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Meat Science 73 (2006) 22–28
MEAT SCIENCE
www.elsevier.com/locate/meatsci

The estimated accuracy of the EU reference dissection method for pig carcass classification

P.M. Nissen [a,*], H. Busk [a], M. Oksama [b], M. Seynaeve [c], M. Gispert [d], P. Walstra [e,1], I. Hansson [f], E. Olsen [b]

[a] Danish Institute of Agricultural Sciences, Department of Food Science, P.O. Box 50, 8830 Tjele, Denmark
[b] Danish Meat Research Institute, Maglegaardsvej 2, 4000 Roskilde, Denmark
[c] University of Ghent, Department of Animal Production, Proefhoevestraat 10, 9090 Melle, Belgium
[d] IRTA-Centre de Tecnologia de la Carn, Granja Camps i Armet, 17121 Monells, Spain
[e] The Animal Sciences Group of Wageningen UR, P.O. Box 65, 8200 AB Lelystad, The Netherlands
[f] Swedish University of Agricultural Science, Department of Food Sciences, Box 7051, 75007 Uppsala, Sweden

Received 4 June 2005; received in revised form 14 October 2005; accepted 14 October 2005

Dedicated to the memory of Hans Busk.

Abstract

This experiment was designed to describe the accuracy of the EU-reference dissection method, and to describe the types of factors influencing the accuracy and assess their size. The experiment was conducted in four different European countries at two abattoirs within each country. A total of 128 carcasses was selected according to carcass weight, fat class and sex, and 8 butchers from different countries dissected the carcasses. Due to the experimental design of the experiment a variation in pig type was found between countries. The accuracy was expressed by the repeatability and reproducibility standard deviation, which were found to be 0.87 and 1.10, respectively, and by the reliability, found to be 0.87. This indicates a high accuracy, although a significant effect was found on the estimation of lean meat percentage (LMP) of butcher, and also that jointing of the carcass was of overall importance to the accuracy of the EU-reference dissection method.

Keywords: EU-reference dissection; Carcass classification; Accuracy; Pigs

1. Introduction

Within the EU-countries the lean meat percentage (LMP) of pig carcasses is estimated, to have a common basis for the price setting of carcass quality. The EUROP Community scale (Commission of the European Communities [EC], 1984) is used to express the leanness by intervals of LMP. The LMP is estimated by different classification instruments at the abattoirs, and common rules are outlined by the EU to calibrate these instruments (EC, 1984, 1985, 1994). The calibration is based on a trial, where an equation for prediction of LMP by the classification instrument is developed. The trial involves the dissection of a sample of pig carcasses (EC, 1994) into meat, fat and bone according to the EU-reference dissection method (Walstra & Merkus, 1996).

The EU-reference dissection method involves the dissection of four main cuts (shoulder, loin, belly and leg) from one-half carcass. The lean meat content is defined by the weight of lean meat in these four cuts together with the tenderloin, in relation to the total weight of the half carcass. A scaling factor of 1.3 is used to estimate the total lean meat content in the half carcass based on all 12 cuts.

The accuracy of the EU-reference dissection method has never been estimated. The accuracy is described by the repeatability, reproducibility and reliability of the dissec-

* Corresponding author. Tel.: +45 8999 1279; fax: +45 8999 1564.
E-mail address: piam.nissen@agrsci.dk (P.M. Nissen).
[1] Retired.

0309-1740/$ - see front matter
doi:10.1016/j.meatsci.2005.10.009

tion, and refers to the ISO standard (ISO 5725-1, 1995). Also factors that influence the accuracy of the method are unidentified. Several types of errors may occur during the slaughter, sampling and dissection processes, which may influence the accuracy of the equation for estimation of LMP.

Thus, the objective of this study was to describe the accuracy of the EU-reference dissection method, and to describe the types of factors influencing the accuracy and to assess their size.

