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# VZŤAHY MEDZI EXTERIÉROM A ÚŽITKOVÝMI VLASTNOSŤAMI HOVÄDZIEHO DOBYTKA

## RELATIONS BETWEEN THE BODY CONFORMATION AND COMMERCIAL TRAITS OF CATTLE

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ABSTRACT: The objective of the present paper was to determine phenotype correlations between body conformation traits, milk and meat performance parameters, and indirect commercial traits. The results of body conformation testing were used as fundamental data; they were obtained in 5,630 bulls of Fleckvieh breed in Bavaria, by evaluation of progenies born in 1987–1994. Data on body conformation evaluation, expressed as relative figures, were consequently combined with breeding values for milk performance, meat performance, milkability, somatic cell counts in milk and calving ease in the evaluated population. The results indicate positive and highly significant correlations of milk production with body measurements determined by linear evaluation of body conformation: withers height ($r$ = 0.291), chest girth ($r$ = 0.144) and body length ($r$ = 0.147) (Tab. I). A similar trend was determined by evaluation of fat and protein production when correlation coefficients ranged from 0.389 to 0.393 for withers height, for height in hips ($r$ = 0.055–0.115), for chest girth ($r$ = 0.203–0.239) and for body length ($r$ = 0.173–0.203). As for the evaluated body measurements, milk production is influenced by withers height to the greatest extent ($r$ = 0.406). Evaluation of the main and partial traits of body conformation showed positive and highly significant correlations with the udder ($r$ = 0.182–0.212) (Tab. I); production of milk, fat and proteins as well as the shape of rear quarters ($r$ = 0.331–0.359) and fore quarters of udder ($r$ = 0.257–0.273) are influenced to the greatest extent. Milk production is influenced by teat shape and position to a much lesser extent ($r$ = 0.080–0.164). The effect of muscling on the evaluated parameters of milk performance in dairy cows of pied cattle is negative and statistically highly significant ($r$ = –0.157 to –0.222). Our results confirm the findings reported by numerous authors that dairy cows with bigger body frames characterized by height, width and girth measures, with uniform fore quarters and spacious, well-positioned quarters and smaller muscling, have higher production of milk, fat and proteins than dairy cows with smaller body frames and lower scores of the basic udder traits. Positive and significant correlations of all body measurements to net weight gains ($r$ = 0.189–0.257) were determined by the analysis of relations of body measurements to meat production parameters (Tab. II) while the effect of the body measurements concerned on meat proportion in the carcass and on commercial class EUROP showed an unambiguously negative trend ($r$ = –0.008 to –0.233). Evaluation of the main trait – body frame – and of its partial characteristics, showed positive effects of body depth ($r$ = 0.075–0.264) and body width ($r$ = 0.200–0.356) on all parameters of meat production (Tab. II). Significant and highly positive effects on meat production parameters were observed in the main trait – muscling ($r$ = 0.329–0.539). The values of correlation coefficients for partial traits muscling of the body forepart and muscling of the barrel and rump were 0.303–0.506 and 0.322–0.536, respectively. The relations of the evaluated traits of muscling to meat proportions in the side of beef were closest ($r$ = 0.506–0.539. All evaluated body measurements showed statistically significant relations to milkability, a functional trait of the udder ($r$ = 0.149–0.487) (Tab. III). Evaluation of the partial traits of body conformation indicated positive and highly significant effects of the shape of fore udder ($r$ = 0.203), rear udder ($r$ = 0.197) as well as of teat shape ($r$ = 0.161) on milkability. The above relations confirm the findings of many studies that dairy cows with better characteristics of udder shape have better milkability. Statistically significant positive relations of the suspensory ligament ($r$ = 0.147) and of teat shape and position ($r$ = 0.109–0.140) to somatic cell counts in milk were determined. Negative correlation ($r$ = –0.232) was found by evaluating the relation of rear udders to somatic cell counts. Evaluation of the effect of body conformation on calving ease showed the positive relation of all body measurements to this parameter ($r$ = 0.115–0.393) while the highest value of correlation coefficient ($r$ = 0.393) was calculated for the relation between withers height and calving ease. Our results confirmed that the body conformation influenced calving ease of dairy cows most significantly.

cattle; milk performance; meat performance; milkability; body measurements; body conformation; phenotype correlations

**ABSTRAKT:** Na základe korelačnej analýzy sme zisťovali vzájomné vzťahy medzi exteriérom a úžitkovými vlastnosťami hovädzieho dobytka. Ako podkladové údaje boli použité výsledky kontroly dedičnosti hodnotenia exteriéru potomstva 5 630 býkov plemena fleckvieh v Bavorsku, ktoré boli spojené s plemennými hodnotami mliekovej úžitkovosti, mäsovej

