Classification of bovine carcasses: New biometric remote sensing tools

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Abstract

Slaughtering plants approved by the European Union have specific processes to guarantee that beef carcasses or half-carcasses, of no less than eight months of age, are provided with health mark and then classified and identified according to the EU carcass classification grid. This classification is based on three criteria: i) Category, ii) Conformation (SEUROP) and iii) Fat Cover (FC). At the end of the classification process each carcass is given a code, consisting of two letters and a number: this operation is called *Identification*. The aim of our study was to evaluate how the European beef carcass quality classification is determined according to the experience of the personnel involved, then comparing the results with those yielded by the Android platform application. West Systems, through its West-Zootech division, has developed an Android platform application (SEUROP APP) that allows SEUROP and FC classification with a smart-phone. The photo taken with the smart-phone will yield the necessary angular parameters to determine the conformation class depending on the animal's muscular mass and based on the convexity of some areas on the half-carcass. It also evaluates the ratio between surface of lean tissue and total carcass surface in order to determine the fat cover and complete the classification. The SEUROP APP was able to obtain objective measurements for as much as 84% of the assessments made during the research and development phase.

Introduction

Beef carcasses must be classified separately in order to record the prices of the different categories/types of animals entering the meat supply chain. Classification is a CAP (Common Agricultural Policy) tool, in particular that of the Common Market Organisation (CMO), introduced in order to support and stabilise markets and make trade simpler and more transparent (Allen, 2009).

All slaughterhouses approved in the EU that slaughter more than 150 animals per week on average, in accordance with Article 4 of Regulation (EC) No. 853/2004 of the European Parliament and of the Council, must take measures to ensure that all carcasses or half-carcasses of bovine animals of at least eight months of age, bearing a health mark, are classified and identified in accordance with the Union grid for the classification of carcasses (Regulation (EU) No. 2017/1182, Chapter 1, Annex I).

The classification is based on three criteria (ANNEX I, Reg. 2017/1182 EC, Article 3): i) *Category (A, B, C, D, E)*: assessed against the information available in the system for the identification and registration of bovine animals set up in each Member State (Title I of Regulation (EC) No. 1760/2000) and by the classifiers, based on precise anatomical features; ii) *Conformation Class (S, E, U, R, O, P)*: according to the animal's muscularity and the convexity of certain regions of the half-carcass; iii) *Fat Cover (1, 2, 3, 4, 5)*: the fat cover of the visible surfaces, including inner thoracic cavity.

At the end of the classification process, the carcass will be assigned a code consisting of two letters and a number, and this must be marked on at least each quarter of the carcass either with a clearly legible mark in indelible, non-toxic and heat-resistant ink or with a tamper-proof label firmly attached to the carcass. This operation is known as *Identification*.

Carcass classification is closely correlated with market price monitoring and works in parallel with the weighing and purchase of live animals. Every week, slaughterhouses collect and report market prices to their designated Ministry, who then processes them in order to calculate a *National Average Weekly Price* and then notifies it to the European Commission through a special portal. The European Union calculates the *Average Union Price* based on a balanced average of medium national prices. The market price of each carcass, which must be used by all slaughterhouses, will be the price at the slaughterhouse, exclusive of VAT, declared for 100 kg of carcass in standard presentation. The weight to be used for the calculation of the price is the *cold* weight, which is obtained by reducing the *hot* weight by 2%, *i.e.* the weight measured on the hook within one hour of slaughter.

To ensure correct classification and price reporting, the Italian regional competent authorities periodically carry out slaughterhouse inspections. In addition, on-the-spot inspections are carried out by experts from the European Commission (EU Control Committee). Inspections are based on an accurate risk analysis aimed at reducing their number but directing them mainly towards larger or non-compliant facilities. Site managers employ certified expert classifiers holding the necessary licenses obtained after passing special courses for these inspections.

Commission Delegated Regulation (EU) 2017/1182, supplementing Regulation (EU) No. 1308/2013 of the European Parliament on the classification of carcasses, entered into force in July 2018, in order to take technological developments in the meat industry into account and to overcome obstacles caused by inadequate visual assessments. These regulations include automated, semi-automated and manual classification methods.

