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Effects of feeding rumen-protected palm oil calcium soaps on carcass and ribeye characteristics in finishing Hanwoo steers (a field study)

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Abstract

This study was conducted to determine the effect of feeding 1.5% palm oil calcium soaps (POCS) (135 g/head/day) on carcass and ribeye characteristics in finishing Hanwoo steers. Feeding POCS did not affect carcass yield traits such as back fat thickness, ribeye area, yield index, or quality traits such as marbling, meat colour, fat colour, texture, maturity, and quality grade at slaughter ($P>0.05$). However, feeding POCS decreased yield grade at farm 1 and increased it at farm 2 ($P<0.05$). Feeding POCS affected ribeye fatty acid composition ($P<0.05$), increased ribeye stearic acid by 19% ($P<0.005$) and n-3 α-linolenic acid by 11% ($P<0.05$), but did not affect the percentage of palmitic, oleic, or linoleic acids, mono-unsaturated fatty acids (MUFA), poly-unsaturated fatty acids and essential fatty acids or the ratio of saturated fatty acids: unsaturated fatty acids ($P>0.05$). Feeding POCS did not affect water holding capacity, cooking loss, pH, moisture, crude protein, ether extract or crude ash of ribeye ($P>0.05$). Furthermore, feeding 1.5% POCS did not affect Hanwoo steer weight gain ($P>0.05$). In conclusion, feeding 1.5% POCS to finishing Hanwoo steers changed the composition of ribeye fatty acids without deleterious effects on carcass or ribeye characteristics and body weight gain.

Keywords: Palm oil; fatty acid; ribeye; beef cattle; Hanwoo

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Introduction

Palm oil is one of the principal vegetable oils used in the animal feed market and can be purchased in the form of oil or calcium (Ca) soaps. The major palm oil fatty acids are palmitic acid (43.5%) and oleic acid (36.5%) (Staples et al., 1998). When 10.6% palm oil was fed to lambs, backfat thickness and contents of ribeye saturated fatty acids (SFA) and palmitic acid increased, but other long chain fatty acids remained unchanged (Solomon et al., 1992; Lough et al., 1993). When 3–5% levels of palm oil Ca soaps were fed to lambs, intramuscular fatty acids including palmitic acid, polyunsaturated fatty acids (PUFA), and SFA were not affected but monunsatuated fatty acids (MUFA) decreased (Castro et al., 2005). Additionally, feeding a variety of animal fats or vegetable oils affected meat fatty acid composition consistently (Brandt and Anderson, 1990; Ponnampalam et al., 2001; Felton and Kerley, 2004; Gillis et al., 2004a; Choi et al., 2006).

Feeding various fats or oils to beef cattle improved meat quality including marbling (Brandt and Anderson, 1990; Felton and Kerley, 2004; Gillis et al., 2004b; Nelson et al., 2004), but in contrast did not affect meat quality in other studies (Huffman et al., 1992; Zinn et al., 2000; Ramiro et al., 2001; Lee et al., 2003). Feeding fats or oils improved weight gain in beef cattle (Huffman et al., 1992; Zinn, 1992; Lee et al., 2003; Nelson et al., 2004), but did not affect it in other studies (Hill and West, 1991; Zinn et al., 2000; Gillis et al., 2004b; Haddad and Younis, 2004). These differences in results can be caused by different lipid sources and experimental conditions. However, a few

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studies are available on the effect of feeding palm oil Ca soaps (POCS) on carcass and ribeye characteristics of Hanwoo steers.

Accordingly, this study was conducted to determine the effect of feeding rumen-protected POCS on carcass and ribeye characteristics of finishing Hanwoo steers.

Materials and Methods

Animals and treatment

All animal care protocols were approved by the Konkuk University Institutional Animal Care and Use Committee. Twenty-four Hanwoo (*Bos taurus coreanae)* steers at 23 months of age (average body weight, 598 kg) were allotted into groups of four steers in each of six pens. Four of the pens were located at farm 1 and two at farm 2. The steers were fed either a control diet (concentrate mix and rice straw) or a treatment diet (the control diet + 1.5% POCS). The POCS product was supplied by Eunjin-Bio Ltd in Seoul, Korea. The dietary addition of 1.5% POCS was a feasible level used in the practical field situation. The diets were fed for 8 months until the animals were slaughtered. The POCS was top-dressed at each feeding time. Feed was supplied twice per day at 07:00 h and 18:00 h. The concentrate mix was fed *ad libitum*, and rice straw was restricted to approximately 10% of the concentrate mix intake level.

