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Review of pork-quality studies in New Zealand

P.C.H. MOREL*, R.W. PURCHAS and B.H.P. WILKINSON

Institute of Food, Nutrition and Human Health, Massey University, Private Bag 11-222,
Palmerston North 4442, New Zealand

*Corresponding author: p.c.morel@massey.ac.nz

ABSTRACT

This paper presents data published between 1990 and 2009 on pork quality in New Zealand. The characteristics considered are pale, soft and exudative (PSE), dark firm and dry (DFD), boar taint, intramuscular fat (IMF%), chemical composition aspects such as fatty acids profile and flavours other than boar taint. Over the years the incidence of PSE has been reduced from 40% to 6%. The percentage of DFD pork was always below 7%. A level of 2.0% of IMF% is considered as a minimum with respect to palatability. Between 1990 and 2009, reported values for IMF% ranged from 0.98% to 3.36% and tended to decrease over time. Skatole and androstenone are the two major compounds responsible for boar taint. In New Zealand, males are slaughtered "entire". In 1996 only 19% of them were below the European Community threshold for boar taint. Results from different feeding experiments show that the fatty acid profile, selenium content and flavours other than boar taint, of pork can easily be changed. Overall pork from New Zealand pigs is of a high quality, but the incidence of boar taint is of concern.

Keywords: pork; quality; composition; New Zealand.

INTRODUCTION

Pork quality is determined by breeding and husbandry practices, particularly the handling of animals and carcasses immediately before and after slaughter. Organoleptic problems of pork can include dryness, hardness, inferior flavour and changes in colour, tenderness, and water-binding capacity. The eating quality of pork is an individual experience and depends on its appearance as evident with its colour, and marbling, and its palatability related to flavour, tenderness and juiciness. Fat tissues also contribute to the eating quality of pork as they contribute to meat flavour. These meat quality characteristics influence the decision of the consumer to buy the meat and to repurchase after consumption. These characteristics can be assessed by a sensory panel made up of trained or untrained people, or by objective measurements of related physico-chemical properties.

This paper reviews published and unpublished data on different aspects of pork quality in New Zealand. The characteristics considered are pale, soft and exudative (PSE) pork, dark firm and dry (DFD) pork, boar taint, intramuscular fat, (IMF%), chemical composition aspects such as fatty acids profile and flavours other than boar taint, as well as tenderness.

Pale soft and exudative (pse) pork

After slaughter, the transition of living muscle to meat is controlled by the glycolytic system, which converts glycogen to lactate, and those processes, which lead to dephosphorylation of adenosine tri-phosphate (ATP). Acidification occurs as a consequence of lactic acid accumulation and

rigor as a result of the loss of ATP. Rigor mortis develops in pig muscle over a period of about 10 hours during which time the pH falls from about 7.0 to 5.5. When the pH falls below 6.0 and the temperature is >30°C, an extensive denaturation of the soluble and structural proteins occurs, which leads to a loss of their water-holding abilities. The precipitated protein interferes with the optical properties of the muscle to cause more light to be reflected to give it a paler appearance. Both genetic and environmental factors can cause a rapid decline in pH after death and consequently the development of PSE characteristics in meat (Honikel & Fischer, 1977; Bendall & Swatland, 1988).

In the late nineties a high percentage of PSE meat, as indicated by a muscle pH at 45 minutes post-mortem (pH45) of <5.8 in the *M. longissimus* and elsewhere, were reported by Gelera (1994) (36 to 38 %) and Morel *et al.* (1997) (26 to 47%). This pork quality problem was addressed by the New Zealand Pork Industry Board who instituted the Pork Quality Improvement Program (PQUIP). Over the following years, the incidence of PSE was greatly reduced to 5 to 10 % (Jensen, 2000). This reduction was achieved both by selection against the halothane gene and improvements in the pre-slaughter handling of the pigs. The National Pig Breeding Company was confirmed to be free of the halothane gene by 1998 (Jensen, 2000). Average pH45 values reported in 2000 were well above 5.8 (Janz *et al.*, 2008), indicating that PSE pork was no longer an issue for the NZ Pork Industry. However, no recent studies with a large number of samples have been conducted to confirm this fact.

TABLE 1: Percentage of intramuscular fat (IMF), pH measured 45 minutes after slaughter (pH45) and ultimate pH (pHu) in the *M. longissimus* reported in the literature for New Zealand pigs as well as the percentage of pigs with a pH45 <5.8 (pale soft and exudative pork (PSE)) and a pHu >6.2 (dark firm dry pork (DFD)). M = Male; F = Female.

