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# KVANTITATIVNÍ ZNAKY JATEČNÉ HODNOTY U BÝKŮ VYBRANÝCH PLEMEN SKOTU

## QUANTITATIVE TRAITS OF CARCASS VALUE IN BULLS OF SOME CATTLE BREEDS

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**ABSTRACT:** The objective of the paper was to determine quantitative traits of carcass value in bulls of Czech Pied breed (C), Limousine breed (Li) and their crossbreds. Our study was focused on a comparison of meatiness and carcass yield in the experimental groups of bulls. A finishing facility was filled with bulls of Czech Pied breed, Limousine breed and their crossbreds after weaning at the age of 210 days. Slaughter bulls of the given genotypes were sacrificed at average slaughter weight 500–550 kg. Carcass value traits were assessed in selected groups of animals after control slaughters when bull carcasses were dissected into butcher's cuts. To assess carcass value these parameters were determined: average daily weight gain during finishing in g, live weight before slaughter in kg, weight of dressed carcass in kg, carcass yield from live weight before slaughter in %, proportions of lean cuts and bones in dressed carcass in %, meat to bone ratio. Statistical data were processed by SAS program – a linear model. C × Li bulls achieved the highest average daily gain during finishing while it was lowest in Li breed. C × Li crossbreds had the highest live weight before slaughter, Li breed the lowest. There were no statistically significant differences between the groups. The highest weight of dressed carcass was determined in Li breed (320.8 kg), the lowest in C breed. Statistical differences were calculated between C and C × Li ( $P < 0.01$ ), between Li and C, and between Li and C × Li ( $P < 0.001$ ). The highest carcass yield was determined in bulls of Li breed (62.3%), the lowest in C breed (59.2%). The proportion of total meat in dressed meat cuts was highest in Li breed (82.0%) while it was lowest in C breed (76.3%); Li breed had the lowest proportion of total bones (16.4%), C breed had the highest (21.2%). The best meat to bone ratio was determined in bulls of Li breed – 5.01, followed by C × Li bulls – 3.81, the worst meat to bone ratio was in C bulls – 3.60. The proportion of fat in the weight of dressed meat cuts was lowest in bulls of Li breed – 1.6% while it was highest in C × Li bulls – 2.7%. Li bulls had the highest proportion of these cuts in the weight of dressed cuts: meat of chuck with shank and bottom chuck cut off (7.5%), brisket with rib and bone and flank with bone (14.5%), rib, foreribs and neck in one piece without bones (11.1%), fore shank with bottom chuck, hind shank and plate (5.4%), short loin (5.0%), sirloin (1.9%), round and rump with shank and plate cut off (19.5%), and the lowest proportion of fat (1.6%), marrow, thin and butcher's bones (16.4%).

**Keywords:** cattle; Czech Pied breed; Limousine breed; commercial crossing; finishing; carcass yield; proportion of lean cuts

**ABSTRAKT:** Cílem práce bylo stanovit kvantitativní znaky jatečné hodnoty u býků plemene české strakaté (C), limousin (Li) a jejich kříženců. Důraz byl kladen na porovnání zmasilosti a jatečné výtěžnosti mezi sledovanými skupinami býků. Býci plemene české strakaté, limousin a jejich kříženců byli zařazeni do výkrmu po odstavu ve věku 210 dní. Jateční býci uvedených genotypů byli poráženi v průměrné porážkové hmotnosti 500–550 kg. Ukazatele jatečné hodnoty byly u vybraných skupin zvířat vyhodnoceny při kontrolních porážkách, kdy byla jatečně opracovaná těla (JOT) býků bourána na jednotlivé výsekové části. Nejvyšší průměrný denní přírůstek ve výkrmu a nejvyšší živá hmotnost před porážkou byly zjištěny u býků C × Li. Nejvyšší hmotnost jatečně opracovaného těla byla stanovena u plemene Li a statistické rozdíly byly zjištěny mezi C a C × Li ( $P < 0,01$ ), mezi Li a C a mezi Li a C × Li ( $P < 0,001$ ). Nejvyšší jatečné výtěžnosti a podíl masa celkem z JOT dosáhli býci plemene Li. Podíl kostí celkem a podíl lože z hmotnosti JOT byl nejnižší u plemene Li. Nejpříznivější poměr maso : kosti byl stanoven u býků plemene Li – 5,01. U býků Li byl zjištěn nejvyšší podíl z hmotnosti JOT u jatečných částí: maso z plece bez kličky a husičky, hrudí se žebrem a kostí a bok s kostí, vysoký roštěnec, podplečí a krk vcelku bez kostí, klička přední s husičkou, klička zadní a plátek z pánevní dutiny, nízký roštěnec bez kostí, svičková, maso z kýty bez kličky a plátku z pánevní dutiny.

**Klíčová slova:** skot; plemeno české strakaté, plemeno limousin; užitkové křížení; výkrm; jatečná výtěžnost; podíl masitých částí

Výsledky byly získány v rámci řešení výzkumného úkolu Ministerstva školství, mládeže a tělovýchovy č. 412100003.

Jednou z nejdůležitějších charakteristik jatečné hodnoty je poměr svalstva, tuku a kostí v trupu. Se zřetelem na stoupající požadavek produkce libového masa je kladen důraz na maximální podíl kosterního svalstva, zatímco vysoký obsah tuku je považován za nežádoucí. Při studiu jatečné hodnoty hospodářských zvířat je hlavní pozornost soustředěna k analýze variability jatečné výtěžnosti, podílu hodnotných a méně hodnotných částí trupu, poměru masa, tuku a kostí.

Bauer *et al.* (1990) uvádějí, že hodnotu jatečného těla zvířete a zejména pak stupeň protučnění ovlivňuje šlechtění, výživa a hlavně porážková hmotnost. Grosse a Ladegast (1989) doporučují za výlučně pomocný znak pro protučnělost u jatečného skotu, podobně jako řada dalších autorů, podíl ledvinového tuku, a to nezávisle na kategorii. Podíl hlavy, končetin a délku jatečného těla označují jako specifické pomocné znaky pro kostnatost. Johnson *et al.* (1989) konstatují, že odhad složení přední čtvrtě může být určen pomocí kombinace hmotnosti jatečné půlky, korigované tloušťky tuku a hmotnosti *musculus pectoralis superficialis*. Z výsledků prací autorů Renard (1988), Rahnfeldt *et al.* (1987) a Lucevič (1989) vyplývá, že složení svaloviny je v první řadě ovlivněno výživou, ale řada ukazatelů u jednotlivých plemen je silně ovlivněna genetickou složkou, např. jemnost svalových vláken u plemene limousin.

Perry a Fox (1997) stanovili na základě zjišťování výšky tuku v bederní oblasti předpoklad složení jatečného trupu. Předpokládána hmotnost JOT byla dosažena z 84–88 %. Ptáček a Suchánek (1985) uvádějí jatečnou výtěžnost u C skotu při porážkové hmotnosti 527 kg (58,49 %). Při této porážkové hmotnosti bylo masa celkem u býků C 65,28 kg, z toho masa I. jakosti 45,26 kg. Šubrt *et al.* (1996) zjistili u býků C, že vyšší úroveň netto přírůstku se pozitivně projevila v klasifikaci jatečných těl podle zmasilosti ( $P < 0,01$ ), v procentuálním zvýšení podílu masa (+3,9 %) a snížení podílu kostí v jatečném těle (-4,47 %). Zvýšení netto přírůstku se kladně projevilo i ve zvýšení procentuálního podílu masa z kýty (+1,08 %,  $P < 0,01$ ) a roštěnce ( $P < 0,05$ ). Suchánek *et al.* (1990a,b) uvádějí u býků C při průměrné hmotnosti jatečné půlky 144,2 kg podíl masa I. jakosti 37,9 % a masa celkem 78,5 %. Voříšková *et al.* (1998) porovnávali ukazatele jatečné hodnoty u býků vybraných masných plemen a u plemene české strakaté. Nejvyšší hmotnost jatečně opracovaného těla zjistili u býků Ch (346,34 kg), nejnižší u býků He (302,05 kg). Jatečná výtěžnost byla od 57,01 % (He) až do 60,37 % (Ch). Šubrt (1994) hodnotil jatečná těla býků-kříženců zušlechtěné populace českého strakatého skotu s masnými plemeny (Li, Ch, Pa, He). Největší procentuální podíl zadního masa byl zjištěn u kříženců C × Li (28,14 %), což bylo o 0,87 % více než u kontrolní skupiny C. Poměr masa : kosti byl u C × Li 4,25. Mikšík *et al.* (1996) uvádějí u býků plemene C průměrný denní přírůstek ve výkrmu 1 208 g, hmotnost JOT 332,5 kg

a jatečnou výtěžnost 58,5 %. Nosál *et al.* (1998) hodnotili býky-křížence slovenského strakatého plemene s plemenem limousin a zjistili, že největší podíl masa (79,22–79,88 %) a největší podíl masa I. jakosti (43,94 %) byl ve hmotnostní skupině 500–550 kg. Býci v rozmezí hmotnosti 451–550 kg se projevovali nejlépe z hlediska protučnění. Za nejvýhodnější porážkovou hmotnost u kříženců slovenského strakatého plemene s plemenem limousin jak z hlediska masné užitkovosti, tak z hlediska protučnělosti se ukazují rozmezí 500–550 kg.

## MATERIÁL A METODA

Jateční býci byli rozděleni do těchto pokusných skupin:

- |  |       |
|--|-------|
| 1. pokusná skupina:                      |       |
| plemeno limousin (Li)                    | 34 ks |
| (býci byli po otcích ZLI 183, 184, 185)  |       |
| 2. pokusná skupina:                      |       |
| plemeno český strakatý skot (C)          | 39 ks |
| 3. pokusná skupina                       |       |
| kříženci plemene C a plemene Li (C × Li) | 41 ks |
| (býci byli po otcích ZLI 161, 183, 184)  |       |

Býci plemene české strakaté, limousin a jejich kříženci byli zařazeni do výkrmu po odstavu ve věku 210 dní. Býci ve výkrmu byli ustájeni volně na hluboké podestýlce, v boxech po 20–25 kusech. Krmnou dávku tvořila siláž, senáž a jádro (4 % směska peluška + oves, 4 % soja, 4 % premix Rindamast, 44 % pšenice, 44 % ječmen). Jateční býci uvedených genotypů byli poráženi v průměrné porážkové hmotnosti 500–550 kg.

Ukazatele jatečné hodnoty byly u vybraných skupin zvířat zhodnoceny při kontrolních porážkách v masokombinátu, kde byla jatečně opracovaná těla býků bourána na jednotlivé výsekové části podle ČSN 57 6510 Hovězí maso pro výsek – norma jakosti.

Jatečné půlky byly rozbourány na části: maso z plece bez klišky a husičky, hrudi se žebrem a kostí a bok s kostí, bok bez kostí, vysoký roštěnec, podplečí a krk vcelku bez kostí, kliška přední s husičkou, kliška zadní a plátek z pánevní dutiny, nízký roštěnec bez kostí, svičková, maso z kýty bez klišky a plátku z pánevní dutiny, výřez na mleté maso (výřez získaný při dělení hovězích čtvrtí pro výsek a při úpravě jednotlivých částí pro výsek), ořez – klouby, ohánka, lůj, kosti morkové a řídké (předloketní včetně kloubové hlavice, pažní včetně kloubové hlavice, kloubová hlavice lopatky, bérčové včetně kloubové hlavice, stehenní včetně kloubové hlavice, kosti pánevní, kosti křížové, kosti z noh s řídkým morkem), harfy (masité kosti – hrudní kost, obratle krční, hrudní a bederní).

V rámci sledování jatečné hodnoty byly zjišťovány tyto ukazatele:

1. hmotnost jatečně opracovaného těla (kg)
2. jatečná výtěžnost z živé hmotnosti před porážkou (%)
3. podíl jednotlivých masitých částí a kostí z jatečně opracovaného těla (%)

4. podíl masa a kostí z jatečně opracovaného těla (%)  
5. poměr maso : kosti

Pro uvedené ukazatele byly vypočítány základní statistické charakteristiky programem SAS – lineárním modelem a výsledky byly vyjádřeny tabulkově a graficky.

Statistické vyhodnocení bylo provedeno podle rovnice:

$$y_{ij} = \mu + PL_i + ROK_j + b(V_{ij} - V) + e_{ij}$$

kde:  $y$  – sledovaný ukazatel  
 $\mu$  – průměr souboru  
 $PL_i$  – vliv  $i$ -tého genotypu;  $i = 1, 2, 3$   
 $ROK_j$  – vliv  $j$ -tého roku,  $k = 1, 2$   
 $b(V_{ij} - V)$  – regrese na průměrný věk  
 $e_{ij}$  – reziduum

Na základě statistického vyhodnocení byly porovnány jednotlivé sledované ukazatele jatečné hodnoty mezi býky uvedených genotypů. Statistické rozdíly mezi pokusnými skupinami byly vyhodnoceny na hladinách významnosti  $P < 0,05$  (statisticky významné),  $P < 0,01$  (statisticky středně významné),  $P < 0,001$  (statisticky vysoce významné).

## VÝSLEDKY

Nejvyšší průměrný denní přírůstek ve výkrmu (tab. 1) byl zjištěn u kříženců  $C \times Li$  (1 142 g) a nejnižší u plemene  $Li$  (1 034 g). Statistické rozdíly byly zjištěny mezi

$Li$  a  $C$  ( $P \leq 0,05$ ) a mezi  $Li$  a  $C \times Li$  ( $P < 0,001$ ). Nejvyšší živou hmotnost před porážkou dosáhlo plemeno  $C$  (520 kg) a nejnižší hmotnost plemeno  $Li$  (515 kg). Mezi jednotlivými skupinami nebyly statisticky významné rozdíly.

Nejvyšší hmotnost jatečně opracovaného těla (tab. 1) byla stanovena u plemene  $Li$  (320,8 kg) a nejnižší u plemene  $C$  (307,8 kg). Statistické rozdíly byly zjištěny mezi  $C$  a  $C \times Li$  ( $P < 0,01$ ), mezi  $Li$  a  $C$  a mezi  $Li$  a  $C \times Li$  ( $P < 0,001$ ). Nejvyšší jatečné výtěžnosti dosáhli býci plemene  $Li$  (62,3 %) a nejnižší býci plemene  $C$  (59,2 %). Byly zjištěny statistické rozdíly mezi  $Li$  a  $C \times Li$  ( $P < 0,01$ ) a mezi  $Li$  a  $C$  ( $P < 0,001$ ).

Podíl masa celkem z JOT (tab. 1) byl nejvyšší u plemene  $Li$  – 263,1 kg (82,0 %) a nejnižší u plemene  $C$  – 234,8 kg (76,3 %), podíl kostí celkem byl nejnižší u plemene  $Li$  – 52,5 kg (16,4 %) a nejvyšší u plemene  $C$  – 65,3 kg (21,2 %). U podílu masa celkem a kostí celkem z JOT byly zjištěny statistické rozdíly mezi  $C$  a  $C \times Li$  ( $P < 0,01$ ), mezi  $Li$  a  $C$  a mezi  $Li$  a  $C \times Li$  ( $P < 0,001$ ). Nejpříznivější poměr maso : kosti byl stanoven u býků plemene  $Li$  – 5,01, dále u býků  $C \times Li$  – 3,81 a nejméně příznivý poměr maso : kosti byl u býků  $C$  – 3,60.

Nejvyšší podíl masa z plece bez klíčky a husičky (tab. 2) byl zjištěn u plemene  $Li$  – 24,2 kg (7,5 % z JOT) a nejnižší u plemene  $C$  – 20,7 kg (6,7 % z JOT). Statistické rozdíly byly zjištěny mezi  $C$  a  $C \times Li$  ( $P \leq 0,05$ ), mezi  $Li$  a  $C$  a mezi  $Li$  a  $C \times Li$  ( $P < 0,001$ ).

Podíl jatečné části hrudí se žebrem a kostí a bok s kostí (tab. 2) byl nejvyšší u býků plemene  $Li$  – 46,5 kg (14,5 %)

Tab. 1. Ukazatele jatečné hodnoty u býků plemene české strakaté, limousin a jejich kříženců – Indicators of carcass value in bulls of Czech Pied breed, Limousin breed and their crossbreeds

Ukazatel <sup>1</sup>	Býci $Li^9$ ( $n = 34$ )			Býci $C^{10}$ ( $n = 39$ )			Býci $C \times Li^{11}$ ( $n = 41$ )		
	$\bar{x}$	$s_{\bar{x}}$	% z JOT <sup>12</sup>	$\bar{x}$	$s_{\bar{x}}$	% z JOT <sup>12</sup>	$\bar{x}$	$s_{\bar{x}}$	% z JOT <sup>12</sup>
Průměrný denní přírůstek <sup>2</sup> (g)	1 034 a*	124,56	–	1 108,0	131,59	–	1 142 c***	109,58	–
Živá hmotnost před porážkou <sup>3</sup> (kg)	515,0	42,54	–	520,0	39,36	–	522,0	44,51	–
Hmotnost JOT <sup>4</sup> (kg)	320,8 a***	18,73	–	307,8 b**	17,78	–	312,3 c***	19,52	–
Výtěžnost <sup>5</sup> (%)	62,3 a***	0,95	–	59,2	0,85	–	59,8 c**	0,79	–
Maso celkem <sup>6</sup> (kg)	263,1 a***	16,82	82,0	234,8 b**	17,31	76,3	240,7 c***	16,58	77,1
Kosti celkem <sup>7</sup> (kg)	52,5 a***	3,46	16,4	65,3 b**	4,43	21,2	63,2 c***	3,41	20,2
Maso : kosti <sup>8</sup>	5,01			3,60			3,81		

$C$  = české strakaté plemeno – Czech Pied breed,  $Li$  = plemeno limousin – Limousine breed,  $C \times Li$  = kříženci  $C$  a  $Li$  –  $C$  and  $Li$  crossbreeds  
 $a$  = statistický rozdíl mezi plemenem limousin a české strakaté – statistical difference between Limousin breed and Czech Pied breed  
 $b$  = statistický rozdíl mezi plemenem české strakaté a kříženci  $C \times Li$  – statistical difference between Czech Pied breed and hybrids  $C \times Li$   
 $c$  = statistický rozdíl mezi plemenem limousin a kříženci  $C \times Li$  – statistical difference between Limousine breed and  $C \times Li$  crossbreeds  
 $*P < 0,05$ ;  $**P < 0,01$ ;  $***P < 0,001$

<sup>1</sup>parameter, <sup>2</sup>average daily gain, <sup>3</sup>live weight before slaughter, <sup>4</sup>weight of dressed lean cuts, <sup>5</sup>dressing percentage, <sup>6</sup>total meat, <sup>7</sup>total bones, <sup>8</sup>meat to bone ratio, <sup>9</sup> $Li$  bulls, <sup>10</sup> $C$  bulls, <sup>11</sup> $C \times Li$  bulls; <sup>12</sup>% dressed carcass cuts

Tab. 2. Hmotnost a podíl jednotlivých jatečných částí u býků plemene české strakaté, limousin a jejich kříženců – Weight and proportion of carcass cuts in bulls of Czech Pied breed, Limousine breed and their crossbreds

Jatečná část <sup>1</sup> (kg)	Býci Li <sup>17</sup> (n = 34)			Býci C <sup>18</sup> (n = 39)			Býci C × Li <sup>19</sup> (n = 41)		
	$\bar{x}$	$s_{\bar{x}}$	%	$\bar{x}$	$s_{\bar{x}}$	%	$\bar{x}$	$s_{\bar{x}}$	%
Maso z plece bez klišky a husičky <sup>2</sup>	24,2 a***	0,44	7,5	20,7 b*	0,36	6,7	21,6 c***	0,45	6,9
Hrudí se žebrem a kostí a bok s kostí <sup>3</sup>	46,5 a***	0,69	14,5	42,3 b**	0,68	13,7	44,0 c**	0,74	14,1
Bok bez kostí (pupek) <sup>4</sup>	13,6 a**	0,22	4,2	16,0 b***	0,25	5,2	10,4 c***	0,36	3,3
Vysoký roštěnec, podplečí a krk vcelku bez kostí <sup>5</sup>	35,5 a***	0,73	11,1	27,0 b*	0,66	8,8	28,8 c***	0,70	9,2
Kliška přední s husičkou, kliška zadní a plátek z pánevní dutiny <sup>6</sup>	17,4 a**	0,42	5,4	16,0 b*	0,38	5,2	16,8	0,41	5,4
Nízký roštěnec bez kostí <sup>7</sup>	15,9 a**	0,35	5,0	14,3 b**	0,37	4,7	15,6	0,39	5,0
Svíčková <sup>8</sup>	6,0 a**	0,11	1,9	4,7	0,13	1,5	4,8 c**	0,12	1,6
Maso z kýty bez klišky a plátku z pánevní dutiny <sup>9</sup>	62,6 a***	0,39	19,5	56,0 b*	0,46	18,2	57,2 c***	0,41	18,3
Výřez na mleté maso <sup>10</sup>	37,2 a***	0,30	11,6	33,7 b***	0,36	11,0	40,0 c***	0,41	12,8
Ořez – klouby <sup>11</sup>	3,1	0,06	1,0	3,1	0,05	1,0	3,2	0,10	1,0
Oháňka <sup>12</sup>	1,1	0,04	0,3	1,0 b**	0,05	0,3	0,3 c**	0,04	0,1
Lůj <sup>13</sup>	5,2 a***	0,15	1,6	7,7 b**	0,17	2,5	8,4 c***	0,19	2,7
Kosti morkové a řídké <sup>14</sup>	30,0 a***	0,25	9,4	37,0 b*	0,35	12,0	36,0 c***	0,33	11,5
Harfy (masité kosti) <sup>15</sup>	22,5 a***	0,26	7,0	28,3 b*	0,28	9,2	27,2 c***	0,24	8,7
Hmotnost JOT <sup>16</sup>	320,8 a***	18,73	100,0	307,8 b**	17,78	100,0	312,3 c***	19,52	100,0

<sup>1</sup>carcass cut, <sup>2</sup>meat of chuck with shank and bottom chuck cut off, <sup>3</sup>brisket with rib and bone and flank with bone, <sup>4</sup>flank without bones, <sup>5</sup>rib, fore ribs and neck in one piece without bones, <sup>6</sup>front shank with bottom chuck, hind shank and plate, <sup>7</sup>short loin without bones, <sup>8</sup>sirloin, <sup>9</sup>round and rump with shank and plate cut off, <sup>10</sup>trimmings for minced meat, <sup>11</sup>knuckle trimmings, <sup>12</sup>tail, <sup>13</sup>fat, <sup>14</sup>marrow and thin bones, <sup>15</sup>butcher's bones, <sup>16</sup>weight of dressed carcass cuts, <sup>17</sup>Li bulls, <sup>18</sup>C bulls, <sup>19</sup>C × Li bulls

a nejnižší u plemene C – 42,3 kg (13,7 %). Statistické rozdíly byly zjištěny mezi C a C × Li, mezi Li a C × Li ( $P < 0,01$ ) a mezi Li a C ( $P < 0,001$ ).

