneous fat samples were taken by biopsies from perianal region, as described by Herta-Leidenz et al. (1996) 3 months after feeding the experimental diets. Six months after the start of experiment, all steers were slaughtered at the slaughter house of Hokkaido meat packing Co. Ltd. Postmortem samples of subcutaneous, intermuscular and kidney fats were collected from all carcasses. All samples of adipose tissues were stored at -30°C until analysis. The carcass grading (yield score and meat quality score) was determined according to the Japanese carcass grading standard for beef. A boneless rib eye was removed between 6 and 7th ribs of the left side carcass and semitendinosus muscle were collected from the left side carcass. The obtained samples were vacuum-packaged and stored at -5°C until analysis.

Melting points of subcutaneous, intermuscular and kidney fat samples were measured according to AOCS procedure (1993). The DM, EE, and CP of beef were determined on semitendinosus muscle samples and were analyzed according to procedure of AOAC (1990). The eating quality of beef was determined on rib eye samples. The rib eye samples were weighed, thawed overnight, mobbed and weighed again to determine the percentage of drip loss (moisture loss during aging), and the rib eye areas were separated and cooked in oven until the internal temperature reached 70°C. When the internal temperature returned to 35°C by cooling in room temperature, the percentage of cooking loss was determined. Six 2.5 cm cores from each rib eye were obtained parallel to the muscle fibers. To determine Warner-Bratzler shear (WBS) value cores were sheared three times through the center on a TA-XT2 Texture Analyzer (Texture Technologies, Scarsdale, NY) equipped with a WBS attachment at a crosshead speed of 20 cm/min.

Fatty acid analysis

About 5 mg of sliced adipose tissues were methylated in 11ml tube containing 5 ml of Methanol hydrochloric acid (95:5, v/v) with cap at 100°C for 3 h. After cooling in room temperature, the methylated samples were washed three times in Hexane. Lipid of feedstuffs was extracted according to the Folch method (Folch et al., 1957) and followed by procedure of Blight and Dyer (Blight and Dyer, 1959). The intramuscular fat was extracted from ground semitendinosus muscle samples in accordance with the Folch method (Folch et al., 1957). The extracted lipids from feed and intramuscular fat were methylated as described in adipose tissues above. Subsequently, the fatty acid methyl esters were analyzed for fatty acid composition with Gas Chromatography (GC14B, Shimadzu, Japan), equipped with auto injector (AOC-20s, Shimadzu, Japan) using a 0.25 mm×30 m capillary column (Rtx-2330 Restek, USA). The operating condition was performed as follows: injection port temperature 260°C; detector temperature 260°C, column temperature-programmed from 160 to 250°C at rate of 2°C/min; Helium (He) was used as carrier gas. The peaks were identified by comparison with the known standard mixture of fatty acids as described by An et al. (2003).

Statistical analysis

Because of big variation of initial body weight of the experimental animals, the data for final body weight, daily weight gains, carcass characteristics, chemical composition, meat quality, and fatty acid composition of adipose tissues, and intramuscular fat were subjected to the analysis of covariance according to GLM procedure of SAS (1996), in which initial body weight was used as covariate. To investigate the effects of feeding period (3 mo vs. 6 mo) and experimental diets (control vs. PBS) on fatty acid composition of subcutaneous fats, GLM procedure of SAS was used. The model included effects of diet, feeding period and diet×feeding period. Significance was declared at $p<0.05$, and trends were determined at $0.05<p<0.10$, unless otherwise stated.

RESULTS

Feed intake and growth performance

The chemical composition of the experimental

Table 2. The fatty acid composition of the experimental feedstuffs

Fatty acid (%)	Concentrate	PBS[1]	SMR[1]	Hay
C14:0	0.1±0.0	0.1±0.1	0.1±0.0	1.1±0.1
C16:0	14.7±0.5	12.9±0.5	12.3±0.2	25.4±5.9
C16:1	0.2±0.1	0.2±0.1	0.1±0.0	2.2±0.2
C18:0	1.7±0.3	4.3±0.4	4.3±0.3	2.2±0.8
C18:1	29.1±0.1	18.7±0.8	19.7±0.6	4.6±2.2
C18:2	50.6±0.5[a]	53.5±0.8[b]	53.7±0.5[b]	22.0±3.0
C18:3	2.5±0.0[a]	9.7±0.3[b]	9.0±0.0[b]	40.5±13
C20:0	0.4±0.3	0.4±0.0	0.3±0.2	1.4±0.5
C20:1	0.5±0.1	0.2±0.0	0.2±0.0	ND[2]
C22:0	0.2±0.0	ND	0.4±0.0	1.4±0.9
SFA[3]	17.0±0.8	17.7±0.8	17.1±0.5	31.3±8.4
MUFA[3]	29.8±0.2	19.1±0.9	19.9±0.6	6.3±1.9
PUFA[3]	53.0±0.8	63.2±1.0	62.7±0.3	62.4±10.2

