Use of Video Image Analysis for the Evaluation of Beef Carcasses

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Abstract

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Video image analysis was used for the objective evaluation of beef carcasses parts as an additional parameter of the carcass classification. The pictures of cross sections of dorsal parts of beef carcasses between 8th and 9th vertebra were taken under industrial conditions and evaluated using LUCIA software. The areas of muscle and adipose tissues were thresholded on several ways (the whole loin area, the areas of individual muscles and those of different loin sections) and the correlations between these areas were searched. The best correlations were found between large areas. Video image analysis proved to be a suitable method for the evaluation of selected carcass parts.

Keywords: beef; carcass; muscle; image analysis; loin

The carcasses of cattle are classified in the abattoirs by muscle conformation and fat content. The carcasses classification is mostly subjective; the objective methods are used rarely, such as video image analysis (whole carcasses or their parts) (Bartoň *et al.* 2001) or sonography. A perspective method for the estimation of beef carcass quality seems to be bioelectric impedance analysis (Bohuslávek 2000, 2003).

The relations between the selected dimensions of some parts (mostly loin) and the total carcass composition are searched. The amounts of muscle and of fat in a carcass can be estimated using the equation containing the rib eye area, the ratio of fat to total area, and the carcass weight (Nade *et al.* 2001). The image analysis can be used for this purpose evaluating the images that are shot by digital camera or acquired using a two-dimensional sonography. Different muscles dimensions, such as those of *musculus longissimus lumborum et thoracis* (MLLT), *musculus iliocostalis* (MI), and *musculus trapezius* (MT) are also used (see Figure 1).

Branscheid (1999) compared three different ways of restriction of the loin cross-section area (see Figures 2–4) and obtained equations for the estimation of the muscle and adipose tissues ratios (r = 0.92 and 0.88, respectively) from the data measured.

Anada & Sasaki (1992), using the computer analysis, evaluated the cross-section images of the loin area which were circumscribed in the

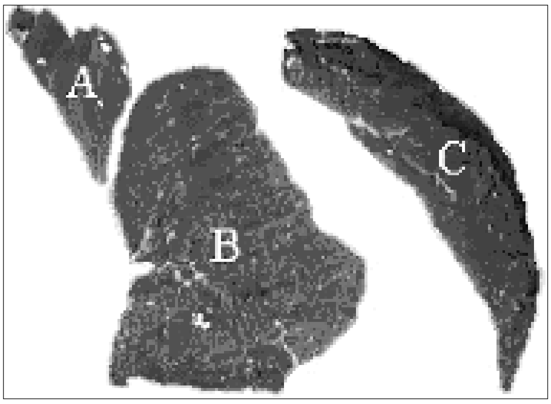

Figure 1. Muscles on the loin cross-section: A – *m. iliocostalis;* B – *m. longissimus lumborum et thoracis*; C – *m. trapezius*

horizontal level by the tangent line from the thoracic vertebra and by a line vertical to the thoracic vertebra (Figure 5). The second evaluated area was restricted by a line that links the end of thoracic vertebra and *musculus iliocostalis* (Figure 6). Prediction equations for estimating the muscle and fat ratio from the measured data had the correlation coefficient $r = 0.94$.

The accuracy of the image analysis was verified by the repeated measurements of the cross-section between the 6th and 7th ribs. The measured parameters were the areas of different muscles, the total cross-section area, and the areas of lean meat, fat, and bone. The corresponding correlation coefficients ranged from 0.95 to 0.99 (Karnuah *et al*. 1999). The correlation coefficients obtained from the adjusted (for age) data between the information extracted by CIA and the carcass composition were only slightly lower than those of the unadjusted data sets (Karnuah *et al.* 1996). This indicates that the computer image analysis enables to estimate the carcass composition independently of the age of the slaughtered cattle.

MATERIAL AND METHOD

Different methods were tested for the measurement of the muscle areas on the cross-section through the beef carcass after quartering between 8th and 9th ribs. 139 cross-sections of bulls and 90 ones of cows were evaluated. The age of animals and the slaughter weights were not taken into consideration during the classification. Correlations were searched between different areas on the dorsal parts of carcasses both generally for all animals and separately for bulls and cows.

