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DETERMINATION OF MATURITY IN CULLED COWS

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SUMMARY

Age and maturity were evaluated on a total of 90 Danish Friesian (SDM) cows ranging in age from 24 to 105 months. The evaluation was carried out by following methods: determination of number of permanent incisors, assessment of ossification of the sacrum, sternum, praesternum and thoracic process cartilage, recording of chronological age and commercial maturity grading.

In Longissimus Dorsi samples Hunterlab-lightness, percent intramuscular fat, shear force, intramuscular collagen and collagen solubility were determined. Ash and dry matter were determined on the 6th, 8th and 10th thoracic process cartilage.

It was possible from the detailed investigation of ossification, especially in the thoracic process cartilage to give a coarse prediction of chronological age (r = 0.52 - 0.83). Only poor relationships were found between maturity and shear force, lightness and intramuscular fat in LD, but the collagen solubility was correlated both to age and degree of ossification. The relationship between collagen solubility and commercial maturity class was as strong as between collagen solubility and chronological age. This indicates that the assessment of ossification in the thoracic process cartilage is as precise a prediction of meat quality as is the chronological age. Determination of ash or dry matter in thoracic process cartilage can be used as an objective reference for determination of maturity.

In general, it seems that a standardized assessment of skeleton ossification with emphasis on judgement of thecranial part of the thoracic process can be recommended as part of beef carcass grading systems.

INTRODUCTION

Determination of age and maturity in beef carcasses is important in relation to meat quality; especially tenderness. The main reason for this is believed to be the development of toughness in the intramuscular connective tissue with increasing age (Cross et al., 1973; Boccard et al., 1979; Sørensen, 1981).

It is probable, that this development in meat quality is more closely connected to general physiological development of the carcass (maturity) than the chronological age of the animal.

The objective of this study was to examine different methods for determination of maturity and age in culled cows and to investigate the relationship between maturity and meat quality characteristics.

MATERIALS AND METHODS

A total of 90 Danish Friesian (SDM) cows ranging in age from 24 to 105 months were included in the investigation. The animals were distributed on three feeding regimens during lactation and were slaughtered 1 to 37 weeks after calving.

All cows were transported, slaughtered and chilled according to the Institute's standard procedures (Buchter, 1976). This includes that the carcasses should be cooled at 6°C for 24 hours and then kept at 4°C.

At slaughter, the number of permanent incisors was determined, and the exact chronological age of each animal was recorded.

Assessment of ossification of the skeleton was carried out the day of slaughter using a visual descriptive scale for each site of assessment (Sørensen, 1983):

Sacrum:	Five-point scale from 1 = all vertebrates clearly separated by cartilage to 5 = complete ossification.
Sternum:	Eight-point scale from 1 = ossification of central bones only to 8 = complete ossification expect between first and second bone.
Praesternum:	Four-point scale from 1 = no ossification to 4 = complete ossification.
Thoracic process cartilage:	Three-point scale from 1 = no ossification to 3 = complete ossification.

Also, the maturity class of cows as defined in the Danish classification system was recorded. This assessment is based on ossification in the thoracic process and sternum, using a three-point scale where 7 = very young cows, 8 = young cows, 9 = cows (Klassificeringsudvalget for Oksekød, 1982).

Five days after slaughter the 6th, 8th and 10th thoracic process cartilages were removed from 45 carcasses, photographed and frozen. The samples were then combined in groups of two to three animals of similar age to obtain sufficient material, ground and analysed for dry matter after Boccard et al. (1981) and ash after ISO-936 (1978).

A sample of Longissimus Dorsi was removed between the 11th rib and 1st lumbar vertebrae five days after slaughter from the right side of the carcass. The sample was vacuum packed and aged until 16 days after slaughter at 2°C. At 16 days post mortem the LD was divided into the following samples: Three 6 cm thick steaks for shear force measurement, a 2 cm thick steak for colour measurement and the remainder of the LD minced for other analyses.

Shortly after cutting the Hunter-lightness (L) was measured on the steak after it has been exposed to air for 80 min.

