



Chemical composition characteristics of the longissimus and semimembranosus muscles for pigs from New Zealand and Singapore

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ABSTRACT

A range of composition characteristics of the longissimus (LL) and semimembranosus (SM) muscles were compared between pigs raised in intensive and extensive production systems in New Zealand (NZ), and pigs raised in an intensive system in Indonesia for supply to the Singapore market ($n = 8/\text{group}$). Ultimate pH was slightly higher for the Singaporean LL muscles ($P < 0.05$), while LL muscle of the NZ extensive group was redder (higher a^* values) and contained more fat ($P < 0.05$). Muscle iron levels were highest for the NZ extensive group and lowest for a lighter group within the Singapore pigs ($P < 0.05$). Differences in fatty acid concentrations, which were also measured in a sample of the belly cut, could largely be attributed to the effects of diet, with higher levels of alpha linolenic acid for the NZ extensive group ($P < 0.05$) due to linseed in the diet, and much higher levels of linoleic acid and the P:S ratio for the Singapore group ($P < 0.05$). Some statistically significant differences in amino acid concentrations were shown between muscles and groups, but they were not large. With respect to compounds with potential bioactive properties, coenzyme Q₁₀, and taurine levels were higher in pork from NZ pigs, and carnosine levels were highest for the NZ intensive group ($P < 0.05$). The LL muscle contained more coenzyme Q₁₀ and taurine, but less carnosine than the SM muscle ($P < 0.001$). It is concluded that some of these composition differences in the pork from the muscles and groups compared may be of commercial importance, but several are likely to have been due to dietary or weight differences.

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1. Introduction

Information on differences in the composition of muscles from pigs is available from a number of sources (e.g. Dickerson & Widdowson, 1960; Lawrie, Pomeroy, & Cuthbertson, 1963; Warner, Kauffman, & Russell, 1993), but the extent to which such differences vary between groups of pigs that differ in breed, size, or nutritional background is limited. Furthermore, there are some aspects of muscle composition for pork that have not received much attention to date because their possible importance from a nutritional or health perspective has only recently been appreciated. These include some of the fatty acids present at low concentrations (Enser, 2001), and some muscle components other than fatty acids that have potential bioactive properties (Purchas, Rutherford, Pearce, Vather, & Wilkinson, 2004). In a project set up to compare the composition of pork on the Singapore market from pigs raised locally in Indonesia, with that from pigs produced either intensively or extensively in New Zealand, data on comparisons between the longissimus lumborum (LL) and semimembranosus (SM) muscles were obtained. In addition, the fatty acid composition of lipid in the belly cut was measured.

Composition characteristics considered included the fatty acid composition of lipids, the amino acid composition within the two muscles, the concentrations of a range of minerals including the proportion of iron as haem and non-haem iron (Uzel & Conrad, 1998), vitamin E levels, and the concentrations within the muscles of compounds with potential bioactive properties including taurine, carnosine, and coenzyme Q₁₀. Taurine is a sulphur-containing amino acid that is present only as a free acid in muscle, and that has been associated with numerous biological functions (Huxtable, 1992) including both eye and heart health. Carnosine is a dipeptide (β -alanine-histidine) that has an important buffering role in muscle, but also has antioxidant properties (Decker & Mei, 1996). Coenzyme Q₁₀ is a component of the mitochondrial electron transport chain (Hargreaves, 2003), that is also an antioxidant and has been investigated widely with respect to its value in treating heart disease (Overvad et al., 1999; Singh, Devaraj, & Jialal, 2007).

2. Materials and methods

2.1. Animals and samples

Samples from the LL, the SM and the belly cut were obtained from the following four groups of female pigs:

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1. The “NZ Intensive” group were Duroc × (Large White × Landrace) crosses run as a typical intensive indoor system in New Zealand. They were part of the “Animal supplemented” group of Morel, Janz, Zou, Purchas, Hendriks, and Wilkinson (2008). Details of diet composition were provided in that paper.
2. The “NZ extensive” group were Duroc × Landrace crosses from a farm where all pigs were run outside in paddocks. They received a grain-based diet (mainly barley with some linseed) with no supplemental minerals or vitamins. Neither did they receive any medicinal drenches or antibiotics.
3. The “Singapore light” and “Singapore heavy” groups were crosses with Landrace, Duroc, and Large White components, raised under intensive conditions on a grain-based diet on the Indonesian island of Pulau Bulan. Details of the diets received by the pigs sampled are not known.

All pigs were slaughtered under normal commercial conditions in an abattoir in Wanganui for the New Zealand groups, and at an abattoir in Singapore for the Singapore groups. Samples (approximately 600 g) for analysis were taken from the cranial portion of the LL, the central portion of the SM, and as a skinned mid-side portion of the belly cut, approximately 250 mm long (cranial to caudal dimension) and 150 mm wide starting just caudal to the last rib.

All samples were frozen at approximately -20°C within four days of slaughter before any measurements were made, and samples were thawed at $0-2^{\circ}\text{C}$ as required.

