The effect of feeding regime, beta – agonists and animal age on intramuscular fat content and fatty acid composition of beef

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Abstract – The effects of animal age, feeding regime and beta – agonists on the intramuscular fat (IMF) content and fatty acid composition of *M. longissimus thoracis* (LT) were studied. Fifteen grain fed Bonsmara steers of A – age (0-tooth) supplemented with beta – agonist (zilpaterol) (AZ) and 15 grain fed without zilpaterol (AC) represented the grain fed groups. Twenty grass fed Bonsmara steers of AB – age (1 – 2 teeth) and 20 of B – age (3 – 6 teeth) were used. Grain feeding increased IMF percentages ($p < 0.001$) and linoleic acid (C18:2n – 6) ($p<0.001$) compared to pasture feeding. Beta – agonists had no effect on fatty acid profile of LT. Pasture feeding significantly ($p<0.001$) increased the percentages of α linolenic acid (C18:3), CLA (C18:2 cis-9, trans11) and saturated phytanic acid (3,7,11,15 tetramethyl hexadecanoic acid). IMF levels did not change with increased age within pasture groups and only α linolenic acid (C18:3) content decreased significantly ($p < 0.001$) with increased animal age in the pasture fed group.

I. INTRODUCTION

In South Africa beef is classified according to the age of the animal determined by dentition. A – age is younger animal (0 tooth) mostly found in feedlots, while AB – and B – ages are older animals (1 – 2 and 3 – 6 teeth, respectively) (1), and are normally grown on pasture. Research has shown that meat quality traits of these two feeding regimes or production systems differ (2). Feeding regime influences fat content of beef, hence fatty acid composition, and ultimately meat quality of fresh meat (3). In the same way, animal age influences fat content of the animal. For example, fattening occurs as a normal part of growth of an animal. Depending on the supply of nutrients, older animals bear more fat tissue than younger animals (4). The review of Wood *et al*. (5) also indicated that as the fat content of the animal and meat increases from early life to time of slaughter, the proportions of fatty acids (FAs) also change.

Most studies compared the effect of pasture feeding and grain feeding on fat content and FA composition of beef (4, 5, 6). Few studies reported on the effects of growth promotents on FA profiles, particularly beta – agonists in interaction with feeding regime.

The objective of this study was therefore to compare the influence of feeding regime, beta – agonists and animal age at slaughter on IMF and FA composition of beef steaks from older steers raised on pasture and younger grain fed steers supplemented with zilpaterol

II. MATERIALS AND METHODS

Twenty each of AB – and B – age Bonsmara steers were purchased from a commercial farmer and represented the two pasture fed groups. Thirty weaner steers which presented the A – age group were grain fed under commercial feedlot conditions for approximately 110 days. Fifteen steers were supplemented with beta – agonist (zilpaterol) (AZ) for the final 30 days with 2 days withdrawal. The remaining fifteen received no zilpaterol, and were used as the control group (AC). All animals were slaughtered at optimum market condition with a subcutaneous fat thickness of ≈ 5mm over the loin at the last rib and electrically stimulated (1).

Extraction of total lipid from the *M. longissimus thoracis* muscle (LT) was performed quantitatively, according to Folch *et al*. (7). FA analysis was performed with gas chromatography according to the methods of Park *et al*. (8) and Cilliard *et al*. (9).

Differences between the four treatments were determined by analysis of variance (ANOVA) and the Tukey – Kramer multiple comparison test ($\alpha = 0.05$) was used to determine differences between treatment means (10).

III. RESULTS AND DISCUSSION

The effect of production system, age classification and beta – agonists on IMF content and FA profiles of LT muscle are shown in (Table 1). Feeding regime had a significant ($p < 0.001$) effect on IMF content. Grain feeding increased IMF percentages significantly ($p < 0.001$) when compared to pasture raised animals in agreement with the study of Faucitano *et al*. (11). Although not statistically significant the AC group had higher IMF content than AZ group. The lower IMF of grass fed and beta – agonist supplemented animals is most likely due to animal physiology. Scollan, *et al*. (3) have shown that the IMF content at the beginning of the finishing period is mainly explained by the number of preadipocytes which depends on genetic and nutritional factors. At the cellular level, this may be due to increased levels of anabolic hormones (insulin) which stimulates lipogenesis and/or to a preference of marbling adipocytes for carbohydrate carbon to synthesise FAs unlike adipocytes of other fat depots.

Age at slaughter did not affect IMF of the pasture raised steers. Schönfeldt, *et al*. (12) also found no significant differences in muscle fat content among A, B and C – age classes from raw cuts of beef sourced from the commercial South African market when their carcass fat levels were similar. This could probably be explained by adipocytes physiology. It has been indicated that advancing age does not influence all stem cells with adipogenetic potential. Germ stem line cells and some of the expression of the transcriptional factors essential for adipogenesis may decline in older animals, as a result older animals may be less able to support adipogenesis even if they have genetic predisposition to fatness (13).

Grain feeding increased myristic acid (C14:0) in LT muscle significantly ($p < 0.001$) compared to pasture feeding while palmitic acid (C16:0) and margaric acid (C17:0) were significantly ($p < 0.001$) lower in feedlot LT muscle compared to pasture LT muscle. Production system had no effect on stearic acid (C18:0) of LT muscle.

Phytanic acid was significantly ($p < 0.001$) influenced by production system with higher phytanic acid levels observed in LT muscle of pasture fed animals compared to grain fed animals. Phytanic acid is a saturated branched FA (3,7,11,15 tetramethylhexadecanoic acid) which is synthesised from phytol, cleaved from chlorophyll (14). Percentage of phytanic acid was ± 0.7 % of total FAs in the LT muscle of pasture fed animals compared to ± 0.3 % of total FAs in the grain fed animals. Young, *et al*. (14) reported that phytanic acid have health improving properties and occur at levels around 0.3 % in organic beef fat.

