PE7.09 Effect of intramuscular fat level on fatty acid composition and texture in pork 105.00

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Abstract— This study evaluated the effect of two levels of intramuscular fat on intramuscular and subcutaneous fatty acid composition and the relationships between instrumental texture, sensory quality and fatty acid composition. Animals were fed with two experimental diets with different composition that produced two animals groups with different percentage of intramuscular fat (High-IMF and Low-IMF). No differences were found in the percentage of saturated fatty acids (SFA) between the two groups, but the percentage of monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids were significantly higher in the High-IMF and Low-IMF groups, respectively. Treatment had little effect on the fatty acid composition of subcutaneous fat. Finally, WBSF appeared as a good predictor of the tenderness of grill-cooked pork.

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Index Terms—intramuscular fat, fatty acid composition, taste panel, instrumental texture.

I. INTRODUCTION

THE nutritional programme can have a major impact on intramuscular fat levels and, in particular, the feeding of protein deficient diets has been shown to increase dramatically intramuscular fat [6; 14; 12]. The industry is faced with the dilemma of producing pork with sufficient IMF to satisfy the eating experience of the consumer but, at the same time, producing pork with minimal amount of visible fat in order to alleviate the health concern of the same consumer [5]. The pig, being a monogastric species, is amenable to changes in the fatty acid composition of adipose tissue and muscle using different feeding strategies. Manipulation of the fatty acid composition of IMF, therefore, plays an important role in producing healthier pork, compromising consumer acceptance between healthy and intramuscular fat content. The most important aspect of meat quality is eating quality, usually defined as scores given by taste panellists for tenderness, juiciness and flavour [14]. As tenderness is considered the most important attribute that determines overall acceptance of pork, the threshold level of IMF for ensuring a positive eating experience was identified as a function of the attributes describing tenderness [5]. The aim of this study was to evaluate the effect of two different levels of intramuscular fat on intramuscular and subcutaneous fatty acid composition and the relationships between instrumental texture, sensory quality and fatty acid composition.

II. MATERIALS AND METHODS

A. Animals and sampling

Forty two entire males pigs, Large White x (Landrace x Large White), were randomly assigned to two dietary treatments with the individual animal as the experimental unit. There were two experimental diets with different composition that produced two animals groups with different percentage of intramuscular fat (2.63 vs 1.76) (High-IMF: Crude protein (CP) 14.92 %, Crude fat (CF) 4.18 % and Metabolisable Energy (ME) 13.42 MJ/kg and Low-IMF: CP 17 %, CF 3.62 % and ME 13.08 MJ/kg). The pigs were stunned using carbon dioxide and slaughtered at an abattoir at approximately 105 ± 6.7 kg live weight. In this study, fourteen carcasses from each of the two groups of different IMF were selected in a weight range of 78.5-91 kg. The loins were refrigerated at 4 ºC for 24 hours, after they sliced into 2 cm and 5 cm thick steaks and placed in vacuum bags and frozen at -20 ºC for meat quality analysis. Also, a sample was taken from subcutaneous fat (SCF) at the level of thoracic ribs that was immediately frozen.

B. Intramuscular fat analysis

Intramuscular fat (IMF) was extracted from the muscle according to the [1] method and quantified as the weight percentage of wet muscle tissue.

C. Fatty acid analysis

The samples were extracted according to [1] to determinate composition in fatty acids from intramuscular and subcutaneous fat and the methyl esters from fatty acids (FAMES) were analysed in a gas chromatograph HP-6890 II, with a capillary column SP-2380 (100 m x 0.25 mm x 0.20 µm), using nitrogen as the carrier gas.

D. Instrumental measurement of meat texture

Texture profile analysis (TPA; [2]) and Warner–Bratzler shear force (WBSF) were measured using a TA-XT2 Texture Analyser (Stable Micro Systems, Godalming, UK) equipped with a 250 N load cell. The Texture Expert, version 1.20 (Spanish), computer program by Stable Micro Systems was used for data collection and calculations. The samples were fast-thawed in tap water (4 h), then the vacuum was broken and the samples were wrapped in aluminium foil and cooked at 200 ºC in a double plate grill (Sammic GRS-5) until the internal temperature reached 72 ºC. Eight cores (1 x 1.5 x 1.5 cm) were cut at angle approximately 45º to the longitudinal axis of muscle fibers from each sample of TPA. A double compression cycle test was performed up to 50% compression of the original portion height with a flat plunger 50 mm, with 1 s between cycles. The samples for Warner–Bratzler shear test were obtained by cutting at least twelve rectangles of 1 x 1 cm2 of cross section and 5 cm long, parallel to the muscle fibre direction.

