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Estimation of the carcass composition of stationary tested pigs

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Introduction

In Germany lean meat content of stationary tested pure and crossbred pigs is currently estimated by a single regression equation (Bonner-formula) which comprises four linear carcass measurements. This formula was developed by Schmitten et al. (1986). Since then, particularly within the sire lines considerable genetic progress has been realized. In addition, several modifications of the stationary performance testing scheme (e.g.: Increase of slaughter weight from 80 to 85 kg, testing of castrates instead of sows within the dam-lines) have been implemented. These changes raise the question whether the accuracy of the Bonner-formula is sufficient to quantify the carcass composition of on-station tested pigs.

Additionally, during the last decade the precision of on-line carcass grading systems has been improved significantly. Along with the lean meat content of the carcass, these systems are nowadays able to determine the composition of carcass cuts automatically with high precision. Compared to the application of the Bonner-formula, the required manual efforts of on-line carcass grading systems are clearly reduced. Therefore, the application of these methods to determine the composition of performance tested pigs is of a great interest for the breeding organisations.

Material and Methods

A total of 292 pigs originating from stationary sibling and progeny performance testing were taken to evaluate the suitability of different carcass composition determining methods. Along with two commercial crossbred lines (Pi×Westhybrid, dbL65×dbSow), the study comprises purebred Piétrain (Pi), German Yorkshire (LW) and German Landrace (LR) pigs (Table 1).

Pigs were housed in groups of two female full sibs which had ad libitum access to feed and water. Animals were fed with wheat-barley-soybean meal diets, which contained 16% CP, 1% lysine and 13.0 MJ/kg ME. The fattening period started at 35 kg and ended between 75 and 115 kg being stratified in four different carcass weight classes.

Table 1: Number of slaughtered pigs, depending on breed, sex and carcass weight groups

Weight group (kg)	Pi	LW	LR	Pi×Westhybrid		dbL65×dbSow	
Sex	f***	m	m	m	f	m	f
75-85	10* (26**)	-	-	10	10	9	9
85-95	9 (29)	10 (9)	10 (9)	9	9	10	9
95-105	-	8 (9)	8 (8)	9	9	9	9
105-115	-	-	-	9	9	9	9
Total	74	36	35	37	37	37	36

*full dissection and tomography **only tomography ***m: barrows; f: gilts

All pigs were slaughtered at a commercial abattoir of the Westfleisch-Company in Hamm-Uentrop, where an AutoFOM device is used in the on-line carcass grading routine. Along with the estimated carcass composition traits (lean content of the carcass and belly cut, weight of the belly, lean, ham, shoulder and loin cut) used in the payment system of the Westfleisch-Company, the 127 most informative single AutoFOM ultrasonic measures could be used in our analysis. This information comprises technical ultrasound signals and various fat and muscle depths used to estimate the carcass composition (Brøndum et al., 1998). In addition, the carcass composition was estimated via the Fat-O-Meater (FOM)-probe and a video imaging system (VCS 2000). This device consists of three cameras which record predominantly linear and square measurements at both sides of the carcass halves.

One day after on-line grading, linear fat measurements were taken according to the rules of station testing of pigs in Germany (ALZ, 2001). Lean content of the entire carcass was estimated by the Bonner-formula as described above. After transportation to the Institute for Animal Breeding in Mariensee (Federal Agricultural Research Centre), the left carcass sides were investigated by magnetic resonance imaging (MRI). This technique provides an insight into the body's interior and is one of the most powerful diagnostic tools in medicine. A detailed description of MRI and its application in animal science was given by Baulain (1997). On basis of the recorded cross sectional images the tissue composition of the whole carcass and of the valuable cuts loin, ham, shoulder and belly was determined.

The tomography was followed by a full dissection of the carcass sides according to the EU-method (Scheper and Scholz, 1985; Walstra and Merkus, 1995), which was used as a reference for all investigated carcass composition determining methods.

Statistical Analyses

Differences and linear relationships between the dissection reference values and the various carcass composition determining methods were calculated throughout and within breed groups using the SAS statistic package (SAS, 2000). Valid estimations are characterised by a coefficient of determination $R^2 > 0.64$ and by a coefficient of variation CV < 5 % (Branscheid und Dobrowolski, 1997).

