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Validation of the first objective evaluation system for beef carcasses

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Abstract

Systems that objectively assess beef carcasses are becoming more common in slaughterhouses. The objectives of this study were to investigate differences in the EUROP classification of beef carcasses between independent national senior assessors and abattoir assessors, and to investigate the results of calibration and validation tests for the German VBS 2000 system in Poland. All the procedures involving calibration sample analysis and the certification test were conducted in accordance with the guidelines of Commission Regulation (EC) no 1249/2008. The results show that evaluations provided by abattoir assessors significantly differ to those given by national assessors ($p < 0.01$), and that fat class is the best predictor of differences in EUROP evaluations. Pearson correlation coefficients for the median of evaluations from five assessors and evaluations from the VBS 2000 system were high for both conformation and fat classes: 0.905 and 0.907 respectively. A strong linear correlation between evaluations of conformation and fat obtained from assessors and the VBS 2000 system was found. Remuneration for livestock producers depends on the assessment of carcasses, and therefore the evaluate process should be improved with an increase in the precision of carcass classification and automated technologies give such possibility.

Keywords: beef, carcass, classification, objective assessment, EUROP system

INTRODUCTION

The beef carcass grading system in Poland, as in the European Union, is based on the EUROP classification system (Commission Regulation (EC) 1249/2008). The overall purpose of the EUROP system is

to form a basis for transactions between beef producers and meat processors. The EUROP system grades beef carcasses using both letters and numbers. The letters start with S (Superior), used for double-muscled carcasses, and then go from E (Excellent) to U, R, O and finally to P (Poor). The numbers range from 1 (low) to 5 (high), and describe the fat class (Council Regulation (EC) no 1234/2007). The EUROP system is a simple method of grading carcasses that describes their most commercially significant characteristics (Allen 2003, Fisher 2007).

The EUROP system is not free of pitfalls. The main problem with EUROP assessment is its subjectivity, which makes this system not fully accurate or objective. Moreover, the EUROP system relies on visual assessment of the beef carcasses. This is inappropriate for the measurements of the phenotype for performance recording and breed improvement caused by the imprecise nature of the assessment. Additionally, the EUROP system does not take into account small differences in carcass quality, which can often be the result of genetic improvement based on cattle conformation (Cegiełka 2013, Wnęk et al. 2014).

As the EUROP grading system is based on subjective carcass assessment, objective methods of carcass evaluation have been widely investigated in order to increase the accuracy and repeatability of the EUROP system (Craigie et al. 2012). The best way to objectively evaluate a carcass is to physically dissect the whole or half of the carcass into meat, fat and bones. However, this is very expensive and time consuming. Video Image Analysis (VIA) systems have therefore been developed to predict lean meat yield as well as to automatically classify carcasses (Cannell et al. 2002) without the need to dissect the carcass. VIA was first developed in the USA specifically for beef carcass evaluation in the 1980s. Since then, VIA has been widely used for both carcass and meat-eating quality assessment (Borggaard et al. 1996, Cross et al. 1983). Presently, VIA is used in many facets, including classifying carcasses into payment categories (Jackman et al. 2009); improving the consistency of the EUROP system (Allen and Finnerty, 2000); estimating lean meat yield (Hopkins 2008), predicting tenderness (Wyle et al. 2003); quantifying the amount of intramuscular fat (Shackelford et al. 2003, Albrecht et al. 1996) and evaluating the water holding capacity of the meat (Irie et al. 1996).

In Europe, there was a need for an objective classification system to standardize the EUROP carcass evaluation system. Due to this, *whole-side* VIA was developed. Whole-side VIA can be integrated into the slaughter plant and can operate autonomously and automatically (Craigie et al. 2012). Some whole side VIA systems that are currently in use are capable of classifying over 1000 carcasses per hour (Craigie et al. 2012). Moreover, the speed of these systems can be adjusted according to the number of carcasses which are passing through. Most of the systems operate on-line via a mechanism that exposes the sides of the carcasses to a

camera. The location of the VIA system is usually close to the chiller, so all necessary carcass dressing is completed before evaluation. All VIA data is processed and stored as digital records at the processing plant.

