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VARYING TECHNOLOGICAL BEEF MUSCLE PROPERTIES AND THE INTRAMUSCULAR FATTY ACID PATTERN

Eichinger, H.M., and M. Seewald
Versuchsstation Thalhausen,
Institute of Animal Science
Technical University of Munich,
D-8050 Kranzberg, West Germany

SUMMARY

Two groups of Simmental calves were fed either a milk replacer or a concentrated hay based diet and slaughtered at 4 months of age.
Laboratory investigations of WBC, texture, reflexion, and further gaschromatographic lipid analysis proved that technological properties of two beef muscles (m. longissimus dorsi and m. supraspinatus) can be largely influenced by the feeding method. There are also marked correlations between technological criteria and the intramuscular post mortem fatty acid pattern.

In a very prominent position is the polyunsaturated linoleic acid accounting for a strong part of the variance in the water binding capacity.

Meat tenderness is more correlated with the depot fatty acids and reflects the indirect effects of the different diets. The color of meat shows also rather high correlations with depot fatty acids, but specifically with those mostly influenced by the feeding system (C_{12} and C_{14}); so that these connections can also be interpreted as indirect feeding effects.
Mean and standard deviation for intramuscular pH was 5.63 ± 0.21, for GOEFO-reflexion value 70.5 ± 16.4, for water binding (GRAU-HAMM, rel. m:f) 36 ± 5.3, and for shear value 8.6 ± 3.8. Total intramuscular fat content was 1.29 % ± 0.22. Most prominent fatty acids were C_{16} (22.1 %), C_{18} (14.0 %), $C_{18:1}$ (23.5 %), $C_{18:2}$ (26.0 %) and $C_{20:4}$ (6.9 %) which account for 92.5 % of the whole pattern. Total fat content was different between the two muscles (1.35 vs 1.08 %), and there were significant differences in their fatty acid patterns (C_{16}, C_{18}, $C_{18:2}$ and $C_{18:3}$).

It is concluded that the differences in technological properties and fatty acid pattern found in this material are not independent and can be largely influenced by feeding.

INTRODUCTION

Intramuscular fat content is a major source of variation of most sensoric and technological properties of meat. Higher fat content is normally associated with higher reflexion values, a brighter appearance, an indirect amelioration of water-binding, and a softer and more tender texture. Meat color is of special interest in veal calf production especially with increasing slaughtering weights.

There are finally two very different slaughter animals available: the ruminating early weaned calf fed on a roughage/concentrate basis, and the still monogastric, milk replacer fed calf. The meat of milk replacer fed calves is lighter and has normally more intramuscular fat than the meat of early weaned calves, but there is little known about special differences in the fatty acid pattern that have to be expected when growing animals already ruminate or do not.

It was therefore the objective of this study to investigate in two different muscles the effects and dependencies of fat content and fatty acid pattern on some major technological properties.

MATERIALS AND METHODS

Eleven male Simmental calves were divided in two groups and fattened at the Experimental Station Thalhausen. One group was kept on a milk replacer (n=5) diet, whereas the other group (n=6) was early weaned and fed with hay and concentrate.

Animals were slaughtered at the age of four months. 24 h post mortem a sample of the longissimus dorsi at the 10th rib and the musculus supraspinatus was removed for measurements and further analysis. pH-value was electrically measured directly in the muscle, meat color was measured as reflexion value at a fresh cut surface by the GOEFO-reflexion-photometer, waterbinding capacity was investigated by the GRAU/HAMM filter paper press method, and tenderness was estimated via threeply repeated cuts of three muscle samples with the WARNER-BRATZLER-SHEAR-press.

Total intramuscular fat was extracted (HALLERMAYER, 1976) by methanol chloroform (1:1, v/v) and, after vacuum-evaporation of the solvent, the amount was measured gravimetrically. Gaschromatographic analysis of fatty acid methylesters (capillary column DURABOND WAX, carrier gas H_2, FID) was performed after transesterification by Na-methylate (Shehata et al., 1970). All measurements including gaschromatography were done in duplication one time and biometric analysis was performed using the SAS[R] package on a IBM 3210 and included analysis of variance and calculation of PEARSON correlation coefficiencies.

RESULTS AND DISCUSSION

In all carcasses the postmortem glycolysis occurred within normal limits (BAUSCHMID et al., 1982), the 24 h value being 5.63 ± 0.21 (Table 1). Reflexion values were markedly lower and standing for a brighter color than those usually measured in older animals with variations of more than 20 %.

Table 1. Means, Standard Deviations and Analysis of Variance of Technological Properties of Two Muscles from Two Rearing Systems (n=22) 24 h Post Mortem

Variable		MEAN	STD.DEV.	longiss. vs supraspin.	milkrepl. vs Early weaning
pH		5.63	0.21	n.s.	n.s.
Reflexion (GOEFO)	Div.	70.5	16.4	*	***
Waterbind. Capacity (G/H)	W/M	36.4	5.3	n.s.	n.s.
Tenderness (Warn.Brt. Sh.)	lbs	8.6	3.8	***	***
Fat content	%	1.29	0.22	*	*

Whereas waterbinding was generally good with only minor fluctuations tenderness showed ample variation (c.v. 44 %) around a mean value of 8.6 lbs shear force. This variation is partly due to the WARNER-BRATZLER-SHEAR-Press-methodology in unheated, raw material but mainly reflects the different amounts of the intrinsic textural components. Intramuscular fat content was rather low in this material (1.29 % ± 0.22).