New estimation functions were constructed by partial least squares (PLS) techniques (de Jong, 1993) which are implemented in the SAS procedure PLS using the underlying linear carcass measurements of AutoFOM, VCS 2000 or measurements recorded on-station. The PLS- techniques have the goal of accounting for variation in the predictors, under the assumption that directions in the predictor space that are well sampled should provide better prediction for new observations when the predictors are highly correlated.

Results and discussion

Carcass lean meat content

The mean lean content recorded by dissection or estimated by various methods for the different breeds is shown in Table 2.

Table 2: Means and standard deviations of the lean content (LMC) of carcass sides

Breed trait	Pi		LW / LR		Pi×Westhybrid		dbL65×dbSow	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
LMC dissection (%)	65.0	2.14	51.1	3.14	57.8	3.46	58.1	3.39
LMC Bonner-formula (%)	64.9	2.00	54.2	2.05	59.7	2.94	60.8	2.64
LMC FOM (%)	62.5	1.52	51.1	3.24	56.9	2.90	58.0	2.89
LMC AutoFOM (%)	63.0	2.34	50.1	3.24	56.8	3.44	57.2	3.59

In comparison to the reference, the Bonner-formula overestimates the lean content of the commercial crossbred and dam-line pigs. In contrast, the on-line grading methods FOM and AutoFOM underestimate the carcass lean content, particularly within the Pi-group.

Sufficient accuracies for the estimation of the lean content are achieved by the FOM and AutoFOM equipments. The root mean square error (RMSE) in both systems is distinctly lower than 2.5 % (Table 3). The accuracy of the FOM-probe is superior in comparison to the AutoFOM ultrasound system. This unexpected result can be explained by the specific accurate trial conditions, which favour particularly non-automatic systems.

The accuracies of the Bonner-formula are unsatisfactory except in case of dam-lines. For the crossbred groups the RMSE is considerably higher than 2.5 % and the coefficients of determination achieve a maximum of only 40 %. However, partly low R^2 values might be explained by the specific housing conditions and the specific genetic background of the on-station performance tested pigs.

Table 3: Accuracies of different methods for the estimation of the lean meat content from dissection

Breed	FOM RMSE (%)	FOM CV (%)	FOM R^2 (%)	AutoFOM RMSE (%)	AutoFOM CV (%)	AutoFOM R^2 (%)	Bonner-formula RMSE (%)	Bonner-formula CV (%)	Bonner-formula R^2 (%)
Pi	1.52	2.34	52.7	1.59	2.45	48.3	1.95	3.00	22.2
LW/LR	2.08	4.07	47.9	1.85	3.62	58.9	1.56	3.05	70.6
Pi×Westhybrid	1.66	2.87	78.0	2.33	4.03	56.8	2.72	4.71	40.9
dbL65×dbSow	1.93	3.32	68.5	2.28	3.92	56.4	2.83	4.87	33.1

RMSE: Root mean square error; CV: RMSE/Mean; R^2: Coefficient of determination

In order to improve the accuracy of the estimation function used by AutoFOM and the Bonner-formula, adjusted equations were constructed by means of PLS-techniques using 127 AutoFOM-base recordings and 11 linear carcass measurements, respectively.
Compared to the valid formulas, both, the readjusted AutoFOM estimation function and the Bonner-formula improve the accuracies of the carcass lean content estimation significantly (Table 4). With the exception of the dam-lines and the AutoFOM adaptation of the Pi×Westhybrids the coefficient of determination was increased more than 15 %, and the root mean square error was reduced more than 0.2 %. Only marginal differences can be observed between accuracies of the AutoFOM- and Bonner-formulas within the Pi- and Pi×Westhybrid groups. However, in the dbL65×dbSow group the AutoFOM system shows a distinctly higher accuracy, whereas the Bonner-formula is superior in the dam-line group.

Tab. 4: Estimation of the carcass lean meat content - differences between valid and adjusted formulas

Breed		AutoFOM Adjusted formulas	AutoFOM Diff. to the valid formulas	Bonner-formula Adjusted formulas	Bonner-formula Diff. to the valid formulas
Pi	CV (%)	1.87	-0.34	1.95	-0.21
	R^2	0.50	+0.30	0.47	+0.15
LW/LR	CV (%)	4.06	+0.13	3.01	-0.19
	R^2	0.62	+0.00	0.79	+0.04
Pi×Westhybrid	CV (%)	3.91	-0.04	3.78	-0.93
	R^2	0.58	+0.01	0.61	+0.20
dbL65×dbSow	CV (%)	3.19	-0.68	3.93	-0.93
	R^2	0.70	+0.23	0.56	+0.23

CV: RMSE/Mean; R^2: Coefficient of determination

Estimation of the proportion and composition of the carcass cuts

As expected the proportions of the valuable cuts ham and loin and the belly lean content are highly correlated with carcass lean content of dissection (r = 0.70 - 0.95). This corresponds to the dissection trials published by Hulsegge et al. (1994). Within one breed the proportion and composition of the different carcass cuts remains on a relatively constant level. From this follows that the improvement of valuable cuts by means of the carcass lean content could be a satisfying option.