The images of cross-sections of dorsal parts of beef carcasses were shot under industrial conditions of a large slaughterhouse two or three days *post mortem*. For the shooting, a digital camera Olympus 2020Z (focal distance 18 mm) was used that was fixed on a special modified frame with two fluorescent tubes that enssured a homogenous lighting of the objects. The photographs were analysed using the software LUCIA 3.52b (Laboratory Imaging, Prague) by three different methods: after Branscheid (1999) (three dif-

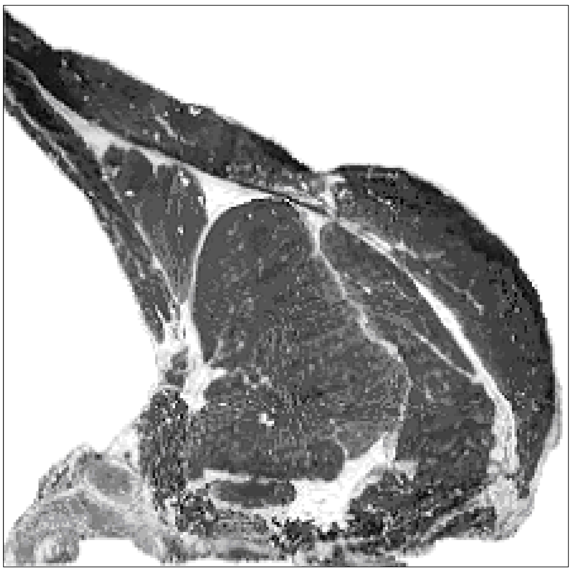

Figure 2. Area of the whole loin cross-section

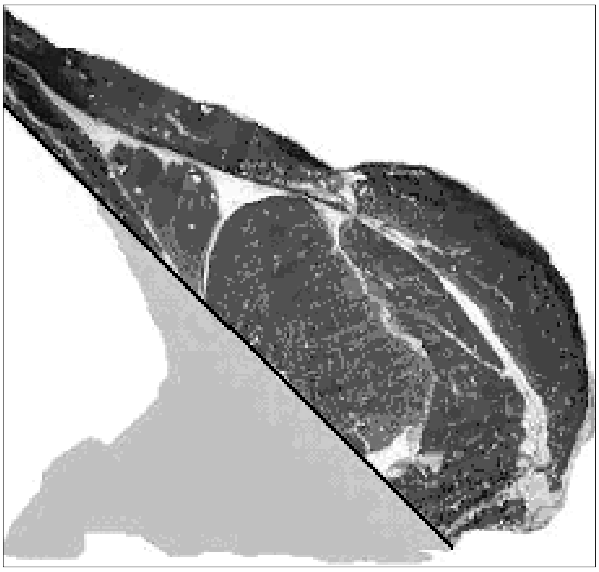

Figure 3. Area restricted by a tangent after Branscheid

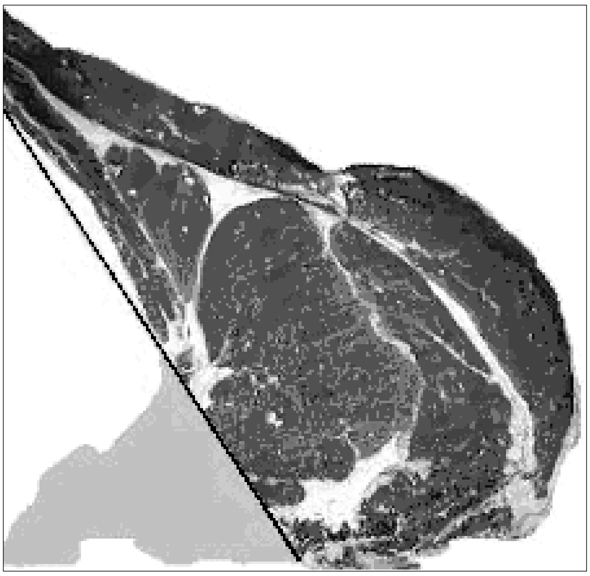

Figure 4. Area restricted by a line after Branscheid

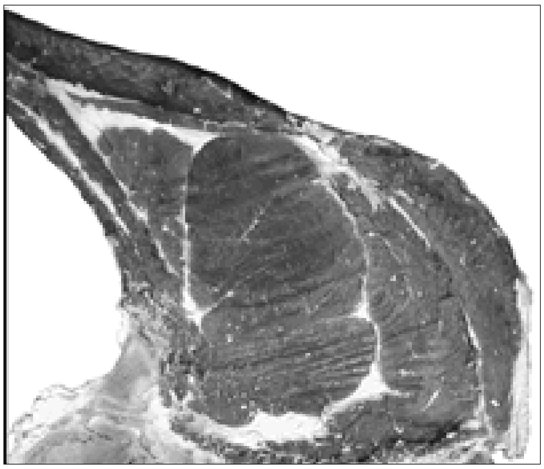

Figure 5. The whole loin area after Anada

ferently bounded areas on the loin cross-section (Figures 2–4), after Anada & Sasaki (1992) two areas bounded according to Figures 5 and 6 and with our own method that evaluated the area of the cross-section without bones (Figure 7), the areas of the muscles *musculus longissimus lumborum et thoracis, musculus iliocostalis* and *musculus trapezius*, and the total area of all muscles on the cross-section.