Percentage fat (SBR) was determined (based on wet weight) on minced meat after a method recommended by the Commission of the European Communities Beef Production Research Programme (Boccard et al., 1981). The minced meat had been frozen before analysis.

The shear force samples were vacuum packed and frozen after ageing at 2°C until 16 days post mortem. The meat samples were thawed at 5°C, cooked to a final internal temperature of 72°C and cooled. Strips of meat were cut 10 x 20 mm in cross section, in the plane perpendicular to the direction of the fibre bundle and about 5 cm long. Each strip was sheared once with a Volodkewich shear attachment on a Karl Frank 81559 equipment.

The content of total and soluble intramuscular collagen was determined after the method described by Sørensen (1981) on the sample used for colour measurement from 33 cows ranging in age from 29 to 105 months.

RESULTS

Mean results and range of variation in age, weight and degree of ossification are presented in Table 1. Considerable variation was found in live weight at slaughter as well as in chronological age. The results for ossification illustrates that most of the assessment scales defined has been used over the whole range.

A clear picture of the pattern of ossification in the thoracic process starting from the caudal part of the animal can be seen, and is further illustrated in Figure 1, in this case for two maturity classes. It is clear from both Table 1 and Figure 1 that the highest variation in ossification is found in the cranial part of the thoracic process cartilage of the animal. The pattern shown in Figure 1 is furthermore in good agreement with the official definition for maturity classes in Denmark (Klassificeringsudvalget for Oksekød, 1982).

Table 1: Mean values from determination of maturity, chronological age and maturity class. Number of observations = 90

	Mean	Standard deviation	Min. value	Max. value
Live weight, kg	544	71	435	779
Age, months	46.5	20.4	24	105
Number of permanent incisors	5.8	2.0	2	8
Ossification of sacrum	4.3	0.4	3	5
Ossification of sternum	4.8	1.0	2	8
Ossification of praesternum	3.2	0.5	2	4.5
Ossification of thoracic p.c.				
1-4 (mean)	1.8	0.5	1	3
5-8 (mean)	2.2	0.3	1.6	3
9-13 (mean)	2.7	0.2	2.2	3
Maturity class 1)	8.2	0.8	7	9

1) Danish classification system

Standard meat quality traits, intramuscular collagen content, collagen solubility and the contents of dry matter and ash in the thoracic process cartilage are shown in Table 2. The shear force values corresponds to good tenderness, and the variation is limited due to the choice of muscle and the standardized chilling and ageing method. Collagen content is somewhat lower and the mean solubility is considerably lower than earlier results with young bull beef (Sørensen, 1981; Cross et al., 1984). Variation was considerably more pronounced in solubility than in total content of intramuscular collagen.

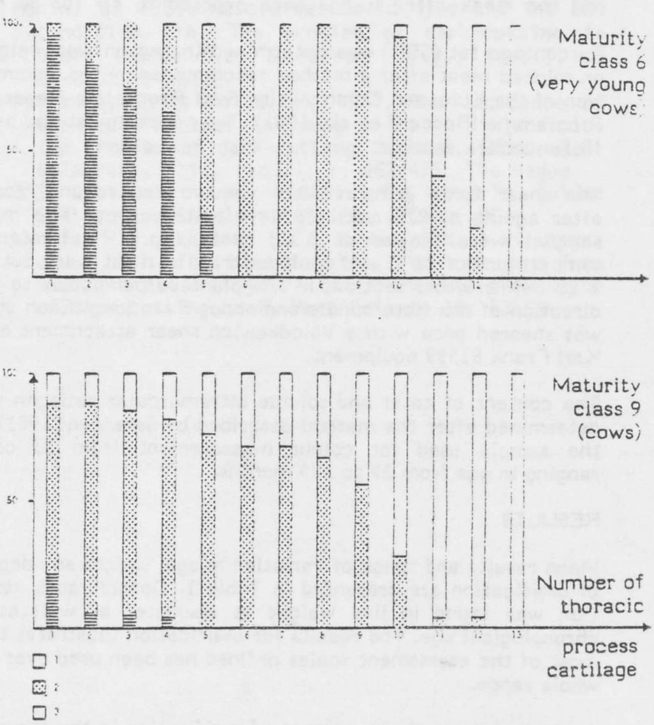

Figure 1: Average distribution of degree of ossification in the 1st to 13th thoracic process cartilage from cows of two maturity groups. (1 = no ossification, 2 = partly ossification, 3 = complete ossification).