Classification accuracy obtained through automated methods is established using a point-based system. In order for such methods to be authorised, they must achieve at least 60% of the maximum number of points, both for conformation and for fat cover, and must be within precise statistical limits (Costa *et al.,* 2014). To date, no

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Member State has received authorisation to use classification systems consisting of an automated technique (using special equipment) and/or an equation (mathematical formula). However, new biometric remote sensing methods based on the technology known as Visual Image Analysis *(VIA)* have been developed in five countries: Denmark *(SFK, BCC-3)*, Germany *(E + V, VBS2000)*, Australia *(Meat and Livestock Australia, VIAscan)*, France *(Normaclass)* and Canada *(Lacombe CVS)*.

VIA involves the acquisition of images with one or more cameras and software capable of extracting data from them, such as lengths, areas, volumes, angles and colours. Additional software is used to process this data and determine the conformation class and fat cover accordingly (Allen, 1999, 2000, 2001). Another advantage of these machines is that they can use the collected data to predict the percentage of meat that can be sold and thus the yield at processing (Borggaard *et al.,* 1996; Sonnichsen *et al.,* 1998).

An important recent development is the *e+v Technology GmbH Beef Instrument* computer vision classification system, which has been approved as a classification aid by the Canadian Food Inspection Agency. This system is linked to the *Beef InfoXchange System* (BIXS), which enables all carcass data to be shared with all parties in the production chain (animal owners, customers, etc.). All analyses carried out through automated systems found good data processing accuracy and the results obtained showed high matching percentages (over 80%) compared to the official classification (Ferguson *et al*., 1995; DMRI, 1996; Tong *et al*., 1997).

However, no biometric remote sensing method has so far been approved and made official in Europe (Allen and Finnerty, 2000). Yet classification based on expert classifier judgement is highly criticised by producers, as it is deemed empirical and not very accurate. The lack of confidence in the reliability of the official classification is mainly due to subjectivity of the classification, differences in the classifier's experience, geographical location of slaughtered animals, differences in external factors (light, carcass position, time of day, etc.), and insufficient measurements.

This has made it difficult to agree on quality-based prices that reflect the true market value of carcasses for the food industry. The lack of effective and objective incentives has undoubtedly contributed to the decline in the quality of beef carcasses (Keane, 1999). Indeed, there are many cases where classification did not correspond to the actual condition. Errors in carcass classification can lead to the sale of products of lower or higher quality (food fraud) (Semeraro, 2011). The Food Business Operators (FBO) and the competent health authority must be aware of the role they play in the production and marketing of safe and guaranteed food. Because of this, it is important to apply the knowledge of the specific sector to evaluate and accept technological innovation so that these do not lead to fraud (Meazza, 2012; Rea, 2012).

The aim of the study was to evaluate how useful these new methods and tools can be to the workers involved in classification. To this purpose, our study analysed the different European quality classification assessments (SEUROP and FC) based on the experience of the classifier (>5 years' experience *vs* <5 years' experience), and then compared the results with those elaborated by the Android platform application (SEUROP APP) developed by West Systems, through its West Zoo-Tech division on Negretti-Bianconi know-how. These new methods must be seen as an aid to traditional classification, part of a modern and increasingly technological society: they can also provide more accurate and precise assessments in many other fields, such as breeding (ZOOMETER - West ZooTech; Patent N 1343431 Negretti-Bianconi).

Materials and Methods

Our analysis was carried out on a total of 135 regularly slaughtered beef carcasses at the Siciliani S.p.A., Industria Lavorazione Carne slaughterhouse in Palo del Colle (BA).

After the Official Veterinarian completed the *post-mortem* inspection, and before the carcasses entered the pre-cooling tunnel, the carcasses were classified by the qualified personnel and each carcass was photographed for objective evaluation with the Android application (SEUROP APP). The surveys were all carried out at the same fixed workstation from 7:00 a.m. to 1:00 p.m. in order to avoid differences caused by external factors (light, carcass position, time of day, etc.).

Classification by official method

Workers were divided into two groups according to their previous level of expertise: i) Group 1: classifiers with less than 5 years' experience (Junior Recorder: JR); ii) Group 2: classifiers with more than 5 years' experience (Senior Recorder: SR).

The carcasses were first placed in front of Group 1 classifiers of assessment and then assessed by Group 2 classifiers. All classifiers worked independently and autonomously, each providing their own classification. For each assessed carcass, the average result was considered as the correct classification for its group. Classification took conformation into account as a development of carcass profiles, in particular its essential parts, *i.e.* the thigh, back and shoulder, and fat cover, *i.e.* the mass of fat covering the carcass and inside the thoracic cavity.

