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## Effectiveness of six highly polymorphic microsatellite markers in resolving paternity cases in Thoroughbred horses in Slovakia

### Využitie šiestich polymorfných mikrosatelitných lokusov pri overovaní pôvodu u anglických plnokrvníkov na Slovensku

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**ABSTRACT:** Six microsatellite loci were evaluated for their suitability for parentage control in horses. A combination of PCR and semiautomatic fluorescence-based detection was applied. A total of 352 animals were tested. The microsatellite loci showed extensive polymorphism with allele numbers ranging from 7 to 11 and polymorphism information content (PIC) values in the range 0.47–0.82. The analysis of these loci also revealed that they had a 98.88% combined probability of exclusion (PE) of false parentage. The results of this study suggested that a very high probability of exclusion could be reached with only six microsatellite loci.

**Keywords:** horse; microsatellite; PCR; parentage control; thoroughbred

**ABSTRAKT:** V našej práci prezentujeme výsledky analýzy šiestich mikrosatelitných systémov pri overovaní pôvodu u 352 anglických plnokrvníkov na Slovensku. Pre polymerázovú reťazovú reakciu (PCR) sme použili publikované primery, pričom podmienky PCR amplifikácie sme optimalizovali pre podmienky laboratória. Príslušné PCR fragmenty, značené fluorescenčnou farbičkou – Texas Red sme hodnotili pomocou sekvenátora (A.L.F. DNA sequencer – Pharmacia). V našich analýzach sme detegovali vo všetkých sledovaných mikrosatelitných lokusoch vysoký stupeň polymorfizmu, s počtom alel 7 až 11 a hodnoty PIC sa pohybovali od 0,47 do 0,82. Pri aplikácii všetkých šiestich mikrosatelitných systémov hodnota kombinovanej pravdepodobnosti vylúčenia (PE) bola 98,88 %. Výsledky našej práce potvrdzujú možnosť použitia len šiestich mikrosatelitných lokusov pri overovaní pôvodu anglických plnokrvníkov na Slovensku.

**Kľúčové slová:** kôň; mikrosatelitné systémy; PCR; pôvod; plnokrvník

In animal breeding accurate determination of relatedness and efficient control of pedigree registration is of great importance.

The discovery of polymorphism in short tandem repeat (STR or microsatellites) loci and the introduction of polymerase chain reaction (PCR) meth-

odology (Litt and Luty, 1989; Weber and May, 1989) has led to the establishment of extremely powerful “universal” method for individual identification and for parentage control in humans and animals.

Microsatellites have been identified in all eukaryotic species studied so far. There are four main aspects of microsatellites/STR-typing that make it particularly attractive as a tool in routine application: abundance of STRs in the genome and their highly polymorphic nature; amenability of STRs to multiplex PCR amplification; possibility to assign specific bands to specific loci and thus to ascertain allele frequencies; use of semi-automated fluorescence gel scanning for the analysis of amplified products.

## MATERIAL AND METHODS

DNA was isolated from peripheral blood collected in tubes coated with Na<sub>2</sub>-EDTA from a total of 352 Thoroughbred horses registered in Slovak Stud Book (25 stallions, 152 foals, 175 dams). For blood samples used in this study, DNA extraction basically followed the protocol of Promega (Wizard Genomic DNA Purification Kit).

A set of 6 microsatellites – *ASB2*, *HMS3*, *HMS6*, *HMS7*, *HTG4*, *VHL20* – was analysed in this study. The primers specific to each locus, i.e. complemen-

tary to sequences flanking the microsatellites, were synthesised by a commercial oligonucleotide synthesising service. The primer sequences used for the amplification of the loci are shown in Table 1.

For each PCR reaction one primer was 5' end-labelled with Texas Red. PCR was performed in a total volume of 30 µl of the following mixture: 0.4 µM of both labelled and unlabelled primers, 1× PCR standard reaction buffer (Perkin Elmer) with MgCl<sub>2</sub> concentrations depending on the distinct properties of each microsatellite (Perkin Elmer), 200 µM of each dNTP, 1 unit of AmpliTaq Gold polymerase (Perkin Elmer) and 100 ng of genomic DNA. The reactions were carried out on a thermal cycler MJ Research (PTC 200). The PCR time, cycles and temperature conditions were optimised for each primer set.

The amplified PCR products were separated and visualised by an Automated Laser Fluorescent DNA sequencer (A.L.F. DNA sequencer, Pharmacia). Sizes were determined using external standards (50–500 bp size marker-ladder, Pharmacia) as well as standard samples specific to the loci of each microsatellite.

Exclusion probabilities and polymorphic information content (PIC) of microsatellite loci were calculated on the basis of the observed allele frequencies (Botstein *et al.*, 1980; Weir, 1996). Observed and expected heterozygosities were calculated according to Ott (1992) and Nei (1973).

Table 1. Primer sequences used for the amplification of microsatellite loci

Locus	Primer sequences (5'–3')	References
<i>HMS3</i>	P1: CCA ACT CTT TGT CAC ATA ACA AGA	Guérin <i>et al.</i> (1994)
	P2: CCA TCC TCA CTT TTT CAC TTT GTT	
<i>HMS6</i>	P1: GAA GCT GCC AGT ATT CAA CCA TTG	Guérin <i>et al.</i> (1994)
	P2: CTC CAT CTT GTG AAG TGT AAC TCA	
<i>HMS7</i>	P1: CAG GAA ACT CAT GTT GAT ACC ATC	Guérin <i>et al.</i> (1994)
	P2: TGT TGT TGA AAC ATA CCT TGA CTG T	
<i>HTG4</i>	P1: CTA TCT CAG TCT TGA TTG CAG GAC	Ellegren <i>et al.</i> (1992)
	P2: CTC CCT CCC TCC CTC TGT TCT C	
<i>VHL20</i>	P1: CAA GTC CTC TTA CTT GAA GAC TAG	Van Haeringen <i>et al.</i> (1994)
	P2: AAC TCA GGG AGA ATC TTC CTC AG	
<i>ASB2</i>	P1: CCT TCC TGT AGT TTA AGC TTC TG	Breen <i>et al.</i> (1997)
	P2: CAC AAC TGA GTT CTC TGA TAG G	

## RESULTS AND DISCUSSION

The number of alleles observed in the six microsatellite systems with their average band size, the allele frequencies in Thoroughbred horses in Slovakia are given in Table 2.

The *HTG4* locus had 7 alleles, ranging in size from 127 to 139 bp. The *HMS6* and *HMS7* microsatellite loci were also highly polymorphic, with 8 and 9 alleles with sizes 157–171 bp and 169–185 bp, respectively. Ten alleles with sizes ranging from 150–170 bp and 87–105 bp were detected

Table 2. Polymorphism of six microsatellite loci in Thoroughbred horses

Locus	Number of alleles	Allele size (bp)	Allele frequencies	Locus	Number of alleles	Allele size (bp)	Allele frequencies
<i>ASB2</i>	11	222	0.033	<i>HMS7</i>	9	169	0.0016
		236	0.0033			171	0.0379
		240	0.2425			173	0.1384
		242	0.0214			175	0.0346
		244	0.0842			177	0.1862
		246	0.1386			179	0.2125
		248	0.0545			181	0.1944
		250	0.0528			183	0.1845
		252	0.2195			185	0.0099
		254	0.1485				
		256	0.0012				
<i>HMS3</i>	10	150	0.0017	<i>HTG4</i>	7	127	0.0198
		152	0.5267			129	0.5025
		154	0.0017			131	0.0215
		158	0.0034			133	0.4248
		160	0.1242			135	0.0165
		162	0.052			137	0.0016
		164	0.0906			139	0.0132
		166	0.1795				
		168	0.005				
		170	0.0151				
<i>HMS6</i>	8	157	0.0201	<i>VHL20</i>	10	87	0.0016
		159	0.146			89	0.3054
		161	0.0973			91	0.0033
		163	0.2735			93	0.0099
		165	0.01			95	0.1379
		167	0.0336			97	0.3153
		169	0.4144			99	0.2069
		171	0.0034			101	0.0066
		103	0.0115				
		105	0.0016				

for *HMS3* and *VHL20*, respectively, while *ASB2* had 11 alleles with a size range of 222–256 bp. The highest exclusion efficiencies were observed with locus *ASB2* and with locus *HMS7*. The PIC values of the six microsatellite loci tested were all above 0.66 (Table 3). The high polymorphism with well balanced frequencies of the alleles makes these systems attractive for parentage control. They are not only highly informative but also quite simple to use and to standardise.

The genetic analysis using the six microsatellite loci has revealed that they have a combined exclusion probability (Weir, 1996) of 98.88%. This study has also shown that at least five microsatellites like those with the highest individual PE values (Table 4) that have a 98.45% combined probability of exclusion should be used to obtain a high degree of excluding incorrect parentage. Usha *et al.* (1994) also reported a combined PE of 0.88 for two microsatellite loci used in cattle parentage control.

Ellegren *et al.* (1992) suggested that at least ten microsatellite loci should be used to achieve a maximum exclusion in horses. Marklund *et al.* (1994) analysed eight microsatellite loci in paternity testing to reach a combined exclusion probability of 0.96–0.99 in different breeds. Comparison of our results with these various results clearly shows that our selected microsatellites have greater power of exclusion given the fact that we could reach a very high level of exclusion with only five loci (PE = 0.98). Analyses of more loci will allow to increase the combination efficiency.

In conclusion, these results (allelic variation, allele frequencies, PIC values) in combination with the fact that microsatellite loci are located on different chromosomes fulfil the basic requirements of a test using the above STR polymorphism for parentage verification.

Table 3. Summary of heterozygosities, polymorphism information content values (PIC) and probability exclusion (PE) in Thoroughbred horses

Locus	Heterozygosity – expected	Heterozygosity – observed	PIC	PE
<i>ASB2</i>	0.837	0.832	0.817	0.678
<i>HMS3</i>	0.664	0.611	0.629	0.446
<i>HMS6</i>	0.721	0.738	0.679	0.492
<i>HMS7</i>	0.826	0.884	0.802	0.651
<i>HTG4</i>	0.566	0.606	0.473	0.278
<i>VHL20</i>	0.745	0.796	0.701	0.509

Table 4. Combined probabilities of exclusion as a function of the number of loci with combinations in descending order of PE values

Locus	1 locus	2 loci	3 loci	4 loci	5 loci	6 loci
<i>ASB2</i>	0.678	0.678	0.678	0.678	0.678	0.678
<i>HMS7</i>		0.651	0.651	0.651	0.651	0.651
<i>VHL20</i>			0.509	0.509	0.509	0.509
<i>HMS6</i>				0.492	0.492	0.492
<i>HMS3</i>					0.446	0.446
<i>HTG4</i>						0.278
Combined PE	0.678	0.887	0.945	0.972	0.984	0.988

## REFERENCES

- Breen M., Lindgren G., Binns M.M., Bell K., Sandberg K., Ellegren H. (1997): Genetical and physical assignments of equine microsatellites – first integration of anchored markers in horse genome mapping. *Mamm. Genome*, 8, 267–273.
- Botstein D., White R.L., Skolnick M., Davis R.W. (1980): Construction of a genetic linkage map in man using restriction fragment length polymorphisms. *Am. J. Hum. Genet.*, 32, 314–331.
- Ellegren H., Johansson M., Sandberg K., Andersson L. (1992): Cloning of highly polymorphic microsatellites in the horse. *Anim. Genet.*, 23, 133–142.
- Guérin G., Bertaud M., Amigues Y. (1994): Characterization of seven new horse microsatellites: *HMS1*, *HMS2*, *HMS3*, *HMS5*, *HMS6*, *HMS7* and *HMS8*. *Anim. Genet.*, 25, 62.
- Litt M., Luty J.A. (1989) A hypervariable microsatellite revealed by *in vitro* amplification of a dinucleotide repeat within the cardiac muscle actin gene. *Am. J. Hum. Genet.*, 44, 397–401.
- Marklund S., Ellegren H., Erikson S., Sandberg K., Andersson L. (1994): Parentage testing and linkage analysis in the horse using a set of highly polymorphic microsatellites. *Anim. Genet.*, 25, 19–23.
- Nei M. (1973): Analysis of gene diversity in subdivided populations. *Proc. Natl. Acad. Sci. USA*, 70, 3321–3323.
- Ott J. (1992): Strategies for characterising highly polymorphic markers in human gene mapping. *Am. J. Hum. Genet.*, 51, 283–290.
- Usha A. P., Simpson S.P., Williams J.L. (1994): Evaluation of microsatellite markers for parentage verification. In: *Proceedings of the 24th ISAG Conference. Anim. Genet.*, 25, 41.
- Van Haeringen H., Bowling A.T., Stott M.L., Lenstra J.A., Zwaagstra K.A. (1994): A highly polymorphic horse microsatellite locus: *VHL20*. *Anim. Genet.*, 25, 207.
- Weber J.L., May P.E. (1989): Abundant class of human DNA polymorphisms which can be typed using the polymerase chain reaction. *Am. J. Hum. Genet.*, 44, 388–396.
- Weir B.S. (1996): *Genetic Data Analysis II*. Sinauer Associates, Inc. Publishers Sunderland, Massachusetts.

