FATTY ACID PROFILE OF BEEF *M. LONGISSIMUS* AS INFLUNCED BY DIET AND AGE

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Abstract – Fatty acid composition and content of meat have potentially negative or positive health implications. Age, duration of feeding and diet determine muscle fat content and fatty acid composition. In this trial the muscle fat content and fatty acid (FA) composition of beef *M. longissimus* (LD) of seven age/feeding regime combinations were compared, namely grass finished A (0 tooth), AB (1 - 2 permanent incisors, p.i.), B (4 p.i.), B (6 p.i.), C (8 p.i.) and grain finished A (0 p.i.) and AB (1 - 2 p.i.). Total lipid, monounsaturated FA and n-6 polyunsaturated FA (n-6 PUFA) in LD of grain fed cattle were higher and n-3 PUFA lower than that in LD of grass fed cattle. Under the conditions of this study, age or duration of grass feeding did not influence FA composition of beef LD but diet had a significant effect

I. INTRODUCTION

The fatty acid (FA) composition of meat (muscle and adipose tissue) determines the nutritional value and affects various aspects of meat quality, including shelf life and flavour (1, 2). Animal source foods (ASF) are commonly blamed as the cause of weight problems and various "modern lifestyle diseases" as a result of their perceived high saturated FA (SFA) content and unfavourable polyunsaturated FA (PUFA) proportions (3, 4). According to Mann *et al*. (5) the negative image of red meat was mainly the result of the production of high fat carcasses, while in certain countries where production systems cater for leaner carcasses and efforts are made to encourage consumption of trimmed red meat, health benefits of red meat consumption are demonstrated. In particular, various studies have proved that the presence of certain FA in lean red meat has beneficial health effects (6, 7).

Carcass fatness, age, fat depot and feeding regime are the most important factors affecting the FA composition of beef (2). However, contradicting results can occur due to interactions among these factors. For example, carcass fatness, that is normally also related to intermuscular fat content (IMF), is usually a function of feeding regime and/or duration of feeding. While feeding regime influences the FA composition of meat, e.g. grass vs. grain diet (2), the duration of feeding may (8) or may not (9) increase IMF or total fat. Furthermore, the duration of feeding under different feeding regimes may have different effects on accumulation of IMF or total fat (8). Consequently the nutritional value in relation to FA in red meat will depend on the interactions among the named factors that will not only influence the proportions but also the actual amount of these FA that are consumed through red meat.

In this study we investigated the effects of feeding regime and animal age on muscle fat *content* and muscle *FA composition* in a commercial production and marketing system. The samples were sourced from the export abattoir of the Meat Corporation of Namibia (Pty, Ltd). Meatco classifies carcasses according to dentition (permanent incisors, p.i.) into five age groups, A (0 p.i.), AB (1 - 2 p.i.), B4 (4 p.i.), B6 (6 p.i.), C (8 p.i.) (10). Animals of age A and AB may originate from pasture or feedlot (grain fed), while all other age groups represent pasture fed animals. According to Lawrence *et al*. (11) variation in age among the four groups could be <23.8 mo, 23.8 to 30.4 mo, 30.4 to 38 mo, 28 to 45.3 mo and > 45.3 m for A, AB, B4, B6 and C, respectively. The duration of grass feeding was accompanied by seasonal variation in quality and quantity of natural pasture.

II. MATERIALS AND METHODS

Seven age (10)/feeding regime groups were used namely, grass fed AP, ABP, BP4, BP6, CP and grain fed AF and ABF. Twenty mm slices of the *M. longissimus* (LD) of one side of the carcass from 12 animals per age/feeding group were sampled, vacuum-packed and stored frozen (-

20°C) until determination of FA profile and fat content. Extraction of lipid from muscle was performed according to Folch *et al*. (12) using chloroform and methanol in a ratio of 2:1. Total lipids from muscle were converted to methyl esters, with sodium methoxide (0.5 M solution in anhydrous methanol), during 2 h at 30°C (13). Fatty acid methyl esters were quantified, using a Varian 430-GC flame ionization GC. Fatty acids were quantitatively determined by using nonadecanoic acid (C19:0) as internal standard and expressed as mg fatty acid/100g muscle. Data of all FA were subjected to analysis of variance (14).