Podíl boku bez kostí (tab. 2) byl nejvyšší u plemene C – 16,0 kg (5,2 %) a nejnižší u C × Li – 10,4 kg (3,3 %). Statistické rozdíly byly zjištěny mezi Li a C ( $P < 0,01$ ), mezi C a C × Li a mezi Li a C × Li ( $P < 0,001$ ).

Podíl vysokého roštěnce, podplečí a krku vcelku bez kostí (tab. 2) byl nejvyšší u býků Li – 35,5 kg (11,1 %) a nejnižší u býků C – 27,0 kg (8,8 %). Byly zjištěny statistické rozdíly mezi C a C × Li ( $P \leq 0,05$ ), mezi Li a C a mezi Li a C × Li ( $P < 0,001$ ).

Podíl jatečné části kliška přední s husičkou, kliška zadní a plátek z pánevní dutiny byl nejvyšší u plemene Li – 17,4 kg (5,4 %) a nejnižší u plemene C – 16,0 kg (5,2 %). Statistické rozdíly byly mezi C a C × Li ( $P \leq 0,05$ ) a mezi Li a C ( $P < 0,01$ ) (tab. 2).

Nejvyšší podíl nízkého roštěnce bez kostí (tab. 2) byl zjištěn u býků plemene Li – 15,9 kg (5,0 %) a nejnižší u býků plemene C – 14,3 kg (4,7 %). Statistické rozdíly byly mezi Li a C a mezi C a C × Li ( $P < 0,01$ ).

Podíl svíčkové (tab. 2) byl nejvyšší u plemene Li – 6,0 kg (1,9 %) a nejnižší u plemene C – 4,7 kg (1,5 %). Statistické rozdíly byly zjištěny mezi Li a C a mezi Li a C × Li ( $P < 0,01$ ).

Podíl masa z kýty bez klišky a plátku z pánevní dutiny byl nejvyšší u býků plemene Li – 62,6 kg (19,5 %)

a nejnižší u býků plemene C – 56,0 kg (18,2 %). Statistické rozdíly byly zjištěny mezi C a C × Li ( $P \leq 0,05$ ), mezi Li a C a mezi Li a C × Li ( $P < 0,001$ ) (tab. 2).

Výřez na mleté maso (tab. 2) byl nejvyšší u býků C × Li – 40,0 (12,8 %) a nejnižší u býků C – 33,7 kg (11,0 %). Mezi všemi sledovanými skupinami byly zjištěny statistické rozdíly ( $P < 0,001$ ).

Podíl loje (tab. 2) byl nejvyšší u býků C × Li – 8,4 kg (2,7 %) a nejnižší u býků plemene Li – 5,2 kg (1,6 %). Byly zjištěny statistické rozdíly mezi C a C × Li ( $P < 0,01$ ), mezi Li a C a mezi Li a C × Li ( $P < 0,001$ ).

Podíl kostí morkových a řídkých byl nejvyšší u býků plemene C – 37,0 kg (12,0 %) a nejnižší u býků plemene Li – 30,0 kg (9,4 %), podíl masitých kostí byl nejvyšší u býků C – 28,3 kg (9,2 %) a nejnižší u býků Li – 22,5 kg (7,0 %). Statistické rozdíly byly zjištěny mezi C a C × Li ( $P \leq 0,05$ ), mezi Li a C a mezi Li a C × Li ( $P < 0,001$ ) (tab. 2).

## DISKUSE

Ve srovnání s našimi výsledky zjistili Golda *et al.* (1988) ve výkrmu býků plemene C o 61 g nižší průměrný denní přírůstek, Frelích a Voříšková (1997) o 52 g vyšší průměrný denní přírůstek, Ptáček a Suchánek (1985) uvádějí u býků českého strakatého plemene o 19 g vyšší průměrný denní přírůstek. Mikšík *et al.* (1996)

zjistili u býků plemene C průměrný denní přírůstek ve výkrmu 1 208 g, což je o 100 g více než jsou námi uváděné hodnoty, Suchánek *et al.* (1990a,b) zjistili proti našim výsledkům u býků českého strakatého plemene o 72 g nižší průměrný denní přírůstek. Gregory *et al.* (1994) uvádějí proti našemu sledování u plemene limousin o 266 g vyšší průměrný denní přírůstek, Frelích a Voříšková (1997) o 8 g vyšší průměrný denní přírůstek.

Ptáček a Suchánek (1985) uvádějí u býků českého strakatého plemene hodnotu jatečné výtěžnosti, která odpovídá námi zjištěným výsledkům. Mikšík *et al.* (1996) zjistili u býků plemene C jatečnou výtěžnost o 0,1 % nižší, Suchánek *et al.* (1990a,b) uvádějí jatečnou výtěžnost o 0,3 % nižší, Šubrt a Mikšík (1995) u českého strakatého skotu o 0,6 % nižší a Trojan a Safarová (1987) zjistili u býků plemene české strakaté proti našim výsledkům jatečnou výtěžnost vyšší. Voříšková *et al.* (1998) uvádějí u plemene C jatečnou výtěžnost ve srovnání s našimi výsledky o 1,1 % nižší a obdobně u plemene Li o 3,8 % nižší. Štráfelda (1992) uvádí u kříženců plemene limousin s českým strakatým skotem zvýšení jejich jatečné výtěžnosti o 1 až 1,5 % proti plemenu C, tedy na úrovni ostatních masných plemen. V našem sledování je jatečná výtěžnost u býků C × Li o 2 % vyšší než u býků C.

Ptáček a Suchánek (1985) uvádějí u býků českého strakatého plemene podíl masa celkem z JOT 65,3 %, což je o 11 % méně než v našem sledování. Šubrt a Mikšík (1995) uvádějí u českého strakatého skotu výtěžnost masa o 3,7 % vyšší, Suchánek *et al.* (1990a,b) zjistili o 2,2 % vyšší podíl masa celkem a Trojan a Safarová (1987) také zjistili vyšší podíl masa z jatečné půlky. Voříšková *et al.* (1998) uvádějí podíl masa celkem z hmotnosti JOT u plemene C o 1,7 % nižší a u plemene Li o 5,7 % nižší. Šubrt (1994) zjistil u býků kříženců C × Li výtěžnost masa 79,85 %, což je o 2,75 % více než v našem sledování.

Suchánek *et al.* (1990a,b) uvádějí u plemene C o 0,3 % vyšší podíl vnitřních lojů z hmotnosti jatečného těla, Šubrt a Mikšík (1995) u českého strakatého skotu výtěžnost vnitřních lojů o 1 % nižší. Suchánek *et al.* (1990a,b) zjistili u býků českého strakatého skotu podíl kostí o 4,4 % nižší. Voříšková *et al.* (1998) uvádějí u plemene C a Li podíl nízkého roštěnce z hmotnosti JOT nižší než v našich výsledcích, a to o 1,3 %. Podíl svíčkové z hmotnosti JOT zjistili u obou plemen opět nižší u plemene C o 0,3 % a u plemene Li o 0,6 %. Podíl kostí celkem z hmotnosti JOT u plemene C uvádějí autoři o 1,6 % nižší a u plemene Li naopak o 2,7 % vyšší. Šubrt (1994) zjistil u býků kříženců C × Li o 3 % vyšší podíl zadního masa celkem z hmotnosti JOT. Také u poměru masa : kosti zjistil autor vyšší hodnotu (4,25).

## ZÁVĚR

Nejvyšší průměrný denní přírůstek ve výkrmu jsme zjistili u býků C × Li a nejnižší u plemene Li.

Nejvyšší živou hmotnost před porážkou dosáhli kříženci C × Li a nejnižší plemeno Li. Mezi jednotlivými skupinami nebyly statisticky významné rozdíly.

Nejvyšší hmotnost jatečně opracovaného těla byla stanovena u plemene Li a nejnižší u plemene C. Statistické rozdíly byly zjištěny mezi C a C × Li ( $P < 0,01$ ), mezi Li a C a mezi Li a C × Li ( $P < 0,001$ ).

Nejvyšší jatečné výtěžnosti dosáhli býci plemene Li (62,3 %) a nejnižší býci plemene C (59,2 %).

Podíl masa celkem z JOT byl nejvyšší u plemene Li (82,0 %) a nejnižší u plemene C (76,3 %), podíl kostí celkem byl nejnižší u plemene Li (16,4 %) a nejvyšší u plemene C (21,2 %). Nejpriznivější poměr masa : kosti byl stanoven u býků plemene Li (5,01), dále u býků C × Li (3,81) a nejméně příznivý poměr masa : kosti byl u býků C (3,60).

Podíl loje z hmotnosti JOT byl nejnižší u býků plemene Li (1,6 %) a nejvyšší u C × Li (2,7 %).

U býků Li byl zjištěn nejvyšší podíl z hmotnosti JOT u jatečných částí: maso z plece bez klišky a husičky (7,5 %), hrudi se žebrem a kostí a bok s kostí (14,5 %), vysoký roštěnec podplečí a krk vcelku bez kostí (11,1 %), kliška přední s husičkou, kliška zadní a plátek z pánevní dutiny (5,4 %), nízký roštěnec bez kostí (5,0 %), svíčková (1,9 %), maso z kýty bez klišky a plátku z pánevní dutiny (19,5 %) a nejnižší podíl loje (1,6 %), kostí morkových, řídkých a masitých (16,4 %).

Mezi jednotlivými skupinami nebyl u živé hmotnosti před porážkou zjištěn statisticky významný rozdíl, přesto hmotnost JOT byla u plemene Li statisticky průkazně vyšší než u dalších skupin. Je nevyhnutelné co nejdříve zavést do praxe zpeněžování systémem SEUROP, při kterém je jatečný skot objektivně zatříděn podle zmasilosti a protučnosti do většího počtu tříd jakosti. Dále je nezbytné nutně při zpeněžování zohlednit kvalitu masa u masných plemen a jejich kříženců.

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# A NEW POINT MUTATION IN EXON 17 OF THE HORSE (*EQUUS CABALLUS*) *RYR1* GENE (Short Communication)

## NOVÁ BODOVÁ MUTACE V EXONU 17 GENU *RYR1* KONÍ (*EQUUS CABALLUS*) (Krátké sdělení)

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**ABSTRACT:** The polymerase chain reaction-single strand conformation polymorphism (PCR-SSCP), and sequencing analysis were used for the study of the ryanodine receptor gene (*RYR1*) of Wielkopolska horses, Thoroughbred, and Pure Arabian. PCR-amplified *RYR1* gene specific fragments were cloned in pGem5 Zf(-) plasmid. Double stranded templates were sequenced by the Sanger dideoxy chain termination method, using Cy-5' labeled primers. The analyzed region of the *RYR1* gene was characterized by a high homology (97.3–98.7%) between all breeds. We detected transversion G→T and as a consequence a substitution of alanine for serine. We did not detect any 1843C→T mutation in the equine *RYR1* gene.

**Keywords:** equine genetics; *RYR1* gene; stress susceptibility

**ABSTRAKT:** Ke sledování genu-receptoru ryanodinu (*RYR1*) u koní plemene Velkopolské, u plnokrevných a čisto-krevných arabských koní jsme použili polymorfismus polymerázové řetězové reakce a jednopramenné konformace (PCR-SSCP), a dále sekvenční analýzu. V plasmidu pGem5 Zf(-) jsme provedli klonování genově specifických fragmentů *RYR1* amplifikovaných pomocí PCR. Sekvencování dvoupramenných šablon proběhlo pomocí Sangerovy metody dideoxy řetězové terminace s použitím Cy-5' značených primerů. Analyzovanou oblast genu *RYR1* charakterizoval u všech plemen vysoký stupeň homologie (97,3–98,7 %). Byla zjištěna transverze G→T, a jako její důsledek substituce alaninu za serin. Mutaci 1843C→T jsme v genu *RYR1* koní nezjistili.

**Klíčová slova:** genetika koní; gen *RYR1*; náchylnost ke stressu

## INTRODUCTION

Contemporary horse breeds are kept for various recreational uses, and exceptional individuals are trained and used in sports. It is necessary for these horses to train intensively in order to participate in high rank competitions. Moreover, taking part in the competition is in itself very stressful for the animals. In practice, deaths of horses are observed not only during the competition but also during transport or veterinary procedures. Anaesthetic-induced malignant hyperthermia (MH) was described in dogs (Short and Paddleford, 1973), cats (De Jong *et al.*, 1974), birds (Henschel, Louw, 1978), wild animals during capture (Harthoorn *et al.*; 1974, Harthoorn, 1975), and horses (Klein, 1975) in the seventies.

The aim of our paper was to investigate the DNA polymorphism of the ryanodine receptor gene, exon 17 among

three equus species. To achieve the aim of our research, it was necessary to select a proper method to obtain a DNA fragment containing the polymorphous region of exon 17 of the *RYR1* gene, and subsequently the molecular and genetic characteristics of these fragments, using PCR-SSCP, PCR-RFLP and sequence analysis methods.

## MATERIAL AND METHODS

The research was performed on genomic DNA of Wielkopolska horses ( $n = 20$ ), Thoroughbred ( $n = 30$ ), Pure Arabian ( $n = 22$ ) isolated from 10 ml of peripheral blood lymphocytes according to the salt out procedure described by Miller *et al.* (1988). Approximately 0.1  $\mu$ g of DNA were subjected to 30 cycles of PCR as described by Fujii *et al.* (1991). For non-radioactive PCR-SSCP

analysis the PCR products were denatured to a single-strand state by mixing a 4 µl aliquot of the product with 6 µl of formamide stop solution and separated in 10% polyacrylamide gel 20 × 20 cm (49 : 1 acrylamide: bis), 5% glycerol, 20 °C, 0.5 × TBE, 70 V, 12 h.

PCR-amplified *RYR1* gene specific fragments were cloned in pGem5 Zf(-) plasmid. Plasmid DNA was purified using Wizard™ columns (Promega). Double stranded templates were sequenced by the Sanger dideoxy chain termination method (Sanger *et al.*, 1979), using the following Cy-5' labeled primers:

– universal primer – 5'-Cy5-d[CGACGTTGTAAACGACGCCAGT]  
 – reverse primer – 5'-Cy5-d[CAGGAAACAGCTATGAC]

according to Cy5™ AutoRed™ Sequencing Kit protocol. Sequencing products were analyzed with the ALF-express™ sequencing system (Pharmacia Bioech).

## RESULTS AND DISCUSSION

The initial aim of our research was to confirm the homology of ryanodine receptor gene in horses and swine. The first step in our investigation was to observe whether primers synthesized on the basis of the cDNA sequence in the porcine *RYR1* gene which would make the amplification of the analogous sequence in the horse possible. The electrophoresis of PCR products indicated the occurrence of a *RYR1* gene fragment of the same size both in the horse and in the pig. We expected to find possibly a mutation analogous to 1843C→T in swine. Therefore, we used the PCR-RFLP analysis with the application of *HinPI* restrictase. However, we did not observe a typical digestion of the PCR product within the G↓CGC locus distinguishable for the *HinPI* enzyme, as is found in the case of 1843 C→T mutation in swine.

Screening for single nucleotide changes in the *RYR1* gene of the individuals was carried out using SSCP method (Orita *et al.*, 1989). In SSCP analysis performed for the *RYR1* gene an additional SSCP pattern was observed in one individual of Wielkopolska horse. There are some techniques of detection of point mutations, however, the only direct nucleotide sequence analysis gives 100% precision of results. The results obtained using various PCR-SSCP variants were finally verified by sequence analysis with the ALFexpress™ DNA Sequencer. It made it possible to establish the nucleotide sequence in the investigated fragment of the *RYR1* gene.

The exon 17 sequence in the horse ryanodine receptor gene in Wielkopolska breed horses differs from that given by Ishida *et al.* (1996), who analyzed exon 17 of the *RYR1* gene in six equus species. We did not phenotype animals for MH, and the main focus was put on the sequence of exon 17 of the ryanodine receptor gene. In our study we found the G→T transversion (Fig. 1) and resulting from it the substitution of alanine by serine. It seems improbable the substitution of neutral amino acid (alanine) with basic amino acid (serine) could result in a change in locus conformation of the active ryanodine receptor in the horse. Moreover, we did not find a homozygous individual in reference to the G→T transversion. Clinical or phenotypic changes in the heterozygote in relation to a healthy heterozygote are, as could be expected, difficult to observe in this case. In swine mutated 1843C→T heterozygotes there is a significant change in the charge from arginine in MHN individuals to cysteine in MHS individuals. In consequence, Ca<sup>2+</sup> easily penetrates the defective calcium channel. However, it can not be ruled out that the substitution of neutral amino acid with amino acid of a basic residue in the site of the active receptor may also cause an undesirable reaction of the organism.

### Wielkopolska Horse

```
GT TCC CTG TGT GTG TGC AAT GGT GTG TCC GTG CGC TCC AAC
C S L C V C N G V S V R S N
CAA GAT CTC ATT ACT GAG AAC TTG CTC CCT GGC
Q D L I T E N L L P G
```

### Thoroughbred (Ishida *et al.* 1996)

1843

```
GT TCC CTG TGT GTG TGC AAT GGC GTG GCC GTG CGC TCC AAC
C S L C V C N G V A V R S N
CAA GAT CTC ATT ACC GAG AAC TTG CTC CCT GGC
Q D L I T E N L L P G
```

Fig. 1. A new polymorphism C1837T found in Wielkopolska horse. Nucleotide and amino acids deduced sequence alignment of *RYR1* gene in the region of nucleotide 1843 (restriction site recognized by *HinPI* – G↓CGC). The substitutions of the nucleotides or amino acids are underlined, and malignant hyperthermia mutation site is bolded.

The degree of homology between the investigated fragment of the *RYR1* gene in horses and swine is high and amounts to 98.7%.

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# DIGESTIBILITY OF NUTRIENTS, NITROGEN DEGRADABILITY AND INTESTINAL DIGESTIBILITY OF RUMEN UNDEGRADED PROTEIN OF ALKALI-TREATED BARLEY

## STRAVITELNOST ŽIVIN, DEGRADOVATELNOST N-LÁTEK A INTESTINÁLNÍ STRAVITELNOST N-LÁTEK NEDEGRADOVANÝCH V BACHORU U LOUHOVANÉHO JEČMENE

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**ABSTRACT:** In this study, nutritive value of barley grain treated with sodium hydroxide and of barley meal were compared. In metabolic trials on wethers, dry matter digestibility of alkali-treated grain increased by 9.9% compared with ground barley (86.2% and 76.3 respectively), organic matter digestibility increased by 9.8% (87.6% and 77.8% respectively,  $P < 0.05$ ), nitrogen-free extract digestibility increased by 6.3% (93.0% and 86.7% respectively) and digestibility of energy increased by 9.4% (85.4 and 76.0% respectively). Nitrogen degradability of alkali-treated barley (65.7%) was 15.6% lower than that of barley meal (81.3%,  $P < 0.01$ ). Intestinal digestibility of rumen undegraded protein of alkali-treated barley (92.6%) was 18.8% higher ( $P < 0.01$ ) than that of barley meal (73.8%). The PDIN and PDIE levels calculated for alkali-treated barley were 76.1 g.kg<sup>-1</sup> dry matter (DM) and 108.1 g.kg<sup>-1</sup> DM, respectively, and 70.2 g.kg<sup>-1</sup> DM and 83.0 g.kg<sup>-1</sup> DM, respectively, in the case of barley meal. The NEL content was in alkali-treated barley (8.393 MJ kg<sup>-1</sup> DM) higher by 0.556 MJ than that in barley meal (7.837 MJ kg<sup>-1</sup> DM). The NEV content in alkali-treated barley (9.075 MJ kg<sup>-1</sup> DM) was higher by 0.788 MJ than that in barley meal (8.287 MJ kg<sup>-1</sup> DM).

