ECONOMIC IMPORTANCE OF MORPHOLOGIC CHARACTERISTICS IN BEEF CARCASSES

by H. de Boer and J. de Rooy.
Research Institute for Animal Husbandry "Schoonoord", Zeist, Netherlands.

Introduction

The value of a carcass per unit of weight is a funtion of the yield and the quality of the saleable meat. Apart from age and sex mainly quantitative aspects are responsible for carcass yield and the organoleptic qualities of the meat. For example lack of finish as well as excessive fatness depreciate succulence and/or appearance of the meat. Excessive fatness leads to trimmings of fat, lowering the value per kg of the carcass. The same is the consequence of a high bone content of the carcass.

The quantitative aspects of a carcass may be expressed by its weight and its composition in terms of muscle, fatty tissue and bone. Also other approaches have been applied, such as determining the percentage of high priced cuts, either wholesale cuts or retail cuts. The value of the latter approach is mainly restricted to giving information on aspects of fatness, which may be of great importance however in markets with carcasses of a high degree of fatness.

Data on carcass composition in terms of muscle, fatty tissue and bone are of an objective nature. For this reason in research much attention has been given to the assessment of carcass composition by dissection and/or chemical analysis of the carcass or a sample (e.g. 3-rib joint) of it. The composition, given in percentages of muscle, fat and bone, carries much information on the value of the carcass. It is not giving direct information however on relative thickness of lean, which is a factor influencing the value per kg of carcass. For this reason carcass composition will not always reflect differences in carcass value, as has been signalized by Weniger (Der Tierzüchter 22, p.666, 1969) when comparing carcasses of Friesian cattle of American and European origin.

A main handicap in utilizing carcass composition data in carcass evaluation is that hitherto no applicable method of determination is available for practical purposes, where large numbers are involved. All commercial carcass evaluation takes place by visual assessment of the characteristics that are supposed to be of influence on the carcass value. As long as no realistic alternatives are available economic aspects of carcass evaluation should be related to commercial methods of deriving carcass value from perceivable morphologic characteristics in the intact carcass.

The purpose of our experiment was to analyse which is the economic importance that is attributed by meat trade to these carcass characteristics separately. Next aim was to deduce the value of the carcass from quantitative assessments of the morphologic characteristics.

H9

Principles of assessment of morphologic characteristics

Visually assessed characteristics are of a morphologic nature, which are perceivable as such. They reflect the relative development of "flesh" (= muscle plus intermuscular fat), fatty tissue and bone and may be expressed in quantitative terms by a scoring system.
"Fleshiness" represents the relative thickness of the layer of flesh over a skeleton of a given size. The degree of fleshiness is derived from the outer shape of muscle groups, that include muscles plus intermuscular fat.
External "fatness", or fat covering represents the relative development of the layer of subcutaneous fat, viz to what degree the surface of the carcass is covered and how is the thickness of the fat cover relative to the size of the carcass.
The quantification of "kidney and channel fat" in a morphologic sense must be seen as expressing in how far it "fills" the body cavity, meaning that its development is estimated in relation to the size of the skeleton.
The fineness of bone indicates whether bones are thick or thin relative to their length. This characteristic is hard to assess in a uniform way however and not of major importance in carcass evaluation. For that reason it is left out of consideration here.

In our experiments fleshiness and fatness are assessed by using a 6 point scoring table, ranging from minimal relative development (1) to the maximum (6). In order to obtain further differentiation each class was subdivided into 3 subclasses by using + and - (e.g. 3-, 3.0, 3+), leading to a total differentiation into 18 classes. The principle is illustrated in fig.1 (p.3).

The perceivable morphologic development of fleshiness and fatness in a carcass of a given weight can be interpretated directly in economic terms. For it gives information on bone content (relatively thick flesh means short and normally light bones), on the importance of fat trimmings or on eventual lack of finish, and on saleable meat yield as far as dependant on muscle mass thickness in various positions.