Values were means±standard deviation; concentrate (n=4), PBS (n=19), SMR (n=4) and hay (n=4).
[1] PBS: potato by-products based silage. SMR: soybean milk residue.
[2] Not detected.
[3] SFA: saturated fatty acid; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid.
Only the proportion of C18:2 and C18:3 fatty acids of PBS, SMR and concentrates were statistically analyzed.
PBS and SMR contained significantly higher proportions of C18:2 and C18:3 fatty acids than those in concentrates ($p<0.05$).

Table 3. Ingredient and nutrient composition (% of DM) and gross energy (Mcal/kg DM) of experimental diets[1]

Item	Ingredient composition (% DM)		Item	Nutrient composition (% DM)	
	CON	PBS		CON	PBS
Concentrates	85.4±0.6	0.0	DM	86.5±0.0	47.1±0.4
PBS	0.0	74.5±1.2	CP	12.0±0.0	13.2±0.1
Hay	14.6±0.6	16.0±1.1	EE	3.7±0.0	2.2±0.1
SMR[2]	0.0	9.5±0.6	GE	4.4±0.0	4.5±0.0

[1] CON: control diet, PBS: PBS diet.
[2] SMR: soybean milk residue.

feedstuffs is presented in Table 1. The PBS contained low DM and EE compared with other feedstuffs. The PBS and SMR contained similar fatty acid profile, which the proportion of C18:2 and C18:3 fatty acids were accounted for 53.5% and 9.0% of total fatty acids, respectively. The PBS and SMR contained higher proportion of C18:2 and C18:3 fatty acids than those in concentrates (Table 2). The ingredient and nutrient composition of experimental diets are presented in Table 3. The control diet comprised, as a DM basis, of 85.4% concentrates and 14.6% hay. The PBS diet comprised, as a DM basis, 74.5% PBS, 16.0% hay, and 9.5% SMR. Both diets had similar gross energy content (4.4 Mcal/kg DM). As fresh basis, the amount of diet offered in PBS diet group was double the amount in control group due to the higher moisture content of PBS.

The changes in body weights of steers in both diet groups are presented in Figure 1. From week 5 to week 17 of the experimental period, there were no significant differences in ADG of steers fed PBS and control diets (1.25 vs. 1.04 kg/d, $p>0.05$). However, from week 19 of the experimental period until slaughter, the ADG of steers fed PBS diet was lower than those fed control diet (0.6 vs. 1.24 kg/d, $p<0.05$); similarly the DM intake of steers fed PBS diet decreased by about 8%, compared to that from previous feeding period, but no decrease of DM intake was observed in control group (data not shown). The initial and final body weight, the overall average daily gain (ADG), dry matter intake (DMI), and feed: gain ratio of steers in both diet groups are presented in Table 4. Despite lack of statistically significant difference, the final body weights of the control steer tended to be heavier than that of PBS-fed steer (832.8 vs. 745.6 kg). However, there were no significant differences in the overall ADG (1.02 vs. 0.98 kg), overall DMI (10.2 vs. 11.1 kg/d) and feed:gain ratio (0.1 vs. 0.1) between control and PBS groups.

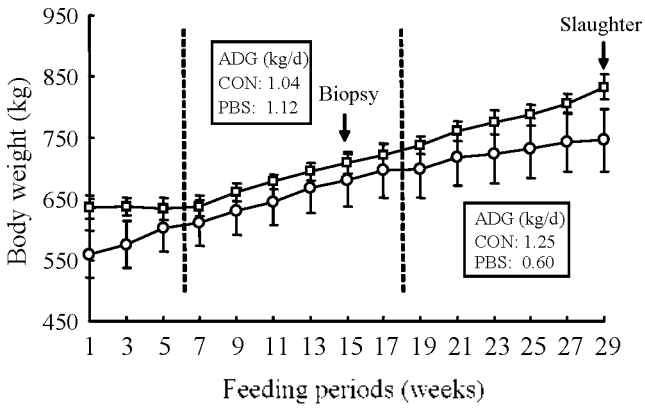

Figure 1. Changes in body weight of steers fed concentrate diet (□) and PBS diet (○) during course of the experiment. From week 1 to 5, all steers were in adaptation to the experimental diets. From week 7 to 17 the ADG of control and PBS groups were similar (1.04 vs. 1.12 kg/d, $p>0.05$); from week 19 until slaughter the ADG of control and PBS groups were significant difference (1.25 vs. 0.6 kg/d, $p<0.05$). Vertical bars represent standard errors.