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# Evaluation of growth and carcass value of kids nursed on a milk replacer for calves

## Zhodnocení růstu a jatečné hodnoty kůzlat odchovaných na bázi mléčné náhražky pro telata

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**ABSTRACT:** The growth and carcass value of kids of the White Short-haired breed receiving a milk replacer for calves and/or nursed traditionally with their mothers were evaluated on a goat farm in Šošůvka. A total of 33 kids were used for the analysis of growth intensity. From birth to the age of 20 days, all kids were reared in the same way, i. e. with their mothers. At the average age of 20 days, a total of 22 kids were weaned and subdivided into two groups (A:  $n = 11$  and B:  $n = 11$ ). The remaining 11 kids were used as a control group (group C:  $n = 11$ ) and stayed with their mothers. The analysis of the effect of milk replacer on growth revealed that the average daily weight gains (ADWG) after weaning in groups A (0.168 kg) and B (0.155 kg) decreased ( $P \leq 0.05$  and  $P \leq 0.01$ ) as compared with group C (0.202 kg). As far as the ADWG from birth to the end of the experiment (i. e. 60 days) were concerned, the highest ADWG was recorded in group C again (0.210 kg) and the differences between groups A (0.183 kg) and C and B (0.178 kg) and C were  $P \leq 0.05$  in both cases. The analysis of the effect of milk replacer on average dressing percentage (ADP) showed that, as compared with group C (48.74%), ADP was significantly lower ( $P \leq 0.05$ ) in groups A (46.56%) and B (45.92%). On the other hand, it should be mentioned that the different level of nutrition did not significantly influence average colour class (1.33 vs. 1.17 vs. 1.33), average fatness class (1.33 vs. 1.50 vs. 1.83), average proportions of leg and rack (31.10% vs. 31.61% vs. 31.11% and 20.85% vs. 20.41% vs. 21.35%) and average proportions of individual tissues in the right rack.

**Keywords:** growth; carcass value; milk replacer; kids; White Short-haired breed

**ABSTRAKT:** Zhodnocení růstu a jatečné hodnoty kůzlat plemene bílá krátkosrstá koza odchovaných na bázi mléčné náhražky pro telata, respektive při aplikaci tradičního odchovu pod matkami, bylo realizováno na farmě v Šošůvce v roce 2001. V rámci hodnocení růstu bylo do sledování zařazeno celkem 33 kůzlat, jež byla v průměrném věku 20 dnů rozdělena do tří identických skupin (A, B, C) z pohledu počtu kusů, pohlaví a četností. U skupin A a B byl v tomto věku realizován odstav od matek s následným využitím mléčné náhražky, skupina C byla po celou dobu sledování odchovávána pod matkami. Ze zhodnocení vlivu mléčné náhražky na růst především vyplývá, že u skupin A a B došlo po odstavu od matek k poklesu růstové schopnosti (A = 0,168 kg, B = 0,155 kg) oproti skupině C (0,202 kg), když rozdíl mezi průměrnou úrovní růstu v intervalu od 21. do 60. dne věku byl mezi skupinami A a C statisticky průkazný ( $P \leq 0,05$ ) a mezi skupinami B a C statisticky vysoce průkazný ( $P \leq 0,01$ ). V intervalu od narození do konce sledování, tzn. do 60 dnů věku kůzlat, byl opětovně zjištěn nejvyšší přírůstek u skupiny C (0,210 kg), když rozdíl oproti skupině A (0,183 kg) a B (0,178 kg) byly v obou případech ( $P \leq 0,05$ ). Z hodnocení vlivu aplikace mléčné náhražky na základní ukazatele jatečných analýz především vyplývá, že u obou skupin kůzlat (A, B), u kterých byla tato náhražka aplikována, byla zjištěna statisticky průkazně ( $P \leq 0,05$ ) nižší průměrná výtěžnost jatečně opracovaného trupu (A = 46,56 %, B = 45,92 %) oproti skupině C (48,74 %). Z hodnocení průměrných

podílů ledvinky vyplývá, že statisticky vysoce průkazně ( $P \leq 0,01$ ) nejvyšší podíl ledvinky byl zjištěn u skupiny kůzlat pod matkami (C = 0,70%), když u skupin A a B činil průměrný podíl ledvinky 0,50 % a 0,49 %. U průměrných hmotností ledvinového tuku, respektive jejich průměrných podílů, nebyl ani v jednom případě zjištěn průkazný vliv odlišné výživy kůzlat na úroveň těchto ukazatelů. Z experimentálního posouzení JOT podle systému SEUROP především vyplývá, že ani v jednom případě nebyl zaznamenán statisticky průkazný vliv odlišné výživy kůzlat na sledované ukazatele; neprůkazně nejlepší zbarvení (1,17) bylo zjištěno u skupiny B a nejmenší protučnění (1,33) u skupiny A. Ze zhodnocení podílů partií kýta a plec vyplývá, stejně jako v případě experimentálního posouzení JOT dle systému SEUROP, že ani v jednom případě nebyl zjištěn statisticky průkazný vliv odlišné výživy kůzlat na úroveň těchto ukazatelů; průměrné podíly kýty, respektive plece se pohybovaly v rozmezí od 31,10 (A) do 31,61 % (B), respektive od 20,41 % (B) do 21,35 % (C). Statisticky neprůkazný vliv odlišné výživy kůzlat (skupiny A, B, C), byl zjištěn i u podílu svaloviny (69,80 % vs. 67,59 % vs. 67,69 %), kostí (23,75 % vs. 25,27 % vs. 25,19 %) a tuku (6,33 % vs. 7,13 % vs. 7,12 %) v partii pravá plec.

**Klíčová slova:** růst; jatečná hodnota; mléčná náhražka; kůzlata; bílá krátkosrstá koza

In general, the majority of goat farms in the Czech Republic apply a traditional method of nursing of kids: they usually stay with their mothers till the age of two to three months. Artificial methods of nursing with application of different types of milk replacers are used above all in cases when the mother dies or cannot produce enough milk to feed the progeny. However, an increasing demand for goat's milk and/or dairy products forces goat farmers to look for methods how to extend the lactation period not only for economic but also competitive reasons. If they want to maintain their position on the home market, the best solution is to replace goat's milk by various types of milk replacers for kids.

Problems concerning the effects of application of maternal milk and/or various milk replacers on some performance parameters of kids of the Creole breed were studied by Perez *et al.* (2001). Pena-Blanco *et al.* (1994) studied this problem in kids of the breed Florida Sevillana. Effects of various forms of milk supply restriction on the growth intensity of kids were investigated by Goetsch *et al.* (2001). Marsico *et al.* (1993) analysed the effect of weaning age on meat quality and growth intensity of kids.

In the Czech Republic, effects of different forms of nutrition (i. e. of cow's milk and some starters) on growth, carcass value and meat quality of kids of the White Short-haired breed were studied by Skřivanová *et al.* (1995). Grazing is an integral part of the system of kid feeding in many circumstances. Effects of grazing and different levels of supply of concentrates on some parameters of carcass value of kids of the West African breed were studied

by Reismann and Seifert (1992). Páleník (1990) analysed the effect of a traditional method of nursing of kids with their mothers on carcass value. Ochodnický *et al.* (1991) evaluated a similar problem but only with regard to the application of an intensive method of fattening.

At present, there are several methods how to nurse kids successfully on milk replacers. However, the basic precondition of success is that the health condition, growth intensity and carcass value of kids should not be markedly deteriorated. Therefore the main objective of our experiment was to evaluate the growth and carcass value of kids receiving a milk replacer for calves. A possibility of kid weaning at older age that is generally recommended was studied as well.

## MATERIAL AND METHODS

The growth and carcass value of kids of the White Short-haired breed receiving a milk replacer for calves and/or nursed traditionally with their mothers were evaluated on a goat farm in Sošůvka in 2001. A total of 33 kids were used for the analysis of growth intensity. From birth to the age of 20 days, all kids were reared in the same way, i. e. with their mothers and their contacts with mothers were not regulated. At the average age of 7 days, all kids were offered meadow hay of top quality. At the age of 20 days, a total of 22 kids were weaned and subdivided into two groups (A:  $n = 11$  and B:  $n = 11$ ). Milking of their mothers ( $n = 10$ ) started immediately after weaning. Total average milk pro-

duction per goat in the period from 21 to 60 days of lactation was 136 litres. The remaining 11 kids were used as a control group (group C:  $n = 11$ ) and stayed with their mothers. Similarly like during the pre-weaning period, their contacts with mothers were not regulated till the end of the study period. All three groups of kids (A, B and C) were identical and each group consisted of 6 males and 5 females; 8 of them originated from twins and 3 from triplets. From the 21st to the 60th day of age, weaned kids in groups A and B were fed according to the formulas presented in Tables 1 and 2. The number of feeding places at automatic milk feeders in each

group was higher than the total number of kids in each group. Unweaned animals (group C) were fed in a way described in Table 3. As one can see, the feeding ration of kids in group A consisted of meadow hay offered *ad libitum*, starter (ČOT) and milk drink. The average real daily consumption of milk replacer, milk drink and starter ČOT per kid for the whole study period in group A was 104 g, 0.94 l and 0.036 kg, respectively. The average values of daily intake of energy and crude protein per head in this group were 2.10 MJ NEF and 44.06 g, respectively. *Ad libitum* consumption of meadow hay was not taken into account. In group B, the post-

Table 1. Feeding schedule/day – group A

Age (days)	Mother's milk (l) – (predicted consumption per kid)	Meadow hay	Starter ČOT (kg)	Milk replacer		
				Dilution ratio	Consumption of milk replacer kid/day (g)	Consumption of milk drink kid/day (l)
1–7	0.90	<i>ad libitum</i>	–	–	–	–
8–14	1.30	<i>ad libitum</i>	–	–	–	–
15–20	1.50	<i>ad libitum</i>	–	–	–	–
21–28	–	<i>ad libitum</i>	0.025	1 : 7	112	0.90
29–35	–	<i>ad libitum</i>	0.040	1 : 8	133	1.20
36–49	–	<i>ad libitum</i>	0.060	1 : 8	167	1.50
50–60	–	<i>ad libitum</i>	0.075	1 : 8.5	189	1.80
ADC*	0.40	–	0.036	–	104	0.94

\*ADC = average daily consumption per kid – in the period from birth to 60 days of age

Table 2. Feeding schedule/kid/day – group B

Age (days)	Mother's milk (l) – (predicted consumption per kid)	Meadow hay	Milk replacer		
			Dilution ratio	Consumption of milk replacer kid/day (g)	Consumption of milk drink kid/day (l)
1–7	0.90	<i>ad libitum</i>	–	–	–
8–14	1.30	<i>ad libitum</i>	–	–	–
15–20	1.50	<i>ad libitum</i>	–	–	–
21–28	–	<i>ad libitum</i>	1 : 7	112	0.90
29–35	–	<i>ad libitum</i>	1 : 8	133	1.20
36–49	–	<i>ad libitum</i>	1 : 8	167	1.50
50–60	–	<i>ad libitum</i>	1 : 8.5	189	1.80
ADC*	0.40	–	–	104	0.94

\*ADC = average daily consumption per kid – in the period from birth to 60 days of age

Table 3. Feeding schedule/kid/day – group C

Age (days)	Mother's milk (l) (predicted consumption per kid)	Meadow hay	Starter ČOT (kg)
1–7	0.90	<i>ad libitum</i>	–
8–14	1.30	<i>ad libitum</i>	–
15–20	1.50	<i>ad libitum</i>	–
21–28	1.80	<i>ad libitum</i>	0.025
29–35	1.80	<i>ad libitum</i>	0.040
36–49	1.70	<i>ad libitum</i>	0.060
50–60	1.60	<i>ad libitum</i>	0.075
ADC*	1.55	–	0.036

\* ADC = average daily consumption per kid – in the period from birth to 60 days of age

weaning feeding ration consisted only of meadow hay offered *ad libitum* and milk drink (Table 2). The average real daily consumption of milk replacer and milk drink per kid in group B was the same as in group A (i. e. 104 g and 0.94 l, resp.). In this group, the average daily intake of energy and crude protein per head was (without *ad libitum* intake of meadow hay) 1.84 MJ NEF and 37.40 g, respectively. In both groups the milk replacer Miktel (manufacturer Mikrop Čebín a.s.) was used. From 21st to 40th day of age, a lukewarm milk drink was given to kids in both groups three times a day and thereafter twice a day till the end of the experiment. In dependence on the age of kids, the dilution ratio of milk replacer : drinking water ranged from 1 : 7 to 1 : 8.5 (Tables 1 and 2). The feeding schedule of kids without weaning (group C) indicates that the predicted average daily consumption of maternal milk per kid was 1.55 litres (Table 3). In this group, the average daily consumption of starter (ČOT) per kid was 0.036 kg and the average daily intake of energy and crude protein per kid was 3.39 MJ NEF and 60.91 g, respectively. The *ad libitum* intake of meadow hay was not taken into account. Besides, all kids had an unrestricted access to drinking water and salt lick.