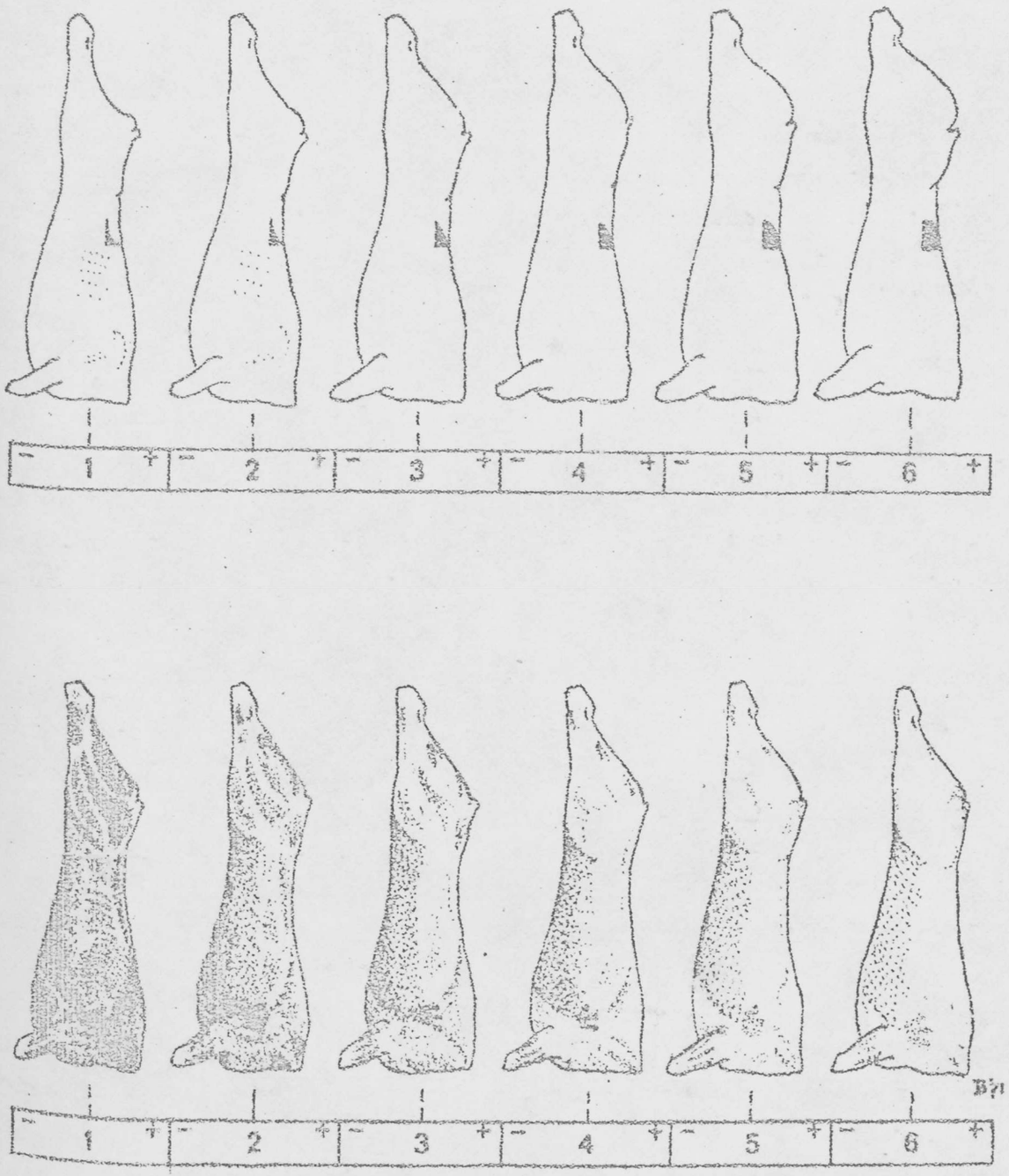

Fig. 1. Illustration of the principle of scoring fleshiness and fatness (fat-covering) in a quantitative sense, applying a 6 point scale and a subdivision of each class into 3 (e.g. 4-, 4, 4+).