Classification by SEUROP APP

Carcasses were individually photographed for objective evaluation with the Android application (SEUROP APP). SEUROP APP's design is neither invasive nor cumbersome, it is easy to handle and user-friendly. A nonspecific instrument was used (the camera of the smartphone) and no specific device was needed. This is because the system is based on Visual Image Analysis (VIA) for the qualitative analysis of carcasses, namely the objective identification of the Conformation Classification (SEUROP) and the Fat Cover (FC).

The worker takes a photo of the carcass through the APP with the set pre-established angular parameters that are necessary to determine the conformation class. The APP can also be used to assess lean mass surface

Table 1. SEUROP APP angular parameters. AC represents the angle defined between a vertical straight-line VI and a straight-line T1 tangent to the caudal profile 52 of the thigh 51 and passing through the first landmark P1. AC1 is the angle comprised between a vertical straight-line V2 and a straight-line T2 passing through the second landmark P2 and the third landmark P3. AC2 represents the angle defined between a straight-line T4 tangent to the caudal profile 52 of the thigh 51 passing through the fourth landmark P4 and a straight-line T3 tangent to the ventral profile 55 passing through said fourth landmark P4. AC3 denotes the angle defined between a vertical straight-line V3 and said straight-line T4 tangent to the caudal profile 52 of the thigh 51 passing through the fourth landmark P4. AC4 represents the angle defined between the straight-line Tl tangent to the caudal profile 52 of the thigh 51 and passing through the first landmark PI and a horizontal straight line 01.

Date	Code	AC	AC1	AC2	AC3	AC4	SI	Classification
05/06/2019	XXX	45	32	47	35	132	3 [79,1%]	U 3

compared to total surface area of the carcass in order to determine the fat coverage and thus complete the classification. The parameters and the system are covered by European Patent EP 2854555 Negretti-Bianconi.

This application is able to: i) carry out semi-automatic angular measurements, meaning that the worker determines the reference points for the various measurements and sets the type of parameter; ii) define the data points by tapping on the required spot for the photo and, if necessary, adjusting its position with a drag & drop interaction (Figure 1); iii) save the measured values for the selected parameters in a PDF file (Table 1); iv) automatically average the measured parameters, *i.e.* AC+AC1+AC2+AC3+AC4 and the numerical value obtained, transforming it into the corresponding class [S(6)E(5)U(4)R(3)O(2)P(1)]; v) make the final value visible on the scanned image as well as on the PDF file.

Statistical analysis

To compare the data obtained from the sample series, a statistical descriptive analysis based on central tendency and concentration indexes was carried out. Assessments were divided into *Conformation* and *Fat Cover* for each chosen group (Table 2). The total number of samples collected was made up of three different subsets: SEUROP APP (assessment carried out with the SEUROP APP Android application); JR (assessment carried out by classifiers with less than 5 years' experience); SR (assessment carried out by classifiers with more than 5 years' experience). Statistical observations for the Conformation Class were then carried out by subdividing the three subgroups into corresponding category groups and then, three corresponding subgroups per subset: i)