úžitkovosti a nepriamych úžitkových vlastností. Zistili sme pozitívne a signifikantné korelácie produkcie mlieka, tuku a bielkovín v kg k telovým mieram na úrovni $r$ = 0,055 až 0,393. Z hodnotených ukazovateľov exteriéru vplýva na produkciu mlieka v najväčšej miere utváranie predných a zadných štvrtiek vemena ($r$ = 0,257 až 0,359). Na ukazovatele mäsovej úžitkovosti najvýznamnejšie vplýva osvalenie ($r$ = 0,303 až 0,539). Ďalej sme zaznamenali pozitívne a signifikantné vzťahy všetkých mier k netto prírastku ($r$ = 0,189 až 0,257). K dojiteľnosti, ako funkčnej vlastnosti vemena, mali štatisticky významný vzťah všetky hodnotené telové miery, utváranie predných štvrtiek vemena ($r$ = 0,203), utváranie zadných štvrtiek vemena ($r$ = 0,197), ako aj utváranie ceckov ($r$ = 0,161). K obsahu somatických buniek v mlieku sme zistili štatisticky preukazné pozitívne vzťahy u závesného väzu ($r$ = 0,147) a utvárania a postavenia ceckov ($r$ = 0,109 až 0,140). Negatívna korelácia na úrovni $r$ = –0,232 bola zaznamenaná pri vzťahu zadných štvrtiek vemena k obsahu somatických buniek. Pri hodnotení vplyvu exteriéru na priebeh pôrodov sme najvyššiu hodnotu korelačného koeficienta ($r$ = 0,393) zistili medzi výškou na kohútiku, telesným rámcom a priebehom pôrodov.

hovädzí dobytok; mliekova úžitkovosť; mäsová úžitkovosť; dojiteľnosť; telové miery; exteriér; fenotypové korelácie

## ÚVOD

Exteriér zvierat má podľa zistení viacerých autorov vzťah k potenciálnym produkčným schopnostiam. Jeho hodnotenie spôsobom, ako sa realizuje v niektorých chovateľsky vyspelých krajinách, nie je samoúčelné, ale prispieva k rýchlejšiemu chovateľskému pokroku vo vysokoprodukčných stádach dojníc.

Na zabezpečenie zvyšovania úžitkovosti je potrebné poznať celý proces tvorby úžitkových znakov od molekulárnej úrovne až po fenotypovú realizáciu a zistiť možnosti, ako a v ktorej fáze ontogenézy je možné úžitkové vlastnosti ovplyvniť, prípadne zistiť, aké objektívne kritériá by umožnili selekciu najvýkonnejších jedincov už vo včasnom období ich života.

Vo vyspelých krajinách, v súvislosti so spresnením selekcie zvierat a zefektívnením produkčnej schopnosti sa na úseku plemenárskej práce u hovädzieho dobytka stále väčší význam pripisuje nepriamym úžitkovým vlastnostiam, ktoré sú postupne v jednotlivých krajinách využívané pri konštrukcii selekčných indexov. Významným sekundárnym znakom je utváranie zovňajšku zvierat. Na základe analýzy znakov a vlastností exteriéru, ktoré súvisia s úžitkovosťou, zdravotným stavom, dlhovekosťou a adaptabilitou, možno zvýšiť celkovú rentabilitu chovu hovädzieho dobytka.

Hodnotenie exteriéru hovädzieho dobytka sa uplatňuje u všetkých plemien prakticky už od začiatku ich šľachtenia. Spôsob hodnotenia sa v jednotlivých krajinách vyvíjal samostatne, vzhľadom na rôzne podmienky, chovné ciele a tradície. V súčasnom období sa u väčšiny plemien presadzuje tendencia zjednotenia metodík hodnotenia exteriéru s cieľom vzájomnej porovnateľnosti výsledkov v kontrole dedičnosti. Vzťahy znakov exteriéru k dôležitým úžitkovým vlastnostiam potvrdilo viacero autorov. Espe (1957) hodnotil vzťahy medzi produkciou mlieka a telesnými rozmermi. Vyvodzuje z nich záver, že korelácie medzi ktorýmkoľvek telesným rozmerom (okrem obvodov) a produkciou mlieka sú také malé, že v selekcii nezohrávajú žiadnu podstatnú úlohu. Urban et al. (1987) zistili preukazný vplyv celkového utvárania exteriéru prvôstok na produkciu mlieka a mliečneho tuku za normovanú laktáciu u čiernostrakatého dobytka. Pri podrobnejšom hodnotení exteriéru zistili preukazný vplyv telesnej stavby, osvalenia a hlavne tvaru a kapacity vemena na mliekovú úžitkovosť prvôstok. U tvaru a kapacity vemena sa diferencie v produkcii medzi skupinami vytvorenými podľa znakov vemena pohybujú od 267,00 do 948,34 kg mlieka. Frelich et al. (1995) overovali vzťahy medzi telesnými rozmermi a mliekovou úžitkovosťou u dojníc českého strakatého plemena a u kríženiek tohto plemena s plemenami holštajnské a ayrshire. U jednotlivých genotypov nezistili štatistickú významnosť medzi hodnotenými mierami a mliekovou úžitkovosťou. Zistili však, že so zvyšujúcim sa poradím laktácie narastala najviac šikmá dĺžka tela, hĺbka hrudníka a obvod hrudníka. Štatisticky významné vzťahy boli medzi priamou dĺžkou tela, hĺbkou hrudníka a mliekovou úžitkovosťou. Naopak Kratochvílová et al. (1996) potvrdili, že významný a úzky vzťah k produkcii mlieka má predovšetkým kapacita zvieraťa, ktorá je daná jeho výškovými rozmermi, hĺbkou hrudníka a dĺžkou tela.