Live weight of all kids was continuously followed during the whole study period. To the end of the experiment when the average age of kids was 60 days, all males from each group were slaughtered. After 24 hours, cooled carcasses were experimentally evaluated and classed according to meat colour and fatness into the corresponding class in the category "Lambs and kids with carcass weight below 13 kg"

(Pour *et al.*, 1998). To evaluate the meat colour of carcasses according to the SEUROP system the following key was used: pink colour – Class 1, other colour shades – Class 2. The subsequent carcass dressing consisted in the estimation of proportions of leg and rack, mainly with respect to their weight and size in accordance with Standard ON 57 6655. The right rack was used for the analysis of weights and/or proportions of individual tissues. Statistical analysis was performed on the basis of the results of periodic weighing and control slaughters using the method of one-factor analysis of variance and testing according to Scheffe's test using the procedure Statgraphics version 7.0.

## RESULTS AND DISCUSSION

A survey of selected growth parameters of all three groups of kids is presented in Table 4. Average values of birth weight were relatively uniform in all three groups and the differences ranged from 2.15 kg (C) to 2.21 kg (B). As far as the average live weights at the average kid age of 20 days were concerned, the statistically insignificantly highest average live weight was determined in group B (6.72 kg) while the lowest one was found in group A (6.47 kg). The highest average daily weight gain (ADWG) from birth to 20 days of age, i. e. in the period when all kids were fed in the same manner, was determined in group C (0.226 g). On the other hand, the lowest ADWG in the same period was found in group A (0.213 kg) but the difference was not significant. Within this time period, the

Table 4. Some growth characteristics

Characteristic		Group			F-test
		A (n = 11)	B (n = 11)	C (n = 11)	
Live weight at birth (kg)	$\bar{x}$	2.20	2.21	2.15	0.09
	$s_x$	0.319	0.432	0.386	
Live weight at 20 days of age (kg)	$\bar{x}$	6.47	6.72	6.67	0.37
	$s_x$	0.628	0.689	0.862	
Live weight at 60 days of age (kg)	$\bar{x}$	13.18 <sup>c</sup>	12.90 <sup>c</sup>	14.76 <sup>ab</sup>	4.11 *
	$s_x$	1.963	1.819	0.965	
Average daily weight gain from birth to 20 days of age (kg)	$\bar{x}$	0.213	0.225	0.226	0.66
	$s_x$	0.031	0.027	0.032	
Average daily weight gain from 21 to 60 days of age (kg)	$\bar{x}$	0.168 <sup>c</sup>	0.155 <sup>C</sup>	0.202 <sup>ab</sup>	5.03 *
	$s_x$	0.044	0.037	0.027	
Average daily weight gain from birth to 60 days of age (kg)	$\bar{x}$	0.183 <sup>c</sup>	0.178 <sup>c</sup>	0.210 <sup>ab</sup>	4.68 *
	$s_x$	0.034	0.028	0.014	

\*a, b, c –  $P \leq 0.05$ \*\*A, B, C –  $P \leq 0.01$ 

level of ADWG in each group was higher than that reported by Goetsch *et al.* (2001) for kids of the Alpine breed but comparable with data mentioned by Skřivanová *et al.* (1995) for kids of the White Short-haired breed. At the average age of 20 days, kids of groups A and B were weaned and started to receive the milk replacer for calves. As for the intake of this replacer, it should be mentioned that all kids in both groups were able to consume the milk drink without any problems within 3 days after weaning; this observation is in agreement with all available literary data. However, as compared with data published by Galina *et al.* (1995), the transition to milk replacer was not associated with the occurrence of diarrhoea in any of the experimental kids and from the viewpoint of the health condition of all kids it is possible to evaluate this period of transition to the consumption of milk replacer as absolutely smooth. When speaking about the transition to the unassisted consumption of milk drink it can be said that 6 and 5 kids (i. e. 55% and 45% in groups A and B, respectively) started with this activity on the first day after weaning. On the second day, the corresponding numbers were 3 and 4 kids in groups A (ca. 27%) and B (ca. 36%), respectively. All other kids began to consume the milk drink on the third day after weaning.

The evaluation of ADWG of kids in all three groups between the 21st and 60th day of age indicates that the growth intensity decreased in both groups of weaned kids (A = 0.168 kg, B = 0.155 kg). In the unweaned group C, ADWG in this period was 0.202 kg and the differences in the growth in this period between groups A and C and B and C were statistically significant ( $P \leq 0.05$ ) and statistically highly significant ( $P \leq 0.01$ ). The growth deceleration observed in groups A and B did not correspond with data published by Skřivanová *et al.* (1995), who observed that after weaning the kids receiving a milk replacer showed average daily weight gains higher than 0.200 kg. On the other hand, it should be mentioned that ADWG observed from 21 to 60 days of age in groups A and B were fully comparable with data published by Goetsch *et al.* (2001) and Galina *et al.* (1995). As far as the ADWG of kids in groups A and B in the period from 21 to 60 days of age were concerned, a higher but statistically insignificant ADWG was recorded in group A. This relatively higher ADWG in the given period can be explained by the fact that this group (A) also received the starter ČOT after weaning so that the average energy intake per kid was higher in this group. The differences in ADWG, especially from 21 to 60 days of age, were

also manifested in the final average live weights of kids in individual groups (A = 13.18 kg; B = 12.90 kg; C = 14.76 kg). The differences between these final live weights in groups A and C and B and C were statistically significant ( $P \leq 0.05$ ) in both cases. This growth analysis indicated that the statistically significantly ( $P \leq 0.05$ ) highest ADWG from birth to 60 days of age was recorded in unweaned kids in group C (0.210 kg). This value was comparable with data published by Kuchtk *et al.* (1999) and Skřivanová *et al.* (1995). The ADWG of kids weaned in the period from birth to 60 days of age were relatively uniform (A = 0.183 kg; B =

0.178 kg). When comparing ADWG in groups A and B from birth to 60 days of age with data published by authors studying the effect of application of milk replacers on growth intensity it should be mentioned that these ADWG were comparable with data reported by Goetsch *et al.* (2001) and/or that these ADWG were higher than those published by Perez *et al.* (2001), Pena-Blanco *et al.* (1994) and Galina *et al.* (1994).

It results from the evaluation of basic parameters of carcass analyses (Table 5) that there were no statistically significant differences between the individual groups in average live weights at slaughter.

Table 5. Evaluation of basic characteristics of carcass analyses (in kg and in %)

Characteristic	Group			F-test
	A (n = 6)	B (n = 6)	C (n = 6)	
Live weight at slaughter (kg)	$\bar{x}$	13.75	13.28	3.11
	$s_x$	1.188	1.749	
Dressed carcass weight (kg)	$\bar{x}$	6.41 <sup>c</sup>	6.10 <sup>c</sup>	4.78*
	$s_x$	0.690	0.747	
Dressing percentage (%)	$\bar{x}$	46.56 <sup>c</sup>	45.92 <sup>c</sup>	4.34*
	$s_x$	1.585	1.666	
Skin (kg)	$\bar{x}$	0.92	0.84	1.83
	$s_x$	0.047	0.077	
Skin (%)	$\bar{x}$	6.70	6.37	0.92
	$s_x$	0.313	0.470	
Kidney (kg)	$\bar{x}$	0.070 <sup>C</sup>	0.066 <sup>C</sup>	9.37**
	$s_x$	0.023	0.018	
Kidney (%)	$\bar{x}$	0.50 <sup>C</sup>	0.49 <sup>C</sup>	8.16**
	$s_x$	0.139	0.103	
Kidney fat (kg)	$\bar{x}$	0.095	0.082	2.56
	$s_x$	0.055	0.046	
Kidney fat (%)	$\bar{x}$	0.67	0.59	2.17
	$s_x$	0.363	0.263	
Colour class	$\bar{x}$	1.33	1.17	0.24
	$s_x$	0.516	0.408	
Fatness class	$\bar{x}$	1.33	1.50	1.59
	$s_x$	0.516	0.548	

\*a, b, c –  $P \leq 0.05$

\*\*A, B, C –  $P \leq 0.01$

On the other hand, there were statistically significant differences ( $P \leq 0.05$ ) between groups A and C and B and C in average dressed carcass weights and in average dressing percentages because in both cases the highest values were recorded in kids of group C (7.33 kg and 48.74%, respectively). On the other hand, the value of average dressing percentage in group C was lower than that reported by Luo *et al.* (2000) or Dhanda *et al.* (1999); however, it was fully comparable with data mentioned by Mioc *et al.* (2001) and Kuchtík *et al.* (1999) for kids of the Alpine and White Short-haired breeds, respectively. The average values of dressing percentage of kids receiving milk replacer in the period of nursing were as follows: A = 46.56%, B = 45.92%, and these values were higher than those published by Daskiran and Ertugrul (1994), Skřivanová *et al.* (1995) and Ochodnický *et al.* (1991). However, Páleník (1990) and Perez *et al.* (2001) reported higher average values of dressing percentages. The average proportions of skin differed in the particular groups and ranged from 6.70% (group A) to 6.34% (group C), and both these values were lower than those mentioned by Ochodnický *et al.* (1991). On the other hand, Páleník (1990) found slightly higher proportions of skin than we did. The evaluation of the average proportion of kidney revealed that the highest value of this parameter was observed in kids nursed together with their mothers (C = 0.70%) while in groups A and B the average values of this parameter were 0.50% and 0.49%, respectively, and the differences between groups A and C and B and C were statistically highly significant ( $P \leq 0.01$ ) in both cases. On the other hand,

no significant effect of individual groups of kids on the average proportion of kidney fat (A = 0.67%, B = 0.59%, C = 0.94%) was determined in our experiment.

The experimental evaluation of carcasses according to the SEUROP system revealed that there were no significant effects of the group of kids on parameters under study. In the concrete, the relatively best average colour class of meat was determined in group B (1.17) and the lowest and the highest classes of fatness were found in groups A and C (1.33 and 1.83, respectively).

The evaluation of average weights and proportions of selected cuts (leg and rack) indicated that there was no statistically significant effect of individual groups of kids on these parameters (Table 6). In the concrete, the average proportions of leg ranged from 31.10% (group A) to 31.61% (group B) and both these average values were comparable with data published by Ochodnický *et al.* (1991), Reismann and Seifert (1992) and Luo *et al.* (2000). The average proportions of rack ranged in individual groups from 20.41% to 21.35% in groups B and C, respectively and both these average values were higher than those mentioned by Ochodnický *et al.* (1991) and Reismann and Seifert (1992).

Proportions of individual tissues in the right rack are presented in Table 7. Similarly like in the evaluation of the proportions of selected carcass cuts, no significant effect of the particular group of kids on this parameter was observed. Depending on the group, the average proportions of muscle in this carcass cut ranged from 67.59% (group B) to 69.80% (group A). As compared with data

Table 6. Evaluation of selected cuts (leg and rack) of dressed carcass (in kg and in %)

Dressed carcass cuts		Group			F-test
		A (n = 6)	B (n = 6)	C (n = 6)	
Leg (kg)	$\bar{x}$	2.00	1.93	2.28	3.13
	$s_{\bar{x}}$	0.283	0.274	0.196	
Leg (%)	$\bar{x}$	31.10	31.61	31.11	0.39
	$s_{\bar{x}}$	1.275	1.167	1.044	
Rack (kg)	$\bar{x}$	1.34	1.25	1.57	3.10
	$s_{\bar{x}}$	0.231	0.224	0.233	
Rack (%)	$\bar{x}$	20.85	20.41	21.35	0.63
	$s_{\bar{x}}$	1.473	1.520	1.320	

Table 7. Evaluation of the tissues in the right rack (in kg and in %)

Tissue		Group			F-test
		A (n = 6)	B (n = 6)	C (n = 6)	
Right rack (kg)	$\bar{x}$	0.67	0.63	0.78	2.80
	$s_{\bar{x}}$	0.121	0.111	0.116	
Muscle (kg)	$\bar{x}$	0.47	0.43	0.53	2.78
	$s_{\bar{x}}$	0.858	0.073	0.069	
Muscle (%)	$\bar{x}$	69.80	67.59	67.69	3.32
	$s_{\bar{x}}$	1.145	1.910	1.643	
Bones (kg)	$\bar{x}$	0.16	0.16	0.20	2.78
	$s_{\bar{x}}$	0.029	0.035	0.032	
Bones (%)	$\bar{x}$	23.75	25.27	25.19	2.51
	$s_{\bar{x}}$	1.057	1.831	0.909	
Fat (kg)	$\bar{x}$	0.04	0.05	0.06	2.76
	$s_{\bar{x}}$	0.008	0.009	0.015	
Fat (%)	$\bar{x}$	6.33	7.13	7.12	2.40
	$s_{\bar{x}}$	0.622	0.607	0.911	

published by Colomer-Rocher *et al.* (1992), Tahir *et al.* (1993), and Luo *et al.* (2000), both these values were relatively high. The highest and the lowest average proportions of fat in the right rack were found in groups B and A (7.13% and 6.33%, respectively) and both these values were higher than those reported by Tahir *et al.* (1993), Kuchťik *et al.* (1999) and Mioc *et al.* (2001); however, similar results were published by Luo *et al.* (2000).