**Keywords:** alkali-treated barley; digestibility; nitrogen degradability; intestinal digestibility; PDI; NEL

**ABSTRAKT:** V práci byla porovnána nutriční hodnota ječného zrna ošetřeného hydroxidem sodným s nutriční hodnotou ječného šrotu. V bilančním pokuse na skopcích byla stanovena u louhovaného ječmene oproti ječnému šrotu vyšší stravitelnost sušiny o 9,9 % (86,2 %, resp. 76,3 %), organické hmoty ( $P < 0,05$ ) o 9,8 % (87,6 %, resp. 77,8 %), BNLV o 6,3 % (93,0 %, resp. 86,7 %) a energie o 9,4 % (85,4 %, resp. 76,0 %). Efektivní degradovatelnost N-látek byla u louhovaného ječmene (65,7 %) nižší o 15,6 % ( $P < 0,01$ ), než u ječného šrotu (81,3 %). Intestinální stravitelnosti N-látek nedegradovaných v bacheru byla u louhovaného ječmene (92,6 %) vyšší o 18,8 % ( $P < 0,01$ ), než u ječného šrotu (73,8 %). Vypočítaný obsah jednotek PDIN a PDIE činil u louhovaného ječmene 76,1 g.kg<sup>-1</sup> sušiny, resp. 108,1 g.kg<sup>-1</sup> sušiny a u ječného šrotu 70,2 g.kg<sup>-1</sup> sušiny, resp. 83,0 g.kg<sup>-1</sup> sušiny. Obsah jednotek NEL byl u louhovaného ječmene (8,393 MJ kg<sup>-1</sup> sušiny) vyšší o 0,556 MJ, než v případě ječného šrotu (7,837 MJ kg<sup>-1</sup> sušiny). Obsah jednotek NEV byl u louhovaného ječmene (9,075 MJ kg<sup>-1</sup> sušiny) rovněž vyšší o 0,788 MJ, než v případě ječného šrotu (8,287 MJ kg<sup>-1</sup> sušiny).

**Klíčová slova:** louhovaný ječmen; stravitelnost; degradovatelnost N-látek; intestinální stravitelnost; PDI; NEL

## INTRODUCTION

Whole grains fed to ruminants are not sufficiently utilized in their digestive tract. To overcome this problem, grains are processed by a number of methods (physical, chemical, biological or combined), with the aim of increasing their nutritive value, digestibility and intake. The most common of these methods is grinding. The problem of this method is the small size of resulting par-

ticles which is responsible for rapid fermentation of nutrients (mainly starches) in the rumen. In high-yielding dairy cows, too high proportions of ground grain may disorder rumen functions, cause acidosis and lower digestibility of fibre.

In the 1970s, sodium hydroxide (NaOH) was used to increase the digestibility of straw and other fibrous materials. Ørskov and Greenhalgh (1977) described the use of caustic soda for the treatment of grain (sodagrains).

The NaOH treatment is suitable for the conservation of wet grain after harvest, but it can also be applied to dry grain if water is added. A chemical reaction takes place in the grain treated, and NaOH is changed to sodium bicarbonate (NaHCO<sub>3</sub>) while a certain amount of heat is generated. The grain swells, the surface husk of the grain breaks, and the endosperm becomes accessible for rumen micro-organisms and their enzymes (Barnes and Ørskov, 1982). It is the best to feed sodagrains in a total mixed ration (TMR) where its high alkalinity (pH 9–11) neutralizes the acidity of silage and stabilizes the rumen environment. As the process of digestion is slower in comparison with ground grains, it is possible to use higher rations of grain feed without disturbing the fermentation processes in the rumen. The nutrients are degraded to a lesser extent in the rumen and more of them are enzymatically digested in the small intestine. Its high pH protects sodagrains against contamination by micro-organisms and the growth of toxicogenic moulds. The alkali treatment protects grain against the proliferation of micro-organisms and moulds for six months at least (Ørskov *et al.*, 1979). The damage caused by rodents and birds is also minimized, because they do not like sodagrains feeds (Loučka *et al.*, 1994).

The aim of the present study was to calculate the digestibility of nutrients, nitrogen degradability and intestinal digestibility of rumen undegraded protein in alkali-treated grain in experiments with ruminants, and make a comparison with data from barley meal experiments. On the basis of the data ascertained, the nutrition value of feeds was expressed in PDI and NEL/NEV units.

## MATERIAL AND METHODS

### Feeds

Dry barley grain was used:

- treated with sodium hydroxide (3 kg NaOH per 100 kg barley) with water added. Thus the final dry matter content of the feed was 64.92%. Metabolic experiments started 3 months after NaOH application,
- ground grain.

Chemical composition and gross energy content of meal samples are given in Table 1.

### Digestibility of nutrients and energy

In order to determine the digestibility of dry matter, organic matter, nitrogen-free extract and energy in *in vivo* metabolic trials, three fattened merino rams weighing 83 ± 9 kg (for procedure, see Vencl, 1985) were

used. The differential method consisting of two experiments was used to determine the balances, i.e. the basic feed digestibility and the basic feed plus the tested feed (sodagrains or meal) digestibility experiments. To calculate the digestibility of the feed tested, the amount of digestible nutrients of the basic feed was subtracted.

### Nitrogen degradability

The nitrogen degradability experiments were performed using in sacco method in three dry cows (Black Pied) with a large ruminal cannulas (120 mm internal diameter). The cows were fed twice a day (at 6 a.m. and 4 p.m.) and their daily rations consisted of 4 kg lucerne hay, 10 kg maize silage and 1 kg barley meal with a vitamin and mineral supplement.

A Retsch cutting grinder with 8mm mesh was used to grind samples of alkali-treated barley at 64.92% original dry matter. This partially broke the grains and substituted for the animal's chewing. Feed prepared in this way was weighed at 2 g to 15 x 5 cm nylon bags of 42 µm pore size (Uhelon 130 T, Silk & Progress Moravská Chrastová). The barley meal was weighed directly, with no adjustments. The bags with the feed were attached to a cylindrical carrier (Třináctý *et al.*, 1996) and incubated in the rumen for 2, 4, 8, 16 or 24 hours. For each time period, 6 bags with tested feed were made, and each of the 3 cannulated cows had two of them placed in the rumen. When removed from the rumen, the bags were washed for 30 min in running water. The feed residues were placed onto filtration paper and dried for 24 hours at 50 °C. To calculate the effective degradability, the method of Ørskov and McDonald (1979) was used at the rumen fractional outflow rate (*k*) of 6%.h<sup>-1</sup>. No corrections for microbial contamination were made.

### Intestinal digestibility of rumen undegraded protein

The mobile bag technique (Frydrych, 1992; Homolka *et al.*, 1996) with dry cows fitted with the T-piece cannula in the proximal duodenum was used to ascertain intestinal digestibility. It consists of three steps:

- Feed incubation in the rumen of three cows to obtain undegraded feed residues. Samples of alkali-treated barley at 64.92% original dry matter were ground on an 8mm mesh Retsch cutting grinder. Barley meal samples were weighed directly without adjustments. The bags (15 x 5 cm, pore size 42 µm) with weighed feed were incubated in the rumen for 16 hours. The bags were then washed for 30 minutes in water and dried for 24 hours at 50 °C.

Table 1. Nutrients and energy contents of barley grain treated with sodium hydroxide (sodagrains) and of barley meal in absolute dry matter

Feed	Dry matter (g)	Crude protein (g)	Ether extract (g)	Crude fibre (g)	Nitrogen-free extract (g)	Organic matter (g)	Gross energy (MJ)
Alkali-treated barley	649.2	107.2	24.1	51.8	755.1	938.2	17.83
Ground barley	885.2	115.1	26.0	54.7	774.3	970.1	18.35

- 2) The residues of each feed were weighed to 22 nylon bags (4 × 4.6 cm, pore size 42 µm). The bags were sealed and incubated in a pepsin and 0.01 N hydrochloric acid solution for 2.5 hours at 39 °C.
- 3) The bags were placed into the duodenum of 3 cows with a simple duodenal T-cannula. The bags found within 24 hours in the faeces were washed in water and subsequently freeze-dried. Intestinal digestibility was calculated from the formula:

$$(A - B)/A \times 100,$$

where: A – amount of proteins (in dry matter) entering the intestine  
 B – protein residues (in dry matter) after passage through the intestine

### Chemical analyses and calculations of PDI and NEL/NEV

Dry matter and nutrients analyses were made in accordance with CSN 46 70 92 Standards. Nitrogen content was determined according to Kjeldahl. The PDIN, NEL and NEV values were calculated according to Sommer *et al.* (1994).

## RESULTS AND DISCUSSION

The changes in the chemical composition of barley after sodium hydroxide treatment are given in Table 1. The lower dry matter value is due to water added during leaching. The higher ash content is due to the addition of 3% NaOH, which also reduced the relative contents of other nutrients. Metabolic experiments with rams (Table 2) showed an increase of 9.9% in digestibility of the alkali-treated grain compared with ground barley (86.2% and 76.3% respectively), 9.8% increase in organic matter (87.6% and 77.8% respectively,  $P < 0.05$ ), 6.3% increase in nitrogen – free extracts (93.0% and 86.7% respectively) and 9.4% increase in energy (85.4 and 76.0% respectively). In experiments on lambs, Ørskov *et al.* (1981) reported a higher digestibility of dry matter and organic matter of alkali-treated barley (85.3% and 87.1% respectively) compared with whole grain barley (78.0% and 82.1% respectively). The reported sodagrain digestibility figures are in agreement with the results of our experiments. In experiments with bulls, Ørskov *et al.* (1980) demonstrated increased digestibility of dry matter of barley ( $P < 0.001$ ) with increasing concentrations of sodium hydroxide. They reported 83.3% dry matter digestibility after an application of 35 g NaOH per kg

Table 2. Digestibility coefficients of nutrients and energy of barley grain treated with sodium hydroxide (sodagrain) and of barley meal

Feed	Dry matter (%)	Organic matter (%)	Nitrogen-free extract (%)	Energy (%)
Alkali-treated barley	86.2	87.6	93.0	85.4
Ground barley	76.3	77.8	86.7	76.0
$P <$	0.1	0.05	0.1	0.1

grain, which is 2.94% less than the present calculated result. The use of alkali-treated grain slows down the process of nutrient digestion by rumen micro-organisms, and the proportion of nutrients that escape degradation in the rumen and pass on to the small intestine increases. From the energy point of view, digestion in the small intestine is more effective than rumen fermentation, because less energy is lost through the generation of methane and fermentation heat (Ørskov, 1986). Barley meal starch is 90% degraded in the rumen and only 10% of it passes on to the small intestine. The increase in the amount of starch passing on to the small intestine is however limited because starch digestion in the small intestine is also limited (Kreikemeier *et al.*, 1991).

The nitrogen effective degradability (Table 3) determined by the in sacco method in cannulated cows was 65.7% and 81.3% for alkali-treated barley and barley meal, respectively, i.e., a decrease in protein degradability in alkali-treated barley by 15.6% compared to barley meal ( $P < 0.01$ ). Because of the fine structure and large surface of meal particles, most of their nutrients are digested by the action of rumen micro-organisms. In the alkali-treated grain, on the other hand, only the grain husk is cracked, the digestion is slower and the proportion of nutrients passing on to the small intestine, where enzymatic digestion takes place, is higher. The lower degradability of sodagrain ensures that a higher proportion of proteins passes on to the small intestine. Compared with ground grains, alkali-treated grains are

Table 3. Protein degradability (DEG %) and intestinal digestibility of rumen undegraded protein (DSI %) in the feeds tested ( $n$  = number of assessments)

Feed	DEG (%)	$n$	DSI (%)	$n$
Alkali-treated barley	65.7	6	92.6	22
Ground barley	81.3	6	73.8	18
$P <$	0.01		0.01	

digested more slowly and maintain a higher pH level in the rumen (Ørskov *et al.*, 1978). Demeterová and Vajda (1998) reported a 35.4% decrease in digestibility of alkali-treated wheat (59.2%) after 24-hour incubation in the rumen compared with ground wheat. In their experiments with cows, O'Mara *et al.* (1997) calculated effective protein degradability (at the rumen fractional outflow rate 5%.h<sup>-1</sup>) 80.9% and 52.4% for wheat meal and sodagrain, respectively.

The intestinal digestibility of rumen undegraded protein determined by the mobile bag technique in cows with rumen and duodenal cannulas (Table 3) was 92.6% and 73.8% for alkali-treated barley and barley meal, respectively. The 18.8% difference between intestinal protein digestibility of alkali-treated barley and barley meal was significant ( $P < 0.01$ ). The higher intestinal digestibility of alkali-treated barley shows that the substances undegraded in the rumen were utilized in the small intestine.

The PDIN and PDIE levels (Table 4) in alkali-treated barley were 76.1 g.kg<sup>-1</sup> dry matter (DM) and 108.1 g.kg<sup>-1</sup> DM, respectively. Corresponding values for untreated barley and barley meal were 70.2 g.kg<sup>-1</sup> DM and 83.0 g.kg<sup>-1</sup> DM, respectively. In alkali-treated barley, the PDIN and PDIE levels were higher by 5.9 g.kg<sup>-1</sup> DM and 25.1 g.kg<sup>-1</sup> dry matter, respectively ( $P < 0.01$ ). By comparing PDIN values, which express the microbial proteosynthesis from degraded feed protein, and PDIE values, which express microbial proteosynthesis from available energy, we can find the balance between the requirements of micro-organisms and the intake of degradable protein (Homolka *et al.*, 1996). As sodagrain has a higher PDIE value, it is a feed with lower degradability, suitable for

Table 4. Contents of PDIN, PDIE, NEL and NEV in absolute dry matter

Feed	PDIN (g)	PDIE (G)	NEL (MJ)	NEV (MJ)
Alkali-treated barley	76.1	108.1	8.393	9.075
Ground barley	70.2	83.0	7.837	8.287
$P <$	0.01	0.01	-	0.1

high-yielding animals. This allows us to use sodagrain in rations with feeds of higher degradability.

The NEL content was higher by 0.556 MJ in alkali-treated barley (8.393 MJ kg<sup>-1</sup> DM) than in barley meal (7.837 MJ kg<sup>-1</sup> DM). The NEV content was higher by 0.788 MJ in alkali-treated barley (9.075 MJ kg<sup>-1</sup> DM) than in barley meal (8.287 MJ kg<sup>-1</sup> DM).

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# DIGESTIBILITY AND GROWTH PERFORMANCE OF GROWING-FINISHING PIGS FED DIETS WITH DIFFERENTLY GROUND OR EXPANDED BARLEY

## STRAVITELNOST ŽIVIN A RŮST PRASAT VE VÝKRMU DOSTÁVAJÍCÍCH RŮZNĚ UPRAVENÝ NEBO EXPANDOVANÝ JEČMEN

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**ABSTRACT:** Nutritive value of diets containing barley grain either milled using different methods or expanded was assessed in an experiment on 24 growing pigs (30–92 kg BW). Four diets were applied: MH – with middle hammer milled barley (1 070 µm), FH – with fine hammer milled barley (640 µm), R – with rolled barley (2 000 µm) and HE – with fine hammer milled and expanded barley. Barley constituted 74% of grower diets and 80.5% of finisher diets. Digestibility of nutrients and energy value of diets were assessed, together with the balance of nitrogen, daily gains and feed conversion. The largest differences in digestibility were found between FH diet with fine hammer milled barley and R diet with rolled barley. Digestibility of crude protein and ether extract in FH diet was significantly higher ( $P < 0.01$ ) than the respective digestibility in R diet. Gross energy digestibility in FH diet was also higher compared with R diet, but the difference was not significant. The expanding of barley did not improve the digestibility of nutrients. Neither the sizes of particles (MH vs. FH) nor the grinding method (R vs. MH and FH) had a significant effect on daily gains of pigs (676–707 g) and feed conversion (3.34–3.50 kg/kg), similarly like grain expanding.

**Keywords:** pig; barley; grinding method; digestibility; growth performance

**ABSTRAKT:** V pokuse s 24 výkrmovými prasaty (30 až 92 kg živé hmotnosti) jsme hodnotili nutriční hodnotu krmných dávek, které obsahovaly ječmen buď mletý různým způsobem, nebo expandovaný. Použili jsme čtyři typy krmných dávek: MH – ječmen mletý ve středních kladivkách (1 070 µm), FH – ječmen mletý ve jemných kladivkách (640 µm), R – ječmen vločky (2 000 µm) a HE – ječmen mletý jemnými kladivkami a expandovaný. Ječmen tvořil 74 % krmné dávky podávané prasatům ve vlastním výkrmu a 80,5 % krmné dávky podávané prasatům v konečné fázi výkrmu. Spolu s bilancí dusíku, denními přírůstky zvířat a konverzí krmiva jsme hodnotili stravitelnost živin a energetickou hodnotu krmiv. Největší rozdíly ve stravitelnosti jsme zjistili mezi krmnou dávkou FH obsahující ječmen mletý jemnými kladivkami a krmnou dávkou R s ječnými vločkami. Stravitelnost dusíkatých látek a éterového extraktu v krmné dávce FH byla významně vyšší ( $P < 0,01$ ) než obdobná stravitelnost krmné dávky R. Stravitelnost brutto energie krmné dávky FH byla ve srovnání s krmnou dávkou R rovněž vyšší, ale rozdíl nebyl významný. Expandovaný ječmen nezlepšil stravitelnost živin. Velikost částic (MH versus FH), ani způsob mletí (R versus MH a FH) neovlivnily významně denní přírůstky prasat (676 až 707 g) a konverzi krmiva (3,34 až 3,50 kg/kg).

**Klíčová slova:** prase; ječmen; způsob mletí; stravitelnost; růst

## INTRODUCTION

With the contribution reaching 70–80% of dietary dry matter grains are a staple fodder in feeding of pigs that are fed on milled or prepared grain. Grinding methods, size of particles as well as preparation methods can dif-

fer. Grain is usually milled in hammer mills, which produce meal of finer or coarser particles and varied granulometric composition. It has been proved that the use of very fine milled grain improves the digestibility of nutrients (Wünsche *et al.*, 1987; Henning *et al.*, 1991) and diminishes the amount of nitrogen excreted to the environment

(Wondra *et al.*, 1995). The influence of the size of particles of milled grain (or diet) on daily gains and feed conversion is less obvious. In their research Henning *et al.* (1991) and Mavromichalis *et al.* (1998) found out that pigs receiving fine milled feed had significantly higher daily gains and better feed conversion than pigs fed on coarse milled feed. In other research (Laurinen *et al.*, 2000) no significant differences were observed as regards daily gains and feed conversion in grower-finisher pigs fed on feed mixtures containing fine or coarse milled barley.

In spite of their better digestibility and nutritive value, fine milled feeds have a negative effect on the digestive tract of pigs as they are associated with a higher incidence of parakeratosis and ulcers in the oesophageal part of stomach (Wondra *et al.*, 1995). This is one of the reasons why roller crushers are becoming a more and more popular machine for grinding grains. Another reason is lower electrical energy consumption. Rolled grain causes fewer pathological changes in the stomach as it contains only small amounts of dusty particles (Lawrence *et al.*, 1980). Digestibility of nutrients and nutritive value of rolled grain in swine feeding depend on how well the grain has been rolled. Nutritive values of well rolled or fine milled grain are comparable (Laurinen *et al.*, 2000).

Attempts are made to improve the nutritive value of grain fed to pigs by grain expanding. The results reported by Nási (1992) seem to suggest that the effect of grain expanding on digestibility of nutrients and net energy content in barley grain fed to grower-finisher pigs is small.

The aim of the experiment was to assess the influence of milled, rolled or expanded barley grain fed to growing-finishing pigs on digestibility of nutrients, nitrogen balance and daily weight gains and feed conversion.

## MATERIAL AND METHODS

Twenty-four castrated male pigs, six in each group, were fed on four diets (complete ration) containing barley grain prepared by different methods: middle hammer milled – 6 mm sieve (MH group), fine hammer milled – 2.5 mm sieve (FH group), rolled in a roller crusher with smooth rolls and a 0.8 mm slot (R group), fine hammer milled – 3.0 mm sieve and expanded (HE group). Barley was expanded in an Amandus Kahl expander at 85–100 °C.

The nutritive value of the diets (Table 1) was balanced according to the Nutrient Requirements of Pigs (1993). Barley constituted 74% of the grower diet (30–67 kg BW) and 80.5% in the finisher diet (67–92 kg BW). The pigs were maintained in individual metabolic cages and were fed twice daily on mash diets, mixed with water (feed : water 1 : 1), feeding level ranged from 1.6 to 2.9 kg. While the pigs were on grower diets, the nitrogen balance and nutrient and energy digestibility were determined (at average body weight 56.5 kg), by the balance method. Faeces and urine collections were carried out for 6 days. Of the faeces excreted daily mean samples for every pig were taken (10%) and put to a freezer.

Table 1. Composition of grower (30–67 kg) and finisher (67–92 kg) diets and their nutritive value

Specification	Diets	
	grower	finisher
	MH, FH, R, HE*	MH, FH, R, HE*
Formulation of diet (g/kg)		
Barley	739.6	804.7
Soybean meal	130.0	70.0
Rapeseed meal	100.0	100.0
Limestone	12.0	14.0
Dicalcium phosphate	7.0	7.0
Sodium chloride	3.0	3.0
Premix PT-1/PT-2	7.0	7.0
L-lysine (78%)	1.4	1.4
Nutritive value (g/kg)		
Crude protein	167.0	148.0
Lysine <sup>1</sup>	8.9	7.5
Methionine <sup>1</sup>	2.7	2.7
Tryptophan <sup>1</sup>	1.9	1.7
Ca <sup>1</sup>	7.5	6.9
P digestible <sup>1</sup>	2.6	1.8
ME, MJ/kg	12.1	12.1

\*diets with barley: middle hammer milled (MH), fine hammer milled (FH), rolled (R), fine hammer milled and expanded (HE)

<sup>1</sup>value calculated according to Nutrient Requirement of Pigs (1993)

At the termination of the six-day collection period all the samples were defrosted, homogenised and sets of two samples were subsequently taken. After drying one set of samples (at 60 °C), the content of dry matter, crude ash, ether extract, crude fibre and gross energy was determined. The other set of samples (fresh ones) was used to determine the content of nitrogen. Sulphuric acid was used for the preservation of urine stored in containers. Three per cent of daily urine amounts was sampled in order to determine the content of nitrogen.

