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SKELETAL MUSCLE CHARACTERISTICS FOR AN OBJECTIVE EVALUATION OF MARBLING AND GRANULATION

ENDER, K. ; PAPSTEIN, H.-J. ; WEGNER, J. ; ALBRECHT, E.
Research Institute for Biology of Farm Animals, 18196 Dummerstorf, Germany

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Background

Marbling and granulation of meat are essential characteristics for the valuation of meat quality. Both characteristics are recorded until now only subjectively. Therefore it is necessary to develop objective methods. Automated image analysis (IA) offers new possibilities. Intramuscular fat content is an important characteristic for marbling, but more information about the distribution of fat within the muscle is necessary. Objective parameters of muscle structure can describe the granulation of meat.

Objective

The aim is to develop objective parameters for measurement of marbling and granulation by the use of image analysis. They are studied to characterize meat of extremely different breeds of cattle.

Materials and Methods

9 to 10 bulls of the breeds White-blue Belgian (WBB), German Angus (GA), Galloway (Ga) and Black Pied (BP) kept under the same conditions, were slaughtered at the age of 12 month. 24 h p.m. a slices of 1 - 1.5 cm thickness from the 12th rib portion of *longissimus* muscle were taken and fixed in 5% formalin. A 1 - 2 mm thick cut was stained with oil-red and differentiated with 70% isopropanol. As result of staining fat appears red and connective tissue white being contrasted to muscle. Also little fat particles can be seen. For image analysis were used a QUANTIMET 570. The fat particles were detected after an image preprocessing. The measurement results of each particle were sorted into different histograms.The following traits were measured :

- sum of fat areas as total fat area
- mean size of fat particles
- number of fat particles
- size of the 3 largest fat particles
- number of round fat particles
- sum of longish fat areas
- sum of fat areas in every eighth part of the muscle area.

From these traits new parameters were created to characterise intramuscular fat distribution (Table 1). The chemical fat content (ether extraction), fat area percentage (IA) and Warner-Bratzler share force value serve as reference parameters.

Different parameters of muscle structure are measured for methodical studies of granulation (Table 3). Haemalum-eosin stained transverse sections of *semitendinosus* muscle samples are evaluated by image analysis. The bundle area is the essential new parameter of granulation.

Results and Discussion

Table 1 shows the results of the objective description of marbling in meat from cattle of various breeds. Differences between the four breeds are apparent. The Galloways exhibit a high number of fat particles per cm² (4.5), a low particle size (0.82 mm²), the lowest percentage of the largest 3 fat areas and the lowest value for fat area distribution. These results characterize a fine and regular distribution of fat particles in muscle cross section.

The Angus bulls establish not so much, larger and not as regular distributed fat particles. The WBB have a very little number of fat particles (0.5/cm²). The results show, that it is not possible to describe the marbling of meat with only one parameter. The evaluation indicates the best fat distribution in the meat of Galloway breed.

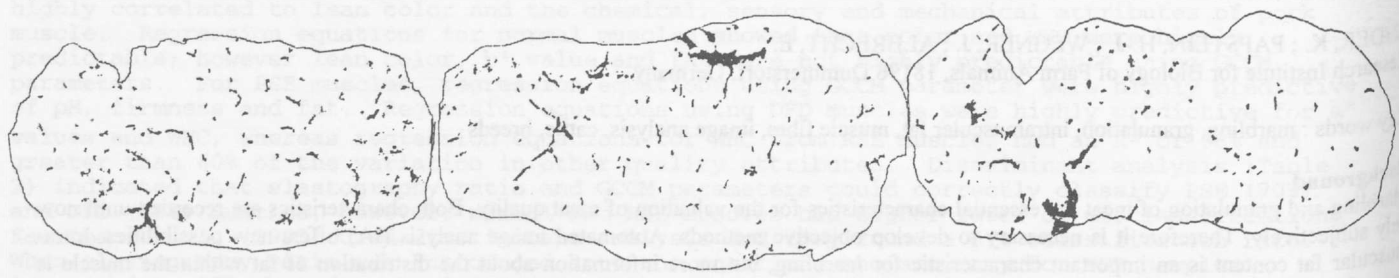
Fig. 1 presents three samples with similar fat area percentage but with different distribution. These samples are typical for the breeds. Differences are given as percentage of the largest 3 fat areas of total fat area. A lower value means few large fat particles. The higher fat area percentage and fat particle number/cm² and the lower the values for the other parameters, the better is the marbling.

The correlation coefficients between fat parameters (IA) and fat content (chem.) or share force value are presented in Table 2. The value r=0.82 indicates a close relation between fat content and fat area percentage. Fat area distribution and fat content are not related (r=-0.21). The share force value has the closest relation to fat particle number/cm² (r=-0.55). Also a regular fat particle distribution has a positive effect on tenderness. However, higher correlation coefficients can not be expected, because meat tenderness is influenced by numerous factors. A simple assignment of various factors affecting tenderness to the point of exclusion of the other is likely to be a gross oversimplification (Purslow, 1994). Dransfield (1992) suggested, that the majority of variation in meat tenderness is controlled mainly by calpain system and only a little by connective tissue, fatness and marbling.