It can be concluded from the results of feeding cost evaluation that the use of milk replacers is economically more favourable than the traditional methods of nursing of kids with their mothers. An increase in milk production by 136 litres per goat and prolongation of the lactation period by 40 days were further positive factors found in our experiment.

## CONCLUSION

The evaluation of the growth of kids of the White Short-haired breed receiving either milk replacer MKS for calves or nursed in a traditional way with their mothers showed that the transition to the milk replacer caused a statistically significant decrease in growth intensity in both groups of kids on milk replacer in comparison with the group of kids nursed in a traditional way. There were no problems

about the intake of the milk replacer by kids, and all kids were able to consume the milk drink within 3 days after weaning. The results of analysis of basic carcass parameters indicated a statistically significantly lower dressing percentage in both groups receiving milk replacer than in the group nursed traditionally. But it can be concluded that different methods of feeding did not markedly influence the fatness class, colour class of meat, proportions of leg and rack and proportions of individual tissues in the right rack.

## REFERENCES

- Colomer-Rocher F., Kirton A.H., Mercer G.J.K., Duganzich D.M. (1992): Carcass composition of New Zealand Saanen goats slaughtered at different weights. *Small Ruminant Res.*, 7, 161–173.
- Daskiran I., Ertugrul M. (1994): Sütten kesim caginda besiyeye alinan ankara kecisi erkek oğlaklarının besi performansi ve karkas özellikleri. *Lalahan Hayvancılık Araştırma Enstitüsü Dergisi*, 34, 59–78.
- Dhanda J.S., Taylor D.G., Mc-Cosker J.E., Murray P.J. (1999): The influence of goat genotype on the production of Capretto and Chevron carcasses. 1. Growth and carcass characteristics. *Meat Sci.*, 52, 355–361.
- Galina M.A., Palma J.M., Pacheco D., Morales R.

- (1995): Effect of goat milk, cow milk, cow milk replacer and partial substitution of the replacer mixture with whey on artificial feeding of female kids. *Small Ruminant Res.*, 17, 153–158.
- Goetsch A.L., Detweiler G., Sahlu T., Dawson L.J. (2001): Effects of different management practices on preweaning and early postweaning growth of Alpine kids. *Small Ruminant Res.*, 41, 109–116.
- Kuchtík J., Chládek G., Hošek M. (1999): Růstová schopnost a jatečná hodnota mléčných kůzlat plemen koza bílá krátkosrstá a koza kašmírová. *Acta Univ. Agric. Brno*, XLVII, 79–86.
- Luo J., Sahlu T., Goetsch A.L. (2000): Growth and carcass traits of Boer × Alpine goats slaughtered at the ages of 31 and 50 weeks. *J Anim. Feed Sci.*, 9, 309–324.
- Marsico G., Vicenti A., Centoducati P., Braghieri A. (1993): Influence of weaning age on productive performance of kids slaughtered at 107 days of age. *Small Ruminant Res.*, 12, 321–328.
- Mioc B., Pavic V., Ivankovic A. (2001): Some carcass traits and chemical composition of different muscle groups in Alpine and Saanen breed kids. *Czech J. Anim. Sci.*, 46, 83–87.
- Ochodnický D., Margetinová J., Mikušová J. (1991): Jatočná kvalita kozliat z intenzívneho výkrmu. *Živoč. Vyr.*, 36, 55–65.
- Páleník Š. (1990): Jatočná hodnota mliečnych kozliat a jahniat. *Živoč. Vyr.*, 35, 817–824.
- Pena-Blanco F., Gitierrez-Cabezas M.J., Herrera-Garcia M. (1994): Crecimiento postnatal y rendimientos canal en cabritos de raza Florida Sevillana. *Arch. Zoot.*, 43, 81–91.
- Perez P., Maino M., Morales M.S., Soto A. (2001): Effect of goat milk and milk substitutes and sex on productive parameters and carcass composition of Creole kids. *Small Ruminant Res.*, 42, 87–93.
- Pour M., Vrchlabský J., Ivánek J., Pulkrábek J., Smolák M. (1998): Prováděcí projekt zavedení objektivní klasifikace jatečných zvířat v České republice. MZE ČR, Praha. 8 s.
- Reismann M., Seifert H. (1992): Mastleitung, Schlachtkorpuszusammensetzung und Fleischbeschaffenheit bei der Afrikanischen Zwergziege. In: *Wiss. Z. Humboldt- Univ. Berlin, R. Agrarwiss.*, 41, 27–33.
- Skřivanová V., Marounek M., Kuboušková M. (1995): Vliv výživy na růst, jatečnou hodnotu a kvalitu masa kůzlat. *Živoč. Vyr.*, 40, 19–24.
- Standard ON 57 6655 (1978): Jahňacie a kozľacie mäso pre výsek. MPVŽ SSR.
- Tahir M.A., Al-Jassim A.F., Abdulla A.H.H. (1993): Influence of live weight and castration on distribution of meat, fat and bone in the carcass of goats. *Small Ruminant Res.*, 14, 219–223.

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# Chemical composition of muscles of hybrid broiler chickens during prolonged feeding

## Chemické složení svaloviny masných hybridů brojlerových kuřat při prodlouženém výkrmu

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**ABSTRACT:** The objective of the present paper was to study changes in the chemical composition of breast and thigh muscles in three hybrid combinations of broiler chickens (Ross 308, Cobb and Hybro) during feeding extended till the 52nd day of age. On the 42nd and 52nd day the breast and thigh muscles of 120 individuals were analysed for the following parameters: dry matter, proteins, fat, ash, Ca, P and Mg. The results of chemical analyses performed on the three hybrids demonstrate that breast and thigh muscles differ significantly in their chemical composition. Consequently, the nutritional value of breast muscles differs from that of thigh muscles, which is particularly important in respect to human nutrition. Breast muscles are characterised by an increased content of proteins (22.5–22.7%), ash (1.11–1.13%) and phosphorus and by a reduced content of dry matter (25.8–26.0%), fat (2.1–2.5%) and calcium. On the other hand, the main features of thigh muscles are an increased content of dry matter (28.5–28.6%), fat (8.9–9.3%) and calcium and a decreased content of proteins (18.3–19.1%), ash (0.97–0.98%) and phosphorus. Magnesium contents in breast and thigh muscles were very similar.

**Keywords:** broiler chickens; prolonged feeding; chemical composition of muscles

**ABSTRAKT:** Cílem práce bylo poznání změn chemismu prsní a stehenní svaloviny u tří masných hybridních kombinací brojlerových kuřat Ross 308, Cobb a Hybro při prodlouženém výkrmu do 52. dne věku. V průběhu výkrmu ve 42. a 52. dnu věku byla u souboru 120 jedinců provedena chemická analýza prsní a stehenní svaloviny (sušina, N-látky, tuk, popel, Ca, P a Mg). Výsledky chemických rozborů prsní a stehenní svaloviny u tří testovaných hybridů potvrzují výrazný rozdíl v chemickém složení prsní a stehenní svaloviny. Z tohoto pohledu vyplývá i velký rozdíl v nutriční hodnotě prsní a stehenní svaloviny vzhledem k výživě člověka. Prsní svalovinu lze charakterizovat vyšším obsahem proteinů (22,5–22,7 %), popelovin (1,11–1,13 %) a fosforu; nižším obsahem sušiny (25,8–26,0 %), tuku (2,1–2,5 %) a vápníku. Stehenní svalovinu lze charakterizovat vyšším obsahem sušiny (28,5–28,6 %), tuku (8,9–9,3 %) a vápníku; nižším obsahem proteinů (18,3–19,1 %), popelovin (0,97–0,98 %) a fosforu. U hořčičku nebyly prokázány rozdíly mezi prsní a stehenní svalovinou.

**Klíčová slova:** brojlerová kuřata; prodloužený výkrm; chemismus svaloviny

Nutritional value of meat can be assessed on the basis of parameters such as content and composition of proteins, contents of amino acids, content of

fat and also from the content of saccharides, mineral substances and vitamins. The most important mineral substances in poultry meat are potassium

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(0.4%), phosphorus (0.2%), sodium (0.09%) etc. (Lazar, 1990). The main quality features of poultry meat are chemical composition and the ratio of muscles to fat in carcass. The chemical composition of poultry meat differs significantly, the differences in chemical composition were found between white and red muscle tissues (Matušovičová, 1986). Steinhauser *et al.* (2000) claimed that proteins are the most important components of meat from nutritional and technological aspects. The content of proteins in muscles is reported to range between 18 and 22%. Proteins are the major component of dry matter of meat, the protein content in muscles is variable and depends on the function of a particular tissue (Ingr, 1996). According to Simeonová (1999) breast muscles contain approximately 22% proteins, while in thigh muscles, which contain more fat, approximately 17.20% of proteins was found. Fat is very important from a sensory aspect since it is a source of many aromatic substances affecting the meat taste. According to Klíma (1996), the content of fat in meat depends on many factors such as animal species, breed, gender, anatomic origin of muscles etc. According to Matušovičová (1986) a statistically significant negative correlation exists between fat and protein contents in muscles, i.e. the fattier the muscles, the lower the portion of lean meat they contain, which makes them less suitable for human nutrition. Muscles of chickens and turkeys are characterised by a high content of proteins (23%), low content of fat (3–8%) and low energetic value (519–741 kJ/100 g). According to Simeonová (1999), poultry meat consists of a large portion of subcutaneous fat and abdominal fat stored in abdomen and in the region of intestines, which contributes most significantly to the total content of body fat. Matušovičová (1986) reports that individual cuts of poultry meat differ in contents of fat. 'Marbling' typical of meat of large farm animals does not occur in poultry meat. An important feature of poultry meat from dietetic aspects is an increased content of fatty acids, particularly linoleic acid, linolenic acid and arachidonic acid. According to Skřivan (2000) the main reason for excessive accumulation of abdominal fat in broilers lies in an imbalance between the intake and consumption of energy. With lowering energy consumption the amount of abdominal fat decreases. Compared with males, females have larger breast muscles and smaller thigh muscles. They also have a lower portion of the most valuable body parts (56.6%) compared with males (57.8%).

According to Ingr (1993) the muscles of females are finer and more tender. One of the factors affecting fat accumulation during growth is gender. Due to different growth intensities of females and males, females accumulate more fat in comparison with males. Furthermore, males grow more intensively and reach higher bodyweights in comparison with females over the same period of time. Becker *et al.* (1979) studied the content of abdominal fat in 58-day-old broilers and showed that male broilers had less abdominal fat (2.18%) in comparison with females (2.82%). A similar trend also applies to fat extracted from carcass (12.0% for males, 13.7% for females), to fat from intestines (47.6% for males, 56.2% for females) and to the total content of fat (10.4% for males, 12.2% for females). Deaton and Lott (1985) dealt with the effect of age and nutrition on the content of abdominal fat in broilers on the 36th, 42nd, 48th and 54th day of age. Females showed a higher portion of abdominal fat compared with males. In their study dealing with the amount of abdominal fat in hybrid broilers Hybro on the 49th day of age, Marek *et al.* (1988) pointed out that male and female chickens should be fed separately and that female chickens should be fed to a lower slaughter weight. Hrdinka *et al.* (1995) found statistically significant differences between the body weights of females and males on the 42nd day of feeding. These authors also reported a lower amount of abdominal fat in males in comparison with females. Skřivan and Tůmová (1990) studied the effect of gender during prolonged feeding on the proportion of breast and thigh muscles in male hybrid chickens (Hybro and Ross 208) and found that the accumulation of fat in hybrid combination Hybro was higher in comparison with that in Ross 208 chickens.

## MATERIAL AND METHODS

The objective of the present paper was to study changes in the chemical composition of breast and thigh muscles of broiler chickens (meat-type hybrid combinations) during feeding extended till the 52nd day of age.

