# Session 3.II

# *Processing as required for the market*

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## GRADING SYSTEMS. YIELD AND MEAT QUALITY, EVALUATION ON LINE

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### 1 - Introduction

Current meat grading systems use mostly subjective decisions, but objective measurements already are being used (Kempster *et al.*, 1982). To move from subjective to objective grading, it is necessary to examine carefully how subjective grading works because it contains both explicit and implicit components. Implicit yield grading occurs when different classes of carcasses are identified, with the implicit assumption from previous experience that one class will have a higher yield of lean meat than another. This originates from common growth patterns of meat animals and poultry. When they are very young, they have a high proportion of bone and visceral weight so that carcass meat yield is low. As they grow, they add muscle bulk, and the meat yield increases. But if they reach or pass maturity, they are probably involved in breeding or milk or egg production, and muscle bulk may be reduced, giving a low carcass yield. In contrast to this implicit decision making explicit yield grading is when a particular measurement is made to predict meat yield, usually within one class of animals.

### 2 - Subjective grading systems

Until recent times, most trade was on a personal basis. The need for methods of carcass description arose from the lengthening of the distribution chain and the decline in face-to-face bargaining. Carcass description, introduced to facilitate trade at a distance, quickly took on a promotional significance. In most countries where the export of meat became an important factor in the national economy, government departments developed to influence or control the pattern of trading. The foremost examples are the Danish bacon and the New-Zealand lamb, although the same principles applied to a lesser extent to the export of beef from Australia and Argentina.

In the USA, carcass grading arose from a different background. By the turn of the century, buyers and sellers had developed their own broad terminology for different categories of cattle. At the end of seventies, the USDA made propositions at two levels: firstly, those concerned with regulating trade, ensuring fair competition and encouraging improvements in the distributive system; secondly, beef quality was highly prized and excellence was closely associated with particular breeds, fed in particular ways. There was strong pressure /1/ to base the grades on criteria believed to be closely related to eating quality, particularly marbling and maturity and /2/ to structure them in such a way that only beef considered of high quality would achieve the higher grades to which names attractive to the consuming public could be applied. At the opposite, the European-wide systems of supporting the market for beef meat, pig meat and sheep meat involved standardized methods of reporting national prices to the Commission headquarters, so that support measures were triggered. Effective management control of this system depended on introducing precision into the prices reported and the subsequent actions: the levies of import, the subsidies on exports, the aids to private storage, intervention buying or various sorts of premium schemes. There has been a common pig grading scheme used for price reporting since the early seventies and a common beef scheme was introduces in 1981.

#### *2.1. – Grading principles*

Most of the early grading schemes for cattle and sheep were designed to focus attention on a top quality, a top grade from which were excluded carcases with meat considered likely to be of inferior eating quality. Such systems led to animals varying widely in age at slaughter, and certainly the meat of older animals is likely to be tougher than that of younger animals. Further, good eating quality of meat bas been associated traditionally with a certain amount of fat on the carcase. Elimination from the top grade tended to be on the evidence of excessive age, inadequate fatness and a carcase shape which suggested that the animal had been poorly grown or had been on a production system in which its weight had fluctuated from year to year. Top grades were reserved for youthful animals with an adequate amount of fat, coupled with shape consistent with well grown animals of the meat type breeds. Second and lower grades tended to be the aggregation of carcases which failed to meet the top grade for one reason or another.

Few of the early systems paid any direct attention to the yield of lean meat from the carcase. Poor conformation, which was rejected anyway because of its expected relation to eating quality through age and breed, was also thought to indicate a high yield of bone and therefore a poor yield of meat. But otherwise the systems tended to favour animals with a low ratio of lean meat to fat because of the requirement that top grades should have a certain level of fatness. As the pattern of meat distribution has changed, traders have become more conscious of the yield of deboned trimmed lean meat obtained from carcases, while at the same time consumers have tended more and more to reject excess fatness. Accordingly there bas been a swing from interest in the grading of carcases according to expected eating qualities to grading according to expected yield of saleable meat. Beef grading in the U.S.A. was among the first to make this distinction, with the addition of a yield-grading parameter to the long-standing quality component.