Sampling and chemical analysis

The meat properties of the live Hanwoo steers at 70-80 days before slaughter were tested using an ultrasonic scanner (SSD-500; Aloka, Wallingford, CT, USA). Steers at 30 months of age were withdrawn from the experimental diets 24 h before slaughter. Following a 24h carcass chill, yield and quality traits were assigned to each carcass using Korean carcass grading standards specified in the attached list no. 4 of the Korean Livestock Enforcement Regulation (KMAF, 2007). The 12th to 13th rib *longissimus* muscle was removed from each steer and frozen for later analysis.

Samples were sent to a certified commercial laboratory for fatty acid analysis of the rib muscle and the POCS product (Scientific Lab Center Co, Ltd. Seoul, Korea). Fat was extracted according to the method of Folch et al. (1957). Fatty acids were methylated by the method of Morrison and Smith (1964) and analyzed using gas chromatography (6890N, Agilent Technologies, Palo Alto, CA, USA).

For the analysis of ribeye quality and proximate components, four meat samples of grade one for each treatment were selected, dried and ground to pass through a 1 mm screen using a sample mill (Cemotec, Tecator, Hillerød, Denmark). Dry matter was determined by drying samples to constant weight at 65°C for 48 h. Crude protein, ether extracts (EE), and crude ash were determined by AOAC methods (2000). Water-holding capacity was measured using a filter paper press method at 24 h postmortem. Cooking loss was determined as a percentage of initial weight. pH was measured at 24 h postmortem using a pH meter (HI9321, Hanna Instrument, Amorim, Portugal).

Statistical analysis

Data were analyzed by a general linear model using farm as the block in a randomized complete block design (Statistix7, 2000). As the farm effect was not significant, most data were pooled except for those on meat properties, which were analyzed separately depending on farms. The comparison of means between the control and POCS treatment was made using Studentized *t*-test (Statistix7, 2000). Significant differences were detected at $P<0.05$.

Results and Discussion

Chemical composition of POCS

The chemical composition of POCS is presented in Table 1. The major fatty acids components of POCS were palmitic acid (45%), oleic acid (38%), linoleic acid (10%), and stearic acid (6%). The ratio of SFA and unsaturated fatty acids (UFA) was approximately 52:48. The values were similar to 43.5% palmitic acid and 36.5% oleic acid reported by Staples et al. (1998). These characteristics of palm oil fatty acid composition and the high SFA: UFA ratio was similar to those of animal tallow rather than vegetable seed oil, which is dominated by UFA (Nelson et al., 2004).

Table 1: Fatty acid composition of rumen-protected POCS[1,2]

Fatty acid	----- % ----
C12:0	0.21
C14:0	1.05
C15:0	0.05
C16:0	44.61
C16:1	0.18
C17:0	0.10
C18:0	5.64
C18:1	37.55
C18:2	9.57
C18:3	0.16
C20:0	0.45
C20:1	0.14
C22:0	0.17
C22:2	0.01
C23:0	0.02
C24:0	0.08
SFA : UFA[3]	52.4 : 47.6

[1]Means of three observations; [2]POCS, palm oil calcium soaps; [3]SFA, saturated fatty acids; UFA, unsaturated fatty acids.

Carcass yield and quality traits

The ultrasonic meat properties of the live steers were tested at 70–80 days before slaughter at 30 months of age (Table 2). Feeding 1.5% POCS to finishing Hanwoo steers did not affect backfat thickness, yield grade, or quality grade appearance (P>0.05).

Table 2: Ultrasonic meat properties of Hanwoo steers fed a POCS-added diet[1,2]

Item	Control	POCS added	SE
No. of heads	12	12	
Back fat thickness, mm	12.4	9.7	
Meat yield grade[3]	1.72	1.30	
Meat quality grade[4]	3.08	3.00	1.6
1^{++}, heads	1	0	0.27
1^{+}, heads	2	3	0.37
1, heads	4	6	
2, heads	5	3	
3, heads	0	0	

[1]Means of 12 observations; [2]POCS, palm oil calcium soaps; [3]Converted to a numeric grade: A = 1, B = 2, C = 3; [4]Converted to a numeric grade: 1^{++} = 1, 1^{+} = 2, 1 = 3, 2 = 4, 3 = 5; [ab]Control group differed from the POCS-added group (P < 0.05).

The experimental Hanwoo steers at the two farms were slaughtered at 30 months of age, and the meat properties are presented in Table 3. Effects on yield grade were different depending on the farm, so each farm's data are presented separately. Feeding 1.5% POCS to finishing steers at farm 1 did not affect cold carcass weight or back fat thickness, but improved carcass yield grade (P<0.05). Although no difference in carcass weight or back fat thickness was observed at farm 2, yield grade was worse (P<0.05). These different results at the two farms indicated that carcass traits could be affected by the different environmental conditions at each farm.