Experimental monitoring was performed on the following meat-type hybrid broilers: Ross 308 (54 ♀ + 54 ♂), Cobb (54 ♀ + 54 ♂) and Hybro (54 ♀ + 54 ♂). Female and male chickens were fed separately on deep bedding in an approved experimental enclosure (with controlled light, tem-

perature, zoo-hygienic and feeding regimens) of the Institute for Nutrition, Dietetics, Zoo-Hygiene and Food Crop Production at the Faculty of Veterinary Hygiene and Ecology, University of Veterinary and Pharmaceutical Sciences in Brno. Conditions of the experiment complied with the requirements for the feeding of broiler chickens (Ross 308, Cobb and Hybro) described in technological instructions for broiler chickens of these types. Feeding and watering of broiler chickens was carried out using plastic tube feeders and hanging drinkers (Plasson MK II). All three kinds of chickens were fed *ad libitum* complete commercial mixtures used for meat-type broiler chickens (BR 1 and BR 2). Till the 14th day of age the chickens received the BR 1 mixture (powdery form) and subsequently the BR 2 mixture (granulated form) till the end of the feeding period (i.e. the 52nd day). The nutritional composition of mixtures was as follows:

BR 1 – 235.1 g of protein/kg, 4.2 g of fat/kg, 55.1 g of ash/kg, 8.8 g of Ca/kg, 7.1 g of P/kg, 2.2 g of Mg/kg and 12.4 MJ of ME/kg

BR 2 – 222.9 g of protein/kg, 69.7 g of fat/kg, 59.6 g of ash/kg, 14.3 g of Ca/kg, 8.5 g of P/kg, 1.9 g of Mg/kg and 12.4 MJ of ME/kg

The lighting regime during the whole period of feeding was adjusted to 24 hours of light.

On the 42nd and the 52nd day, 10 female and 10 male chickens of each group (Ross 308, Cobb and Hybro) were randomly selected (120 broilers in total) and slaughtered; then chemical analysis of breast and thigh muscles without skin was carried out. Samples of breast and thigh muscles were minced, dried and homogenised, and analysed for the content of dry matter, proteins, fat, ash, Ca, P and Mg. Chemical composition of breast and thigh muscles is expressed in g per one kg of original weight of muscles. All analyses were made according to the following standards: water content, proteins, fat and ash (CSN 46 7092), Ca, P, Mg (UDC 636.087.7 SABS 517-1962).

The results were processed using mathematical and statistical methods; arithmetic means ( $\bar{x}$ ) and standard deviations ( $s_{n-1}$ ). Student's test with probability of  $P \leq 0.05$  (\*) and  $P \leq 0.01$  (\*\*) was used to assess significance of differences between mean values. Mathematical and statistical processing of the results was performed by means of the Statgraphics program.

## RESULTS

The results of chemical analyses show that breast and thigh muscles of three tested hybrids differ significantly in their chemical composition (Tables 1–3).

The results of dry matter determinations show that on the 42nd and on the 52nd day thigh muscles have a higher content of dry matter in comparison with breast muscles; this applies to females as well as to males in all three groups of hybrids. On the 42nd day of feeding the mean content of dry matter of females ranged from 256.99 g/kg to 263.62 g/kg and from 285.20 g/kg to 299.00 g/kg for breast and thigh muscles, respectively. The differences between the mean contents were highly significant ( $P \leq 0.01$ ). Analogously, the mean content of dry matter in breast muscles of males on the 42nd day differed significantly from that in thigh muscles ( $P \leq 0.01$ ). In tested hybrids the mean content of dry matter ranged from 252.44 g/kg to 267.14 g/kg or from 271.95 g/kg to 288.57 g/kg for breast and thigh muscles, respectively. The same trend with regard to the content of dry matter in breast and thigh muscles was also observed on the 52nd day. The mean content of dry matter in females ranged from 254.07 g/kg to 259.88 g/kg per kg for breast muscles and from 281.04 g/kg to 291.88 g/kg for thigh muscles. In males the mean content of dry matter content ranged from 257.24 g/kg to 263.11 g/kg for breast muscles and from 275.93 g/kg to 293.21 g/kg for thigh muscles. It can be unambiguously concluded on the basis of the above results that for all three tested hybrids (Ross, Cobb and Hybro) the content of dry matter in thigh muscles is significantly higher ( $P \leq 0.01$ ) than that in breast muscles. Neither gender nor age of chickens affected this trend.

The content of proteins (PR) in breast muscles differed considerably from that in thigh muscles. On the 42nd day of feeding the mean content of PR in females ranged between 219.55 g/kg and 228.12 g/kg in breast muscles and from 182.14 g/kg to 187.81 g/kg in thigh muscles while in males the mean content of PR ranged from 219.57 g/kg to 230.80 g/kg in breast muscles and from 180.30 g/kg to 183.20 g/kg in thigh muscles. Similarly, on the 52nd day of feeding the mean content of PR in females ranged from 221.64 g/kg to 226.89 g/kg in breast muscles and from 185.54 g/kg to 190.65 g/kg in thigh muscles while in male chickens the mean content of PR ranged from 224.58 g/kg to

Table 1. Differences in the chemical composition of breast and thigh muscles of Ross 308 broiler chickens (g/kg)

Muscles		Day 42		Day 52		Day 42		Day 52	
		♀	♂	♀	♂	♀	♂	♀	♂
		Dry matter				Proteins			
B	$\bar{x}$	263.62	259.94	255.82	257.24	228.12	223.88	221.64	224.58
	SD	10.476	6.606	5.815	6.835	10.137	5.521	2.865	5.267
		**	**	**	**	**	**	**	**
T	$\bar{x}$	285.20	271.95	281.04	293.21	185.14	180.30	187.74	198.03
	SD	14.962	12.579	12.086	41.011	2.980	16.148	5.450	19.960
		Fat				Ash			
B	$\bar{x}$	23.99	24.86	23.18	22.70	11.72	11.34	11.11	11.13
	SD	5.971	3.106	5.450	4.952	0.391	0.135	0.160	0.231
		**	**	**	**	**	**	**	**
T	$\bar{x}$	90.44	76.95	83.59	85.73	9.82	9.92	9.76	9.70
	SD	17.499	10.127	11.073	23.468	0.370	0.215	0.280	0.620
		Ca				P			
B	$\bar{x}$	0.28	0.30	0.29	0.29	2.23	2.25	2.24	2.33
	SD	0.018	0.020	0.013	0.016	0.194	0.157	0.051	0.100
		**	–	–	*	**	**	**	**
T	$\bar{x}$	0.32	0.30	0.29	0.31	2.01	2.04	1.94	2.07
	SD	0.008	0.013	0.012	0.027	0.061	0.072	0.044	0.167
		Mg							
B	$\bar{x}$	0.10	0.11	0.13	0.13				
	SD	0.004	0.014	0.013	0.014				
		**	**	–	–				
T	$\bar{x}$	0.13	0.13	0.13	0.14				
	SD	0.006	0.007	0.007	0.013				

B = breast muscles, T = thigh muscles, SD = standard deviation

\* $P \leq 0.05$ , \*\* $P \leq 0.01$

230.17 g/kg in breast muscles and from 183.12 g per kg to 198.11 g/kg in thigh muscles. The results of PR analysis demonstrated that for all three hybrid broilers (aged 42 or 52 days) the content of PR in breast muscles was significantly higher ( $P \leq 0.01$ ) than that in thigh muscles.

On the 42nd day of feeding the mean content of fat in females ranged from 23.99 g/kg to 27.67 g/kg in breast muscles and from 90.44 g/kg to 107.55 g per kg in thigh muscles while the mean content of fat in males ranged from 21.87 g/kg to 27.31 g/kg in breast muscles and from 76.95 g/kg to 96.83 g per kg in thigh muscles. On the 52nd day of feeding the mean content of fat in females ranged from 16.7 g/kg to 23.18 g/kg in breast muscles, from

83.59 g/kg to 95.97 g/kg in thigh muscles while in males the values of fat ranged from 18.64 g/kg to 22.70 g/kg in breast muscles and from 85.73 g/kg to 92.11 g/kg in thigh muscles. The above results demonstrated that for all three hybrid broilers (male and female) the fat content in thigh muscles was significantly higher ( $P \leq 0.01$ ) than that in breast muscles.

Ash is an important indicator of the content of mineral substances in muscles. Breast and thigh muscles differed significantly also in this parameter. On the 42nd day of feeding the mean values of ash in females ranged from 10.82 g/kg to 11.72 g/kg in breast muscles and from 9.51 g/kg to 9.98 g/kg in thigh muscles while in males the content of ash

Table 2. Differences in the chemical composition of breast and thigh muscles of Cobb broiler chickens (g/kg)

Muscles	Day 42		Day 52		Day 42		Day 52		
	♀	♂	♀	♂	♀	♂	♀	♂	
	Dry matter				Proteins				
B	$\bar{x}$	262.68	267.14	259.88	263.11	225.67	230.80	226.89	230.17
	SD	8.942	5.472	5.784	7.807	8.198	8.933	5.467	5.644
		**	**	**	—	**	**	**	**
T	$\bar{x}$	298.88	288.57	291.88	275.93	182.14	183.20	190.65	198.11
	SD	19.766	12.595	27.870	26.666	4.169	4.005	8.528	42.996
	Fat				Ash				
B	$\bar{x}$	25.51	27.31	22.01	22.69	11.47	11.37	11.15	11.34
	SD	4.567	5.337	4.410	7.032	0.478	0.221	0.344	0.165
		**	**	**	**	**	**	**	**
T	$\bar{x}$	107.55	96.83	91.95	92.11	9.51	9.72	9.50	10.07
	SD	17.883	13.291	21.844	11.187	0.372	0.274	0.394	0.271
	Ca				P				
B	$\bar{x}$	0.28	0.28	0.29	0.30	2.36	2.36	2.31	2.25
	SD	0.012	0.013	0.012	0.012	0.115	0.076	0.075	0.076
		**	**	—	—	**	**	**	**
T	$\bar{x}$	0.31	0.31	0.30	0.31	1.99	2.02	1.98	1.96
	SD	0.009	0.013	0.016	0.015	0.047	0.098	0.153	0.146
	Mg								
B	$\bar{x}$	0.12	0.12	0.13	0.13				
	SD	0.015	0.015	0.009	0.009				
		—	—	*	—				
T	$\bar{x}$	0.12	0.13	0.12	0.13				
	SD	0.008	0.014	0.009	0.012				

B = breast muscles, T = thigh muscles, SD = standard deviation

\* $P \leq 0.05$ , \*\* $P \leq 0.01$

ranged from 11.16 g/kg to 11.34 g/kg in breast muscles and from 9.45 g/kg to 9.92 g/kg in thigh muscles. On the 52nd day of feeding the mean content of ash in females ranged from 11.00 g/kg to 11.15 g/kg in breast muscles and from 9.46 g/kg to 9.76 g/kg in thigh muscles, in males the content ranged from 11.04 g/kg to 11.37 g/kg in breast muscles and from 9.70 g/kg to 10.07 g/kg in thigh muscles. It can be concluded from these results for all three hybrid broilers (males and females) that the content of ash in breast muscles is significantly higher ( $P \leq 0.01$ ) in comparison with thigh muscles.

The differences between the content of Ca in breast muscles and that in thigh muscles were

not as significant as for previous parameters. On the 42nd day of feeding the mean values of Ca in females ranged from 0.28 g/kg to 0.29 g/kg in breast muscles and from 0.31 g/kg to 0.32 g/kg in thigh muscles. The differences between the mean contents were found highly significant ( $P \leq 0.01$ ). On the 42nd day of feeding the mean content of Ca in males ranged from 0.28 g/kg to 0.30 g/kg in breast muscles and from 0.30 g/kg to 0.31 g/kg in thigh muscles. A highly significant difference ( $P \leq 0.01$ ) between breast muscles (0.28 g/kg) and thigh muscles (0.31 g/kg) was found only for the Cobb hybrid. On the 52nd day of feeding no significant differences were found between breast and thigh muscles in females. The mean content of Ca in

Table 3. Differences in the chemical composition of breast and thigh muscles of Hybro broiler chickens (g/kg)

Muscles	Day 42		Day 52		Day 42		Day 52		
	♀	♂	♀	♂	♀	♂	♀	♂	
	Dry matter				Proteins				
B	$\bar{x}$	256.99	252.44	254.07	258.95	219.55	219.57	226.39	229.61
	SD	7.198	3.093	12.591	6.009	8.080	4.506	10.725	4.673
		**	**	**	**	**	**	**	**
T	$\bar{x}$	299.00	274.01	290.88	279.96	187.81	181.01	185.54	183.12
	SD	25.264	14.395	8.445	12.273	19.636	9.805	5.113	5.346
	Fat				Ash				
B	$\bar{x}$	27.67	21.87	16.70	18.64	10.82	11.16	11.00	11.04
	SD	7.264	4.219	4.844	3.806	0.262	0.158	0.459	0.372
		**	**	**	**	**	**	**	**
T	$\bar{x}$	101.42	83.85	95.97	87.16	9.98	9.45	9.46	10.04
	SD	12.332	13.460	9.950	11.765	0.551	0.420	0.392	0.458
	Ca				P				
B	$\bar{x}$	0.29	0.30	0.29	0.29	2.24	2.19	2.21	2.28
	SD	0.012	0.013	0.018	0.020	0.098	0.050	0.143	0.065
		**	–	–	*	**	**	**	**
T	$\bar{x}$	0.32	0.30	0.30	0.31	2.04	2.02	2.03	2.00
	SD	0.016	0.019	0.012	0.014	0.193	0.085	0.095	0.084
	Mg								
B	$\bar{x}$	0.12	0.13	0.13	0.13				
	SD	0.016	0.013	0.009	0.008				
		–	–	–	–				
T	$\bar{x}$	0.13	0.13	0.13	0.13				
	SD	0.009	0.008	0.007	0.011				

B = breast muscles, T = thigh muscles, SD = standard deviation

\* $P \leq 0.05$ , \*\* $P \leq 0.01$

breast muscles was 0.29 g/kg; the mean content of Ca in thigh muscles was in a very narrow interval of 0.29–0.30 g/kg. In males on the 52nd day of feeding the mean content of Ca in breast muscles also ranged in a very narrow interval from 0.29 to 0.30 g/kg, the mean content of Ca in thigh muscles was 0.31 g/kg. A statistically significant difference ( $P \leq 0.05$ ) between the mean contents of Ca in breast (0.29 g/kg) and thigh muscles (0.31 g/kg) was found for Ross hybrid. An analogous dependence was observed for Hybro hybrid.