Colour of thawed samples of the two muscles was measured on a cut surface that had been exposed to the atmosphere for approximately 30 min using a Minolta Chromameter (CR-200) reflectance spectrophotometer to provide L^* , a^* , and b^* values. Ultimate pH of the muscles was measured with a spear combination electrode on a freshly cut surface.

2.2. Analytical measurements

The proportions of iron as haem iron and non-haem iron in the water-soluble and water-insoluble fractions were assessed as described by Purchas, Simcock, Knight, and Wilkinson (2003). Briefly, haem iron was assessed using the colorimetric method of Hornsey (1956), and non-haem iron was assayed colorimetrically using the ferrozine method after removal of haem iron by trichloroacetic acid precipitation. Minerals were analysed in freeze-dried samples by inductively coupled plasma-mass spectrometer (ICP-MS) (Hill Laboratories, Hamilton, New Zealand).

Vitamin E was assayed following the saponification/extraction procedures of Bayfield and Romalis (1979) and quantification on HPLC using a Lunar C18 column according to ISO Method 6867 (ISO, 2000). Intramuscular fat content was measured by Soxhlet extraction with petroleum ether (bp $60-80^{\circ}\text{C}$) (AOAC 991.36; AOAC, 2000, Soxtec), protein was measured by the Leco total combustion method (AOAC 968.06; AOAC, 2000), and muscle dry matter by drying at 110°C for 24 h.

The fatty acid composition of intramuscular lipid was determined by gas chromatography (Shimadzu GC-17A, capillary column Supelco SP-2560, $100\text{ m} \times 0.25\text{ mm}$ ID, $0.2\text{ }\mu\text{m}$ film) (Shanthar, Decker, & Henning, 1993), following extraction with chloroform/methanol (Folch, Lees, & Stanley, 1957).

The amino acid content of the muscles were determined on 5 mg of freeze-dried and defatted samples, hydrolysed in 6 M glass-distilled HCl (containing 1% phenol w/v) at 110°C for 24 h, in sealed evacuated tubes (Finley, 1985; Rutherford & Moughan, 2000). Amino acids were determined using a Waters ion-exchange HPLC system (Waters WISP715, Waters Corp., Milford, MA) with post-column ninhydrin derivatization and detection at 570 nm (440 nm for proline). Free amino acid molecular weights were used to convert moles to mg of amino acid.

Taurine, carnosine, and coenzyme Q_{10} , were assayed as described by Purchas et al. (2004). Briefly, taurine and carnosine were quantified using an HPLC system after a buffer extract (67 mM sodium citrate buffer, pH 2.2) had been passed through an ultrafilter with a 5000 MW cutoff. Coenzyme Q_{10} was measured in hexane extracts by HPLC.

2.3. Statistical analysis

Analysis was by a block design used within the GLM Procedure of SAS (SAS Inst. Inc., Cary, NC), with animals as the blocks and with the two muscles and belly cut within each animal. Thus, the group effect was tested against the animal-within-group term, and the muscle and interaction effects were tested against the overall error term. Multiple comparisons between groups were tested using the least-significant difference tests or by a set of orthogonal contrasts as explained in the relevant tables.

3. Results and discussion

3.1. Carcass and meat quality

Mean carcass weights (Table 1) were similar for three of the groups, at about 80 kg, but were only 47.5 kg for the Singapore light group. Ages and fat depths were not available for the Singapore pigs. Despite a similar carcass weight, the NZ extensive group was 26 days older and had a 38% greater fat depth than the NZ intensive group. Comparisons of pigs that have been raised under indoor-intensive versus extensive-outdoor conditions have produced inconsistent results with respect to carcass composition at the same weight (see, for example, Heyer, Andersson, & Lundstrom, 2006), and the current comparison needs to be interpreted with care as the pigs in the two systems did not come from the same original population. Measures of meat quality were restricted to ultimate pH, colour, and proximate composition (Table 2). Ultimate pH was available for only the longissimus (LL) muscle for Singapore groups, and for both those groups it was significantly higher than for either NZ group, but the mean

Table 1

Numbers of pigs, mean carcass weights and fat depths for groups of female pigs raised either intensively (NZ intensive) or extensively (NZ extensive) in New Zealand, or raised in Indonesia and slaughtered in Singapore at either a lower weight (Singapore light or S-Lo) or a heavier weight (Singapore heavy or S-Hi).

	Group				Orthogonal contrast (P values)			$R^2\%$, RSD ^b
	NZ intensive	NZ extensive	Singapore light	Singapore heavy	NZ vs Sing	Int vs Ext	S-Lo vs S-Hi	
Number	8	8	4	4				
Carcass weight (kg)	81.4	79.6	47.5	[80.0] ^c	<0.0001	0.27	–	95.1, 3.2
Age (d)	146	172	na ^a	na	–	<0.0001	–	83.0, 6
Fat depth (mm)	11.5	15.9	na	na	–	0.0007	–	57.4, 2.0

^a na = not available.

^b Measures of goodness of fit of the model are given by coefficients of determination [$R^2(\%)$] and residual standard deviations (RSD).

^c Individual carcass weights for this group were not available so it was excluded from analysis.

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