The areas in pixels were transferred to the values in mm^2 using two-dimensional calibration of software LUCIA and known dimensions in the picture.

RESULTS AND DISCUSSION

The video image analysis was used as an additional method for the testing of the bioelectrical impedance analysis of beef carcasses. Correlations were searched between the selected differently defined areas in the images of the loin cross section. This investigation was part of an extensive research focused on the use of bioelectric impedance analyses. This partial research intended to find a suitable object to which the electrical data could be correlated. As there are different models for the evaluation in the literature using image analysis, we tried to compare and correlate them to find the most suitable one.

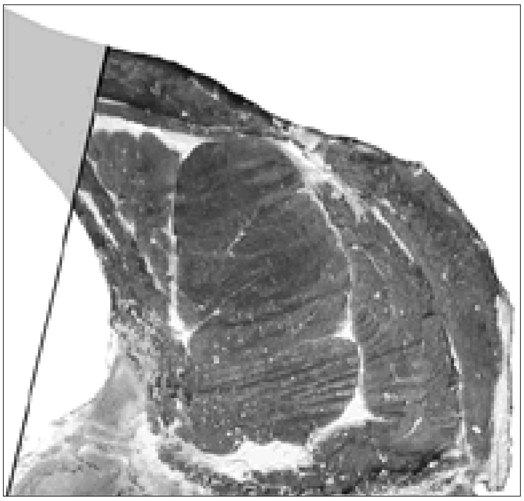

Figure 6. Area restricted by a line after Anada

Figure 7. Loin area without bones

Table 1. Correlations between individual areas on the cross-section of the loin

	lwb.	bll.	Σ muscles	arlB	artB
bll.	0.99	–	0.84	0.99	0.92
Σ muscles	0.85	0.84	–	0.83	0.77
MLLT	0.80	0.78	0.91	0.78	0.74
MI	0,65	0.61	0.75	0.60	0.55
MT	0,75	0.68	0.83	0.66	0.58
arlB	0.99	0.98	0.83	–	0.96
artB	0.92	0.92	0.77	0.96	–
arlA	0.99	0.89	0.88	0.87	0.79

MI – *musculus iliocostalis*; MT – *musculus trapezius*; MLLT – *musculus longissimus lumborum et thoracis*; Σ muscles – sum of the areas of muscles MI, MT and MLLT; bll – boneless loin, arlB – area restricted by line after Branscheid; artB – area restricted by tangent after Branscheid; arlA – area restricted by line after Anada; lwb – loin with bones

It was found that relatively close correlations exist between the individual areas (r = 0.55–0.99) as evident from Table 1. The selected relations are also demonstrated in figures. The results indicate with a certain probability the possibility of prediction the loin composition using the measurement of the selected area.

Very good correlations were achieved between large areas, especially between the whole loin area and the one after avoiding the bones (r = 0.99; see Figure 8). The same high correlation was also obtained between the whole loin area and the area restricted by a line according to Anada (Figure 9). The omitting of the bones in both cases represents only a small change of the total area of the loin cross-section and the variability of the bones dimensions is relatively small in comparison with the muscle and fat tissues areas.

The total area of loin (including bones) correlated highly (r = 0.99) also with the area restricted by the line after Branscheid (Figure 4). The correlation was higher with the cows (r = 0.99) in comparison with the bulls (r = 0.98).

The dependences of the areas of the individual muscles varied considerably, being much higher in the case of larger muscles in comparison with the small ones. A relatively good correlation (r = 0.91) was found between the area of *musculus longissimus lumborum et thoracis* and the total area of all muscles (Σ_{muscle}) (Figure 10). With the bulls, the correlation coefficient was lower (r = 0.86) than with the cows (r = 0.94).