The two muscles were from different anatomical origin. They differed not in pH and not in their waterbinding capacity, but were significantly different in their reflexion values, tenderness and total fat content, whereas the longissimus was brighter, much more tender, and slightly leaner than the supraspinatus. The analysis of variance proved the feeding systems as a further source of variation in meat color, tenderness and total intramuscular fat content. The very energy rich milk replacer diet produced a highly significant brighter, more tender, but only slightly fatter meat. No significant interactions were found between "muscle" and "feeding system". These results support the traditional appreciation of special retail cuts and further confirm the technological specialities of veal even at higher slaughter weights.

Regarding the intramuscular fatty acid pattern (Tab. 2) the most prominent fatty acids are the palmitic (22.1 %), the stearic (14.2 %), oleic (23.5 %) and the linoleic acid (26.0 %). The rather high proportion of phospholipids in muscle extracts account also for the high amount of arachidonic acid (7.0 %), so that the total amount of polyunsaturated fatty acids (PUFA) augments to more than one third of the whole pattern. Significant differences between muscles occur at C_{16}, C_{18}, $C_{18:1}$, $C_{18:2}$, and $C_{18:3}$, whereas the m. supraspinatus has the higher PUFA values.

The milk replacer diet produces a positive difference in the myristic and lauric acid value and slightly increased arachidonic acid values, which are compensated by lower stearic acid values. Further details of the lipid fractions are published elsewhere (SEEWALD et al., 1987).

Meat color (GOEFO) and pH were highly significantly correlated (Table 3) as well as meat color and total intramuscular fat content, the brighter muscle having lower pH_{24}-values and a higher fat content. Other correlations between technological criteria were in an expected direction, but not high enough for significance, presumably partly due to the dominating effect of the intramuscular fat content.

The correlations between the different fatty acids focus mainly on PUFA's, and for compensation on C_{12}, C_{14}, C_{16} and $C_{18:1}$, whereas other fatty acids remain rather unchanged in this material, e.g. the stearic acid. This indicates the influence of the relative amount of structural lipid components, which normally contain more PUFA, especially arachidonic acid.

Considering the technological criteria, the fatty acids C_{16}, C_{18} and $C_{18:1}$ are correlated significantly with the tenderness with changing signs for possible compensations. Water binding capacity is positively correlated with the linoleic acid fraction, and negatively with C_{12}, C_{14} and $C_{18:1}$, suggesting that the molecular basis of the WBC is more associated with the phospholipid specific fatty acids.

The reflexion values are mostly correlated with the lauric and myristic acid, the latter being very specific for the milk replacer diet, so that the diet has to be considered as the reason for variations in the meat color. There are finally no marked dependencies between the pH-values and the fatty acid pattern, but type and extend of post mortem glycolysis were already not very different in this material.

Literature

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Table 2. Means, Standard Deviation and Analysis of Variance of Fatty Acids from Two Beef Muscles from Two Rearing Systems (n=22)

Variable		MEAN	STD.DEV.	Longiss. VS Supraspin.	MR VS EW
C_{10}	%	0.01	0.03	n.s.	n.s.
C_{12}	%	0.35	0.39	n.s.	***
C_{14}	%	2.85	1.97	n.s.	***
C_{16}	%	22.10	2.75	**	n.s.
$C_{16:1}$	%	1.44	0.62	n.s.	n.s.
C_{18}	%	14.22	2.51	*	**
$C_{18:1}$	%	23.45	2.72	*	n.s.
$C_{18:2}$	%	26.03	3.77	*	n.s.
$C_{18:3}$	%	1.22	0.45	***	n.s.
C_{20}	%	0.25	0.35	n.s.	n.s.
$C_{20:4}$	%	6.98	2.75	n.s.	**

Table 3. Correlations between technological criteria and the relative amount of major fatty acids in beef muscle (n=22)

	C_{12}	C_{14}	C_{16}	C_{18}	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	$C_{20:4}$	pH	GOEFO[1)]	WBC[2)]
FAT	0.84***	0.61**	-0.18	0.00	0.20	-0.32	0.14	-0.33	-0.27	-0.64**	-0.26
WBS[3)]	-0.29	-0.40	-0.46*	0.61**	-0.42*	0.28	0.47*	0.21	-0.20	0.08	0.26
WBC[2)]	-0.46*	-0.64***	-0.29	0.06	-0.59**	0.62**	0.36	0.55**	0.04	0.34	-
GOEFO[1)]	-0.61**	-0.53**	0.07	-0.02	0.17	0.24	-0.06	0.42*	0.77***	-	
pH	-0.16	-0.08	0.25	-0.24	0.16	-0.08	-0.16	0.08	-		
$C_{20:4}$	-0.59**	-0.78***	-0.55**	-0.04	0.76***	0.75***	0.37	-			
$C_{18:3}$	-0.13	-0.27	-0.78***	0.30	-0.42*	0.48*	-				
$C_{18:2}$	-0.60**	-0.77***	-0.62***	-0.07	-0.75***	-					
$C_{18:1}$	0.49*	0.73***	0.50*	-0.40	-						
C_{18}	-0.06	-0.19	-0.18	-							
C_{16}	0.10	0.36	-								
C_{14}	0.84***	-									

	WBS[3)]
FAT	-0.17

1) reflexion

2) water binding capacity

3) Warner–Bratzler–Shear