Experimental procedures and material

Under commercial conditions graded carcasses of different categories have been described by using a standardized scoring system. The following assessments were included:

warm carcass weight, kgs
sex and age (ossification criteria)
fleshiness (scoring 1-6)
fatness: fatcovering (scoring 1-6)
fatness: kidney and channel fat (scoring 1-6)
colour of lean (scoring 1-6)
colour of fat (scoring 1-6)

The carcasses have been graded commercially by the cooperating firm according to the norms of their usual classification system, distinguishing between 5 main classes each of which is subdivided in 6 subclasses, giving 30 value classes in total. In this investigation each two subclasses were combined, resulting in 15 value classes with price intervals of H.Fl. 0.10 (between the top grades H.Fl. 0.20). Class 1 represents the top grade, class 15 the lowest grade.

Table 1 gives the number of carcasses in the different categories. The classification according to age is only roughly, based on ossification criteria. From the mean scores for fleshiness and fatness appears that there are differences in level between categories. The standard deviations indicate a broad variation within categories.

Table 1: Numbers of carcasses in different categories and average scores for fleshiness and fatness.

Category		Number	Fleshiness (1-6)		Fatness (1-6)	
Sex	Age (years)		Average	St.Dev.	Average	St.Dev.
Bulls	1 1/2-2 1/2	54	3.54	0.53	1.85	0.79
Steers	1 1/2-2 1/2	125	3.47	0.62	3.04	0.75
"	> 2 1/2	57	3.61	0.48	3.13	0.65
Heifers	1 1/2-2 1/2	308	3.36	0.48	3.75	0.70
"	> 2 1/2	133	3.55	0.50	3.90	0.57
Cows	2 1/2-5	230	3.12	0.58	3.67	0.84
"	5 -9	500	3.07	0.69	3.82	1.02
"	> 9	199	2.79	0.66	3.48	1.26

The frequency distribution of carcass weight is given in the table 2, which shows a great spread in all categories.

Table 2: Frequency distribution of carcass weight.

Carcass weight class	Sex and age class (years)							
	Bulls	Steers		Heifers		Cows		
	1 1/2-2 1/2	1 1/2-2 1/2	>2 1/2	1 1/2-2 1/2	>2 1/2	2 1/2-5	5-9	>9
176-190							1	
191-205				2		1	1	2
206-220				9	1	2	5	
221-235		1		18		7	6	
236-250	5	4	1	35	3	14	13	12
251-265	8	9	4	62	19	21	22	22
266-280	17	22	4	85	20	35	42	13
281-295	9	15	9	55	26	47	60	19
296-310	7	17	13	25	24	51	89	30
311-325	2	14	11	18	17	26	79	23
326-340	2	21	6	2	14	13	74	28
341-355		10	3	2	6	8	50	25
356-370	1	6	3		3	8	32	16
371-385	1	3	2			3	18	8
386-400		3	1			2	8	2
401-415						1	3	2
416-430								
431-445							2	
446-460								
461-475								1

The carcasses belonged to cattle of two dairy breeds, viz. the Dutch Friesian and the Meuse-Rhine-Yssel breed. The latter breed has a higher adult weight and is heavier muscled than the Friesian.

The relations between the carcass characteristics assessed according to the standardized scoring system and the value-class has been analysed by calculating multiple regressions. The calculations have been made within sex/age-groups, assuming that the relations are linear except in the case of fatness. In fatness there-is an optimum and it was assumed that its relation with carcass value could be characterized by a parabola, which means the addition of a quadratic term in the regression model. In a former experiment of this series this assumption has been tested statistically, as well as skipping one of the two fatness criteria in the regression model. Scorings of fat covering and of kidney & channel fat are correlated (simple correlation + 0.8) and in multiple regression analysis omission of the latter characteristic did not lower the square of the multiple correlation coefficient (R^2) very much.