The first feasibility study investigating the ability of whole-side VIA to objectively classify beef carcasses was carried out in Denmark (Sorensen 1984). In 1993, the first French VIA system was installed in France for commercial purposes. A few years later, German company developed the VBS 2000 system, which consisted of a mechanism that presents the side of the beef carcass to the camera. As the carcass passes through the system, a two dimensional image and a three dimensional image are taken using structured light. Some VIA systems, for example a German model VBS 2000, can evaluate the colour of fat and meat and additionally can localize and measure areas of carcass damage and defects.

The accuracy of whole-side VIA systems has been investigated in commercial units all over the world. However, it is difficult to draw conclusions on this as there are currently no clear definitions of carcass traits, e.g. saleable meat yield (SMY%), and there is also a lack of information on the level of trim (Cannel et al. 1999, Vote et al. 2003).

In order to introduce an objective carcass evaluation system to improve accuracy of the EUROP system, European Union Guidelines require a certification test. The certification test requires a panel of five trained assessors, trained and tested by Polish Agricultural and Food Quality Inspection, to classify carcasses and compare their classifications to those of the evaluation system being tested (European Community 2003). According those requirements the approval of a new method of evaluation of carcasses require its confrontation with at least 5 licensed assessors, who should evaluate a minimum of 600 beef carcasses. Based on their ratings, the median is calculated and this score is compared to the rating of the device. During the certification test, points are awarded (or deducted) for the percentage of carcasses within 0, 1, 2, 3 and greater than 3 subclasses of the median panel reference score on the EUROP 15-point scale. The statistical error of measurement should not exceed 5%. (European Community 2003, Allen and Finnerty 2000).

Certification tests have been undertaken in the EU for four different VIA systems. However, results of these certification tests have varied. Due to this, information gathered from other referencing research trials is necessary in order to draw conclusions on the application of VIA systems in commercial solutions.

The objectives of this study were to investigate differences in the EUROP classification of beef carcasses between independent national senior assessors and abattoir assessors and present results of tests performed between 2013 and 2015 in Poland for the whole-side VBS 2000 system.

MATERIAL AND METHODS

All animals (used in three trials, breed: Polish Holstein-Friesian) were transported in accordance with the guidelines contained in Council Regulation (EC) No 1/2005 of 22 December 2004 on the protection of animals during transport (obligatory for all states of the European Union). After arrival at the slaughterhouse, the animals were examined by a veterinarian and weighed. Before slaughter, the cattle completed the required period of rest and fasting of 20 to 24 hours in suitable premises. The animals were stunned to deprive them of consciousness and awareness, so that they would not feel pain during slaughter. Stunning took place in an immobilized cage using electric current. The carcasses were then subjected to exsanguination. All carcasses were then chilled at 4 ° C for 1 hour and graded using the EUROP system by a German E+V Technology model VBS 2000 and assessors at the same time.

VBS 2000 and the installation procedures

VBS 2000 is a whole-side VIA system developed for the EUROP beef carcass classification system. As the system was designed to operate on hot (pre-rigour) half carcasses suspended by the Achilles tendons, VBS 2000 is installed in the slaughter line just before the scale and the chiller. The system consists of a handling unit, cameras, lights, projectors and a computer system. The VBS 2000 system is fully automated and operates online. The handling mechanism of VBS 2000 presents the external side of the carcass to the camera.. The handling unit moves the carcass to a specified angle and two images are taken. The VBS 2000 system used in this study was equipped with high-resolution digital cameras and LED light tubes. The first image taken by VBS 2000 shows the two-dimensional view of the carcass and the second image shows the projected stripes. As the images are taken, the computer software analyses the digitised images and the handling unit moves back. Then the analysed data are sent to the server. The server program estimates the conformation and fat classes after receiving the carcass number, weight and category from the plant operating system.

Preparations for testing the VBS 2000 system

In May 2013, the Polish Association of Beef Producer and E+V Technology agreed to install and built into a commercial slaughter line and test the VBS 2000 system for the EUROP classification of beef carcasses under Polish conditions. The Polish abattoir ECO-Beef, located in Węgrzynowo, near Płoniawy, in the centre of

Poland was chosen for the installation of the newest model of the whole-side VBS 2000 VIA system. The installation of VBS 2000 was completed in June 2013. After the installation and the technical tests were completed, a classified a necessary minimum number of carcasses in each of the categories of slaughter in the EUROP system aim calibrate this device.