On the contrary, a low correlation (r = 0.78) was found between the area of the boneless loin and the area of *musculus longissimus lumborum et thoracis* (Figure 11). This fact can be related to the variable fat content (both intramuscular as intermuscular); the white fat tissue area then significantly influenced the total area of the loin cross-section. The high variability of the fat content caused a lower correlation coefficient with the bulls (r = 0.67) in comparison to that with the cows (r = 0.85). Whereas old cows have mostly a relatively constant fat content, the fat content in old bulls is more dependent on the age.

The lowest correlation coefficient was found between the area *musculus iliocostalis* and the total area of all muscles (Σ_{muscle}) (see Figure 12), being with the bulls only 0.65 (with the cows r = 0.75). This muscle has a relatively small area on

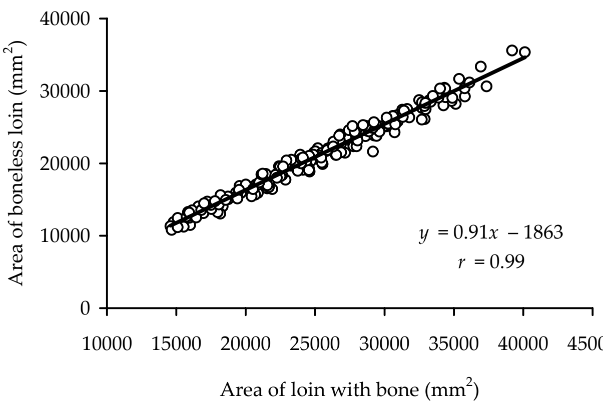

Figure 8. Relation of the area of boneless loin (bll) to the area of loin with bone (lwb)

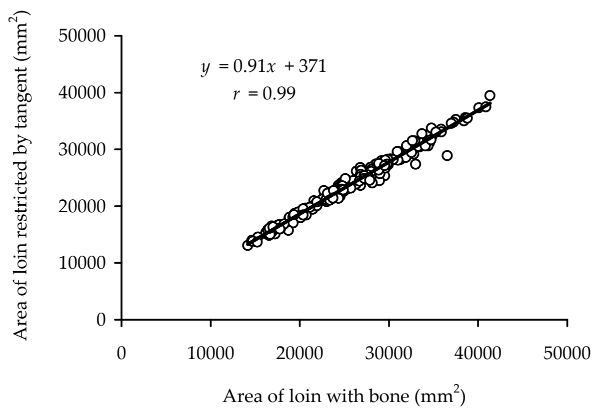

Figure 9. Relation of the area of loin restricted by line after Anada (arlA) to the area of loin with bone (lwb)

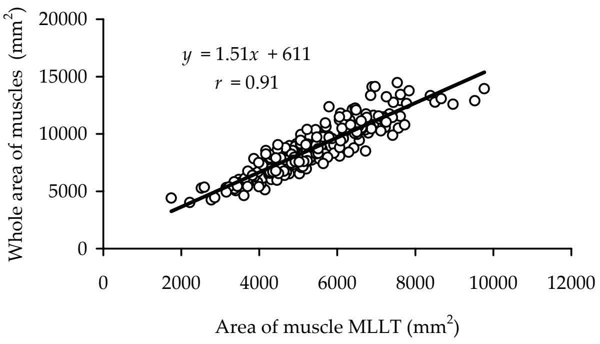

Figure 10. Relation of the area of muscles sum (Σ muscles) to the area of muscle MLLT

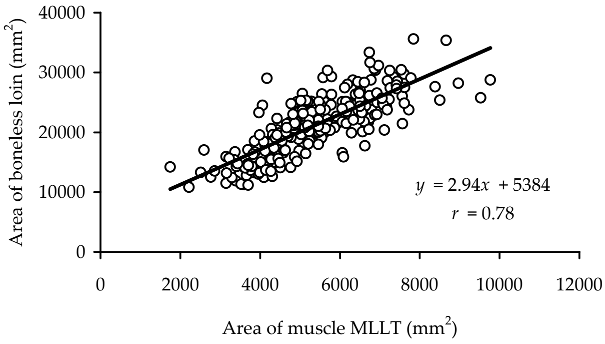

Figure 11. Relation of the area of boneless loin (bll) to the area of muscle MLLT

the cross-section and thus every small inaccuracy during thresholding induces a high deviation. In addition to this, *m. iliocostalis* narrows in this place, and so every small deviation at the level of the cross-section used substantially influenced the measures of the muscle area.

The correlations with the bulls and cows were summarised in Table 2. It is evident that these correlations are higher with the cows in comparison to the bulls. This can be explained by different ages of the slaughter animals and a higher variability in the breed of the bulls.

