Molecular Distribution and Fatty Acid Profiles of Triacylglycerol Isolated from M. longissimus and Subcutaneous Fat of Heavy Angus Steers Grown on Two Pasture Types

Makoto Itoh[1], Cecil B. Johnson[2], Gerald P. Cosgrove[3], M. Greg Lambert[3] and Roger W. Purchas[4]

1) School of Veterinary Medicine and Animal Science, Kitasato University, Towada-shi 034, Japan
2) The Horticulture and Food Research Institute of New Zealand Ltd., Private Bag 11030, Palmerston North, New Zealand
3) AgResearch Grasslands, Private Bag 11008, Palmerston North, New Zealand
4) Department of Animal Science, Massey University, Private Bag 11222, Palmerston North, New Zealand

Keywords: triacylglycerol, molecular species, Angus, fatty acid, pasture

INTRODUCTION

The quantity and chemical composition of fats in meat are important factors affecting its organoleptic qualities. Characteristics such as fatty acid composition of fat is affected by many factors including breed, sex, age, diet, degree of fatness, and anatomical location. Depot fats consist mainly of triacylglycerol, and the characteristics of triacylglycerol may influence meat qualities in many ways.

The objective of the present study was to compare the fatty acid and molecular species composition of triacylglycerol of intramuscular and subcutaneous fat from Angus steers grown on two pasture types.

MATERIALS AND METHODS

Angus steers were grazed on one of the following pasture systems from eight months age to slaughter (Cosgrove *et al.* 1996).

A: Red clover and lotus for late-spring, summer and autumn forage, and annual ryegrass for winter and spring forage.

B: Perennial ryegrass and white clover dominant pasture.

Animals of Group A (n=14) were slaughtered at thirty-seven months of age (mean carcass weight and fat depth were 470kg and 31mm) and those of Group B at thirty-eight months of age (mean carcass weight and fat depth were 469kg and 30mm) . Group A steers grew significantly faster. Samples for the fatty acid and molecular species distribution determinations were obtained from the *M. longissimus lumborum* and the subcutaneous fat at about the second or third lumbar vertebrae. The extraction of total lipid from samples was carried out by chloroform:methanol extraction. Triacylglycerol in total lipid was fractionated by thin layer chromatography using n-hexane : diethylether : acetic acid (80:30:1).

Determination of fatty acid composition of triacylglycerol, trans-esterified by 3N HCl-anhydrous methanol, was analyzed by gas chromatography using an Econo-Cap (Alltech Associates, Deerfield, IL) capillary column (30m x 0.25 mm ID) containing bonded Carbowax. The column was programmed from 100°C to 240°C at a rate of 5°C/min and held at 240°C for 10 min. The carrier gas was H_2 at a head pressure of 75 kPa. Injection port and detector temperatures were 220°C and 240°C respectively. Individual fatty acid peaks were identified by comparison of retention times with those of known mixtures of standard fatty acids.

Molecular distribution of triacylglycerol was analyzed by high-temperature on-column gas chromatography. The column was a UA-DX30 (Frontier Lab., Koriyama, Fukushima) stainless steel capillary column (15m x 0.25mmID) having a carbon-siloxane (Dexsil 300GC) layer. Column temperature was programmed from 300°C to 400°C at a rate of 5 °C/min and held at 400°C for 4 min. Carrier gas was H_2 at a pressure of 175 kPa. Injection temperature was programmed from 303°C to 403°C at a rate of 5 °C/min and held at 403°C for 4 min. Detector temperature was 420°C. Individual peaks of triacylglycerol molecules were identified by comparison of retention times with those of known standard triacylglycerols.

The molecular species composition of triacylglycerol was analyzed by high temperature gas chromatography. The column was an UA$^+$-65 (Frontier Lab, Koriyama, Fukushima, JAPAN) stainless steel capillary column (15m x 0.25mm) having 65% diphenyldimethylpolysiloxane layer . Column temperature was programmed from 350°C to 360°C at a rate of 1°C/min after increasing from 270°C to 350°C at a rate of 20°C/min. Carrier gas was He at a pressure of 50 kPa for the splitless method. Injection port and detector temperatures were 360°C respectively. Individual peaks of triacylglycerol molecular species were identified by comparison of retention times with those of known standard triacylglycerols (SIGMA TRI-5, SIGMA TRI-10, SIGMA TRI-19 etc).