Calibration procedures

From August 2013 to April 2015 a calibration process was carried out, where categories of slaughter for the animals and conformation and fat classes for the carcasses were assessed according to the EUROP system. In total of 3, 135 beef carcasses were classified by Polish expert assessors. Because of the small amount of bulls from the age of 2 years, slaughter categories A and B were listed together in order to obtain the necessary number of animals for device calibration.

TRIALS

First trial: Visual assessment of beef carcasses by national assessors and the assessor from the abattoir

In the first stage of the study, each carcass was graded by four professional assessors with valid certificates. The assessors that participated in this trial were divided into two groups:

- abattoir assessor (assessor 4),
- national senior assessors (assessors 1 to 3).

The national senior assessors were highly trained assessors from the Polish Agricultural and Food Quality Inspection. Carcass evaluation was conducted independently and under the same conditions – including the same lighting in the abattoir. The carcasses were arranged in a random order for each assessor. The results of the carcass classification were written on paper, and then transferred to a MS Excel database. For each of the EUROP grades, a coding system was applied. Conformation and fat classes were each assigned the numbers 1, 2, 3, 4 and 5. For fat and conformation subclasses, the symbols, “=”, “-” and “+” were assigned the values of 0.25, 0.5 and 0.75, respectively.

The material analysed by the assessors consisted of 3135 beef carcasses classified according to EUROP guidelines contained in Commission Regulation (EC) No 1249/2008. This material included

-1093 carcasses belonging to slaughter category A - carcasses of not castrated, young males aged from 12 months to less than 24 months – bulls,

-473 carcasses belonging to slaughter category B - carcasses of other not castrated males - bulls,

-947 carcasses belonging to slaughter category D - carcasses of cows that have calved,

-622 carcasses belonging to slaughter category E - carcasses of other females aged 12 months - heifers

The Presented average $\bar{x}$ describes the arithmetic average of the four independent classifications by the four assessors. The experimental data were evaluated by running ANOVA on IBM SPSS 21 (Statistical Product and Service Solution) according to following statistical model (1):

$$Y = \mu + A_i + e_{ij}; \text{ where: } \mu - \text{mean, } A_i - \text{assessor (1 -4), } e_{ij} - \text{random error.} \quad (1)$$

After obtaining a significant omnibus F-test, a *post hoc* LSD test using ANOVA was applied to further explore the data.

Second trial: Calibration of the whole-side VBS 2000 system performed between 2013 and 2015 in Poland

All carcass evaluations were conducted independently and under the same conditions (including lighting) in a slaughterhouse by five Polish national senior assessors. During the calibration process, a total of 1868 carcasses in three slaughter categories were classified: A+B (1034 carcasses), D (463 carcasses) and E (371 carcasses). Young bulls and bulls above the age of 2 years were combined into one group of bulls because the number of carcasses in categories A and B was too low. The same carcasses were classified by the assessors and the device. The median results of the assessors' evaluations were then compared to the results from the VBS 2000 system.

Third trial: Certification test procedure

During a certification test, each conformation and fat class is divided into three subclasses. At the required number of 600 approved carcasses, the failure rate, i.e. the percentage of carcasses that the automated system fails to classify, should not exceed 5 %.

The median of the evaluation results given by the assessors is considered to be the correct grade of the carcass. These results are compared with evaluation results from the system being tested. The system must obtain at least 60 % of the total number of points for both conformation and fat class to successfully pass the

test. Presented below are the minimum requirements, the numerical range of error and the regression coefficients which must be obtained by automated systems to pass a certification test.

Bias

The bias limits for conformation class is $-0.3 \leq x \leq +0.3$

The bias limits for fat class is $-0.6 \leq x \leq +0.6$

Slope

The limits for the slope for conformation class is $0.85 \leq x \leq 1.15$

The limits for the slope for fat class is $0.7 \leq x \leq 1.3$

In June 2015, a validation trial was carried out. During this trial, a total of 667 beef carcasses in three slaughter categories were classified (A+B – 344 carcasses, D – 202 carcasses and E – 121 carcasses). This trial was organized in a very similar way to an official certification test with the exception that all expert assessors were from Poland (other assessors than in trials 1 and 2). During this trial, the VBS 2000 system conducted fully automatic carcass evaluation. The same carcasses were then classified by the five Polish assessors. After all carcasses were evaluated by all assessors, the median grade of their evaluations was calculated. All analyses were performed according to Commission Regulation (EC) no 1249/2008.

