Conformation and meatiness of pork belly

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ABSTRACT: Based on the results of dissections of 126 pig carcasses, the proportions of pork belly and its parts, i.e. belly with bones, belly without bones and tip of belly, were determined. In addition, proportions of lean meat, bones, intermuscular and subcutaneous fat were determined in belly with bones as percentages of the weight before the dissection. Lean meat content of carcass was the most important factor for determining the pork belly composition. The correlation between lean meat content of carcass and lean meat percentage of belly with bones was 0.92 ± 0.035. Sex and slaughter weight had a greater impact on the composition of pork belly than the cross-bred combination. The lean meat percentage of belly with bones in gilts was higher by 4.4% than in barrows. For slaughter weights higher than 100 to 110 kg, lean meat content in pig belly decreased with increasing slaughter weight.

Keywords: pig; belly; lean meat percentage; correlations

An increase in lean meat percentage in pork carcass is at first reflected in a reduced fat cover particularly over the leg and back. At the same time, the composition of cuts formerly indicated as "fatty" is improved. In this case, a significant role is played by pork belly which accounts for a substantial part of the carcass.

In the past, a considerable variance was observed in fat and muscle proportions of pork belly. However, in currently produced pigs, lean meat content of belly implicates its use in the processing industry and its popularity in consumers (Pfeiffer *et al.*, 1993; Baulain *et al.*, 1998; Tholen *et al.*, 1998; Čítek, 2002; Tholen *et al.*, 2003). According to Pulkrábek *et al.* (1998), a lean meat content exceeding 50% of belly weight is considered as a favourable belly composition.

Pork belly composition is closely related to the evaluation of pork carcasses based on lean meat content. Basic contributions to the development of methods for estimating the lean meat percentage in pork carcasses were made by Branscheid *et al.* (1987) and Engel and Walstra (1991). Under the conditions of the Czech Republic, the same problem was examined by Pulkrábek *et al.* (1994). The importance of pork belly is further stressed in the process of developing new regression equations used for the estimation of carcass lean meat percentage. This estimation has recently been based on the simplified detailed dissection of a representative group of pigs (120 animals or more, Walstra and Merkus, 1995). To determine the lean meat content in the whole carcass, the analysis involves detailed dissections of leg, back, shoulder, and also belly. The importance of the described evaluation of pork carcasses based on methods used in the countries of the European Union for further development of pig production in the Czech Republic was stressed by Matoušek *et al.* (1995) and Čechová *et al.* (1997). The economic impact on the production of pork was described in the report of Daňo *et al.* (1998).

The objective of the present study was to evaluate factors influencing the conformation and meatiness of pork belly in a representative sample of slaughter pigs.

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MATERIAL AND METHODS

Totally 126 pigs were included in the analysis. The group consisted of final hybrids originating from crosses of Large White × Landrace crossbred sows with purebred boars of a sire line of Large White (LWSL – n = 50) or with crossbred boars of the combinations Pietrain × Duroc (PN × D – n = 38) or Pietrain × Hampshire (PN × H – n = 38). Both sexes (gilts and barrows) were represented by equal numbers of animals in all subgroups. The number of animals in different slaughter weight categories is shown in Table 1. Basic characteristics of the data set with respect to fat thickness are given in Table 2.

Fattening conditions corresponded to the common production conditions currently used in the Czech Republic.

Twenty-four hours after slaughter, the carcass analysis was carried out and carcasses were divided into individual cuts. The method described by Walstra and Merkus (1995) was used for the detailed carcass dissection. Lean meat percentages were calculated for all cuts.

The present study was focused on the analysis of pork belly and its different parts (belly with bones, belly without bones and tip of belly). Particular analyses were carried out for belly with bones where different tissues (muscles, bones, intermuscular fat and subcutaneous fat) were determined. The impact of genotype, sex and slaughter weight on the composition of pork belly was investigated by a linear statistical model. Slaughter weight was treated as class variable or alternatively as regression variable. Five classes were formed for slaughter weight (99.9 kg or less, 100.0 to 109.9 kg, 110.0 to 119.9 kg, 120.0 to 129.9 kg, 130.0 kg and higher). The procedure GLM of SAS/STAT® (SAS Institute Inc., 1989) was used for estimating least-squares means and their standard errors. The overall impact of the individual factors was tested by the F-test using an experimentwise error rate of 0.05. Differences between pairs of least-squares means were tested for the comparisonwise error rate of 0.05 using the multiple t-test.