Veľké množstvo prác sa zaoberá vzťahmi medzi znakmi vemena a výškou mliekovej úžitkovosti. Jones (1976), ako aj Speight a Fairlie (1977) uvádzajú pozitívne vzťahy medzi indexom mlieka a hodnotenými znakmi exteriéru. K podobným výsledkom u 5 911 dojníc plemena brown swiss dospeli aj Van Vleck et al. (1980), ktorí zistili jednoznačne pozitívne vzťahy medzi ukazovateľmi exteriéru a mliekovou úžitkovosťou. Sieber (1986) na základe rozsiahlych analýz u plemena fleckvieh dokázal, že medzi produkciou mlieka, produkciou tuku v kg a charakteristikami vemena je tesnejšia závislosť ako medzi inými parametrami exteriéru. Z telových mier autor zaznamenal signifikantné vzťahy k produkcii mlieka u výšky na kohútiku, obvodu hrudníka a dĺžky tela. Averdunk (1993) uvádza, že v posledných rokoch sa u populácie nemeckého strakatého plemena neustále znižuje vplyv telesného rámca na produkciu mlieka, pričom vyššie hodnoty korelačného koeficienta zaznamenal k produkcii tuku a bielkovín ako k produkcii mlieka.. Autor ďalej uvádza pozitívne vzťahy medzi netto prírastkom a rámcom tela na úrovni $r$ = 0,19 a vysoký vplyv osvalenia na plemennú hodnotu podielu mäsa ($r$ = 0,35) a na index mäsa ($r$ = 0,54).

Vzťahmi medzi tvarovými vlastnosťami vemena, resp. ďalšími znakmi zovňajšku a počtom somatických buniek sa zaoberali Monardes et al. (1990) a Rogers, Spencer (1991). Fenotypové korelácie medzi znakmi vemena a počtom somatických buniek mali dosť veľký rozptyl, ale kravy s väčšou hĺbkou vemena mali nižší obsah somatických buniek v mlieku. Genetické korelácie medzi počtom somatických buniek a hĺbkou vemena, prednými štvrtkami a rozmiestnením ceckov boli negatívne ($r$ = –0,21 až –0,64) a medzi počtom somatických buniek a medzi dĺžkou ceckov boli kladné ($r$ = 0,20).

## MATERIÁL A METÓDA

Ako základný súbor dát sme použili výsledky kontroly dedičnosti exteriéru 5 630 býkov plemena fleckvieh v Bavorsku, získané v rámci hodnotenia potomstva narodeného v rokoch 1987–1994. Exteriér bol hodnotený podľa platnej metodiky lineárneho hodnotenia hovädzieho dobytka plemena fleckvieh v Nemecku, označenej ako „Bewertungssystem 87" s touto schémou hodnotenia (telové miery: výška na kohútiku, výška na krížoch, obvod hrudníka, dĺžka trupu):

| Hlavné znaky | Čiastkové znaky |
|---|---|
| Rámec tela | výška tela, hĺbka tela, šírka tela, dĺžka tela |
| Osvalenie | osvalenie predotrupia, osvalenie stredotrupia a zadotrupia |
| Stavba tela | plece, chrbát, sklon zadku, postoj zadných končatín, vyjadrenie pätového kĺbu, sponka, paznecht, uzavretie paznechtu |
| Vemeno | predné štvrtky, zadné štvrtky, upnutie – závesný väz, utváranie ceckov, postavenie ceckov |
| Čistota vemena | čistota vemena |

Výsledky hodnotenia exteriéru boli následne spojené s plemennými hodnotami mliekovej úžitkovosti, mäsovej úžitkovosti a nepriamych úžitkových vlastností. Použitie plemenných hodnôt ako vstupných údajov zabezpečovalo odstránenie vplyvu definovaných fixných a náhodných efektov na zistené výsledky. V rámci hodnotenia mliekovej úžitkovosti sme použili plemennú hodnotu mlieka, plemennú hodnotu kg tuku, plemennú hodnotu kg bielkovín a index mlieka.

$$\text{Index mlieka} = 97{,}7 + 0{,}200 \times \text{PH tuk-kg} + 0{,}800 \times \text{PH bielkoviny-kg}$$

Pri hodnotení mäsovej úžitkovosti sme analyzovali vzťahy k plemennej hodnote netto prírastku, plemennej hodnote podielu mäsa v jatočnom tele, obchodnej triede EUROP a indexu mäsa.

$$\text{Index mäsa} = 54\ \%\ \text{PH netto prírastok} + 28\ \%\ \text{PH podiel mäsa} + 18\ \%\ \text{PH EUROP}$$

Z nepriamych úžitkových vlastností vstupovali do hodnotenia plemenné hodnoty dojiteľnosti, obsahu somatických buniek v mlieku a priebehu pôrodov. Na základe korelačnej analýzy sme zistili vzájomné vzťahy medzi úžitkovými vlastnosťami a hodnotenými znakmi exteriéru.

## VÝSLEDKY A DISKUSIA

### Vplyv exteriéru na ukazovatele mliekovej úžitkovosti

Pri hodnotení sme zistili pozitívne a vysoko signifikantné korelácie produkcie mlieka k telovým mieram, zisťovaným v rámci lineárneho hodnotenia exteriéru – k výške na kohútiku ($r$ = 0,291), k obvodu hrudníka ($r$ = 0,144) a k dĺžke trupu ($r$ = 0,147) – tab. I.