Scholz and Gregor (1993) used fresh samples for video image analysis to determine marbling in *longissimus* muscle of pigs. Our studies show, that automated image analysis on unprepared meat is not useful. However, the connective tissue plays a more important role in cattle than in pigs. It is necessary to discriminate fat and connective tissue optically. The technique based on stained meat cuts allows to detect also the little fat particles described by Hoshino et al. (1990) as dotty type. These fat particles are fat cells within the muscle fibre bundles.

A macroscopically coarse structure of meat is related to larger muscle fibre bundles. The measurement of primary bundle area allows a statement about granulation. A primary bundle is the smallest unit of muscle fibres surrounded by connective tissue. Table 3 shows the finest granulation in meat of Black Pied bulls (bundle area=0.25 mm²), and the coarsest granulation in White-blue Belgian (bundle area=0.67 mm²). However, the differences in muscle fibre areas are small between these extremely different breeds. The almost double muscle area of WBB in comparison to the other breeds corresponds to a higher total muscle fibre number.

Fig. 1 *M. longissimus dorsi* cross sections with different fat area distribution and equal fat area percentage



	Galloway (sample 95)	**Black Pied** (sample 137)	**German Angus** (sample 160)
fat area percentage [%]	**3.22**	**3.30**	**3.18**
fat particle number / cm²	**3.27**	**2.99**	**2.33**
fat particle size [mm²]	**1.00**	**1.18**	**1.37**
percentage of largest 3 fat areas [%]	**24.6**	**37.4**	**44.8**
percentage of longish fat areas [%]	**62.4**	**68.2**	**70.6**
fat area distribution [%]	**7.9**	**9.5**	**15.0**

Conclusions

By means of automated image analysis new parameters were established, wich allow an objektive characterization of meat marbling and granulation. The comparison of extremely different cattle breeds showed that Galloway bulls exhibit the meat with the most regular and finest marbling. The intramuscular fat in Angus bulls is disproportionally distributed and it is stored in larger fat particles. The meat of Black Pied cattles has the finest granulation. Meat of White-blue Belgian is very low marbled and coarsly granulated.

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Table 1 Structure of intramuscular fat in *M. longissimus dorsi*

		White-blue Belgian	**German Angus**	**Galloway**	**Black Pied**
	N	**9**	**9**	**10**	**9**
muscle area [cm²]	MEAN	**112.1**	**67.1**	**64.6**	**64.6**
	STD	6.1	10.7	8.0	7.2
marbling	MEAN	**1.0**	**1.6**	**1.5**	**1.9**
[pt.]	STD	0.0	0.5	0.5	0.3
fat content (chem.)	MEAN	**0.27**	**1.34**	**1.26**	**2.18**
[%]	STD	0.11	0.56	0.38	0.80
W-B share force	MEAN	**21.6**	**15.8**	**12.2**	**16.2**
value [kp]	STD	3.4	4.0	3.4	4.4
fat area percentage	MEAN	**0.58**	**3.22**	**3.51**	**3.92**
[%]	STD	0.24	0.69	1.46	1.02
fat particle	MEAN	**0.5**	**2.5**	**4.5**	**4.0**
number / cm²	STD	0.2	0.7	1.8	0.9
fat particle size	MEAN	**1.12**	**1.32**	**0.82**	**0.99**
[mm²]	STD	0.26	0.23	0.29	0.22
percentage of largest 3 fat areas [%]	MEAN	**28.7**	**36.7**	**20.6**	**29.2**
	STD	6.4	8.0	13.0	6.6
percentage of longish fat areas [%]	MEAN	**50.5**	**68.3**	**57.2**	**66.6**
	STD	12.1	1.9	11.4	5.4
fat area distribution [%]	MEAN	**11.5**	**10.5**	**6.2**	**8.7**
	STD	3.3	3.2	2.9	0.9

Table 2 Relations between fat content (chem.), share force value and parameters of intramuscular fat (n=37)

	fat content (chem.)	**fat area percentage**	**fat particle number / cm²**	**fat particle size**	**percentage of largest 3 fat areas**	**percentage of longish fat areas**	**fat area distribution**
share force value	**-0.32**	**-0.46**	**-0.55**	0.23	0.20	-0.17	**0.35**
fat content (chem.)		**0.82**	**0.65**	-0.02	0.10	**0.52**	-0.21

Table 3 Muscle structure of *M. semitendinosus*

		White-blue Belgian	**German Angus**	**Galloway**	**Black Pied**
	N	**9**	**9**	**9**	**10**
muscle area [cm²]	MEAN	**97.8**	**59.3**	**46.4**	**50.3**
	STD	14.2	4.7	7.3	5.6
bundle area [mm²]	MEAN	**0.67**	**0.38**	**0.35**	**0.25**
	STD	0.19	0.08	0.08	0.07
muscle fibre area	MEAN	**2939**	**2974**	**2802**	**2480**
[µm²]	STD	617	780	648	638
total muscle fibre	MEAN	**2.78**	**1.73**	**1.45**	**1.70**
number [x10⁶]	STD	0.48	0.40	0.37	0.40