In our study, the accuracy of the currently implemented AutoFOM formulas to estimate the different carcass cut proportions are satisfying under certain conditions. In particular the coefficient of variation in predicting the loin cut proportion considerably exceeds the 5 % limit (Fig. 1).
Similar to the carcass lean content, the AutoFOM accuracies in estimating the proportions of the major carcass cuts are clearly improved by PLS–adaptation. However, in contrast to the newly constructed formulas of the ham, shoulder and belly cut proportions, the CV of the loin proportion remains above 5 %. A possible explanation for this contradictory result can be given by problems in the caudal and cranial demarcation of this trait during the dissection of pigs with different numbers of vertebrae.

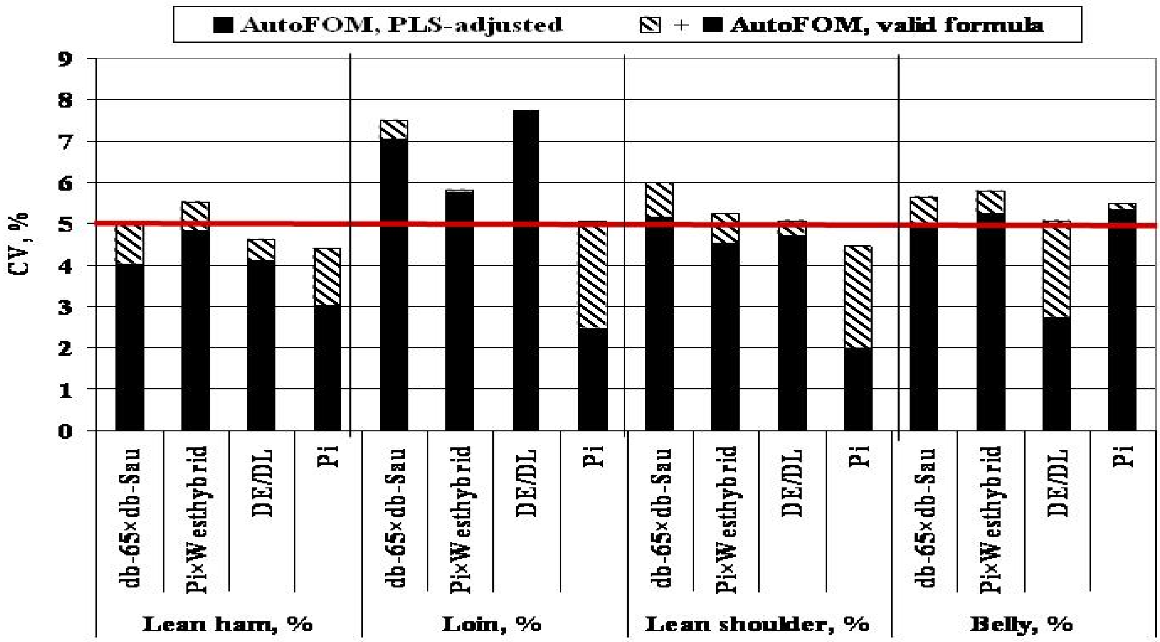

Fig. 1: Relative measurement errors (CV) in estimating the proportion of different carcass cuts using currently implemented and PLS-adjusted AutoFOM functions

Only marginal differences can be observed when comparing the differences between the accuracies of the adjusted carcass cut functions constructed with the AutoFOM-base recordings or the on-station recorded carcass measurements (Fig. 2). Exceptions are the higher accuracies of the AutoFOM system in estimating the loin or lean shoulder proportion within the Pi-breed or the lean ham proportion within the crossbred group dbL65×dbSow. A considerably higher precision of the on-station test formulas can only be observed within the dam-lines.
Because of the close relationship between the carcass lean content and the proportion of the valuable carcass cuts it seems to be hardly possible to achieve specific carcass cut improvements. However, compared to the accuracies achieved by estimating the loin proportion on basis of the entire carcass lean content, a specific AutoFOM estimation of the loin proportion leads to a considerable decrease of the relative measurement error within the purebred lines, whereas the estimation of ham proportions is improved within the dbL65×dbSow crossbreds (Fig. 2). Some formulas used to estimate the carcass lean content are presumably influenced by linear carcass measurements located in the ham (purebred pigs) or in the loin area (dbL65×dbSow). In these situations the application of carcass cut specific formulas could be a useful option.