Podobnú tendenciu sme zaznamenali aj pri hodnotení produkcie tuku a bielkovín v kg. Korelačné koeficienty sa pohybovali k výške na kohútiku v rozpätí od 0,389 do 0,393, k výške na krížoch od 0,055 do 0,115, k obvodu hrudníka od 0,203 do 0,239 a pri dĺžke trupu od 0,173 do 0,203. Kratochvílová et al. (1996) zistili tiež významný a úzky vzťah kapacity zvieraťa k produkcii mlieka. V zásade zhodná tendencia bola zistená aj vo vzťahu telových mier k indexu mlieka, ktorý je považovaný za vyslovene produkčný index, ktorý kombinuje produkciu mlieka, tuku a bielkovín s rozdielnou ekonomickou váhou. Z hodnotených telových mier sa na produkcii mlieka v najväčšej miere prejavila výška na kohútiku ($r$ = 0,406) a obvod hrudníka ($r$ = 0,237), čo je v súlade s výsledkami autorov Frelich et al. (1995). Potvrdil sa užší vzťah telových mier k produkcii tuku a bielkovín ako k samotnej produkcii mlieka. Takúto skutočnosť zistil vo svojej práci aj Averdunk (1993).

V súvislosti s genetickým pokrokom populácie dochádza k zvyšovaniu mliekovej úžitkovosti a súčasne k zväčšovaniu telesného rámca populácie, čo mohlo ovplyvniť aj naše výsledky tým, že do hodnotenia boli zaradení aj starší býci. Naše výsledky potvrdzujú zistenia viacerých autorov, že dojnice s väčším telesným rámcom, charakterizovaným výškovými, šírkovými a obvodovými mierami, vyprodukujú viac mlieka, tuku a bielkovín v porovnaní s dojnicami menšieho telesného rámca.

V rámci hodnotenia hlavných znakov exteriéru sme zistili pozitívne a vysoko signifikantné vzťahy k vemenu ($r$ = 0,182 až 0,212) – tab. I. Z čiastkových znakov najvyššou mierou ovplyvňuje produkciu mlieka, tuku a bielkovín utváranie predných štvrtiek ($r$ = 0,257 až 0,273) a utváranie zadných štvrtiek s hodnotami korelačného koeficienta od 0,331 do 0,359. Z výsledkov vyplýva, že dojnice s rovnomernými a ďaleko dopredu siahajúcimi prednými štvrtkami, ako aj priestrannými, dobre rozloženými zadnými štvrtkami produkujú viac mlieka, tuku a bielkovín ako dojnice s horším hodnotením základných charakteristík vemena. V podstatne menšej miere sa na produkcii mlieka podieľa utváranie a postavenie ceckov ($r$ = 0,080 až 0,164).

Na základe rozsiahlych analýz u plemena fleckvieh v Bavorsku potvrdil tesnú závislosť medzi charakteris-

I. Vzťahy medzi ukazovateľmi mliekovej úžitkovosti, telovými mierami a hodnotenými znakmi exteriéru – Relations between the parameters of milk performance, body measurements and evaluated traits of body conformation

| Ukazovateľ[1] | $n$ | RPH mlieka kg[15] | RPH tuku kg[16] | RPH bielkovín kg[17] | Index mlieka Milchwert[18] |
|---|---|---|---|---|---|
| TELOVÉ MIERY[2] | | $r$ | | | |
| Výška na kohútiku[3] | 5 601 | $0{,}291^{+++}$ | $0{,}389^{+++}$ | $0{,}393^{+++}$ | $0{,}406^{+++}$ |
| Výška na krížoch[4] | 5 601 | $0{,}034^{+++}$ | $0{,}055^{+++}$ | $0{,}115^{+++}$ | $0{,}093^{+++}$ |
| Obvod hrudníka[5] | 5 601 | $0{,}144^{+++}$ | $0{,}203^{+++}$ | $0{,}239^{+++}$ | $0{,}237^{+++}$ |
| Dĺžka trupu[6] | 5 601 | $0{,}147^{+++}$ | $0{,}173^{+++}$ | $0{,}203^{+++}$ | $0{,}199^{+++}$ |
| RÁMEC TELA[7] | 2 261 | 0,011 | 0,004 | $0{,}068^{+}$ | 0,054 |
| OSVALENIE[8] | 2 261 | $-0{,}222^{+++}$ | $-0{,}216^{+++}$ | $-0{,}157^{+++}$ | −0,182 |
| STAVBA TELA[9] | 2 261 | 0,023 | 0,039 | 0,035 | 0,038 |
| VEMENO[10] | 2 261 | $0{,}182^{+++}$ | $0{,}212^{+++}$ | $0{,}183^{+++}$ | $0{,}203^{+++}$ |
| Predné štvrtky[11] | 2 261 | $0{,}271^{+++}$ | $0{,}273^{+++}$ | $0{,}257^{+++}$ | $0{,}275^{+++}$ |
| Zadné štvrtky[12] | 2 261 | $0{,}359^{+++}$ | $0{,}322^{+++}$ | $0{,}331^{+++}$ | $0{,}346^{+++}$ |
| Utváranie ceckov[13] | 2 261 | $0{,}100^{+++}$ | $0{,}164^{+++}$ | $0{,}123^{+++}$ | $0{,}141^{+++}$ |
| Postavenie ceckov[14] | 2 261 | $0{,}080^{+++}$ | $0{,}128^{+++}$ | $0{,}096^{+++}$ | $0{,}110^{+++}$ |

RPH = relatívna plemenná hodnota – relative breeding value

[1]trait, [2]body measurements, [3]withers height, [4]hip height, [5]chest circumference, [6]carcass length, [7]frame, [8]muscling, [9]body conformation, [10]udder, [11]fore udders, [12]rear udders, [13]teat position, [14]teat shape, [15]RBV – milk-kg, [16]RBV – fat-kg, [17]RBV – protein-kg, [18]milk index

tikami vemena, produkciou mlieka a produkciou tuku aj Sieber (1987).

