Czech Journal of
ANIMAL SCIENCE

ŽIVOČIŠNÁ VÝROBA

11

CZECH JOURNAL OF ANIMAL SCIENCE

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Original Paper

Relationships between milk yields in the first three lactations of Czech Pied cows

Vztahy mezi mléčnou užitkovostí na prvních třech laktacích u dojnic českého strakatého plemene

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ABSTRACT: The observation was carried out in a group of 9 150 cows with 50–100% proportion of Czech Pied cattle in genotype. All cows finished the first three lactations. The total mean milk yield was 3 836.4 kg (first lactation), 4 415.5 kg (second lactation) and 4 792.6 kg of milk (third lactation). The relationships between lactations were described by individual estimation coefficients that were calculated as a ratio of milk yield in later lactation to milk yield in earlier lactation. The mean estimation coefficient between the first and second lactation was 1.171, between the first and third lactation 1.274 and between the second and third lactation 1.103. Estimation coefficients between all lactations highly significantly decreased with increasing milk yield in the first lactation. The proportion of Czech Pied breed in genotype also affected estimation coefficients, but less significantly. Estimation coefficients between the first and third lactation significantly increased with increasing estimation coefficients between the first and second lactation while the coefficients between the second and third lactation significantly decreased.

Keywords: Czech Pied cattle; cows; milk yield; relationships between lactations

ABSTRAKT: Byl sledován soubor 9 150 dojnic s podílem českého strakatého plemene 50 až 100 %. Všechny dojnice měly ukončeny první tři laktace. Průměrná užitkovost celého souboru byla 3 836,4 kg (1. laktace), 4 415,5 kg (2. laktace) a 4 792,6 kg (3. laktace) mléka. Vztahy mezi laktacemi byly hodnoceny na základě přepočtových koeficientů mezi laktacemi jednotlivých dojnic, které byly vypočteny jako podíl mléčné užitkovosti na pozdější laktaci a mléčné užitkovosti na dřívější laktaci. Průměrná hodnota přepočtového koeficientu celého souboru z 1. na 2. laktaci byla 1,171, z 1. na 3. laktaci 1,274 a ze 2. na 3. laktaci 1,103. Se vzrůstající užitkovostí na 1. laktaci klesala vysoce průkazně hodnota přepočtových koeficientů mezi všemi laktacemi. Podíl českého strakatého plemene ovlivnil hodnoty přepočtových koeficientů mezi laktacemi méně výrazně. Hodnoty přepočtových koeficientů z 1. na 3. laktaci se průkazně zvyšovaly se zvyšující se hodnotou přepočtových koeficientů z 1. na 2. laktaci, zatímco přepočtové koeficienty z 2. na 3. laktaci se průkazně snižovaly.

Klíčová slova: české strakaté plemeno; dojnice; mléčná užitkovost; přepočtové koeficienty; vztahy mezi laktacemi

Mikšík and Poul (1969) studied milk yield in an identical group of cows during five consecutive lactations. They observed that 1 175 Czech Pied cows produced 2 544.4 kg, 3 037.7 kg, 3 354.1 kg, 3 371.1 kg and 3 332.9 kg of milk in lactation one to five, respectively. The authors suggested coefficients for estimation of milk yield in the fourth (maximum) lactation based on the production in

previous lactations; the coefficient for the first lactation was 1.32, for the second 1.11 and the third 1.01.

Coefficients for estimation of milk yield of the same cows in different lactations have not been published in the Czech Republic since the above-mentioned paper. Many authors have studied milk yield in different lactations and the results could be used for calculation of estimation coefficients. However, the observed populations were not identical in all lactations. Thus, the calculated estimation coefficients would be skewed due to the selection of cows in later lactations and due to the lower breeding value of older cows.

Dědková and Wolf (2001) presented milk production results in the first three lactations of Czech Pied cows. Cows produced 3 963 kg, 4 541 kg and 4 739 kg of milk in the first, second and third lactations, respectively. Chrenek *et al.* (1996) found out milk yield in the first three lactations of Slovak Pied cows: 3 486.6 kg, 4 086.8 kg and 4 292.0 kg of milk. Kučera *et al.* (1999) presented milk yield of Czech Pied cows of C1 and C2 groups in the first three lactations: 3 642 kg, 4 106 kg and 4 328 kg of milk.

Chládek and Kučera (2002) studied in detail relationships between milk yields in the first three lactations of Holstein cows and their crosses. The observed cows produced 4 124.8 kg, 4 766.2 kg and 5 247.0 kg of milk in the first, second and third lactation. The estimation coefficient between the first and second lactation was 1.175, between the first and third lactation 1.297 and between the second and third lactation 1.119. The authors found a highly significant negative effect of milk

yield in the first lactation on estimation coefficients between all lactations. They also reported a significant positive relationship between estimation coefficients for the first and second lactation and the first and third lactation, while the relationship between the estimation coefficients for the first and second lactation (and/or first and third lactation) and the second and third lactation was negative. The breed had no significant effect on estimation coefficients between all lactations in their study.

Changes in dairy production management and production type of Czech Pied cattle in the last years have brought about a question whether the existing estimation coefficients for milk yield in different lactations were not affected. The aim of this paper was to quantify relationships between milk yield of the same cows in first three lactations with respect to their milk yield in the first lactation and proportion of Czech Pied breed in their genotype.

MATERIAL AND METHOD

The data on milk yield of 9 150 cows during the first three lactations were analysed. The cows were born in Northern Moravia region in the period from 1990 to 1995. They were divided into two groups according to the proportion of Czech Pied cattle in genotype. The first group (C1) included 3 176 cows with 75–100% of Czech Pied cattle; the second group (C2) included 5 974 cows with 50–74.9% of Czech Pied cattle in genotype. Furthermore, the cows were divided according to the level of milk yield into two groups, M1 (up to 3 999 kg) and M2 (above 4 000 kg) or into three

Table 1. Main statistical parameters of milk production in the observed groups of cows

Proportion of Czech Pied breed	n	first lactation (kg milk)			second lactation (kg milk)			third lactation (kg milk)		
		$\overline{x}$	$s_{\overline{x}}$	Vx	$\overline{x}$	$s_{\overline{x}}$	Vx	$\overline{x}$	$s_{\overline{x}}$	Vx
C1	3 176	3 799.5 [A]	800.2	21.06	4 348.5 [A]	979.8	22.46	4 676.7 [A]	1 069.6	22.87
C2	5 974	3 856.0 [B]	795.6	20.63	4 451.2 [B]	969.9	21.79	4 854.2 [B]	1 091.9	22.49
Total	9 150	3 836.4	797.8	20.80	4 415.5	973.5	20.05	4 792.6	1 087.4	22.69

The values in the same column marked with different letters (A, B) differ highly significantly ($P < 0.01$)
n = number of data
C1 = 75 to 100% of Czech Pied breed in genotype
C2 = 50 to 74.9% of Czech Pied breed in genotype

groups MI (up to 3 499 kg), MII (from 3 500 to 4 499 kg) and MIII (above 4 500 kg).

The relationships between lactations were described by individual estimation coefficients. Individual estimation coefficients between lactations (between first and second, first and third and between second and third) were calculated as a ratio of milk yield in later lactation to milk yield in earlier lactation. Estimation coefficients in groups (breed, milk yield) were calculated as simple mean values of individual coefficients. Main statistical parameters mean ($\bar{x}$), standard deviation ($s_{\bar{x}}$) and coefficient of variation (Vx) of the observed traits and phenotypic correlations (r) between them were calculated. The significance of differences was tested by GLM of Unistat 4.53.

RESULTS

The main statistical parameters of milk production in the first three lactations of observed cows are shown in Table I. The total mean milk yield was 3 836.4 kg in the first, 4 415.5 kg in the second and 4 792.6 kg in the third lactation. Milk yield of the cows with lower proportion of Czech Pied cattle (C2) was highly significantly higher in all lactations (by 56.5 kg, 102.7 kg and 177.5 kg) than in cows C1. Both parameters of variability ($s_{\bar{x}}$ and Vx) ranged from 795.6 and 20.63 in the first lactation, respectively, to 1 091.9 and 22.87 in the third lactation.

The estimation coefficients for relationships between the first three lactations with different milk yield in the first lactation are presented in Table 2.

The coefficients describing the relationship between the first and second lactation (1.283, 1.132 and 1.061) are highly significantly different in all three levels of milk yield (MI, MII and MIII). Similarly, highly significantly different were the coefficients between the first and third lactation (1.411, 1.230 and 1.132), also in all the three levels of milk yield. Similar results were found in the relationship between the second and third lactation (coefficients 1.117, 1.103 and 1.081); the differences between different levels of milk yield were highly significant.

The estimation coefficients between the first three lactations with respect to the level of milk yield and proportion of Czech Pied breed are shown in Table 3. The differences in estimation coefficients were found between group C1 and C2; the coefficients between the first and third lactation and between the second and third lactation were highly significantly different but no significant difference was found in the coefficients between the first and second lactation. The cows with lower milk yield in the first lactation (to 3 999 kg) showed highly significantly higher estimation coefficients than the cows with higher milk yield (above 4 000 kg). Highly significantly higher estimation coefficients between the cows with higher and lower milk yield were found in both sub-populations (C1 and C2). But the difference in the coefficients between the second and third lactation in sub-population C2 was only significant.

Effects of the estimation coefficients between milk yields in the first and second lactation on the coefficients between milk yields in the second and third lactation and the first and third lactation are

Table 2. Estimation coefficients between the first three lactations of cows with different milk yield in the first lactation

Milk yield in the first lactation	n	Estimation coefficients between lactations		
		first and second	first and third	second and third
Less than 3 499 kg (MI)	3 224	1.283 [A]	1.411 [A]	1.117 [A]
3 500 to 4 499 kg (MII)	4 137	1.132 [B]	1.230 [B]	1.103 [B]
More than 4 500 kg (MIII)	1 789	1.061 [C]	1.132 [C]	1.081 [C]
Total	9 150	1.171	1.274	1.103

The values in the same column marked with different letters (A, B, C) differ highly significantly ($P < 0.01$)

n = number of data

Table 3. Estimation coefficients between the first three lactations of cows with different milk yield in the first lactation according to the proportion of Czech Pied breed

Factor/Combination		n	Estimation coefficients between lactations		
			first and second	first and third	second and third
Proportion of	C1	3 176	1.164 aA	1.256 aA	1.094 aA
Czech Pied breed	C2	5 974	1.174 aA	1.284 bB	1.108 bB
Milk yield in the	less than 3 999 kg	3 224	1.283 aA	1.411 aA	1.117 aA
first lactation	more than 4 000 kg	5 926	1.110 bB	1.200 bB	1.097 bB
C1	less than 3 999	1 192	1.267 aA	1.387 aA	1.112 aA
	more than 4 000	1 984	1.103 bB	1.178 bB	1.084 bB
C2	less than 3 999 kg	2 032	1.292 aA	1.425 aA	1.119 aA
	more than 4 000	3 942	1.114 bB	1.212 bB	1.103 bA

The values of one factor or combination marked with different letters (a, b) and (A, B) in the same column are significantly different (*P* < 0.05) and highly significantly different (*P* < 0.01), respectively
n = number of data
C1 = 75 to 100% of Czech Pied breed in genotype
C2 = 50 to 74.9% of Czech Pied breed in genotype

Table 4. The effect of the estimation coefficient between first and second lactation on the coefficients between second and third or first and third lactation

Groups of estimation coefficients between first and second lactation	n	Mean values of estimation coefficients between lactations	
		second and third	first and third
Lower than 0.9	1 000	1.304 aA	1.046 aA
0.91 to 1.0	1 071	1.166 bB	1.111 bB
1.01 to 1.1	1 550	1.122 cC	1.180 cC
1.11 to 1.2	1 691	1.078 dD	1.237 dD
1.21 to 1.3	1 469	1.053 eE	1.315 eE
1.31 to 1.4	1 009	1.034 fF	1.391 fEF
1.41 to 1.5	636	1.032 gG	1.491 gEF
Higher than 1.51	724	1.018 hH	1.688 hF

The values in the same column marked with different letters (a–h) and (A–H) differ significantly (*P* < 0.05) and highly significantly (*P* < 0.01), respectively
n = number of data

described in Table 4. The data set was arranged according to the estimation coefficients between the first and second lactation, in ascending order from 0.9 to 1.51. The tendency of mean values of estimation coefficients between the first and third lactation was similar; it increased from minimum 1.046 to maximum 1.688. On the contrary, the mean values of estimation coefficients between the second and third lactation decreased from maximum 1.304 to minimum 1.018.

DISCUSSION

Our milk production data corresponded with results of most of the quoted authors who also observed Czech or Slovak Pied cattle. Only Mikšík and Poul (1969) presented a considerably lower milk yield that can be explained by the time when the studies were performed. Variability of the data set was comparable with results of Chládek et al. (1999) or Kučera et al. (1999). Milk yield in all lactations of cows with lower proportion of Czech Pied cattle was higher, which was most likely caused by a different size of sub-populations.

Our estimation coefficients were based on the data collected in the identical group of cows in all three lactations. Only Mikšík and Poul (1969) applied the same methods. Milk yield of the cows observed by those authors was by 30% lower than our values; however, their estimation coefficients were almost identical with ours. Chládek and Kučera (2002) applied the same methods in their study of Holstein cows. They also found only small differences in estimation coefficients (maximum 0.023) even though the milk yield of the analysed population was higher by 20%. In agreement with the above-mentioned authors we also found a significant negative relationship between milk yield in the first lactation and estimation coefficients for all lactations. But we found a more significant effect of the proportion of breed in genotype.

Other authors presented data on milk yield of a population of cows that was not identical in all three lactations. It is clear that milk performance of older cows in their later lactations was affected by various factors (most of all by selection and breeding value). The effect was higher with higher lactation number. This accounts for agreement of our estimation coefficient between the first and second lactation with possible coefficients calculated from

the results of Chrenek et al. (1996) or Dědková and Wolf (2001). Slightly different was our estimation coefficient between the second and third lactation and the coefficient that could be calculated from the results of Kučera et al. (1999) or Přibyl and Přibylova (2001). The difference was also found in the estimation coefficient between the first and third lactation in our study and the coefficient calculated from the results of Dědková and Wolf (2001) or Kučera et al. (1999).

The fact that higher values of estimation coefficients between the first and second lactation were accompanied by higher values of the coefficient between the first and third lactation but lower values of the coefficient between the second and third lactation can possibly be explained by subsequent compensation of lower milk yield in the second lactation.

The study quantified relationships between milk yield of Czech Pied cows in the first three lactations. A significant effect of milk yield in the first lactation on estimation coefficients was found; with increasing milk yield in the first lactation estimation coefficients between all lactations decreased. Proportion of breed affected estimation coefficients but less significantly than milk yield in the first lactation. Estimation coefficients between the first and third lactation significantly increased with increasing estimation coefficients between the first and second lactation while the coefficients between the second and third lactation significantly decreased.

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Original Paper

Comparison of production traits of Large White and White Meaty pig breeds for 1996 to 2001 in Slovakia

Porovnanie produkčných ukazovateľov materských plemien ošípaných biele ušľachtilé a biele mäsové za roky 1996 až 2001 na Slovensku

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ABSTRACT: Fattening performance and carcass value traits of Large White (LW) and White Meaty (WM) breeds were evaluated from data obtained at progeny testing stations (PTS) in Slovakia in the years 1996–2001. We recorded the following results: average daily gain (ADG) during fattening from 30 to 100 kg live weight 811.5 ± 1.31 g in LW breed and 803.9 ± 2.38 g in WM breed, feed consumption per 1 kg gain during fattening (FC) 2.95 ± 0.005 kg and/or 3.10 ± 0.010 kg, backfat thickness (BF) 19.2 ± 0.0006 mm in LW breed and 19.8 ± 0.001 mm in WM breed, proportion of lean cuts (PLC) 52.13 ± 0.04% in LW breed and 51.61 ± 0.07% in WM breed, proportion of meat from thigh (PMT) 21.12 ± 0.02% in LW breed and 20.86 ± 0.04% in WM breed and area of *musculus longissimus thoracis* (AMLT) 45.36 ± 0.07 cm² in LW breed and 44.73 ± 0.12 cm² in breed WM. The carcass traits, except backfat thickness, were improved under the influence of selection in both breeds compared with previous years. The analyses of variance of analyzed traits showed statistically significant differences between the years in ADG, PLC, PMT and AMLT. There were also statistically highly significant differences in all traits, except for ADG, between the LW and WM breeds. The difference was only statistically significant in ADG. The year x breed interactions were also highly significant in all traits.

Keywords: pigs; Large White; White Meaty; fattening performance; carcass value

ABSTRAKT: V práci sme hodnotili ukazovatele výkrmnosti a jatočnej hodnoty ošípaných bieleho ušľachtilého (BU) a bieleho mäsového (BM) plemena z podkladov získaných na stanici VJH na Slovensku v rokoch 1996 až 2001. Zaznamenali sme tieto výsledky: priemerný denný prírastok vo výkrme od 30 do 100 kg ž. hm. (PDPV) 811,5 ± 1,31 g pre BU a 803,9 ± 2,38 g pre BM, spotreba krmív na 1 kg prírastku vo výkrme od 30 do 100 kg (SKRM) 2,95 resp. 3,10 kg, hrúbka chrbtovej slaniny (HRCHS) 19,2 ± 0,0006 mm pre plemeno BU a 19,8 ± 0,001 mm pre plemeno BM, podiel cenných mäsových častí (PCMČ) 52,13 % resp. 51,61 %, podiel mäsa zo stehna (PMSTH) 21,12 % resp. 20,86 % a plocha *musculus longissimus dorsi* pre BU 45,36 cm2 a 44,73 cm² pre BM. Jednotlivé ukazovatele sa v porovnaní s minulými rokmi u obidvoch plemien vplyvom selekcie zlepšili. Analýzy rozptylu a interakcie ukazovateľov medzi rokmi a plemenami poukázali na štatisticky významné rozdiely v PDPV, PCMČ, PMSTH, PMLD. Aj medzi plemenami BU a BM boli štatisticky vysoko významné rozdiely vo všetkých ukazovateľoch, okrem PDPV.

Kľúčové slová: ošípané; biele ušľachtilé; biele mäsové; výkrmnosť; jatočná hodnota

An essential problem of pig selection and hybridisation in recent years in Slovakia has been the improvement of meat performance at reduced feed consumption per production unit maintaining simultaneously the required level of reproduction traits. Further success in this area is impossible without the optimisation of methods of breeding value estimates.

