Available online at www.sciencedirect.com
ScienceDirect
Meat Science 76 (2007) 54–60
MEAT SCIENCE
www.elsevier.com/locate/meatsci

Comparison of the lipid content and fatty acid composition of intermuscular and subcutaneous adipose tissues in pig carcasses

M. Monziols [a,b], M. Bonneau [a], A. Davenel [b], M. Kouba [a,*]

[a] UMR SENAH INRA-Agrocampus-Rennes, 35590 Saint Gilles, France
[b] CEMAGREF, 17 Avenue de Cucillé, 35044 Rennes cedex, France

Received 20 April 2006; received in revised form 16 October 2006; accepted 17 October 2006

Abstract

Lipid contents and compositions were measured in 35 pigs from seven genotype-sex groups with large variations in body composition. The animals were slaughtered at 115 kg live weight, and the left side was separated into four primal cuts: belly, ham, loin, and shoulder. Samples of adipose tissues were taken from flare fat and from subcutaneous and intermuscular adipose tissues in each of the four cuts. In the loin, the outer and inner layers of subcutaneous adipose tissue were sampled separately. Total lipid content was lower in intermuscular than in subcutaneous adipose tissue. It was the highest in flare fat.

There was a gradient of decreasing unsaturation from the outer layer of subcutaneous adipose tissue, to the inner layer, to intermuscular adipose tissue, to flare fat. The monounsaturated fatty acid concentrations followed the same pattern. There was a statistically positive correlation between the linoleic acid concentration of the different adipose tissues and the half carcass muscle content.

Keywords: Pig; Intermuscular fat; Adipose tissue; Lipids; Fatty acids

1. Introduction

Porcine carcass fat is deposited in four depots, with different anatomical locations: visceral, subcutaneous, intermuscular (between muscles), or intramuscular (within muscle). Considerable anatomical variation in fatty acid composition in the pig has been reported (Hilditch, 1944; Sink, Watkins, Ziegler, & Miller, 1964). More recently, some authors have suggested that not all adipose tissues are similar but each shows specific development and metabolism (Budd, Atkinson, Buttery, Salter, & Wiseman, 1994; Mourot, Kouba, & Peiniau, 1995; Mourot, Kouba, & Bonneau, 1996). Most of these experiments have been undertaken on the subcutaneous adipose tissue because a high proportion of fat is subcutaneous and it is very obvious at retail or in cuts. Consequently, pigs are selected for low backfat thickness (Wood, Whelehan, Ellis, Smith, & Laird, 1983). Very few studies have been carried out on the intermuscular adipose tissue in pigs, most likely because the only way to measure it, namely, physical dissection of the whole carcass, is time consuming, tedious, and expensive. However, if visceral and subcutaneous fats can be easily trimmed off the lean meat that is delivered to consumers, in most instances it contains intermuscular fat that cannot be removed. Therefore, intermuscular fat content has a high impact on consumer acceptability of pork meat.

We have undertaken a research program on the development of intermuscular adipose tissue in the pig, with the aim of better understanding the development and the composition of intermuscular fat relative to other fat deposits. Within this programme, one objective was to determine the suitability of magnetic resonance imaging (MRI) to predict tissue composition of pig carcasses and cuts (Monziols et al., 2006). The specific objectives of the present study were to characterize the lipid content and fatty acid

* Corresponding author. Present address: Laboratoire SPA, Agrocampus-Rennes, 65 rue de Saint Brieuc, 35042 Rennes Cedex. Tel.: +33 2 23 48 53 67; fax: +33 2 23 48 59 00.
E-mail address: maryline.kouba@agrocampus-rennes.fr (M. Kouba).

0309-1740/$ - see front matter © 2006 Published by Elsevier Ltd.
doi:10.1016/j.meatsci.2006.10.013

composition of the different porcine adipose tissues, with special emphasis on intermuscular adipose tissues from the four main cuts in pig carcasses exhibiting large variability in body composition.