RESULTS AND DISCUSSION

Basic characteristics of used animals and their carcasses are given in Table 3. The average slaughter weight was 115.9 kg, which is 4.6 kg more than

Table 1. Number of carcasses in different weight categories

Slaughter weight (kg)	Final hybrids after different sire breeds						Total	
	LWSL		PN × D		PN × H			
	♀	♂	♀	♂	♀	♂	♀	♂
99.9 or less	4	4	3	3	3	3	10	10
100.0 to 109.9	6	3	2	4	4	2	12	9
110.0 to 119.9	3	9	6	6	5	5	14	20
120.0 to 129.9	6	5	5	3	4	5	15	13
130.0 and more	6	4	3	3	3	4	12	11
Total	25	25	19	19	19	19	63	63

Table 2. Number of carcasses according to fat and skin thickness measured between 2nd and 3rd last rib 70 mm from the line of the splitting cut

Fat thickness (mm)	Final hybrids after different sire breeds						Total	
	LWSL		PN × D		PN × H			
	♀	♂	♀	♂	♀	♂	♀	♂
<14	10	5	9	2	8	5	27	12
14–20	7	11	5	11	7	7	19	29
>20	8	9	5	6	4	7	17	22
Total	25	25	19	19	19	19	63	63

reported by Pulkrábek and Pavlík (2003). This value fits into the weight range of pigs commonly slaughtered in the Czech Republic.

The proportion of belly shown in Table 3 confirms that the size of this part is relatively large. Its importance is also pointed out in the study of Pfeiffer *et al.* (1993). Table 3 also shows percentages of different parts of belly. Expressing the individual parts as percentages of belly total, the following values were obtained: belly with bones 58.6%, belly without bones 22.3% and tip of belly 19.1%. The lean meat content in belly with bones was approximately 53%.

Table 4 presents a survey of the impact of individual factors on the analysed traits. Generally it can be stated that the model which treats slaughter weight as regression variable is more sensitive for finding an impact of the given factor. When forming classes, the originally continuous trait is transformed to a discontinuous trait and a part of the original information is lost. On the other hand, when forming classes, no concrete functional relation must be assumed and especially non-linear relations might be treated better in this way. Therefore, for either of the two models there are reasons which justify their use.

Table 3. Basic characteristics of the analysed set (n = 126)

Trait		$\bar{x}$	s
Slaughter weight (kg)		115.9	13.182
Carcass weight (kg)		90.55	10.298
Percentage of carcass weight (%)	tip of belly	3.30	0.443
	belly with bones	10.15	0.826
	belly without bones	3.86	0.588
	belly total	17.31	0.998
Percentage of belly with bones weight (%)	lean meat	52.94	6.101
	bones	7.33	1.003
	intermuscular fat	18.72	4.288
	subcutaneous fat	20.56	3.708
	dissection losses	0.45	0.186

Table 4. Impact of sex, crossbred combination, lean meat percentage and slaughter weight on pork belly characteristics

Trait	Sex	Crossbred combination	Slaughter weight
Percentage of carcass weight:			
belly with bones	–/–[1]	–/–	+/+
tip of belly	–/–	+/+	–/–
belly without bones	+/+	–/–	–/+
belly total	–/–	–/–	+/+
Percentage of pork belly with bones:			
lean meat	+/+	–/–	–/+
bones	–/–	–/–	+/+
subcutaneous fat	–/–	–/–	–/–
intermuscular fat	+/+	–/–	+/+
dissection losses	–/–	–/–	–/–

[1]Significance was tested on the 5% level (+ significant, – not significant). The specification before the slash refers to the model where all factors were treated as class variables; the specification after the slash refers to the model where slaughter weight was treated as covariable

The sex of the animals had an impact on belly with bones as percentage of carcass weight and on lean meat and intermuscular fat, both as percentage of pork belly with bones. The crossbred combination influenced only the tip of belly measured as percentage of carcass weight. Slaughter weight was important for belly with bones and belly total as percentage of carcass weight and for bones and intermuscular fat as percentage of pork belly with bones. Furthermore, when slaughter weight was treated as regression variable, there was a significant influence on belly without bones as percentage of carcass weight and on lean meat as percentage of belly with bones.