2. Material and methods

The experiments were conducted in four different European countries (A, B, C and D), and the pigs were selected at two abattoirs per country. A total of one hundred and twenty-eight carcasses were selected and dissected during this experiment. Thus, sixteen carcasses were selected at each abattoir. The abattoirs used similar slaughter procedures, but within country they were situated in different regions to ensure some variation in pig type.

2.1. Slaughter and selection

In each abattoir a number of carcasses (distributed across four slaughter days) were selected during slaughter according to sex, carcass weight and back fat thickness. In relation to sex, a distribution of 50% gilts and 50% castrates was achieved, although in country B entire males were used instead of castrates. All carcasses were selected according to their hot carcass weights within ±1.5 standard deviation of the national mean. Back fat thickness was also distributed within three fat groups; thin, medium and thick in the proportions 37.5%, 25% and 37.5%, respectively. The thick and the thin groups were in excess of ±1.0 standard deviation of the national mean. Selection criteria are outlined in Table 1.

Table 1
Selection criteria (hot carcass weight and fat thickness) for carcasses dissected by the EU-reference dissection method and their national means in the four countries participating in the experiment

Item	Country			
	A	B	C	D
Selection criteria				
Hot carcass weight[a] (kg)	75–95	66–92	78–106	76–99
Fat thickness[b] (mm)				
Thin	<13.4	<12.0	<10.0	<11.8
Medium	13.4–18.8	12.0–19.0	10.0–20.0	11.8–19.0
Thick	>18.8	>19.0	>20.0	>19.0
National means				
Hot carcass weight (kg)	85.0	79.0	92.0	87.5
Fat thickness (mm)	16.1	15.5	15.0	15.4

[a] Hot carcass weight: selected within ±1.5 standard deviation of national mean.
[b] The thin and thick groups were in excess of ±1.0 standard deviation of the national mean. Fat thickness was measured with the national classification instrument between the 3rd and 4th last rib, 6 cm off the midline.

The carcasses were split in the middle of the vertebral column and the belly in the middle of the sternum during the slaughter process with the aim of achieving two identical half carcasses. However, at all abattoirs there were problems with the splitting, where especially the back and sternum was difficult to split exactly in the middle. The day after slaughter, 16 carcasses (four from each of the four slaughter days) were selected for dissection. During sampling only carcasses with acceptable splitting results were selected. Before dissection the splitting of the sternum was corrected if necessary. During dissection the weight of the vertebral column from each of the two halves was recorded to identify the need for corrections. An expert classified the carcasses visually by assessing the conformation of ham, i.e., shapes of the ham inclusive of subcutaneous fat. The scale consisted of four classes: AA (very round), A (round), B (fair) and C (straight) divided further by − and +.

2.2. Jointing and dissection

The day after slaughter both halves of the carcasses were dissected according to the EU-reference dissection method (Walstra & Merkus, 1996). Eight butchers, one from each of eight European countries, dissected one-half carcass per day in a pair wise combination system without influencing each other. This combination system was used to be able to compare the butchers. The same butcher had to perform both jointing (Fig. 1) and dissection (Fig. 2). The butchers were trained in their home country in the EU-reference dissection method, and no further training was given, as the aim was to get an estimate of the procedures used in the different countries.

2.3. Statistics

The data were analyzed using a variance component model (Little, Milliken, Stroup, & Wolfinger, 1996; SAS software version 8, 1999). A mixed analysis of variance

Fig. 1. The four main cuts (shoulder, loin, belly and leg) and the tenderloin from a half pig carcass after performing jointing according to the EU-reference dissection method. copyright by BFEL, Kulmbach; Germany.

Fig. 2. The result of EU-reference dissection of the loin into meat, fat and bone.

was used to examine the effects of random and fixed variables. Least square means for each main effect were obtained from the model.