Pozitívne a signifikantné vzťahy medzi utváraním vemena a výškou produkcie mlieka potvrdili vo svojich prácach aj Jones (1976), Speight, Fairlie (1977), Van Vleck et al. (1980), Urban et al. (1987) a Vravková, Huba (1996). Negatívne a štatisticky vysoko preukazne sa na hodnotených ukazovateľoch mliekovej úžitkovosti u dojníc strakatého dobytka prejavilo osvalenie ($r$ = –0,157 až –0,222), čo poukazuje na skutočnosť, že dojnice s lepším osvalením vyprodukovali menej mlieka a vo väčšej miere inklinovali k produkcii mäsa.

**Vplyv exteriéru na ukazovatele mäsovej úžitkovosti**

V rámci analýzy vzťahov telových mier k charakteristikám mäsovej úžitkovosti sme zistili pozitívne a signifikantné korelácie všetkých zisťovaných telových mier k netto prírastku (od 0,189 do 0,257) – tab. II. Jednoznačne negatívne sa prejavil vplyv zisťovaných telových mier na podiel mäsa v jatočnom tele, ako aj na obchodnú triedu pri kvalitatívnom hodnotení jatočných polovičiek ($r$ = –0,008 až –0,233). Averdunk (1993) potvrdzuje výsledky našej práce so zistenou koreláciou medzi výškou na kohútiku a netto prírastkom na úrovni $r$ = 0,24 a negatívnym vzťahom výšky na kohútiku k obchodnej triede EUROP. Problematikou hodnotenia vzťahov medzi utváraním exteriéru a mäsovou úžitkovosťou sa zaoberali aj Chrenek et al. (1992).

Pri hodnotení hlavného znaku – rámec tela – a čiastkových znakov sa na všetkých ukazovateľoch mäsovej úžitkovosti pozitívne prejavuje predovšetkým vplyv hĺbky tela ($r$ = 0,075 až 0,264) a šírky tela s korelačným koeficientom od 0,200 do 0,356 (tab. II). Významný a vysoko pozitívny vplyv na ukazovatele mäsovej úžitkovosti sme zistili u hlavného znaku – osvalenie – s hodnotami korelačného koeficientu 0,329 až 0,539 (tab. II). Pri čiastkových znakoch osvalenie predotrupia a osvalenie zadotrupia nadobúdali hodnoty korelačného koeficienta úroveň 0,303 až 0,506, resp. 0,322 až 0,536. Hodnotené znaky osvalenia sa najmarkantnejšie prejavili vo vzťahu k podielu mäsa v jatočnej polovičke ($r$ = 0,506 až 0,539). Vzájomné vzťahy medzi veľkosťou telesného rámca, osvalením a ukazovateľmi mäsovej úžitkovosti, ktoré uvádza Averdunk (1993), potvrdili zistené výsledky našej práce.

**Vplyv exteriéru na nepriame úžitkové vlastnosti**

Pri tejto skupine znakov má hodnotenie exteriéru podstatný význam, nakoľko sú charakteristické nižšími koeficientmi heritability.

K dojiteľnosti, ako funkčnej vlastnosti vemena, sa prejavil štatisticky významný vzťah všetkých hodnotených telových mier s hodnotami korelačného koeficienta od 0,149 do 0,487 (tab. III). Z hľadiska hodnotenia čiastkových znakov exteriéru má na dojiteľnosť pozitívny a vysoko preukazný vplyv utváranie predných štvrtiek vemena ($r$ = 0,203), zadných štvrtiek ($r$ = 0,197) a ceckov ($r$ = 0,161). Zistené vzťahy potvrdzujú poznatky viacerých autorov, že dojnice s lepšími tvarovými vlastnosťami vemena sa vyznačujú lepšou dojiteľnosťou, nevyhnutnou pre realizovanie technologickej selekcie v stádach dojníc.