Therefore it was decided to leave out the characteristic "kidney and channel fat" from the analysis in order to avoid statistical complications.
Consequently the regression model used became as follows:

$$y = a + b1\ x1 + b2\ x2 + b3\ x3 + b4\ x4 + b5\ x5 + b6\ x6$$

in which

x1 represents carcass weight (classes of 15 kg)
x2 score of fleshiness (1-18)
x3 score of fat covering (1-18)
x4 square of score of fat covering (1-18)
x5 colour of lean (1-6)
x6 colour of fat (1-6)

For computer analysis the differentiated scorings for fleshiness and fatness were transformed to whole numbers as follows:

1-, 1, 1+, 2- etc. .....6, 6+.
1 2 3 4 etc. ....,.....17, 18.

Regression formulae are based on the latter transformed scoring values.

Results and discussion

In order to find the best equation the R^2 values have been calculated from stepwise multiple regressions of carcass value-class on the six variables above.
It was found that R^2 values are not so much lower when only 3 variables are taken in the regression instead of all 6. In far most of the cases, in which only 3 variables are taken, the highest R^2 or the next highest is found for the combination of fleshiness score, score for fatcovering and the square of the score for fatcovering.
As far as the quantitative characteristics are concerned these squares of multiple correlation coefficients are given in table 3.

Table 3: Values of R^2 x 1000 from regressions of carcass grade on carcass weight (1), fleshiness (2), fatcovering (3) and square of fatcovering (4).

Category		Breed	Number	R^2 x 1000					
Sex	Age (years)			1	2	1,2	1,3,4	2,3,4	1,2,3,4
Bulls	1 1/2-2 1/2	Fr	38	424	447	539	596	676	682
"	1 1/2-2 1/2	MRY	16	31	380	419	191	704	753
Steers	1 1/2-2 1/2	Fr	64	55	582	622	156	630	684
"	> 2 1/2	Fr	21	45	480	562	227	635	639
"	1 1/2-2 1/2	MRY	61	89	661	669	195	670	678
"	> 2 1/2	MRY	36	5	437	513	190	519	553
Heifers	1 1/2-2 1/2	Fr	127	0	235	302	403	599	601
"	> 2 1/2	Fr	33	0	210	220	366	627	633
"	1 1/2-2 1/2	MRY	181	2	220	286	218	478	478
"	> 2 1/2	MRY	100	0	169	240	282	502	502
Cows	2 1/2-5	Fr	104	6	139	154	84	249	251
"	5 -9	Fr	236	110	303	305	359	488	488
"	> 9	Fr	78	84	373	410	520	695	707
"	2 1/2-5	MRY	134	37	239	247	356	481	494
"	5 -9	MRY	264	74	357	370	261	502	503
"	> 9	MRY	121	77	296	322	330	503	505

It is remarkable that in most cases carcass weight does not show up in the best combination. Not so much because weight as such may be expected to have much influence on carcass value per kg, but because of its correlation with fleshiness and fatness. In this material the simple correlation between carcass weight and fleshiness is a rule between 0,4 and 0,7, being highest in the categorie of cow carcasses.

The values of R^2 indicate that about 50 - 70 % of the variation in value-class is explained by the variables involved in the regression analysis. Similar values have been found in preceding investigations. It is doubtful whether much higher values are possible as long as the determination of the value-class is depending on visual assessment and does not represent an absolute value of reference. It may be that deriving the carcass value from retail cutting and selling practices will give a more perfect basis for such analysis.

Calculation of regression coefficients of carcass value class on the variables fleshiness, fatcovering and square of fatcovering gave the results as summarized in table 4.