Nutrients in the feeds, faeces and N in urine were determined according to the conventional methods. Energy content in the feeds and in dried faeces was determined in an adiabatic bomb calorimeter. Content of neutral detergent fibre (NDF) and acid detergent fibre (ADF) in barley grain was determined according to the method by Van Soest and Wine using a Fibertec apparatus. Starch gelatinisation in expanded barley was determined according to the method of Tsuge *et al.* (1990). Particle size distribution and geometric mean of ground barley were determined according to the Polish Norm (PN 84/R-64798).

The results were analysed statistically by a one-factor analysis of variance and Duncan's multiple range test.

## RESULTS AND DISCUSSION

Geometric means of ground barley particle size was significantly varied: 1 070, 640 and 2 000 µm for MH, FH

and R barley, respectively (Table 2). The parameters of FH barley corresponded to the parameters of properly ground feedstuffs for pigs (Kirchgeßner *et al.*, 1985); only 22% of particles did not pass through a sieve with 1020 µm square mesh. The expanding of ground barley posed a technical difficulty. Water steam was applied to overcome this problem, so that starch gelatinisation reached 26.8% (Table 3). Expanded grain, compared to the grain prior to expanding, contained slightly more ether extract (2.34% vs. 1.85%) and NDF (17.19% vs. 15.63%), while the content of the other nutrients remained nearly unchanged.

The use of fine hammer milled barley in grower pig diet had no significant effect on the digestibility of nutrients (Table 4). However, FH diet had a slightly higher digestibility of crude protein (79.1% vs. 77.0%) and ether extract (50.1% vs. 44.7%) compared to MH diet. An in-

crease in the digestibility of nutrients in diets composed of fine ground grain was also observed by Wünsche *et al.* (1987), Wondra *et al.* (1995) and Ayles *et al.* (1999).

Table 2. Particle size distribution of hammer milled and rolled barley (%)

Particle size (µm)	Middle hammer milled (MH)	Fine hammer milled (FH)	Rolled R
4 000–5 000	0.0	0.0	7.5
3 000–4 000	5.1	0.0	13.7
2 000–3 000	11.8	3.0	43.9
1 020–2 000	37.3	19.3	21.1
430–1 020	33.0	50.8	9.5
< 430	12.8	26.9	4.3
Geometric mean of particle size	1 070	640	2 000

Table 3. Chemical composition of barley grain and grower and finisher diets (% air dry basis)

Ingredient	Barley		Grower diet				Finisher diet			
	ground	expanded	MH <sup>1</sup>	FH	R	HE	MH	FH	R	HE
Dry matter	86.21	85.62	87.54	87.62	87.59	86.96	88.16	88.14	88.14	88.03
Ash	2.00	2.04	4.71	4.81	4.74	4.78	4.32	4.38	4.30	4.44
Crude protein	10.64	10.67	16.51	16.70	16.74	16.55	15.07	14.84	14.74	14.60
Ether extract	1.85	2.34	2.01	2.00	1.98	2.49	1.86	1.94	1.86	2.46
Crude fibre	3.62	3.72	4.69	4.62	4.62	4.65	4.50	4.48	4.46	4.50
ADF <sup>2</sup>	3.84	3.88								
NDF <sup>3</sup>	15.63	17.19								
DF <sup>4</sup>	17.38	17.36								
Gross energy	15.02	15.14	16.34	16.27	16.28	16.28	15.65	15.54	15.56	15.65
Starch gelatinisation (%)	3.7	26.8								

<sup>1</sup>explantation below Table 1; <sup>2</sup>acid detergent fibre; <sup>3</sup>neutral detergent fibre; <sup>4</sup>dietary fibre

Table 4. Digestibility coefficients of nutrients of grower diets and nitrogen balance results

Indices	Group				SE
	MH <sup>1</sup>	FH	R	HE	
Number of animals	5	5	5	5	
Digestibility coefficients (%)					
Crude protein	77.0 ± 1.57 <sup>ab</sup>	79.1 ± 1.24 <sup>aa</sup>	75.1 ± 2.89 <sup>bb</sup>	75.3 ± 1.99 <sup>b</sup>	0.36
Ether extract	44.7 ± 9.42 <sup>A</sup>	50.1 ± 6.23 <sup>A</sup>	29.0 ± 6.06 <sup>B</sup>	49.0 ± 6.43 <sup>A</sup>	1.32
Crude fibre	35.0 ± 2.53	34.9 ± 4.97	31.3 ± 1.36	32.4 ± 3.82	0.48
N-free extract	89.3 ± 2.00	89.1 ± 1.17	89.5 ± 0.75	88.6 ± 0.52	0.21
Gross energy	80.4 ± 1.77	81.0 ± 1.15	79.5 ± 1.50	79.5 ± 0.42	0.23
Digestible crude protein (g/kg diet)	127	132	126	125	
Metabolizable energy (MJ/kg diet <sup>2</sup> )	12.35	12.45	12.17	12.15	
Daily N balance					
Intake (g)	60.7	61.4	61.6	61.3	
Retained (g)	21.4 ± 3.37	23.0 ± 2.66	21.8 ± 3.99	21.4 ± 2.31	0.58
Retained/intake (%)	35.3 ± 5.58	37.5 ± 4.34	35.4 ± 6.41	34.9 ± 3.75	0.94

<sup>1</sup>explanation below Table 1; <sup>2</sup>calculated from digestible nutrients; SE standard error of mean

Means in a row with different superscripts are significantly different : a, b -  $P < 0.05$ ; A, B -  $P < 0.01$

As confirmed by the results reported hereby, application of fine ground grain typically leads to an improved digestibility of crude protein rather than that of dry matter or gross energy (Wondra *et al.*, 1995; Ayles *et al.*, 1999).

The largest differences in digestibility were observed between R and FH grower diets. Digestibility of crude protein and ether extract of R diet was significantly worse ( $P < 0.01$ ) and digestibility of gross energy was insignificantly worse versus FH diet. As a result of lower digestibility of several nutrients in R diet the amount of metabolizable energy (computed from digestible nutrients) was by 0.3 MJ/kg lower than in FH diet. The lower digestibility of R diet nutrients may be attributed to the insufficient grinding of grain. In research of Laurinen *et al.* (2000) the digestibility of crude protein diets with barley ground by three different roller mills ranged from 71.1% to 79.0%, depending on the mill type and a slot between the rolls of the roller.

The expanding of barley did not improve the digestibility of nutrients. Except ether extract, HE diet nutrients were digested in a similar way like the nutrients of R diet. Näsi (1992) did not find any positive effect of barley grain expanding on digestibility of nutrients either.

Retained nitrogen and retained/intake nitrogen showed no significant differences between the groups fed diets with barley prepared by the four methods (Table 4).

Neither degree of grinding (MH v. FH groups) nor the grinding method (R vs. MH and FH groups) or barley grain expanding had a statistically significant effect on daily gains and feed conversion (Table 5). In the whole growth period (30–92 kg) the largest differences, albeit not significant, were observed in daily gains between FH group (fed on fine hammer milled barley) and R group (given rolled barley). Daily weight gains in R group were

38 g lower in the grower period and 31 g lower in the grower-finisher period compared to the respective daily gains in FH group. In the grower-finisher period, R group consumed 0.16 kg more feed per 1 kg of weight gain than FH group ( $P > 0.05$ ). The results of Henning *et al.* (1991) and Ayles *et al.* (1999) seem to suggest a positive influence of fine hammer milled feed for pigs on daily gains and feed conversion. No such relationship was confirmed by Ohh *et al.* (1983) and Laurinen *et al.* (2000). Giesemann *et al.* (1990) and Skomial *et al.* (1992) reported that the use of rolled grain might cause a slight decrease in daily gains of pigs, which seems to find confirmation in our study.

Feed conversion and daily gains in pigs fed on diet with expanded barley resembled the results achieved in pigs receiving milled or rolled barley. Van de Ginste and de Schrijver (1998) also concluded that the expanding of starter, grower and finisher diets with barley (57–50%), wheat, cassava and soybean meal did not significantly affect feed consumption, daily gains or feed conversion of starting, growing or finishing pigs.

Percentage of meat in carcass (46.3–47.3%) did not differ statistically significantly between the groups (Table 5).

In conclusion, it can be suggested that the application of differently ground (middle hammer milled, fine hammer milled, rolled) or fine hammer milled and expanded barley grain in complete rations slightly influenced feeding results. Statistically significant differences were observed only in terms of the digestibility of crude protein and ether extract between grower diets with fine hammer milled barley (higher digestibility) and rolled barley (lower digestibility). Daily gain (676–707 g) and feed conversion in the whole growth period were slightly influenced by

Table 5. Growth performance of growing and finishing pigs

Indices	Groups				SE
	MH <sup>1</sup>	FH	R	HE	
Number of animals	6	6	6	6	
Initial body weight (kg)	30.8 ± 3.18	30.3 ± 2.65	29.5 ± 2.58	29.5 ± 3.12	0.51
Final body weight (kg)	93.2 ± 2.80	94.0 ± 5.36	90.3 ± 3.02	91.1 ± 3.64	0.66
Days of feeding	90	90	90	90	
Average daily gains (g)					
30–67 kg	674 ± 68.9	682 ± 74.9	644 ± 59.7	665 ± 21.7	10.47
67–92 kg	723 ± 49.8	750 ± 62.4	727 ± 38.0	718 ± 34.9	8.44
30–92 kg	693 ± 49.0	707 ± 68.2	676 ± 36.3	684 ± 15.9	7.88
Feed/gain ratio (kg/kg)					
30–67 kg	3.20 ± 0.34	3.13 ± 0.31	3.34 ± 0.30	3.17 ± 0.07	0.05
67–92 kg	3.80 ± 0.28	3.67 ± 0.31	3.76 ± 0.18	3.80 ± 0.21	0.04
30–92 kg	3.42 ± 0.24	3.34 ± 0.30	3.50 ± 0.18	3.42 ± 0.08	0.04
Dressing percentage (%)	76.6 ± 2.32	76.3 ± 1.72	77.2 ± 1.98	77.3 ± 2.52	0.38
Proportion of meat in carcass (%)	46.3 ± 4.06	46.6 ± 5.02	46.3 ± 4.40	47.3 ± 1.39	0.69

<sup>1</sup>explanation below Table I; SE standard error of mean

fineness of grinding (640 vs. 1 070  $\mu\text{m}$ ), mill type or expanding barley applied in pig grower and finisher diets at an amount of 74% and 80.5%, respectively.

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# APPARENT DIGESTIBILITY OF FAT AND NITROGEN RETENTION IN YOUNG CHICKS<sup>1</sup>

## BILANČNÍ STRAVITELNOST TUKU A RETENCE DUSÍKU U MLADÝCH KUŘAT

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**ABSTRACT:** Apparent fat digestibility and nitrogen retention were examined in broilers and laying type cockerels within the first 15 days of life. Differences between birds with and without deutectomy were studied as well. In chicks without deutectomy, there was a rapid decrease in fat digestibility from Day 2 to Day 6 and from Day 3 to Day 7 in broiler and egg type hybrids, respectively. This drop was followed by an increase till Day 14. Observed changes may be connected with excretion of endogenous nutrients originating primarily from the yolk sac. In deutectomized chicks, fat digestibility increased within the period of Days 2 to 14. The utilisation of nitrogen in broilers was highly significantly ( $P < 0.001$ ) higher than in egg type chicks. The dependence of coefficients of apparent nitrogen retention on the age of chicks could be expressed by means of parabola equations with the maximum values on Days 12–13. The amount of N retained in the organism per unit of weight gain increased with the increasing age.

**Keywords:** young cockerels; deutectomy; digestibility of fat; nitrogen retention

**ABSTRAKT:** U kohoutků masného a nosného typu jsme v prvních 15 dnech života sledovali bilanční stravitelnost tuku a bilanční retenci dusíku. Zjišťovali jsme také rozdíly mezi deutektomovanými kuřaty a kohoutky s ponecháním žloutkovými vaky. U intaktních kuřat brojlerového typu klesala stravitelnost tuku od 2. do 6. dne a u kuřat nosného typu od 3. do 7. dne věku. Pokles byl následován vzestupem do 14. dne. Pozorované změny mohou být spojovány s vylučováním endogenních živin původně pocházejících ze žloutkového vaku. U deutektomovaných kuřat se stravitelnost tuku zvyšovala od 2. do 14. dne věku. Využití dusíku bylo u brojlerů vysoce průkazně ( $P < 0,001$ ) vyšší než u kuřat nosného typu. Závislost koeficientů bilanční retence dusíku na věku kuřat lze vyjádřit rovnicí paraboly s maximem ve 12. až 13. dni života. Množství dusíku uloženého v organismu na jednotku přírůstku se s přibývajícím věkem zvyšuje.

**Klíčová slova:** mladá kuřata; deutektomie; stravitelnost tuku; retence dusíku

### INTRODUCTION

About 90% of the energy requirement of the developing chick is supplied by yolk lipids (Romanoff, 1960). For the uptake of yolk nutrients, an organ or structure is necessary. Such a structure, the yolk sac membrane (YSM), takes a position of primary importance with regard to lipid metabolism, being responsible for the uptake of lipids from the yolk and the subsequent transfer of these lipids to the body of the embryo (Noble and Cocchi, 1990). This membrane is essentially an extension of the embryo's small intestine and is connected with it. Its inner surface is histologically similar to intestinal epithelium and has the same absorptive function (Holdsworth and Wilson, 1967). A network of capillaries adjacent to

the basal surface of the endodermal layer feeds into the major vitelline veins which enter the portal system of the embryo via the yolk stalk which connects the YSM to the body of the embryo (Noble and Cocchi, 1990). Current evidence indicates that yolk lipids are taken up by the apical surface of the YSM endodermal cells, subjected to hydrolysis, re-esterification and co-assembly with apoproteins, and subsequently secreted in the form of very low density lipoprotein particles from the basal surface of the endoderm for delivery into embryonic circulation (Speake *et al.*, 1998). The newly synthesised triglycerides, phospholipids and cholesterol esters are used to assemble small lipoproteins which are delivered to the embryonic liver through the vitelline portal veins. The cholesterol esters accumulate mainly in the liver, where

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they account for 80 per cent of hepatic lipid and 30 per cent of its dry matter (Klasing, 1998). The YSM preferentially absorbs yolk lipids over protein, so the yolk that remains at hatching is enriched with protein (Romanoff, 1960).

Following hatching, part of the remaining yolk is absorbed by the YSM in a similar manner like in the embryo. Also, some remnant yolk material is expelled through the yolk stalk into the small intestine during the process of retraction of the yolk into the peritoneal cavity during hatching (Klasing, 1998). As Freeman and Vince (1974) report, the withdrawing begins from the 19th day of incubation. In this connection, yellowish or greenish material resembling the yolk sac's content was found in the intestine on the last three days of incubation by Haller (ex Romanoff, 1960). Part of the yolk sac's contents was also found in the caeca in the study of Zelenka and Jilek (1970). Yolk contents that reach the proximal small intestine by antiperistaltic movements are hydrolysed and probably absorbed, whereas those which remain in the ileum and caecum were not hydrolysed and therefore not utilised by the hatching bird and are thus excreted. The higher endogenous losses depress digestibility values. This may explain the low apparent digestibility values for fatty acids in very young birds (Noy and Sklan, 1998).

The rate of passage of digesta increases with age post-hatch. This is accompanied by a dramatic increase in secretion of pancreatic enzymes and activity of brush-border enzymes (Klasing, 1998). According to Katongole and March (1980), the digestibility of dietary lipids during the first week posthatch is low due to limiting rates of bile-salt production. Another reason could be a lag in the developmental increase in pancreatic lipase secretion (Klasing, 1998). Chicks hatch with some reserves of trypsin, amylase and lipase which were accumulated in the pancreas during embryonic development (Nir *et al.*, 1993). The synthesis of these enzymes is limited during early age and therefore, although total activities (relative to body weight) in the pancreas increase from the first day after hatching, specific activities (units/g pancreas) decrease during 3 to 6 days after hatching (Nitsan, 1995). Later on, as synthesis of enzymes matures, there is a rapid increase in the specific activity of all enzymes (Nir *et al.*, 1993). In the pancreas, maximal values are attained on Day 8 for amylase and lipase and Day 11 for trypsin and chymotrypsin (Nitsan *et al.*, 1991a). So the limited syntheses of digestive enzymes in the pancreas during early growth and their increase to maximum values around Day 10, when relative growth rate is maximal, indicate a possible association between these two traits (Nitsan *et al.*, 1991a). In a study by Noy and Sklan (1995) net duodenal secretion of trypsin and lipase was low on Day 4 and increased 50- and 20-fold, respectively, by Day 21.

In an experiment by Zelenka and Jilek (1970), the yolk sacs of chicks were weighed and their energy content was determined immediately after expiration of the 17th, 18th, 19th, and 20th day of incubation and at the end of incubation (20 days and  $18.4 \pm 0.3$  hours). The

average weight and energy content of the yolk sac were 14.5 g and 234 kJ, 12.9 g and 211 kJ, 12.2 g and 197 kJ, 10.7 g and 164 kJ, 7.9 g and 126 kJ, 90, 66, 42 and 18 hours before hatching and at the time of hatching, respectively. On the energy content basis, 90 hours before hatching energy content of yolk sac decreased by 10 per cent till 66 hours before hatching and by 46 per cent till the moment of hatching. In the experiment by Holmes *et al.* (1936), the content of fat was 3 818 mg on Day 18 of incubation. If it is assumed that this value represented 90 per cent of yolk sac fat content at the end of 17th day of life the total content of fat was 4 242 mg at this moment. Six hours after hatching the content of fat in yolk sac was 2 009 mg, so the drop was 53 per cent.

A significant amount of the yolk sac fat is stored in the liver (Zelenka and Jilek, 1970). Total liver lipids were found to decrease from 19% at hatching to 8.8% by Day 2 (Nitsan *et al.*, 1991a). A part of these lipids can be excreted by means of bile into the intestine. Zelenka and Jilek (1970) determined concentration of chromic oxide in dry matter of the digestive tract contents in fed chicks for the period from 3rd to 7th day of life; in all cases the established values were lower than those in dry matter of the feed mixture.

Changes in nitrogen deposition in the organism of growing chicks were studied by Mitchell *et al.* as early as 1926. They found an increasing nitrogen percentage in gains with increasing live body weights. Moss *et al.* (1968) determined nitrogen content in the skeletal muscles in the chicks at the age of 0, 4, 8, 16 and 32 days. Till Day 8, the content of nitrogen increased very quickly and thereafter this increase was slower. In a study by Murakami (1992), carcass protein content increased gradually from 12 to 18 per cent at hatch and 15 days of age, respectively, and was not affected by deutectomy.

This study compares fat digestibility and nitrogen retention in broilers and egg type chicks with substantially different growth rate and in chicks with and without deutectomy during the first 15 days of postembryonal life.

## MATERIAL AND METHODS

Effects of age on the apparent digestibility of fat and on the apparent nitrogen retention were investigated within successive one-day balance periods using 95 intact and 87 deutectomized male chicks of hybrid combination Isa Brown and 52 intact Ross 208 cockerels during the growth period till the 15th day of age. Yolk sacs were surgically removed immediately after hatch, which was defined as the time when birds completely cleared the shell. Observations of Isa Brown chicks were made from the time of hatching and those of Ross 208 from one day of age.

Chicks were kept in balance cages. The initial environmental temperature 35 °C was decreased daily by 0.7 °C. Continuous artificial lighting was used. All chicks were fed a not pelletized starter diet containing 225 g crude

protein (i.e. 36 g N), 36.6 g crude fat and 12.06 MJ nitrogen-corrected metabolisable energy per kg during the whole experimental period (Table 1). The feed was supplied *ad libitum* and its consumption was recorded. Parameters under study were estimated using the chromic oxide indicator method. The content of chromic oxide in feed and freeze-dried excreta was estimated iodometrically

Table 1. Formulation of the diet

Ingredient	(g/kg)
Maize meal	510
Wheat meal	120.5
Soybean meal	260
Meat-and-bone meal	60
Fish meal	30
Dicalcium phosphate	7
Ground limestone	5
Sodium chloride	1.5
DL-methionine	2
Premix of feed additives <sup>1)</sup>	4

<sup>1)</sup>The premix supplied the following (mg/kg diet): Cu 9.6; Zn 19.2; Fe 35.2; Mn 64; Co 0.096; Se 0.128; I 0.72; retinyl acetate 4.13; cholecalciferol 0.06; DL- $\alpha$ -tocopherol acetate 32; menadione 0.8; thiamine 2.4; riboflavin 4.8; pyridoxine 4; cyanocobalamine 0.0272; biotin 0.112; niacin amide 24; folic acid 1.12; pantothenic acid 8.8; L-lysine.HCl 1152; sodium monensinate 80

(Mandel *et al.*, 1960), nitrogen was determined according to Kjeldahl and crude fat gravimetrically after extraction with diethyl ether under the reflux for 6 hours. When estimating fat digestibility, urinary fat was not taken into consideration (Mehring *et al.*, 1961). The body weight of the chicks was estimated daily at the end of each balance period. The contents of nitrogen in the live body gain (mg/g) were calculated from feed intake, contents of N in the diet, coefficients of its utilisation and body weight gain in the following day. The regression analysis of determined values was performed according to Snedecor and Cochran (1967).