It must be noted that the standardization of assessments made by different people is particularly difficult. Factors influencing accuracy and consistency are :

- the experience of the assessors,
- the nature and extent of the definitions of the different between steps on the scoring scale,
- whether or not value judgements have to be made,
- the range and average level in the carcasses being assessed,
- how much the environmental conditions in which the assessments are made vary

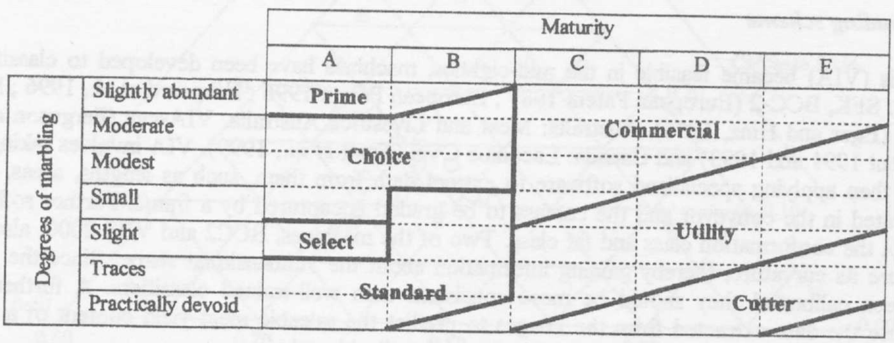
#### *2.2. – USDA beef scheme*

For beef grading in the current USDA grading system, there are three major factors (Swatland, 1995):

- the sex or type of animal from which the class of carcass originated,
- the age or maturity of the animal,
- the amount of intramuscular or marbling fat within major muscles.

The class of carcass (steer, bullock, bull, heifer, or cow) is determined first Next, the beef carcass of an identified class is placed into one of five possible maturity groups, using features of the skeleton and lean meat. The current USDA maturity groups are from A to E in order of increasing maturity. Groups A and B include young steers and heifers, while groups C, D, and E include mature dairy cows, old breeding stock, and animals with retarded or overfinished growth. The longissimus dorsi is examined between ribs 12 and 13, where the forequarter and hindquarter are separated. If the texture and color of the lean are acceptable, the amount of marbling fat is currently the main factor that determines the quality grade of the carcass. Degrees of marbling in a beef carcass are described by a series of subjective terms, related to the percentage area of meat that contains marbling fat (Table I). Considerable training is required to use these subjective terms properly, and some degree of spatial interpretation is involved, so that the judgment is not a simple function of the area of fat.

**Table I** – Relationship between marbling, maturity and carcass quality grade




However, in the current USDA beef grading system, marbling level is a primary determinant of the grade in the various maturity groups. The grades are: prime, choice, good, standard, commercial, utility, and cutter. In working with on-line systems, the top grades attract the most attention because there are more of them, they are worth more, and they have a bigger impact than the lower grades. But the lower grades are equally important economically because, among these carcasses, there are a few that are being downgraded for one reason or another, but that still may have quite reasonable meat. If an on-line system can identify these carcasses, allowing maximum use of their commercial potential, then an on-line system will directly increase profitability Thus, to the scientist and engineer, working with the lower grades of carcasses has a particular interest.

### *2.3. – EU beef scheme*

In Europe, beef carcasses are classified by visual inspection according to the S-EUROP scheme (Council Regulation 1208/81 and Commission Regulation 2930/81) regulated by the European Union (EU). This scheme is made up as follows:

- separate classification of conformation (in six classes: SEUROP) and fat cover (in five classes: 12345),,
- when describing carcasses, the conformation classification is given first,
- for domestic purposes, member states may subdivide the basic classes: a 1-15 scale for fat cover (where 1 = very thin and 15 = very fat) or a 1-18 scale for conformation (1 corresponds to a very poor musculature and 18 to a very developed one)
- the conformation is defined by reference to 'profiles' with the muscular criterion being an optional extra element
- the fat classification includes reference to fat inside the thoracic cavity as well as external fat cover.

The table II contains the general description of the EUROP grading scheme. Additional provisions are also used by classifiers (round, back, shoulder, topside and rump).