III. RESULTS AND DISCUSSION

LD of grain fed animals (AF and ABF) contained more total lipids than those of grass fed animals but duration of grass feeding, or age, had no effect on muscle lipid (P<0.001; Table 1). In contrast to our study, Warren *et al*. (9) reported higher carcass fat and muscle lipid levels in cattle rounded off on grass silage than on concentrates. In addition, total lipids increased between 14 to 24 months irrespective of type of diet. In our study the difference in age between AP and CP cattle could have been up to 5 years that included seasonal weight loss and gain resulting in relatively lean carcasses compared to grain fed animals. Grain fed cattle were fed on a high energy diet that would have increased the muscle fat levels (15).

Feeding regime had a significant effect on FA content, while age within feeding regime had minimal effects (Table 1, 2, 3). Neither SFA nor PUFA content differed between grass fed and grain fed animals or among age groups of grass fed cattle. Myristic acid (14:0) made a relative small contribution to total SFA, but was higher in grain fed groups than in grass fed groups (P=0.027). Proportional and actual MUFA levels were higher in grain fed groups (P=0.002) than in grass fed groups. In support, Smith *et al*. (16) and Shirouchi *et al*. (17) reported a positive relationship between the % MUFA and IMF level. Ntambi *et al*. (18) ascribe this to the elevated levels of enzyme, stearoyl-CoA desaturase (SCD), which is responsible for the formation of MUFA from SFA. Therefore SFA will not necessarily increase with an increase in muscle fat as was reported by Scolan *et al*. (19) who demonstrated a decline in the P:S ratio as a result of higher SFA levels when muscle fat increased. Wood *et al*. (2) reported on various studies where the simultaneous effects of age and fatness on changes in FA proportions were investigated. However, in all of these studies the increase in age was always accompanied by an increase in fatness that led to an increase in proportions (and probably actual level) of MUFA and a decrease in proportions of PUFA.

In our study where the carcass condition and IMF level of grass fed cattle remained relatively constant among age groups, no significant variation in proportions and therefore actual levels of MUFA or PUFA were recorded. It therefore seems that the level of fat mainly affects SFA, PUFA and MUFA levels rather than age or diet. The latter was confirmed by the study of Warren *et al*. (9) who recorded higher proportions and actual levels of MUFA and SFA and lower PUFA in muscle of cattle fed grass silage compared to those on concentrate. The

Table 1 Total lipids and SFA in *M. longissimus* of 7 age/feeding regime groups (mg/100 g of muscle). 14:0 – Myristic acid; 16:0 – Palmitic acid; 18:0 – Stearic acid.

Age	Total lipid	SFA	14:0	16:0	18:0
AF	2.4^{bc}	1061	63^{c}	586	379
ABF	2.6^{c}	1119	53^{bc}	590	446
AP	1.7^{a}	792	37^{ab}	414	304
ABP	1.8^{ab}	659	32^{a}	356	340
B4	1.8^{ab}	834	40^{ab}	463	295
B6	1.8^{ab}	864	41^{ab}	489	297
C8	1.7^{a}	841	36^{a}	432	345
SEM	0.680	126.4	6.53	63.3	55.1

^{a,b,c}Means with different supercripts differ significantly.
SEM – standard error of mean

Table 2 MUFA and PUFA in *M. longissimus* of 7 age/feeding regime groups (mg/100 g of muscle).

Age	MUFA	PUFA	n-6 PUFA	n-3 PUFA	n-3 LCP
AF	1023^{b}	186	158^{b}	28^{a}	13^{a}
ABF	1167^{b}	194	168^{b}	26^{a}	14^{a}
AP	639^{a}	165	106^{a}	60^{bc}	29^{b}
ABP	654^{a}	186	120^{a}	66^{bc}	30^{b}
B4	687^{a}	158	103^{a}	56^{b}	33^{b}
B6	668^{a}	190	123^{a}	66^{bc}	33^{b}
C8	606^{a}	184	110^{a}	73^{c}	40^{b}
SEM	107	13.79	9.01	5.77	4.11

^{a,b,c}Means with different supercripts differ significantly
SEM – standard error of mean

animals on silage had higher levels of muscle lipid than those on concentrates which was in contrast to our study. For both diets the proportional and actual levels of PUFA and MUFA, respectively decreased and increased as the animals became fatter over time. The lack of differences in MUFA, SFA and PUFA, and therefore P:S ratio among age groups of grass fed cattle, is in contrast to the study of Noci *et al*. (20) who reported a cubic effect of duration of grass feeding on P:S ratio with a quadratic decline in SFA and linear increase in PUFA over 158 days. Despite maintaining similar muscle lipid levels over this time as in the present study, the actual fat level in the study of Noci *et al*. (20) and the duration of feeding did not correspond with the present study where animals were leaner and included seasonal effects (over two to possibly six years) where animals probably lost and gained weight and condition which could have expressed itself differently in FA composition.