Table 4. Live weight, DM intake, ADG and feed:gain ratio of steers fed control and PBS diets

Items	CON	PBS	SE[1]	P-value
Initial weight (kg)	636.6	559.8	26.83	ns[2]
Final weight (kg)	832.8	745.6	16.24	ns
DMI[3] (kg/d)	10.2	11.1	-[5]	-
ADG[4] (kg/d)	1.03	0.98	0.09	ns
Feed:gain ratio	0.10	0.09	-	-

[1] Standard error of least square mean.
[2] Not significant difference ($p>0.05$).
[3] Dry matter intake. [4] Average daily gain.
[5] No calculation was made because animals were fed as group.

Table 5. The carcass characteristics of steers fed control and PBS diets

Items	CON	PBS	SE[6]	P-value
Carcass weight (kg)	456.2	413.2	9.69	ns[7]
Dressing percentage (%)	57.8	55.5	0.74	ns
Rib eye area (cm^2)	48.2	43.2	5.84	ns
Rib thickness (cm)	6.3	5.2	0.28	ns
S.C. fat thickness (cm)	2.1	1.2	0.31	ns
Yield score[1]	69.6	70.2	0.41	ns
Marbling score[2]	2.2	2.0	0.16	ns
Beef color and brightness[3]	2.6	2.0	0.31	ns
Firmness and texture[4]	2.2	1.8	0.21	ns
Fat color, luster and quality	4.0	3.4	0.15	ns

[1] Yield score: 67.37+(0.130×rib eye area in cm^2)−(0.667×rib thickness in cm)-(0.025×cold left side weight in kg)-(0.896×s.c. fat thickness in cm).
[2] Beef marbling standard number, rating from 0 (none) to 12 (most abundant).
[3] Beef color standard number, rating from 1 (very bright) to 7 (dark).
[4] Firmness grade, rating from 1 (rough) to 5 (smooth).
[5] Beef fat color standard number, rating from 1 (white) to 7 (yellow).
[6] Standard error of least square mean.
[7] Not significant difference ($p>0.05$).

Carcass characteristics and meat quality

The yield scores and meat quality scores of dressed carcass are summarized in Table 5. There were no significant differences in yield scores and meat quality scores of the dressed carcass between the two diet groups. The yield scores of control and PBS groups were 69.6 vs. 70.2%, the dressing percentage were 57.8 vs. 55.5%, and the marbling scores were 2.2 vs. 2.0. The rib eye area, rib thickness and s.c. fat thickness of PBS group were numerically smaller than those of control group. The chemical composition, drip loss, cooking loss, and WBS value of beef and melting point of carcass fats from both diet groups are shown in Table 6. No significant differences were observed in beef DM (32.6 vs. 31.1%), CP (19.2 vs. 19.3%), and EE (11.1 vs. 9.2%) between control and PBS diet groups. There were no significant differences in drip loss (0.7 vs. 0.9%) and cooking loss (29.3 vs. 25.9%) between beef from steers fed control and PBS diets. However, the PBS-fed beef tended to have lower WBS values than in control group (13.0 vs. 17.7 lb, $p<0.10$). No significant differences were observed in melting point of

Table 6. Chemical composition, drip loss, cooking loss and WBS value of beef and melting point of carcass fats

Items	CON	PBS	SE[1]	P-value
Meat composition (%)				
Dry matter	32.6	31.1	1.03	ns[2]
Crude protein	19.2	19.3	0.37	ns
Ether extract	11.1	9.2	1.53	ns
Eating quality				
Drip loss (%)	0.7	0.9	0.25	ns
Cooking loss (%)	29.3	25.9	2.25	ns
WBS value (lb)	17.7	13.0	1.21	ns
Melting point (°C)				
Subcutaneous fat	28.4	30.4	0.94	ns
Intermuscular fat	33.8	37.7	0.83	ns
Kidney fat	43.5	43.2	0.67	ns

[1] Standard error of least square mean.
[2] Not significant difference ($p>0.05$).

subcutaneous (28.4 vs. 30.4°C), intermuscular (33.8 vs. 37.7°C), and kidney fats (43.2 vs. 43.5°C) between steers fed control and PBS diets.