Modern pig breeding proceeds from well-defined selection objectives. If productivity improvement of purebred and hybrid pig populations is taken as a priority, the development of selection procedures in selection organisations has typically been focused on economic results. However, in addition to economically important traits, it is also necessary to consider biological factors.

Selection pressure in pigs in recent decades has been aimed at the improvement of production traits. Sellier (1982) reported on average 0.5 per cent annual improvement of growth traits and carcass value traits, in some cases even more. The traits such as efficiency of feed conversion and proportion of lean cuts have shown selection responses in some countries topping the average values by 2 per cent annually. That is why modern selection emphasises not only growth and carcass values but also an efficient reduction of *ad libitum* feed consumption (Riley, 1989).

Further increase in pig productivity can generally be expected due to fat content reduction in carcasses (via achieving lower limits for this trait), input reproduction or due to faster growth of lean meat proportion (Fowler *et al.*, 1976; Webb *et al.* 1989). With regard to this, it is necessary to constantly test our breeds for their fattening capacity and carcass value.

Fattening performance and carcass value traits of Large White (LW) and White Meaty (WM) pig breeds and their mutual crosses tested in 1980–1983 at Bučany Progeny Testing Station were evaluated by Fľak *et al.* (1994). Average daily gains of LW and WM breeds were 801.20 g and 790.68 g, respectively; *musculus longissimus thoracis* area (AMLT) values were 3 675 mm^2 and 3 534 mm^2, respectively; backfat thickness in the two breeds was the same, 24.1 mm. In the portion of lean cuts and proportion of meat from thigh LW ranked above WM 46.46% to 44.87%, respectively, and 18.66% to 17.94%, respectively. Feed consumption per 1 kg daily gain of LW and WM breeds ranged between 3.32 and 3.34 kg.

Subsequent evaluations of LW and WM breeds and their mutual crosses from all pig progeny testing stations in Slovakia were made by Fľak *et al.* (1994, 1997), Bobček *et al.* (1991, 1997), Bobček and Řeháček (2000), Peškovičová *et al.* (1997); in the Czech Republic Matoušek *et al.* (1999), Čechová *et al.* (1993), Čechová and Buchta (1995). Compared with the previous years, production traits showed an increasing trend, which was also confirmed by the cited authors.

MATERIAL AND METHODS

The basic data for the evaluation of pig fattening performance and carcass value were obtained from

Table 1. Review of the number of observations, marginal numbers and harmonic estimate number of observations

Years	LW	WM	n_i	N_i
1996	1 296	434	1 730	1 300.49
1997	1 028	327	1 355	992.34
1998	811	341	1 152	960.24
1999	1 041	278	1 319	877,62
2000	1 203	280	1 483	908.53
2001	1 330	320	1 650	1 031.75
n_j	5 629	1 980	8 689	8 677.00
N_j	6 520.36	1 936.69		

LW = Large White, WM = White Meaty

all progeny testing stations in Slovakia for the period 1996–2001.

The paper evaluates the following traits: average daily gain (ADG) during fattening from 30 to 100 kg live weight in g, feed consumption per 1 kg daily weight gain (FC), backfat thickness in mm (BF), proportion of lean cuts in % (PLC), proportion of meat from thigh in % (PMT), area of *musculus longissimus thoracis* in cm^2 (AMLT).

The obtained observations were evaluated using mathematical and statistical methods:
– determination of basic variation-statistical characteristics of individual traits,
– evaluation of the effect of years and genotypes based on two-factor analysis of variance with interaction of years Y and genotypes G with unequal number of observations in subclasses $Yi \times Gi$. In the case of significant $Y \times G$ interac-

tions the differences between the years within genotypes were tested by one-factor analysis of variance and differences between the genotypes by Student's *t*-test. The above mathematical and statistical methods were those used by Grofík and Flak (1990).

RESULTS AND DISCUSSION

The total number of LW and WM pigs tested at progeny testing stations in Slovakia in the period 1996–2001 is shown in Table 1. Marginal numbers and harmonic estimate numbers were calculated from the given data.

Evaluation of means, standard errors of means and estimates μi, μj, μ of fattening and carcass traits are shown in Tables 2 and 3 and Figures 1–6.

Table 2. Means and standard errors of means, and estimates μ_i μ_j and μ of fattening performance traits

Years	LW		WM		Total		
	$\overline{x}$	$s_{\overline{x}}$	$\overline{x}$	$s_{\overline{x}}$	$\overline{x}$	$s_{\overline{x}}$	μ_i
Average daily gain g (ADG)							
1996	830.71	2.90	832.16	4.93	831.52	2.50	831.47
1997	841.02	3.19	786.07	5.59	827.72	2.84	831.51
1998	819.08	3.73	816.25	5.81	818.17	3.14	817.67
1999	787.85	3.38	788.63	6.48	787.96	2.99	788.23
2000	786.11	3.03	793.05	6.25	787.32	2.73	789.52
2001	807.07	2.83	794.08	5.76	804.47	2.54	800.55
Total	811.49	1.31	803.95	2.38	809.77	1.69	
μ_j	811.91		801.65				μ = 806.78
Feed consumption per 1 kg average daily gain (FC)							
1996	3.08	0.011	3.19	0.019	3.10	0.009	3.14
1997	3.07	0.015	3.36	0.024	3.14	0.013	3.21
1998	3.02	0.014	3.09	0.021	3.04	0.011	3.05
1999	2.81	0.012	2.98	0.024	2.84	0.010	2.89
2000	2.88	0.012	2.95	0.025	2.89	0.011	2.91
2001	2.85	0.011	2.99	0.025	2.87	0.010	2.92
Total	2.95	0.005	3.10	0.010	2.98	0.046	
μ_j	2.95		3.09				μ = 3.02
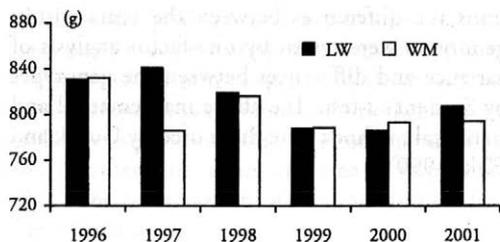
Figure 1. Average daily gains in LW and WM pigs (g)
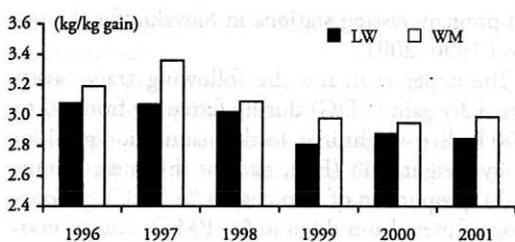
Figure 2. Feed consumption per 1 kg of weighga in LW and WM pigs (kg)
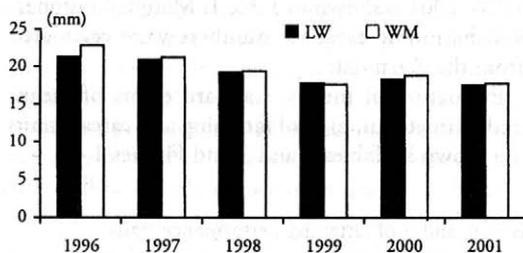
Figure 3. Backfat thickness in LW and WM pigs (mm)
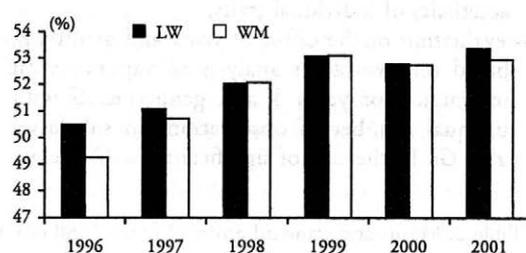
Figure 4. Proportion of lean cuts in LW and WM pigs (%)
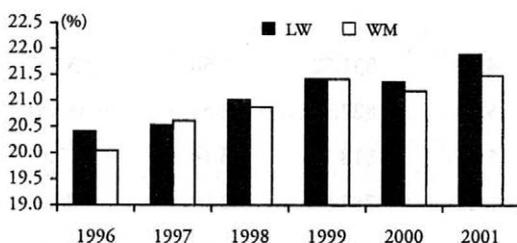
Figure 5. Proportion of meat from thigh in LW and WM pigs (%)
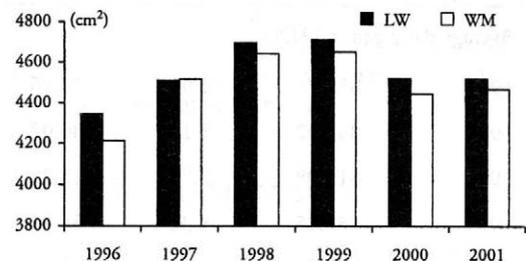
Figure 6. MLT area in LW and WM pigs (cm²)

The following results of average daily gains (ADG) from 30 to 100 kg live weight were obtained for the period 1996–2001: 811.93 ± 1.83 and 801.65 ± 3.43 g for LW and WM, respectively, feed consumption (FC) per 1 kg weight gain 2.95 ± 0.005 and 3.01 ± 0.013 kg for LW and WM, respectively.

In carcass value traits backfat thickness (BF) amounted to 19.2 ± 0.0007 and 19.6 ± 0.0014 mm for LW and WM, respectively, proportion of lean cuts (PLC) 52.13 ± 0.05 and 51.80 ± 0.08% for LW and WM, respectively, proportion of meat from thigh (PMT) 21.10 ± 0.02 and 20.93 ± 0.04%, respectively, and area of *musculus longissimus thoracis* (AMLT) 45.51 ± 0.08 and 44.90 ± 0.12 cm² for LW and WM, respectively. Individual traits were

improved under selection if compared with previous years (1991–1995), except for average daily gains in both LW and WM breeds (Fľak *et al.*, 1997).

Two-factor analyses of variance for fattening performance and carcass value traits by years and breeds are presented in Table 4. Statistically significant differences in fattening performance and carcass value traits can be emphasised in this evaluation as caused by years. Statistically highly significant differences between LW and WM breeds were found in all traits except for ADG and FC, which showed only significant differences. Year × breed interactions in carcass value traits were highly significant whereas they were only significant in fattening performance traits.

Table 3. Means and standard errors of means, and estimates $\mu_i \mu_j$ and μ of carcass value traits

Years	LW $\overline{x}$	LW $s_{\overline{x}}$	WM $\overline{x}$	WM $s_{\overline{x}}$	Total $\overline{x}$	Total $s_{\overline{x}}$	μ_i
Backfat thickness, mm (BF)							
1996	21.5	0.0013	22.8	0.0018	21.8	0.0011	22.1
1997	20.9	0.0013	21.2	0.0023	20.9	0.0011	21.0
1998	19.2	0.0015	19.4	0.0021	19.2	0.0012	19.3
1999	17.8	0.0013	17.6	0.0024	17.7	0.0011	17.7
2000	18.3	0.0013	18.8	0.0025	18.3	0.0012	18.5
2001	17.5	0.0012	17.7	0.0023	17.5	0.0011	17.6
Total	19.2	0.0006	19.8	0.0010	19.3	0.0005	
μ_j	19.2		19.5				$\mu = 19.4$
Proportion of lean cuts, % (PLC)							
1996	50.49	0.087	49.25	0.138	50.17	0.075	49.87
1997	51.08	0.099	50.72	0.164	50.99	0.086	50.90
1998	52.02	0.111	52.07	0.152	52.03	0.090	52.04
1999	53.06	0.098	53.09	0.165	53.06	0.085	53.07
2000	52.77	0.093	52.74	0.172	52.76	0.082	52.75
2001	53.35	0.087	52.93	0.155	53.26	0.077	53.14
Total	52.13	0.041	51.61	0.072	52.01	0.036	
μ_j	52.18		51.80				$\mu = 51.96$
Proportion of meat from thigh, % (PMT)							
1996	20.41	0.043	20.04	0.073	20.31	0.037	20.22ˑ
1997	20.53	0.049	20.61	0.086	20.54	0.043	20.57
1998	21.01	0.055	20.87	0.086	20.96	0.047	20.94
1999	21.41	0.050	21.41	0.097	21.41	0.044	21.41
2000	21.36	0.042	21.18	0.091	21.32	0.038	21.27
2001	21.89	0.040	21.48	0.077	21.81	0.036	21.68
Total	21.12	0.020	20.86	0.036	21.06	0.018	
μ_j	21.14		20.93				$\mu = 21.02$
Area of musculus longissimus thoracis, cm² (AMLT)							
1996	43.45	0.162	42.13	0.284	42.75	0.141	42.79
1997	45.11	0.184	45.18	0.252	45.13	0.152	45.14
1998	46.96	0.201	46.42	0.258	46.62	0.161	46.69
1999	47.12	0.181	46.51	0.305	46.78	0.157	46.81
2000	45.23	0.142	44.47	0.312	44.81	0.129	44.85
2001	45.20	0.154	44.70	0.271	44.96	0.135	44.95
Total	45.36	0.071	44.73	0.120	45.22	0.061	
μ_j	45.51		44.90				$\mu = 45.21$

Table 4. Two-factor analyses of variance for fattening performance and carcass value traits in Large White and White Meaty breeds of pigs

Trait		Years A $f_a = 5$	Breeds B $f_b = 1$	Interaction AB $f_{ab} = 5$	Error of experiment $f_e = 8\ 677$
ADG (g)	MS	308 398.32	157 389.65	130 125.48	11 018.38
	F	27.989**	14.284**	11.809**	
FC (kg)	MS	17.8771	29.9674	1.6720	0.1671
	F	106.963**	179.301**	10.004**	
BF (cm)	MS	37.8368	2.1942	0.7294	0.1931
	F	195.925**	11.362**	3.777**	
PLC (%)	MS	1 961.379	160.9754	69.9936	9.7065
	F	202.068**	16.584**	7.211**	
PMT (%)	MS	332.1166	43.1540	9.9217	2.3647
	F	140.445**	18.249**	4.195**	
AMLT (cm²)	MS	2402.94	555.6174	57.2604	30.6406
	F	78.423**	18.133**	1.868**	

$F_{0.05} (5. \infty) = 2.214$ $F_{0.05} (1. \infty) = 3.842$ $F_{0.01} (5. \infty) = 3.017$ $F_{0.01}(1. \infty) = 6.635$
ADG = average daily gain   PLC = portion of lean cuts (%)
FC = feed consumption per 1 kg of average daily gain HCHS   PMT = portion of meat from thigh (%)
BF = backfat thickness (mm)   AMLT = area of *musculus longissimus thoracis* (cm²)

Table 5. Significance of comparisons of means between years in Large White and White Meaty breeds

Trait	1 (1996)	2 (1997)	3 (1998)	4 (1999)	5 (2000)
Large White					
ADG	4,5,6,**	3,4,5,6,**	4,5,**	6**	6**
FC	3,4,5,6,**	3*,4,5,6,**	4,5,6,**	5**,6*	
BF	2,3,4,5,6,**	3,4,5,6,**	4,5,6,**	5**	6**
PLC	2,3,4,5,6,**	3,4,5,6,**	4,5,6,**		6**
PMT	3,4,5,6,**	3,4,5,6,**	4,5,6,**	6**,	6**
AMLT	2,3,4,5,6,**	3,4,**	5,6,**	5,6**	
White Meaty					
ADG	2,4,5,6,**	3**	4**		
FC	3*,2,4,5,6,**	3,4,5,6,**	4*,6*,5,**		
BF	2,3,4,5,6,**	3,4,5,6,**	4, 6,**	5**	6*
PLC	2,3,4,5,6,**	3,4,5,6,**	4, 6,**		
PMT	2,3,4,5,6,**	4,5,6,**	4,6,**		
AMLT	2,3,4,5,6,**	3,4,**	5,6,**	5,6**	

Table 6. Significance of comparisons of breed means within years

Trait	1996	1997	1998	1999	2000	2001
ADG		*				*
FC	*		*	*	*	*
BF	*					
PLC	*					*
PMT	*					*
AMLT	*				*	

Table 7. Linear regressions of the studied growth, fattening performance and carcass value traits by the year

Trait	Breed	a	s_a	b	s_b	R^2
ADG	LW	843.3866	15.5184	−8.9914	3.9847	0.5600
	WM	821.3600**	15.6644	−5.6314	4.0222	0.3288
	LW and WM	832.3733**	10.7341	−7.3114*	2.7562	0.4130*
FC	LW	3.1446**	0.6152	−0.5514*	0.0157	0.7528*
	WM	3.3273**	0.1001	−0.0668	0.0257	0.6281
	LW and WM	3.2360**	0.0736	−0.0610**	0.00189	0.5098**
BF	LW	2.2120**	0.0599	−0.0834**	0.0153	0.8801**
	WM	2.3033	0.0940	−0.0985	0.0241	0.8063*
	LW and WM	2.2576**	0.0526	−0.0910**	0.0135	0.8194**
PLC	LW	50.0873**	0.3653	0.5831**	0.0938	0.9061**
	WM	49.2520**	0.7046	0.7280*	0.1809	0.8018*
	LW and WM	49.6696**	0.3846	0.6555**	0.0987	0.8149**
PMT	LW	20.0726**	0.1351	0.9240**	0.0346	0.9472**
	WM	19.9866**	0.2171	0.2700**	0.0557	0.8542**
	LW and WM	20.0296**	0.1306	0.2820**	0.0335	0.8760**
AMLT	LW	44.5846**	1.3202	0.2648	0.3390	0.1323
	WM	43.8206**	1.5584	0.3088	0.4001	0.1296
	LW and BM	44.2026**	0.9399	0.2868	0.2413	0.1237

A survey of significance comparing year averages within breeds and breed averages within years is shown in Table 5. The comparison of breeds showed highly significant differences in all traits except for ADG and FC.

Fattening performance and carcass value traits were evaluated for LW and WM breeds in Slovakia by Fľak *et al.* (1994, 1997), Bobček *et al.* (1991, 1995), Bobček and Řeháček (2000), Peškovičová *et al.* (1997).