A statistical model (1) was used, which included observations on the same carcass, to analyze the variation in LMP of the carcass and of the joints. The model includes the variation between butchers and the variation between carcasses as random effects, with components of variance σ_B^2 and σ_C^2, respectively, and with country and carcass side as fixed effects. Also, fat classes, abattoir and sex nested within country are included as fixed effects.

$$Y_{ijklmno} = \mu + \alpha_i + \delta_{j(i)} + \gamma_{k(i)} + \varsigma_{l(i)} + \xi_m + B_n + C_{o(i)} + \varepsilon_{ijklmno}, \quad (1)$$

where

μ = general mean α_i = effect of country (i = A–D) fixed effect

$\delta_{j(i)}$ = effect of fat group within country ($j = 1 - 3$) fixed effect

$\gamma_{k(i)}$ = effect of abattoir within country ($k = 1 - 2$) fixed effect

$\varsigma_{l(i)}$ = effect of sex within country ($l = 1 - 2$) fixed effect

ξ_m = effect of carcass side ($m = 1, 2$) fixed effect

B_n = effect of butcher ($n = 1 - 8$) random effect, independently, identically distributed $N(o,\ \sigma_B^2)$

$C_{o(i)}$ = effect of carcass ($o = 1 - 32$) random effect, independently, identically distributed $N(o,\ \sigma_C^2)$

$\varepsilon_{ijklmno}$ = random error random effect, independently, identically distributed $N(o, \sigma^2)$

The estimated repeatability standard deviation is defined as $s_r = \hat{\sigma}$.

The estimated reproducibility standard deviation is defined as $s_R = \hat{\sigma}_R = \sqrt{\hat{\sigma}_B^2 + \hat{\sigma}^2}$ using the nomenclature in ISO 5725.

The reliability is defined as $(\sigma_C^2)/(\sigma_C^2 + \sigma_R^2)$, which expresses the correlation between repeated measurements or the relation between the 'true' and the observed variation.

The differences between butchers was also assessed by including the effect of butcher as fixed effect instead of random effect in model (1).

A second model (2) was used to analyze the variation in weight of the different joints with cold carcass weight as a covariate. All other parameters are the same as for model (1). Again a similar model was also used to evaluate the difference between butchers by including butcher as a fixed effect.

$$Y_{ijklmno} = \mu + \alpha_i + \delta_{j(i)} + \gamma_{k(i)} + \varsigma_{l(i)} + \xi_m + \lambda^* \text{weight} + B_n + C_{o(i)} + \varepsilon_{ijklmno}, \quad (2)$$

where λ is the coefficient to covariate weight.

No significant interactions were found between butchers and the influencing factors, and therefore these interactions are not included in the models.

3. Results

3.1. Differences in types of pigs and carcass proportions between countries

Thirty-two carcasses were selected from at least 19 and up to 29 producers in each country (Table 2). Thus, the selected carcasses had varying background. Carcass weights were significantly different between the countries, where country C had heavy pigs (average: 93.4 kg) and country B had relatively light pigs (average: 80 kg), whereas country A and D were in between. Based on results from national on-line measurements, countries A, B and D had carcasses with very similar muscle thicknesses, whereas carcasses from country C had a higher muscle thickness than carcasses from the other countries. This leads to a higher estimate for LMP in country C, whereas the LMP is very similar among the other three countries. From the conformation scores (Table 2) it can also be seen that the pig type differs among the countries, and the scores are in agreement with the other carcass characteristics mentioned. Generally the selection of carcasses has been in accordance with the experimental plan and the sample represents different types of pigs in Europe.