RESULTS AND DISCUSSION

First trial: Visual assessment of beef carcasses by national assessors and the assessor from the abattoir

The conformation and fat classes of a beef carcass largely depend on the age and sex of the animal (Bureš et al. 2006, Mach et al. 2008, Węglarz et al. 2013). The assessors' evaluations for the conformation and fat classes of each slaughter category are presented in figure 1. Table 1 presents the average assessments and standard error (Se) in assessors' evaluations of each slaughter category. Both fat and conformation scoring in the case of a classifier 4 significantly differed to scores granted by other classifiers ($p < 0.01$).

The accuracy of the evaluation of conformation was higher than the accuracy of the assessment of fat, also in the case of visual evaluation of the comparison of the objective system (Kien et al. 2000). There were significant differences ($p < 0.01$) in the EUROP grades given by the abattoir assessor (4) and the three national senior assessors (1-3). For fat subclasses, a larger difference between mean values was identified, for both within an individual assessor's scores and between assessors' scores, irrespective of slaughter category. However, fat

subclasses seemed to be the best predictor of differences in EUROP evaluation (Wnęk et al. 2015b). In the case of fat subclasses, differences in grading can reach up to two classes (Wnęk et al. 2014). Figure 1 shows that the abattoir assessor seemed to over-classify the conformation of the carcass and under-classify the carcass fatness. The standard deviations for both conformation and fat classes between assessors are very similar (table 2). Small differences in analysed values were only found for carcasses in categories A and B (young and old uncastrated bulls).

Visual assessment of carcasses as required by the EUROP system depends on human judgment, which can be subjective and inconsistent (Allen and Finnerty 2000, Węglarz et al. 2013). Carcass evaluation affects the economic value of the carcass, and therefore precision and repeatability of carcass evaluation is required (Wnęk et al. 2015a). Although conformation is important in the EUROP system, fat class also affects the economic value of the carcass (Pawelec 2010). A lack of precision and accuracy in the classification of carcasses can be caused by, for example, assessor fatigue, the subjectivity of the assessor, an abnormal colour of fat, and fat thickness accompanied by a high percentage of muscle tissue (Craigie et al. 2012, Cegielka 2013).

Second trial: Calibration of the whole-side VBS 2000 system performed between 2013 and 2015 in Poland

Table 3 shows the Pearson correlation coefficients for the median of evaluations from the five assessors and the VBS 2000 system. Evaluations of both conformation and fat showed a strong linear correlation between the median obtained from the assessors and the VBS 2000 system. Fig. 2 shows the scatter plot for the average of the assessors' evaluations and evaluations from VBS 2000. The correlations (R) were 0.905 and 0.907 for conformation class and fat class, respectively. Similar results were obtained Johansen et al. (2006) when they compared a Norwegian abattoir's EUROP classification of lamb carcasses to classifications given by national senior assessors. The correlations between national and abattoir assessors were 0.96 and 0.92 for conformation class and fat class, respectively. There were no significant differences between slaughter category or hot carcass weight (HCW), so the correlation analysis was carried out without those two factors. Tables 4 and 5 show the results for conformation and fat for the calibration sample. Both sets of equations have been in the limits in all criteria.

Third trial: Certification test procedure

Table 6 shows the results for conformation and fat classes of the validation sample. According to Craigie et al. (2012), systems that objectively evaluate carcasses are highly accurate and provide results that are repeatable.

Wassenberg et al. (1986) performed one of the first studies that evaluated the ability of VIA technologies to objectively classify carcasses for scientific and commercial applications. The team confirmed that VIA systems have an equal or even higher accuracy in classifying carcasses compared to qualified assessors.