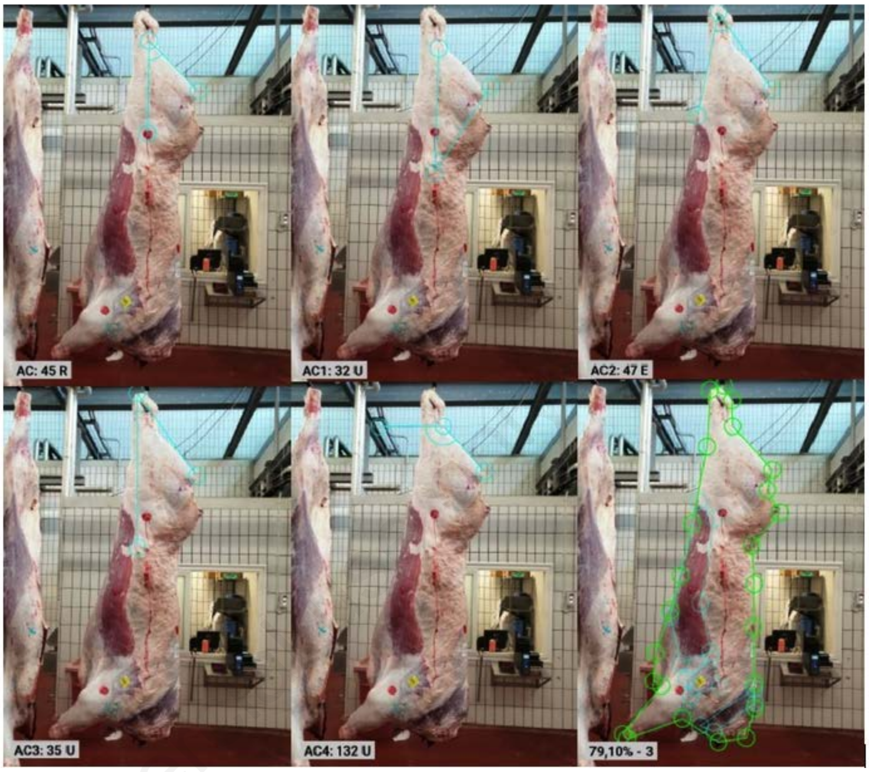

Figure 1. SEUROP APP angle parameters of the carcasses.

Table 2. Assessment by SEUROP APP, classifiers with <5 years' experience (JR) and classifiers with >5 years' experience (SR).

Fat class	Conformation class																				
	SEUROP APP							JR							SR						
	S	E	U	R	O	P	tot	S	E	U	R	O	P	tot	S	E	U	R	O	P	tot
1			2	5	5	4	16	2	1	1	3	3	6	16			1	4	5	6	16
2		1	19	12	8	10	50		13	12	6	8	10	49		1	18	13	9	8	49
3		3	17	8	3		31		13	13	4	2		32		4	18	7	3		32
4			1				1			1				1			1				1
5				1	1		2				1	1		2				1	1		2
tot	0	4	39	26	17	14	100	2	27	27	14	14	16	100	0	5	38	25	18	14	100

Table 3. Assessment carried out on beef half-carcass, heifer half-carcass and steer half-carcass

Conformation	Beef half-carcass			Heifer half-carcass			Steer half-carcass		
	APP	JR	SR	APP	JR	SR	APP	JR	SR
S	0	0	0	0	0	0	0	2	0
E	0	0	0	0	6	0	4	23	5
U	0	0	0	18	19	16	30	18	30
R	11	9	9	18	13	20	11	2	10
O	14	12	15	9	7	9	0	0	0
P	20	24	21	0	0	0	0	0	0

adult beef half-carcass; ii) heifer half-carcass; iii) steer half-carcass (Table 3). The central and dispersion trend describing statistics were calculated for each of these, creating polar charts (Radar or Kiviat) in which the assessment trends in the three groups studied were highlighted.

Results

During the research and development phase of the SEUROP APP, the results obtained were more than 84% of a total of 500 carcasses assessed and the remainder of the sample with a difference of only one class, compared to the official assessment determined by several experts.

Our analysis has shown that the assessments were different depending on the experience of the personnel involved, mainly for the Conformation Class, whereas for the Fat Cover there was greater consistency in the three groups analysed (Figure 2). Indeed, in the case of the *Fat cover*, out of about 10% of the assessed carcasses, only one class difference was found between the SEUROP APP and the classifiers, whereas, for the *Conformation Class*, 45% of the assessed carcasses showed only one class difference between the SEUROP APP and the classifiers. As shown in Figure 2, the analysis showed a greater deviation, compared to the SEUROP APP application, in the samples collected from assessments carried out by classifiers with less than 5 years' experience (JR). Figure 3 clearly shows the deviation between the three groups under study compared to the *Category* examined.

Discussion

The cattle that we surveyed were all found to be fit for slaughter following the *ante-mortem* examination and, subsequently, fit for human consumption following the *post-mortem* examination. All have been classified by fully licensed classifiers with different experience. The classifications were carried out regularly at the end of slaughter, before the half-carcasses entered the pre-cooling tunnel.

All external factors (variations in light, carcass position, time of day, etc.) that could have affected the classifiers' assessments were reduced to a minimum; the measurements were carried out at a fixed location and within a specific time frame (from 7:00 a.m. to 1:00 p.m.). The most relevant finding, which emerged after the survey conducted on the half-carcasses under study, was the discrepancy found among the classifiers with less than 5 years of experience, the classifiers with more than 5 years of experience and the data collected by the SEUROP APP Android application.

