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INTRAMUSCULAR FAT AND FATTY ACID PROFILES IN BEEF MUSCLES FROM DIFFERENT ANATOMICAL LOCATIONS OF NEW ZEALAND GRASS-FED CATTLE

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I. INTRODUCTION

Intramuscular fat (IMF) content and fatty acid (FA) composition are critical factors influencing beef quality, including flavor, tenderness, juiciness, and nutritional value. Grass-fed beef is valued for its favorable FA profile, particularly its higher omega-3 (n-3) content compared to the grain-fed; however, FA composition can vary significantly among muscles due to anatomical and metabolic differences [1]. Carcass grading is traditionally based on the exposed *Longissimus* muscle, yet its lipid content and FA composition may not accurately represent other muscles within the carcass. A comprehensive understanding of these variations is crucial for optimizing sensory and nutritional quality of beef, enhancing consumer satisfaction, and informing industry grading systems. This study evaluated IMF content and FA composition across four beef muscles from different anatomical locations of New Zealand grass-fed cattle, providing insights into muscle-specific lipid profiles.

II. MATERIALS AND METHODS

The cattle used in this study were representative of typical animals produced in New Zealand, raised on the most widely used mixed pasture of ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*). Animals were humanely slaughtered at a commercial meat processing plant, and meat cuts were collected 48 hours postmortem. Four cuts (loin, rump, topside, and chuck tender) were sourced from twenty cattle consisting of five animals from each of the following types: Friesian bulls; Angus-crossed steers, heifers, and cows. Eighty cuts were vacuum-packed and transported chilled to the meat pilot plant at AgResearch Ltd, Palmerston North, New Zealand. From each cut, steak samples of about 200 grams with subcutaneous fat removed were taken to obtain meat from four muscles: *Longissimus thoracis* (LT from the loin), *Gluteus medius* (GM from the rump), *Semimembranosus* (SM from the topside), and *Supraspinatus* (SS from the chuck tender). Samples were cut into ~1×1×1 cm cubes, freeze-dried (Operon FTDI-5050, Alphatech Systems Ltd., New Zealand), and ground into powder for analysis of IMF percentage and FA composition using a direct trans-methylation method [2].

III. RESULTS AND DISCUSSION

There were no interactions ($P>0.05$) between animal and muscle type for the presented variables except for monounsaturated FA (MUFA) and omega 6 FA (n-6) (Table 1). IMF and FA composition varied significantly among the evaluated beef muscles. The LT had higher IMF percent than the other muscles which did not differ ($P>0.05$). These differences align with previous findings that IMF distribution is muscle-dependent associated with variations in metabolic activity and muscle function [1]. Total saturated FA (SFA) and straight-chain SFA followed a similar trend, with the highest percentages in the LT compared to the other muscles, while GM had higher proportions than the SS. However, branched-chain FA percent was higher in the SS and GM muscles than in the SM, with no significant difference observed between the LT and the other muscles. There were no differences in MUFA percent ($P>0.05$) among muscles for Angus-crossed heifers and steers. However, in Angus-crossed cows, MUFA percentages were higher in SM and SS compared to LT, whereas in Friesian bulls, MUFA was similar in LT, SM, and GM but higher than in SS. The proportion of polyunsaturated FA (PUFA) was also muscle-dependent, with SS having the highest percent, GM and SM being intermediate, and LT the lowest. Long-chain n-3 (LC-n-3) percent was similar among SS, GM, and SM but higher than LT. In contrast, there were no differences ($P>0.05$) in CLAc9,t11 (conjugated linoleic acid cis-9,trans-11 isomer) percent among muscles. The PUFA:SFA ratio, a key indicator of dietary health benefits, was higher in SS and GM followed by SM, and lowest in LT. All muscles had PUFA:SFA values below the recommended ratio (>0.45) for a healthy diet, a trend commonly reported in beef including those from grass-fed animals [3]. Omega-6 percent was highest in SS with GM and SM being intermediate, and LT the lowest, except in Angus-crossed cows, where the lowest n-6 was observed in SM. In contrast, n-3 percentages were

similar (P>0.05) among SS, GM, and SM but higher (P<0.05) than LT. The n-6:n-3 ratio, which should be ≤4.0 for a balanced diet, was within recommended dietary guidelines in all muscles, ranging from 1.43 to 1.73. These values confirm the favorable FA profile of NZ grass-fed beef, as low n-6:n-3 ratios are associated with reduced inflammation and improved cardiovascular health [4]. Finally, the Atherogenic Index (AI) was highest for LT, intermediate for GM and SM and lowest for SS (P<0.05), indicating a lower potential risk of cardiovascular disease associated with consuming SS due to its more favorable FA profile.