**Table II** – The definitions of the classes of the E.E.C. beef carcass classification scheme as set out in Council Regulation 1208/81

| | Class | | Description |
|---|---|---|---|
| Conformation | E | Excellent | All profiles convex to superconvex; exceptional muscle development |
| | U | Very good | Profiles on the whole convex; very good muscle development |
| | R | Good | Profiles on the whole straight; good muscle development |
| | O | Fair | Profiles straight to concave; average muscle development |
| | P | Poor | All profiles concave to very concave; poor muscle development |
| Fatness | 1 | Low | None to low fat cover |
| | 2 | Slight | Slight fat cover, flesh visible almost everywhere |
| | 3 | Average | Flesh, with the exception of the round and shoulder, almost everywhere covered with fat, slight deposits of fat in the thoracic cavity |
| | 4 | High | Flesh covered with fat, but on the round and shoulder still partly visible, some distinctive fat deposits in the thoracic cavity |
| | 5 | Very high | Entire carcass covered with fat; heavy fat deposits in the thoracic cavity |

This classification combined with the weight and the category (young bull, bull, steer, cow and heifer) is the basis for payment to the farmer. The meat plant's assessor who grades all the carcasses, is trained to grade according to the EUROP scheme. In order to maintain and control the classification system throughout the Union, a hierarchy of control agents was set up. But the EUROP scheme has some imperfections: the evaluation can be biased for a series of carcasses, the classifier's grading varies over time, there are systematic differences between classifiers or between classifier and the hierarchy.

## 3 - On-line grading

To be applicable in a practical situation, the on-line evaluation of meat quality and meat yield must be fast enough to keep pace with processing line speeds in major plants and must be based on objective measurements (Swatland, 1995). Measurements must be non-contaminating and relatively non-destructive. On-line evaluation of meat could (Swatland, 1999) :

- improve the feed-back of information and financial incentives to producers of high quality carcasses,
- improve meat grading to allow reliable quality control procedures
- enhance profitability by allowing niche marketing and least-cost optimization of meat processing

### *3.1. – Subjective grading scheme*

When Video Image Analysis (VIA) became feasible in the mid-eighties, machines have been developed to classify carcasses in many countries included Denmark: SFK, BCC-2 (European Patent 1987 ; European Patent 1996 ; Borgaard et al., 1996 ; Madsen *et al.*, 1996), Germany: E+V, V13S2000 (Eger and Hinz, 1996), Australia: Meat and Livestock Australia, VIAscan (Ferguson *et al.*, 1995), France: NormaClass (European Patent 1991 and 1993) and Canada: Lacombe CVS (Tong *et al.*, 1999). VIA involves taking images of a carcass with one or more cameras then applying specialized software to extract data from them, such as lengths, areas, volumes, angles and colors. Machines are integrated in the conveyor and the carcass to be graded is captured by a frame. Further software is then used to process these data to predict the conformation class and fat class. Two of the machines, BCC2 and VBS 2000, also project striped light onto the carcass and measure its curvature, thereby gaining information about the 3dimensionat shape. Since the process is automatic, once the machines have been calibrated they should be more consistent than well-trained classifiers. A further advantage of these machines is that they can use the data extracted from the images to predict the saleable meat yield content of a carcass. The saleable meat yield is of interest to the processor because it is closely related to the realizable value.

The classification gives a reasonably good indication of the saleable meat yield but previous tests have shown that the VIA systems are able to predict saleable with greater accuracy than classifiers (Borggaard et al., 1996 ; Sonnichsen et al;, 1998). Even though it is not likely that saleable meat yield will replace EUROP classification in the near future, this information would be of use to the beef processor in deciding which carcasses to bone out to different specifications.

**Table III** – Percentage correspondence with the reference panel and residual standard deviation for conformation and fat cover class by four systems (15-point scale)

| | | BCC2 | | VIAScan | | VBS2000 | | | Normaclass |
|---|---|---|---|---|---|---|---|---|---|
| | | Test 1 [a] | Test 2 [a] | Test 1 [a] | Test 2 [a] | Test 1 [b] | Test 2 [a] | Test 3 [a] | Test 1 [b] |
| Conformation | % under scored by 1 | 47.4 | 22.5 | 18.5 | 15.1 | 14.1 | 18.5 | 14.2 | 22.2 |
| | % correspondence | 39.9 | 58.3 | 56.3 | 45.0 | 68.8 | 56.3 | 52.2 | 46.5 |
| | % over scored by 1 class | 5.5 | 16.3 | 21.7 | 30.9 | 13.8 | 21.7 | 29.0 | 23.9 |
| | Total | 92.8 | 97.0 | 96.5 | 91.0 | 96.7 | 96.5 | 95.4 | 92.7 |
| | RSD | 0.93 | | 0.92 | 0.91 | 0.64 | 0.92 | | 0.90 |
| Fat cover | % under scored by 1 | 26.7 | 22.9 | 21.3 | 21.9 | 19.4 | 21.3 | 16.8 | 21.1 |
| | % correspondence | 34.4 | 34.8 | 29.4 | 28.0 | 49.1 | 29.4 | 30.8 | 24.3 |
| | % over scored by 1 class | 19.3 | 22.0 | 23.9 | 22.1 | 18.6 | 23.9 | 26.7 | 22.9 |
| | Total | 80.4 | 79.6 | 74.6 | 72.0 | 87.1 | 74.6 | 74.4 | 68.3 |
| | RSD | 1.14 | | 1.38 | 1.38 | 1.01 | 1.38 | | 1.56 |

a = Allen, P. and Finnerty, N., 2000
b = European Commission, 2000

Some considerations can be formulated by examining table III :