Fatty acid composition of adipose tissues

The effects of experimental diets and feeding period on fatty acid composition of subcutaneous adipose tissues were shown in Table 7. The subcutaneous fat of PBS group contained significantly higher proportion of C18:2 and lower proportion of C18:1 fatty acids than those in control group ($p<0.05$). The C18:0 fatty acid proportions decreased ($p<0.05$), but PUFA proportions significantly increased ($p<0.05$) at slaughter (6 mo of feeding) compared with those from biopsy samples (3 mo of feeding) ($p<0.05$).

The fatty acid composition of intermuscular, intramuscular and kidney fats are shown in Table 8. In all adipose tissues the proportions of PUFA, especially C18:2 fatty acids from PBS-fed steers were significantly higher than those in control steers ($p<0.05$). However, there were no significant differences in proportions of SFA and MUFA among all adipose tissues between the two experimental diets.

DISCUSSION

The ADG of steers in both diet groups were regulated to 1.0 kg/d because it is the moderate growth rate for beef cattle, and carcass weight and pre-slaughter growth rate have been shown to affect meat quality, especially tenderness and flavor (Spanier et al., 1990). There were no significant differences in the overall ADG and DMI between steers fed PBS and control diets as the experiment was designed. However, a decrease in ADG of steers fed PBS diet was observed from week 19 of the experimental period, which was probably due to a decrease in DM intake of steers in PBS group. Makela (1956) stated that as the

Table 7. The effect of diets and feeding duration on fatty acid composition of subcutaneous adipose tissues in Holstein steers

Fatty acid (%)	CON		PBS		SE[1]	Significance		
	3 mo	6 mo	3 mo	6 mo		Diet	Time	Diet×time
C14:0	3.8	3.6	3.7	3.2	0.18	ns[2]	ns	ns
C14:1	2.9	2.7	2.4	2.9	0.16	ns	ns	ns
C16:0	26.0	25.7	25.3	25.8	0.41	ns	ns	ns
C16:1	9.4	9.5	8.6	11.0	0.52	ns	ns	ns
C18:0	6.2	5.8	8.9	5.8	0.52	ns	*	ns
C18:1	48.2	47.9	45.5	44.3	0.57	**	ns	ns
C18:2	3.4	4.2	5.6	5.9	0.27	**	ns	ns
SFA	36.0	35.1	37.9	34.8	0.84	ns	ns	ns
MUFA	60.6	60.4	56.5	58.6	0.79	*	ns	ns
PUFA	3.4	4.4	5.6	6.6	0.29	**	*	ns

[1] Standard error of least square mean. [2] Not significant difference ($p>0.05$). * $p\leq0.05$. ** $p\leq0.01$.

Table 8. Fatty acid composition of adipose tissues of steers fed control and PBS diets

Items (%)	Intermuscular fat			Intramuscular fat			Kidney fat		
	CON	PBS	SE[1]	CON	PBS	SE	CON	PBS	SE
C14:0	4.8	3.0**	0.27	4.2	3.0**	0.23	3.3	2.4	0.24
C14:1	1.5	0.7*	0.12	0.5	0.3*	0.05	1.4	0.9	0.13
C16:0	24.4	24.6	4.60	27.4	24.4**	0.99	26.1	24.0	0.59
C16:1	5.0	3.5	0.44	2.3	1.9	0.17	6.3	5.4	0.27
C18:0	12.4	16.5	1.09	21.4	25.8	1.05	9.4	10.9	0.42
C18:1	44.1	43.2	2.01	40.0	36.4	1.58	47.8	47.3	0.86
C18:2	4.1	7.3**	0.54	3.9	7.2**	0.49	5.3	8.2*	0.72
C18:3	0.3	0.9**	0.07	0.3	0.9**	0.05	0.3	0.8**	0.06
C20:1	0.3	0.2	0.08	ND[2]	ND	-	ND	ND	-
SFA	41.5	44.1	4.75	53.0	53.3	1.90	38.7	37.4	0.92
MUFA	50.8	47.7	2.44	42.8	38.6	1.74	55.6	53.6	0.80
PUFA	4.4	8.2**	0.60	4.2	8.1**	0.54	5.6	9.0**	0.78

[1] Standard error of least square mean. [2] Not detected. * Diet difference ($p<0.05$). ** Diet difference ($p<0.01$).

cattle grow fat the volume of abdominal fat increases and subsequently reduces their feed intake. It is possible that the decrease in feed intake in PBS group at the later stage of feeding period might be attributed to the increase of abdominal fat. In previous experiment, Stanhope et al. (1980) reported decreased DMI as level of potato processing residue increased from 0 to 60% of the diet DM in barley-based finishing diets. However, Heinemann and Dyer (1972) and Sauter et al. (1980) reported no effects of addition of potato by-products up to 51.9% of DM in barley-based diets to cattle on weight gain, DM intake and feed efficiency.