RESULTS AND DISCUSSION

The composition of six major fatty acids from triacylglycerols (TG) of intramuscular and subcutaneous fat are shown in Fig. 1. The sum of the concentration of the major fatty acids, palmitic acid (C16:0), stearic acid (C18:0) and oleic acid (C18:1), was 78-86 %. The concentrations of major fatty acids of intramuscular TG were similar for Group A and Group B except linoleic acid (C18:2), while for subcutaneous TG significant group differences ($p<0.05$) were found for C16:0, palmitoleic (C16:1), C18:0, C18:1, and C18:2 acids. In subcutaneous TG the concentration of saturated fatty acids was higher for A than for B, while the unsaturated fatty acids for B were higher than those for A.

Molecular distributions of intramuscular TG and subcutaneous TG are shown in Fig. 2. TG consisted mainly of C48, C50, C52 and C54. The numbers of carbon atoms in an acyl chain were principally 14, 16 and 18 (Fig. 1). The combinations of carbon atom number in these triacylglycerol molecules are as follows; C48 = C14 + C16 + C18 or 3 x C16 , C50 = C14 + 2 x C18 or 2 x C16 + C18 , C52 = C16 + 2 x C18 , C54 = 3 x C18 . The C18 fatty acids in these equations may be either 18:0 or 18:1. TG of C49, C51 and C53 have mainly acyl chains of 17 carbon atoms in a molecule. Concentration of C46, C49, C50 and C51 of subcutaneous TG were significantly higher for Group A than for Group B, but the C52 concentration of subcutaneous A was significantly lower. Therefore, ratios of C52/C50 and C52/C54 of subcutaneous fat for Group B were larger than for Group A.

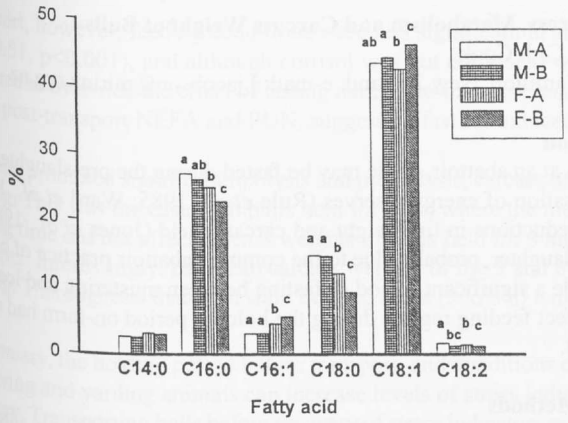

Fig.1 Fatty acid composition of triacylglycerol(TG).

M:intramuscular TG F:subcutaneous TG

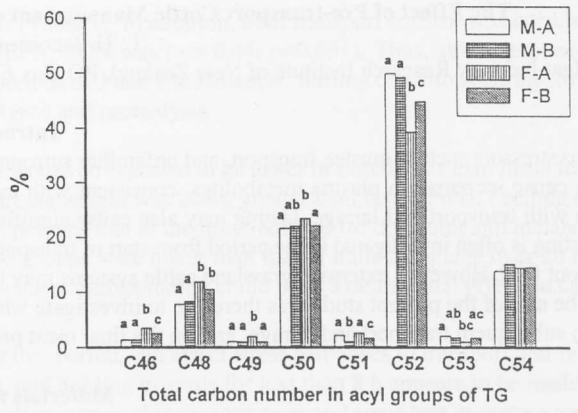

Fig. 2 Molecular distribution of triacylglycerol(TG).

M:intramuscular TG F:subcutaneous TG

Molecular species compositions of intramuscular and subcutaneous TG are shown in Fig. 3. Of the more than sixteen molecular species in intramuscular and subcutaneous TG, the major ones were palmitoyl(P)-P-oleoyl(O)-glycerol(PPO) , P-P-linoleoyl(L)-glycerol(PPL), P-stearoyl(S)-O-glycerol(PSO), and POO. Intramuscular TG from A had higher concentrations of PSS (not presented) and POL than B ($p<0.05$). Intramuscular TG had higher concentrations of PPO and PSO, and lower concentrations of PPL, POL and OOO than subcutaneous TG ($p<0.05$).