Individual polyunsaturated FAs (PUFAs) were significantly affected by feeding regime. Pasture feeding significantly ($p < 0.001$) increased percentages of C18:3 *cis* 9 and C18: 2 *cis* 9 *trans* 11 (CLA), when compared to grain feeding. Faucitano *et al*. (11) reported similar increases of these FAs in the LT of steers. Grain feeding increased linoleic acid (C18:2n – 6 *cis* 9) significantly ($p<0.001$) in LT muscle when compared to pasture feeding. This effect was more pronounced with beta – agonists showing a numerically higher linoleic acid level than the control grain fed group. This is contradictory to the findings of Webb & Casey (15) who observed a shift towards a more SFA profile in the LT muscles of animals receiving beta – agonists.

Age within pasture affected C18:3 significantly ($p < 0.001$**)**. The α linolenic acid (C18:3) content decreased significantly ($p < 0.001$) with increased animal age. SFAs (C14:0), (C16:0) tended to be higher in B – age group when compared to AB – age group. The C18:2 was also slightly higher in AB – age group than in the B – age group. This tendency is in agreement with the results of Schönfeldt *et al*. (12) who reported increased C16:0 with increasing animal age while C18:2 decreased with increasing animal age.

FA ratios are shown in Table 2. Finishing ruminants on pasture significantly ($p < 0.001$) decreased the n – 6/n – 3 ratio in muscle fat to a value of less than 2. This ratio was more than 13 in the LT muscle of grain fed animals. The lower n – 6:n –3 ratio was due to significantly ($p<0.001$) higher n – 3 in the LT muscle of pasture fed animals when compared to grain fed animals. Furthermore, the n – 6 ratio also

showed slighly higher values in grain fed animals compared to pasture fed animals in agreement with the findings of Enser *et al*. (16).

The P/S ratio, atherogenicity index and desaturase index was not significantly influenced by feeding regime or age within pasture feeding, however AB pasture had the highest P/S ratio, followed by the grain fed AZ, with AC showing the lowest P/S ratio. In beef P/S ratio is mainly determined by level of fatness and it increases with lower IMF content (17).

IV. CONCLUSION

Our results confirm findings of previous studies that type of diet influences FA composition of beef that may have health benefits. In particular higher ratios of certain PUFA (linoleic acid, CLA and alpha – linolenic acid) but also of the branched chain SFA, phytanic acid, were found in loins of pasture fed animals. Furthermore, animal age will have a minimal effect on FA composition of meat from pasture animals if IMF content is the same. The FA composition of meat from grain fed cattle is generally not influenced by the use of beta agonists except for a tendency towards higher n – 6 PUFA in beta – agonist produced LT.

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Table 1: Effect of production system and age on intramuscular fat content and fatty acid profiles of LD muscle (Tukey-Kramer Multiple comparison test)

Means with different superscripts in the same row differ significantly

Feeding regime	Pasture		Grain fed		Sign. level
Age/beta agonist treatment	AB	B	A: Control	A: zilpaterol	
%Fat	1.73 [a]	1.93 [a]	3.29 [b]	2.81 [b]	p < 0.001
FAME (% of total fatty acids)					
C14:0	2.29 [a]	2.80 [ab]	3.17 [b]	3.28 [b]	p = 0.001
C16:0	31.8 [bc]	32.8 [c]	30.6 [ab]	29.8 [a]	p < 0.001
C17:0	0.94[b]	0.95[b]	0.64[a]	0.64 [a]	p < 0.001
C18:0	16.5	15.7	17.2	16.9	p = 0.100
C18:1c9	33.1	33.2	34.6	33.3	p = 0.388
C18:2c9,12 (n-6)	3.94 [a]	3.40 [a]	5.87 [b]	7.23 [b]	p < 0.001
3,7,11,15 tetramethylhexadecanoic acid	0.66 [b]	0.71[b]	0.30[a]	0.36 [a]	p < 0.001
C18:3c9,12,15 (n-3)	1.32[c]	1.09[b]	0.16[a]	0.24[a]	p < 0.001
C18:2c9,t11 (CLA) (n-6)	0.19 [b]	0.21[b]	0.02[a]	0.03[a]	p < 0.001

Table 2: Effect of production system and age on intramuscular fat content and fatty acid profiles of LD muscle (Tukey-Kramer Multiple comparison test)

Means with different superscripts in the same row differ significantly

Feeding regime	Pasture		Grain fed		Sign. level
Age/beta agonist treatment	AB	B	A: Control	A:zilpaterol	
Fatty acid ratios:					
Total SFA	52.5	53.4	52.0	51.1	p = 0.254
Total MUFA	37.8 [a]	38.8 [ab]	40.6 [b]	40.0 [ab]	p < 0.039
Total PUFA	9.7	7.9	7.4	8.9	p = 0.252
Total (n-6)	5.9 [ab]	4.9 [a]	6.8 [ab]	8.2 [b]	p < 0.017
Total (n-3)	3.54 [c]	2.72 [b]	0.55 [a]	0.68 [a]	p < 0.001
PUFA:SFA	0.19	0.15	0.15	0.17	p = 0.390
n-6/n-3	1.64 [a]	1.90 [a]	16.47 [b]	13.53 [b]	p < 0.001
Atherogenicity Index	0.87	0.95	0.91	0.88	p = 0.317
Desaturase Index	2.05	2.14	2.04	1.99	p = 0.614

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