Feeding POCS did not affect marbling, meat colour, fat colour, texture, maturity, or quality grade of the steers at the two farms (P>0.05). Feeding palm oil to lambs increased backfat thickness (Solomon et al., 1992; Lough et al., 1994), but did not affect it in other studies (Castro et al., 2005; Dutta et al., 2008). When 3.8% palm oil was fed to fattening lambs, carcass quality including intramuscular fat was not different (Dutta et al., 2008). Feeding various fats or oils to beef cattle improved meat quality including marbling (Brandt and Anderson, 1990; Felton and Kerley, 2004; Gillis et al., 2004b; Nelson et al., 2004), but contrarily did not affect meat quality in other studies (Huffman et al., 1992; Zinn et al., 2000; Ramiro et al., 2001; Lee et al., 2003). When 3% bypass fat (Megalac) was fed to beef cattle, it did not affect carcass yield or quality traits (Ramiro et al., 2001). These inconsistent results seemed to be due to differences in the fat source, fat feeding level, and feeding period in different experiments.

Table 3: Meat properties at slaughter in Hanwoo steers fed a POCS-added diet[1,2]

Item	Control	POCS added	SE
Farm 1			
Marketing wt, kg	731	727	31
Cold carcass wt, kg	433	419	23
Yield traits			
Back fat thickness, mm	14.5	11.3	2.5
Longissimus muscle (ribeye)	84.5	88.9	4.4
area, cm^2	62.9	65.9	1.9
Yield index	2.3^{a}	1.8^{b}	0.2
Yield grade[3]			
Quality traits	6.00	5.25	1.0
Marbling score	4.25	4.13	0.21
Meat color	3.00	2.88	0.13
Fat color	1.25	1.13	0.21
Texture	2.38	2.13	0.22
Maturity	2.13	2.50	0.5
Quality grade[4]	3:2:2:1:0	1:2:5:0:0	
1++ : 1+ : 1 : 2 : 3, heads			
Farm 2	720	740	18
Marketing wt, kg	406	427	12
Cold carcass wt, kg			
Yield traits	15.0	17.5	3.7
Back fat thickness, mm	79.0	81.0	5.3
Longissimus muscle (ribeye)	62.6	60.8	2.5
area, cm^2	2.0^{a}	3.0^{b}	0.4
Yield index			
Yield grade[3]	4.0	3.8	1.1
Quality traits	4.8	4.5	0.4
Marbling score	3.0	3.0	0
Meat color	1.5	1.3	0.4
Fat color	2.0	2.0	0
Texture	3.25	3.25	0.5
Maturity	0:0:2:2:0	0:0:3:1:0	
Quality grade[4]			
1++ : 1+ : 1 : 2 : 3, heads			

[1]Means of eight observations for farm 1 and means of four observations for farm 2; [2]POCS, palm oil calcium soaps; [3]Converted to a numeric grade: A = 1, B = 2, C = 3; [4]Converted to a numeric grade: 1^{++} = 1, 1^{+} = 2, 1 = 3, 2 = 4, 3 = 5; [ab]Control group differed from the POCS-added group (P<0.05)

Ribeye fatty acid composition

The chemical composition of ribeye fatty acids is presented in Table 4. Feeding POCS to finishing Hanwoo steers affected ribeye fatty acid composition (P<0.05). Feeding POCS increased ribeye stearic acid by 19% (P<0.005) and n-3 α-linolenic acid by 11% (P<0.05), but did not affect ribeye palmitic acid, oleic acid, linoleic acid, MUFA, PUFA, EFA, or the SFA: UFA ratio. Ribeye fatty acids in steers fed 1.5% POCS were high in the order of oleic acid (41%), palmitic acid (27%), stearic acid (19%), palmitoleic acid (5%), myristic acid (3%), and linoleic acid (2%).

Unexpectedly, feeding palm oil rich in palmitic acid was not followed by an increase in ribeye palmitic acid content. In contrast, stearic acid content in ribeye increased ($P<0.05$). This phenomenon can occur by the biochemical metabolic processes such as elongation of palmitic acid and biosaturation (biohydrogenation) of UFA in the body of steer (Church, 1988).

Table 4: Fatty acid composition of the *longissimus* muscle (ribeye) fat in Hanwoo steers Fed a POCS-added diet[1,2]

Item[3]	Control	POCS added	SE
C10:0	0.05	0.03	0.01
C12:0	0.09	0.08	0.009
C14:0	3.83	3.48	0.24
C14:1	1.31	1.10	0.12
C15:0	0.29	0.28	0.03
C16:0	28.06	27.07	0.82
C16:1	5.50	5.09	0.23
C17:0	0.64	0.67	0.06
C18:0	15.82[a]	18.76[b]	0.81
C18:1	41.53	40.50	1.17
C18:2n6	1.92	1.98	0.10
C18:3n6	0.034	0.032	0.002
C18:3n3	0.127[a]	0.141[b]	0.007
C20:0	0.099	0.105	0.004
C20:1	0.354	0.364	0.04
C20:2	0.033	0.034	0.002
C20:3n6	0.100	0.090	0.006
C20:4n6	0.088	0.076	0.007
C22:0	0.010	0.010	0.001
C22:1	0.012	0.010	0.001
C22:2	0.013	0.015	0.001
C22:5n3	0.027	0.019	0.007
C23:0	0.052	0.049	0.004
C24:0	0.013	0.010	0.002
SFA	49.0	50.6	1.26
UFA	51.0	49.4	1.26
MUFA	48.6	47.0	1.21
PUFA	2.34	2.39	0.11
EFA	2.18	2.25	0.11