An objective assessment of beef carcasses may also be used to create a classification system for carcass quality in terms of flavour of meat. Such a system is particularly useful for identifying carcasses from which the meat has a bad flavour. In 2006, Moore et al. conducted a three-stage study of the accuracy, precision and repeatability of a VIA system. Despite many reports describing the low precision of these systems, Moore et al.'s results confirmed that modern VIA systems have increased their accuracy (by more than 89%) compared to previous systems at a high rate of repeatability (>99.5%).

CONCLUSIONS

In practice, the visual assessment of beef carcasses that is required for the EUROP classification system is performed by only one person, so it is not a fully representative or very accurate assessment. Remuneration for livestock producers strongly depends on the assessment of carcasses, and therefore the assessment process should be improved with an increase in the precision of carcass classification. This would result in the growth of consumer satisfaction and an increase in the supply of good quality beef. Automated technologies for the objective assessment of beef carcasses provide a possibility to improve precision in carcass evaluation.

This study has shown that there were some systematic differences in beef carcass evaluation between the abattoir assessor and national senior assessors. On average, the abattoir assessor seemed to over-classify conformation class and under-classify fat class (a farmer-friendly classification). In this study, was also collected a calibration sample using five Polish assessors. Based on this sample, equations for conformation and fat classes were built using linear regression analysis. The obtained results fit within the standards set by the EUROP system. This study provides sound evidence to suggest that an objective evaluation of beef carcasses in Polish slaughterhouses should continue to be implemented.

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References

- Albrecht, E., Wegner, J., Ender, K. 1996. A new technique for objective evaluation of marbling in beef. *Fleischwirtschaft*, 76: 95–98.
- Allen, P. 2003. Beef carcass grading in Europe and USA – The prospects for using VIA systems. *Proc. 49th Cong. Meat Sci. and Technology*, Sao Paulo, Brazil. (pp. 96-101).
- Allen, P., Finnerty, N. 2000. Objective beef carcass classification — A report of a trial of three VIA (video image analysis) classification systems. Dublin: The National Food Centre, Teagasc and Department of Agriculture, Food and Rural Development.
- Borggaard, C., Madsen, N. T., Thodberg, H. H. 1996. In-line image analysis in the slaughter industry, illustrated by Beef Carcass Classification. *Meat Sci.* 43: S151–S163.
- Bureš, D., Bartoň, L., Zahradková, R., Teslík, V., Krejčová, M. 2006. Chemical composition, sensory characteristics, and fatty acid profile of muscle from Aberdeen Angus, Charolais, Simmental, and Hereford bulls. *Czech J. Anim. Sci.*, 51 (7): 279-284.
- Cannell, R. C., Belk, K. E., Tatum, J. D., Wise, J. W., Champain, P. L., Scanga, J. A., et al. 2002. Online evaluation of a commercial video image analysis system (computer vision system) to predict beef carcass red meat yield and for augmenting the assignment of USDA yield grades. *J. Anim. Sci.* 80: 1195–1201.
- Cannell, R. C., Tatum, J. D., Belk, K. E., Wise, J. W., Clayton, R. P., Smith, G. C. 1999. Dual-component video image analysis system (VIASCAN) as a predictor of beef carcass red meat yield percentage and for augmenting application of USDA yield grades. *J. Anim. Sci.* 77: 2942–2950.

Cegiełka, A. 2013. Przegląd rozwoju i wykorzystania analizy obrazu wideo (VIA) do oceny tusz wołowych jako alternatywy wobec systemu EUROP i innych subiektywnych systemów. *Gosp. Mięsna*, 1: 22-23. [in Polish].

Commission Regulation (EC) no 1215/2003 of 7 July 2003 amending Regulation (EEC) no 344/91 laying down detailed rules for applying Council Regulation (EEC) no 1186/90 to extend the scope of the community scale for the classification of carcasses of adult bovine animals. *Official Journal of the European Communities*, 169/L, 32–36. Available: <http://publications.europa.eu/en/publication-detail/-/publication/8496f096-838d-4a4b-9f0d-f5213c0d4f83/language-en> [2017 July 03].

Commission Regulation (EC) No 1249/2008 Laying down detailed rules on the implementation of the Community scales for the classification of beef, pig and sheep carcasses and the reporting of prices thereof. Available: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:337:0003:0030:EN:PDF> [2017 June 03].