The deviations were more obvious in relation to the category of the animal; the trend was not correlated to high or low classes but it was a function of the category. The deviations were more evident in two specific categories (Heifer and Steer half-carcasses), probably as a result of a not very variable conformation due to the half-carcasses examined. In addition, the *habit* of operators in classifying carcasses according to the geographical provenance of the slaughtered animals should not be underestimated. In fact, the category depends above all on the type of breeds present on the national territory and on the type of breeding practiced in that specific geographical area. On the other hand, as far as the *Fat Cover* is concerned, there was no statistically significant deviation. A study conducted by Negretti and Bianconi (2015), based on remote sensing biometric methods for the assignment of conformation classes and fat coverage, showed that these methods can be a good support to reveal food fraud and overcome the insufficiency caused by eye surveys.

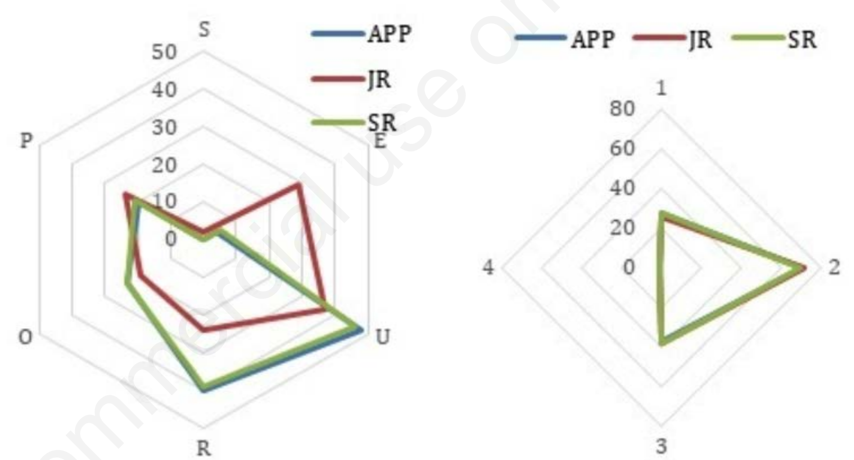

Figure 2. Polar charts for *Conformation Class* (left) and *Fat Cover* (right).

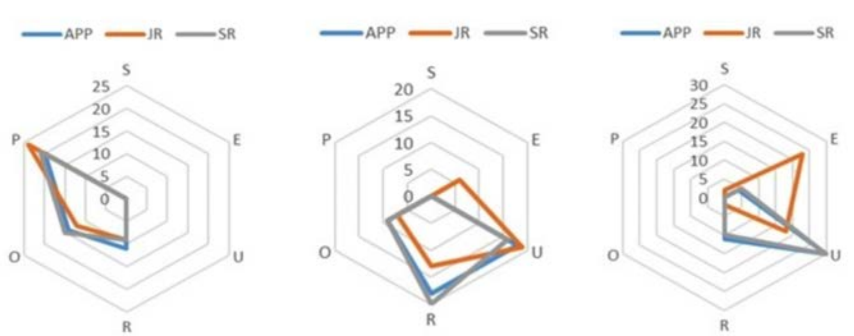

Figure 3. Polar charts for the A*dult Beef Half-Carcass* category (left), the *Heifer Half-Carcass* category (centre) and the *Steer Half-Carcass* category (right).

Conclusions

The use of tools capable of automatically classifying carcasses would help to improve quality-based payments, which would be fairer and more realistic. Such equipment could promote growing confidence in all involved parties, overcoming the obstacles of insufficient eye evaluations (empiricism and lack of precision). Indeed, a study conducted by Moore *et al.* (2006) showed that modern VIA systems had great accuracy (by more than 89%) compared with previous systems at a high rate of repeatability (>99.5).

It is clear that these new methods are intended as support to experienced personnel and not as their replacement. The automated device must be used by personnel who knows the application and who must have attended a training course. In fact, according to our study, it is crucial that these tools are used by field experts who offer an overall assessment and who can also, if necessary, amend the classification provided by the automated system.