The relationship between POO and PSO in intramuscular TG and subcutaneous TG of Group A and Group B are shown in Fig. 4. The distribution area of intramuscular TG was different from that of subcutaneous TG. There were negative relationships between POO and PSO in intramuscular TG and subcutaneous TG for Group B, but not for Group A (Fig. 4).

The higher concentration of C18:2 in intramuscular TG of Group A compared with Group B was associated with a higher POL concentration. The higher level of C18:1 for B was based on many molecular species having C18:1 (POO, OOO etc.). The sum of POO, PSO and POL concentrations caused the highest level of C52 in molecular distribution of TG. The differences in concentrations of molecular species between intramuscular TG and subcutaneous TG are likely to be caused by (1) differences in the volatile fatty acid composition produced in the rumen of groups A and B, (2) differences in the enzyme activities for fatty acid synthesis, or (3) differences in the enzyme activities for triacylglycerol synthesis.

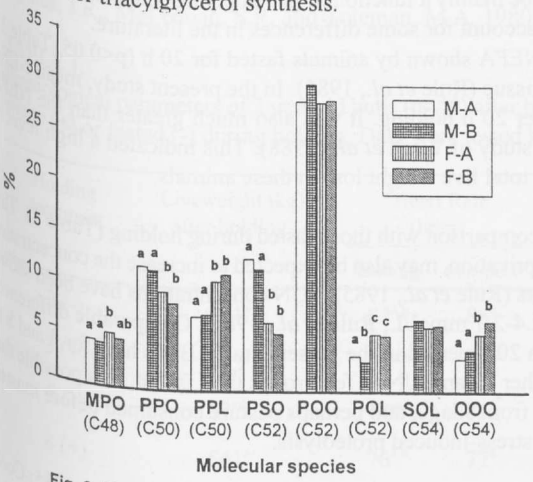

Fig. 3 Molecular species composition of intramuscular and subcutaneous triacylglycerol(TG).

M:intramuscular TG F:subcutaneous TG

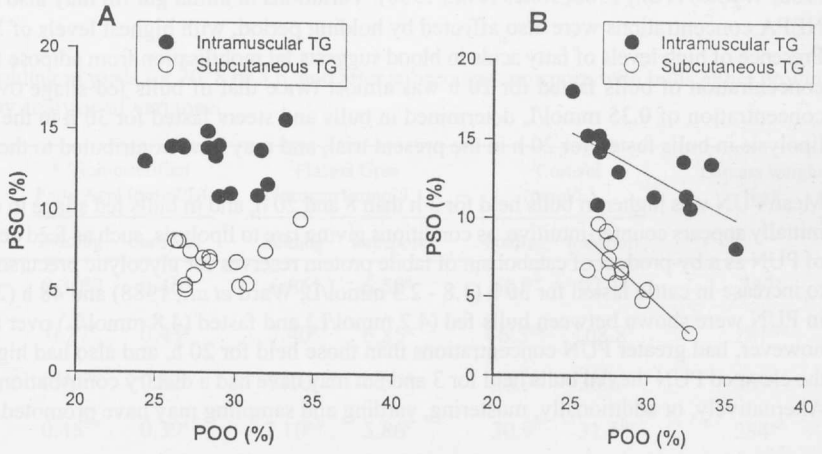

Fig. 4 The relationship between POO and PSO in intramuscular TG and subcutaneous TG.

A:samples grazed by A B:samples grazed by B

CONCLUSIONS

Triacylglycerols from subcutaneous and intramuscular lipid of Angus steers grazed on pastures containing red clover, lotus and annual ryegrass contained more C18:2 and less C18:1 than lipid of steers grazed on pastures containing perennial ryegrass and white clover.

Pasture diet changes can influence the fatty acid composition and molecular configuration of intramuscular and subcutaneous triacylglycerols.

REFERENCE

Cosgrove G P, Muir P D, Lambert M G 1996 Nutritional options and implications for maximum growth rate of steers. *Proc New Zealand Grassland Assoc* **57**: 217-222.