Table 2. Intake and excretion of fat and nitrogen

Age of chicks in days	Fat in mg						Nitrogen in mg					
	intake			excretion			intake			excretion		
	Isa Brown		Ross 208	Isa Brown		Ross 208	Isa Brown		Ross 208	Isa Brown		Ross 208
	YS+	YS-	YS+	YS+	YS-	YS+	YS+	YS-	YS+	YS+	YS-	YS+
1	2.0	0.8	-	3.8	4.2	-	1.9	0.8	-	34.2	23.1	-
2	24.7	14.9	97.5	2.9	5.2	10.6	24.4	14.7	96.1	48.8	25.7	63.4
3	83.0	63.5	295.0	8.5	13.4	44.9	81.8	62.6	290.7	89.9	52.4	153.9
4	135.5	96.3	402.0	23.0	23.8	95.0	133.5	94.9	396.2	109.3	68.8	200.2

YS+ chicks with yolk sacs  
YS- deutectomized chicks

## RESULTS AND DISCUSSION

Surgically removed yolk sac contained 448 mg of fat and 228 mg of nitrogen.

In the first two days of postembryonal life, the body weight of Isa Brown decreased while that of Ross 208 increased on the second day. Live body weights on Day 15 of age were 120, 151 and 417 g in Isa Brown with and without deutectomy and in Ross 208 chicks, respectively.

In Isa Brown chicks, 3.8 mg and 4.2 mg of fat were found in the excreta while the intake of fat from feed mixture was only 2.0 and 0.8 mg in intact and deutectomized chicks on the first day after hatching, respectively. Also on the 2nd, 3rd and 4th day of life the fat content in excreta was higher in deutectomized (5.2, 13.4, 23.8 mg, resp.) than in normal chicks (2.9, 8.5 and 23.0 mg, resp.) in spite of substantially higher feed intake in the latter (Table 2).

The coefficients of apparent digestibility of fat were lower in chicks with deutectomy than in chicks with yolk sacs not only on the above days but till Day 6 of age. We do not know the reason of this phenomenon but the same observation was made also in the experiment of Murakami *et al.* (1992). In their study, digestibility of fat in chicks with removed residual yolk was lower till the 5th day of age (Fig. 1); the differences on Day 2 and Day 3 were significant ( $P < 0.05$ ). In the following three days, i.e. till Day 9 in our experiment and till Day 8 in experiment by Murakami *et al.* (1992), the digestibility of fat was much higher in deutectomized than in intact chicks.

In the experiment by Carew *et al.* (1972) with chicks on the low fat diet, fat excretion was 10 times higher than its intake during the early age period of 2 to 7 days and twice as high as the intake during the following period of Day 8 to 15. The amount of total fat excreted during the first week of life attributable to endogenous sources would appear to be about 0.2 g.

In Fig. 2, data are presented about apparent digestibility of fat found out in chicks without deutectomy in our present study and in two trials by Zelenka (1973) using White Plymouth Rock chickens fed mixture containing either 29 g (Zelenka 73/1) or 33 g of fat per 1 kg of dry

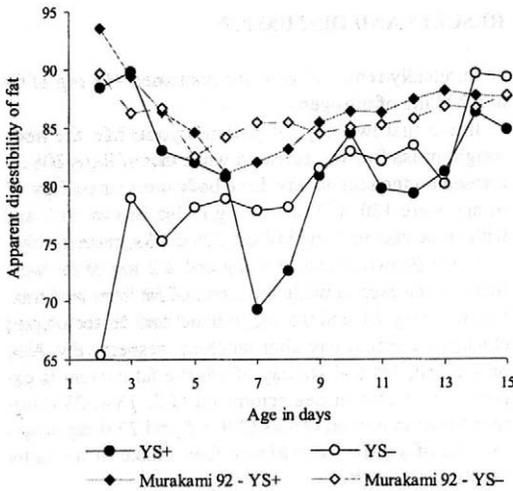


Fig. 1. Fat digestibility in chicks with (YS+) and without (YS-) yolk sac

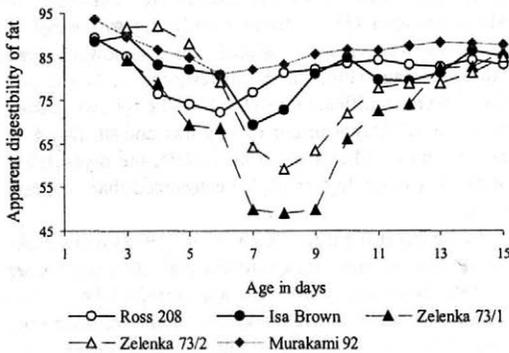


Fig. 2. Fat digestibility

matter (Zelenka 73/2) and in a study with Arbor Acres chicks by Murakami *et al.* (1992). In our present experiment, apparent digestibility of fat in intact Isa Brown chicks rapidly decreased from 90 to 69 per cent on Day 3 and Day 7, respectively, while in intact Ross 208 cockerels from 89 to 72 per cent on Day 2 and Day 6, respectively. In Experiments 1 and 2 by Zelenka (1973) the rapid decrease observed at the beginning came to a standstill between Day 7 and 9 and on Day 8, respectively. Murakami *et al.* (1992) observed a similar decrease with the minimum on Day 6. This drop was followed by an increase till Day 13 (Murakami *et al.*, 1992), Day 14 (Isa Brown and Ross 208 in our experiment) and Day 15 (Zelenka, 1973). In chicks with removed residual yolk (Fig. 1), apparent digestibility increased within the period from Day 2 to Day 14 in our experiment with Isa Brown chicks and within the period from Day 6 to Day 15 in the experiment by Murakami *et al.* (1992). Polin and Hussein

(1982) found that in the first week of age chicks digested 62–67 per cent of the dietary fat whereas in the second more than 82 per cent of fat consumed were digested.

Significant changes in values of apparent digestibility can hardly be associated with those of true digestibility. Changes in the activity of esterase originating from the small intestine (Laws and Moore, 1963; Nir *et al.*, 1993) showed a considerably different course than those observed in our experiments. Based on observations by Noy and Sklan (1999), who registered that the intestinal absorption of labeled exogenous fatty acids was more than 80 per cent at hatching and that it slightly increased till Day 4 as well as on results by Zelenka and Jilek (1970), who found a lower concentration of chromic oxide in dry matter of digesta from Day 3 to Day 7 than in dry matter of feed mixture, it is possible to explain changes observed in these experiments more probably on the basis of increased excretion of endogenous nutrients originating primarily from the yolk sac. When accepting such an explanation, it seems to be probable that these surplus nutrients are transiently deposited in other sites of chick organism and that they are eliminated only slowly, i. e. step by step, within the period of the first two weeks; this was indicated also by the fact that the yolk sac was resorbed rather quickly because it contained only 1/7 and 1/30 of the initial content of energy two and four days after hatching, respectively (Zelenka and Jilek, 1970).

Consumption of nitrogen in Isa Brown cockerels was lower than the content of this element in excreta within the first two or three days after hatching in chicks with or without deutectomy, respectively. In contrast to the situation with fat excretion, the content of nitrogen in droppings of deutectomized chicks was lower than that in intact birds (Table 2). In experiment by Zelenka and Jilek (1970), chicks without deutectomy obtained from their yolk sacs by 132 mg more nitrogen than chicks with yolk sac surgically removed. The average nitrogen contents of the yolk sac were 491 and 359 mg 90 hours before hatching and at the moment of hatching, respectively. Intake of nitrogen in Ross 208 chicks was higher than the excreted amount from the beginning of our observation on Day 2. An average apparent utilisation of nitrogen in broilers was highly significantly ( $P < 0.001$ ) higher ( $53.7 \pm 0.95$  per cent; mean  $\pm$  standard error of the mean) than in egg type chicks ( $35.1 \pm 4.33$  per cent). This difference can be associated with enzyme activities. In an experiment by Nitsan *et al.* (1991b), chicks selected for high body weight showed higher enzymatic activities in their intestinal contents than the line with low body weight. Nevertheless these results did not fit with those of Nir *et al.* (1993). In this experiment the intestinal contents of meat type chicks exhibited lower activities of trypsin and chymotrypsin than that of egg type chicks.

The dependence of coefficients of apparent nitrogen retention ( $Y$ ) on the age of chicks in days ( $X$ ) within the period of Day 3 to Day 15 (Fig. 3) could be expressed by means of the 2nd degree parabola equations:

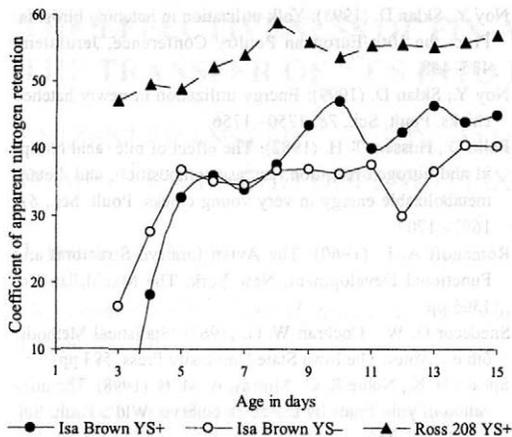


Fig. 3. Nitrogen retention

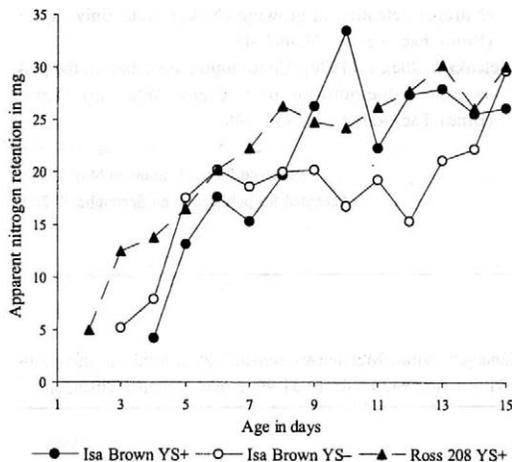


Fig. 4. Nitrogen retention per 1 g of body gain

for Isa Brown chicks without deutectomy

$$Y = -33.3 + 14.07X - 0.612049X^2; I_{YX} = 0.914; P < 0.01; \text{maximum } X = 11.5, Y = 47.5,$$

for Isa Brown chicks with deutectomy

$$Y = 11.9 + 4.45X - 0.186129X^2; I_{YX} = 0.754; P > 0.05; \text{maximum } X = 11.9, Y = 38.5,$$

and for Ross 208 chicks without deutectomy

$$Y = 40.2 + 2.68X - 0.110794X^2; I_{YX} = 0.877; P < 0.05; \text{maximum } X = 12.1, Y = 56.3.$$

Similarly, in experiments by Zelenka (1976), percentages of retained nitrogen from N-consumed increased

from hatching approximately to the end of the 2nd week of age.

In the present experiment, the highest increase in coefficients of apparent retention of nitrogen was observed till Days 8, 10 and 5 in Ross 208, intact Isa Brown and deutectomized Isa Brown, respectively. Polin and Hussein (1982) reported an increase in relative retention of nitrogen from Week 1 to Week 3 of age. These data do not support the findings of Mahagna *et al.* (1995), who determined nitrogen retention at the age of one and two weeks. They registered a significant ( $P < 0.05$ ) decrease in followed values with the increasing age.

With the increasing age the amount of N retained in the organism per 1 g of weight gain increased. The most marked increase was observed within the first 10, 8 and 6 days after hatching in Isa Brown with yolk sacs, Ross 208 and deutectomized Isa Brown, respectively (Fig. 4). Similar results were obtained in experiments by Moss *et al.* (1968) in skeletal muscles, by Zelenka (1976) in the whole body gain and by Murakami *et al.* (1992) in carcass where the highest increase was observed till the Day 8, 9 and 3, respectively.

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# THE EFFECTIVENESS OF FIX-A-TOX IN REDUCING THE TRANSFER OF $^{137}\text{Cs}$ INTO BROILER CHICKEN MEAT

## SNÍŽENÍ TRANSFERU $^{137}\text{Cs}$ DO MASA KUŘECÍCH BROJLERŮ POMOCÍ KRMNÉHO DOPLŇKU FIX-A-TOX

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**ABSTRACT:** The effect of FIX-A-TOX (F-A-T, dried colloid silicic acid with addition of clay minerals) on radiocaesium ( $^{137}\text{Cs}$ ) uptake into meat was tested in broiler chickens. F-A-T, which was added to the feed mixture at a dosage of 0.1% of feed mixture, decreased the radiocaesium uptake into meat only slightly, but significantly ( $P < 0.05$ ). Reduction factors ( $^{137}\text{Cs}$  transfer without F-A-T compared to that observed after inclusion of the additive into the feed mixture) of 1.17–1.33 and 1.00–1.18, respectively, were achieved after single and repeated administrations of artificially contaminated feed. F-A-T as a supplement during the decontamination period decreased the biological half-life of  $^{137}\text{Cs}$  mostly by about 5 hours. Independent on the effect of F-A-T, the uptake and also the decontamination of radiocaesium were faster in thigh than in breast meat.

**Keywords:**  $^{137}\text{Cs}$ ; Cs-binders; broiler chicken; countermeasure; animal nutrition

**ABSTRAKT:** Byl testován vliv krmného doplňku FIX-A-TOX (F-A-T, vysušená koloidní kyselina křemičitá s přísadkou jílových minerálů) na příjem radiocesia ( $^{137}\text{Cs}$ ) do masa brojlerových kuřat. F-A-T, přidávaný do krmné směsi v dávce 0,1%, snížil akumulaci radiocesia svalovinou nohou a prsní svalovinou pouze mírně, ale statisticky významně ( $P < 0,05$ ). Redukční faktory (poměr transferu  $^{137}\text{Cs}$  bez přísadky F-A-T ku transferu po přidání F-A-T do krmiva) dosáhly hodnot 1,17 až 1,33 po jednorázové aplikaci a 1,00 až 1,18 po opakovaném podávání kontaminovaného krmiva. F-A-T aplikovaný během dekontaminační fáze snížil biologický poločas radiocesia nejvíce o 5 hodin. Nezávisle na působení aditiva příjem radiocesia a také dekontaminace byly rychlejší u svaloviny nohou ve srovnání s prsní svalovinou.

**Klíčová slova:**  $^{137}\text{Cs}$ ; absorbent radiocesia; brojlerová kuřata; výživa zvířat

### INTRODUCTION

The accident in the Chernobyl nuclear power plant contaminated a vast area of Europe with radionuclides, among them radiocaesium ( $^{137}\text{Cs}$ ). The half-life of radiocaesium is relatively long (30 years) and due to its chemical properties it can migrate in the food chain very easily, presenting a potential danger for man.

The fallout resulted in high levels of radiocaesium mainly in pasture grass and other forage (Bertilsson *et al.*, 1988). In some areas, a higher accumulation of  $^{137}\text{Cs}$ , up to 300–600 Bq.kg<sup>-1</sup>, was also monitored in grain (Lantbruksstyrelsen, 1987). Therefore, the uptake of radiocaesium and its reduction were studied in farm animals, including broiler chickens.

Chemical methods belong to the most effective and cost-effective countermeasures which are useful in limit-

ing radionuclide uptake and accumulation in farm animals. The effectiveness of clay minerals in reducing radiocaesium concentrations in various farm animals (goat, lamb, sheep, cow, pig and chicken) and their products (milk, meat) was reported by many authors during 1969–1990, reviewed by Voigt (1993). The reduction factor of the different clays in the animals varied from 1.2 to 14 when they received an addition of tens to hundreds of grams of the clays based on the respective animal species.

After the Chernobyl accident interest was focused on the use of hexacyanoferrate derivatives which showed the highest effectiveness in the prevention of radiocaesium uptake in comparison with other additives (Giese, 1988). Many authors (e.g. Lindner *et al.*, 1987; Pearce *et al.*, 1989; Daburon *et al.*, 1991; Voigt *et al.*, 1989, 1993) confirmed that the advantage for most farm animals (sheep,

cow, pig, hen) was that hexacyanoferrates were highly effective binders (reduction factors 1.7–33) which could be fed in low quantities (2–10 g.d<sup>-1</sup>).

The prevention of radiocaesium uptake was also studied in poultry because it accumulates a high fraction of ingested <sup>137</sup>Cs per kg meat compared with other farm animals (Andersson *et al.*, 1990). Voigt *et al.* (1993) quantified the reducing effect of the feed additive ammonium-ferric-cyano-ferrate (at concentrations of 0.66 g.kg<sup>-1</sup> and 1.33 g.kg<sup>-1</sup> of feed mixture) on the contamination of broiler chicken meat by factors of more than 6. The reduction factors reached as much as 44 and 100 for eggs and breast meat of hens, respectively. Vitorovic *et al.* (1997) observed a 60–70 % reduction of the radiocaesium uptake in 6-week-old broiler chickens when zeolite (clinoptilolite) or AFCF (ammonium-ferric-cyano-ferrate) was added to the diet, while Fe-ascorbate reduced the uptake by only 20–40%.

Pöschl and Balás (1999) determined the influence of RADEKONT (a natural clinoptilolite modified by 2% of hexacyanoferrate) on radiocaesium transfer after single or repeated applications of artificially contaminated feed mixtures and also investigated the effect of the additive when feeding a mixture containing wheat contaminated by the Chernobyl fallout. Reduction factors (<sup>137</sup>Cs transfer without the RADEKONT additive compared to that observed after inclusion of the additive into the feed mixture) of 1.1–1.3 and 1.2–2.3 respectively, were achieved after single and repeated administrations of artificially contaminated feed. No significant differences in the reduction effect between breast and thigh meat were observed. RADEKONT was more effective when chickens were fed the Chernobyl-contaminated wheat (reduction factors of up to 3.7) than when the feed mixture was artificially contaminated with <sup>137</sup>Cs. The addition of RADEKONT during the decontamination period decreased the biological half-life of <sup>137</sup>Cs to less than 1 day.

The Czech market offers FIX-A-TOX (a preparation supplied by the firm AN Brno s.r.o., Czech Republic, and produced by Werfft-Chemie Gesellschaft m.b.H., Austria), a feed additive suitable for farm animals due to its very good absorption capacity (Werther and Herzig, 1996). It is particularly effective when eliminating mycotoxins. The composition of this preparation suggests that it could bind radiocaesium, limiting its retention. The objective of the present study was to find the effectivity of FIX-A-TOX (hereinafter F-A-T) for the reduction of <sup>137</sup>Cs uptake into the breast and thigh meat of broiler chickens.

## MATERIAL AND METHODS

### Experiments

Two experiments were carried out with broiler chickens (hybrid combination Ross 208). The principles of labo-

ratory animal care (the current version of the Czech Law on the Protection of Animals) were applied. All the animals tested were kept in metabolic cages under environmental conditions in terms of light, temperature, and space, consistent with the standard required for broiler chicken breeding in Europe (Standards of the Ministry of Agriculture of the Czech Republic consistent with EU). The broiler chickens received a standard feed mixture containing 430 g of wheat, 300 g of maize, 160 g of soybean meal, 60 g of meat and bone meal, 20 g of fish meal, 10 g of vegetable oil, and 20 g of mineral and vitamin premix in 1 kg. The feed was provided *ad libitum* twice a day (7:00 and 17:00 h).

The influence of F-A-T (containing 73% of dried colloidal silicic acid, 12% of kaolinite, 8% of sepiolite, 7% of steatite) was tested by adding F-A-T to the diet at a dosage of 0.1% of the weight of the feed mixture.

Artificially contaminated feed was prepared by mixing aqueous <sup>137</sup>Cs as caesium chloride (Amersham) with the feed mixture at a 3 : 1 weight ratio. The feed was administered into the crop perorally using a special applicator.

In experiment 1, a single artificially contaminated oral dose of 2.57 kBq of <sup>137</sup>Cs (activity concentration 0.826 kBq.g<sup>-1</sup>) was administered to 30 14-day-old chickens (live weight 520 ± 27 g). Immediately after the <sup>137</sup>Cs application, F-A-T was fed to 15 chickens, the other 15 chickens were fed without the binder. The <sup>137</sup>Cs activity concentration in meat was observed for 66 hours. Five animals of both groups of chickens were slaughtered at 18, 42 and 66 hours after radiocaesium application and samples of breast and thigh meat were prepared for <sup>137</sup>Cs determination.

In experiment 2, artificially contaminated oral doses of 268 Bq of <sup>137</sup>Cs (activity concentration 86.5 Bq.g<sup>-1</sup>) were administered to 70 14-day-old chickens (live weight 475 ± 20 g) twice a day (at 8:00 and 20:00 h) and the administration continued the following 10 days. Feeding of F-A-T started in 35 chickens (experimental animals) immediately after the application of the first dose of <sup>137</sup>Cs. The remaining 35 chickens (intact animals) were fed mixtures without F-A-T. The accumulation of <sup>137</sup>Cs was observed in 20 experimental and 20 intact animals for 11 days. When the administration of <sup>137</sup>Cs was finished, the decontamination process was examined in the remaining 15 experimental and 15 intact animals for 10 days. From both the experimental and intact animals, five chickens were slaughtered 1, 4, 7, 11, 12, 14 and 21 days after the first application of <sup>137</sup>Cs and samples of breast and thigh meat were prepared for <sup>137</sup>Cs determination.