Table 8. Quadratic regressions of the studied growth, fattening performance and carcass value traits by the year

Trait	Breed	a	s_a	b	s_b	c	s_c	R^2
ADG	LW	865.7700	30.9281	−25.7789	20.2340	2.3982	2.8296	0.6450
	WM	843.4100**	31.3963	−22.1689	20.5403	2.3625	2.8724	0.4523
	LW and WM	854.5900**	19.9372	−23.9739	13.0435	2.3803	1.8240	0.5064*
FC	LW	3.2080	0.1296	−0.1026	0.1185	0.0067	0.0118	0.7771
	WM	3.3790**	0.2194	−0.1056	0.1435	0.0055	0.0200	0.6373
	LW and WM	3.2935**	0.1474	−0.1041	0.0964	0.0061	0.0134	0.5209*
BF	LW	23420**	0.0998	0.1809	0.0653	0.0139	0.0091	0.9324*
	WM	25450**	0.1298	−0.2798*	0.0849	0.0258	0.0118	0.9249*
	LW and WM	2.4435**	0.0780	−0.2303**	0.0510	0.0199*	0.0071	0.9031**
PLC	LW	49.2590**	0.5861	1.2043	0.3834	−0.0887	0.0536	0.9509*
	WM	47.0520**	0.4815	2.3780**	0.3150	−0.2357*	0.0440	0.9812**
	LW and WM	48.1555**	0.5076	1.7911**	0.3321	−0.1622**	0.0464	0.9214**
PMT	LW	20.0610**	0.2996	0.3027	0.1960	−0.0012	0.0274	0.9472*
	WM	19.4350**	0.3051	0.6837*	0.1996	−0.0591	0.0279	0.9415*
	LW and WM	19.7480**	0.2406	0.4932**	0.1574	−0.0301	0.0220	0.8974**
AMLT	LW	40.6830**	1.2737	3.1911*	0.8332	−0.4180*	0.1165	0.8359
	W	39.2840**	1.5962	3.7113*	1.0443	−0.4860*	0.1460	0.8145
	LW and BM	39.9835**	0.9549	3.4512**	0.6247	−0.4520**	0.0873	0.7795**

Comparison of these results with the present ones shows improvement of almost all carcass value traits whereas in fattening performance traits a decrease in average daily gains occurred both in LW and WM breeds.

Significant improvement was found in carcass value traits where backfat thickness was reduced from 23.2 to 17.5 mm, i.e. by 0.057 mm, and from 23.8 to 17.7, i.e. by 0.061 mm, for LW and WM, respectively, compared with 1991 and 2001 years. A significant increase occurred in the proportion of lean cuts between 1991 and 2001 for LW (from 48.90 to 53.35%, i.e. by 4.45%) and for WM (from 47.76 to 52.93%, i.e. by 5.17%). A similar increase was found in the proportion of meat from thigh (PMT) for LW, from 19.33 (1991) to 21.89% (2001), i.e. by 2.56%, and for WM, from 18.99 to 21.48% between 1991 and 2001, i.e. by 2.49%, in MLT area the increase was in LW from 43.45 cm² and in WM from 42.1 cm² to 44.70 cm² in both breeds. Fattening performance traits showed a decrease in average daily gain (ADG) for LW from 865 g (1991) to 807 g (2001), i.e. by 58

g; similarly for WM from 868 g to 794 g between 1991 and 2001, i.e. by 74 g, which was significantly influenced by the composition and quality of feed. Feed consumption per 1 kg gain (FC) decreased from 3.16 kg in LW (1991) to 2.85 kg (2001), i.e. by 0.31 kg; in WM from 3.24 kg to 2.99 kg between 1991 and 2001, i.e. by 0.25 kg.

The above facts also confirm the results of both linear and quadratic regressions of the studied traits as depending on the succession of years. A survey of parameters comparing linear and quadratic regressions by breeds and their total is shown in Tables 7 and 8. Except for ADG and AMLT the linear regression functions were significant to highly significant in all traits. The decrease in daily gain totalled 7.31 g but the reduction of feed consumption was 0.06 kg per year. Backfat thickness reduction totalled 0.009 mm as opposed to PMLC and PMT increases by 0.65 and 0.28%, respectively. Quadratic regressions confirmed these findings in linear trait evaluation, also confirming a highly significant linear trait at AMLT. The regression functions prove that selection and improvement

work, in spite of sometimes rather poor and even disputable results, has brought palpable progress in genetic evaluation of meat pigs.

CONCLUSION

The results show that it is important to check continually the fattening performance and slaughter value of our pure breeds and at progeny testing stations. It will help to increase the selection pressure, to improve and stabilize the desired traits in final types of pigs. It is necessary to pay more attention to a decrease in backfat thickness in pigs of White Meaty breed in selection and breeding work.

These results underline the positive selection and improvement work done in the last 10 years for the two most numerous pig breeds in Slovakia.

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The effect of drinker type and drinker height on the performance of broiler cockerels

Vliv typu napáječky a výšky umístění napáječky na užitkovost brojlerových kohoutků

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ABSTRACT: In this study, the effects of drinker type and drinker height on broiler performance were investigated. Standard nipple type, nipple with tray and round type drinkers were used, and these drinkers were adjusted at three different heights: low, medium and high. Broilers in the groups on round type drinkers and nipple with tray drinkers reached higher live weight compared with those in the groups in which nipple type drinkers were used ($P < 0.01$). The lowest live weight value on the 42nd day was determined as 2 010.60 g in the broilers on the nipple type drinkers. No difference was observed between low and medium height of nipple drinkers with respect to live weight and the live weight values on these drinkers were determined as 2 098.62 and 2 115.47 g, respectively. The live weights of broiler cockerels watered from nipple with tray and round drinkers at low, medium and high levels were determined as 2 267.54, 2 265.41, 2 200.76 g, respectively; and 2 291.38, 2 276.35, 2 215.14 g, respectively. Feed consumption was lower in the broiler cockerel groups on nipple type drinkers compared with the groups on nipple with tray and round drinkers ($P < 0.01$). The cumulative feed consumption values of broiler cockerels (on the 42nd day) watered from nipple, round and nipple with tray drinkers at low, medium and high levels were determined 3 718.23, 3 735.60, 3 614.78 g, respectively; and 3 976.80, 3 970.03, 3 826.52 g, respectively; and 4 035.70, 4 028.09, 3 941.52 g, respectively. Cumulative feed consumption was determined to be lower in the groups watered from nipple drinkers, compared with the groups on round and nipple with tray drinkers. No difference was determined between drinker types and between drinker heights with regard to feed conversion ratios and mortality rates. The feed conversion ratio in the groups was determined between 1.74 and 1.79. The effect of drinker type on litter moisture and water temperature was found significant ($P < 0.01$). The highest litter moisture and water temperature were determined in round drinkers.

Keywords: drinker; litter moisture; live weight; broiler

ABSTRAKT: V této studii jsme sledovali vliv typu napáječky a výšky napáječky na užitkovost brojlerových kohoutů. Použili jsme napáječky kapátkové standardního typu (bez odkapové misky), kapátkovou napáječku s odkapovou miskou a kloboukovou napáječku, napáječky byly zavěšeny ve třech výškách: nízko, středně vysoko a vysoko. Kuřata ve skupinách s kloboukovými napáječkami a kapátkovými napáječkami s odkapovou miskou dosáhla ve srovnání s kuřaty ve skupinách s kapátkovými napáječkami bez odkapové misky vyšší živé hmotnosti ($P < 0,01$). Nejnižší živou hmotnost ve 42. dnu věku 2 010,60 g jsme zaznamenali u kuřat napájených ze standardních kapátkových napáječek. Nezjistili jsme žádný rozdíl v živé hmotnosti mezi nízko a středně vysoko umístěnými kapátkovými napáječkami, přičemž živá hmotnost dosahovala u těchto napáječek 2 098,62 g resp. 2 115,47 g. Živá hmotnost brojlerových kohoutků napájených kapátkovými napáječkami s odkapovou miskou a kloboukovými napáječkami umístěnými nízko, středně vysoko a vysoko dosahovala těchto hodnot: 2 267,54; 2 265,41 a 2 200,76 g; resp. 2 291,38; 2 276,35 a 2 215,14 g. Spotřeba krmiva byla nižší ve skupinách brojlerových kohoutků u standardních kapátkových napáječek ve srovnání se skupinami u kapátkových napáječek s odkapovou miskou a kloboukových napáječek ($P < 0,01$). Hodnoty kumulativní spotřeby krmiva kohoutků do 42 dnů věku napájených ze standardních kapátkových,

kloboukových a kapátkových napáječek s odkapovou miskou umístěných nízko, středně vysoko a vysoko byly tyto: 3 718,23; 3 735,60 a 3 614,78 g; 3 976,80; 3 976,80 a 3 826,52 g; a 4 035,70; 4 028,09 a 3 941,52 g. Ve srovnání se skupinami u kloboukových a kapátkových napáječek s odkapovou miskou jsme u skupin napájených ze standardních kapátkových napáječek zaznamenali nižší kumulativní spotřebu krmiva. Pokud se jedná o konverzi krmiva a úhyn, nezjistili jsme žádný rozdíl mezi typy napáječek a výškami umístění napáječek. Konverze krmiva v jednotlivých skupinách se pohybovala od 1,74 do 1,79 kg. Vliv typu napáječky na vlhkost podestýlky a teplotu vody byl významný ($P < 0,01$). Nejvyšší vlhkost podestýlky a teplotu vody jsme zjistili u kloboukových napáječek.

Klíčová slova: napáječka; vlhkost podestýlky; živá hmotnost; brojlerové kuře

Water has a great effect on poultry performance. Water consumption by poultry depends on many factors such as ambient temperature, water temperature, water quality, age, poultry performance level, feed consumption, feed content and form.

Various researches were carried out with the aim of determining the effect of different drinker types on the performance of broilers (Carpenter *et al.*, 1990, 1992; Smith and McGhee, 1994; Brown *et al.*, 1995; May *et al.*, 1997). Different reports were coincided in these researches aimed at determining the effect of different drinker types on live weight. It was reported that bell drinkers gave significantly higher live weights in spring, summer and fall (Wabeck *et al.*, 1994). Lott *et al.* (2001), determined in their study that the broilers on open drinkers reached higher live weights than those on nipple drinkers. There are also research results indicating that chicks on nipple drinkers had a higher live weight in the 6th week compared with those on round drinkers, nearby these research findings (Günsan *et al.*, 1999). The effects of drinker type on feed consumption, feed conversion ratio and mortality rate of broilers were investigated by a number of researchers (Smith and McGhee, 1994; Lott *et al.*, 2001; Günsan *et al.*, 1999; Middelkoop and Harn, 1992; Hess *et al.*, 1994). On the other hand, the effect of drinker systems on litter moisture and the relation between litter quality and carcass quality were examined in the same studies.

MATERIAL AND METHODS

In this study, 675 commercial male broiler chicks were used as material. Standard nipple, nipple with tray and suspended round drinkers were used in the trial, and these drinkers were organized in three systems depending on their heights as low (no neck stretch and drink from the side of the beak), me-

dium (stretch neck and drink from the end of the beak) and high (first elevate the breast, then stretch the neck and drink from the end of the beak) (Lott *et al.*, 2001). Drinker heights were controlled daily and adjusted by visual inspection. The chicks were weighed using a balance at ± 0.1 g precision at the beginning of trial, and wing numbers were put on the chicks. The experimental group chicks were randomly distributed into 27 pens with a surface area of 1.25 × 2.0 m², 25 chicks in each pen. Wood-shavings were used as litter material. The litter material was laid at a thickness of 7–8 cm on the floor of the pens.

The chicks received a standard pelleted broiler starter diet (22.5% CP and ME 12.8 MJ/kg of diet) between the 1st and 14th day. A grower diet (22.0% CP and ME 13.3 MJ/kg of diet) was fed between the 15th and 28th day. A finisher diet (21.0% CP and ME 13.5 MJ/kg of diet) was administered between the 29th and 42nd day. The chicks were exposed to 24 hours light in the first week and 23 hours light and 1 hour dark at the end of the experiment. Water was supplied to both groups at *ad libitum* level by refreshing constantly. Feeding was performed at the same hours at night and daylight.

Temperature, humidity and other environmental factors were provided equally to each group during the trial. Live weight gain values were monitored through weekly individual weighing until the end of the 6th week, feed conversion ratios were calculated using the live weight gains and feed consumption values. The mortality values in each pen were recorded on the pen charts daily and the mortality rates in the groups were determined depending on these data. Moreover, litter conditions were determined considering the litter samples taken from the parts containing drinkers in each pen, in the 5th and 6th weeks. During the trial, water temperatures in the drinkers were determined daily at the same hour every day using a digital thermometer. Data

were analyzed by the general linear model program of SAS software (SAS, 1985) using Duncan's multiple range test to compare treatment means. Mortality data were analyzed using chi-square.

RESULTS

The effects of drinker type and height on live weight are given in Table 1. Effects of these parameters on live weight were found insignificant by the 28th day. These effects were significant on the 28th, 35th and 42nd day. The lowest daily increase in live weight was determined in broiler chicks included in the high nipple drinker group. Live weights of broiler chicks on nipple with tray and round drinker systems at low, medium and high drinker heights were statistically similar to each other.

The effects of drinker type and drinker height on live weight gain are given in Table 2. Effects of these parameters on live weight gain were significant on the 28th, 35th and 42nd day, being insignificant by the 28th day, similar to the case of live weight values.

The effects of drinker type and drinker height on feed consumption and feed conversion ratios are shown in Tables 3 and 4. Effects of these parameters on feed consumption were found significant on the 28th, 35th and 42nd day. In the study, feed consumption was determined to be lower in the broiler groups on nipple drinker, compared with broilers on round and nipple with tray drinkers. No difference was determined in drinker types and drinker heights with respect to feed conversion ratios. The effects of drinker type and drinker height on mortality are given in Table 4. No effect of these parameters on mortality rate was determined.

The effects of drinker type on litter moisture and water temperature are given in Tables 5 and 6, respectively. The effects of this parameter on drinker type and water temperature were found significant. The highest litter moisture and water temperature were determined with round drinkers. No statistical difference was determined between nipple and nipple with tray drinkers.

DISCUSSION

The broilers on round drinkers and nipple with tray drinkers reached higher live weight compared with those on nipple drinkers. The establishment of nipple drinkers at either low or medium height did not cause any difference between the live weights of broilers in these groups, however the lowest live weight value was determined in the broilers on high-nipple drinkers. The results obtained for live weight in the research were similar to the results of the research in which the effects of drinker type and drinker height on the performance of broilers were investigated (Lott *et al.*, 2001). Wabeck *et al.* (1994), Lott *et al.* (1998), determined a higher live weight value in broilers on round drinkers compared with broilers on nipple drinkers. However, Carpenter *et al.* (1992), and Middelkoop and Harn (1992), reported that the effects of nipple drinkers and open drinkers on broiler performance were similar to each other. In the research, feed consumption was determined to be lower in broilers on nipple drinkers compared with those on round and nipple with tray drinkers. This result is similar to the results of Smith and McGhee (1994), Middelkoop and Harn (1992). No difference was determined in drinker types and heights with respect to feed conversion ratios. The results obtained for this parameter are similar to the results of Lott *et al.* (2001). There are research results reporting that the use of nipple type drinkers in broilers improved the feed conversion ratio (Carpenter *et al.*, 1990; Günsan *et al.*, 1999). However, drinking from a nipple drinker is an unnatural drinking act for birds. Therefore, the further the neck has to be stretched, especially during a panting situation, the more detrimental the effect on body weight and feed: gain ratio (Lott *et al.*, 2001). No effect of drinker type could be determined with respect to mortality rates. This result is in accordance with the results of many researches (McMasters *et al.*, 1971; Gunsan *et al.*, 1999; Lott *et al.*, 2001). There are research results reporting that there was a relation between the drinker type used in a broiler house and the first week mortality rates, and the use of nipple drinkers reduced the first week mortality (Hess *et al.*, 1994).

In the study it was determined that the litter moisture ratio and water temperature were higher in round drinkers compared with nipple and nipple with tray drinkers. Wet litter, which is one of the factors adversely affecting the carcass quality, also leads to the production of an excessive amount of ammonia, thus negatively effecting the broiler house conditions. Günsan *et al.* (1999) determined the mean moisture ratio of the litter at the end of 6th week as 55.6 and 25.6% in round and nipple drinkers, respectively.