- the percentage correspondence between the systems and the reference panel was higher for conformation class than for fat class for all systems. However, this may to a large extent reflect the greater variation in fat class compared to conformation class in the population.
- a deviation of a single subclass is small in absolute terms and would be a reasonable tolerance to allow the systems.
- the accuracy of the systems, as measured by the residual standard deviations, for both conformation class and fat class appear to be reasonable.

The overall conclusion is that there are some positive outcomes for the VIA systems.

### 3.2. – *Meat yield – Meat quality*

In commercial practice, muscle or lean is usually sold with some adhering fat. This mixture of lean and fat is referred to as 'saleable meat' or 'trimmed deboned cuts', although depending on the species, cut, and country, saleable meat may contain some bone (kempster *et al.*, 1982). The ratio of lean to fat in the meat sold depends on the fatness of the carcase from which the cuts are derived, the nature of the cut and the preferences of retailers and their customers. Callow in 1948 established that meat yield is directly proportional to carcass weight but is inversely proportional to carcass fatness. Figure 1 shows in a triangular scatter plot (in which the sum of the coordinates is equal to one) the evolution of meat, bone of fat of thirty eight carcasses of cows.

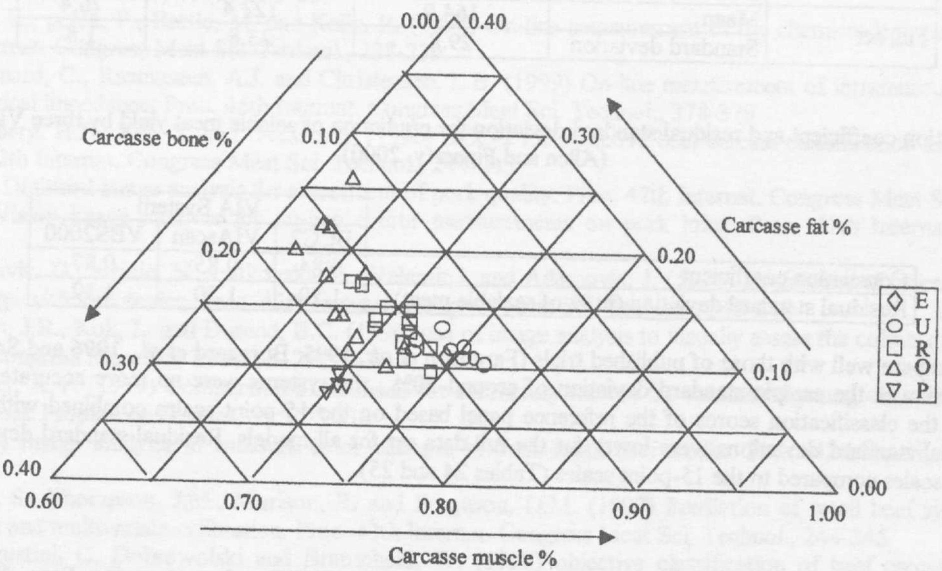



**Figure 1** – the relationship between muscle, fat and bone for a wide range of cow carcasses (Lebert, unpublished data)

Most carcase evaluation work is carried out with an economic objective ultimately in mind and is concentrated on those characteristics which have the greatest effect on carcase retail value. Setting aside carcase weight, the description of carcase leanness or saleable meat yield is of most importance. This raises the question of how this should be defined. For most purposes, a base-line in terms of cutting seems preferable to chemical analysis since value judgments by consumers are made on the basis of the appearance or physical composition of the carcase or joint. Chemical analysis is relevant mainly to processors but is expensive to operate as a base-line technique if accuracy is to be achieved.