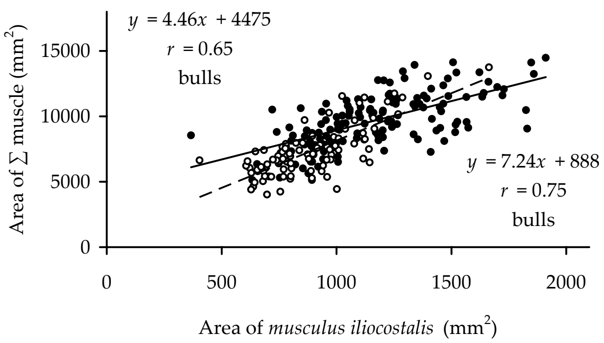

Figure 12. Relation of the area of muscles sum (Σ muscles) to the area of muscle MI

The results presented indicate a possibility to predict with certain probability the dimensions of the individual loin parts using the measurement of the investigated areas on the loin cross-section. These areas will be used for the following correlation with bioelectrical parameters.

Table 2. Correlations between individual areas on the cross-section of the loin for bulls and cows

	lwb	bll	Σ muscles	arlB	artB
bll	**0.98** 0.99	–	**0.79** 0.88	**0.98** 0.99	**0.88** 0.94
Σ muscles	**0.81** 0.86	**0.79** 0.88	–	**0.78** 0.87	**0.68** 0.83
MLLT	**0.79** 0.87	**0.67** 0.85	**0.86** 0.94	**0.67** 0.85	**0.61** 0.82
MI	**0.53** 0.72	**0.48** 0.70	**0.65** 0.75	**0.46** 0.70	**0.40** 0.67
MT	**0.70** 0.74	**0.65** 0.64	**0.79** 0.78	**0.63** 0.60	**0.52** 0.55
arlB	**0.98** 0.99	**0.98** 0.99	**0.78** 0.87	–	**0.94** 0.97
artB	**0.88** 0.95	**0.88** 0.94	**0.68** 0.83	**0.94** 0.97	–
arlA	**0.98** 0.99	**0.89** 0.85	**0.85** 0.86	**0.87** 0.83	**0.75** 0.78

MI – *musculus iliocostalis*; MT – *musculus trapezius*; MLLT – *musculus longissimus lumborum et thoracis*; Σ muscles – sum of the areas of muscles MI, MT and MLLT; bll – boneless loin, arlB – area restricted by line after Branscheid; artB – area restricted by tangent after Branscheid; arlA – area restricted by line after Anada; lwb –.loin with bones
bold marked correlations – **bulls,** the other correlations – cows

CONCLUSION

The computer video analysis proved to be a suitable method for the prediction of some parts of the cattle loin composition. Best correlations were achieved between large areas on the cross-section of loin. These correlations were higher with cows in comparison with bulls. This partial data obtained will be used in an extensive research focused on the bioelectric impedance analyses.

References

Anada K., Sasaki Y. (1992): Image analysis prediction of beef carcass composition from the cross section. Animal Science and Technology, **63**: 846–854.

Bartoň L. *et al*. (2001): Učební texty pro školení klasifikátorů jatečných těl skotu (SEUROP). Výzkumný ústav živočišné výroby, Praha-Uhříněves.

Bohuslávek Z. (2000): Estimation of EUROP – Conformation and Fatness of Beef Carcasses by Bioelectrical Impedance Analysis. Scientia Agriculturae Bohemica, **31**: 55–64.

Bohuslávek Z. (2003): Odhad složení jatečně upravených těl skotu pomocí počítačové analýzy obrazu příčných řezů mezi 8. a 9. žebrem. In: Sborník XXXIV. sympozia o nových směrech výroby a hodnocení potravin. Skalský dvůr: 50–53.

Branscheid W. (1999): Application of video image in grading of carrle. Fleischwirtschaft International, **4**: 12–15.

Karnuah A.B., Moriya K., Sasaki Y. (1999): Image analysis prediciton of beaf carcass composition from the cross sections. Asian-Australasian Journal of Animal Science, **12**: 1171–1176.

Karnuah A.B., Moriya K., Mitani K., Yamazaki T., Sasaki Y. (1996): Estimation of carcass image analysis in the cross section of cross-breed steers. Canadian Journal of Animal Science, **76**: 498–506.

Nade T., Karnuah A.B., Masuda Y., Hirabara S., Fujita K. (2001): Estimation of carcass composition from the cross-section at ribloin of Japanese Black steers by computer image analysis. Animal Science Journal, **72**: 313–320.

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