Table 1. The effects of drinker type and drinker height on live weights (g)

Drinker		Age (day)						
		day 1	day 7	day 14	day 21	day 28	day 35	day 42
Type	Height	NS	NS	NS	*	**	**	**
Nipple	Low	41.01 ± 052	138.40 ± 2.30	366.78 ± 8.90	790.66 ± 28.19	1235.55 ±42.21b	1652.41 ± 48.52b	2098.62 ± 44.81b
Nipple	Medium	41.95 ± 0.63	140.01 ± 2.21	363.45 ± 7.41	778.36 ± 27.33	1241.78 ± 62.71b	1678.49 ± 56.27b	2115.47 ± 51.12b
Nipple	High	41.80 ± 0.54	139.20 ± 2.41	369.21 ± 9.03	786.92 ± 18.21	1227.45 ± 53.82c	1610.54 ± 65.21c	2010.60 ± 61.22c
Nipple with tray	Low	42.04 ± 0.39	139.14 ± 2.25	365.12 ± 7.55	795.36 ± 19.57	1311.03 ± 49.57a	1746.41 ± 44.41a	2267.54 ± 49.34a
Nipple with tray	Medium	42.10 ± 0.66	139.48 ± 1.98	364.18 ± 8.28	773.64 ± 26.62	1300.23 ± 44.13a	1727.12 ± 59.43a	2265.41 ± 51.65a
Nipple with tray	High	41.90 ± 0.57	141.02 ± 2.25	370.22 ± 9.30	780.25 ± 23.33	1229.51 ± 6158b	1642.45 ± 66.53b	2200.76 ± 62.14a
Round	Low	41.70 ± 0.63	139.65 ± 2.94	361.25 ± 10.10	785.16 ± 16.37	1320.36 ± 50.30a	1752.54 ± 54.54a	2291.38 ± 65.56a
Round	Medium	42.08 ± 0.62	140.25 ± 2.73	367.27 ± 8.89	793.62 ± 22.21	1295.77 ± 66.62a	1736.45 ± 52.36a	2276.35 ± 45..38a
Round	High	41.87 ± 0.59	138.89 ± 2.66	368.29 ± 9.90	781.55 ± 17.43	1238.25 ± 58.34b	1700.25 ± 64.83a	2215.14 ± 71.11a

Table 2. The effects of drinker type and drinker height on live weight gains (g)

Drinker		Period (wk)					
		1	2	3	4	5	6
Type	Height	NS	NS	NS	*	**	**
Nipple	Low	96.39 ± 4.21	228.38 ± 20.15	423.88 ± 27.59	444.89 ± 29.45b	416.86 ± 18.69a	446.21 ± 22.14b
Nipple	Medium	98.06 ± 4.86	223.44 ± 19.78	414.91 ± 24.41	463.42 ± 30.12b	436.71 ± 19.84a	436.98 ± 21.69b
Nipple	High	97.40 ± 4.30	230.01 ± 20.43	417.71 ± 25.09	440.53 ± 24.40b	383.09 ± 17.42b	400.06 ± 18.57c
Nipple with tray	Low	97.10 ± 3.93	225.98 ± 19.90	430.24 ± 29.14	515.67 ± 32.87a	426.38 ± 19.87a	521.13 ± 25.47a
Nipple with tray	Medium	97.38 ± 4.25	224.70 ± 19.69	409.46 ± 22.30	526.59 ± 33.10a	426.89 ± 17.97a	538.29 ± 28.81a
Nipple with tray	High	99.12 ± 5.23	229.20 ± 20.16	410.03 ± 23.00	449.26 ± 27.66b	412.94 ± 18.46ab	558.31 ± 29.52a
Round	Low	97.95 ± 4.40	221.60 ± 21.14	423.91 ± 24.66	535.20 ± 35.17a	432.18 ± 18.53a	538.84 ± 27.44a
Round	Medium	98.17 ± 3.79	227.02 ± 20.14	426.35 ± 25.79	502.15 ± 32.48a	440.68 ± 21.24a	539.90 ± 26.87a
Round	High	97.02 ± 3.47	229.40 ± 19.78	413.26 ± 21.98	456.70 ± 28.12b	462.00 ± 18.78a	514.89 ± 29.50a

a, b, c = the values in columns with no common letter differ significantly ($P < 0.05$), ($P < 0.01$); *$P < 0.05$; **$P < 0.01$

Table 3. The effects of drinker type and drinker height on weekly feed consumption and cumulative feed consumption values (g)

Drinker		Period (wk)					
		1	2	3	4	5	6
Type	Height	NS	NS	NS	*	*	**
Nipple	Low	121.12 ± 7.10	290.15 ± 11.15	693.20 ± 25.47	720.10 ± 29.65b	850.00 ± 16.47b	1 043.66 ± 26.73c
			411.27 ± 50.32	1 104.47 ± 78.57	1 824.57 ± 30.52b	2 674.57 ± 30.69b	3 718.23 ± 123.48c
	Medium	121.22 ± 7.12	287.00 ± 11.08	678.41 ± 21.52	743.20 ± 30.14b	885.63 ± 17.58a	1 020.14 ± 24.54c
			408.22 ± 48.52	1 086.63 ± 76.48	1 829.83 ± 32.88b	2 715.46 ± 31.50a	3 735.60 ± 124.54c
	High	120.65 ± 6.98	285.40 ± 9.20	705.73 ± 24.78	713.67 ± 29.87b	841.13 ± 15.87b	948.20 ± 25.39c
			406.05 ± 47.16	1 111.78 ± 80.12	1 825.43 ± 33.11b	2 666.58 ± 29.78b	3 614.78 ± 121.87c
Nipple with tray	Low	121.19 ± 7.52	291.18 ± 10.57	715.40 ± 26.49	782.90 ± 35.40a	915.50 ± 17.40a	1 150.63 ± 33.27b
			.412.37 ± 51.21	1 127.77 ± 81.44	1 910.67 ± 68.12a	2 826.17 ± 112.21a	3 976.80 ± 163.54b
	Medium	119.68 ± 6.69	288.20 ± 15.41	700.10 ± 23.62	780.73 ± 36.35a	920.62 ± 15.78a	1 160.70 ± 34.52b
			07.88 ± 47.53	1 107.98 ± 78.69	1 888.71 ± 57.14a	2 809.33 ± 98.65a	3 970.03 ± 162.14b
	High	122.60 ± 7.95	293.35 ± 12.44	702.60 ± 24.28	710.45 ± 29.58b	823.12 ± 17.63b	1 174.40 ± 38.87b
			415.95 ± 54.08	1 118.55 ± 80.69	1 829.00 ± 41b	2 652.12 ± 27.32b	3 826.52 ± 154.47b
Round	Low	120.78 ± 6.78	290.00 ± 13.59	705.52 ± 24.68	790.71 ± 37.00a	893.38 ± 15.39a	1 235.31 ± 31.21a
			410.78 ± 50.25	1 116.30 ± 79.95	1 907.01 ± 64.47a	2 800.39 ± 89.13a	4 035.70 ± 221.19a
	Medium	120.89 ± 6.47	281.22 ± 10.54	698.44 ± 24.96	785.25 ± 34.12a	900.74 ± 16.24a	1 241.55 ± 30.14a
			402.11 ± 44.87	1 100.55 ± 75.18	1 885.80 ± 52.46a	2 786.54 ± 68.47a	4 028.09 ± 219.78a
	High	121.93 ± 5.63	290.54 ± 12.35	700.15 ± 22.14	714.47 ± 30.78b	892.33 ± 19.14a	1 222.10 ± 31.88a
			412.47 ± 52.14	1 112.62 ± 81.79	1 827.09 ± 31.10b	2 719.42 ± 35.12a	3 941.5 ± 157.25a

a, b, c = the values in columns with no common letter differ significantly ($P < 0.05$), ($P < 0.01$)

Table 4. The effects of drinker type and drinker height on feed conversion ratios from 1 to 6 wk of age and mortality

Drinker		Period (wk)						Mortality rate (%)
Type	Height	1	2	3	4	5	6	
		NS	NS	NS	NS	NS	NS	NS
Nipple	Low	0.87 ± 0.08	1.12 ± 0.09	1.39 ± 0.07	1.48 ± 0.06	1.62 ± 0.05	1.77 ± 0.08	5.33
	Medium	0.86 ± 0.07	1.12 ± 0.10	1.39 ± 0.07	1.47 ± 0.05	1.62 ± 0.05	1.76 ± 0.08	6.66
	High	0.86 ± 0.07	1.09 ± 0.08	1.41 ± 0.06	1.49 ± 0.06	1.65 ± 0.07	1.79 ± 0.09	4.00
Nipple with tray	Low	0.87 ± 0.08	1.13 ± 0.11	1.42 ± 0.09	1.46 ± 0.05	1.62 ± 0.06	1.75 ± 0.07	4.00
	Medium	0.85 ± 0.07	1.11 ± 0.09	1.43 ± 0.10	1.45 ± 0.04	1.63 ± 0.06	1.75 ± 0.07	5.33
	High	0.87 ± 0.07	1.12 ± 0.11	1.43 ± 0.09	1.48 ± 0.06	1.61 ± 0.08	1.74 ± 0.08	4.00
Round	Low	0.86 ± 0.06	1.13 ± 0.09	1.42 ± 0.08	1.44 ± 0.04	1.59 ± 0.04	1.76 ± 0.06	4.00
	Medium	0.86 ± 0.07	1.09 ± 0.09	1.38 ± 0.09	1.45 ± 0.06	1.60 ± 0.04	1.77 ± 0.05	4.00
	High	0.88 ± 0.08	1.12 ± 0.10	1.42 ± 0.08	1.47 ± 0.07	1.60 ± 0.05	1.78 ± 0.07	6.66

a, b, c = the values in columns with no common letter differ significantly

Table 5. The effects of drinker type on litter moisture (%)

Drinker type	Period (day)		
	day 28	day 35	day 4
	*	*	**
Nipple	23.5 ± 1.20b	26.3 ± 1.41b	29.4 ± 1.44b
Nipple with tray	22.4 ± 1.23b	25.1 ± 1.39b	28.6 ± 1.61b
Round	30.5 ± 1.43a	41.7 ± 1.54a	58.5 ± 1.81a

a, b, c = the values in columns with no common letter differ significantly

Table 6. The effects of drinker type on water temperature (°C)

Drinker type	Period (day)			
	day 21	day 28	day 35	day 42
	*	*	**	**
Nipple	21.40 ± 0.33b	18.95 ± 0.33b	15.25 ± 0.33b	13.18 ± 0.33b
Nipple with tray	21.37 ± 0.33b	18.80 ± 0.33b	15.40 ± 0.33b	13.10 ± 0.33b
Round	23.54 ± 0.33a	20.69 ± 0.33a	16.95 ± 0.33a	14.87 ± 0.33a

a, b, c = the values in columns with no common letter differ significantly ($P < 0.05$), ($P < 0.01$)

$*P < 0.05$; $**P < 0.01$

After these results obtained from the study were evaluated, it was concluded that the nipple with tray drinker which optimizes the growth and feed conversion at every age, which could be adjusted at different heights from the ground and which does not lead to wettening of litter and so does not bring about any problems in carcass quality was most suitable.

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Carcass quality in crossbred bulls in relation to SEUROP system grading

Kvalita jatečných těl býků-kříženců v závislosti na zatřídění v systému SEUROP

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ABSTRACT: The aim of this study was to contribute to an explanation of relations in the composition of cattle dressed carcasses in relation to carcass grade. By measuring dressed carcasses statistically highly significant differences ($P < 0.01$) were found between the grades in the length of dressed carcass (125.00–131.68 cm), round length (76.88–80.50 cm), round girth (111.38–118.82 cm), spiral round girth (157.79–166.09 cm) and in the dressed carcass weight/length ratio (2.33–2.69 kg/cm). Statistically highly significant differences ($P < 0.01$) were found between the grades in the weight of prime cuts (E 133.44 kg, U 121.86 kg, R 109.65 kg), 2nd grade meat (E 143.29 kg – R 117.42 kg) and meat as a whole. Evaluation of the percentual proportion of meat in dressed carcass showed statistically significant differences ($P < 0.05$) only between class U (79.06%) and class R (77.96%). The bone percentage in dressed carcass reached the maximum value in class R (19.72%), which was statistically highly significantly ($P < 0.01$) more than in class U (18.60%) and significantly ($P < 0.05$) more than in class E (18.55%). In evaluating the amount of separable fat the differences between the grades were not assessed as statistically significant ($P > 0.05$).

Keywords: slaughter cattle; carcass grade; carcass composition

ABSTRAKT: Cílem této studie bylo přispět k objasnění poměrů ve skladbě jatečně upravených těl skotu v závislosti na jatečné třídě. Při měření rozměrů JUT byly zjištěny statisticky vysoce významné rozdíly ($P < 0,01$) mezi třídami v délce JUT (125,00–131,68 cm), délce kýty (76,88–80,50 cm), obvodu kýty (111,38–118,82 cm), spirálním obvodu kýty (157,79–166,09 cm) a poměru hmotnost/délka JUT (2,33–2,69 kg/cm). Mezi třídami byly zjištěny statisticky vysoce významné ($P < 0,01$) diference ve hmotnosti masa I. jakosti (E 133,44 kg; U 121,86 kg; R 109,65 kg), II. jakosti (E 143,29 až R 117,42 kg) a masa celkem. Při hodnocení procentického podílu masa v JUT byly statisticky významné ($P < 0,05$) rozdíly pouze mezi třídami U (79,06 %) a R (77,96 %). Procento kostí v JUT dosáhlo nejvyšší hodnoty ve třídě R (19,72 %), což bylo statisticky vysoce významně ($P < 0,01$) více než u třídy U (18,60 %) a signifikantně ($P < 0,05$) více než u třídy E (18,55 %). Při posuzování množství oddělitelného tuku nebyly zjištěné rozdíly mezi třídami vyhodnoceny jako statisticky významné ($P > 0,05$).

Klíčová slova: jatečný skot; jatečná třída; skladba jatečného těla

An increase in consumer prices of meat and health problems in cattle husbandry connected with food safety led to a decreased demand in particular for beef. A steep fall of cow stocks in the first six years after transition to market economy resulted in a relative surplus of beef. It became evident in the carcass grade system and prices of slaughter cattle. After the marked decrease in cattle stocks terminated, a decrease in slaughter cattle production and hence in beef production occurred. The described changes in cattle husbandry evoked a reduction of beef consumption in the last ten years, which at present makes less than 50% of its initial consumption. The most important indicator for breeders and for the processing industry is the carcass value of animals expressed by carcass yield, net weight gain, and carcass and meat quality. The aim of the improvement and technology of breeding commercial beef cattle types is to reduce the production of internal and subcutaneous fat, to increase the meat proportion and to improve the meat/bone ratio in dressed carcass. The objective evaluation of cattle carcasses then considerably affects the aims and trends of breeding and the proper production of slaughter cattle. In view of the markedly higher heterogeneity of the characteristics and traits of beef efficiency of the whole cattle population resulting from the use of different commercial types (breeds and hybrids) for quite a different final production (milk, meat), the problems of the objective evaluation of carcasses are more complicated than for instance in pigs. In spite of the adoption of carcass evaluation by the SEUROP system (CSN 46 6120) it is desirable to limit as much as possible a subjective interfering of classifiers in the evaluation of carcasses in slaughterhouses. One of the alternatives is to use instrumental methods for the grading of cattle carcasses by which the content of meat, fat and bones, and commercially usable parts in dressed carcass can be determined.

The results of carcass dissection in different commercial cattle types were described in foreign and Czech literature by many authors. The relations between the results of cattle carcass grading in regard to fleshing and fat content (EUROP and later SEUROP standards) and the percentual content of carcass tissues were studied in substantially fewer publications. Reinsch et al. (1999) calculated the coefficient of heritability for carcass grade by EUROP system for over 200 thousand head of cattle on a level of 0.12–0.20. At the same time the relations between net weight gain, market value, quality grade

of beef in dependence on fleshing and fat score were evaluated in the paper. The correlations between the grade of cattle carcasses and some parameters of carcass value in Fleckvieh were studied by Strapak and Auman (1998). The data analysis indicated the relations between carcass measurements and carcass weight ($r = 0.189$–0.250), and between the proportions of meat in dressed carcass and carcass grade by EUROP standard ($r = -0.008$ to 0.223). The estimation of the stated carcass values pointed at the correlations between the measurements of carcass depth and width and all the observed parameters of meat production ($r = 0.075$–0.260 and $r = 0.200$–0.356, respectively). Significant relations were assessed between the parameters of carcass fleshing and the traits of meat production ($r = 0.322$–0.530). The values of correlation coefficients for partial characteristics of body and round muscling were 0.303–0.506 and 0.322–0.536, respectively. A less favourable classification of the body meatiness in EUROP system and an inclinable fatty cover of the carcass in animals from organic management compared with conventional husbandry were found by Hansson et al. (2000). Kögel et al. (2000) described a better evaluation of carcass meatiness of crossbreds with Blonde d'Aquitaine and Charolaise breeds slaughtered at a higher age (+5 weeks) compared with the early matured crossbreds of Fleckvieh and Limousine. Fiems et al. (2000) studied the effects of fleshing (bulls with and without double muscling) of the Belgian Blue cattle on the relations between carcass grade and fat class evaluated by SEUROP standard and the anatomical content in the carcass and the qualitative parameters. Čuboň et al. (2000) classified the carcasses of bulls and heifers of the Slovak Pied Cattle and its crossbreds with beef breeds by EUROP standard. They reported significant value differences between the contents of meat in different carcass grades. The highest content of meat in bull carcasses was 78.78% in class E, gradually decreasing to the value of 74.50% in class O. At the same time the proportion of bones in the carcass increased from 15.97% in class E to 18.35% in class O. The same trend of values was observed in the proportion of separable fat in dressed carcasses (E = 5.27% and O = 7.13%, resp.) Significant differences were also found between the proportions of separable fat in different classes by fat score. The lowest content of separable fat in bulls was in the first class (2.78%). Then the fat content in bulls gradually increased through classes, and the highest content of separable fat was found in class 5 (8.96%). The content of meat

and bones in the carcass decreased as fat in classes 1–5 increased. The ratio of meat was 78.63% in 1st class of fat, gradually decreasing to 74% in class 5. The content of bones gradually decreased from 18.56% in class 1 to 16.08% in class 5.

MATERIAL AND METHODS

Within the framework of Research Project QC 1083 eighty-seven bulls of Czech Pied Cattle crossed with beef breeds were slaughtered in the period from 19 June 2001 to 4 December 2001. The bulls were slaughtered after intensive fattening at the average slaughter age of 501 days (Table 1). The weight of the animals at the end of fattening is affected by daily average gain and by birth weight of calves. The mean daily gain made 1 014 g in all monitored animals.

After bull slaughter, 24-hour cooling and dissection of right half-carcasses, the dimensions of carcasses, i.e. carcass length, round length, girth, width, depth, and chest depth, were measured. The measurements were performed in accordance with the methodology described by Šubrt et al. (2000).

The aim of dissection of the right half-carcass, i.e. right fore and hindquarters, was to obtain data for assessment of the technological quality of carcasses. It concerns an objective determination of the portions of retail parts, content of meat, bones and fat in the carcass of the evaluated animal. After the dissection of right half-carcasses was completed, the weights of tissues (meat, i.e. muscles with inter- and intramuscular fat, separable fat, and bones) were determined. In case the carcass was bisected unequally and the differences between the left and right half-carcasses exceeded 2 kg, both half-carcasses were dissected.