Our results showed that the final body weight of the PBS-fed steers tended to be lighter than that of control group. This was probably due to the PBS-fed steers had lower initial body weight and lower ADG than those of control steers. In the present study, no significant differences were observed in yield scores and meat quality scores between steers fed PBS and control diets. These results were consistent with Nelson et al. (2000) and Heinemann and Dyer (1972) who reported that carcass characteristics and yield scores were not affected by inclusion of potato wastes up to 20 and 51.9% of diet DM, respectively. However, Radunz et al. (2003) reported that hot carcass weight, 12^{th} rib fat thickness and yield score decreased with increasing potato processing waste inclusion, but marbling score was no affected. In comparing 25 and 50% addition of potato by-product, Sauter et al. (1980) observed the decreased fat thickness, rib eye area, and yield grade. The mixed effects of potato by-products in beef cattle diets on carcass characteristics and meat quality scores may be due to the differences in levels and types of potato by-products and the way the potato by-products were treated before incorporated into cattle rations. Although there were no significant differences in carcass characteristics between the two groups, the rib eye area, rib thickness and s.c. fat thickness of PBS group were numerically lower than those of control group. This might be due to PBS-fed group had lower initial and final body weight than those of control group.

No significant differences were observed in beef DM, EE, and CP between the two diet groups. In addition, no significant effect of PBS was observed in drip loss, cooking loss of beef, but PBS-fed beef tended to have lower WBS values than control beef. These results were consistent with Nelson et al. (2000), Boshoom et al. (2000), and Radunz et al. (2003). No significant differences were observed in melting point of carcass fats between both diet groups.

In both diet groups, the proportions of PUFA in subcutaneous fat 6 mo after the start of the experiment increased compared with 3 mon. Herta-Leidenz et al. (1996) stated that percentages of C18:1 and C18:2 fatty acids increase with animal age and weight, whereas a proportion of C18:3 fatty acids decrease. The increase of C18:2 fatty acid proportion with age and weight of animals was consistent with our result, but a decrease of C18:3 contradicted with ours. On the other hand, Hecker et al. (1975) demonstrated that C12:0, C14:0 and C18:0 fatty acids decrease with animals' growth, which were consistent with our results.

The steers fed PBS diet had higher proportions of PUFA, especially C18:2 fatty acids in carcass fats and semitendinosus muscle than steers fed control diet. French et al. (2000) reported that decreasing the proportion of concentrates and increased grass in the diet caused a linear decrease in saturated fatty acid concentration and PUFA:SFA ratio in intramuscular fat. However, Nelson et al. (2000) reported that inclusion of potato by-products at 20% of DM in barley or corn based diets had little effects on fatty acid profile of intramuscular fat. The deposition of C18:2 fatty acids in ruminant tissues must derive from the amount of its escape from rumen biohydrogenation or microbial lipids which flow from rumen because the host animals itself cannot synthesize this fatty acid (Vernon et al., 1988). The proportion of C18:1, C18:2 and C18:3 fatty acids in the rumen fluid are influenced by the fatty acid composition of dietary fats (Wang et al., 2003). Therefore, it is possible that higher proportion of C18:2 and C18:3 fatty acids found in carcass fats of steers fed PBS than control steers might be due to higher proportion of C18:2 and C18:3 fatty acids of PBS and soybean milk residue. On the other hand, an increase in the amount of feed intake has been shown to enhance rumen particulate passage rate (Mudgal et al., 1982), which help to increase the flow of dietary C18:2 and C18:3 fatty acids to small intestine and consequently higher proportion of these fatty acids deposit in the carcass fats.

In conclusion, feeding the PBS to fattening steers seems to have the same potential as concentrates feeding in term of the effect on growth performance, carcass characteristics, and fatty acid composition of the carcass fats. Interestingly, it also excelled concentrates because it tended to produce tender beef with higher concentration of C18:2 and C18:3 in adipose tissues and intramuscular fat. On the other hand, as the cost of PBS is about one third of the concentrates, the beef production from PBS would generate more benefit than concentrates, particularly at the fattening stage as PBS contained the same gross energy content as the concentrates.

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