Also the amount of meat in the four joints and the tenderloin as a percentage of total weight of these joints in the four countries was measured (Table 3). Some variation in amount of meat is shown between countries. The higher meat content within the carcass in pigs from country C can mainly be explained by a higher meat content in the leg compared with the other three countries. Carcasses from country B has a significantly higher meat content in the shoulder, whereas carcasses from country D has a significantly lower meat content in both loin and tenderloin compared with the other countries. Thus, carcasses from country A and B do not differ much from each other, whereas carcasses from country C has more meat in the

Table 2
Characteristics of selected carcasses[A] in the four participating countries

Item	Country				SEM
	A	B	C	D	
No. of herds	27	19	26	29	
Hot carcass weight (kg)	86.3[a]	80.0[b]	93.4[c]	85.7[a]	0.82
Fat thickness[B] (mm)	16.9	16.2	15.6	15.8	0.62
Muscle thickness[B] (mm)	56.4[a]	57.4[a]	61.9[b]	55.1[a]	0.76
Lean meat percentage[C]	56.7[a]	56.4[a]	58.7[b]	56.6[a]	0.60
Conformation score					
Ham type	6.4 (B+)[a]	4.9 (A)[b]	3.5 (A+)[c]	4.9 (A)[b]	0.23

[a, b, c] Values within row with different superscripts differ ($P < 0.05$).
[A] Least squares means of 32 carcasses per country.
[B] Measured with the classification instrument used at each abattoir between the 3rd and 4th last rib, 6 cm off the midline.
[C] Estimated with the classification instrument and national equation used at each abattoir.

Table 3
Amount of meat in the 4 joints and the tenderloin as a percentage of the total weight of these joints in the four countries

Item	Country				SEM
	A	B	C	D	
Shoulder	13.5[a]	13.9[b]	13.5[a]	13.5[a]	0.09
Belly	9.7	9.5	9.5	9.8	0.12
Loin	16.9[a]	16.6[a]	16.9[a]	16.0[b]	0.13
Leg	25.0[c]	25.3[c]	26.9[a]	25.8[b]	0.16
Tenderloin	1.6[a]	1.6[a]	1.6[a]	1.5[b]	0.02

[a, b, c] Values within row with different superscripts differ ($P < 0.01$).

leg, which leads to a significantly higher total meat content in the carcass compared with the other countries. Carcasses from country D have a lower meat content in the loin, whereas the meat content in the leg is higher than in carcasses from country A and B but lower than in carcasses from country C.

3.2. Accuracy of the EU-reference dissection method

The accuracy of the EU-reference dissection method is described by the standard deviation (s.d.) for repeatability and reproducibility and by the reliability. Based on the statistical model (1) the s.d. for repeatability and reproducibility have been estimated as 0.87 and 1.10, respectively. The variation of carcasses (s_C) is estimated as 2.81 and consequently the reliability is estimated as 0.87 (Table 4).

The estimated s.d. for the LMP for butcher (s_B) is high for shoulder and belly compared to the other two joints and the carcass as a whole. The repeatability and reproducibility s.d. is highest for belly, which show that the belly is difficult to dissect. Also, the dissection of the shoulder is difficult to repeat, which can be seen by a high reproducibility s.d. The reliability is lowest for shoulder and belly, which is another indicator of the difficulty in dissecting these joints. A reliability of 0.87 for carcass is at a relatively high level compared with the joints, although it is even higher for the leg.

3.3. Reliability of jointing

The reliability and s.d. of jointing is estimated by the statistical model (2). The estimated s.d. for butchers (s_B) relative to the carcass variation (s_C) is highest for the weight of the shoulder compared to the other three joints (Table 5). This indicates that the shoulder is the most difficult joint to cut for the butchers (Fig. 3). For carcasses (s_C), the variation in weight of the joints is highest for the leg and loin and lowest for the shoulder. Thus, the variation in the weight of the shoulder is the same for butcher and carcass, whereas for the other joints the variation is higher between carcasses than between butchers. Consequently, the reliability for shoulder is very low. The leg is anatomically easier to cut correctly and therefore the reliability for the weight of this joint is much higher than for the other 3 joints. Also, the s.d. for repeatability (s_r) and reproducibility (s_R) for the weight of the joints is equal for the leg.