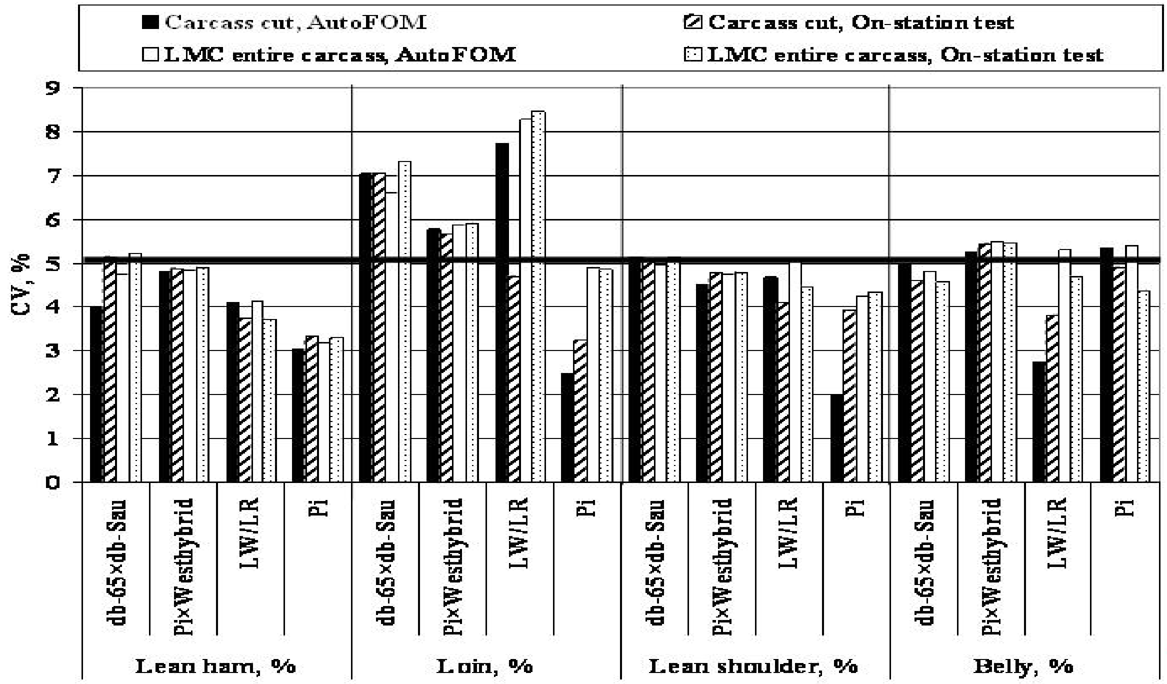

Fig. 2: Relative measurement errors (CV) in estimating the proportion of carcass cuts using specific PLS-adjusted carcass cut functions or estimated lean content (LMC) of the entire carcass

Summary

Within the scope of stationary performance testing in Germany, the currently applied Bonner-formula allows a satisfying estimation of the lean content only within the dam-line group. The use of PLS-adjusted formulas with better prediction accuracies can be recommended for the Pi-pigs and commercial crossbreds. However, in comparison to on-station testing similar accuracies in the estimation of the carcass lean content can be achieved by on-line carcass grading systems like AutoFOM with less manual efforts. The application of breed specific PLS-functions, constructed by means of the underlying base recordings of the on-line grading system and possibly complemented by on-station recorded carcass measures can be recommended.

In our investigations, the application of the currently implemented AutoFOM formulas used to estimate specific carcass proportions have led to unsatisfactory accuracies. With the exception of the loin proportion, the relative measurement errors dropped after PLS-readjustments of the AutoFOM equation considerably lower than 5 %. Similar accuracies were achieved by carcass cut functions constructed by means of on-station recorded carcass measurements. However, because of close relationships between the proportions of valuable carcass cuts it is only in special cases possible to improve the proportion of a specific carcass cut without altering the carcass lean content.

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