Grain fed samples recorded higher actual levels of n-6 and lower levels and proportions of n-3 PUFA than samples of grass fed animals. All grass fed groups consequently had lower n-6:n-3 ratios compared to grain fed groups which is consistent with other studies (1, 2) and could be accounted to the high n-3 content of grass that escaped the biohydrogenisation in the rumen. As expected, higher n-3 PUFA levels in grass fed samples included higher levels and ratios of long chain PUFA (LCP = 20:5n-3 + 22:5n-3 + 22:6n-3) compared to samples of grain fed animals. Age or duration of grass feeding did not have an effect on n-3 PUFA, n-6 PUFA or LCP values which is in contrast to the study of Noci *et al*. (20) where muscle n-6:n-3 PUFA ratio declined due to a cubic increase in n-3 proportions over time on grazing.

Table 3 Proportions (%) of SFA, MUFA and PUFA in *M. longissimus* of 7 age/feeding regime groups.

	SFA	MUFA	PUFA	n-6 PUFA	n-3 PUFA	P:S
AF	46.6^{ab}	45.0^{b}	8.4^{a}	7.1	1.3^{a}	0.18
ABF	45.0^{a}	46.5^{b}	8.6^{a}	7.3	1.3^{a}	0.19
AP	48.6^{abc}	39.3^{a}	12.1^{ab}	7.7	4.4^{b}	0.26
ABP	48.1^{abc}	37.7^{a}	14.2^{b}	9.1	5.1^{b}	0.30
B4	48.9^{bc}	40.4^{a}	10.7^{ab}	6.8	3.9^{b}	0.23
B6	49.6^{bc}	38.6^{a}	11.8^{ab}	7.7	4.1^{b}	0.24
C8	51.3^{c}	37.3^{a}	11.4^{ab}	6.8	4.5^{b}	0.23
SEM	1.316	1.255	1.297	0.825	0.499	0.031

^{a,b,c}Means with different supercripts differ significantly
SEM – standard error of mean

Despite significant differences in certain FA levels between grass and grain fed cattle, the effect on nutritional quality of trimmed steaks from the various groups should be minimal. In the light of the negative image of SFA in meat (3, 4) our study showed that, despite higher IMF levels in samples of grain fed cattle, consumers will only ingest marginally more SFA per portion compared to grass fed steaks. Based on a 100 g raw steak, the mean values in Table 1 represent respectively 4.8 and 3.5% of the 23 g daily allowance for SFA (21). There is convincing evidence that replacing certain SFA (C12:0 – C16:0) with PUFA will decrease LDL cholesterol (21), while a similar but lesser effect is achieved by replacing these SFA with MUFA. Samples of grain fed cattle recorded marginally higher PUFA (non-significant) but more than 40% higher levels of MUFA than samples of grass fed cattle and this would benefit the intake of MUFA. There is no real evidence for the existence of a favourable n-6:n-3 PUFA ratio if the intake of each are according to recommended levels (21). Both types of PUFA, but particularly n-3 PUFA have health benefits such as the lowering of risk of modern lifestyle diseases but particularly coronary heart disease (CHD) that is favourably addressed by n-3 PUFA consumption (21). Potential intake of n-6 PUFA per portion in our study would be 46% higher for steaks of grain fed cattle than of grass fed cattle although steaks of grass fed cattle will provide three times more n-3 PUFA (5% of minimum daily requirement based on 100 g raw steak)(21) than steaks of grain fed cattle despite the higher total muscle fat of the latter groups. Health benefits related to regular consumption of LCP are increasingly recognized (21). Howe *et al*. (22) demonstrated the importance of meat as a source of LCP and reported that 48% of the 246 mg LCP consumed per day by Australian consumers comes from meat sources. In our study, grass fed samples will provide more than twice as much LCP (33 mg/100 g raw trimmed steak) than their grain fed counter parts (13% of minimum daily recommended intake).

IV. CONCLUSIONS

Under the conditions of this study, duration of grass feeding (or age) will not have an effect on FA composition. However, our results confirmed previous results that type of diet (grain vs. grass will affect FA composition.

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