In addition, 4 chickens of each experiment were kept as controls to monitor the <sup>137</sup>Cs background level. In the 1<sup>st</sup> experiment two animals were slaughtered 24 hours after <sup>137</sup>Cs application and two animals after 66 hours. In the 2<sup>nd</sup> experiment the animals were slaughtered 11 days and 21 days after the first application of <sup>137</sup>Cs.

## Sampling and radiometry

All breast muscles (breast meat) and all thigh muscles (thigh meat) were prepared for  $^{137}\text{Cs}$  determination. Samples of homogenized and weighed breast or thigh meat were counted in Marinelli beakers until the statistical counting errors were < 3%. Gamma-spectrometric measurements were performed with a pure germanium detector (25% efficiency, typical energy resolution 2.0 keV) of 61 mm length and 51 mm diameter. The spectra were evaluated with the canberra S-100 hardware-software system. Energy and efficiencies were calibrated with the national standard (Decree of the COSMT) prepared by the Czech Metrological Institute (Prague).

## Transfer parameters and reduction factors

For the single dose experiment 1, the transfer of radiocaesium from feed into chicken meat was expressed as a relative activity concentration ( $\text{TV} \cdot \text{kg}^{-1}$ ), i.e. the ratio of the  $^{137}\text{Cs}$  activity concentration in meat ( $\text{Bq} \cdot \text{kg}^{-1}$ ) to the  $^{137}\text{Cs}$  activity administered as a single dose (Bq). For the multiple dose experiment 2, the transfer was quantified as the transfer coefficients ( $F_f$ ,  $\text{d} \cdot \text{kg}^{-1}$ ), defined as the activity concentration in meat ( $\text{Bq} \cdot \text{kg}^{-1}$ ) divided by the daily activity intake ( $\text{Bq} \cdot \text{d}^{-1}$ ) at equilibrium.

Reduction factors were calculated as the ratio of the  $^{137}\text{Cs}$  transfer values listed above without F-A-T to that with F-A-T.

## Biological half-lives and statistical analyses

Biological half-lives were derived from time-dependent  $^{137}\text{Cs}$  activity concentrations using a method published earlier (Pöschl et al., 1997). The results were analysed using the UNISTAT statistical package (UNISTAT 4.53d, 1984-1998).

## RESULTS

### Live weights and feed intake

Live weights, feed intake and feed conversion in the experiments were consistent with standards for fattening chickens and no significant difference was recorded in these factors with and without F-A-T application. The composition of feed mixtures was similar in both experiments.

### Experiment 1

The maximal  $^{137}\text{Cs}$  activity concentrations in both breast and thigh meat were observed 18 hours after radiocaesium application. Then the  $^{137}\text{Cs}$  concentrations decreased rapidly ( $P < 0.05$ , Figs. 1 and 2) with the bio-

logical half-lives ( $T_{1/2b}$ , calculated from means of  $^{137}\text{Cs}$  activity concentrations) 55 and 47.5 hours in breast and thigh meat, respectively. The TV for  $^{137}\text{Cs}$  in meat (Table 1)

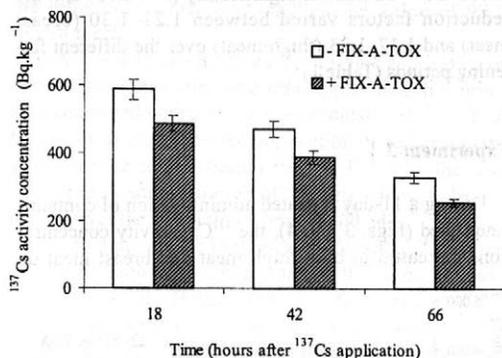


Fig. 1. Effect of FIX-A-TOX addition to the feed on accumulation and loss phases of  $^{137}\text{Cs}$  activity concentration in breast meat after a single dose of  $^{137}\text{Cs}$  in 14-day-old broiler chickens (bars represent SEM)

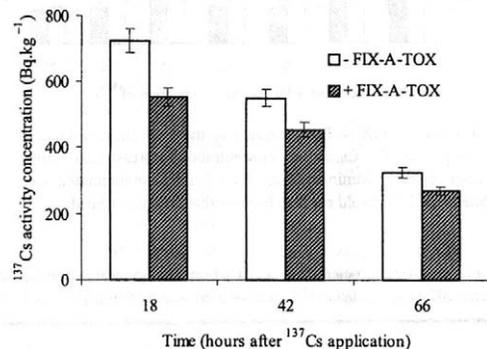


Fig. 2. Effect of FIX-A-TOX addition to the feed on accumulation and loss phases of  $^{137}\text{Cs}$  activity concentration in thigh meat after a single dose of  $^{137}\text{Cs}$  in 14-day-old broiler chickens (bars represent SEM)

Table 1. Transfer values (TV, a relative activity concentration) of a single oral administration of  $^{137}\text{Cs}$  from feed to meat and reduction factors in broiler chicken meat after treatment with F-A-T (mean  $\pm$  SEM)

	Duration after $^{137}\text{Cs}$ administration (h)		
	0-18	0-42	0-66
<b>Breast meat</b>			
Transfer values (kg)			
- F-A-T	0.23 $\pm$ 0.02	0.18 $\pm$ 0.02	0.13 $\pm$ 0.01
+ F-A-T	0.19 $\pm$ 0.01	0.19 $\pm$ 0.01	0.10 $\pm$ 0.01
Reduction factor	1.21 $\pm$ 0.05	1.20 $\pm$ 0.04	1.30 $\pm$ 0.06
<b>Thigh meat</b>			
Transfer values (kg)			
- F-A-T	0.28 $\pm$ 0.02	0.21 $\pm$ 0.01	0.13 $\pm$ 0.01
+ F-A-T	0.21 $\pm$ 0.01	0.18 $\pm$ 0.02	0.10 $\pm$ 0.01
Reduction factor	1.33 $\pm$ 0.06	1.17 $\pm$ 0.03	1.30 $\pm$ 0.03

reached 0.13–0.28 kg<sup>-1</sup> without F-A-T and 0.10–0.21 kg<sup>-1</sup> with the additive. TV was higher ( $P < 0.05$ ) in thigh meat than in breast meat up to the 42<sup>nd</sup> hour. F-A-T reduced the <sup>137</sup>Cs transfer significantly ( $P < 0.05$ ) and the reduction factors varied between 1.21–1.30 (breast meat) and 1.17–1.33 (thigh meat) over the different fattening periods (Table 1).

## Experiment 2

During a 11-day repeated administration of contaminated feed (Figs. 3 and 4), the <sup>137</sup>Cs activity concentrations increased in both thigh meat and breast meat up

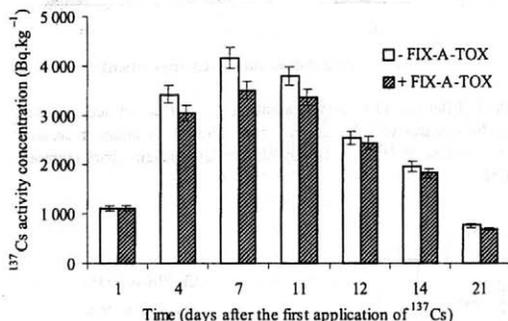


Fig. 3. Effect of FIX-A-TOX addition to the feed on accumulation and loss phases of <sup>137</sup>Cs activity concentration in breast meat during and after repeated administration of artificially contaminated feed mixture to 14-24-day-old broiler chickens (bars represent SEM)

to the 7<sup>th</sup> day after the first <sup>137</sup>Cs application, and the concentrations decreased insignificantly on the 11<sup>th</sup> day. Starting on the 12<sup>th</sup> d the concentration in breast and thigh meat decreased rapidly ( $P < 0.01$ ) with  $T_{1/2b}$  3.9 and 3.6 days, respectively. The  $F_f$  values were 2.08–6.32 d.kg<sup>-1</sup> and 2.78–7.24 d.kg<sup>-1</sup> in breast meat and thigh meat, respectively. The transfer was higher ( $P < 0.05$ ) into breast meat than into thigh meat up to the 4<sup>th</sup> day after the first application of radiocaesium and, on the contrary, lower ( $P < 0.05$ ) during the following days of the experiment. The transfer was markedly higher ( $P < 0.01$ ) than in experiment 1, i.e. the transfer after single administration of <sup>137</sup>Cs. F-A-T decreased the transfer of <sup>137</sup>Cs from feed to both breast and thigh meat significantly ( $P < 0.05$ ) but only 4 days

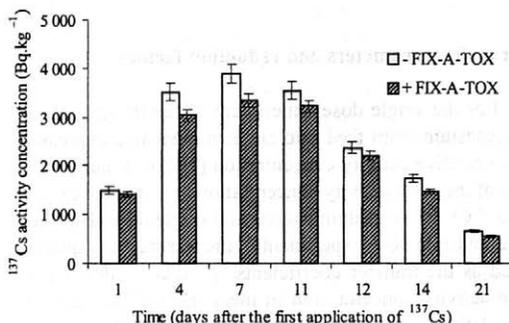


Fig. 4. Effect of FIX-A-TOX addition to the feed on accumulation and loss phases of <sup>137</sup>Cs activity concentration in thigh meat during and after repeated administration of artificially contaminated feed mixture to 14-24-day-old broiler chickens (bars represent SEM)

Table 2. Transfer coefficients ( $F_f$ ) of <sup>137</sup>Cs from feed to meat and reduction factors in broiler chicken meat after treatment with FIX-A-TOX (F-A-T) (mean  $\pm$  SEM) (Cumulative <sup>137</sup>Cs intake increased by 536 Bq for each day of the 11-day period)

	Duration after <sup>137</sup> Cs administration (hours)			
	0–1	0–4	0–7	0–11
<b>Breast meat</b>				
Transfer coefficient (d.kg <sup>-1</sup> )				
- F-A-T	2.08 $\pm$ 0.08	6.37 $\pm$ 0.25	7.73 $\pm$ 0.36	6.32 $\pm$ 0.22
+ F-A-T	2.09 $\pm$ 0.09	5.67 $\pm$ 0.14	6.53 $\pm$ 0.19	5.71 $\pm$ 0.24
Reduction factor	1.00 $\pm$ 0.03	1.12 $\pm$ 0.03	1.18 $\pm$ 0.06	1.11 $\pm$ 0.03
<b>Thigh meat</b>				
Transfer coefficient (d.kg <sup>-1</sup> )				
- F-A-T	2.78 $\pm$ 0.10	6.55 $\pm$ 0.31	7.24 $\pm$ 0.30	5.86 $\pm$ 0.14
+ F-A-T	2.64 $\pm$ 0.06	5.67 $\pm$ 0.18	6.21 $\pm$ 0.28	5.45 $\pm$ 0.21
Reduction factor	1.05 $\pm$ 0.04	1.16 $\pm$ 0.05	1.17 $\pm$ 0.03	1.08 $\pm$ 0.04

Table 3. Biological half-lives of <sup>137</sup>Cs in meat of broiler chickens from the elimination phase of each experiment after treatment with and without FIX-A-TOX (F-A-T)

Experiment	Biological half-life			
	breast meat		thigh meat	
	- F-A-T	+ F-A-T	- F-A-T	+ F-A-T
1	55 h	50 h	47.5 h	47.0 h
2	3.9 d	3.9 d	3.6 d	3.4 d

and 7 days after the first application of radiocaesium. The reduction factors varied from 1.0 to 1.18 in breast meat and from 1.05 to 1.17 in thigh meat over the different fattening periods (Table 2). The differences between breast and thigh meat, in terms of radiocaesium transfer, did not affect the reduction effect of F-A-T.

In experiments 1 and 2, the F-A-T additive decreased the biological half-lives of radiocaesium in meat mostly by 5 hours (Table 3).

## DISCUSSION

The published results of the effect of the application of both clay minerals and hexacyanoferrates have shown a reduction in radiocaesium transfer from feed to animal products. After the administration of different clays the reduction factors in meat of various farm animals varied from 1.2 to 8 when fed high amounts of the clays (review by Voigt, 1993). Hexacyanoferrate derivatives, however, were found to be more effective as higher reduction factors were achieved with much lower doses (2–10 g d<sup>-1</sup>).

In the present study, the reduction effect of F-A-T (an absorbent composed of natural clean clay minerals) on radiocaesium in broiler chicken meat was tested. The absorbent decreased the uptake of <sup>137</sup>Cs into broiler chicken meat significantly ( $P < 0.05$ ) after single and repeated administration of contaminated feed. Reduction factors of 1.17–1.33 and 1.00–1.18, respectively, were achieved for single and multiple administrations of <sup>137</sup>Cs in the accumulation period.

The dynamics of <sup>137</sup>Cs time-dependent activity concentrations both in breast and thigh meat after a single administration of <sup>137</sup>Cs was in accordance with earlier results (Pöschl *et al.*, 1997; Pöschl and Baláš, 1999). The activity concentrations rapidly increased in the first hours after the administration and quickly decreased when radiocaesium application was stopped. The 17–33% F-A-T-based reduction of <sup>137</sup>Cs uptake into the meat (reduction factors 1.17–1.33) can be compared with the effect of RADEKONT (reduction factors 1.10–1.35, Pöschl and Baláš, 1999) and the effect of Fe-ascorbate (the 14.1% decrease 7 hours after introducing contamination) described by Vitorovic *et al.* (1997).

The transfer of radiocaesium from the feed into the meat of broiler chickens after long-term administration is comparable with the results published by Andersson *et al.* (1990), Voigt *et al.* (1993) and Pöschl *et al.* (1997). The dynamics of activity concentrations copies the typical theoretical curve for contamination and decontamination of meat (Hove, 1993) and is also similar to the characteristic decrease in the values in the decontamination period.

It is not clear why the activity concentration on the 11<sup>th</sup> day decreases, but it may be connected with tissue turnover rates or radical changes in the digestion process and metabolism of the broiler chicken (e.g. Tyleček *et al.*, 1963; Zelenka, 1973), the result being a considerable increase in the meat, typical of these animals. This is probably why the reduction effect of F-A-T (particularly in thigh meat, i.e. 1.08) is lower on the 11<sup>th</sup> day after the beginning of radiocaesium application than on the 4<sup>th</sup> and the 7<sup>th</sup> day. After long-term administrations of <sup>137</sup>Cs the radiocaesium uptake was lower when F-A-T was used (reduction factors 1.08–1.18) than when RADEKONT was added to the feed (reduction factors 1.25–1.54) in our earlier experiments (Pöschl a Baláš, 1999). The effect of F-A-T comes close to the effect of clay minerals, e.g. in chickens (Andersson *et al.*, 1990) and pigs (Mirna, 1970;

Giese, 1989), but is markedly lower than the effect of hexacyanoferrate derivatives in farm animals (reviewed by Voigt, 1993), especially in hens (Voigt *et al.*, 1993) where the reduction coefficient reached the value of 99.5 (breast meat).

F-A-T was more effective after a single application of radiocaesium than after long-term application. It is probably connected with a much higher transfer of <sup>137</sup>Cs from feed to meat after repeated application of radiocaesium. Therefore the administration rates of F-A-T in the case of long-term administration of <sup>137</sup>Cs may have to be enhanced over the currently recommended ones.

The finding that the biological half-lives of <sup>137</sup>Cs were shorter in thigh meat corresponds with our earlier conclusions (Pöschl a Baláš, 1999). The fact that F-A-T decreased the half-lives by only 5 hours suggested that this additive probably affected the excretion of radiocaesium from the body insignificantly.

The previously published differences in radiocaesium transfer into the different types of skeletal muscles (Ekman, 1961; Johnson *et al.*, 1969; Andersson and Hansson, 1989; Andersson *et al.*, 1990; Pöschl *et al.*, 1997) were also found in the present study. These differences did not affect the reduction effects of F-A-T.]

Man consumes relatively large amounts of chicken meat, and poultry accumulate a high fraction of the ingested <sup>137</sup>Cs per kg meat compared with other farm animals. For broiler chickens only a limited number of effective countermeasures reducing the uptake of <sup>137</sup>Cs is known. In addition to the capacity of FIX-A-TOX (F-A-T) to bind mycotoxins in pigs and poultry, it was also found to reduce the uptake of radiocaesium (<sup>137</sup>Cs) into the meat of broiler chickens. At the given dosage (i.e., 0.1% of the weight of the feed) the reduction factor for breast and thigh meat reached up to 1.33. Therefore, it can be recommended as an alternative chemical countermeasure after a major radioecological accident, although administration rates may have to be enhanced over those currently recommended.

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# OBSAH NIEKTORÝCH MIKROELEMENTOV V KŔMNYCH DÁVKACH PRE FARMOVÉ NORKY (*MUSTELA VISON*)

## CONTENTS OF SOME MICRO-ELEMENTS IN DIETS FOR FARM MINKS (*MUSTELA VISON*)

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**ABSTRACT:** The experiment objective was to study contents of some micro-elements (Fe, Zn, Cu, Mn, Pb, Cd, Co, Cr) in diets for minks. Four diets were analyzed consisting of identical feed ingredients (poultry heads, beef, fish waste – herrings, NOR II – groats mixture, milk powder) but with different formulation of these ingredients. Diets had increasing proportions of secondary raw materials from poultry processing, and a decreasing beef proportion. Atom absorption spectral photometry on a UNICAM 939 instrument was used to determine micro-element contents. Experimental data were statistically processed. Mean values indicate the highest contents of Fe ( $591.38 \pm 60.19$  mg/kg dry matter) and Zn ( $186.64 \pm 21.53$ ) and the lowest content of Cd ( $0.0099 \pm 0.0035$ ). It is possible to state on the basis of the results that there were no statistically significant differences in the contents of the micro-elements except Pb and Mn between the diets with different feed proportions but balanced in accordance with physiological needs of farm minks. The results indicate sufficiently high proportions of most micro-elements in mink diets except manganese: its deficit is increasing in diets with higher proportions of secondary raw materials from poultry processing, so it should be supplied to diets at a sufficient amount. Dietary lead content increased proportionately to the quantity of poultry waste while cadmium content increased in diets containing mainly beef. These elements can cause health or reproduction disorders in animals chronically receiving their higher contents.

**Keywords:** mink; diets; contents of Fe, Zn, Cu, Mn, Pb, Cd, Co, Cr

**ABSTRAKT:** Cieľom experimentu bolo štúdium obsahu vybraných mikroelementov (Fe, Zn, Cu, Mn, Pb, Cd, Co, Cr) v kŕmnych dávkach pre norky. Analyzovali sme štyri kŕmne dávky, v ktorých boli používané rovnaké krmivá (hydinové hlavy, hovädzie mäso, rybí odpad – slede, NOR II – zmes šrotov, sušené mlieko), avšak pri rôznom množstve v kŕmnych dávkach. Kŕmne dávky boli charakteristické zvyšujúcim sa podielom sekundárnych surovín pri spracovaní hydiny a naopak, znižujúcim sa podielom hovädzieho mäsa. Koncentráciu sledovaných mikroelementov sme stanovovali metódou atómovej absorpčnej spektrálnej fotometrie na prístroji UNICAM 939. Získané výsledky sme štatisticky vyhodnotili. V priemere najvyššia koncentrácia bola Fe ( $591,38 \pm 60,19$  mg/kg sušiny) a Zn ( $186,64 \pm 21,53$ ) a najnižšia Cd ( $0,0099 \pm 0,0035$ ). Na základe získaných výsledkov môžeme konštatovať, že medzi jednotlivými kŕmnymi dávkami s rôznym zastúpením krmív, ale vyvážených podľa fyziologických potrieb farmových noriek, neboli štatisticky významné rozdiely v obsahu sledovaných minerálnych látok, s výnimkou Pb a Mn. Z výsledkov vyplýva, že v kŕmnych dávkach noriek je väčšina sledovaných minerálnych prvkov zastúpená v dostatočnom množstve, s výnimkou mangánu, ktorého nedostatok je zreteľnejší v kŕmnych dávkach s vyšším podielom sekundárnych surovín zo spracovania hydiny a je potrebné zabezpečiť jeho dodatočný prívod do krmiva. Obsah olova v kŕmnych dávkach stúpal úmerne so zvýšeným skrmovaním hydinového odpadu, kým obsah kadmia sa zvyšoval v kŕmnych dávkach zvierat kŕmených prevažne hovädzím mäsom. Uvedené prvky môžu byť príčinou porúch zdravia alebo reprodukcie zvierat pri chronickom skrmovaní ich vyšších dávok.

**Kľúčová slová:** norka; kŕmne dávky; obsah Fe, Zn, Cu, Mn, Pb, Cd, Co, Cr

### ÚVOD

Cieľom práce bolo stanoviť obsah vybraných minerálnych látok – Fe, Zn, Cu, Mn, Pb, Cd, Co, Cr, v kŕmnych dávkach noriek používaných v podmienkach slovenských fariem.

Obsah minerálnych látok je jedným z dôležitých ukazovateľov hodnoty kŕmnej dávky zvierat. Minerálne látky majú v tele zvierat mnohotvárne funkcie, ktoré sa pevne viažu na ich formu a stav. Základné funkcie sú: účasť na stavbe oporných tkanív organizmu, udržiavanie homeostázy vnútorného prostredia, udržiavanie rovno-

váhy bunkových membrán, aktivácia biochemických reakcií pôsobením na enzymatické systémy, priamy alebo nepriamy vplyv na funkciu endokrinných žliaz, pôsobenie na symbiotickú mikroflóru tráviaceho aparátu (Georgievskij *et al.*, 1982). Fyziologické účinky každého esenciálneho minerálneho prvku závisia od množstva, ktoré sa prijme. Existuje určitý rozsah, tzv. bezpečný a adekvátny rozsah, zaisťujúci optimálnu funkciu prvku. Pri prijme výrazne nižšom sa objavujú známky deficitu, ak príjem presahuje bezpečný a adekvátny rozsah, začínajú sa objavovať známky toxicity (Kvasničková, 1998). Poznaním a zabezpečením požiadaviek zvierat na minerálnu výživu sa predchádza poruchám látkového metabolizmu, ktoré sa v súčasnosti až 90 % podieľajú na chorobnosti zvierat (Vrzgula *et al.*, 1982), pričom poruchy z nedostatku minerálnych látok sa v súčasnosti objavujú oveľa častejšie ako poruchy z nedostatku iných živín (Malík *et al.*, 1984). Naopak prekročenie určitej hranice koncentrácie niektorých prvkov (Sr, Cd, Pb, Hg, Ag) môže spôsobiť depresiu produkcie a porúch látkovej premeny alebo vyvolať toxikózy (Sommer *et al.*, 1985).