E. Sensory analysis

The steaks used for sensory panel evaluations were cooked as previously described for TPA and WBSF. Sensory tests were performed during 3 sessions to evaluate the effects of the two IMF groups (10 animals per group; 2 replicates). Panellists used numerical scales to quantify tenderness (1 = very tough to 10 = very tender), juiciness (1 = very dry to 10 = very juicy), fibrousness (1 = low fibrous to 10 = very fibrous), pork flavour intensity (1 = no flavour to 10 = very intense flavour) and overall acceptance (1 = unpleasant, 10 = very pleasant). F. Statistical analysis All data were statistically analyzed by the GLM procedure of SPSS, version 14.0 [11]. The model included IMF groups as main effect. Relationships among parameters of instrumental texture, sensory quality and fatty acid composition of intramuscular fat were evaluated using Pearson's correlations.

III. RESULTS AND DISCUSSION

The intramuscular fat or marbling of loin was statistically different between both treatments which is in accordance with the results of [14] and [12] when the effect of low and high protein level were compared. In our study, the High-IMF group diet had a lower and higher percentage of protein and animal fat, respectively, compared to Low-IMF group diet. This fact could cause a protein synthesis limitation and an increase of the amount of energy available for fat deposition, which would have been used for muscle synthesis, resulting in higher intramuscular fat content. The fatty acid composition of the intramuscular fat (IMF) is shown for the two IMF groups in Table 1. There were not significant differences in the concentration of total saturated fatty acids (SFA) between the two groups. The proportion of oleic acid (C18:1 n-9) and monounsaturated fatty acids (MUFA) was significantly higher in the High-IMF group, whereas the percentage of polyunsaturated fatty acid (PUFA) was higher in the Low-IMF group. Similar results were reported by [12] who observed that the low protein diets (higher intramuscular fat) had not significant differences for C18:0, but had higher significantly differences in all individual MUFA and total MUFA percentages. Also, the total PUFA and all the individual PUFA percentages were significantly higher on the high protein diet. Treatment had little effect on the fatty acid composition of subcutaneous fat (SCF) (Table 1). No differences between IMF groups were detected for SFA, MUFA and PUFA. A similar backfat thickness was expected, since several authors ([14] and [12]) have found that a low protein diet increased the level of intramuscular lipids in pig meat with a smaller effect on the amount of subcutaneous adipose tissue. Table 2 shows the Pearson's correlation among different parameters: instrumental texture, sensory quality and fatty acid composition of IMF. Only significant correlations are shown. Chewiness was positively correlated with Warner–Bratzler shear force (WBSF). Similar results were reported by [4] who found a positive relationship between WBSF and the TPA characteristics of hardness (0.35) and chewiness (0.36), indicating that both instrumental methods were probably measuring similar textural properties in beef loins. Other authors [10] have also found that the WBSF parameter was positively related to hardness (0.26) and chewiness values (0.25) in pork loins. Chewiness and WBSF were negatively correlated with tenderness and juiciness. Similar correlations between some parameters of instrumental texture and sensory quality have been reported by some authors in pork [3] and beef meat [4]. WBSF and texture profile analysis (TPA) have similar capabilities to predict the sensory measurement of tenderness and other subjective traits. The most widespread method normally used as an indicator of meat sensory tenderness is the Warner-Braztler shear test and it is usually used in raw meat, whereas the texture profile analysis is rarely used by research in meat [9]. In our study both instrumental methods were good to predict the tenderness of pork meat, but the highest correlation value was with Warner-Bratzler shear force (-0.81). It could be due to the action of back teeth on the samples produce compression and shearing and it is more similar to the action of WBSF than TPA [7]. Also, we carried out sensory and instrumental analysis under similar conditions (grill cooking method and 72 ºC end point temperature) and it could be the reason for the high correlations in our work. The proportion of MUFA was significantly correlated with chewiness (-0.44) and WBSF (-0.59), whereas the proportion of PUFA was positive correlated with WBSF. It could be related to that the effect of fatty acids on firmness of fat is due to the different melting points of the fatty acids in meat [13]. The sensory quality (tenderness (0.61) and juiciness (0.55)) was significantly correlated with the proportion of MUFA too. However, the percentage of PUFA had a negative correlation with tenderness and juiciness. It could be due to the human perception that the meat is juicer, as intramuscular fat increases. On the other hand, the overall acceptance was significantly correlated with MUFA (0.61) and PUFA (-0.44). It could be due to the fact that tenderness was the most important attribute that determined overall acceptance of pork, which agrees with [8].