Table 2: Analysis of longissimus dorsi and thoracic pro[...] cartilage samples

	Number	Mean	Standard deviation	Min. value	Max. value
Longissimus dorsi					
Hunterlab - lightness	90	29.9	1.6	26.7	[illegible]
Intramuscular fat, %	90	3.1	1.4	0.8	[illegible]
Shear force, kg	90	7.0	2.1	4.0	[illegible]
% total collagen 1)	33	0.22	0.04	0.14	[illegible]
Collagen solubility 2), %	33	7.0	1.9	2.1	[illegible]
Dry matter					
6th thoracic process cartilage	16	54.8	14.9	37.9	[illegible]
8th thoracic process cartilage	16	54.2	14.6	38.4	[illegible]
10th thoracic process cartilage	16	55.6	12.5	38.9	[illegible]
Ash					
6th thoracic process cartilage	16	19.2	8.0	9.3	[illegible]
8th thoracic process cartilage	16	18.0	6.4	10.2	[illegible]
10th thoracic process cartilage	16	18.9	6.9	8.6	[illegible]

1) Percentage of wet weight
2) Percentage of total collagen soluble after 2 h at 80°C.

Analysis of thoracic process cartilage revealed a dry mat[...] content of around 55%, around one third of the dry ma[...] being determined as ash. There is considerable variation [...] both results, but any differences between anatomical lo[...] tions was not found - in contrast to the findings for ass[...] ment of ossification.

Correlation coefficients between standard meat quality tr[...] and age, number of incisors and degree of ossification [...] presented in Table 3. No relationship was found betw[...] colour or fat content and age, illustrating the meat pigm[...] ation has been fully developed in all three maturity gro[...] and the fat content has been controlled by feeding regime[...]

For shear force values, low but positive correlations w[...] found to age and age indicators, illustrating a minor decre[...] in tenderness with age in the LD muscle. Unfortunat[...] tenderness has not been investigated in muscles with hig[...] collagen content.

It can be seen from Table 3, that the strongest relationship [...] chronological age was found for assessment of ossification [...] the cranial part of the thoracic process cartilage, but co[...] mercial maturity class and number of permanent incis[...] were also strongly correlated to age, in the latter case o[...] up to $3\frac{1}{2}$ years of age, where the teeth set is fully develop[...] Correlations between age and ossification of sacrum [...] sternum were significant, but at a lower level. Examina[...] of the sacrum and sternum can be complicated by variatio[...] in splitting of the carcass, which also were concluded [...] Leach and Akers (1972).

Table 3: Correlations between the degree of ossificat[...] and meat quality traits (n = 90)

	Age, months	Shear force	Hunterlab lightness	% intra-muscular fat
Age, months	-	0.26	0.01	0.16
Number of permanent incisors	0.76	0.31	0.04	0.14
Ossification of sacrum	0.52	0.05	-0.08	0.04
Ossification of sternum	0.64	0.11	-0.02	0.11
Ossification of praesternum	0.63	0.19	-0.08	0.10
Ossification of thoracic p.c. (1-4)	0.82	0.16	0.02	0.13
(5-8)	0.83	0.24	0.06	0.12
(9-13)	0.72	0.13	0.01	0.05
Maturity class	0.72	0.32	0.09	0.10

Correlations above ± 0.20 are significant different from 0.