Breed	Number of pigs	Sex	IMF (%)	pH45	pHu	PSE		DFD		Authors
						pH45 <5.8 (%)		pHu >6.2 (%)		
Duroc X	12	M+F	2.02		5.61					Purchas <i>et al.</i> (1990)
Hampshire X	12	M+F	1.86		5.48					"
Landrace X	12	M+F	1.28		5.87					"
Large White X	12	M+F	1.64		5.82					"
Mixed breed	78	M+F				38		3.3		Gelera (1994)
"	66	M+F				36		1.5		"
Large White x Landrace	7	F	2.8		5.67					Smith <i>et al.</i> (1995)
"	7	M	2.7		6.15					"
"	20	M+F	3		5.6					"
Crossbred	1,331	M+F				30		7 (409) ¹		Morel <i>et al.</i> (1995)
Large white	289	M+F				26		6 (87) ¹		"
Landrace	220	M+F				47		4 (78) ¹		"
Crossbred	22	F	2.41	5.89	5.49					Masqualala (1997)
Crossbred	1,115	M+F		6.29		10				Jensen (2000)
"	1,193	M+F		6.37		6				"
Crossbred	56	M+F	0.98							Morel <i>et al.</i> (2006)
PIC hybrids	28	F			5.44					Janz <i>et al.</i> (2007)
Duroc X	59	F	1.38							Morel <i>et al.</i> (2008)
Duroc X	59	F		6.43	5.51					Janz <i>et al.</i> (2008)
Duroc X	8	F	1.44		5.53					Purchas <i>et al.</i> (2009)
Large White x Landrace ²	8	F	3.36		5.47					"

¹Number of carcasses for pHu quoted in brackets.

²Outdoor extensive production system

Dark firm dry (dfd) pork

Pork with an ultimate pH >6.2 will result in meat that is dark, firm and dry (DFD) (Honikel & Fischer, 1977). Pork that is DFD occurs when there is insufficient glycogen in the muscle at the time of slaughter, as a result of pre-slaughter stress, to allow the full development of acidification through the accumulation of lactic acid. The incidence of DFD pork has always been low in New Zealand with values between 1.5% and 7.0% being reported in the late nineties by Gelera (1994) and Morel *et al.* (1997) (Table 1). Ultimate pH values between 5.4 and 5.6 in the *M. longissimus* have recently been reported suggesting that DFD is not a real problem for the New Zealand Pork Industry (Table 1) (Janz *et al.*, 2008).

Intramuscular fat percentage (imf%)

Intramuscular fat is located inside the muscle. The IMF% in a muscle will influence meat appearance or marbling, and have an effect on meat tenderness, juiciness and flavour. A minimum level of 2% IMF in the *M. longissimus* has been proposed (Bejerholm & Barton Gate, 1987; Fortin *et al.*, 2005). The IMF% reported for new Zealand pork was over this threshold in the nineties (Table 1), but values reported recently, for modern pig genotypes were between 1.0% and 1.5% with the exception of 3.36% reported for pigs kept in an extensive outdoor

system (Purchas *et al.*, 2009). This reduction in IMF% over time could be associated with the genetic selection for high carcass leanness or low carcass backfat thickness. The IMF% is genetically negatively correlated with carcass leanness (Schwoerer *et al.*, 1987) and positively correlated with backfat thickness (Hermesch *et al.*, 2000). Backfat thickness between 12 mm and 14 mm were observed for Duroc, Hampshire Landrace and Large White pigs at 65 kg hot carcass weight by Smith *et al.* in 1990, and between 11 mm and 12 mm for Duroc-cross pigs at 80 kg hot carcass weight in 2008 by Morel *et al.* (2008). The lower than optimal level of IMF% in the loin for New Zealand Pork could limit the acceptability of sensory characteristics that can be achieved.

Boar taint

Rearing entire males instead of castrated males is economically advantageous to pork producers. Entire males grow faster, use their feed more efficiently and produce leaner carcasses. Boar taint is a distinct unpleasant odour, which is sometimes present when fat or meat from boars is cooked. Not all pork from entire males will exhibit boar taint and individual consumers may differ in their ability to detect taint. Nevertheless, boar taint is considered a major risk to consumer confidence in pork. The two compounds that are mainly responsible for causing

TABLE 2: Androstenone and skatole concentration (ppm) in subcutaneous fat and the percentage of pigs above and below the international thresholds of 1 ppm for androstenone and 0.2 ppm for skatole.

Number of pigs	Androstenone		Skatole		Both below thresholds (%)	Both above thresholds (%)	Authors
	Mean (ppm)	Proportion >1 ppm (%)	Mean (ppm)	Proportion >0.2 ppm (%)			
228	0.89	34	0.10	8	6	64	Hennessy <i>et al.</i> (1997) ¹
43	1.30	56	0.12	14	12	42	"
49	0.72	25	0.22	41	18	52	"
49	0.44	10	0.23	43	6	53	"
136	1.44	50	0.27	32	19	37	P.C.H. Morel (Unpublished data) ²

¹Data from two piggeries in New Zealand and two piggeries in Australia

²Data from 24 piggeries in New Zealand

taint are skatole, produced in the intestine by bacterial fermentation of the amino acid tryptophan, and 5- α androstenone, a C19-steroid. Androstenone is synthesised in the testes by the sexually mature boar. In New Zealand male pigs are slaughtered entire, and with the industry trending towards producing heavier carcasses, it brings with it an increased risk of producing tainted carcasses (Bonneau, 1998).