3.4. Effect of butcher on the estimate for LMP and jointing

The effects of butcher are assessed by the statistical models (1) and (2) with butcher as a fixed effect. The differences

Table 4
Standard deviations and the reliability for estimation of lean meat percentage in joints and carcass by dissection[a]

Item	Standard deviation				Reliability
	Butcher, s_B	Carcass, s_C	Repeatability, s_r	Reproducibility, s_R	
Shoulder	1.13	2.30	0.98	1.50	0.70
Belly	1.43	3.47	1.30	1.94	0.76
Loin	0.69	3.12	1.08	1.29	0.85
Leg	0.45	2.57	0.67	0.81	0.91
Carcass	0.68	2.81	0.87	1.10	0.87

[a] Lean meat percentage in joints and carcasses are estimated by the EU-reference dissection method.

Table 5
Standard deviations and the reliability for the weight of joints[a]

Item (kg)	Standard deviation				Reliability
	Butcher, s_B	Carcass, s_C	Repeatability, s_r	Reproducibility, s_R	
Shoulder	0.15	0.16	0.20	0.25	0.28
Belly	0.13	0.26	0.19	0.23	0.56
Loin	0.12	0.31	0.28	0.30	0.50
Leg	0.06	0.39	0.25	0.25	0.70

[a] All joints corrected for cold carcass weight.

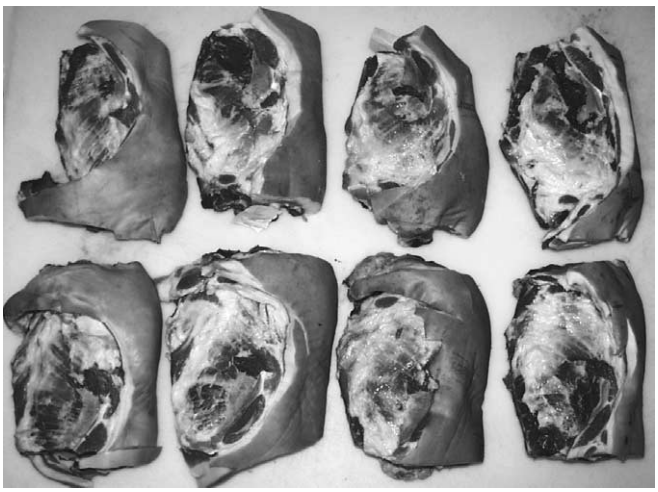

Fig. 3. Differences in jointing of the shoulder according to the EU-reference dissection method performed by eight different butchers.

between butchers for estimation of LMP in joints and carcass are shown in Table 6. The differences in LMP between butchers are very high for shoulder and belly with the highest differences being 3.20 and 4.05, respectively. For loin and leg the variation between butchers is lower with highest values at 1.82 and 1.57, respectively. The highest difference for LMP in the carcass is 1.96. Generally, butcher 3 has the lowest estimates for LMP, whereas butcher 1 has the highest. Note the agreement with the estimate of the butcher s.d. $s_B = 0.68$, which indicates a maximum difference (95% probability) between two butchers of $(t_{\infty,2.5\%} = 1.96) \times \sqrt{2} \times s_B = 1.9$.

There is a very high variation in the weight of joints between the eight butchers (Table 7), which means that the difference between the butcher with the lowest weight of a joint and the butcher with the highest weight of the same joint are large. For the shoulder, belly and loin the biggest average difference between butchers is 410 g, which is between 6% and 10% of the weight of the joint. For the leg the largest average difference is 280 g, which is less than 3% of the weight of the leg. These results show that the jointing varies significantly between butchers. Also, the variation between butchers is lowest for the leg, showing that the leg is easier to cut at the right position at jointing than the other three joints.