Unlike Ca, the content of P in breast and thigh muscles showed quite a large variability. On the

42nd day of feeding the mean content of P in females ranged from 2.23 g/kg to 2.36 g/kg in breast muscles and from 1.99 g/kg to 2.04 g/kg in thigh muscles, in males the content ranged from 2.19 g/kg to 2.36 g/kg in breast muscles and from 2.02 g/kg to 2.04 g/kg in thigh muscles. On the 52nd day of feeding the mean content in females ranged from 2.21 g/kg to 2.31 g/kg in breast muscles and from 1.94 g/kg to 2.03 g/kg in thigh muscles, in males the content ranged from 2.25 g/kg to 2.33 g/kg in breast muscles and from 1.96 g/kg to 2.07 g/kg in thigh muscles. The results of analyses of P in breast and thigh muscles clearly show that for all tested

hybrids regardless of gender and age the content of P in breast muscles was significantly ( $P \leq 0.01$ ) higher than that in thigh muscles.

Basically, breast and thigh muscles did not considerably differ in the content of Mg. On the 42nd day of age the mean values of Mg in females ranged from 0.10 g/kg to 0.12 g/kg in breast muscles and from 0.12 g/kg to 0.13 g/kg in thigh muscles. For ROSS hybrid the mean content of Mg in breast muscles was statistically significantly ( $P \leq 0.05$ ) lower (0.10 g/kg) than that in thigh muscles (0.13 g per kg). In males the mean content of Mg ranged from 0.11 g/kg to 0.13 g/kg in breast muscles while in thigh muscles the Mg content was 0.13 g/kg for all tested hybrids. Similarly like in females, Ross 308 hybrid males also showed a significantly lower ( $P \leq 0.05$ ) content of Mg in breast muscles (0.11 g/kg) compared with thigh muscles (0.13 g/kg). On the 52nd day of feeding the differences between breast and thigh muscles were minimal. The mean content of Mg ranged from 0.12 g/kg to 0.14 g/kg for all tested hybrids regardless of gender. The only significant difference ( $P \leq 0.05$ ) was found for Cobb hybrid females when the mean content of Mg in breast muscles was higher (0.13 g/kg) than that in thigh muscles (0.12 g/kg).

## DISCUSSION

The results of chemical analysis (Tables 1–3) clearly demonstrate that for all tested hybrid broilers (aged 42 or 52 days) the breast and thigh muscles significantly differ in their nutritional composition. In respect to human nutrition this implies a large difference between the nutritional values of breast and thigh muscles. A significant difference between breast and thigh muscles was found for dry matter. The content of dry matter in thigh muscles was significantly higher ( $P \leq 0.01$ ) than that in breast muscles. When expressed relatively, the content of dry matter in thigh muscles was 28.6% (on the 42nd day) and 28.5% (on the 52nd day) on average, while in breast muscles the content of dry matter was 26.0% (on the 42nd day) and 25.8% (on the 52nd day). It is evident from the above results that the content of dry matter in thigh muscles is by 2.6–2.7% higher than that in breast muscles. Although breast muscles contain less dry matter (and therefore more water) in comparison with thigh muscles, the results of analyses showed that the content of proteins in breast muscles was

significantly higher than in thigh muscles. The differences in the content of proteins between breast and thigh muscles were highly significant ( $P \leq 0.01$ ) in all cases (hybrid, age, gender). When expressed relatively, the content of proteins in breast muscles of chickens was 22.5% on the 42nd day and 22.7% on the 52nd day while in thigh muscles the content of proteins was 18.3% on the 42nd day and 19.1% on the 52nd day. It is evident from the above results that breast muscles contained 3.6%–4.2% more proteins than thigh muscles. Interestingly, a trend found for fat was opposite to that of proteins. Furthermore, the content of fat in thigh muscles of chickens was 3–4 times higher than that in breast muscles. The differences between mean contents of fat in breast and thigh muscles were found to be highly significant ( $P \leq 0.01$ ). When evaluated relatively, the content of fat in thigh muscles of chickens was 9.3% (on the 42nd day) and 8.9% (on the 52nd day) while in breast muscles the content of fat was only 2.5% (on the 42nd day) and 2.1% (on the 52nd day), i.e. thigh muscles contained 6.8% more fat than breast muscles.

The content of ash in breast muscles was significantly higher ( $P \leq 0.01$ ) compared with that in thigh muscles. The relative content of ash in breast muscles was 1.13% (on the 42nd day) and 1.11% (on the 52nd day) while in thigh muscles it was 0.97% (on the 42nd day) and 0.98% (on the 52nd day). It follows from the results that the breast muscles contained 0.13%–0.16% more ash than thigh muscles. Although being relatively too small, the difference was proved to be statistically highly significant ( $P \leq 0.01$ ). Analytical tests performed on chicken muscles also included the determination of Ca, P and Mg. In contrast to breast muscles the content of Ca in thigh muscles showed a tendency to rise. However, statistics did not fully confirm this trend in older chickens (on the 52nd day). It follows from the results that neither breast nor thigh muscles are important sources of Ca from nutritional aspects. However, both types of muscles exhibited high contents of P. The differences between the contents of P in breast and thigh muscles were highly significant ( $P \leq 0.01$ ). In respect to the content of P, breast muscles in particular can be considered as a suitable source of P in human nutrition. We concluded on the basis of evaluating the content of Mg in muscles that there was no significant difference between breast and thigh muscles. Our results demonstrate that breast and

thigh muscles of chickens are not a distinct source of Mg for human nutrition. Furthermore, our results also support the findings of a number of other authors (e.g. Matušovičová, 1986) who claim that thanks to its dietetic composition poultry meat is a high-quality meat. Similarly like the above authors, we also found large differences between 'breast' and 'thigh' muscles. Steinhauser et al. (2000) reported that the content of proteins in muscles was in the range of 18–22%. As seen from our results, the protein content in chicken breast muscles ranges from 22.5 to 22.6%. Therefore chicken meat can be classified as a high-protein meat. Lower content of proteins (18.3–19.1%) was found in thigh muscles. These differences in protein contents between breast and thigh muscles are in agreement with findings of Ingr (1996), who reported that muscles differ in the content of proteins, which could result from different functions of particular muscle tissues. The contents of proteins in breast and thigh muscles we found by our research agree with the results reported by Simeonovová (1999). Furthermore, the content and quality of fat are considered to be important quality features of meat (Steinhauser et al., 2000). In our experiment the mean content of fat in breast and thigh muscles ranged from 2.1 to 2.5% or from 8.9 to 9.3%, respectively. Matušovičová (1986) reported similar contents of fat in chicken muscles (3–8%). Analogous results were also published by other authors, e.g. Kolda and Zelinka (1993) and Simeonovová (1999). The content of ash is an important parameter to assess the amount of minerals in muscles.

The analyses have shown that breast and thigh muscles differ in the content of individual elements. Thigh muscles have a higher content of Ca in comparison with breast muscles. In breast muscles the content of P is significantly higher ( $P \leq 0.01$ ) than that in thigh muscles. No significant difference in the content of Mg between breast and thigh muscles was found. Furthermore, we have found that the content of P in breast and thigh muscles was 0.227% (ca 2.00 g) and 0.20%, respectively. This

value corresponds to that reported for poultry meat (0.2%) by Lazar (1990).

## REFERENCE

- Becker W.A., Spencer J.V., Mirosh L.W., Verstrate J.A. (1979): Prediction of fat and fat free live weight in broiler chickens using backskin fat, abdominal fat and live bodyweight. *Poultry Sci.*, 58, 835–845.
- Deaton J.W., Lott B.D. (1985): Age and dietary energy effect on broiler abdominal fat deposition. *Poultry Sci.*, 64, 2161–2164.
- Hrdinka Č., Skřivan M., Tůmová E. (1995): The effect of gender, genotype and the content of methionine in feeding mixtures on fat accumulation in broiler chickens (in Czech). *Živoč. Výr.*, 40, 489–495.
- Ingr I. (1993): Evaluation of Animal Products (in Czech). Brno, 180.
- Ingr I. (1996): Meat Technology (in Czech). Brno, 290 pp.
- Klíma D. (1996): Animal fats. *Meat*, 6, 3–5.
- Kolda O., Zelinka K. (1993): Meat Processing (in Czech). Sobotáles, Brno. 120 pp.
- Lazar V. (1990): Poultry-raising (in Czech). VŠZ, Brno. 210 pp.
- Marek J., Splítek M., Jiřík J. (1988): The effect of live body weight and gender on the amount of abdominal fat in hybrids Hybro (in Czech). *Živoč. Výr.*, 33, 555–559.
- Matušovičová E. (1986): Technology of Poultry Production (in Slovak). Príroda, Bratislava. 393 pp.
- Simeonovová J. (1999): Technology of Poultry, Eggs and other Minor Animal Products (in Czech). MZLU, Brno. 247 pp.
- Skřivan M., Tůmová E. (1990): Slaughter utility of 5- to 8-weeks' male chickens Hybro, Ross 208 and Ross PM 3 (in Czech). *Živoč. Výr.*, 35, 1049–1257.
- Skřivan M. (2000): Poultry Raising 2000 (in Czech). Agrospoj, Praha. 203 pp.
- Steinhauser L. et al. (2000): Meat Production (in Czech). Last, 464 pp.

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# Spectrum of amino acids in muscles of hybrid broilers during prolonged feeding

## Aminokyselinové spektrum svaloviny masných hybridů brojlerových kuřat při prodlouženém výkrmu

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**ABSTRACT:** The main goal of our research was to examine changes in the levels of amino acids in breast and thigh muscles of three meat-type hybrid combinations of broiler chickens (Ross 308, Cobb and Hybro) during feeding till the 52nd day of age. On the 42nd and 52nd day of feeding the breast and thigh muscles of 120 chickens were subjected to aminoanalysis to determine the following amino acids: aspartic acid (Asp), threonine (Thre), serine (Ser), glutamic acid (Glu), proline (Pro), glycine (Gly), alanine (Ala), valine (Val), methionine (Met), isoleucine (Ile), leucine (Leu), tyrosine (Tyr), phenylalanine (Phe), histidine (His), lysine (Lys) and arginine (Arg). The levels of the above amino acids in muscles determined on the 42nd day differed from those found on the 52nd day of feeding. The differences between the levels of individual amino acids in breast and thigh muscles were highly significant ( $P \leq 0.01$ ) or significant ( $P \leq 0.05$ ). The results obtained in this study can be used not only for more accurate evaluation of the nutritional value of broiler meat but also for the formulation of feed mixtures to control the conversion process of feed in broiler chickens during feeding.

**Keywords:** broiler chickens; prolonged feeding; spectrum of amino acids in muscles

**ABSTRAKT:** Cílem práce bylo poznání změn aminokyselinového spektra prsní a stehenní svaloviny u tří masných hybridních kombinací brojlerových kuřat Ross 308, Cobb a Hybro při prodlouženém výkrmu do 52. dne věku. V průběhu výkrmu ve 42. a 52. dnu věku byla u souboru 120 jedinců provedena aminoanalýza prsní a stehenní svaloviny. Z aminokyselinového spektra svaloviny byla sledována kyselina asparagová (Asp), threonin (Thre), serin (Ser), kyselina glutamová (Glu), prolin (Pro), glycin (Gly), alanin (Ala), valin (Val), metionin (Met), izoleucin (Ile), leucin (Leu), tyrozin (Tyr), fenylalanin (Phe), histidin (His), lyzin (Lys) a arginin (Arg). Změny aminokyselinového spektra svaloviny, ke kterým dochází u brojlerů v průběhu výkrmu (ve 42. i 52. dnu věku) byly charakterizovány zejména vysoce významným ( $P \leq 0,01$ ) a významným ( $P \leq 0,05$ ) rozdílem v aminokyselinovém spektru mezi prsní a stehenní svalovinou u všech sledovaných aminokyselin. Dosažené výsledky jsou významné nejen pro kvalitnější posouzení nutriční hodnoty masa brojlerových kuřat, ale především je pokládáme za vysoce přínosné pro přesnější sestavování krmných směsí z pohledu řízeného konverzního procesu ve výživě brojlerových kuřat.