Council Regulation (EC) No 1/2005 of 22 December 2004. On the protection of animals during transport and related operations and amending Directive 64/432 / EEC and 93/119 / EC and Regulation (EC) No 1255/97. Available: <http://extwprlegs1.fao.org/docs/pdf/eur69655.pdf> [2017 June 03].

Council Regulation (EC) no 1234/2007 of 22 October 2007 establishing a common organisation of agricultural markets and on specific provisions for certain agricultural products (Single CMO Regulation). *Official Journal of the European Communities*, 299/L, 1–148. Available: <http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:299:0001:0149:EN:PDF> [2017 July 03].

Craigie, C. R., Navajas, E.A., Purchas, R.W., Maltin, C.A., Bünger, L., Hoskin, S.O., Ross, D.W., Morris, S.T., Roehe, R. 2012. A review of the development and use of video image analysis (VIA) for beef carcass evaluation as an alternative to the current EUROP system and other subjective systems. *Meat Sci.* 92: 307-318.

Cross, H. R., Gilliland, D. A., Durland, P. R., Seideman, S. 1983. Beef carcass evaluation by use of a video image analysis system. *J. Anim. Sci.* 57: 908–917.

Fisher, A. L. 2007. Beef carcass classification in the EU: An historical perspective. In C.

Hopkins, D. L. 2008. An industry applicable model for predicting lean meat yield in lamb carcasses. *Aust. J. Exp. Agr.* 48: 757–761.

- Irie, M., Izumo, A., Mohri, S. 1996. Rapid method for determining water-holding capacity in meat using video image analysis and simple formulae. *Meat Sci.* 42: 95–102.
- Jackman, P., Sun, D. W., Du, C. J., Allen, P. 2009. Prediction of beef eating qualities from colour, marbling and wavelet surface texture features using homogenous carcass treatment. *Pattern Recognition*, 42, 751–763.
- Johansen, J., Aastveit, A. H., Egeland, B., Kvaal, K., Roe, M. 2006. Validation of the EUROP system for lamb classification in Norway; repeatability and accuracy of visual assessment and prediction of lamb carcass composition. *Meat Sci.* 74: 497–509.
- Kien, S., Wichlacz, H., Borzuta, K. 2000. Aparaturowa klasyfikacja tusz wołowych w Unii Europejskiej i w Polsce. *Konf. nauk.: Perspektywy produkcji mięsa wołowego w aspekcie przystąpienia Polski do UE. Leszno, 28–29.09.2000*, ss. 1–9. [in Polish].
- Mach, N., Bach, A., Velarde, A., Devant, M. 2008. Association between animal, transportation, slaughterhouse practices, and meat pH in beef. *Meat Sci.* 78: 232–238.
- Moore, C. B. 2006. Thesis: Instrument evaluation of beef marbling. Colorado State University, Department of Anim. Sci., Fort Collins, CO.
- Pawełec, A. 2010. System EUROP klasyfikacja tusz zwierząt rzeźnych. *Przem. Spoż.* 3: 12–16. [in Polish].
- Shackelford, S. D., Wheeler, T. L., Koohmaraie, M. 2007. On-line prediction of yield grade, longissimus muscle area, preliminary yield grade, adjusted preliminary yield grade, and marbling score using the MARC beef carcass image analysis system. *J. Anim. Sci.* 81: 150–155.
- Sorensen, S. E. 1984. Possibilities for application of video image analysis. In D. Lister (Ed.). *In vivo measurement of body composition in meat animals*. London and New York: Elsevier Appl. Sci., pp. 113–122.
- Wassenberg, R. L., Allen D. M., Kemp. K. E. 1986. Video image analysis prediction of total kilograms and percent primal lean and fat yield of beef carcasses. *J. Anim. Sci.* 62: 1609.
- Węglarz, A., Balakowska, A., Choroszy, Z. 2013. Poubojowe metody oceny użytkowości mięsnej bydła. *Rocz. Nauk. Zoot.*, T. 40, 2: 109–126. [in Polish, English abstract].