References

Allen P, 1999. Automatic beef classification. Drystock Farmer Autumn, 41.
Allen P, 2000. Automatic beef classification. Proceedings of Meat Automation Congress (MAC), 2000 June, Malaga, Spain.
Allen P, 2001. Accurate readings: Automated carcass grading system. Butchershop 3:1-13.
Allen P, 2009. Automated grading of beef carcasses. In: Improving the sensory and nutritional quality of fresh meat, pp 479-492.
Allen P, Finnerty N, 2000. Objective beef carcass classification - A report of trial of three VIA classification systems. The National Food Centre, Dublin, 15.
Borggaard C, Madsen NT, Thodberg NH, 1996. In-line image analysis in the slaughter industry, illustrated by beef carcass classification. Meat Sci 43:S151-S163.
Costa C, Negretti P, Vandeputte M, Pallottino F, Antonucci F, Aguzzi J, Bianconi G, Menesatti P, 2014. Innovative automated landmark detection for food processing: the backwarping approach. Food Bioprocess Technol 7:2291-8. doi: 10.1007/s11947-013-1227-0.
Danish Meat Research Istitute (DMRI), 1996. BCC-2 Objective classification, Manuscript No. 1325 E, 3 April 1996.
European Commission, 2013. Regulation of the European Parliament and of the Council of 17 December 2013 establishing a common organisation of the markets in agricultural products and repealing Council Regulations (EEC) No 922/72, (EEC) No 234/79, (EC) No 1037/2001 and (EC) No 1234/2007, EU/1308/2013. In: OJ L 347/671.
European Commission, 2017. Commission Delegated Regulation of 20 April 2017 supplementing Regulation (EU) No 1308/2013 of the European Parliament and of the Council as regards the Union scales for the classification of beef, pig and sheep carcasses and as regards the reporting of market prices of certain categories of carcasses and live animals, EU/2017/1182. In: OJ L 171/74.
Ferguson DM, Thompson JM, Barrett-Lennard D, Sorensen B, 1995. Prediction of beef carcass yield using whole carcass VIAscan. Proceedings of the 41st International Congress of Meat science and Technology, 1995 Aug 20-25, San Antonio, USA, paper B16:183-4.
Keane MG, 1999. A comparison of carcass grades of streers in the Republic of Ireland, Northern Ireland and Great Britain. Farm and Food, Summer/Autumn 1999.
Meazza M, 2012. Analisi della normativa nazionale e comunitaria. In: Colavita G, Meazza M, Rea S, Nasali M. Frodi alimentari. Tecniche ispettive, aspetti tecnici e giuridici. Le Point Vètérinarie Italie.
Negretti P, Bianconi G, 2007. Brevetto Italiano per invenzione industriale: Apparecchiatura innovativa atta alle misurazioni morfo-ponderali di animali liberi e/o semiliberi da immagini fotografiche e/o video n. 1343431.
Negretti P, Bianconi G, 2015. Method and apparatus for the SEUROP classification of the conformation of carcasses of slaughtered cattle. Pub. No. US 2015/0146937 Al.
Negretti P, Bianconi G, 2019. Brevetto Europeo. Method and apparatus for the SEUROP classification of the conformation of carcasses of slaughtered cattle. EP 2854555.
Rea S, 2012. Le frodi nelle diverse filiere dei prodotti alimentari d'origine animale. Edizione 2010-2012. In: Colavita G., Meazza M., Rea S, Nasali M. Frodi alimentari. Tecniche ispettive, aspetti tecnici e giuridici. Le Point Vètérinarie Italie, pp 37-72.
Semeraro AM, 2011. Frodi Alimentari: aspetti tecnici e giuridici. In: Rassegna di Diritto, Legislazione e Medicina Legale Veterinaria. 10:2. doi: https://doi.org/10.13130//31 90.
Sonnichsen M, Augustini C, Dobrowolski A, Brandscheid W, 1998. Objective classification of beef carcasses and prediction of carcass composition by video image analysis. Proceedings of the 44th International Congress of Meat Science and Technology, 1998 Aug-Sep 30-4, Barcelona, Spain, paper C59:938-939.
Tong AKW, Richmond RJ, Jones SDM, Robinson DJ, Chabot BP, Zawadski SM, Robertson WM, Li X, Liu T, 1997. Development of the Lacombe computer vision system (Lacombe CVS) for beef carcass grading. Agriculture and Agri-food Canada, Lacombe Research Centre, AB, Canada.