K obsahu somatických buniek v mlieku sme zistili štatisticky preukazné pozitívne vzťahy u závesného

II. Vzťahy medzi ukazovateľmi mäsovej úžitkovosti, telovými mierami a hodnotenými znakmi exteriéru – Relations between the parameters of meat performance, body measurements and evaluated traits of body conformation

| Ukazovateľ[1] | n | RPH | RPH | RPH | Index mäsa |
|---|---|---|---|---|---|
| | | netto prírastok[17] | podiel mäsa[18] | obchodná trieda[19] | Fleischwert[20] |
| TELOVÉ MIERY[2] | | r | | | |
| Výška na kohútiku[3] | 4 029 | 0,189$^{+++}$ | –0,009$^{+++}$ | –0,233$^{+++}$ | 0,108$^{+++}$ |
| Výška na krížoch[4] | 2 636 | 0,236$^{+++}$ | –0,088$^{+++}$ | –0,186$^{+++}$ | 0,144$^{+++}$ |
| Obvod hrudníka[5] | 4 029 | 0,257$^{+++}$ | 0,182$^{+++}$ | –0,124$^{+++}$ | 0,229$^{+++}$ |
| Dĺžka trupu[6] | 3 981 | 0,246$^{+++}$ | –0,038$^{+++}$ | –0,139$^{+++}$ | 0,171$^{+++}$ |
| RÁMEC TELA[7] | 2 320 | 0,243$^{+++}$ | –0,056$^{+++}$ | –0,161$^{+++}$ | 0,163$^{+++}$ |
| Veľkosť tela[8] | 2 320 | 0,227$^{+++}$ | –0,085$^{+++}$ | –0,180$^{+++}$ | 0,139$^{+++}$ |
| Dĺžka tela[9] | 2 320 | 0,290$^{+++}$ | –0,005$^{+++}$ | –0,025$^{+++}$ | 0,242$^{+++}$ |
| Hĺbka tela[10] | 2 320 | 0,264$^{+++}$ | 0,228$^{+++}$ | 0,075$^{+++}$ | 0,286$^{+++}$ |
| Šírka tela[11] | 2 320 | 0,327$^{+++}$ | 0,356$^{+++}$ | 0,200$^{+++}$ | 0,392$^{+++}$ |
| OSVALENIE[12] | 2 320 | 0,323$^{+++}$ | 0,539$^{+++}$ | 0,351$^{+++}$ | 0,456$^{+++}$ |
| Predotrupie[13] | 2 320 | 0,303$^{+++}$ | 0,506$^{+++}$ | 0,311$^{+++}$ | 0,423$^{+++}$ |
| Stredo- a zadotrupie[14] | 2 320 | 0,322$^{+++}$ | 0,536$^{+++}$ | 0,354$^{+++}$ | 0,455$^{+++}$ |
| STAVBA TELA[15] | 2 320 | –0,008 | 0,099 | 0,025 | 0,017 |
| VEMENO[16] | 2 320 | –0,002 | 0,019 | –0,061 | –0,007 |

[1]trait, [2]body measurements, [3]withers height, [4]hip height, [5]chest circumference, [6]carcass length, [7]frame , [8]stature, [9]body length, [10]body depth , [11]body width, [12]muscling, [13]body forepart, [14]barrel and rump, [15]body conformation, [16]udder, [17]RBV – net gain, [18]RBV – meat content, [19]RBV – conformation score, [20]beef index

III. Vzťahy medzi nepriamymi úžitkovými vlastnosťami, telesnými mierami a hodnotenými znakmi exteriéru – Relations between indirect commercial traits, body measurements and evaluated traits of body conformation

| Ukazovateľ[1] | n | RPH dojiteľnosti[16] | n | RPH somatických buniek[17] | RPH priebehu pôrodov[18] |
|---|---|---|---|---|---|
| TELOVÉ MIERY[2] | | r | | | |
| Výška na kohútiku[3] | 2 355 | 0,487$^{+++}$ | 1 895 | 0,014$^{+++}$ | 0,393$^{+++}$ |
| Výška na krížoch[4] | 2 355 | 0,149$^{+++}$ | 1 895 | 0,014$^{+++}$ | 0,115$^{+++}$ |
| Obvod hrudníka[5] | 2 355 | 0,348$^{+++}$ | 1 895 | 0,025$^{+++}$ | 0,239$^{+++}$ |
| Dĺžka trupu[6] | 2 355 | 0,240$^{+++}$ | 1 895 | 0,016$^{+++}$ | 0,203$^{+++}$ |
| RÁMEC TELA[7] | 2 261 | 0,054 | 1 895 | 0,050 | 0,213$^{+++}$ |
| OSVALENIE[8] | 2 355 | –0,107$^{+++}$ | 1 895 | 0,100$^{+++}$ | 0,030 |
| STAVBA TELA[9] | 2 261 | 0,013 | 1 895 | 0,002 | 0,049$^{+}$ |
| VEMENO[10] | 2 355 | 0,163$^{+++}$ | 1 895 | 0,129$^{+++}$ | –0,003 |
| Predné štvrtky[11] | 2 355 | 0,203$^{+++}$ | 1 895 | 0,028$^{+++}$ | – |
| Zadné štvrtky[12] | 2 355 | 0,197$^{+++}$ | 1 895 | –0,232$^{+++}$ | – |
| Upnutie – závesný väz[13] | 2 355 | 0,092$^{+++}$ | 1 895 | 0,147$^{+++}$ | – |
| Utváranie ceckov[14] | 2 355 | 0,161$^{+++}$ | 1 895 | 0,140$^{+++}$ | – |
| Postavenie ceckov[15] | 2 355 | 0,086$^{+++}$ | 1 895 | 0,109$^{+++}$ | – |