Potrebu minerálnych látok pre kožušinové zvieratá, ako ju uvádzajú Kangas (1978), Pereldik *et al.* (1987), je nevyhnutné zabezpečiť zvieratám v optimálnom množstve, pričom je potrebné brať do úvahy aj formu a interakcie medzi jednotlivými minerálnymi prvkami v krmive (Slawon, 1987; Anke *et al.*, 1993; Gürtler a Anke, 1993). Wiesemüller a Leibetseder (1993) konštatujú, že potreba minerálnych látok u noriek dosiaľ nie je dostatoč-

ne preskúmaná. Predpokladá sa, že krmné dávky obsahujú dostatok minerálnych látok, avšak za určitých podmienok môže byť zistený nedostatok predovšetkým Cu a Fe.

Pre kŕmenie mäsozravných kožušinových zvierat sa v našich podmienkach obyčajne používajú niektoré druhy natívnych krmív živočíšneho pôvodu. Minerálne zloženie krmív používaných pre norky (kuracieho mäsa, sekundárnych surovín z porážok hydiny, hovädzieho mäsa, hovädzích pľúc, hovädzej mliečnej žľazy, hovädzích odrezkov, králičej pečene a zmesi Mäsomix) sledovali Mertin *et al.* (1995). Sokol *et al.* (1998a) v prehľade o výskyte kadmia v potravinách a krmivách na Slovensku uvádzajú, že jeho hladiny v surovinách živočíšneho pôvodu nie sú vysoké, z krmív pridávaných do kŕmnych dávok noriek vyššie hodnoty boli zistené v hovädzích obličkách, pečeni a v minerálnych doplnkoch pre zvieratá. Anke *et al.* (1994) sa zaoberali výskumom obsahu kadmia v hydinovom mäse, v hovädzom mäse, v hovädzej pečeni a v hovädzej obličke. Podľa Sokola *et al.* (1998b) sa hladiny kadmia v krmivách v jednotlivých krajinách líšia.

Obsah minerálnych prvkov v kŕmnych dávkach používaných v oblasti Škandinávie skúmali Kangas (1974, 1978), Nielsen (1975), Hansen (1986), Työppönen *et al.* (1988), Vejgaard a Lohi (1988), Lohi a Jensen (1991). Z ich výskumov vyplýva, že v obsahu minerálnych látok v kŕmnych dávkach noriek je značná variabilita v závislosti od oblasti. Pingel *et al.* (1992) uvádzajú obsah zinku v kŕmnych dávkach noriek 124 mg/kg sušiny pre rastúce norky a 80 mg/kg sušiny pre chovné norky.

Tab. 1. Zloženie kŕmnych dávok pre norky – Formulation of diets for minks

Krmivo <sup>1</sup> (g/ks/d)	Kŕmna dávka <sup>13</sup>			
	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>4</sub>
Hydinový odpad – hlavy <sup>2</sup>	36,0	60,0	81,0	105,0
Hovädzie mäso <sup>3</sup>	96,0	81,0	75,0	60,0
Rybí odpad (slede) <sup>4</sup>	15,0	15,0	4,5	2,4
NOR II	18,0	18,0	18,0	18,0
Sušené mlieko <sup>5</sup>	3,0	3,0	2,4	–
Spolu <sup>6</sup>	168,0	177,0	180,9	185,4
Chemické, zloženie (%) <sup>7</sup>				
Sušina <sup>8</sup>	31,65	33,41	37,34	38,04
Voda <sup>9</sup>	68,35	66,59	62,66	61,96
N-látky (N x6,25) <sup>10</sup>	14,44	13,61	14,60	12,93
Tuk <sup>11</sup>	6,75	9,64	11,63	14,94
BNLV <sup>11A</sup>	6,50	6,10	6,67	5,85
Popol <sup>12</sup>	3,96	4,06	4,44	4,31

NOR II = komerčne vyrábaná zmes šrotov pre mäsozravné kožušinové zvieratá (PNZP Galanta) – NOR II – a commercial mixture of groats for carnivorous fur-bearing animals (PNZP Galanta)

zloženie (%): sušené odtučnené mlieko 4, kvasnice melasové 9, extrahovaný šrot sójový 5, kukurica 20, pšenica 20, jačmeň 23, ovos 16, minerálny doplnok MD NORVIT 3 – composition (%): skim milk powder 4, molasses yeast 9, soybean meal 5, corn 20, wheat 20, barley 23, oats 16, mineral supplement MD NORVIT 3

<sup>1</sup> feed ingredient (g/animal/d), <sup>2</sup>poultry waste – heads, <sup>3</sup>beef, <sup>4</sup>fish waste – herrings, <sup>5</sup>milk powder, <sup>6</sup>total, <sup>7</sup>chemical composition (%), <sup>8</sup>dry matter, <sup>9</sup>water, <sup>10</sup>proteins (Nx6.25), <sup>11</sup>fat, <sup>11A</sup>nitrogen free extract, <sup>12</sup>ash, <sup>13</sup>diet

## MATERIÁL A METÓDA

Analýzovali sme štyri kŕmne dávky, v ktorých boli používané rovnaké krmivá, (hydinné hlavy, hovädzie mäso, rybi odpad – slede, NOR II – zmes šrotov, sušené mlieko), avšak pri rôznom množstve v kŕmnych dávkach.

Kŕmne dávky sú uvedené v tab. 1. Nutričná hodnota kŕmnych dávok (tab. 2) korešpondovala s normou, ktorú

Tab. 2. Nutričná hodnota kŕmnych dávok pre norky – Nutritive values of diets for minks

Ukazovateľ <sup>1</sup>	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>4</sub>
ME (kJ/ks/d)	1 259,39	1 275,59	1 281,35	1 289,65
SNL (g/ks/d)	24,96	25,05	24,90	25,29
ST (g/ks/d)	15,03	15,39	15,69	15,90
SBNLV (g/ks/d)	12,00	12,03	11,85	11,43

ME = metabolizovateľná energia – metabolizable energy

ME<sub>100</sub> = (18,81 × SNL) + (38,87 × ST) + (17,14 × SBNLV) – (18,81 × DP) + (38,87 × DF) + (17,14 × DNFE) (Pereldik *et al.*, 1987)

SNL = stráviteľné dusíkaté látky – digestible proteins (DP)

ST = stráviteľné tuky – digestible fats (DF)

SBNLV = stráviteľné bezdusíkaté látky výťažkové – digestible nitrogen free extract (DNFE)

<sup>1</sup>parameter

uvádzajú Mertin *et al.* (1994). Použili sme asi 100 kg zhomogenizovanej zmesi z každého druhu kŕmnej dávky. Z pripravených kŕmnych dávok sme odobrali z každej tri priemerné vzorky o hmotnosti 200 g. Zo zhomogenizovaných priemerných vzoriek sme odvážili 1 g do platínovej misky a nechali spaľovať v muflovej peci pri teplote 550 °C v priebehu šiestich hodín. Získaný popol sme zaliali 10 ml HCl 1 : 3 a nechali odpariť na piesokovom kúpeli. Po odparení sme opäť zaliali 10 ml HCl a previedli do 100ml odmernej banky. Zo získaného mineralizátu boli spektrofotometrickým prístrojom

UNICAM 939 analyzované Fe, Mn, Zn a Cu. Príprava vzoriek na spektrofotometrické stanovenie Co, Pb, Cd a Cr bola nasledovná: Zo zmrazenej vzorky kŕmnej dávky bolo navážené paralelne 0,5 g do teflónových nádobiek. Mineralizácia bola vykonaná v uzavretom systéme za zvýšeného tlaku. Mineralizát bol prenesený pomocou deionizovanej vody do 25ml odmeriek. V tomto mineralizáte boli stanovené jednotlivé prvky. Z každej vzorky kŕmnej dávky (A<sub>1</sub> až A<sub>4</sub>) boli urobené dve priemerné merania (4 × 2 = 8 *n*).

V pokusoch boli sledované kŕmne dávky pre norky používané v Slovenskej republike. Zostavené boli z dostupných surovín podľa súčasnej normy (Mertin *et al.*, 1994). Kŕmne dávky označené ako A<sub>1</sub>, A<sub>2</sub>, A<sub>3</sub> a A<sub>4</sub> boli charakteristické zvyšujúcim sa podielom sekundárnych surovín pri spracovaní hydiny (21,4 %, 33,9 %, 44,8 % a 56,6 %) a naopak, znižujúcim sa podielom hovädzieho mäsa (57,1 %, 45,8 %, 41,5 % a 32,4 %). Obsah dusíkatých látok a tukov v kŕmnych dávkach je vyvážený aj obsahom rýb, ktorých podiel tiež klesá (8,9 %, 8,4 %, 2,5 %, 1,3 %).

Získané hodnoty koncentrácie sledovaných mikroelementov sme štatisticky vyhodnotili takto:

- stanovili sme základné variačno-štatistické charakteristiky ( $\bar{x}$ ,  $s_x$ ),
- obsah v jednotlivých kŕmnych dávkach sme porovnali pomocou jednofaktorovej analýzy rozptylu s pevnými efektmi.

## VÝSLEDKY A DISKUSIA

V tab. 3 sú uvedené koncentrácie sledovaných mikroelementov v mg/kg sušiny a obsah sušiny v testovaných kŕmnych dávkach v %.

Priemerný obsah sušiny v kŕmnych dávkach bol 35,11 ± 1,09 %. Preukazné rozdiely boli len medzi kŕmnou dávkou A<sub>1</sub> a A<sub>4</sub> ( $P \leq 0,05$ ).

Tab. 3. Obsah mikroelementov (mg/kg sušiny) v kŕmnych dávkach pre norky (*n* = 8) – Micro-element contents (mg/kg dry matter) in diets for minks (*n* = 8)

Kŕmna dávka <sup>1</sup>	Sušina <sup>3</sup>		Fe		Zn		Cu		Mn	
	$\bar{x}$	$s_x$	$\bar{x}$	$s_x$	$\bar{x}$	$s_x$	$\bar{x}$	$s_x$	$\bar{x}$	$s_x$
A <sub>1</sub>	31,65	0,52	745,00	43,80	234,08	42,23	30,87	3,76	34,01	0,18
A <sub>2</sub>	33,41	1,92	688,85	29,05	226,20	40,40	25,31	1,10	30,88	1,25
A <sub>3</sub>	37,34	0,82	558,45	129,35	163,30	23,50	33,00	8,65	22,81	3,04
A <sub>4</sub>	38,04	0,54	373,23	12,83	122,99	24,41	28,59	0,42	14,82	0,28
Priemer <sup>2</sup>	35,11	1,09	591,38	60,19	186,64	21,53	29,44	2,09	25,63	2,89
	Pb		Cd		Co		Cr			
A <sub>1</sub>	0,14	0,01	0,0215	0,0125	0,87	0,01	0,33	0,06		
A <sub>2</sub>	0,16	0,04	0,0070	0,0030	1,40	0,38	0,96	0,68		
A <sub>3</sub>	0,22	0,02	0,0055	0,0005	0,62	0,14	0,27	0,03		
A <sub>4</sub>	0,34	0,04	0,0055	0,0015	0,61	0,04	0,31	0,03		
Priemer	0,22	0,03	0,0099	0,0035	0,87	0,14	0,47	0,17		

<sup>1</sup>diet, <sup>2</sup>mean, <sup>3</sup>dry matter

Zo sledovaných prvkov bol v kŕmnych dávkach najvyšší obsah železa (priemerný obsah  $591,38 \pm 60,19$ ). Najvyšší obsah železa bol v kŕmnej dávke  $A_1$  ( $745,00 \pm 43,80$ ) s najnižším podielom hydínového odpadu a vyšším obsahom hovädzieho mäsa a rýb, najnižší obsah Fe bol v kŕmnej dávke  $A_4$  ( $373,23 \pm 12,83$ ), ale rozdiely neboli signifikantné.

Priemerný obsah zinku v sledovaných kŕmnych dávkach bol  $186,64 \pm 21,53$ . Podobne ako u železa, aj obsah Zn bol najvyšší v kŕmnej dávke  $A_1$  ( $234,08 \pm 42,23$ ) a najnižší v kŕmnej dávke  $A_4$  ( $122,99 \pm 24,41$ ), pričom rozdiely neboli preukazné.

Obsah medi v kŕmnych dávkach len málo kolísal a zistené rozdiely neboli preukazné. Priemerný obsah medi bol  $29,44 \pm 2,09$ . Najvyšší bol obsah v kŕmnej dávke  $A_3$  ( $33,00 \pm 8,65$ ), najnižší v kŕmnej dávke  $A_2$  ( $25,31 \pm 1,10$ ).

Obsah mangánu v kŕmnych dávkach signifikantne klesal od kŕmnej dávky  $A_1$  ( $34,01 \pm 0,18$ ) po kŕmnu dávku  $A_4$  ( $14,82 \pm 0,28$ ), tak ako sa znižoval podiel hovädzieho mäsa a rýb a zvyšoval podiel hydínového odpadu. Preukazné rozdiely na hladine významnosti  $P \leq 0,01$  boli medzi kŕmnymi dávkami  $A_1 : A_3$ ,  $A_1 : A_4$  a  $A_2 : A_4$ . Priemerný obsah Mn bol  $25,63 \pm 2,89$ .

Obsah olova mal v sledovaných kŕmnych dávkach stúpajúcu tendenciu od kŕmnej dávky  $A_1$  ( $0,14 \pm 0,01$ ) po  $A_4$  ( $0,34 \pm 0,04$ ), pričom medzi skupinami  $A_1$  a  $A_3$  bol signifikantný rozdiel ( $P \leq 0,05$ ). Priemerný obsah Pb bol  $0,22 \pm 0,03$ .

Naopak obsah kadmia v kŕmnych dávkach mal len klesajúcu tendenciu od kŕmnej dávky  $A_1$  ( $0,0215 \pm 0,0125$ ) po kŕmnu dávku  $A_4$  ( $0,0055 \pm 0,0015$ ). Priemerný obsah Cd bol  $0,0099 \pm 0,0035$ .

Obsah kobaltu sa v sledovaných kŕmnych dávkach len málo menil. Najvyšší obsah Co bol zistený v kŕmnej dávke  $A_2$  ( $1,40 \pm 0,38$ ), najnižší v  $A_4$  ( $0,61 \pm 0,04$ ). Priemerný obsah Co bol  $0,87 \pm 0,14$ .

Rozdiely v obsahu chrómu v sledovaných kŕmnych dávkach neboli významné. Najvyšší obsah Cr bol zistený v kŕmnej dávke  $A_2$  ( $0,96 \pm 0,68$ ), najnižší v kŕmnej dávke  $A_3$  ( $0,27 \pm 0,03$ ). Priemerný obsah Cr bol  $0,47 \pm 0,17$ .

Pri porovnaní s výsledkami, ktoré uverejnili Mertin *et al.* (1995), udávajúcimi obsah minerálnych látok v niektorých natívnych krmivách pre mäsozravé kožušinové zvieratá, je zrejme, že napr. obsah Zn v kŕmnych dávkach sa mení v závislosti od zastúpenia hovädzieho mäsa bohatého na zinok. V porovnaní s údajmi autorov Pingel *et al.* (1992), ktorí uvádzajú obsah zinku v kŕmnych dávkach noriek  $124 \text{ mg/kg}$  sušiny pre rastúce norky a  $80 \text{ mg/kg}$  sušiny pre chovné norky, bol obsah Zn v našich kŕmnych dávkach vyšší (priemerný obsah  $186,64 \pm 21,53 \text{ mg/kg}$  sušiny).

Obsah minerálnych látok v kŕmnych dávkach bol ovplyvnený zastúpením jednotlivých krmív, avšak preukazné rozdiely medzi kŕmnymi dávkami boli zistené len v obsahu Mn a Pb (tab. 4).

Tab. 4. Jednofaktorové analýzy rozptylu obsahu mikroelementov v kŕmnych dávkach pre norky – One-factor analyses of variance for microelement contents in diets for minks

Zdroj premenlivosti <sup>1</sup>		Kŕmne dávky <sup>3</sup> A $f_A = 3$	Chyba pokusu <sup>4</sup> e $f_e = 4$	Významné porovnanie <sup>5</sup>
Sušina <sup>2</sup>	MS	18,8920	2,4481	1 : 4*
	F	7,7169		
Fe	MS	54516,9962	9829,1228	
	F	5,5465		
Zn	MS	5607,4339	2281,6044	
	F	2,4577		
Cu	MS	21,6890	45,1469	
	F	0,4804		
Mn	MS	148,4528	5,4346	1 : 3**
	F	27,3160		1 : 4** 2 : 4**
Pb	MS	0,0164	0,0017	1 : 3*
	F	9,7068		
Cd	MS	0,0001	0,0001	
	F	1,4441		
Co	SM	0,2714	0,0811	
	F	3,3464		
Cr	SM	0,2169	0,2309	
	F	0,9391		

$F_{0,05}(3,4) = 6,591$

$F_{0,01}(3,4) = 16,694$

<sup>1</sup>source of variability, <sup>2</sup>dry matter, <sup>3</sup>diets, <sup>4</sup>error, <sup>5</sup>significant comparisons

Potreba niektorých mikroelementov v kŕmnych dávkach pre norky podľa autorov Kangas (1978) a Pereľdik *et al.* (1987) je (mg/100 g sušiny krmiva):

	Pereľdik <i>et al.</i> (1987)	Kangas (1978)
železo	8,80–7,90	20,62–26,88
meď	0,45–0,60	0,82–1,39
zinok	5,90–6,60	5,13–6,90
mangán	4,00–4,40	3,50–4,77

V porovnaní s uvedenou potrebou je možné konštatovať, že priemerný obsah Fe, Cu a Zn v kŕmnych dávkach je oveľa vyšší, ako je základná potreba, avšak obsah Mn v kŕmnych dávkach je nedostatočný. Nedostatok Cu a Fe, ako to uvádzajú Wiesemüller a Leibetseder (1993), by sa v našich podmienkach chovu pri využívaní dostupných kŕmív nemal vyskytovať. Na druhej strane, uvedeným spôsobom kŕmenia nie je zabezpečený norkám dostatočný prívod mangánu, čo je potrebné riešiť formou minerálneho doplnku do kŕmiva (2,5–3 mg/100 g sušiny kŕmnej dávky). Nedostatok mangánu môže byť jednou z príčin porúch reprodukcie (znížené libido, odumieranie a vstrebávanie embryí), u mláďat spôsobuje zaostávanie v raste, deformity vo vývoji kostry, prípadne nervové poruchy (Georgievskij *et al.*, 1982; Vrzgula *a kol.*, 1982).

Rizikovým faktorom v našom chove noriek môže byť vysoký obsah olova v kŕmnych dávkach s vyšším zastúpením sekundárnych surovín z hydinárskeho priemyslu, nakoľko tieto kŕmivá sú základným zdrojom krmoviny základne pre chov noriek na Slovensku. Poškodenie zdravia zvierat nastáva po chronickej záťaži organizmu olovom. Dosať nie je dostatočne preskúmané, aké množstvo olova v kŕmnej dávke a za aké obdobie môže byť pre norky nebezpečné, avšak pri zostavovaní kŕmnych dávok je potrebné brať do úvahy i obsah ťažkých kovov v niektorých typoch kŕmnych dávok.

## ZÁVER

Na základe sledovania obsahu vybraných minerálnych látok (Fe, Zn, Cu, Mn, Pb, Cd, Co, a Cr) v štyroch typoch kŕmnych dávok pre norky, bežne používaných vo farmách v Slovenskej republike, môžeme konštatovať, že medzi jednotlivými kŕmnymi dávkami s rôznym zastúpením kŕmív, ale vyvážených podľa fyziologických potrieb farmových noriek, neboli štatisticky významné rozdiely v obsahu sledovaných minerálnych látok, s výnimkou Pb a Mn. Z výsledkov vyplýva, že v kŕmnych dávkach noriek je väčšina sledovaných minerálnych prvkov zastúpená v dostatočnom množstve, s výnimkou mangánu, ktorého nedostatok je zreteľnejší v kŕmnych dávkach s vyšším podielom sekundárnych surovín zo spracovania hydiny a je potrebné zabezpečiť jeho dodatočný prívod do kŕmiva (v množstve 2,5–3 mg na 100 g sušiny kŕmnej dávky).

Je potrebné tiež mať na zreteli, že obsah olova v kŕmnych dávkach stúpa úmerne so zvýšením skrmovaním hydínového odpadu, kým obsah kadmia sa zvyšoval v kŕmnych dávkach zvierat kŕmených prevažne hovädzím mäsom. Uvedené prvky môžu byť príčinou porúch zdravia alebo reprodukcie zvierat pri chronickom skrmovaní ich vyšších dávok, čo je potrebné brať do úvahy pri zostavovaní plánu kŕmenia.