Table 1. Basic characteristics of the set

Indicator		E	U	R	Set
	n	11	56	20	87
Slaughter age (days)	x	500.09	501.64	499.70	501.00
	s	5.92	5.35	3.60	5.10
	v	1.18	1.07	0.72	1.02
Slaughter weight (kg)	x	603.00[ef]	552.82[df]	504.15[de]	547.98
	s	41.41	32.79	45.03	46.73
	v	6.87	5.93	8.93	8.53
Daily gain (g)	x	1126.02[ef]	1022.34[df]	929.03[de]	1 014.00
	s	85.36	65.20	91.82	93.59
	v	7.58	6.38	9.88	9.23
Carcass yield (%)	x	58.76	58.16	58.05	58.21
	s	0.83	1.08	1.71	1.23
	v	1.41	1.86	2.95	2.11
Weight of carcass (kg)	x	354.36[ef]	321.43[df]	292.50[de]	318.94
	s	25.78	18.82	25.90	27.91
	v	7.28	5.86	8.85	8.75
Daily net weight gain (g)	x	708.80[ef]	640.81[df]	585.48[de]	636.68
	s	54.12	37.69	53.25	56.23
	v	7.64	5.88	9.10	8.83

a(E), b(U), c(R) – $P < 0.05$
d(E), e(U), f(R) – $P < 0.01$

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Table 2. Measurements of dressed carcass by carcass grades

Indicator		E	U	R	Set
	n	11	54	17	82
Length of carcass (cm)	x	131.68[ef]	127.80[ce]	125.00[be]	127.74
	s	4.01	3.73	4.52	4.33
	v	3.05	2.92	3.62	3.39
Length of round (cm)	x	80.50[bf]	78.74[af]	76.88[de]	78.59
	s	2.17	2.43	2.25	2.56
	v	2.70	3.09	2.93	3.26
Round fullness (cm)	x	42.91[b]	41.10[a]	40.76	41.27
	s	3.15	2.68	2.53	2.76
	v	7.34	6.52	6.21	6.69
Width of round (cm)	x	28.91	28.14	26.35[de]	27.87
	s	1.28	1.25	1.33	1.50
	v	4.43	4.44	5.05	5.38
Girth of round (cm)	x	118.82[ef]	115.05[f]	111.38[e]	114.80
	s	5.64	2.74	2.46	3.83
	v	4.75	2.38	2.21	3.34
Spiral girth of round (cm)	x	166.09[ef]	161.90[f]	157.79[e]	161.61
	s	5.55	4.47	4.51	5.16
	v	3.34	2.76	2.86	3.19
Depth of chest (cm)	x	39.59	40.56	40.29	40.38
	s	3.46	3.10	1.88	2.93
	v	8.74	7.64	4.67	7.26
Ratio of carcass weight/length (kg/cm)	x	2.69[ef]	2.51[f]	2.33[e]	2.50
	s	0.13	0.12	0.17	0.17
	v	4.83	4.78	7.30	6.80

a(E), b(U), c(R) – $P < 0.05$
d(E), e(U), f(R) – $P < 0.01$

The dissection was carried out pursuant to CSN 57 6510 standard "Beef for market" and yield standards of the meat industry No. H2-04 and H2-08.

For the basic statistical data processing the statistical package UNISTAT (UNISTAT®, 1984) was used. Differences between the parameters were tested by t-test.

RESULTS AND DISCUSSION

The evaluation of growth intensity in relation to the carcass grade is shown in Table 1. Significant differences were found between all carcass grades in daily gain from birth to slaughter, and in net weight gain. The dressing percentage decreased

from 58.76% in class E to 58.05% in class R. Net weight gain decreased (709–585 g) with worse classification of carcasses by meatiness.

The results of the measurements can be seen in Table 2. The highest ($P < 0.01$) average value of carcass length was found in class E (131.68 cm) as compared with the other classes while a statistically significant difference ($P < 0.05$) was determined between U and R classes. The shortest round ($P < 0.01$) was found in class R (76.88 cm). The average value of the round fullness amounted to 41.2 cm

in the whole set where a statistically significant difference ($P < 0.05$) was determined between E and U classes. Highly significant differences ($P < 0.01$) were found by measuring the round width between R (26.35 cm), E (28.91 cm) and U (28.14 cm) classes. In measuring the girth and spinal girth of the round the highest values were found in class E (118.82 cm; 166.38 cm) followed by class U (115.05 cm; 161.90 cm) and class R (111.38 cm; 157.79 cm). In this case, statistically highly significant differences ($P < 0.01$) were found

Table 3. Content of meat in dressed carcass by carcass grades

Indicator		E	U	R	Set
	n	11	50	11	72
Grade II meat (kg)	*x*	143.29[ef]	130.16[f]	117.42[e]	130.22
	s	11.86	8.15	17.56	12.69
	v	8.28	6.26	14.95	9.75
Grade II meat/carcass (%)	*x*	40.88	40.82	40.20	40.73
	s	1.34	1.31	1.74	1.39
	v	3.28	3.21	4.33	3.41
Prime cuts (kg)	*x*	133.44[ef]	121.86[f]	109.65[e]	121.76
	s	9.70	6.51	11.25	10.21
	v	7.27	5.34	10.26	8.39
Prime cuts/carcass (%)	*x*	38.09	38.24	37.76	38.14
	s	1.11	1.26	2.07	1.38
	v	2.91	3.29	5.48	3.62
Meat (kg)	*x*	276.74[ef]	252.02[f]	227.07[e]	251.98
	s	20.49	12.90	27.28	21.68
	v	7.40	5.12	12.01	8.60
Meat/carcass (%)	*x*	78.97	79.06[c]	77.96[b]	78.87
	s	1.47	1.27	1.71	1.41
	v	1.86	1.61	2.19	1.79
Prime cuts/grade II meat ratio	*x*	0.93	0.94	0.94	0.94
	s	0.05	0.05	0.08	0.06
	v	5.38	5.32	8.51	6.38

a(E), b(U), c(R) – $P < 0.05$
d(E), e(U), f(R) – $P < 0.01$

Table 4. Content of bones in dressed carcass by carcass grades

Indicator		E	U	R	Set
	n	11	50	11	72
Butcher's bones (kg)	x	20.52[f]	18.26[e]	18.23	18.60
	s	3.13	2.15	3.44	2.63
	v	15.25	11.77	18.87	14.14
Butcher's bones/carcass (%)	x	5.86	5.72[f]	6.26[e]	5.83
	s	0.77	0.58	0.85	0.68
	v	13.14	10.14	13.58	11.63
Technical bones (kg)	x	44.47[ef]	41.09	38.94	41.28
	s	4.15	3.43	3.73	3.87
	v	9.33	8.35	9.58	9.38
Technical bones/carcass (%)	x	12.70	12.88[f]	13.47[e]	12.94
	s	0.86	0.70	1.41	0.88
	v	6.77	5.43	10.47	6.80
Bones (kg)	x	64.99[ef]	59.35	57.17	59.88
	s	6.27	4.90	5.67	5.66
	v	9.65	8.26	9.92	9.45
Bones/carcass (%)	x	18.55	18.60	19.72[de]	18.77
	s	1.30	1.02	1.40	1.18
	v	7.01	5.48	7.10	6.29

a(E), b(U), c(R) – $P < 0.05$
d(E), e(U), f(R) – $P < 0.01$

between all classes. The average value of the chest depth amounted to 40.38 cm for all data set, the differences between individual classes being evaluated as statistically insignificant. The highest value of the carcass weight/length ratio was found in class E where it was 2.69 kg/cm. U (2.51 kg/cm) and R (2.33 kg/cm) classes followed in descending order. The statistical evaluation of the differences between the individual classes was significant at a level ($P < 0.01$). Our results of morphometric measurements of carcasses evaluated by the carcass grade correspond with the results reported by Strapak and Aumann (1998).

The proportion of meat in dressed carcass is shown in Table 3. The total weight of 2nd grade meat ranged from 117.42 kg in class R to 143.29 kg in class E. Statistically highly significant differences were found between all classes ($P < 0.01$). The percentual proportion of grade II meat was 40.73% on average. The weight of prime cuts ranged from 109.65 kg in class R to 143.29 kg in class E. The differences between the classes were statistically highly significant ($P < 0.01$). The percentual proportion of prime meat was between of 37.76% and 38.24% (R and U, resp.) while the differences between the groups were not statistically significant. The highest total weight of meat in the carcass was 276.74 kg in class E, which was by 24.72 kg more than in class U and by 49.69 kg more than in class R. The differences between the individual groups were found as statistically highly significant ($P < 0.01$). The lowest percentual pro-

Table 5. Meat/bone ratio

Indicator		E	U	R	Set
	n	11	50	11	72
Meat/bone ratio in forequarters	*x*	3.96	4.04[c]	3.72[b]	3.98
	s	0.47	0.32	0.34	0.36
	v	11.87	7.92	9.14	9.05
Meat/bone ratio in hindquarters	*x*	4.62	4.51	4.24	4.49
	s	0.30	0.46	0.47	0.45
	v	6.49	10.20	11.08	10.02
Meat/bone ratio in dressed carcass	*x*	4.28	4.27[f]	3.97[e]	4.22
	s	0.36	0.30	0.35	0.33
	v	8.41	7.03	8.82	7.82

a(E), b(U), c(R) – $P < 0.05$
d(E), e(U), f(R) – $P < 0.01$

in the carcass was recorded in class R (77.96%), which is a value higher by 2% when compared with the results described by Čuboň *et al.* (2000) in the Slovak Pied Cattle and its crossbreds. The weight ratio of prime cuts to grade II meat reached an average value of 0.94 for the whole set, that means there was a higher amount of grade II meat in the carcasses.

There were 18.23 kg (R) to 20.52 kg (E) of butcher's bones (bones of the spinal column) in the carcasses (Table 4). A statistically highly significant difference ($P < 0.01$) was determined between the groups E and U. The ratio of butcher's bones made 5.72% in class U up to 6.26% in class R. The difference between these groups was found statistically significant ($P < 0.05$). The highest weight of technical bones in the carcass was found in class E (44.47 kg), which differed statistically highly significantly from U (41.09 kg) and R (38.94 kg) classes. We found statistically significant ($P < 0.05$) differences in the percentual content of technical bones between R (13.47%) and U (12.88%) groups. The highest total weight of bones was found in class E (64.99 kg). This group differed statistically highly ($P < 0.01$) from R (57.17 kg) and U (59.35 kg) classes.

The bone percentage reached the highest value in class R (19.72%), which was highly significantly ($P < 0.01$) more than in class U (18.60%) and markedly more than in group E ($P < 0.05$). Depression of bones ratio in dependence on the in-

creased commercial class of carcasses corresponded to the results described by Čuboň *et al.* (2000).

The meat/bone ratio in the individual quarters and in the carcass is shown in Table 5. The highest value (4.04) of this indicator in the forequarters was found in class U whereas the lowest value was in class R (3.72). The difference between these classes was statistically significant on the level $P < 0.05$. In the hindquarters the meat/bone ratio ranged from 4.24 (class U) to 4.62 (class E) where the differences between the groups were not statistically significant. The worst meat/bone ratio in the carcass was found in class R (3.97) being lower by 0.31 than in the best class E. Statistically highly significant differences ($P < 0.01$) were found between R and U classes only. In this case, a decrease in the carcass grade could be denoted as a decline of meat /bone ratio in the carcasses.

Table 6 describes the content of separable fat in the quarters and in the carcass. The maximum amount of separable fat in the forequarters was found in class E (2.99 kg). Separable fat from the forequarters made 1.51% of the weight of the forequarters and 0.71% of the carcass weight. The amount of separable fat in the hindquarters ranged from 3.05 kg in class R to 3.94 kg in class E.

The average values of separable fat in the hindquarters were 2.10% of the hindquarters weight and 1.12% of the carcass weight. The total of separable fat in the carcass ranged from 5.16 kg in

Table 6. Content of separable fat in dressed carcass by carcass grades

Indicator		E	U	R	Set
	n	11	50	11	72
Separable fat in forequarters (kg)	x	2.99	2.19	2.11	2.30
	s	2.52	0.85	0.96	1.27
	v	84.28	38.81	45.50	55.22
Separable fat in forequarter/forequarter (%)	x	1.75	1.46	1.55	1.51
	s	1.32	0.56	0.63	0.73
	v	75.43	38.36	40.65	48.34
Separable fat in forequarter/carcass (%)	x	0.83	0.68	0.73	0.71
	s	0.66	0.26	0.30	0.35
	v	79.52	38.24	41.10	49.30
Separable fat in hindquarter (kg)	x	3.94	3.61	3.05	3.58
	s	0.70	1.41	1.30	1.32
	v	20.06	39.06	42.62	36.87
Separable fat in hindquarter/hind-quarter (%)	x	2.15	2.12	1.96	2.10
	s	0.50	0.77	0.80	0.74
	v	23.26	36.32	40.82	35.24
Separable fat in hindquarter/carcass (%)	x	1.14	1.13	1.04	1.12
	s	0.26	0.42	0.44	0.40
	v	22.81	37.17	42.31	35.71
Separable fat in dressed carcass (kg)	x	6.94	5.80	5.16	5.87
	s	2.72	2.12	2.07	2.24
	v	39.19	36.55	40.12	38.16
Separable fat in carcass/carcass (%)	x	1.97	1.81	1.77	1.83
	s	0.68	0.64	0.66	0.64
	v	34.52	35.36	37.29	34.97

a(E), b(U), c(R) – $P < 0.05$
d(E), e(U), f(R) – $P < 0.01$

class R to 6.95 kg in class E. The average content of separable fat in the whole set was about 1.83%.

The differences between the groups in all indicators of separable fat were found to be insignificant. In the conclusions of Čuboň et al. (2000) a significant trend of the increase in the content of separable fat ranged from 5.27% in class E up to 7.13% in class 0. The values of separable fat from the right half-carcass recorded in our paper are very low (1.77–1.97%) compared with the previously quoted paper. In our results, on the contrary, the content of separable fat declined with decreasing carcass grade.

In spite of the fact that it is necessary to analyse a substantially higher number of slaughter bulls in

order to draw a conclusion, these processed results of evaluation of cattle carcasses fleshing show a necessity of the investigation of the observed indicators. Some more significant differences were found between carcass grades in the parameters of morphometric measurements, weight of meat, bones and separable fat. However, in technologically important indicators of the percentage content of prime cuts and grade II meat, meat as a whole, bones and separable fat, the differences between carcass grades were statistically insignificant. Likewise, it must be taken into account that this method of carcass grading is subjective and does not give a true picture of the quality of cattle carcasses in the full scale. Therefore, the actual state of evaluating cattle carcasses requires further development of instrumental methods that will be able to predict the quality of carcasses by a substantially exacter assessment of the content of meat, bones and fat in dressed carcass.

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Prediction of lean content in breeding pigs by *in vivo* and *post mortem* methods

Predikce podílu svaloviny u plemenných prasat metodami *in vivo* a *post mortem*

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ABSTRACT: The objective of the paper was to evaluate lean content measured with PIGLOG-105 (PI-105) and SONOMARK 100 (SM-100) instruments applying current methodology for determination of breeding pig performance in vivo and by *post mortem* two-point (ZP) method and/or FOM probing method in half-carcasses. Data were acquired at a pig testing station during progeny tests of pure pig breeds of base populations of (n = 111 animals). Pigs were measured at live weight of 98–105 kg. After slaughter the same measures were determined with slide gauge at identical points of measurement. They were used for a regression equation in FOM instrument and measures necessary to calculate lean content by ZP method were found out at the same time. Average backfat thickness t_1 (t_2) was 13.0 mm (11.6 mm), depth of m.l.l.t. muscle 53 mm and lean content 59.1%. Minimum differences (between the used methods) were observed in backfat thickness t_2, but they were statistically highly significant in muscle depth. High goodness of fit existed for lean content between the results presented by PI-105 instruments and FOM method (R^2 = 0.63), coincidence between the results of SM-100 and both *post-mortem* methods was satisfactory.

Keywords: pig; ultrasound instruments; FOM and ZP methods; regression equation

ABSTRAKT: Cílem příspěvku bylo posouzení úrovně podílu svaloviny zjištěného přístroji PIGLOG-105 (PI-105) a SONOMARK 100 (SM-100) na základě platné metodiky pro zjišťování vlastní užitkovosti plemenných prasat *in vivo* a dvoubodovou (ZP) metodou, resp. sondovou metodou FOM *post mortem* na jatečných půlkách. Data byla získána na testační stanici v rámci zkoušek výkrmnosti a jatečné hodnoty čistokrevných plemen prasat výchozích populací (n =111 ks). Zvířata byla měřena v živé hmotnosti 98–105 kg. Po poražení byly na shodných měřicích místech zjištěny stejné míry pomocí posuvného měřítka. Sloužily pro regresní rovnici používanou v přístroji FOM a zároveň byly zjišťovány míry potřebné pro výpočet podílu svaloviny ZP metodou. Průměrná výška hřbetního tuku t_1 (t_2) byla 13,0 mm (11,6 mm), výška svalu m.l.l.t. 53 mm a podíl svaloviny 59,1 %. Minimální diference (z hlediska použitých metod) byly nalezeny u výšky tuku t_2, statisticky vysoce významné u výšky svalu. Pro podíl svaloviny byla nalezena velmi dobrá shoda mezi výsledky prezentovanými přístroji PI-105 a metodou FOM (R^2 = 0,63), uspokojivě korespondovaly výsledky SM-100 a obou metod *post mortem*.

Klíčová slova: prase; ultrazvukové přístroje; FOM a ZP metody; regresní rovnice

To estimate breeding value of an animal before it is included in a herd ultrasound instruments are currently used for acquisition of necessary data. They enable to determine *in vivo* total lean content in animal carcass. Pig carcass grading in EU countries is guided by Regulation No. 3127/94. Instrumentation is applied for two purposes: to determine total lean content in live animals as a selection criterion in breeding process and to determine pig carcass quality in order to assign a class in the SEUROP grading system.

A non-invasive ultrasound instrument PIGLOG-105 (PI-105) was used in breeding pigs in the CR by mid-2001, but it has been replaced by Hungarian-made SONOMARK-100 (SM-100) model. Besides these instruments, e.g. FOM probing instrument, two-point method and other methods are used in accordance with SEUROP standard to determine lean content in half-carcasses of animals after slaughter. As there arise some deviations between determinations of lean content *in vivo* and *post mortem*, it is necessary to compare these different and most frequently used methods.

Ultrasound instruments for prediction of lean content in pigs were evaluated e.g. by Stern *et al.* (1984), Sather *et al.* (1987), Gresham *et al.* (1992).

Relatively high informative capacity of ultrasonically measured data in vivo was reported e.g. by Mersmann (1982), Forrest *et al.* (1989) and by Kiray (1995) for Sonomark. Informative capacity was found to be relatively high, at the level R^2 = 0.40–0.93.

Chiba (1992) determined measures ultrasonically in 177 crosses at slaughter weight of 90.45–123.3 kg. After slaughter identical measures from carcasses and dissections were taken as control. The correlation of ultrasonically measured to *post mortem* backfat thickness was r = 0.82, and to actual lean content r = 0.79. He proposed two regression equations for lean content prediction, separately for gilts and barrows. After carcass weight was substituted into regression equations, their informative capacity increased to 83% and 78%, respectively.