Table 1. Intramuscular fat and selected fatty acids in four beef muscles from New Zealand grass-fed cattle.

	Muscles[1]					
IMF and FA, %[3]	**LT**	**GM**	**SM**	**SS**	**SE[2]**	**P-value**
IMF	4.78^{a}	3.26^{b}	2.87^{b}	2.55^{b}	0.39	0.0006
SC-SFA	50.43^{a}	45.21^{b}	43.72^{bc}	42.39^{c}	0.76	<.0001
BCFA	1.48^{ab}	1.54^{a}	1.36^{b}	1.58^{a}	0.05	0.0076
SFA	51.91^{a}	46.75^{b}	45.07^{bc}	43.97^{c}	0.78	<.0001
MUFA	39.69	40.92	42.92	40.62	0.79	*
CLAc9,t11	0.34	0.41	0.41	0.42	0.02	0.1035
EPA	0.60^{b}	1.06^{a}	0.97^{a}	1.04^{a}	0.09	0.0008
DPA	0.76^{c}	1.14^{b}	1.15^{b}	1.57^{a}	0.10	<.0001
DHA	0.07^{b}	0.15^{a}	0.13^{a}	0.16^{a}	0.01	<.0001
LC-n-3	1.42^{b}	2.45^{a}	2.26^{a}	2.76^{a}	0.19	<.0001
PUFA	8.40^{c}	12.33^{b}	12.01^{b}	15.41^{a}	0.97	<.0001
PUFA:SFA	0.18^{c}	0.29^{b}	0.30^{ab}	0.38^{a}	0.03	<.0001
n-6	4.81	7.23	7.01	9.64	0.58	*
n-3	3.25^{b}	4.69^{a}	4.60^{a}	5.34^{a}	0.38	0.0020
n-6:n-3	1.43^{c}	1.54^{b}	1.50^{bc}	1.73^{a}	0.03	<.0001
AI	0.80^{a}	0.63^{b}	0.61^{b}	0.53^{c}	0.03	<.0001

[1]**LT**: *Longissimus thoracis*, **GM**: *Gluteus medius*, **SM**: *Semimembranosus*, **SS**: *Supraspinatus.*
[2]**SE**: Standard Error.
[3]**IMF**: Intramuscular Fat; **FA**: Fatty Acids; **SC-SFA**: Straight-Chain Saturated FA ∑ C10:0, C12:0, C14:0, C15:0, C16:0, C17:0, C18:0, C20:0; **BCFA**: Branched-Chain FA ∑ isoC15, anteisoC15, isoC16, isoC17, anteisoC17; **SFA**: Saturated FA ∑ SC-SFA, BCFA; **MUFA**: Monounsaturated FA ∑C14:1, C16:1, C17:1, C18:1t9, C18:1t11, C18:1c9, C18:1c11; **CLAc9,t11**: Conjugated linoleic acid cis-9,trans-11 isomer; **EPA**: Docosapentaenoic acid (C22:5n-3); **DPA**: Eicosapentaenoic acid (C20:5n-3); **DHA**: Docosahexaenoic acid (C22:6n-3); **LC-n-3**: Long-chain omega-3 FA; **PUFA**: Polyunsaturated FA ∑ C18:2n-6, C18:3n-3, CLAc9,t11, C20:3n-6, C20:4n-6, C20:5n-3, C22:5n-3, C22:6n-3; **n-3**: Omega-3 FA ∑ C18:3n-3, C20:5n-3, C22:5n-3, C22:6n-3; **LA:ALA**: C18:2/C18:3; **n-6**: Omega-6 FA ∑ C18:2n-6, C20:3n-6, C20:4n-6. **AI**: Atherogenic index = [C12:0 + (4*C14:0) + C16:0] / [n-6 PUFA + n-3 PUFA + MUFA].
*No P-value is provided for MUFA and n-6 due to a significant interaction (Animal type*Muscle type P<0.05) discussed in the text.

IV. CONCLUSION

This study demonstrated significant differences in IMF and FA composition among four beef muscles from NZ grass-fed cattle. LT had the highest IMF percent but the lowest PUFA:SFA ratio and LC-n-3 levels. In contrast, SS exhibited the most favorable FA profile, with higher PUFA and a lower AI, suggesting a potential health advantage. All muscles had n-6:n-3 ratios within recommended dietary guidelines, reinforcing the nutritional value of grass-fed beef. These findings highlight the importance of considering muscle-specific lipid profiles to improve sensory and nutritional quality of beef. Future analyses will examine the relationship between IMF content and FA composition in the LT and other muscles, to assess the LT's representativeness as a reference for grading other muscles.

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