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# CONTROL OF THE HOUSEFLIES (*MUSCA DOMESTICA*) USING THE INSECT GROWTH REGULATOR – DIFLUBENZURON

## OCHRANA PRED MUCHAMI (*MUSCA DOMESTICA*) POUŽITÍM RASTOVÉHO REGULÁTORA HMYZU – DIFLUBENZURONU

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**ABSTRACT:** Insecticidal effects of diflubenzuron in Dimilin 25 WP on the house fly, particularly on its individual developmental stages, were verified under laboratory conditions and in a pig delivery room and a calf house. Individual tests were carried out on eggs, 1<sup>st</sup>-, 2<sup>nd</sup>- and 3<sup>rd</sup>-instar larvae, pupae and adult flies. The preparation was applied in three different ways, namely by adding to the diet for adults, to rearing substrate for larvae and topically to pupae. The percentage of live adults, hatched after the application into rearing media, is closely connected to the developmental stages of fly larvae and ability to accept the preparation through feed. The overall percentage hatchability ranged from 0 to 3.1. The topical application to 3<sup>rd</sup>-instar larvae and pupae resulted in 3–5-fold increase in the hatchability of flies in dependence on the developmental stage in which the preparation was applied. The larvicidal effectiveness in field tests was in the range of 76–92 %. The results obtained in field experiments allow us to state that the preparation Dimilin 25 WP caused all-season suppression of fly populations in comparison with insect control preparations to which a resistance has developed in the respective population of flies. Its use can help to resolve to a great extent the problem of resistance of flies to conventional insecticides, which has become a crucial issue of the present day.

**Keywords:** *Musca domestica*; diflubenzuron; IGRs; animal houses; effectiveness

**ABSTRAKT:** Insekticídny účinok diflubenzuronu v prípravku Dimilin 25 WP na muchu domácu bol sledovaný na jednotlivých vývojových štádiách, ako aj na dospelých muchách v laboratórnych i praktických podmienkach chovu hospodárskych zvierat. Jednotlivé testy boli robené na vajíčkach, larvách 1., 2. a 3. štádia, kuklách a dospelých muchách. Prípravok bol aplikovaný priamo do kultivačného média lariev, topikálne na povrch lariev a kukiel, a pridaním do kŕmnej dávky dospelých múch. V prípade aplikácie do kultivačného média bolo celkové percento liahnivosti múch v rozsahu od 0 do 3,1. Po topikálnej aplikácii sa liahnivosť zvýšila 3–5násobne v závislosti od vývojového štádia na ktoré prípravok pôsobil. Larvicídna účinnosť v praktických testoch sa pohybovala od 76 do 92 %, čím sa dosiahlo dostatočné celosezónne zníženie početnosti mušich populácií v porovnaní s kontrolnými prevádzkami.

**Kľúčové slová:** mucha domáca; diflubenzuron; IGR; maštal'né prostredie; účinnosť

### INTRODUCTION

The housefly, *Musca domestica* (L.), is one of the most important pests of humans and livestock because of its role in the mechanical transmission of certain pathogens and its behavioural traits. Application of chemical insecticides represents the most common tactic for effective control. The majority of presently used insecticides puts a load on the environment resulting in reducing the populations of natural predators, bees, fish, birds, and free living animals (Košuth, 1993; Kottferová *et al.*, 1996; Toporčák *et al.*, 1999). Their repeated use leads to the development of resistance to organophosphorus, carbamate and pyrethroid insecticides (Kočišová and Para, 1998). The simplest and most effective way of resolving the problem of resistance is

the exclusion of the preparation from the insect control programme and its replacement by an alternative substance to which the resistance has not developed and which has no cross-resistance potential. However, the development of preparations based on new active ingredients is very long and costly. Therefore an effort has been put to the development of optimum forms of integrated control of flies, i.e., to reaching the best possible insect control effect at lowest possible costs and low load on the environment using a combination of the highest possible number of preparations (Roush, 1989). A more effective strategy could be to use, in combination, a toxic fly bait or pyrethrin based aerosol to reduce quickly the number of housefly adults and a larvicide applied to manure to prevent any eggs laid to reach maturity (Kočišová *et al.*, 1999).

Much attention has been focused on synthetic insect growth regulators (IGRs). They were first synthesised in the late 1960's, even before synthetic pyrethroids. Two types of IGRs have been commercialised, both disrupting the growth and development of insects, but in completely different ways. Firstly, the chitin synthesis inhibitors which belong to benzoyl ureas, and secondly, the juvenile hormone analogues (JHA's or juvenoids), completely specific to insects despite similar modes of action. One of such compounds diflubenzuron belonging to IGRs, inhibits the synthesis of chitin and causes abnormal endocuticular deposition leading to abortive moulting (Wright, 1974). The biochemical principle of the diflubenzuron effect is in disturbing the final stage of chitin synthesis, especially the *x*-acetylglucosamine polymerization (Staal, 1975).

In the present study, we describe the effectiveness of the preparation Dimilin 25 WP based on diflubenzuron, on house fly under laboratory and field conditions.

## MATERIAL AND METHODS

### Insect

House-flies (*Musca domestica* L.) – sensitive strain SRS/WHO (University of Pavia, Italy), reared in an insectary at the University of Veterinary Medicine in Košice, free of any contact with insecticides. A wild population of houseflies, marked RE, was captured on a pig farm in the district Košice-suburbs. The tests were carried out on eggs (12-hour lay), 1<sup>st</sup>-, 2<sup>nd</sup>- and 3<sup>rd</sup>-instar larvae, white and dark pupae and also on adult flies of the strain SRS/WHO and the wild population RE. Flies were reared under laboratory conditions at 26–28 °C and relative atmospheric humidity 40–60%. The larvae and adults were reared on standard substrates (Rupeš and Rettich, 1998).

### Preparation

DIMILIN 25 WP – spray insecticidal preparation produced in the form of wettable powder (WP) with 25% active ingredient (a.i.) of diflubenzuron. It is intended exclusively for professional use to protect agricultural crops against animal pests and flies in animal production housings. The preparation doses applied in laboratory and field tests were based on the selected dose of 2–4 g/m<sup>2</sup>, i.e., 0.5–1 g of active ingredient per m<sup>2</sup>.

### Laboratory tests

Application of Dimilin 25 WP into the rearing substrate. House fly larvae were kept in a medium prepared from agar (20 g), dried milk (100 g), yeast (100 g) and water (1 000 ml). Fifty ml of rearing substrate was transferred to plastic containers and let to solidify. Thirty minutes

prior to the test, the substrate was mixed with the tested preparation investigated at the selected basic dose recalculated per quantity of rearing substrate (0.5–1 g of a.i. per m<sup>2</sup>). Fly eggs (12 h lay) or larvae (1<sup>st</sup> instar larvae – 1 day old; 2<sup>nd</sup> instar larvae – 2 days old; 3<sup>rd</sup> instar larvae – 3–5 days old) were placed onto the substrate. The effectiveness was determined after 7–12 days. The number of hatched adults present in the control were considered to be 100% and the numbers of live adults hatched in individual containers were compared with the control value. The results were presented as mean numbers of live adults from five hatchings and the respective percentage proportions of hatchability or mortality of adult flies.

Topical application – Dimilin 25 WP suspended and dissolved in acetonitrile was applied in 1 µl volume to 3<sup>rd</sup>-instar larvae – 24 h before pupation, white and dark pupae. Treated larvae and pupae were kept in plastic containers with 30-mm layer of sawdust.

Feeding test with adult flies – Dimilin 25 WP was added to the standard diet for adults. 1 g of Dimilin 25 WP was mixed with 10 g of dried milk and glucose, and put to the cage with flies (50 ♀ : 50 ♂). The oviposition medium was placed on the bottom of plastic containers. All eggs deposited from day 5 to 10 were collected, allowed to hatch and develop on the larval medium. The number of adults in the F<sub>1</sub> generation was counted. All experiments were carried out at 22–26 °C, relative humidity 42–55% and constant illumination 80 lx.

### Field tests

They were carried out in a pig delivery room and calf house. The preparation was applied with a watering-can. The solution for spraying was prepared by dissolving 80 g of the preparation in 10 l of water. The quantity was sufficient for the treatment of 20 m<sup>2</sup> of the surface. Diluted preparation was used to treat the floor of the individual pig and calf house as well as the area around the manure containers. The abundance of flies in animal housing and the effectiveness of Dimilin 25 WP were evaluated by the method specified by the centre of veterinary sanitation institutes in Bratislava (Venglovský, 1992). The infestation with flies was determined by means of flypapers hanging along the diagonal axis of the house at a 5-m distance and 1 m above the housed animals. It was determined as a statistical mean of flies caught during 24 h on one flypaper. The preparation was applied from May 4 to September 26, in 2–3week intervals. There were no other insecticides used in the experimental and control houses.

## RESULTS

The effect on the eggs (Table 1) was strong and no adults emerged after Dimilin 25 WP application in comparison with the control in which on average 73.8 or 75.8

Table 1. The number of adults of F<sub>1</sub> generations hatching after the treatment of rearing substrate

Treatment	SRS/WHO strain				"RE" wild population			
	experiment DIMILIN 25 WP		control		experiment DIMILIN 25 WP		control	
	mean	Sd	mean	Sd	mean	Sd	mean	Sd
Eggs	0	–	75.2	±4.2	0	–	73.8	±3.7
1 <sup>st</sup> instar larvae	0	–	82.4	±3.9	0	–	75.2	±3.5
2 <sup>nd</sup> instar larvae	0	–	85.0	±2.9	0	–	82.4	±3.9
3 <sup>rd</sup> instar larvae (3 days old)	0	–	86.0	±2.6	0	–	85.2	±2.4
3 <sup>rd</sup> instar larvae (5 days old)	2.4	±1.14	84.6	±3.8	2.6	±2.7	83.4	±4.4

flies were hatched, respectively. When using the basic dose (2 g/m<sup>2</sup>) equal to 0.001 g of the preparation per 50 g of rearing substrate under laboratory conditions, no pupae developed. It was difficult to observe the influence on larvae of the 1<sup>st</sup>- and 2<sup>nd</sup>-instars because the larvae in the stage following the shedding died and decomposed in the substrate. Out of the total number of 100 applied larvae only few larvae or pupae reached higher developmental stages. The effect of the preparation on 3<sup>rd</sup>-instar larvae (Table 1), we observed as an increased number of as larvoid as barrel-shaped pupae. However, in 5 days old larvae per cent of hatchability was 2.4 for the strain SRS/WHO and 2.6 for the wild population RE, in comparison with the control in which on average 84.6 or 83.4 flies were hatched, respectively. Morphologically many larvae were elongated and dark, some acquired atypical shapes with thickened central parts or spindle-shaped endings, or some were unable to produce the typical barrel-like shape.

The topical application of the preparation to 3<sup>rd</sup>-instar larvae 24 h before pupation resulted in increased hatching

of adults (Table 2), to 18.1% in the strain SRS/WHO or 24.2% in the RE population. The topical application of the preparation to white or dark pupae did not reach the assumed effect. The hatchability of white pupae ranged from 79.6 to 89.9% and that of dark pupae from 87.7 to 95.2%.

In the feeding tests (Table 3) diflubenzuron failed to affect the egg production. Eggs laid within a 12h period weighed from 1.39 to 1.52 g for experimental groups and from 1.41 to 1.47 g for control groups. However, interesting were the irreversible changes in hatchability because, in the experimental groups of flies, larvae of stages 1, 2 and 3 were observed only sporadically and only 7 or 12.8 flies on average were hatched. The development of larvae in the control groups was normal and altogether 883 or 902.2 flies were hatched.

The results obtained in field conditions are illustrated in Figs. 1 and 2, and indicate that a significant decrease in the population of flies was observed approximately one month after the initial application of the tested preparation. After this time, another slight decrease was recorded and the population stabilised at the final level

Table 2. The number of adults of F<sub>1</sub> generations hatching after topical application

Treatment	SRS/WHO strain				"RE" wild population			
	experiment DIMILIN 25 WP		control		experiment DIMILIN 25 WP		control	
	mean	Sd	mean	Sd	mean	Sd	mean	Sd
3 <sup>rd</sup> instar larvae – 24h before pupation	15.6	±2.7	91.6	±2.0	20.0	±1.5	82.8	±2.4
White pupae	82.4	±3.7	91.6	±2.1	72.6	±4.7	91.2	±1.3
Dark pupae	90.4	±2.1	95.0	±2.9	84.4	±3.0	96.2	±2.2

Table 3. The influence of Dimilin 25 WP on adult flies, their egg production, hatchability and mortality after it was added to the standard diet

	SRS/WHO strain				"RE" wild population			
	experiment DIMILIN 25 WP		control		experiment DIMILIN 25 WP		control	
	mean	Sd	mean	Sd	mean	Sd	mean	Sd
Mortality of adult flies	9.4	±1.5	8	±3.3	10.4	±2.2	9	±1.5
Weight of eggs (12 h period)	1.39	±0.2	1.41	±0.1	1.52	±0.14	1.47	±0.1
Number of hatched adults	7	±2.9	883	±31.7	12.8	±2.6	909.2	±9.0

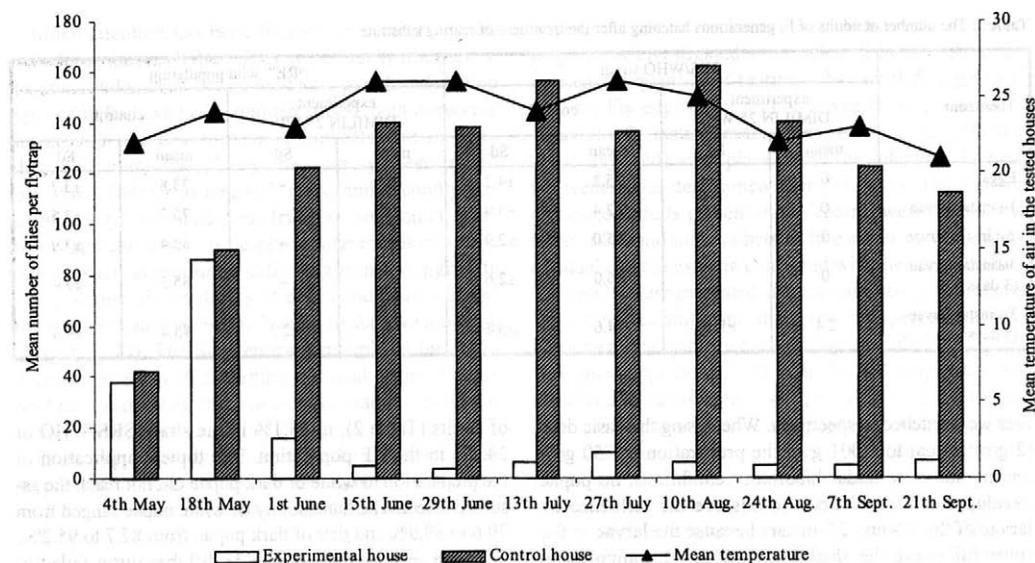


Fig. 1. The effect of diflubenzuron (Dimilin 25 WP) on the abundance of flies in pig delivery room

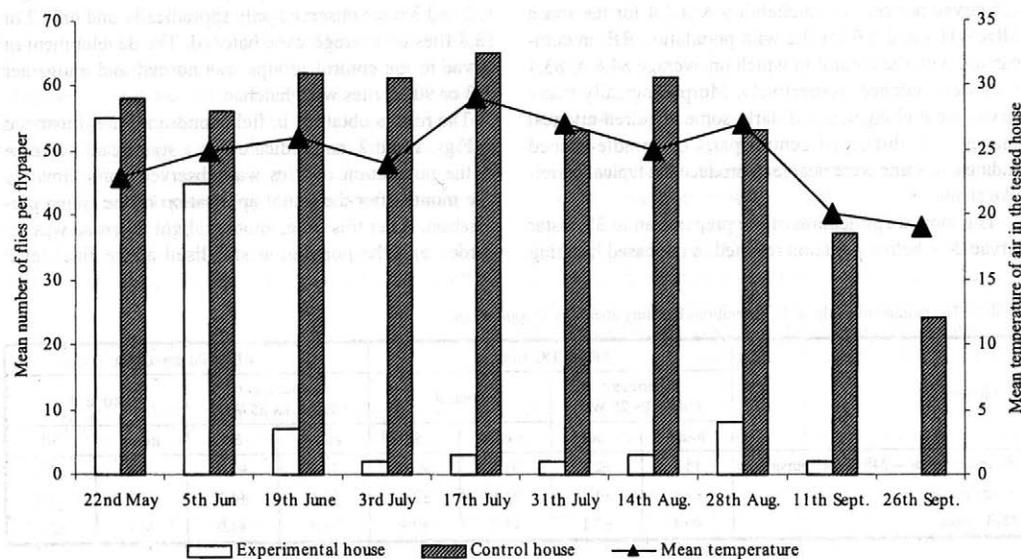


Fig. 2. The effect of diflubenzuron (Dimilin 25 WP) on the abundance of flies in calf house

without any larger variations (Fig. 1). The effectiveness of the preparation in the pig delivery room was 92%. In the course of calf house experiment (Fig. 2), the initial mean number of flies was decreased by two thirds. During the 18-week experiment (May–September), the mean

number of flies per flypaper trap in the experimental house was 13, ranging from 0 to 55, while in the control the mean number was 53 flies in the range from 24 to 65. We recorded a 76% decrease in the number of flies in this experiment in comparison with the control house.

## DISCUSSION

Diflubenzuron belongs to typical stomach poisons which negatively influence the production of chitin. The formation of insect cuticle, in which chitin and glucosamine are involved, is catalysed by the enzyme chitin-UDP-N-acetyl-glucosaminyl-transferase (Staal, 1975). The synthetic substance diflubenzuron increases the activity of the enzyme mentioned, so inhibiting the production and storage of chitin in the cuticle. Housefly larvae pass three larval instars separated by moulting. In the third and final stage, larvae migrate from the wet and warm environment to colder and drier places where barrel-shaped puparia develop from the hardened pigmented skin. They are white at first and turn brown and hard within 24 h. Our results indicate that diflubenzuron, depending on the way and time of application, can influence the development and reproduction in flies in the following characteristic ways: Larvae of the 1<sup>st</sup> and 2<sup>nd</sup> instar are unable to moult into the next instar, larvae of the 3<sup>rd</sup> instar do not form puparia. In the early larval stages, i.e., stages 1 and 2, characterised by intensive acceptance of feed, hatching of live adults was interrupted and no adults emerged. Younger 3<sup>rd</sup>-instar larvae exhibited hatchability 2.4–2.6%.

Therefore the oldest 3<sup>rd</sup>-instar larvae accept feed for only a part of their life. In the period before pupation as well as during pupation the effectiveness of the preparation Dimilin 25 WP was lower than that observed in early larval instars. Mortality ranged from 4.8 to 81.9% for the strain SRS/WHO and from 12.3 to 75.8% for the wild population RE. However, contrary to Wright (1974), who observed complete ineffectiveness of diflubenzuron in his experiments with its topical application, our experiments with application of higher doses of the preparation revealed almost 50% mortality. The results allow us to assume that the ability of the active ingredient in Dimilin 25 WP to penetrate into the pupa is decreased.

Miller (1974) first described the activity of diflubenzuron in the housefly. Later on, Miller *et al.* (1990, 1991) and Cilek and Knapp (1991) investigated the effect of diflubenzuron on the control of developmental stages of flies in the manure of grazing and lactating cows. Animals accepted diflubenzuron in feed and no unfavourable effects on production of milk or its qualitative properties were observed. The development of resistance to this substance has not been detected yet (Farkas and Pap, 1991). A risk of its development, pointed by Keiding *et al.* (1992) and Sheppard *et al.* (1992), exists mainly as a result of intensive and long-term selection pressure supported by both the multiplication treatment of locations and feeding diflubenzuron to animals.

Diflubenzuron applied at the manufacturer's recommended deposit rates was effective in controlling the housefly populations. It was a positive finding because

the fly populations were resistant to a number of conventional insecticides; larvicides are likely to become increasingly important in control regimes. Dimilin 25 WP worked very well and is therefore a good candidate for supplementing traditional insecticide treatments in pig and calf units.

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### Změna publikačního jazyka ve vědeckých časopisech ČAZV

Předsednictvo České akademie zemědělských věd přijalo na zasedání dne 6. 4. 2000 usnesení, kde mj. doporučuje změnu publikačního jazyka ve vědeckých časopisech vydávaných pod gescí ČAZV. Předsednictvo navrhuje Vydavatelské radě ČAZV zavést angličtinu jako jediný jazyk ve všech vědeckých časopisech od 1. 1. 2001. Redakce časopisu *Czech Journal of Animal Science* přijímá od 1. 7. 2000 příspěvky psané pouze v angličtině.

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### A change of publication language in Scientific Journals of the Czech Academy of Agricultural Sciences

At its session on the 6<sup>th</sup> April 2000, the Presidium of the Czech Academy of Agricultural Sciences adopted a resolution recommending, among other things, to change the publication language in scientific journals published under the Academy patronage. The Presidium proposes to the Publishing Board of the Academy to introduce English as the only language in all scientific journals from the 1<sup>st</sup> January 2001. The papers written exclusively in English are accepted by the editor's office of the *Czech Journal of Animal Science* from the 1<sup>st</sup> July 2000.

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Original scientific papers, short communications, and selectively reviews, that means papers based on the study of technical literature and reviewing recent knowledge in the given field, are published in this journal. Published papers are in Czech, Slovak or English. Each manuscript must contain a short and a longer summary (including key words).

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