3.5. Effect of carcass side on the estimate of LMP

The LMP in the carcass and in the joints, except for belly, was significantly affected by carcass side (Table 8). The highest LMP was observed in the right side, and for carcass the left side had 0.6% less lean meat than the right side. The weight of the vertebral column was measured, to identify whether the splitting of the carcass in two identical halves was performed correctly. The weight of the vertebral column from the right side was 0.516 kg and from the left side 0.502 kg. The cold carcass weights were 42.3 and 42.0 kg for the left and right side, respectively. Thus, the difference between halves in carcass weight cannot be explained by the difference in weight of the vertebral column, and the splitting of sternum was corrected before dissection and thus does not influence the weight difference.

Table 6
Differences between butchers[a] in the estimate of lean meat percentage in joints and carcasses[b]

Item	Butcher							
	1	2	3	4	5	6	7	8
Shoulder	3.20***	1.81***	0	3.09***	0.89**	2.15***	0.55	1.43***
Belly	3.88***	4.05***	0.80	2.50***	0	2.08***	0.96*	2.74***
Loin	1.82***	1.41***	0	0.12	1.06**	0.43	0.22	1.68***
Leg	1.57***	0.92***	0	0.86**	0.74**	1.19***	0.48*	1.12***
Carcass	1.96***	1.90***	0	0.86**	0.26	1.13***	0.91**	1.43***

[a] Differences between the butcher with the lowest lean meat percentage (0) and the other butchers.
[b] Lean meat percentage in joints and carcasses are estimated by the EU-reference dissection method.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

Table 7
Differences (in kg) between butchers in the weight of joints[a]

Item	Butcher							
	1	2	3	4	5	6	7	8
Shoulder	0.04	0.15*	0.39***	0	0.21**	0.13*	0.41***	0.33***
Belly	0.16**	0.22***	0.01	0.04	0.40***	0	0.09	0.15*
Loin	0.31***	0.37***	0.14	0.29***	0	0.37***	0.40***	0.21*
Leg	0.28**	0.22**	0.10	0.18*	0	0.19*	0.05	0.10

[a] Differences between the butcher with the lowest joint weight (0) and the other butchers.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

Table 8
Lean meat percentage[a] estimated by dissection of joints[b] and carcasses[c] from the right and left carcass side

Item	Side		Difference	SEM	*P*
	Right	Left	Right − left		
Shoulder	67.66	67.37	0.29	0.23	<0.01
Belly	57.14	56.87	0.27	0.33	NS
Loin	60.53	60.10	0.43	0.30	<0.01
Leg	72.13	71.88	0.25	0.24	<0.01
Carcass	58.96	58.34	0.62	0.26	<0.001

[a] Least squares means of 128 carcasses.
[b] Weight of dissected lean meat in each joint expressed as a percentage of the weight of that joint.
[c] Lean meat percentage in carcasses is estimated by the EU-reference dissection method.

4. Discussion

In this study, performed in four countries, abattoirs were selected to ensure some variation in pig types and to reflect differences in pig populations and production conditions between countries. Thus, some variation in pig type was found between countries due to the experimental design. We found significant differences in LMP in joints (data not shown) and in carcasses between countries. Also, the LMP in belly and loin was significantly different between abattoirs within country, and for shoulder and belly between sexes within country (data not shown). The LMP of the carcass and the meat content as a percentage of the carcass weight was higher in carcasses from country C than from the other countries. This could be explained by differences in the amounts of meat in the different joints, where carcasses from country C had higher meat content especially in the leg than carcasses from the other countries.

The accuracy of the EU-reference dissection method is given by the repeatability standard deviation (0.87), the reproducibility standard deviation (1.10) and the reliability (0.87) of the carcass. As a rule of thumb, reliability above 0.8 is considered acceptable accuracy. Thus, the reliability in this trial indicates a high accuracy; however, it can be argued as to whether the accuracy is high enough for a reference method. If the result reflects a possible systematic difference in LMP levels between countries, the accuracy may be considered too poor. Also the difference of 1.96 units of LMP between butchers may be considered an indicator of a high difference between countries, as butchers represented different countries. The difference between butchers may also indicate a systematic error in the calibration of the classification equipment based on dissection in the different countries. This may be the reason why the measured lean meat percentage (Table 2) in some cases are lower than the lean meat percentage estimated by dissection (Table 8). Thus, there seems to be some variation between countries within the EU, regarding the estimation of LMP by the EU-reference dissection method. In order to improve the EU-reference dissection method, it therefore may be useful to introduce common training of the responsible persons on a regular basis and thus achieve a higher degree of uniformity between countries.