The least-squares means of the analysed traits for all classes of the factors considered in the model are summarized in Tables 5 and 6. When deciding which test to use for multiple comparisons we followed the philosophy of Carmer and Walker (1982). For the reasons given by these authors the comparisonwise error rate should be more appropriate than the experimentwise error rate for effectively finding differences between least-squares means.

At first, the differences between final hybrids of various crossbred combinations will be considered. All three combinations showed very similar results. Significant differences occurred rarely and mostly in traits which were of minor importance as the tip of belly. Therefore there is no reason to prefer a certain crossbred combination.

The next factor of interest which was considered was the sex of the animals. Gilts showed a better conformation of belly than barrows. The differences were significant in three traits (belly without bones as percentage of carcass weight and lean meat and intermuscular fat, both as percentage of belly with bones). The difference in lean meat percentage of belly with bones was as large as 4.3% in favour of the gilts. Similar results were reported by Stupka *et al*. (2004). In their study the lean meat proportion in belly with bones of gilts was by 3.32% higher than in barrows.

As expected, increasing slaughter weight resulted in a reduction of the lean meat percentage. In this study, however, this effect was expressed only in slaughter live weight exceeding 100 kg. The ability of pigs slaughtered at live weights over 100 kg to produce a corresponding lean meat yield was confirmed by Höreth (1995). This is particularly important from the producers' point of view as they will not be so strictly forced to reduce slaughter weight due to the required high percentage of lean meat in carcass. A somewhat higher slaughter weight may positively influence the economics of pig production especially through a decrease in the piglet production costs which would result in lower cost per kg of slaughter weight (Pavlík, 1993).

The higher deposition of fat in pigs with live weight higher than 100 kg may be explained by the

Table 5. Least-squares means (with standard errors) of belly and its parts as percentage of pork carcass

Factor	Classes		*n*	Percentage from carcass weight (%)							
				tip of belly		belly with bones		belly without bones		belly total	
				$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$
Crossbred combination	final hybrids sired by	LWSL	50	3.19^{a}	0.058	10.31^{a}	0.112	3.82^{ab}	0.078	17.32^{a}	0.138
		(D × Pn)	38	3.17^{a}	0.067	10.00^{a}	0.130	3.98^{a}	0.091	17.15^{a}	0.160
		(H × Pn)	38	3.57^{b}	0.067	10.02^{a}	0.130	3.73^{b}	0.090	17.32^{a}	0.159
Sex	gilts		63	3.27^{a}	0.052	10.00^{a}	0.101	4.01^{a}	0.070	17.28^{a}	0.124
	barrows		63	3.35^{a}	0.053	10.22^{a}	0.102	3.67^{b}	0.071	17.24^{a}	0.126
Slaughter weight (kg)	99.9 or less		20	3.36^{a}	0.092	9.81^{a}	0.178	3.56^{a}	0.124	16.73^{a}	0.218
	100.0 to 109.9		21	3.36^{a}	0.090	9.85^{a}	0.174	3.85^{ab}	0.121	17.06^{ab}	0.213
	110.0 to 119.9		34	3.36^{a}	0.071	10.14^{ab}	0.137	3.91^{b}	0.095	17.41^{bc}	0.168
	120.0 to 129.9		28	3.20^{a}	0.078	10.33^{b}	0.150	3.91^{b}	0.104	17.44^{bc}	0.184
	130.0 and more		23	3.27^{a}	0.086	10.43^{b}	0.167	3.99^{b}	0.116	17.69^{c}	0.204

Means with the same superscripts do not differ significantly on the 5% level
LWSL – Large White sire line, Pn – Pietrain, D – Duroc, H – Hampshire

Table 6. Least-squares means (with standard errors) of individual parts of pork belly as percentage of pork belly with bones