Table 4: Correlations between the degree of ossification and the content of collagen, ash and dry matter

	6th thoracic p.c.[1)]		8th thoracic p.c.[1)]		10th thoracic p.c.[1)]		Collagen[2)]	
	ash	dry matter	ash	dry matter	ash	dry matter	total	% solubility
Age, months	0.92	0.92	0.93	0.97	0.88	0.94	-0.18	-0.61
Number of permanent incisors	0.89	0.93	0.86	0.88	0.80	0.84	-0.05	-0.52
Ossification of sacrum	0.73	0.70	0.64	0.68	0.49	0.55	-0.10	-0.36
Ossification of sternum	0.76	0.74	0.77	0.77	0.65	0.71	0.00	-0.27
Ossification of praesternum	0.87	0.86	0.81	0.86	0.82	0.87	-0.33	-0.49
Ossification of thoracic p.c.								
(1-4)	0.92	0.94	0.95	0.97	0.89	0.93	-0.03	-0.69
(5-8)	0.85	0.86	0.91	0.94	0.87	0.90	-0.18	-0.59
(9-13)	0.90	0.94	0.91	0.95	0.90	0.94	-0.06	-0.52
Maturity class	0.91	0.94	0.92	0.92	0.87	0.91	0.20	-0.60
Shear force, kg	0.34	0.31	0.35	0.28	0.30	0.31	0.01	-0.12
Total collagen	-0.15	-0.02	-0.04	-0.06	-0.03	-0.02	-	-0.16
Collagen solubility, %	-0.65	-0.64	-0.66	-0.71	-0.73	-0.73	-	-

1) 16 observations, correlations above ± 0.49 are significant different from 0.
2) 33 observations, correlations above ± 0.33 are significant different from 0.

The relationships between chemical analysis of cartilage and intramuscular collagen, age, degree of ossification, teeth development and shear force are shown in Table 4. The limited number of observations should be noticed, especially for analysis of cartilage.

The ash or dry matter content of cartilage was strongly correlated both to chronological age and subjective evaluated ossification, including maturity class. The correlation between ash and dry matter in the same sample was 0.97-0.98 showing that either analysis can be used alone as an objective method for estimation of age and maturity.

Whereas correlations between intramuscular collagen content and age/ossification were small and insignificant, the collagen solubility was correlated both to age and objectively or subjectively determined degree of ossification. It is especially worth noticing that the relationship between collagen solubility and commercial maturity class is as strong as between collagen solubility and chronological age, and that the detailed assessment or analysis of thoracic process cartilage has given the highest correlations to collagen solubility.

The correlations between shear force values and other traits investigated were small and not significant, reflecting that longissimus dorsi was not affected by changes in maturity to any great extent.

DISCUSSION

It seems clear from the results reported here that it is possible from a detailed investigation of ossification especially in the thoracic process cartilage to give a coarse prediction of chronological age in cows of different ages, but also that the precision is limited. The method is more precise than prediction from number of incisors which seems to be the only alternative in daily practice. In several countries prediction of ossification is important, because it is used in relation to payment to the producer.

To our judgement, however, the differential in price between maturity classes should mainly reflect differences in meat quality, more than differences in chronological age of the animal. The important question seems therefore to be whether the assessment of ossification gives a sufficient clear picture of the age-related changes in meat quality, e.g. mainly changes in "background toughness".

Unfortunately, it has not been possible in this study directly to measure tenderness in the muscles where these changes are predominant, i.e. the muscles containing relatively much intramuscular connective tissue. No relationship between maturity and shear force in LD was found here, but this is not surprising taking into account the low collagen content of this muscle and the unability of the shear force method to reflect connective tissue tenderness.

It has earlier been demonstrated (Sørensen, 1981) that solubility of collagen in LD gives a fairly good prediction of connective tissue toughness also in other muscles of the animal. If this is assumed to be the case in this study also, and the results for collagen solubility presented here is taken as indicator of age-related variation in meat tenderness, the study indicates that assessment of ossification in the thoracic process cartilage is as precise a prediction of meat quality as is the chronological age. It must of course be remembered that the correlations are based on a limited number of observations.

It seems furthermore possible to conclude that determination of ash or dry matter in thoracic process cartilage can be used as an objective reference for maturity, although a precise sampling and preparation is rather difficult due to inaccurate carcass splitting etc.

In general, it seems that a standardized assessment of skeleton ossification with emphasis on judgement of the cranial part of the thoracic process can be recommended as part of beef carcass grading systems.

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