[1]Means of 12 observations. [2]POCS, palm oil calcium soaps; [3]SFA, saturated fatty acids; UFA, unsaturated fatty acids; MUFA, mono-unsaturated fatty acids; PUFA, poly-unsaturated fatty acids; EFA, essential fatty acids; [ab]Control group differed from the POCS-added group ($P<0.05$)

Table 5: Property of the *longissimus* muscle (ribeye) of Hanwoo steers fed a POCS-added diet[1,2]

Item	Control	POCS added	SE
Water holding capacity,%	50.8	51.3	2.9
Cooking loss,%	20.8	20.8	3.3
pH	5.41	5.44	0.04
Dry matter	40.2	40.6	1.4
Crude protein	45.5	48.7	3.8
Ether extract	52.8	50.1	3.1
Crude ash	8.4	6.3	0.9

[1]Means of four observations of grade one meats; [2]POCS, palm oil calcium soaps; [ab]Control group differed from the POCS-added group ($P<0.05$)

Generally, it has been known that feeding dietary fats or oils affected composition of ribeye fatty acids (Brandt and Anderson, 1990; Ponnampalam et al., 2001; Felton and Kerley, 2004; Gillis et al., 2004a; Choi et al., 2006). When 10.6% palm oil was fed to lambs, back fat thickness, ribeye palmitic acid, and SFA increased, whereas ribeye stearic acid, linolenic acid, and lipid contents was unaffected, but the fat became hard (Solomon et al., 1992; Lough et al., 1993). Feeding 3–5% POCS to lambs did not affect intramuscular palmitic acid, other fatty acids, PUFA, or SFA content, but decreased MUFA content (Castro et al., 2005). These results indicate that as the feeding levels of palm oil increase, the effects seem to get more significant.

The higher the n-3 α-linolenic acid content and the lower the arachidonic acid content is in food, the better it is for consumer health (Department of Health, 1994; Choi et al., 2006). In the present study, feeding POCS increased ribeye n-3 α-linolenic acid content ($P<0.05$). Feeding fish oil and fish meal rich in n-3 PUFA to lambs increased n-3 fatty acids in muscular phospholipids (Ponnampalam et al., 2001). Feeding rumen-protected conjugated linoleic acid (CLA) or corn oil to fattening cows for 1–2 months decreased meat adipose MUFA and oleic acid contents (Gillis et al., 2004a). Feeding linseed rather than whole soybean increased CLA content in meat triglycerides and n-3 α-linolenic acid (C18:3) in meat phospholipids (Choi et al., 2006). These results indicate that feeding fats can affect meat fatty acid composition differently depending on the fat source, feeding conditions, feeding period and animal species. In the present study, feeding POCS did not affect meat colour, fat colour, texture, maturity or meat quality grade.

Other ribeye characteristics

Other ribeye characteristics affected by feeding POCS are presented in Table 5. Feeding POCS did not affect water holding capacity, cooking loss, or pH ($P>0.05$). Feeding POCS did not affect dry matter, crude protein, EE, or crude ash contents ($P>0.05$). In a similar study, feeding 10.6% palm oil to lambs did not affect ribeye EE content (Solomon et al., 1992).

Feed intake and weight gain of steers

Feeding 1.5% POCS to finishing Hanwoo steers did not reduce concentrate mix intake (control group 8.58 vs. POCS group 9.30 kg/d) or average daily weight gain (control group 0.59 vs. POCS group 0.66 kg, Table not presented). In other studies also, feeding fats or oils did not increase weight gain (Hill and West, 1991; Zinn et al., 2000; Gillis et al., 2004b; Haddad and Younis, 2004). In general, very low levels of dietary fat may be the cause for the statistically insignificant results.

Conclusions

Feeding POCS to finishing Hanwoo steers changed ribeye fatty acid composition without deleterious effects on carcass characteristics or performance of finishing Hanwoo steers. These results indicate that POCS can be used as a high energy-containing additive during the finishing period when voluntary feed intake decreases. The findings that feeding POCS resulted in increased ribeye n-3 α-linolenic acid content can be used as basic data for producing beef high in this beneficial fatty acid. Future studies should determine the proper feeding level and period for POCS supplementation.

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