Zhang *et al.* (1993) carried out serial measurements of backfat thickness at 4 points during pig growth and estimated the lean content using Renco instrument. The measures were compared with the results obtained with HGP instrument. The calculated correlation coefficients for lean content indicate the highest correlation of measures from the region between the 3rd and 4th last but one

rib, 63 mm laterally, at live weight 100 kg. Higher correlation was reported between lean content and backfat thickness for barrows than (r = –0.85) for gilts (r = –0.81).

Demo et al. (1994) determined selected parameters of carcass value *in vivo* and *post mortem* in a group of hybrid pigs. The coefficient of correlation between lean cuts (dissection) and backfat thickness above the m.g.m. middle was r = –0.75. The closest correlation with lean cuts was found for fatty parts, separable and kidney fat (r = –0.90). The measures of backfat thickness determined in vivo and *post mortem* showed statistically significant and close correlations (r = 0.79–0.81) while less close correlations were calculated for m.l.l.t. depth (r = 0.27–0.29).

The values of coefficients of correlation calculated by Demo (1994) between lean content and measures of backfat thickness ranged from r = –0.44 to –0.85 (PIGLOG-105) and/or from r = –0.62 to –0.83 (Aloka). The coefficients of correlation between lean content and m.l.l.t. depth (at the 3rd to the 4th last but one rib) amounted to r = 0.09–0.19, between lean content and eye-muscle area to r = 0.31–0.52; as the informative capacity of m.l.l.t. depth was not obviously high enough, the authors recommend to use the eye-muscle area instead.

Adamczyk and Duniec (1994) carried out investigations on 104 gilts of Polish Large White and Polish Landrace breeds tested at a central testing station. On slaughter day (100 kg) backfat thickness was determined *in vivo* at 9 points and m.l.l.t. depth at 3 points with PIGLOG-105 instrument. Dissection was made after 24-hour chilling and lean and fat contents were determined in prime cuts. Correlations between the measurement of backfat thickness *in vivo* and lean content were r = –0.40 to –0.58 and fat content r = 0.47–0.69. The best indicator of lean and fat content in prime cuts was backfat thickness measured in the back middle 60 mm from the dorsal line. Correlations between this thickness and lean content were significant (r = –0.40 to –0.58).

At a testing station in 216 pigs of various genotypes Demo *et al.* (1995) found the content of prime cuts and lean content determined *in vivo* (PIGLOG-105 at the 3rd to 4th last but one rib 70 mm laterally from the central line) to be 49.15% and 50.98%, respectively, at r = 0.81. The levels of correlations between backfat thickness *in vivo* and the content of prime cuts *post mortem* were r = –0.70 and r = –0.76, respectively.

Adamczyk *et al.* (1996) measured backfat thickness at 8 points and m.l.l.t. depth at 3 points with PIGLOG-105 instrument. They calculated correlations of these parameters and compared them with the content of prime cuts. The closest correlation existed between the measures determined at the contact of the 3rd and 4th last but one rib ($r = -0.47$ and $r = -0.59$). They also proposed regression equations for an estimate of meat content in prime cuts while the most exact equation was solved at $R^2 = 0.41$.

Pulkrábek (1997) calculated $r = 0.77$ and $r = 0.80$ for correlations between lean content (dissection) and those measured with FOM instrument or by ZP method, and $r = 0.72$ between lean content measured with FOM instrument and that determined by ZP method.

Martyniuk *et al.* (1996) used PIGLOG-105 and Aloka 210 instruments for measurements *in vivo* on 279 pigs. Backfat thickness and m.l.l.t. depth were measured, and eye-muscle area was determined with Aloka. The measures of backfat thickness correlated with the values determined *post mortem*: $r = 0.62$ (PIGLOG-105, 3rd and 4th lumbar vertebra), $r = 0.51$ (PIGLOG-105, 3rd and 4th last thoracic vertebra) and $r = 0.61$ (Aloka, 3rd and 4th thoracic vertebra). The values of m.l.l.t. depth were in correlation with *post mortem* measures at levels $r = 0.59$ (PIGLOG-105, 3rd and 4th thoracic vertebra) and $r = 0.73$ (Aloka, 3rd and 4th thoracic vertebra).

Krška *et al.* (1998) investigated the musculature of pigs of various genotypes instrumentally *in vivo* (PIGLOG, SONOMARK, Aloka) and *post mortem* (UNIFOM, ZP method). In the group of investigated pigs average half-carcass weight was 42.12 kg, average backfat thickness 23.4 mm, content of prime cuts 49.72% and lean content (dissection) 53.72%. Insignificant differences in averages determined by dissection and of lean content estimated with PIGLOG instrument ($r = 0.85$) and ZP method with equation proposed by the authors ($r = 0.87$) or with Czech equation ($r = 0.87$) indicated their informative capacity.

According to Koschin (1992) a suitable function of regression analysis is sought that would describe with sufficient accuracy the relation between dependent variable (lean meat) on the one hand and group of independent variables (instrumentally determined measures) on the other. When statistical programs are used, besides the proposed regression equation determination index of the equation is listed (R^2). The European Commission requires R^2 to be higher than 0.64 (Krška, 2001). Experience has shown that with high numbers (tens) of parameters included in regression not even an adjusted determination index (R^2 adj.) is a suitable measure of the used model quality. The author believes that currently the most suitable method to determine regression equation exactness is calculation of residual standard error RSD, also designated as standard error (SE).

MATERIAL AND METHODS

The objective of the paper was to evaluate lean content measured with Danish-made PIGLOG-105 (PI-105) and Hungarian-made SONOMARK (SM-100) instruments on the basis of current methodology for determination of breeding pig performance *in vivo* and by two-point (ZP) method, and/or with the use of exactly determined measures for FOM probing method *post mortem* in half-carcasses.

We used a data set on 111 pigs of base populations collected at a testing station during progeny tests of pure breeds. Pigs were measured with both instruments a day before slaughter at live weight of 98–105 kg. In accordance with current methodology for determination of performance parameters backfat thickness was measured at points designated in advance: backfat thickness (t_1), backfat thickness (t_2) and at the same point m.l.l.t. depth (sv), 70 mm left laterally from the central line. The points of measurements were checked by post-mortem measuring with slide gauge (M). The values measured with slide gauge between the 2nd and 3rd thoracic vertebra, i.e. backfat thickness ($t_{2\text{-}FOM}$) and m.l.l.t. depth ($sv_{\text{-}FOM}$), were used to calculate lean content by help of a regression function for FOM instrument. Other parameters examined in carcass dissection were eye-muscle area, number of lumbar and thoracic vertebrae and their position in relation to actual points of measurement (from the tail root). Measures for the calculation of lean content (LM) by ZP method were also determined.

Data were summarized, analysis of variance was used for their processing, linear correlation coefficients were calculated for correlations between parameters and regression functions were solved to evaluate the relations between the methods used for determination of lean content in live animals and *post mortem*. SAS statistical program was used for data processing.

Regression function: $y = 63.870 - 0.447\ t_1 - 0.510\ t_2 + 0.128\ sv$ was used for both instruments. For a better review, we also include the regression equation supplied by the Hungarian manufacturer for SM-100 instrument: $y = 56.333 - 0.123\ t_1 - 0.786\ t_2 + 0.006\ t_2^2 + 0.238\ sv$, equations used for FOM probing method where $y = 81.891 + 0.201\ M_{FOM} - 14.191\ \ln S_{FOM}$ and for calculation of lean content by ZP method where $y = 76.672 - 1.048\ M_{ZP} + 0.008\ M_{ZP}^2 - 0.003\ S_{ZP}^2 + 9.015\ \ln (M_{ZP}/S_{ZP})$.

Explanatory notes:

FOM method:

M_{FOM} = muscle depth at the 2nd to the 3rd last thoracic vertebra (mm)

S_{FOM} = backfat thickness including skin at the 2nd to the 3rd last thoracic vertebra (mm)

ZP method:

M_{ZP} = muscle depth from the dorsal edge of spinal canal to the cranial edge of *musculus gluteus medius* (mm)

S_{ZP} = backfat thickness including skin in the lumbar region at a point of the lowest layer above the middle of *musculus gluteus medius* (mm)

RESULTS AND DISCUSSION

Table 1 shows basic statistical variables for parameters measured with ultrasonic instruments PI-105 and SM-100 and/or mechanically with slide gauge, for lean content determined *in vivo* and *post mortem* including analysis of variance. Table 2 documents simple linear coefficients (r) for the studied parameters while regression functions calculated by the used methods for lean content determination are given in Table 3.

Differences between the values of backfat thickness t_1 (Table 1) determined by three different methods were statistically highly significant for *in vivo* ultrasonic measurements with both instruments in comparison with the values measured with slide gauge on half-carcasses in favour of exact measurement. The coefficient of correlation between thickness t_1 measured with PI-105 and slide gauge *post mortem* was $r = 0.60$ (Table 2). Similar values were reported by Martyniuk *et al.* (1996) $r = 0.62$, and by Adamczyk and Duniec (1994) $r = 0.47$–0.69. Differences between the values t_1 determined with PI-105 and SM-100 were statically significant. Statistically significant differences were also estab-

Table 1. Basic statistics of parameters studied in breeding pigs

Methods Parameters			SM-100 (a) 111	PI-105 (b) 111	FOM (c) 111	ZP (d) 111
Fat 1 (mm)	t_1	x	11.81[Ac]	12.87[Bc]	14.39[AB] *	
		s	3.08	3.23	4.42	
Fat 2 (mm)	t_2	x	11.22[a]	12.17[a]		
		s	3.92	3.35		
	$t_{2\text{-}FOM}$	x			11.38	
		s			3.30	
Muscle depth (mm)	sv	x	51.70[AC]	47.00[BC]		
		s	5.98	4.92		
	$sv_{\text{-}FOM}$	x			60.20[AB]	
		s			4.30	
Lean content (%)	LM	x	59.64[c]	57.94[Ac]	60.05[Ab]	58.79[b]
		s	3.21	3.01	4.53	3.92

A, B, C = $P \le 0.01$; a, b, c = $P \le 0.05$

*t_1 = not used for the equation in FOM instrument

Table 2. Simple linear correlations for studied parameters

	SMt₁	SMt₂	SM_sv	SM_LM	PIt₁	PIt₂	PI_sv	PI_LM	ZP_LM	Mt₁	Mt₂	M_sv
SMt_2	0.54											
SM_{sv}	0.00	-0.29										
SM_{LM}	-0.74	-0.91	0.44									
PIt_1	0.74	0.58	-0.08	-0.70								
PIt_2	0.63	0.81	-0.13	-0.81	0.70							
PI_{sv}	-0.02	-0.16	0.54	0.29	-0.05	-0.12						
PI_{LM}	-0.72	-0.77	0.22	0.85	-0.88	-0.92	0.31					
ZP_{LM}	-0.61	-0.60	0.27	0.71	-0.57	-0.64	0.28	0.69				
Mt_1	0.59	0.55	-0.17	-0.63	0.60	0.56	-0.11	-0.63	-0.75			
Mt_2	0.65	0.70	-0.11	-0.75	0.67	0.81	-0.15	-0.80	-0.76	0.71		
M_{sv}	-0.13	-0.20	0.43	0.29	-0.11	-0.23	0.45	0.29	0.39	-0.23	-0.28	
FOM_{LM}	-0.63	-0.66	0.18	0.73	-0.62	-0.76	0.23	0.77	0.79	-0.69	-0.97	0.46

$r \geq 0.19 : P \leq 0.05; r \geq 0.24 : P \leq 0.01; r \geq 0.31 : P \leq 0.001$

Table 3. Regression functions calculated by help of the methods used for determination of lean content and their relations

Methods		Regression equations	R^2
ZP +	PI-105	$y = 67.660 - 0.303^*t_1 - 1.558^*t_2 + 0.040^*(t_2)^2 + 0.163^*sv$	0.501
	SM-100	$y = 71.674 - 0.505^*t_1 - 1.825^*t_2 + 0.063^*(t_2)^2 + 0.090^*sv$	0.552
FOM +	PI-105	$y = 74.101 - 0.244^*t_1 - 1.929^*t_2 + 0.041^*(t_2)^2 + 0.128^*sv$	0.631
	SM-100	$y = 77.376 - 0.541^*t_1 - 1.697^*t_2 + 0.050^*(t_2)^2 + 0.019^*sv$	0.564

lished for backfat thickness t_2 that arose from measurements on live animals (Table 1). This measure is often considered as a parameter with higher informative capacity than e.g. t_1. This fact is supported by high to very high, negative correlation coefficients ($r = -0.75$ to -0.92), statistically highly significant, determined between lean content and measure t_2 (Table 2). Zhang et al. (1993) reported $r = -0.81$ to -0.85, Demo (1994) $r = -0.85$, Adamczyk et al. (1996) found a lower value $r = -0.59$ for PI-105.

Most differences were observed for measurements of muscle depth (Table 1). The differences were statistically highly significant in favor of exactly determined values on half-carcasses, contrary

to ultrasonically measured values, there were also statistically highly significant differences in the values measured with both instruments in vivo in favor of SM-100. But correlations (Table 2) between lean content and m.l.l.t. depth were low even though statistically highly significant ($r = 0.31–0.46$). Demo (1994) reported rather lower values $r = 0.10–0.20$. The correlations calculated between m.l.l.t. depth in vivo and post mortem were $r = 0.43–0.45$. The values reported by Demo et al. (1994) were lower $r = 0.27–0.29$, those calculated by Martyniuk et al. (1996) were higher $r = 0.59$ for PI-105.

As for lean content statistically highly significant differences were calculated between the values measured with PI-105 and by FOM method in
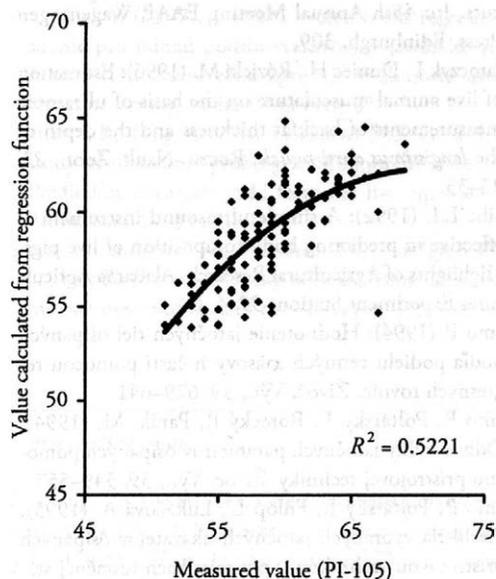
Figure 1. Calculated and measured values of lean content in % (ZP-Piglog 105)
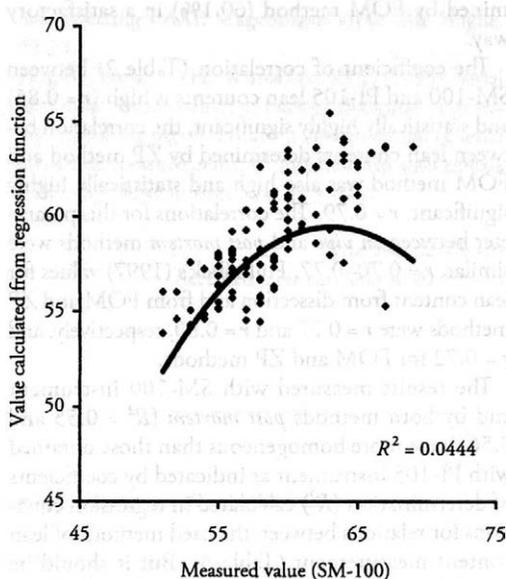

Figure 2. Calculated and measured values of lean content in % (ZP-Sonomark 100)

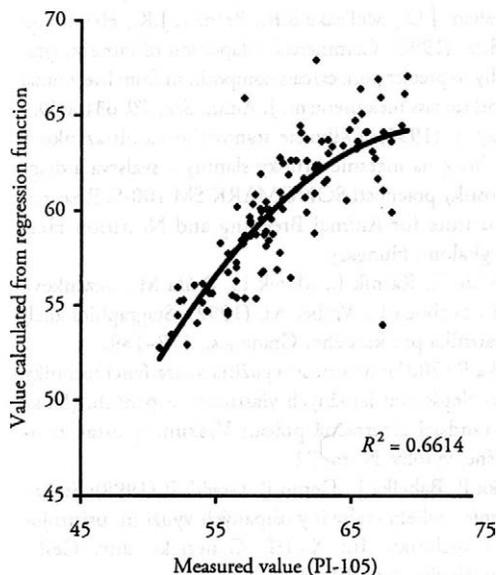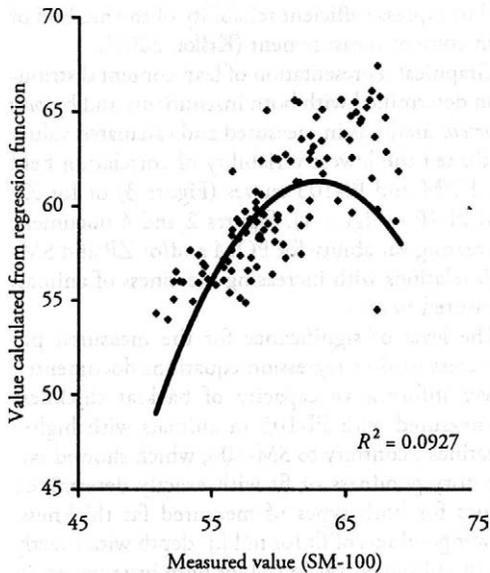Figure 3. Calculated and measured values of lean content in % (FOM-Piglog 105)

Figure 4. Calculated and measured values of lean content in % (FOM-Sonomark 100)

favor of *post mortem* measurement, and statistically significant differences were established between the values measured with both ultrasonic instruments (in favor of SM-100) and between both methods used on half-carcasses (in favor of FOM). The re-

sults of lean content determined *in vivo* and *post mortem* document that the lean content measured with PI-105 (57.9%) corresponded well to that determined by ZP method (58.8%) and SM-100 instrument (59.6%), and to lean content deter-

mined by FOM method (60.1%) in a satisfactory way.

The coefficient of correlation (Table 2) between SM-100 and PI-105 lean contents is high ($r = 0.85$) and statistically highly significant, the correlation between lean contents determined by ZP method and FOM method was also high and statistically highly significant, $r = 0.79$. The correlations for this parameter between *in vivo* and *post mortem* methods were similar, $r = 0.70–0.77$. Pulkrábek's (1997) values for lean content from dissection and from FOM and ZP methods were $r = 0.77$ and $r = 0.80$, respectively, and $r = 0.72$ for FOM and ZP methods.