[1]trait, [2]body measurements, [3]withers height, [4]hip height, [5]chest circumference, [6]carcass length, [7]frame, [8]muscling, [9]body conformation, [10]udder, [11]fore udders, [12]rear udders, [13]suspensory ligament, [14]teat shape, [15]teat position, [16]RBV – milkability, [17]RBV – somatic cell count, [18]RBV – calving ease

väzu ($r$ = 0,147) a utvárania a postavenia ceckov ($r$ = 0,109 až 0,140). Podobne nízke fenotypové korelácie medzi rámcom tela, stavbou tela a obsahom somatických buniek v mlieku zistili aj R o g e r s et al. (1991). Negatívna korelácia na úrovni $r$ = –0,232 bola zaznamenaná pri vzťahu zadných štvrtiek vemena k obsahu somatických buniek. Uvedená skutočnosť potvrdzuje viaceré poznatky zo štúdia danej oblasti, že priestranné, dobre rozložené a lepšie hodnotené zadné štvrtky pozitívne vplývajú na množstvo vyprodukovaného mlieka, rýchlejšie spúšťanie mlieka a tým zrejme na vyšší obsah somatických buniek v mlieku. Problematikou hľadania

vzťahov medzi tvarovými vlastnosťami vemena a počtom somatických buniek v mlieku sa zaoberali aj Monardes et al. (1990).

Pri hodnotení vplyvu exteriéru na priebeh pôrodov sme zaznamenali pozitívny vzťah všetkých telových mier k tomuto ukazovateľu ($r$ = 0,115 až 0,393), pričom najvyššiu hodnotu korelačného koeficienta (0,393) sme zistili k výške na kohútiku. Z toho vyplýva, že dojnice väčšieho telesného rámca majú nižší podiel komplikovaných pôrodov. Je pozoruhodné, že na hodnotenej sekundárnej úžitkovej vlastnosti sa neprejavil vplyv čiastkového znaku – sklon zadku, resp. utváranie chrbáta.

Výsledky našej práce dokázali, že lineárne hodnotenie exteriéru má v selekcii hovädzieho dobytka svoje opodstatnenie, pričom sa potvrdili viaceré pozitívne a signifikantné vzťahy medzi úžitkovými vlastnosťami a hodnotenými znakmi exteriéru.

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# ESTIMATION OF HERITABILITY OF LIPIZZANER HORSES FOR MORPHOLOGICAL TRAITS BY MEANS OF VARIOUS METHODS

## ODHAD DĚDIVOSTI MORFOLOGICKÝCH ZNAKŮ U LIPICÁNSKÝCH KONÍ POMOCÍ RŮZNÝCH METOD

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ABSTRACT: Heritability of morphological traits of Lipizzaner horses in Croatia was estimated by various methods. Heritability for withers height, obtained by the method of intraclass correlation, was somewhat higher ($h^2$ = 0.32) compared to the method of regression and the REML method ($h^2$ = 0.29 and 0.26, respectively). The same was estimated for chest girth and cannon bone circumference. For the three investigated traits the variance within sires was higher than the variance between sires. The heritability obtained by the ML method for withers height of mares exceeds the heritability estimated by the REML method for 0.01. For the chest girth, the estimated heritabilities by the ML and REML method show the same value. The heritability of the cannon bone circumference of mares estimated by the ML method is 0.02 higher than the heritability estimated by the REML method. The average heritability for body measurements at foaling and at six months of age increased with the increase of foaling number. For the first and second foaling heritability was $h^2$ = 0.27, and for the first to the fifth foaling it was $h^2$ = 0.34. The same trend was found for the heritability level of chest girth and cannon bone circumference at foaling and at six months of age. This points to slightly higher influence of genetic factors upon variability of the analysed morphological traits in later foalings.

Lipizzaner horse; morphological traits; intraclass correlation; offspring-on-dam-regression; ML; REML

**ABSTRAKT:** Pomocí různých metod jsme provedli odhad dědivosti morfologických znaků u lipicánských koní v Chorvatsku. Dědivost výšky v kohoutku, kterou jsme vypočítali na základě intraklasní korelace, byla poněkud vyšší ($h^2$ = 0,32) ve srovnání s hodnotami dědivosti vypočítanými regresní metodou a metodou restringované maximální věrohodnosti (REML) ($h^2$ = 0,29 a 0,26). Stejné metody jsme použili pro odhad dědivosti obvodu hrudníku a obvodu hlezna. U těchto tří šetřených znaků byl rozptyl uvnitř plemeníků vyšší než rozptyl mezi plemeníky. Dědivost výšky v kohoutku u klisen vypočítaná podle metody maximální věrohodnosti (ML) je vyšší než dědivost, jejíž odhad jsme získali pomocí metody REML. U obvodu hrudníku vykazují odhady dědivosti pomocí ML a REML shodné hodnoty. Dědivost obvodu hlezna vypočítaná pomocí metody ML je o 0,02 vyšší než podle REML. Průměrná dědivost tělesných rozměrů v době hřebení a v šesti měsících věku se zvyšovala s vyšším počtem porodů. Dědivost pro první a druhé hřebení činila $h^2$ = 0,27 a pro první až páté hřebení $h^2$ = 0,34. Stejný trend jsme zjistili pro výšku dědivosti obvodu hrudníku a obvodu hlezna v době hřebení a v šesti měsících věku. Naznačuje to mírně vyšší vliv genetických faktorů na variabilitu analyzovaných morfologických znaků při pozdějších porodech klisen.

lipicán; morfologické znaky; intraklasní korelace; regrese potomků na matku; metoda ML; REML

### INTRODUCTION

Estimation of genetic parameters is an important factor for a successful horse selection. A small number of investigations concerning genetic analysis of morphological and reproductive horse traits have been conducted in Croatia so far, whereas modern methods such as maximum likelihood and restricted maximum likelihood (ML and REML), as well as BLUP animal model have not been used at all. Methods for estimation of genetic parameters (variance analysis, regression analysis) and maximum likelihood methods that have been used so far, require a specific genetic data structure on height and the relation between the components of property variance and co-variance.