Factor	Classes		*n*	Percentage of pork belly with bones (%)									
				lean meat		bones		intermuscular fat		subcutaneous fat with skin		dissection losses	
				$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$
Crossbred combination	final hybrids sired by	LWSL	50	53.58^{a}	0.792	7.13^{a}	0.134	18.11^{a}	0.549	20.70^{ab}	0.514	0.48^{a}	0.026
		(D × Pn)	38	51.59^{a}	0.916	7.46^{ab}	0.155	19.20^{a}	0.635	21.36^{a}	0.595	0.39^{b}	0.030
		(H × Pn)	38	53.80^{a}	0.911	7.60^{b}	0.154	18.72^{a}	0.631	19.39^{b}	0.591	0.49^{a}	0.030
Sex	gilts		63	55.17^{a}	0.710	7.45^{a}	0.120	17.06^{a}	0.491	19.87^{a}	0.460	0.45^{a}	0.023
	barrows		63	50.82^{b}	0.722	7.34^{a}	0.122	20.30^{b}	0.500	21.09^{a}	0.468	0.45^{a}	0.024
Slaughter weight (kg)	99.9 or less9		20	54.21^{a}	1.250	7.89^{a}	0.212	17.65^{a}	0.865	19.74^{a}	0.811	0.51^{a}	0.041
	100.0 to 109.9		21	55.04^{a}	1.224	7.73^{ab}	0.207	17.04^{a}	0.847	19.74^{a}	0.794	0.45^{a}	0.040
	110.0 to 119.9		34	52.76^{ab}	0.961	7.27^{bc}	0.163	18.95^{ab}	0.666	20.56^{a}	0.624	0.46^{a}	0.032
	120.0 to 129.9		28	52.28^{ab}	1.057	7.19^{c}	0.179	19.17^{ab}	0.732	20.93^{a}	0.686	0.43^{a}	0.035
	130.0 and more		23	50.68^{b}	1.169	6.89^{c}	0.198	20.58^{b}	0.809	21.43^{a}	0.758	0.42^{a}	0.039

Means with the same superscripts do not differ significantly on the 5% level
LWSL – Large White – sire lines, Pn – Pietrain, D – Duroc, H – Hampshire

increasing percentage of belly. Within this process, considerable changes in the belly composition occur. This is confirmed by the lean meat percentage in belly with bones which was in the range from 54 to 55% for pigs with live weight lower than 110 kg and which decreased to a value between 50 and 51% for pigs heavier than 130 kg.

The estimates of correlation coefficients between slaughter weight or lean meat content in carcass and pork belly characteristics are shown in Table 7. Lean meat percentage of carcass weight was very closely correlated with the lean meat percentage of belly with bones. Furthermore, the correlations between lean meat percentage of carcass weight and both intermuscular and subcutaneous fat percentages of belly with bones showed high negative values. Therefore selection on lean meat content of carcass will be very efficient for increasing lean meat content and decreasing fat content of pig bellies. As the belly as such has a relatively high fat percentage, the correlation between lean meat content of carcass and belly total is negative.

The results also demonstrate that the belly takes a higher share of carcass with increasing slaughter weight. The percentages of lean meat, but also of bones in pork belly decreased with increasing

Table 7. Correlation coefficients (± standard errors) between slaughter weight or lean meat percentage of carcass weight and pork belly characteristics

Correlation between		Slaughter weight	Lean meat percentage of carcass weight
Proportion of carcass weight	tip of belly	–0.06 ± 0.090	0.03 ± 0.090
	belly with bones	0.28 ± 0.087	–0.37 ± 0.083
	belly without bones	0.18 ± 0.088	–0.22 ± 0.088
	belly total	0.31 ± 0.085	–0.42 ± 0.081
Proportion of weight of belly with bones	lean meat	–0.21 ± 0.088	0.92 ± 0.035
	bones	–0.31 ± 0.085	0.54 ± 0.080
	intermuscular fat	0.25 ± 0.087	–0.79 ± 0.055
	subcutaneous fat with skin	0.15 ± 0.089	–0.75 ± 0.059

slaughter weight. On the other hand, intermuscular fat was positively correlated with slaughter weight.

Summarizing the results, it can be concluded that the belly composition is mainly influenced by the lean meat percentage of carcass. The impact of slaughter weight and sex is much more important than the influence of the crossbred combination.

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