The results measured with SM-100 instrument and by both methods *post mortem* ($R^2 = 0.55$ and 0.56) were more homogeneous than those obtained with PI-105 instrument as indicated by coefficients of determination (R^2) calculated in regression equations for relations between the used methods of lean content measurement (Table 3). But it should be stated that the best goodness of fit in this parameter was achieved with PI-105 instrument in comparison with FOM probing method ($R^2 = 0.63$), and the model approximated the limit $R^2 > 0.64$ used in EU to express sufficient reliability of the method of lean content measurement (Krška, 2001).

Graphical representation of lean content distribution determined with both instruments and by *post mortem* methods in measured and calculated values indicated the lowest variability of correlation field for FOM and PI-105 curves (Figure 3) or for ZP and PI-105 (Figure 1). Figures 2 and 4 document increasing variability for FOM and/or ZP and SM-100 relations with increasing meatiness of animals measured *in vivo*.

The level of significance for the measured parameters used in regression equations documented lower informative capacity of backfat thickness t_1 measured with PI-105 in animals with higher meatiness, contrary to SM-100, which showed satisfactory goodness of fit with exactly determined values for both types of measured fat thickness. Lower goodness of fit for m.l.l.t. depth with exactly measured values was found for both instruments in animals with higher meatiness.

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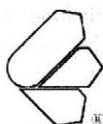Mersmann H.J. (1982): Ultrasonic determination of backfat depth and loin area in swine. J. Anim. Sci., *5*, 268–284.

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Relations between some physical and mechanical properties of selected teat-cup liners

Vzájomné závislosti niektorých fyzikálno-mechanických vlastností vybraných ceckových gúm

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ABSTRACT: We measured and evaluated some physical and mechanical properties of selected teat-cup liners (rigidity, strength and extension at the moment of rupture in accordance with Standards STN 62 1431 and STN 62 1436) after expiration of the given operating time. Teat-cup liners were exchanged 4 times on each farm (after 300, 600, 900 and 1 200 operating hours), and the quality of unused liners was also evaluated. The studied parameters were evaluated and tested in an accredited testing laboratory of the Plastics Processing and Application Research Institute in Nitra. Statistical processing of the data indicated that an increase in rigidity resulted in significant differences between the variants of individual liner specimens. Within the variants of liner specimens in some cases we recorded significant differences also in the values of strength at rupture in MPa and percentage extension at rupture. A statistically significant negative correlation between the operating time of liners and their rigidity was found in two cases only ($P < 0.01$) while a negative correlation was generally determined between the operating time and the liner strength but it exceeded the level of significance in one case only ($P < 0.01$). No significant relationship was observed between the operating time of liners and extension at rupture. As the change in physical and mechanical properties of the four tested specimens of teat-cup liners does not show the same trend of changes and mutual relationships in all parameters during usage, it is not possible to determine the life of teat-cup liners only on the basis of this test. It is necessary to include other parameters in research on liners such as degradation of the liner inner side and its suitability for cleaning.

Keywords: teat-cup liner; operating time; physical and mechanical properties

ABSTRAKT: V príspevku sme hodnotili niektoré fyzikálno-mechanické vlastnosti vybraných ceckových gúm (tvrdosť, pevnosť a predĺženie pri pretrhnutí podľa noriem STN 62 1431 a STN 62 1436) po uplynutí stanoveného času činnosti. Výmenu sme uskutočnili celkove štyrikrát v každom poľnohospodárskom podniku (po 300, 600, 900, 1 200 hodinách činnosti) a súčasne sme hodnotili aj kvalitu nepoužitých ceckových gúm. Sledované ukazovatele boli vyhodnotené v akreditovanom skúšobnom laboratóriu Výskumného ústavu spracovania a aplikácie plastických látok v Nitre. Zo štatistického vyhodnotenia sledovaných ukazovateľov vyplýva, že zvýšenie tvrdosti dosiahlo medzi variantmi jednotlivých vzoriek gúm preukazných rozdielov. V niektorých prípadoch sme zaznamenali v rámci variant vzoriek gúm významné rozdiely aj v zistených hodnotách pevnosti pri pretrhnutí v MPa a predĺžení pri pretrhnutí v percentách. Medzi časom činnosti ceckových gúm a ich tvrdosťou sa štatisticky významný záporný vzťah zistil iba v dvoch prípadoch ($P < 0,01$), medzi časom činnosti a pevnosťou gúm bol všeobecne zaznamenaný záporný vzťah, ktorý však hranicu významnosti presahoval iba v jednom prípade ($P < 0,01$). Medzi časom činnosti gúm a predĺžením pri pretrhnutí sa preukazný vzťah nezaznamenal. Vzhľadom k tomu, že zmena fyzikálno-mechanických

vlastností skúmaných štyroch vzoriek ceckových gúm v priebehu exploatácie nevykazuje vo všetkých ukazovateľoch rovnaký charakter priebehu tendencie zmien a vzájomných súvislostí, nie je možné len na základe tejto skúšky určiť životnosť ceckových gúm. Je potrebné rozšíriť skúmanie ceckových gúm o ďalšie ukazovatele ako sú degradácia vnútorného povrchu a s tým súvisiaca jeho čistiteľnosť.

Kľúčové slová: cecková guma; čas činnosti; fyzikálno-mechanické vlastnosti

An important source of milk contamination is the components of milking machines such as teat-cup liners that were not exchanged on time. Holes and pores appear in teat-cup liners and liner hoses in which the remnants of proteins and milk fat are caught. They create a suitable environment for the growth and development of contaminating microflora. The level of sanitization of teat-cup liners therefore depends not only on the cleaning itself but also on their regular exchange (Mihina *et al.*, 2001).

In relation to the declared life of teat-cup liners, regular checks of their state are important. Worn out liners that have unsuitable physical properties negatively affect the health status of teats (Foltys *et al.*, 1996; Tančin *et al.*, 2001). The liner operates under extreme conditions: it pulses once a second, 200 thousand times a month and during this time it extends by up to approximately 20% of its length. The liner gets worn, loses its flexibility and decreases the milking effect. Its flexibility has to allow the compression of rubber walls in rhythm to the compressions in parts below the udder and momentarily to ease the liner passage and tissue of the milk glands from the suction action (Přikryl *et al.*, 1997). Changes in liner rigidity in laboratory and operational conditions were studied by Mašková and Los (2000). To improve the functional properties of liners they recommend decreasing rigidity in the studied groups of products in the range of 50–55° Sh A. The main parameters that influence liner durability are suitability of working surfaces for cleaning, resistance to the effects of cleaning and disinfectant agents and change in the physical and mechanical properties of the materials. Physical and mechanical properties of liners were studied by Karas (2001), Karas and Gálik (2001) and Karas *et al.* (2001). They found out that atmospheric factors undoubtedly have a considerable effect on the change in physical and mechanical properties of liners during usage. In the winter period the liner temperature is between +5°C and 65°C according to the type of activity carried out in the milking

room. As for Henry's standards, a temperature increase by 10°C causes chemical reactions to occur twice as fast as normal.

It follows from the studies of cited authors that the most important part of the milking machine is the teat-cup liner that ensures contact between the milking machine and the dairy cow. The properties of the liner directly affect the technological milking process, state of health of the udder and milk quality. Hence the objective of our study was to examine the change in physical and mechanical properties of liners according to the operating time as one of the evaluated criteria to determine the final parameter of liner usage.

MATERIAL AND METHODS

Some physical and mechanical properties of teat-cup liners from four manufacturers of milking machines and their changes in relation to operating time were evaluated. The specimens were taken from three farms. One farm used liners of two makes. The liners were tested altogether 4 times (after 300, 600, 900 and 1 200 operating hours). At the same time we also evaluated the physical and mechanical properties of inactive liners. To protect the manufacturers of milking machines their names are not mentioned in this paper. We used specimens designated numbers 1, 2, 3, and 4. The number of specimens used for the study of physical and mechanical properties was limited by the number of liners and specimen size required by the standard. This is the reason why rigidity and extension at the moment of rupture were measured in 5 specimens and rigidity during the given operating time was measured in 10 specimens.

Nature of the tests

Rigidity (Sh A) is defined by standard STN 62 1431. The method is based on measurements of the

liner resistance to the pressure point and is valid for testing the liner whose rigidity is from 20 to 90 units Sh A. The thickness of tested components must be at least 6 mm. It is suitable to use for tests specimens made of several layers of the same kind of liner, but not more than 3. The thickness of the top layer should be a minimum of 2 mm. Rigidity is calculated on the scale of the machine after 15 s from the moment of testing. The testing point for the ZWICK 7201 rigidity testing equipment is in Figure 1.

Strength (MPa) and **extension at rupture** (%) are defined by Standard STN 62 1436.

The purpose of the test is to stress the test specimen by pulling at a constant speed until its rupture and to measure the following characteristics:
– the force causing rupture of the test specimen,
– extension of the measured length of the working parts of the paddles at the moment of its rupture. The test specimens must have the shape of a double-ended paddle. The shape and size of the paddle are shown in Figure 2. The tensile strength is calculated as follows:

$$\sigma = \frac{F_r}{A_0} \qquad (MPa) \qquad (1)$$

where: F_r = force needed to cause a rupture of the test specimen (N)
A_0 = initial section of the test specimen (mm^2)

The rupture extension is calculated from this equation:

$$\varepsilon = \frac{l_r - l_0}{l_0} \, 100 \qquad (\%) \qquad (2)$$

where: l_r = measured length of working parts of the paddle (mm)
l_0 = initial measured length of working parts of the paddle (mm)

The figures shown were evaluated in a testing room of the Plastics Processing and Application Research Institute in Nitra. The results were processed by the Statgraphics statistics package version 5.0 and Excel 97. The methods used were analysis of variance, computation of correlation relationships and regression analysis. Basic statistical characteristics, the arithmetical mean and the standard deviation were also calculated.

RESULTS AND DISCUSSION

Specimen No. 1

Physical and mechanical properties are shown in Table 1. As can be seen from this table, the rigidity of this liner specimen ranges from 46.7 Sh A (900 operating hours) to 56.5 Sh A (after 600 operating hours). According to the results of statistical evaluation through the analysis of variance it was found out (Table 2) that the difference in the rigidity of the liner specimen after 600 operating hours in comparison with the other operating periods (inactive, after 300, 900, 1 200 operating hours) was statistically significant ($P < 0.05$). In the other case (rigidity at rupture) it was found that the longer the operating time, the lower the liner rigidity. While an inactive liner had the strength of 16.7 MPa, after
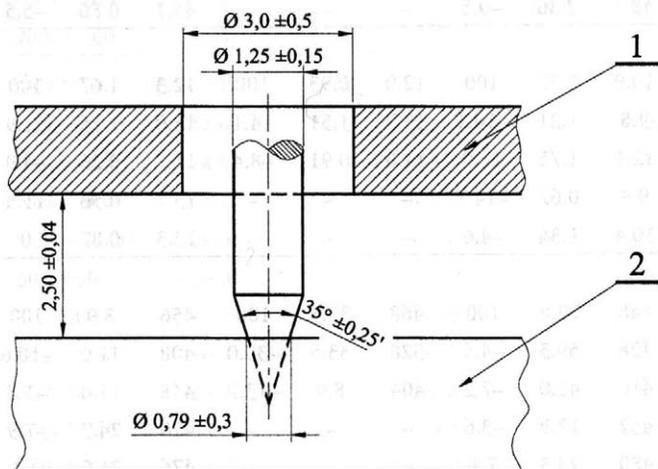

Figure 1. Indication point of the rigidity testing facility. 1 – guiding part of machine, 2 – test specimen
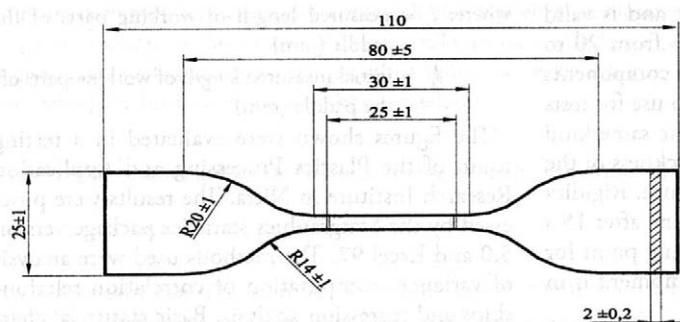
Figure 2. The shape and size of the test specimen

1 200 operating hours it decreased to 11.9 MPa. It was proved through the analysis of variance that the difference in the rigidity of a new liner and the liner after 1 200 hours of operation was statistically significant ($P < 0.05$). In the third case (extension at rupture) there was no statistically significant difference dependent on the operating period and the limitations were in the range from 412% (after 1 200 operating hours) to 444% (after 600 operating hours). Within the calculations

of correlation relationships for the figures studied, a statistically important negative correlation was confirmed between the operating time and rigidity at rupture ($r = -0.5624$). As a result of the high correlation coefficient, we carried out regression analysis with a linear function ($y = a + bx$). The results of this analysis are shown in Figure 3. According to the index of determination ($R^2 = 0.8604$) the liner rigidity is affected by the operating time at 86.04%.

Table 1. Physical and mechanical properties of teat-cup liners

Operating time (h)	Specimen 1			Specimen 2			Specimen 3			Specimen 4		
	$\bar{x}$	s	%	$\bar{x}$	s	%	$\bar{x}$	s	%	$\bar{x}$	s	%
Rigidity (Sh A)												
0	49.5	1.36	100	54.9	0.71	100	49.8	1.48	100	47.7	1.63	100
300	47.4	1.90	–4.3	54.5	0.41	–0.8	60.4	0.53	21.2	54.8	1.01	14.9
600	56.5	0.60	14.1	53.9	1.56	–1.9	45.6	3.31	–8.5	44.9	1.82	–5.8
900	46.7	1.69	–5.7	45.9	1.18	–16.4	–	–	–	43.1	1.57	–9.7
1 200	50.3	2.03	1.6	49.7	2.36	–9.5	–	–	–	45.1	0.86	–5.5
Strength at rupture (MPa)												
0	16.7	1.35	100	10.9	1.32	100	12.0	0.93	100	12.3	1.67	100
300	14.0	4.74	–16.2	9.8	1.21	–10.1	13.7	1.51	14.1	15.0	1.15	21.9
600	14.2	0.68	–15.0	12.1	1.75	11.0	11.0	0.91	–8.4	11.7	0.26	–4.9
900	13.4	0.59	–19.8	9.3	0.62	–14.7	–	–	–	13.7	0.56	11.3
1 200	11.9	0.96	–28.8	10.4	1.34	–4.6	–	–	–	12.3	0.87	0
Extension at rupture (%)												
0	440	28.3	100	448	22.8	100	468	33.5	100	456	8.9	100
300	428	17.9	–2.8	428	59.3	–4.5	328	33.5	–30.0	408	11.0	–10.6
600	444	26.1	0.9	416	41.0	–7.2	404	8.9	–13.7	448	11.0	–1.8
900	416	68.3	–5.5	432	17.9	–3.6	–	–	–	420	24.7	–7.9
1 200	412	22.8	–6.4	480	28.3	7.1	–	–	–	476	21.9	4.3

Table 2. Significance of differences in the studied parameters of teat-cup liners in dependence on the operating time

Operating time (h)	Specimen 1		Specimen 2		Specimen 3		Specimen 4	
	differ-ence	significance of differ-ences	differ-ence	significance of differ-ences	differ-ence	significance of differ-ences	differ-ence	significance of differ-ences
Rigidity (Sh A)								
New – 300	2.1	+	0.4	–	–10.6	+	–7.1	+
New – 600	–7.8	+	1.0	–	4.2	+	2.8	+
New – 900	2.8	+	9.0	+	/	/	4.6	+
New – 1 200	–0.8	–	5.2	+	/	/	2.6	+
300–600	–9.1	+	0.6	–	14.8	+	9.9	+
300–900	0.7	–	8.6	+	/	/	11.7	+
300–1 200	–2.9	+	4.8	+	/	/	9.7	+
600–900	9.8	+	8.0	+	/	/	1.8	+
600–1 200	6.2	+	4.2	+	/	/	–0.2	–
900–1 200	–3.6	+	–3.8	+	/	/	–2.0	+
Strength at rupture (MPa)								
New – 300	2.7	–	1.1	–	–1.7	–	–2.7	+
New – 600	2.5	–	–1.2	–	1.0	–	0.6	–
New – 900	3.3	–	1.6	–	/	/	–1.4	–
New – 1 200	4.8	+	0.5	–	/	/	0	–
300–600	–0.2	–	–2.3	–	2.7	+	3.3	+
300–900	0.6	–	0.5	–	/	/	1.3	–
300–1 200	2.1	–	–0.6	–	/	/	2.7	+
600–900	0.8	–	2.8	+	/	/	–2.0	–
600–1 200	2.3	–	1.7	–	/	/	–0.6	–
900–1 200	1.5	–	–1.1	–	/	/	1.4	–
Extension at rupture (%)								
New – 300	12.0	–	20.0	–	140.0	+	48.0	+
New – 600	–4.0	–	32.0	–	64.0	+	8.0	–
New – 900	24.0	–	16.0	–	/	/	36.0	+
New – 1 200	28.0	–	–32.0	–	/	/	–20.0	–
300–600	–16.0	–	12.0	–	–76.0	+	–40.0	+
300–900	12.0	–	–4.0	–	/	/	–12.0	–
300–1 200	16.0	–	–52.0	–	/	/	–68.0	+
600–900	28.0	–	–16.0	–	/	/	28.0	–
600–1 200	32.0	–	–64.0	–	/	/	–28.0	–
900–1 200	4.0	–	–48.0	–	/	/	–56.0	+
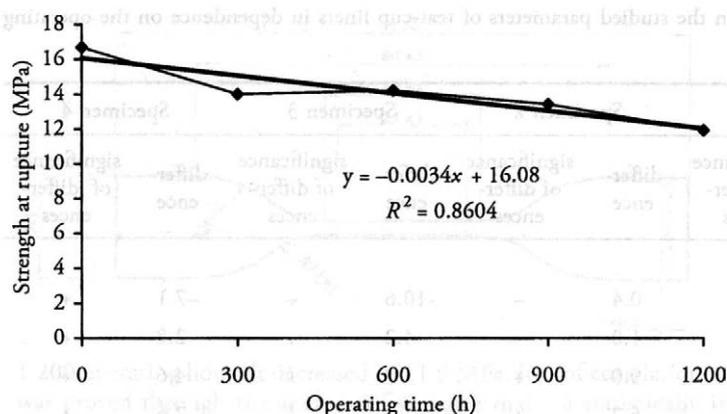
Figure 3. Regression relation between operating time and strength at liner rupture

Inside the figure:
$$y = -0.0034x + 16.08$$
$$R^2 = 0.8604$$

Specimen No. 2

In fact this specimen is satisfactory as its rigidity is on the same level for 600 operating hours in comparison with other liner specimens, and then it decreases. The other specimens show an increase in their rigidity during the operating time of 300–600 hours followed by a decrease afterwards. The rigidity of specimen No. 2 in Sh A is from 45.9 (after 900 operating hours) to 54.9 (unused specimen) in Table 1. These changes are reflected in the results of the statistical evaluation of the significance of differences (Table 2). Differences in quality between the liners that were used for 300–600, 900–1 200 operating hours were statistically significant. Between liners in the new – 300 hours category, new – 600 hours category, and the 300 – 600 hours category there were no statistically significant differences found. The highest strength at moment of rupture is shown by the specimen after 600 hours operation time (12.1 MPa), the lowest in the specimen after 900 h (9.3 MPa) while the difference between them was statistically significant. This result corresponds with the previous parameter where the lowest specimen rigidity also appeared after 900 hours and was statistically significant, whereas in the specimen after 600 hours it was not. In the case of the inactive liner and the liner after 300 hours operation the strength at rupture is higher than after 900 hours of operation, though these differences are not statistically significant. In terms of extension at rupture the range from 416 (600 operating hours) to 480% (after 1 200 operating hours) was achieved while the differences between the specimens were not statistically proved. A proved negative correlation coefficient

($r = -0.7513$) was determined by the calculation of the correlation relations for the parameters involved (Table 3) between the operating time and the rigidity. Concerning the high correlation coefficient calculation of the regression relationship was done by help of the linear function ($y = a + bx$). The results of this analysis are shown in Figure 4. According to the calculated index of determination ($R^2 = 0.5964$), liner rigidity is influenced by the time of its operation at 59.64%.