2. Materials and methods

2.1. Animals, slaughter, tissue sampling and dissection

A total of 35 pigs from seven different groups of genotype and sex were used in the experiment: 5 Large White X Meishan castrated males, 5 Large White X Meishan females, 5 Large White X (Large White X Meishan) castrated males, 5 Large White X (Large White X Meishan) females, 5 Large White castrated males, 5 Large White females and 5 Large White X Pietrain castrated males. The combinations of genotypes and sex were chosen so as to achieve a very large variability in carcass composition.

The animals were born in two litters from two sires [LWMS], two litters from one sire [LWLWMS], four litters from three sires [LW], and one litter [P X LW]. All animals of the nine litters were raised and the animals included in this study were selected among the litters in accordance with the plan of dissection and their live weight.

Pigs were moved into individual pens at about 90 days of age (live weight ranges from 38 to 53 kg, respectively, for the LWMS-CM and the LWP-CM groups) and were fed ad libitum a standard diet for commercial slaughter pigs. The diet was based on barley, wheat, maize and soybean meal (Tables 1 and 2). Excess feed was registered daily and individual net feed intake calculated.

The animals were reared and slaughtered in compliance with regulations for the humane care and use of animals in research, as operated at INRA. The animals were slaughtered at an average live weight of 115 kg (live weight ranges from 114 to 119 kg). On the following day, each left half carcass was cut according to a standardized procedure described by Metayer and Daumas (1998).

Table 1
Composition of the standard diet (%)

Item	
Barley	24.6
Wheat	24.3
Soybean meal (48% crude protein)	23
Yellow maize	15
Wheat bran	5
Sugarcane molasses	3
Vegetable oil	0.75
Animal fat	1.25
Calcium carbonate	1.18
Dicalcium phosphate	0.56
Phosphore	0.50
Salt	0.45
L-lysine	0.12
DL-methionine	0.02
L-threonine	0.03
Acid	0.10
Phytase	0.20

Table 2
Proximate analysis and fatty acid composition of the standard diet

Item	
Proximate analysis	
Digestible energy (MJ/kg)	13.7
Dry matter (g/kg)	872
Crude proteins (g/kg)	177
Fat (g/kg)	42
Linoleic acid (g/kg)	16
Fatty acid composition (% of total fatty acids)	
14:0	0.5
14:1	0.1
16:0	24.1
16:1 ($n-7$)	0.4
18:0	3.7
18:1 ($n-9$)	26.3
18:2 ($n-6$)	41.2
18:3 ($n-3$)	3.8

A total of 11 samples of adipose tissue were taken from the four main cuts (ham, loin, shoulder and belly), as described in Table 3, vacuum-packed and deep frozen at −20 °C until analysed. The aim was to take one sample of subcutaneous (SC) and one sample of intermuscular (IM) adipose tissue from each of the four cuts. In the loin, one sample of subcutaneous fat was taken from each of the two layers. Two intermuscular samples were taken from the belly. The XIM_Belly sample was taken from a tissue which is in anatomical continuity with the inner layer of the subcutaneous adipose tissue of the loin. The IM_Belly sample was taken from a more internal location. A sample of flare fat was also taken.

The four main cuts were then physically dissected into six tissue fractions (skin, bone, muscle, subcutaneous fat, intermuscular fat and miscellaneous) which were subsequently weighed. Muscle content of the carcass was computed as the sum of the muscle weights of the four main cuts divided by the weight of the dissected half carcass.

2.2. Measurement of lipid content and fatty acid composition

The lipids were extracted from the different samples of adipose tissues using chloroform/methanol (2:1), according to Folch, Lees, and Sloane Stanley (1957). The extracts

Table 3
Distribution of the 11 adipose tissue samples according to cuts and tissues

	Ham	Shoulder	Loin	Belly	Flare fat
Subcutaneous fat	SC_Ham	SC_Shou	OuterSC_Loin InnerSC_Loin	SC_Belly	
Intermuscular fat	IM_Ham	IM_Shou	IM_Loin	IM_Belly XIM_Belly	
Flare Fat					Flare

SC: subcutaneous adipose tissue; IM: intermuscular adipose tissue; Shou: shoulder; OuterSC: outer layer of subcutaneous adipose tissue; InnerSC: inner layer of subcutaneous adipose tissue; XIM_Belly: intermuscular fat in the belly, in anatomical continuity with the inner layer of the subcutaneous fat in the loin (InnerSC_Loin).