**Klíčová slova:** brojlerová kuřata; prodloužený výkrm; aminokyselinové spektrum svaloviny

Thanks to its dietetic properties (low content of fat, high digestibility) and safety poultry meat together with fish meat meets most nutritional

requirements and therefore it is a component of rational diet for humans. Poultry meat is valuable particularly due to a large portion of high-quality

ity proteins containing essential amino acids. The nutritional value of meat is usually assessed on the basis of parameters such as content and composition of proteins, levels of amino acids and content of fat. According to Matusovičová (1986), proteins with a high content of essential amino acids are the most important components of poultry meat. Furthermore, muscles from different parts of carcass have different chemical composition. It has been found that the chemical composition of breast muscles is different from that of thigh muscles. According to Simeonová (1999) breast muscles contain ca. 22% of proteins. On the other hand, thigh muscles which contain more fat consist of approximately 17.20% of proteins. Amino acids as basic structural units of proteins can be metabolized to key precursors of substances that are crucial for a living organism (e.g. heme). In his experiment performed on (Ross) hybrid broilers Holsheimer (1993) studied the effect of energy and lysine content in feed mixtures on performance, carcass composition and yield. Deschepper (1995) dealt with the effect of a diet containing proteins and essential and non-essential amino acids on performance and carcass composition. The study conducted on broiler chickens demonstrated that a low-protein diet enriched with synthetic amino acids affected neither slaughter yield nor the concentration of proteins in carcass. However, the content of fat in carcass increased. Acar *et al.* (2001) focussed on the effect of methionine in a diet of broiler chickens on performance and carcass composition. Szakall *et al.* (1998) studied the effect of fat and lysine in a diet on the body composition of broilers. It follows from the results that diets enriched with lysine increased the capacity of muscles to retain water. The highest retention of water was observed in a group of broilers fed a common diet (with typical amount of metabolized energy) that contained higher amounts of lysine.

## MATERIAL AND METHODS

The main goal of our study was to monitor the spectrum of amino acids in breast and thigh muscles of broiler chickens (meat-type hybrid combinations) during prolonged feeding till the 52nd day of age. These experimental commercial meat-type hybrid broilers were used: Ross 308 (54 ♀ + 54 ♂), Cobb (54 ♀ + 54 ♂) and Hybro (54 ♀ + 54 ♂). Female and male chickens were fed

separately on deep bedding in an approved experimental enclosure (with controlled light, temperature, zoo-hygienic and feeding regimes) of the Institute for Nutrition, Dietetics, Zoo-Hygiene and Food Crop Production at the Faculty of Veterinary Hygiene and Ecology, University of Veterinary and Pharmaceutical Sciences in Brno. Conditions of the experiment complied with the requirements for the feeding of broiler chickens (Ross 308, Cobb and Hybro) described in technological instructions for these types of broiler chickens. Feeding and watering of broilers were carried out using plastic tube feeders and hanging drinkers (Plasson MK II). All three types of broiler chickens were fed *ad libitum* complete commercial mixtures used for meat-type broiler chickens (BR 1 and BR 2). Till the 14th day of age the chickens received the BR 1 mixture (powdery form) and subsequently the BR 2 mixture (granulated form) till the end of the feeding period (i.e. till the 52nd day of age). The nutritional composition of mixtures was as follows:

BR 1 – 235.1 g of protein/kg, 4.2 g of fat/kg, 55.1 g of ash/kg, 8.8 g of Ca/kg, 7.1 g of P/kg, 2.2 g of Mg/kg and 12.4 MJ of ME/kg

BR 2 – 222.9 g of protein/kg, 69.7g of fat/kg, 59.6 g of ash/kg, 14.3 g of Ca/kg, 8.5 g of P/kg, 1.9 g of Mg/kg and 12.4 MJ of ME/kg

A lighting regimen during the whole period of feeding was adjusted to 24 hours of light.

On the 42nd and 52nd day, 10 female and 10 male broiler chickens of each group (Ross 308, Cobb and Hybro) were randomly selected (120 broilers in total) and slaughtered; determination of the content of amino acids in breast and thigh muscles without skin followed. The levels of amino acids in muscles were related to 100% of dry weight.

After acid hydrolysis of muscles in 6 N HCl at 110°C for 24 hours the levels of amino acids were determined on the basis of a colour reaction between an amino acid and ninhydrine (oxidizing agent) using an automatic amino-acid analyzer (AAA 339 manufactured by Mikrotechna Prague). The following amino acids were monitored: aspartic acid (Asp), threonine (Thre), serine (Ser), glutamic acid (Glu), proline (Pro), glycine (Gly), alanine (Ala), valine (Val), methionine (Met), isoleucine (Ile), leucine (Leu), tyrosine (Tyr), phenylalanine (Phe), histidine (His), lysine (Lys) and arginine (Arg). The results were processed by mathemati-

cal and statistical methods; arithmetic means ( $\bar{x}$ ) and standard deviations ( $s_{n-1}$ ) were calculated. Student's test with the probability of  $P \leq 0.05$  (\*) and  $P \leq 0.01$  (\*\*) was used to assess significance of differences between the mean values. Mathematical and statistical processing of the results was performed by the Statgraphics program.

## RESULTS

Tables 1–3 show the results of aminoanalysis performed on breast and thigh muscles. It is obvious that the content of most amino acids in breast muscles is higher than that in thigh muscles. The levels of the following amino acids in breast muscles were significantly higher compared with those in thigh muscles: Asp, Thre, Ser, Glu, Gly, Ala, Val, Met, Ile, Leu, Tyr, Phe, His, Lys and Arg. In breast muscles the levels of 15 out of 16 monitored amino acids were higher in comparison with those in thigh muscles. These differences were highly significant ( $P \leq 0.01$ ) for most amino acids. Proline (Pro) was the only amino acid for which the difference between its level in breast and thigh muscles was insignificant. The mean levels of individual amino acids expressed either absolutely (g/kg) or relatively (%) are given in Table 4. It follows from this table that the levels of amino acids in breast muscles (on dry basis) ranged from 19.77 g/kg to 110.33 g/kg on the 42nd day of feeding and from 20.05 g/kg to 120.81 g/kg on the 52nd day of feeding. Similarly, the levels of amino acids in thigh muscles ranged from 14.02 g/kg to 93.53 g/kg on the 42nd day of feeding and from 14.39 g/kg to 92.09 g/kg on the 52nd day of feeding. It is obvious from the results of aminoanalysis that the relative levels of individual amino acids in both types of muscles differ in the range of 2–15%. In this respect, amino acids can be divided into 3 groups: low-level amino acids (0–5%), medium-level amino acids (5–10%), high-level amino acids (above 10%). In the case of breast muscles amino acids such as Pro, Met, Phe, Ser, Tyr, Thre and Gly belong to the first group (0–5%), Ile, His, Val, Ala, Arg, Leu and Lys to the second group (5–10%), Asp and Glu to the third group (above 10%). The levels of amino acids in thigh muscles can be classified analogously although the sequence of some amino acids has changed. For thigh muscles, Met, Pro, Tyr, Phe, His, Ser and Thre belong to the first group (0–5%); Ile, Val, Gly, His, Ala, Leu, Lys to the second group (5–10%);

Asp and Gly to the third group (above 10%). The only significant difference between breast and thigh muscles was observed for the level of His. In breast muscles His was a medium-level amino acid while in thigh muscles it belonged to the group of low-level amino acids. Interestingly, the total content of amino acids ( $\Sigma$  AA) on the 42nd day (on the 52nd day) of the feeding period was 786.86 g/kg (834.46 g/kg) for breast muscles and 591.32 g/kg (667.18 g/kg) for thigh muscles (Table 4). These results demonstrate that the total content of amino acids in breast as well as in thigh muscles increases during prolonged feeding. Furthermore, very promising results in respect to the content of proteins were obtained for breast muscles. Breast muscles contained 78.69–83.45% of amino acids (on dry basis) while in thigh muscles the content of amino acids was only 59.13–60.72% (on dry basis).

## DISCUSSION

Since no detailed studies of this kind have been published in the available literature so far, the results of our study cannot be compared. The only paper that provides the levels of some amino acids (Arg, His, Ile and Lys) in muscles of broiler chickens ('chicken meat') in order to compare them with the levels detected in meat of ostriches was published by Snížek (1995). The levels of particular amino acids except for histidine (His) reported for 'chicken meat' are higher than those in our experiment. Since the author did not specify the type of tested tissue, we cannot really compare our results with his findings. Our results are in general agreement with those reported by Ingr (1996), who shows that the composition of proteins as the main components of chicken meat varies according to the function of the tissue. The levels of valine in breast muscles (3.90% Val) and in thigh muscles (3.67%) published by Ingr (1996) and Simeonová (1999) are lower in comparison with our results. This could be due to the fact that these authors related the content of valine to the total content of essential amino acids while in our studies the level of valine was calculated from the total sum of amino acids (essential and non-essential).

The results of aminoanalysis of breast and thigh muscles also show that both types of muscles differ in the total content of amino acids rather than in the levels of individual amino acids. The results presented in this paper are completely new in this

Table 1. Levels of amino acids in breast and thigh muscles of Ross 308 broiler chickens (g/kg dry matter)

Muscles	Day 42		Day 52		Day 42		Day 52		
	♀	♂	♀	♂	♀	♂	♀	♂	
B	$\bar{x}$	79.43	80.01	79.78	79.45	35.30	36.60	37.15	36.52
	SD	2.034	2.531	2.047	2.051	2.012	1.613	0.869	2.245
T	$\bar{x}$	59.41	64.21	61.42	61.23	24.56	29.16	29.09	30.47
	SD	3.736	3.427	4.119	3.202	1.294	2.365	3.067	2.692
B	$\bar{x}$	27.57	31.56	32.40	32.49	111.35	114.18	112.44	113.22
	SD	3.426	1.246	0.794	0.712	3.891	3.950	2.895	2.988
T	$\bar{x}$	25.90	27.36	26.62	26.71	92.12	103.43	95.63	93.47
	SD	1.598	1.599	1.915	1.312	3.934	6.201	5.351	4.398
B	$\bar{x}$	25.29	21.26	19.54	17.68	38.21	39.22	38.24	38.89
	SD	8.188	2.696	1.166	1.636	1.196	1.620	1.052	2.524
T	$\bar{x}$	17.97	20.72	19.22	20.20	34.54	36.04	35.28	35.43
	SD	1.406	3.014	2.564	2.831	2.654	2.943	2.683	2.028
B	$\bar{x}$	49.00	51.21	48.74	49.53	47.22	48.04	46.89	45.89
	SD	1.718	2.243	1.224	1.472	1.641	2.025	3.111	1.207
T	$\bar{x}$	38.33	41.03	40.66	40.65	32.74	36.30	35.68	35.05
	SD	2.615	2.318	1.563	2.158	2.100	1.479	1.513	1.653
B	$\bar{x}$	20.14	23.03	22.99	21.94	42.98	44.86	44.24	42.48
	SD	1.928	1.364	1.661	1.035	1.152	1.397	2.439	1.982
T	$\bar{x}$	14.82	15.70	13.23	14.96	29.78	33.06	32.01	31.68
	SD	1.580	1.713	1.675	2.004	2.020	1.498	1.998	2.280
B	$\bar{x}$	67.85	71.32	71.02	70.24	27.31	42.73	50.95	46.79
	SD	1.459	1.586	3.473	1.790	13.179	14.023	14.029	18.594
T	$\bar{x}$	52.85	56.01	56.55	54.30	17.95	19.77	22.76	20.69
	SD	3.450	3.922	3.225	2.540	2.872	4.578	3.229	8.258
B	$\bar{x}$	19.02	25.70	33.46	32.61	46.56	47.04	50.55	47.86
	SD	1.367	0.855	13.124	12.637	1.771	1.858	2.643	1.522
T	$\bar{x}$	20.71	24.55	25.64	24.02	24.58	27.86	26.59	26.69
	SD	0.951	2.260	1.796	2.548	1.874	2.481	2.024	1.718
B	$\bar{x}$	80.30	81.37	77.45	77.31	65.48	69.93	60.51	63.86
	SD	3.017	3.033	2.505	2.500	1.999	5.557	11.055	1.893
T	$\bar{x}$	58.04	63.52	62.07	59.65	39.33	44.73	53.67	51.32
	SD	4.125	4.263	4.116	3.028	14.387	16.013	3.559	5.823

B = breast muscles, T = thigh muscles, SD = standard deviation

\* $P \leq 0.05$  \*\* $P \leq 0.01$

Table 2. Levels of amino acids in breast and thigh muscles of Cobb broiler chickens (g/kg dry matter)