Specimen No. 3

For the technical reasons (specimen depreciation) we can only evaluate physical and mechanical properties on the inactive liner after 300 and 600 operating hours. As can be seen from Table 1, the highest value of rigidity was found in the liner after 300 operating hours and ranged from 45.6 (600 operating hours) to 60.4 Sh A (after 300 operating hours). The rigidity calculated by analysis of variance showed significant differences in the case of specimen 3 (Table 2). From the results regarding rigidity, the strength evaluation corresponds with evaluation of rigidity, which after the operating time of 300 hours reached the value 13.7 MPa and was lowest after 600 operating hours (11.0 MPa). The difference in the rupture strength between these two specimens was statistically significant. The average value of extension at rupture ranged from 328% (300 operating hours) to 468% (inactive liner) with lowest rupture extension recorded in the specimen with the highest rigidity and rupture strength after 300 operating hours. The differences between the individual specimens were statistically significant
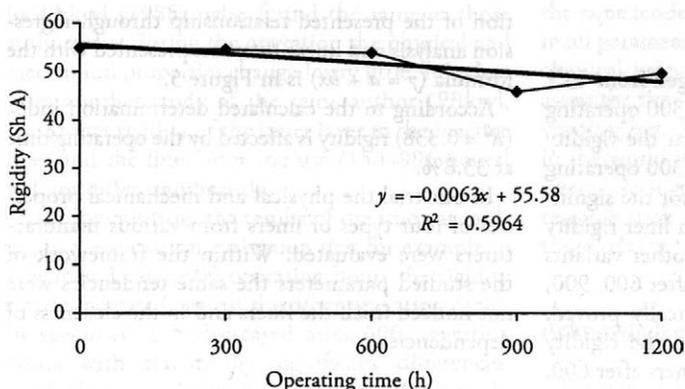
Figure 4. Regression relation between operating time and rigidity of liner

$$y = -0.0063x + 55.58$$
$$R^2 = 0.5964$$

Table 3. Coefficients of correlation between the studied parameters

Parameter	Time	Rigidity	Strength	Extension
Specimen No. 1				
Time	–	0.0349⁻	−0.5624**	−0.3005⁻
Rigidity	0.0349⁻	–	−0.0167⁻	0.3135⁻
Strength	−0.5624**	−0.0167⁻	–	0.1389⁻
Extension	−0.3005⁻	0.3135⁻	0.1389⁻	–
Specimen No. 2				
Time	–	−0.7513**	−0.1411⁻	0.2417⁻
Rigidity	−0.7513**	–	0.3898⁻	−0.1626⁻
Strength	−0.1411⁻	0.3898⁻	–	0.1476⁻
Extension	0.2417⁻	−0.1626⁻	0.1476⁻	–
Specimen No. 3				
Time	–	−0.2715⁻	−0.2721⁻	−0.4187⁻
Rigidity	−0.2715⁻	–	0.7092**	−0.6419**
Strength	−0.2721⁻	0.7092**	–	−0.2517⁻
Extension	−0.4187⁻	−0.6419**	−0.2517⁻	–
Specimen No. 4				
Time	–	−0.5643**	−0.1336⁻	0.2541⁻
Rigidity	−0.5643**	–	0.5036*	−0.4139*
Strength	−0.1336⁻	0.5036*	–	−0.5832**
Extension	0.2541⁻	−0.4139*	−0.5832**	–

$*P < 0.05$, $**P < 0.01$

although the standard deviation calculated for the studied measurements was relatively high. In terms of the calculation of correlation relationships between the studied indicators, positive and statisti-
cally proved correlation coefficients ($r = 0.7092$ and $r = -0.6419$, in Table 3) were determined between the rigidity of the liner and its rupture strength, and also between rigidity and extension at rupture.

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Specimen No. 4

The determined value in Sh A ranged from 43.1 (after 900 operating hours) to 54.8 (300 operating hours). We can see from Table 1 that the rigidity of the liner specimen increased after 300 operating hours, then it decreased rapidly. As for the significance of differences, the difference in liner rigidity at 300 operating hours against the other variants of liner specimen No. 4 (inactive – after 600, 900, 1 200 operating hours) was statistically proved. Besides, although the differences in the rigidity between a new liner and the other liners after 600, 900 and 1 200 operating hours were not as clear as the difference between the new liner and the liner active for 300 operating hours, these differences were still statistically significant (Table 2). The liner with highest rigidity had the highest strength at rupture in MPa and at the same time it had the lowest extension at its rupture. The strength in MPa ranged from 11.7 (after 600 operating hours) to 15.0 (after 300 operating hours). Resulting from the analysis of variance it is obvious that the differences in the rupture strength between the specimen after 300 hours and the new liner, also the liners after 600 and 1 200 operating hours, were statistically proved. The percentage extension at rupture achieved the values from 408 (after 300 operating hours) to 476 (after 1 200 operating hours). The differences concerning the rupture extension after 300 operating hours, the new liner and the other liners after 600 and 1 200 hours were statistically significant. The calculation of correlation relationships between the operating time and the liner rigidity yielded a statistically significant negative relation ($r = -0.5643$). The graphical representation of the presented relationship through regression analysis and linear function presented with the formula ($y = a + bx$) is in Figure 5.

According to the calculated determination index ($R^2 = 0.338$) rigidity is affected by the operating time at 33.8%.

In our trial the physical and mechanical properties of four types of liners from various manufacturers were evaluated. Within the framework of the studied parameters the same tendencies were not noticed in all the liners and in the closeness of dependencies.

Example

A negative correlation coefficient was always calculated between the operating time and the extension strength, which reached conclusive figures in the case of liner specimen No. 1 only. A negative correlation coefficient was determined between the operating time of liners and their rigidity in specimens 2, 3 and 4 while the statistically proved figures were found only in the case of specimens 2 and 4. Regarding the fact that the data regarding the formation of the liners during production is not available, it can only be supposed according to our results that the inconsistent tendency of the results can be affected also by the presence of individual components for the production of liners from different manufacturers. Mašková and Czinegová (1990) came to the conclusion that the changes in physical and mechanical properties of liners of different makes in the interval up to 800 operating hours were very small in comparison with their original figures. The same conclusion was drawn
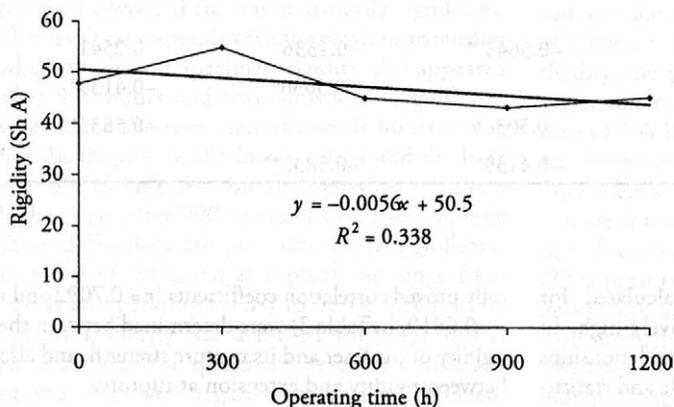

Figure 5. Regression relation between operating time and rigidity of liner

$y = -0.0056x + 50.5$
$R^2 = 0.338$

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by Přikryl (1988), who found the same as those authors that during the operation the physical and mechanical properties changed very little. It is clear from another study of the same author (Přikryl, 1988) that rigidity of the inner layer in the inactive liner and the liner after the use (150–996 hours) did not differ significantly.

It is obvious from the results of the study according to the statistical evaluation that for example in specimen 1 after 600 operating hours the rigidity clearly increased against the other operating times. In specimen 2 it decreased after 600 operating hours with statistically significant differences. Similarly in specimen 3 significant differences in rigidity were observed when the liner was used for 300 operating hours, in comparison with the new liner and the liner used for 600 operating hours. A similar tendency was also observed in specimen 4 where the highest rigidity was found after 300 operating hours and the differences from the other variants of specimen 4 (new, 600, 900, 1 200 operating hours) were statistically significant. Malík et al. (1989) reported that the rigidity of the liner surface of 55 Sh A was traumatic to the udders during milking. Mašková and Czinegová (1990) stated that the materials used for the production of liners should have rigidity in the range from 40 to 45 Sh A. It was found out in this study that rigidity over 55 Sh A was reached by specimen 1 after 600 operating hours (56.5 Sh A) and specimen 3 after 300 operating hours (60.4 Sh A).

In the case of the specimens tested in the study new liners already had rigidity from 47.7 to 54.9 Sh A, which considerably exceeded the recommended value by the authors Mašková and Czinegová (1990). The statistical significance of differences in the strength at rupture of the liner does not exactly match the presented differences that were achieved in rigidity. It corresponds with the results of the regression analysis, according to which the increase in strength was relevant to the increase in rigidity only in the case of specimens 3 and 4.

The values of strength in MPa that were recorded during the tests of our liners are on the level of data by Mašková and Czinegová (1990) in liner tests from the developmental mixture 1606. The average percentage value of extension at rupture from their results also corresponds.

The set objective was reached. It follows from the results of the study that the physical and mechanical properties of the four examined specimens dependent on the operating time did not always show the same tendency of change and mutual coherence in all parameters. On the basis of physical and mechanical properties it is not possible to definitely assess the time for changing liners in regard to their wearing out. Since there is no testing equipment in the world that would assess the life of teat-cup liners, we suggest to include other parameters in research such as condition of the inner lining and those related to its biology contamination.

Acknowledgements

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Professor Ing. Josef Mácha, DrSc.

Died suddenly at the age of 75 years on 28 September 2002. We have lost a colleague, teacher, professor emeritus of general animal husbandry, head of the department of animal genetics, head of the department of general animal husbandry and animal genetics, consultant of many diploma and PhD theses, member of the scientific board and vice-dean for research and scientific activities of the Faculty of Agronomy, Mendel University of Agriculture and Forestry Brno and member of the editorial board of the Czech Journal of Animal Science.

Till the end of his life, he, as a creative personality, was full of enthusiasm and interest in the university life and, above all, in tuition and research of genetics. His last paper, finished two weeks before his death, was published in Proceedings of XXth Genetic Days which took place on 12–13 September 2002. Those who listened to his presentation at this conference had to be sure that his genome would be fully functional for many years to come and for that reason we were all surprised very much to hear about his unexpected death.

Professor Mácha worked all his life in the field of animal husbandry as a teacher, researcher and also manager. After university studies in Prague and Brno, he worked in the State Breeding Service for five years. As the General Director of the State Breeding Service Prague he contributed significantly to the development of animal breeding work in the Czechoslovak Republic.

In 1964 he began to teach the subject of genetics at the Faculty of Agronomy, line of Animal Husbandry. Together with his colleagues and students he managed to establish the Department of Genetics. The department flourished and thanks to obtained results its name became well known both in Czechoslovakia and abroad. After the beginning of lectures on genetics of farm animals, he also contributed to the development of research activities of the department. His scope of interest covered studies on genetic polymorphism of milk proteins in cattle and other species, genetics of selection parameters in dairy cattle and many other genetic problems. His scientific results contributed to the development of cattle breeding in the Czech Republic. He published about 250 original studies in the field of genetics and animal husbandry. He finished 18 research projects.

As a scientist and teacher, he educated many followers – researchers, teachers and experts who further develop his ideas. For more than 20 years, he also organized postgraduate studies for people working in practice, especially in the State Breeding Service. Prof. Mácha contributed significantly to the development of animal genetics science and breeding work.

After retirement, he worked actively in the field of preservation of the genetic pool of farm animals, especially of the Kladrub horse breed. He was also a member of commissions for the defence of dissertations at several universities.

On 7 October 2002, many of his colleagues and friends from Mendel University of Agriculture and Forestry Brno, Slovak Agricultural University Nitra, Agricultural Faculty of South Bohemian University České Budějovice, Veterinary and Pharmaceutical University Brno, Research Institute of Veterinary Medicine and many other workplaces came to pay the last honour to this extraordinary man.

Prof. Ing. Josef Dvořák, CSc. and Prof. Ing. Jiří Kuciel, CSc.

Professor Ing. Vojtěch Hruban, DrSc.

Professor Ing. Vojtěch Hruban, DrSc. passed away on August 4, 2002. He was 58 years old. The Czech agricultural science lost a prominent scientist and the Czech University of Agriculture in Prague lost an excellent lecturer and teacher who will be missed very much.

Hruban studied at the University of Agriculture and Forestry in Brno. Soon after finishing his university studies he came to Animal Genetics Laboratory in Liběchov, now called Institute of Animal Physiology and Genetics, Academy of Sciences of the Czech Republic, to study animal genetics.

Hruban was always in the forefront of genetics and biological research and made significant scientific contributions. In the early 70's, while a postgraduate student, together with Dr. Michal Simon, CSc., he initiated studies of leukocyte antigens in pigs. Among other contributions, he and his colleagues were the first to describe new leukocyte loci, SLB, SLC and SLD. In the 80's he established a laboratory for production of monoclonal antibodies and used them to study different biological and genetic problems. At the end of the 80's he established and became the head of a research group of molecular genetics. Hruban will also be remembered for his experiments with tissue transplantations and his long-lasting research in devitalization, in collaboration with Dr. Karel Fortýn, CSc.

In 1991 he joined the Czech University of Agriculture in Prague, Department of Genetics and Animal Breeding, to become a lecturer and teacher. He had a great talent for guiding students but he was also deeply involved in research. His lectures on genetics and molecular genetics were never boring. He filled hundreds of students with enthusiasm for this branch of science and imprinted the sign of importance of this discipline in their minds. In this way he influenced the Czech agriculture and Czech animal science for future decades. The combination of his excellent teaching abilities, abundant knowledge, hard work in research and friendly attitudes towards students and colleagues will never be forgotten and will continue to influence all who knew him.

He published numerous research papers and reviews, of which about 50 appeared in international scientific journals. He was an author or co-author of textbooks on General Genetics and Molecular Genetics and its application in animal breeding. He was a member of several scientific boards, advisory committees and a member of a committee for the defence of doctoral dissertations. He was also a consultant of many diploma and PhD theses.

Doc. Ing. Antonín Stratil, DrSc. and Doc. Ing. Jaroslav Petr, DrSc.

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Original scientific papers, short communications, and selective reviews (i.e. papers based on the study of agricultural literature and reviewing recent knowledge in the given field) are published in this journal. Papers are published in English. Each manuscript must contain a English and a Czech (Slovak) summary (including key words). Czech abstracts will be provided for foreign authors. The author is fully responsible for the originality of his paper, for its subject and format. The author should make a written declaration that his paper has not been published in any other information source. The board of editors of this journal will decide on paper publication, with respect to expert opinions, scientific importance, contribution and quality of the paper. The paper should not exceed 10 typescript pages, including tables, figures and graphs.

Manuscript layout: paper of standard size (210 × 297 mm), double-spaced typescript. The manuscript must be provided on a PC disquette or sent by e-mail (the used program should be indicated). Tables, figures and photos should be enclosed separately. The text must contain references to all these appendices.

If any abbreviation is used in the paper, it is necessary to mention its full form for the first time it is used, abbreviations should not be used in the title or in the summary of the paper.

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Review of literature should be a short section, containing only references closely related to the main topic of the paper.

Only original **methods** should be described, in other cases cite the method used and any modifications. This section should also contain a description of experimental material.

In the **Results** section figures and graphs should be used rather than tables for presentation of quantitative values. A statistical analysis of recorded values should be summarized in tables. This section should not contain either theoretical conclusions or deductions, but only experimental data.

Discussion contains an evaluation of the study, potential shortcomings are discussed, and the results of the study are compared with previously published results (only those authors whose studies are closely related to the published paper should be cited). The section Results and Discussion may be presented as one section.

The **References** section contains citations arranged alphabetically according to the surname of the first author. References in the text include the author's name and year of publication. Only the papers cited in the text of the study should be included in the list of references.

The author should give his full name (and the names of other collaborators), academic, scientific and pedagogic titles, full address of his workplace and postal code, telephone and fax number or e-mail.

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CZECH JOURNAL OF ANIMAL SCIENCE

Volume 47, No. 11   November 2002

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