Table 4: Regression coefficients of carcass grade on fleshiness and fatness (fatcovering).

Categories		Fleshiness		Fat covering		Fat covering^2		Intercept	$\Sigma(O-C)^2$
Sex (N)	Age (years)	b_2	Sb_2	b_3	Sb_3	b_4	Sb_4	a	
Bulls (54)	1 1/2-2 1/2	-0,47	0,08	-0,70	0,19	0,04	0,02	13,57	33,51
Steers (125)	1 1/2-2 1/2	-0,65	0,04	-0,20	0,15	0,01	0,01	13,08	75,28
" (57)	> 2 1/2	-0,60	0,09	-0,92	0,37	0,07	0,02	14,18	44,85
Heifers (308)	1 1/2-2 1/2	-0,61	0,04	-0,62	0,16	0,05	0,01	12,90	294,34
" (133)	> 2 1/2	-0,75	0,07	-0,85	0,50	0,07	0,02	14,67	177,97
Cows (239)	2 1/2-5	-0,59	0,05	-0,77	0,16	0,05	0,01	13,99	338,64
" (500)	5 -9	-0,60	0,03	-0,66	0,07	0,04	0,00	14,44	633,87
" (199)	> 9	-0,58	0,05	-0,83	0,10	0,05	0,01	14,99	248,06

Though there will be differences between categories (e.g. age-effect in cow categories) it may be concluded that the relationship can be given roughly by the formula:

$$\text{Carcass grade} = 14{,}5 - 0{,}6\ Fl - 0{,}7\ Fc + 0{,}05\ Fc^2$$

in which

Carcass grade = value-class, 1 (highest) to 15 (lowest) included.

Fl = transformed score of fleshiness, 1 to 18 included.

Fc = transformed score for fatcovering, 1 to 18 included.

From similar investigations based on carcass grade assessed in the live animal a somewhat higher intercept value (a) has been found, which seems more acceptable.

In steers and heifers the influence of fleshiness on carcass value seems to count somewhat heavier than in cow carcasses. In all cases however, fleshiness must be regarded as the major factor influencing carcass value per unit of weight.

As such formulae, even in a more refined form, only constitute a schematized approach to carcass evaluation on the basis of visually assessed characteristics, further adjustments are necessary. One circumstance for example is the fact that optimal fatness is not the same for all types of carcasses, but will depend a.o. on the degree of fleshiness. In thinly fleshed carcasses optimal fatness will be lower than in thickly fleshed carcasses. As far as fleshiness and fatness are concerned this may be visualized and checked by the use of twodimensional diagrams as given in fig. 2 (p 9) for young cows. The basic relationships are the same as developed in the regression formula, but on details modifications have been introduced on the ground of meat trade practice.