Wnęk, K., Gołębiewski, M., Przysucha, T., Wójcik, A. 2014. Powtarzalność i dokładność oceny wizualnej tusz wołowych w systemie EUROP. *Farmer* 5: 155-159. [in Polish].

Wnęk, K., Gołębiewski, M., Przysucha, T., Woźniak, A., Wierzbicki, J. 2015a. The objective evaluation of beef carcasses. *Logistyka* 4: 9922-9929.

Wnęk, K., Gołębiewski, M., Przysucha, T., Woźniak, A., Wierzbicki, J. 2015b. Differences in the assessment of beef carcasses in EUROP system. *Annals of Warsaw University of Life Sciences – SGGW. Anim.Sci.* 54 (1): 105–113.

Wyle, A. M., Vote, D. J., Roeber, D. L., Cannell, R. C., Belk, K. E., Scanga, J. A., et al. 2003. Effectiveness of the SmartMV prototype BeefCam System to sort beef carcasses into expected palatability groups. *J. Anim. Sci.* 81: 441–448.

Vote, D. J. 2003. Dissertation: Instrument grading of beef. Colorado State University, Department of Anim. Sci. Fort Collins, CO.

Figure Captions:

Figure 1. Changes in assessor's evaluations regarding to conformation (Assessor 1C – 4C) and fatness (Assessor 1F – 4F) for each slaughter category

Figure 2. Average assessment all assessors vs. average assessment device - conformation and fat class

For Review Only

Table 1. EUROP classification of beef carcass by four independent assessors (N carcasses =3135)

assessor	1		2		3		4	
feature	$\bar{x}$	Se	$\bar{x}$	Se	$\bar{x}$	Se	$\bar{x}$	Se
fatness	3.12 ^a	1.00	3.12 ^b	0.99	3.09 ^c	1.02	2.53 ^{abc}	0.91
conformation	4.52 ^{Aa}	0.77	4.53 ^b	0.76	4.53 ^c	0.77	3.96 ^{abc}	0.58

Note: Values in the rows marked with the same letters differ significantly ^{a,b,c} P ≤ 0.01

Table 2. Average assessments and standards error (Se) in assessor's evaluations regarding to conformation (Assessor 1C-4C) and fatness (Assessor 1F – 4F) for each slaughter category

	Category A		Category B		Category D		Category E	
	$\bar{x}$	Se	$\bar{x}$	Se	$\bar{x}$	Se	$\bar{x}$	Se
Assessor 1C	4.27	0.2	4.3	0.3	5.02	0.21	4.39	0.26
Assessor 1F	2.91	0.28	2.88	0.43	3.12	0.3	3.68	0.37
Assessor 2C	4.27	0.2	4.28	0.3	5.03	0.21	4.4	0.26
Assessor 2F	2.92	0.28	2.88	0.43	3.1	0.3	3.68	0.37
Assessor 3C	4.3	0.2	4.29	0.3	5.01	0.21	4.38	0.26
Assessor 3F	2.85	0.28	2.9	0.43	3.08	0.3	3.65	0.37
Assessor 4C	3.8	0.2	3.76	0.3	4.34	0.21	3.83	0.26
Assessor 4F	2.22	0.28	2.22	0.42	2.61	0.3	3.19	0.37

Table 3. Pearson correlation coefficients for the median off evaluations assessors and VBS 2000 device

Trait	Value
Conformation	0.905
Fatness	0.907

Table 4. Results for conformation for the calibration sample

conformation	all	cat A + B	cat D	cat E
score	708.2	702.6	736.6	701.0
bias	0.01	0.01	0.0	0.0
slope	1.0	1.0	1.0	1.0

Table 5. Results for fat class for the calibration sample

fat class	all	cat A+B	cat D	cat E
score	802.0	807	739.6	798.5
bias	0.0	0.0	0.0	0.0
slope	1.0	1.0	1.0	1.0

Table 6. Results for conformation and fat class for the validation sample

	conformation class	fat class
score	653.82	625.79
bias	0.03	0.14
slope	0.97	0.78

Figure 1. Changes in assessor’s evaluations regarding to conformation (Assessor 1C – 4C) and fatness (Assessor 1F – 4F) for each slaughter category

Figure 2. Average assessment all assessors vs. average assessment device - conformation and fat class