How detailed should the cutting be? Commercial cutting procedures are cheap, and results are immediately relevant to meat traders. But, commercial practice differs from place to place and over time as livestock populations and production and marketing methods change. Such procedures are also difficult to standardise and often do not provide the precision necessary in breeding programmes and experimental work. Tissue separation, on the other hand, although more expensive is suitable for a range of applications and considered to be a more suitable general base-line technique for carcase evaluation work (De Boer, 1976 ; Laville *et al.*, 1995). A realistic approach to the degree of detail in the base-line is necessary. There is a danger that the importance of precision will be over-estimated and only the most detailed technique chosen. The expense of such techniques will inevitably limit the extent and effectiveness of their use. Just as it is necessary to find a compromise between the precision of alternative predicting measurements and their cost, so it is important to find a compromise between the cost of a baseline technique and its precision.

There are numerous methods for on-line evaluation of meat yield and meat quality based on various properties of meat or carcasses. The most familiar are listed below and need no further introduction.

- video image analysis for measuring the carcass shape, the rib-eye area and marbling (Borgaard et al., 1996 ; Eiger and Hinz, 1996 ; Ferguson et al., 1995 ; Gigli et al., 1996 ; Hopkins, 1996 ; Hopkins et al., 1997 ; Madsen et al., 1996 ; Murray, 1996 ;Smith et al., 1997 ; Sonnichsen et al., 1998 ; Tong et al., 1999 ; Zhang and Clarke, 1997)
- video image analysis for measuring the muscle and fat colour (Murray, 1996 ; Nielsen, 1995 ; Piette et al, 1996 ; Ringkob et al., 1996)
- velocity of sound or ultrasounds for determining meat yield (Borggaard et al., 1996, Brondun and Jensen, 1996 ;Busk *et al.*, 1999 ; Denoyelle et al., 1995 ; Fisher, 1997 ; Goldenberg and Lu, 1997 ; Renand and Fisher, 1997 ; Strzelecki et al., 1998)
- electrical properties of the meat in order to predict carcass composition and meat quality (Allen and Fallon, 1996 ; Calkins et al., 1995 ; Madsen et al., 1999 ; Walstraw et Hulsegge, 1995)
- near-infrared reflectance for measuring triglyceride or collagen content and fat quality (Andersen et al., 1997 ; Daumas and Dhorne, 1998 ; Daumas et al. 1998 ; Devine and McGlone, 1998 ; Petrovic et al., 1996)
- miscellaneous : X-ray (Bartle, 1997 ; Hollo *et al.*, 1998), γ-ray (Loeffen *et al.*, 1997)

In Europe (Allen and Finnerty, 2000), a recent trial compared the possibilities of three VIA machines (BCC2, VIAscan and VBS2000) to predict the sealable meat. The left sides of a sample of 400 steer carcasses were boned-out to a standard specification to determine saleable meat yield. These were divided into calibration (260) and validation sets (140) to determine the accuracy of saleable meat yield prediction, expressed as the residual standard deviation (root mean square error). Both sides of 50 of these selected carcasses were boned-out to determine the repeatability of the saleable meat yield determination (table III). Table IV shows the performances of the trhee machines.

**Table III** – mean and standard deviations for side weight, sealable meat yield for the validation set (N=133) and full set (N=394)

| | | Side weight (kg) | Yield weight (kg) | Yield (%) |
|---|---|---|---|---|
| Validation set | Mean | 164.0 | 122.7 | 76.1 |
| | Standard deviation | 33.8 | 27.4 | 2.24 |
| Full set | Mean | 164.9 | 123.4 | 76.4 |
| | Standard deviation | 29.8 | 23.8 | 1.8 |

**Table IV** – Correlation coefficient and residual standard deviation for prediction of selable meat yield by three VIA system (N=133) (Allen and Finnerty, 2000)

| | VIA System | | |
|---|---|---|---|
| | BCC2 | VIAscan | VBS2000 |
| Correlation coefficient | 0.84 | 0.85 | 0.87 |
| Residual standard deviation (in % of sealable meat) | 1.20 | 1.20 | 1.12 |

White these results compare well with those of published trials (Ferguson *et al.*, 1995, Borgaard *et al.*, 1996 and Sonnichsen *et al.*, 1998) and represent a reduction in the sample standard deviation of around 50%,, the systems were no more accurate at predicting saleable meat yield than were the classification scores of the reference panel based on the 15-point scales combined with weight (rsd = 1.2%, Table 24). The residual standard deviations were lower for the full data set for all models. Residual standard deviations were generally higher for the 5-point scales compared to the 15-point scales (Tables 24 and 25).

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