Mus- cles	Day 42		Day 52		Day 42		Day 52			
	♀	♂	♀	♂	♀	♂	♀	♂		
			Asp				Thre			
B	$\bar{x}$ 79.29	77.88	80.92	87.32	36.78	36.23	36.44	40.59		
	SD 3.041	1.500	4.470	3.236	2.214	0.826	3.605	2.388		
		**	**	**	**	**	**	**		
T	$\bar{x}$ 58.97	56.94	58.48	58.02	26.33	28.70	27.62	26.52		
	SD 3.569	3.817	4.651	2.804	3.538	2.722	2.482	2.699		
		**	**	**	**	**	**	**		
			Ser				Glu			
B	$\bar{x}$ 31.62	30.72	32.62	34.94	106.69	109.98	112.94	130.15		
	SD 1.159	2.134	1.311	1.196	14.003	3.399	4.283	4.195		
		**	**	**	*	**	**	**		
T	$\bar{x}$ 25.43	24.72	23.39	20.75	95.15	88.51	91.50	89.51		
	SD 1.439	1.485	2.670	2.328	6.316	7.822	8.103	4.472		
		**	**	**	**	**	**	**		
			Pro				Gly			
B	$\bar{x}$ 17.63	16.41	18.68	22.72	37.98	37.07	38.48	35.01		
	SD 1.877	1.332	1.824	2.198	2.267	1.014	1.916	1.056		
		**		**	*	*	**			
T	$\bar{x}$ 17.72	19.28	18.98	17.70	35.30	33.26	34.32	33.16		
	SD 2.625	2.689	3.279	2.743	2.892	4.658	3.844	3.130		
		**	**	**	**	**	**	**		
			Ala				Val			
B	$\bar{x}$ 49.26	47.63	51.63	50.87	45.54	44.06	46.20	49.20		
	SD 1.849	1.566	3.495	1.481	1.252	2.050	1.832	1.432		
		**	**	**	**	**	**	**		
T	$\bar{x}$ 38.35	32.13	38.84	37.87	33.48	32.13	34.72	34.00		
	SD 2.084	2.032	3.559	2.299	1.827	2.032	2.825	1.649		
		**	**	**	**	**	**	**		
			Met				Ile			
B	$\bar{x}$ 22.16	20.99	21.77	19.34	41.61	41.31	42.44	44.51		
	SD 0.727	1.867	1.369	2.969	1.579	1.585	1.758	1.376		
		**	**	**	**	**	**	**		
T	$\bar{x}$ 13.56	14.25	12.92	15.10	32.51	28.80	31.18	32.15		
	SD 1.840	2.122	1.571	1.293	8.582	1.975	2.308	1.554		
		**	**	**	**	**	**	**		
			Leu				Tyr			
B	$\bar{x}$ 67.74	67.52	70.42	73.82	32.42	37.05	31.70	21.85		
	SD 1.664	2.331	2.820	3.297	16.662	14.365	15.315	2.434		
		**	**	**	*	**	**	**		
T	$\bar{x}$ 47.79	47.47	52.36	51.34	20.36	19.29	16.23	16.03		
	SD 10.452	4.635	4.226	2.501	2.642	2.763	5.284	4.911		
		**	**	**	**	**	**	**		
			Phe				His			
B	$\bar{x}$ 25.87	24.24	29.50	33.72	42.44	40.95	49.02	51.84		
	SD 2.435	0.725	9.655	2.280	1.744	1.837	2.547	2.853		
			*	**	**	**	**	**		
T	$\bar{x}$ 21.54	23.34	22.78	23.56	22.91	23.38	25.32	24.49		
	SD 2.041	1.639	1.390	2.644	2.216	1.581	2.152	1.312		
		**	**	**	**	**	**	**		
			Lys				Arg			
B	$\bar{x}$ 72.38	74.02	78.15	84.25	52.02	62.67	63.18	71.20		
	SD 10.220	2.352	3.053	2.914	18.333	2.730	4.568	2.096		
		**	**	**	**	**	**	**		
T	$\bar{x}$ 56.71	54.06	56.07	54.20	20.84	35.44	49.44	48.38		
	SD 3.060	3.569	5.455	6.189	1.101	16.086	6.375	5.067		
		**	**	**	**	**	**	**		

B = breast muscles, T = thigh muscles, SD = standard deviation

\* $P < 0.05$  \*\* $P < 0.01$

Table 3. Levels of amino acids in breast and thigh muscles of Hybro broiler chickens (g/kg dry matter)

Muscles	Day 42		Day 52		Day 42		Day 52		
	♀	♂	♀	♂	♀	♂	♀	♂	
B	$\bar{x}$	75.37	81.90	84.49	86.68	36.75	37.65	39.94	39.54
	SD	3.703	4.073	1.820	2.376	3.907	1.540	1.029	2.429
T	$\bar{x}$	56.20	61.79	58.86	60.61	29.66	28.26	27.99	29.35
	SD	2.908	4.157	3.422	2.351	2.569	2.760	2.144	2.395
Asp				Thre					
B	$\bar{x}$	30.22	31.77	33.79	35.06	106.76	113.01	124.97	131.19
	SD	1.188	1.573	0.859	0.669	4.816	6.995	3.023	2.594
T	$\bar{x}$	24.62	26.71	23.23	23.24	86.59	95.36	88.78	93.63
	SD	1.143	1.699	1.935	2.824	4.729	6.138	5.678	3.957
Ser				Glu					
B	$\bar{x}$	19.38	18.63	19.94	21.71	34.00	38.20	40.48	42.05
	SD	2.388	1.285	1.955	2.460	6.758	1.815	1.320	1.419
T	$\bar{x}$	18.27	22.40	18.04	19.32	31.42	35.76	33.95	36.23
	SD	1.930	2.455	1.263	1.745	1.993	3.020	1.905	2.060
Pro				Gly					
B	$\bar{x}$	48.72	48.94	52.66	54.83	45.00	44.87	49.38	51.68
	SD	2.081	1.892	1.336	1.616	2.734	2.302	1.066	2.561
T	$\bar{x}$	37.10	40.46	38.52	40.07	32.61	34.43	34.33	36.00
	SD	2.104	2.434	1.740	1.438	1.676	1.934	1.923	1.189
Ala				Val					
B	$\bar{x}$	19.35	18.95	17.83	20.16	41.48	41.46	46.76	45.13
	SD	1.833	2.681	2.103	2.770	1.675	1.395	6.247	1.415
T	$\bar{x}$	11.99	13.77	14.53	15.57	29.02	32.00	30.96	32.46
	SD	0.736	2.291	2.353	1.574	1.395	1.782	1.951	1.285
Met				Ile					
B	$\bar{x}$	68.13	70.19	75.44	74.76	33.12	38.58	26.54	32.22
	SD	3.264	2.137	5.839	3.541	15.701	18.759	15.534	15.890
T	$\bar{x}$	46.98	56.25	51.77	54.02	18.88	20.60	15.71	18.45
	SD	2.172	2.982	2.718	1.702	2.429	1.384	3.518	5.754
Leu				Tyr					
B	$\bar{x}$	28.47	26.08	29.76	30.58	44.50	45.03	52.44	48.71
	SD	1.944	1.033	1.818	1.808	2.151	1.722	2.615	1.478
T	$\bar{x}$	24.36	25.32	23.54	24.69	24.05	25.44	24.93	26.56
	SD	1.302	1.842	2.935	2.454	1.184	1.309	1.436	0.918
Phe				His					
B	$\bar{x}$	75.00	83.26	79.90	81.86	51.84	83.25	68.19	69.48
	SD	4.239	5.725	2.267	2.021	16.714	21.693	4.546	1.743
T	$\bar{x}$	54.89	61.46	56.05	58.64	30.80	54.64	43.25	50.14
	SD	2.738	3.743	2.518	3.299	14.070	3.701	12.604	10.378
Lys				Arg					

B = breast muscles, T = thigh muscles, SD = standard deviation

\* $P \leq 0.05$  \*\* $P \leq 0.01$

Table 4. Spectrum of amino acids in breast and thigh muscles on the 42nd and 52nd day of feeding (dry matter)

On the 42nd day of feeding						On the 52nd day of feeding					
breast muscles			thigh muscles			breast muscles			thigh muscles		
AA	g/kg	%	AA	g/kg	%	AA	g/kg	%	AA	g/kg	%
Pro	19.77	2.51	Met	14.02	2.37	Pro	20.05	2.40	Met	14.39	2.37
Met	20.77	2.64	Pro	19.39	3.28	Met	20.67	2.48	Tyr	18.31	3.02
Phe	24.99	3.16	Tyr	19.48	3.29	Phe	31.61	3.79	Pro	18.91	3.11
Ser	30.58	3.89	Phe	23.30	3.94	Ser	33.55	4.02	Ser	23.99	3.95
Tyr	36.20	4.47	His	24.70	4.18	Tyr	35.01	4.20	Phe	24.04	3.96
Thre	36.55	4.65	Ser	25.79	4.36	Thre	38.36	4.60	His	25.76	4.24
Gly	37.45	4.76	Thre	27.78	4.70	Gly	38.86	4.66	Thre	28.51	4.70
Ile	42.28	5.37	Ile	30.86	5.22	Ile	44.26	5.30	Ile	31.74	5.23
His	44.42	5.65	Val	33.62	5.69	Val	48.21	5.78	Gly	34.73	5.72
Val	45.79	5.82	Gly	34.39	5.82	His	50.07	6.00	Val	34.96	5.76
Ala	49.13	6.24	Arg	37.63	6.36	Ala	51.37	6.16	Ala	39.44	6.50
Arg	64.20	8.16	Ala	37.90	6.41	Arg	66.07	7.92	Arg	49.37	8.13
Leu	68.79	8.74	Leu	51.23	8.66	Leu	72.62	8.70	Leu	53.39	8.79
Lys	77.72	9.88	Lys	58.11	9.83	Lys	79.82	9.57	Lys	57.78	9.52
Asp	78.98	10.04	Asp	59.59	10.08	Asp	83.11	9.96	Asp	59.77	9.84
Glu	110.33	14.02	Glu	93.53	15.82	Glu	120.81	14.48	Glu	92.09	15.17
Σ	786.86	100.00	Σ	591.32	100.00	Σ	834.46	100.00	Σ	607.18	100.00

AA = amino acid

research area where only a very few studies on this topic have been published so far. Furthermore, the paper provides new data on absolute and relative levels of individual amino acids in breast and thigh muscles pointing out to the differences between these two muscle tissues. Our findings also demonstrate that the content of amino acids in breast and thigh muscles increases significantly when the feeding period is prolonged. Furthermore, the total content of amino acids and the levels of individual amino acids are considerably higher in breast muscles in comparison with thigh muscles. The presented results will enable a more reliable assessment of the nutritional value of chicken meat. We also believe that these results can be used for optimizing the composition of feed mixtures to control the conversion process of feed in broiler chickens during feeding.

Our results show that the levels of amino acids in breast muscles differ considerably from those in thigh muscles. This fact should be reflected in the production of broilers to achieve higher weight gains and also in the preparation of feed mixtures that will be used after the 42nd day of feeding when breast muscles grow significantly. Therefore, in this period of feeding the composition of feed mixtures should be adjusted particularly in respect to amino acids in order to ensure the maximum growth of breast muscles.

It follows from the aminoanalysis of broiler muscles that the increase in the total content of amino acids is accompanied only by very small changes in the levels of individual amino acids. As a result, the nutritional value of muscles increases during prolonged feeding.

To enhance the growth of breast muscles in this period it is advisable to enrich feed mixtures with some amino acids and to adjust the ratio of these amino acids according to the needs of a particular organism. Furthermore, the results presented in this paper support current trends pointing out the advantages of separate feeding of male and female chickens. The feed mixtures for male chickens should contain higher amounts of amino acids, particularly arginine, which is crucial for the optimum growth of muscles.

## REFERENCES

- Acar N., Barbato G.F., Patterson P.H. (2001): The effect of feeding excess methionine on live performance, carcass traits and ascitic mortality. *Poultry Sci.*, 80, 1585–1589.
- Deschepper K. (1995): Effect of dietary-protein, essential and nonessential amino-acids on the performance and carcass composition of male broiler chickens. *Brit. Poultry Sci.*, 36, 229–245.
- Holsheimer J.P. (1993): Effect on performance, carcass composition, yield, and financial return of dietary energy and lysine levels in starter and finisher diets fed to broilers. *Poultry Sci.*, 72, 806–815.
- Ingr I. (1996): Meat Technology (in Czech). MZLU, Brno. 290 pp.
- Matušovičová E. (1986): Technology of Poultry Industry (in Slovak). *Príroda*, Bratislava. 393 pp.
- Simeonovová J. (1999): Technology of the production of poultry, eggs and other minor animal products (in Czech). MZLU, Brno. 247 pp.
- Snížek J. (1995): Raising of ostriches as a new branch of poultry raising (in Czech). *Stud. Inf.*, No. 2, 36 pp.
- Szakall I., Fekete S., Andrasofszky E., Romvari R., Szita G. (1998): Relationship of dietary fat and lysine level with body composition in broiler chickens. *Acta Vet. Hung.*, 46, 243–257.

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