A survey conducted on 24 farms in New Zealand in 1996 showed that 32% of the samples exceeded the European Community (EC) threshold level for skatole, 50% exceeded the EC threshold for 5- α -androsterone and 37% exceeded both EC threshold levels (P.C.H. Morel, Unpublished data). This means that only 19% of the samples would have been considered as not boar tainted according to the EC standards (Table 2). Over the same period a similar survey was conducted on two farms in New Zealand and two farms in Australia by Hennessy *et al.* (1997) and found that 58% of the carcasses were classified as not tainted. In a study conducted in New Zealand on commercial carcasses (Morel *et al.*, 1997), no relationships were found between age, which ranged from 120 days to 180 days of age; carcass weight, which ranged from 55 kg to 90 kg; thickness of the backfat which ranged from 7 mm to 17 mm; or growth rate and the skatole and androstenone levels in subcutaneous fat. This means that traits routinely recorded at slaughter cannot be used to predict boar taint while the carcasses of young pig can already display boar taint. In Norway, high levels of skatole and androstenone were found in young boars of less than 100 days of age slaughtered at between 56 kg and 63 kg live weight (Aldal *et al.*, 2005). Currently boar taint is certainly one of the major quality problems for New Zealand Pork.

Fatty acid profile

There is an increasing consumer awareness of improved health and well-being through good nutrition. The potential for marketing health improvement through dietary ingredients has been

recognized by the food industry. Consumers are demanding pork with less fat and at the same time they are very aware of the type of fat food contains. The *n*-3 polyunsaturated fatty acids (PUFA's) have a wide range of beneficial effects on human health, especially against heart diseases (Ruxton *et al.*, 2005). Besides the concentration of some specific fatty acids in fat, their relative and comparative proportions are also relevant for human health. Modifying the fatty acid profile of muscle and adipose tissue by dietary means is easier in monogastric species than in ruminant species. In terms of human nutrition and health, a PUFA to saturated fatty acid (SAT) ratio greater than 0.4, and a ratio between C18:2 (linoleic) and C18:3n-3 (linolenic) lower than 4.0 are recommended (Wood *et al.*, 2003). The substitution of tallow by a blend of soybean oil and linseed oil in pig diets increased the PUFA:SAT ratio in subcutaneous fat from between 0.23 and 0.28 to between 0.61 and 0.73 and the linoleic: linolenic ratio decreased from between 5.9 and 6.3 to between 2.9 and 3.1 (Morel *et al.*, 2006, 2008). These ratios are primarily influenced by the total dietary PUFA intake rather than by the time when high PUFA diets are fed (Morel & McIntosh, 2001).

Other pork quality attributes

Recent research has indicated that the nutrient content of New Zealand pork is similar to that from other countries. There are suggestions that there can be differences between pork from pigs raised intensively compared to that from pigs raised more extensively outdoors and that New Zealand pork contains a number of compounds with bioactive properties (Purchas *et al.*, 2009). The selenium, vitamin E and conjugated linoleic acid (CLA) content of pork can be increased by the dietary addition of Sanovite™ (Morel *et al.*, 2008). Based on the latest recommended daily intake of selenium for Australia and New Zealand of 70 μ g for men and 60 μ g for women (NHMRC, 2006), the consumption of 100 g of Sanovite pork would provide about one-third of the recommended daily intake of Se (Morel

et al., 2008). The flavour of pork can be improved significantly by judicious manipulation of the pig's diet. The removal of animal-by products namely, blood meal, meat and bone meal and tallow from a pig's diet resulted in less mutton flavour and a higher overall acceptability for Asian consumer as shown by sensory evaluation conducted in Singapore (Leong et al., 2010a). When similar types of pork were evaluated in New Zealand no differences in flavour were observed (Janz et al., 2008). When garlic, ginger, rosemary and oregano flavour were added to pig's diets no difference in pork flavours were detected by a New Zealand flavour panel (Janz et al., 2007). However, when at least a total of 60 g of garlic oil was fed to the pigs over a 57 day period, both Singaporean and New Zealand panellists were able to indentify garlic flavour and aroma in the resultant pork (Leong et al., 2010b). These results suggest that the addition of fragrant essential oils and oleoresins to a pig's diet has the potential to produce pork with specific flavours that meet the consumer's preferences. In a survey on the tenderness of New Zealand pork (n = 400) it was found that 93% of the loins tested were either very tender or tender and that only 0.25%, equivalent to one loin, was tough (K. Rosenfold, Personal communication).

CONCLUSION

Research in New Zealand has indicated that pork from New Zealand pigs is tender and of a high quality. However, the incidence of boar taint is likely to become an increasingly important concern with high slaughter weights, and the relatively low levels of IMF% may limit the levels of palatability that can be achieved. This review has indicated that there are opportunities to enhance the value of pork in term of its nutritive value and flavours.

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