The estimated accuracy in this trial does not reflect the accuracy between butchers within a country. Within country butchers will be trained together and therefore be more uniform in their work. Also the trial set-up would usually be different within a country, where one butcher would perform the jointing and the other butchers would perform the dissection together, and not in a pair wise combination as was the case in this trial.

The jointing of the carcass according to the EU-reference dissection method is well described (Walstra & Merkus, 1996), but some deviations have been observed during this experiment. The reliability for shoulder is very low (0.28) and indicates the difficulties to cut out this part because there are no exact anatomic lines to follow. Also,

Fig. 4. Difference in the cutting line between loin and belly between butchers after jointing according to the EU-reference dissection method.

a big variation in the cutting line between loin and belly was observed between the butchers (Fig. 4). This variation influences the weight of the joints, but it has no influence on the LMP of the carcass as both joints are dissected. Cutting inaccuracies between two joints used for dissection have no influence on the LMP in the carcass, whereas it has an influence on the estimation of LMP in the joints. The critical borders are between joints that are dissected and the rest of the carcass. In such cases jointing errors do influence the LMP in the carcass as well. Generally, the low reliabilities for weight of the joints (0.28–0.70), as well as the significant differences between butchers for weight of joints, indicate that the jointing procedure is more difficult than the dissection itself. It also shows that the jointing procedure needs further attention in order to get a more uniform jointing between countries within the EU.

5. Conclusions

In this trial, the accuracy of the EU-reference dissection method is expressed by the repeatability (0.87) and reproducibility (1.10) standard deviation, and by the reliability (0.87) for the carcass. The reliability indicates a high accuracy although a significant effect of butcher was found on the estimation of LMP. The largest difference between butchers was 1.96 units of LMP. Although the reliability for estimation of LMP in the carcass may be considered high enough, the estimation for shoulder and belly was too low and shows that some attention may be needed regarding the dissection of these joints. The reliability for the weight of joints was also low for all joints especially for shoulder, which indicates that jointing of the carcass is a critical point in the EU-reference dissection method. Also, a significant effect of carcass side for the estimate of LMP was found, where the largest difference between sides was 0.6 units of LMP.

Acknowledgements

This research was conducted under the EC project G6RD-CT-1999-00127 EUPIGCLASS of the Measurements and Testing activity (Competitive and Sustainable Growth programme).

Hans Busk from the Danish Institute of Agricultural Sciences in Denmark was work package leader in this EU-project, but unfortunately he passed away in December 2002. We dedicate this paper to the memory of Hans Busk.

The authors thank the people at the abattoirs and at the research institutes for their contribution to the trial. Special thanks are given to the dissection team: S. Lescouhier, Belgium; H.V. Ammitzbøll, Denmark; M. Spindler, Germany; A. Quintana, Spain; A. Nictou, France; E. Vesey, Ireland; C. Richter, the Netherlands and Leif Sandberg, Sweden. Special thanks also to R. Höreth, Germany, who was responsible for all the measurements and documentation. Special thanks are also given to the other participants in the EUPIGCLASS project for advise and discussions in connection to the experiment: E. Ongenae, Belgium; S. Højsgaard, J. Blom-Hansen, Denmark; A. Dobrowolski, Germany; M. Font i Furnols and A. Diestre, Spain; T. Dhorne, D. Causeur and P. Marty-Mahé, France; P. Allen, Ireland, and B. Engel and E. Lambooij, the Netherlands.

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