IV. CONCLUSION

There was little effect of two intramuscular fat levels studied on fatty acid profile of subcutaneous fat. However, approximately two points of difference in the percentage of crude protein between treatments modified the percentage of MUFA and PUFA in the intramuscular fat, but not SFA. The use of the same type of cooking (grill) in sensory and instrumental texture could produce higher correlations. Therefore, WBSF appeared as a good predictor of the tenderness of grill-cooked pork.

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Table 1. Fatty acid composition of intramuscular and subcutaneous fat (% of total fatty acids).

	Intramuscular fat					Subcutaneous fat				
	Low-IMF		High-IMF		Sign.	Low-IMF		High-IMF		Sign.
N	10		11			10		11		
	x	se	x	se		x	se	x	se	
C16:0	22.79	0.52	23.10	0.73	ns	21.90	1.16	21.93	0.74	ns
C16:1	3.13a	0.50	3.50b	0.46	t	1.81	0.12	1.81	0.22	ns
C18:0	10.31	1.02	10.24	0.85	ns	12.93	1.06	12.69	1.33	ns
C18:1 n-9	39.87a	2.16	42.30b	1.62	**	37.67	1.19	38.60	1.50	ns
C18:2 n-6	10.02b	1.28	8.41a	1.54	*	15.32	1.88	14.90	1.12	ns
C18:3 n-3	0.45b	0.06	0.38a	0.04	**	1.21b	0.23	1.06a	0.12	t
C20:4 n-6	2.14b	0.39	1.52a	0.35	***	0.28	0.05	0.25	0.03	ns
C20:5 n-3	0.14b	0.05	0.09a	0.02	**	0.02	0.00	0.01	0.01	ns
C22:6 n-3	0.11	0.04	0.09	0.03	ns	0.03	0.01	0.03	0.01	ns
SFA	34.88	1.38	35.10	1.45	ns	36.87	2.01	36.59	1.88	ns
MUFA	48.63a	2.55	51.65b	1.96	**	43.62	1.16	44.63	1.71	ns
PUFA	14.18b	1.92	11.46a	2.07	**	17.94	2.25	17.28	1.26	ns
n-6	12.88b	1.72	10.51a	1.94	**	16.37	2.00	15.92	1.16	ns
n-3	1.27b	0.22	0.94a	0.15	***	1.55b	0.28	1.35a	0.16	t
P/S	0.41b	0.05	0.33a	0.07	**	0.49	0.08	0.47	0.05	ns
n-6/n-3	10.23a	0.85	11.18b	0.94	*	10.69a	1.19	11.86b	1.03	*

Different letters in the same row indicate significant differences among mean values; ns = p>0.1; t = p≤0.1; * = p≤0.05; ** = p≤0.01; *** = p≤0.001.

Table 2. Pearson´s correlations among some parameters of texture, sensory quality and fatty acid composition of intramuscular fat (n = 21).

	CH	WBSF	T	J	F	PF	OA	MUFA (%)	PUFA (%)
Hardness	0.81**								
Chewiness (CH)	–	0.58**	-0.49*	-0.46*		-0.45*		-0.44*	
WBSF		–	-0.81**	-0.56**	0.65**		-0.50*	-0.59**	0.48*
Tenderness (T)			–	0.80**	-0.83**		0.71**	0.61**	-0.58**
Juiciness (J)				–	-0.73**	0.50*	0.60**	0.55*	-0.48*
Fibrousness (F)					–		-0.64**		
Pork flavour (PF)						–		0.54*	
Overall acceptance (OA)							–	0.61**	-0.44*
SFA (%)									-0.68**

Only significant (* = p≤0.05; ** = p≤0.01) correlation coefficients are shown.