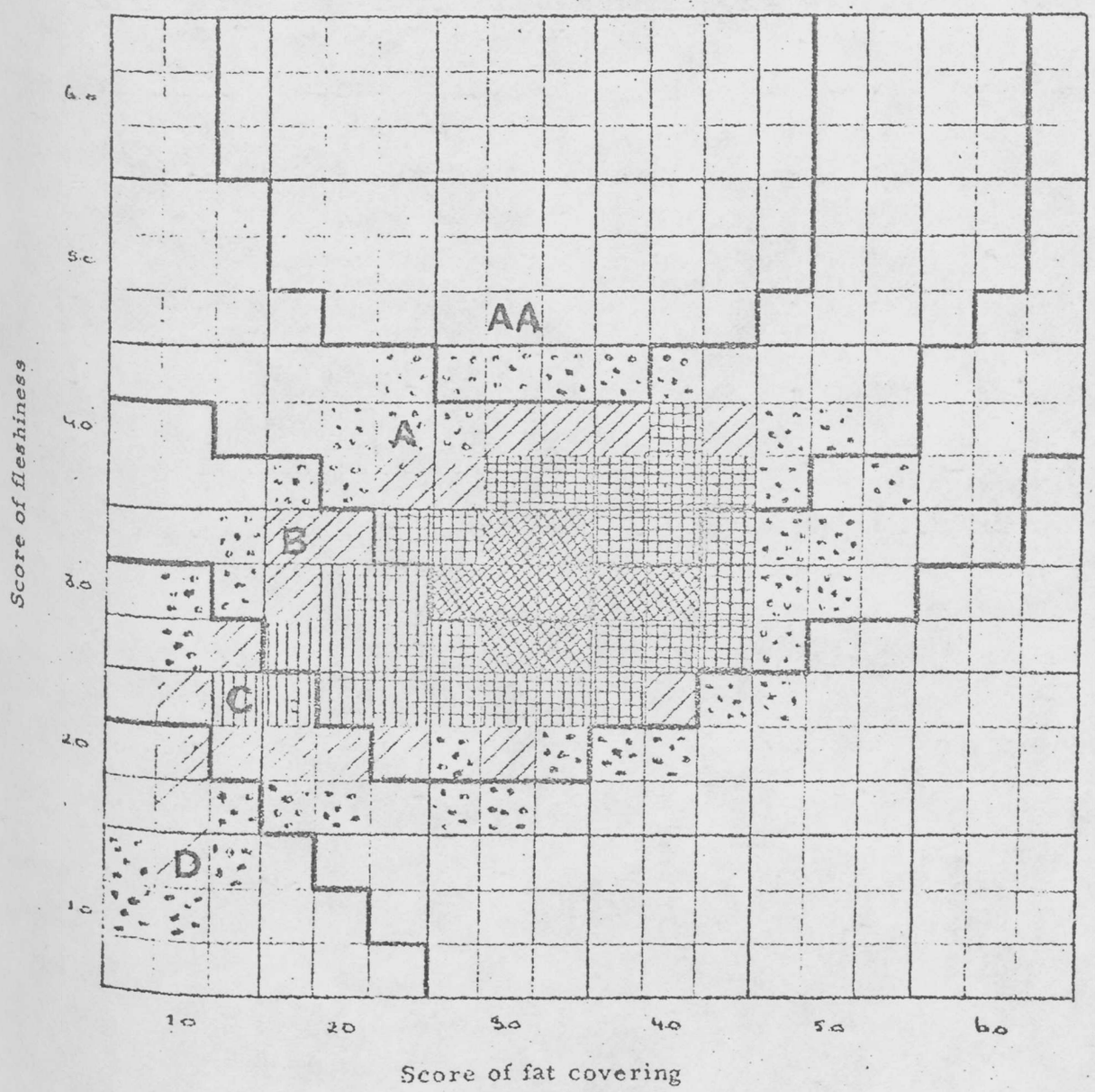

Fig. 2: Combinations of fleshiness and fatness that determine substantially the value-classes (AA, A, B, C and D) of carcasses of young cows. The frequency distribution of combinations refers to a sample of 6382 carcasses of young cows in Dutch slaughterhouses.

5-25 26-50 51-200 >200

Conclusions

In meat trade the value of beef carcasses is assessed by visual estimation, which should be accepted as an issue in research on economic aspects of beef production.

Analysis of the value attributed by Dutch meat trade to different carcass characteristics demonstrated that within sex/age groups the characteristics involved explain 50 - 70 % of the variation in value-class of the carcass. Multiple correlation coefficients are not so much lower if only scores for fleshiness and fatness are included. In almost all categories fleshiness is responsible for about 2/3 of the price variation per unit of carcass weight.

The schematized approach as well as particular uncertainties in the basic material necessitate further adjustments of the relationships between visually assessed carcass characteristics and the carcass value.

For this purpose two things will be helpful:

1. Application of a standardized system for carcass description, functioning as an "objective" common language.
2. More precise and objective assessment of the real carcass value class in order to be able to check relationships to the "absolute truth".