Heritability of body measurements (withers height, chest girth, cannon bone circumference) is a significant genetic parameter in horse breeding. Knowledge of genetic and phenotypic parameters for body measurements makes it possible to choose such horses which

show the optimal development and a desirable body frame. The aim of this paper was to estimate the heritability values for morphological traits of Lipizzaner horses, estimated by means of various methods. In completing this aim, the results by some European researchers regarding the estimation of genetic parameters of horses will be of great use for this paper.

According to the investigations conducted by Saastamoinnen (1990) estimation of heritability for body measurements of young horses was rather high and it increased as the horses grew older. The highest heritability estimated for paternal half-sib analysis was for body weight ($h^2 = 0.22 \pm 0.16$ to $h^2 = 0.88 \pm 0.27$), which was confirmed by Klemetsdal and Wallin (1986). The estimated heritability for cannon bone circumference was from $h^2 = 0.25 \pm 0.17$ to $h^2 = 0.56 \pm 0.20$, whereas for the absolute withers height the estimated heritability was $h^2 = 0.67 \pm 0.27$. The heritability for total withers height increase at young horses was low and it had large standard errors, especially during their first years. The estimation of heritability performed by this investigation was within the limits predetermined for developing horses. In order to estimate the influence upon withers height and main body indices of riding horses Sabeva (1995) used the estimation of variability and heritability, multifactor analyses of variability and progeny testing by the BLUP method. Such an estimation of heritability for body indices varied from $h^2 = 0.28$ to $h^2 = 0.37$. According to Grosshauser and Butler-Wamken (1993) heritability for withers height measured by a stick was $h^2 = 0.55$, and $h^2 = 0.60$, when measured by tape, whereas the estimates for chest girth and cannon bone circumference were $h^2 = 0.66$ and $h^2 = 0.44$, respectively.

Fedorsky and Pikuta (1988a, b) found the following heritability estimates for two-year old foals: $h^2 = 0.28$ for withers height, $h^2 = 0.44$ for chest girth, and $h^2 = 0.12$ for cannon bone circumference. At the age of three years withers height was $h^2 = 0.19$, whereas chest girth and cannon bone circumference were $h^2 = 0.30$, and $h^2 = 0.08$, respectively.

The method of restricted maximum likelihood (REML) has recently been presented as the method with the most desirable statistical properties for the estimation of variance components. Estimation of genetic parameters by this method was introduced by Buttram et al. (1988a, b, c), Huizinga et al. (1990), Oki et al. (1995), Arnason, Sigurdsson (1997), Christmann, Bruns (1997), Gerber et al. (1997), Janssens et al. (1997) and Nowicka-Posluszna et al. (1997).

## MATERIAL AND METHODS

The state-owned stud farm of Lipizzaner horses in Dakovo is recognized all over Europe, because for centuries it has been known for its high-quality Lipizzaner horse-breed. Today this stud farm has seven sire lines and twelve dam families with the total number of 177 adult horses. Our investigation included 92 mares, 55 stallions and 432 foals.

The material for this study was obtained from the Lipizzaner stud-book of the Horse-Breeding Centre in Dakovo. The data presented in this paper concern individuals with a three-generation pedigree, which made it possible to analyse the genetic and phenotypic changes through generations. Morphological traits observed included body measurements (withers height, chest girth, cannon bone circumference) of mares and foals at foaling and at six months of age.

Various methods for the estimation of heritability have been used, i.e.

- Intraclass correlation (ANOVA)
- Offspring-on-dam regression
- Maximum likelihood method – ML
- Restricted maximum likelihood method – REML.

Heritability obtained by intraclass correlation and its standard errors were derived from the components of sire variances, whereas the estimation by regression was based on the dam mare-foal relation.

Estimation of heritability by means of the ML and REML methods was based on the components of sire variances, whereas the model itself had previously been adapted to the specific qualities of the available data.

The estimation of $h^2$ for the properties observed was deduced individually and on an average by the method of intraclass correlation.

For the estimation of $h^2$ by the restricted maximum likelihood method (REML) – multidimenzional classification – the following mixed model has been used:

$$Y = Xb + Zu + e \quad (1)$$

where: $Y, b, u, e$ – vectors of variables including fixed effects, random sire effect and "error"

$X, Z$ – matrix of variable phenotypic unexpected influences with the following expected ($E$) values

$$E(Y) = Xb \quad (2)$$

$$E(u) = E(e) = 0 \quad (3)$$

$$V(u) = G \quad (4)$$

$$V(e) = R \quad (5)$$

Cov $(u, e) = 0$, whence follows that $V(Y) = V = ZGZ' + R$

Differently from the method of maximum likelihood (ML), which maximizes the probability logarithm of the data vector ($Y$) during the production, ignoring the differences which appeared under the influence of selection and some other systematic influences, the method of restricted maximum likelihood (REML) replaces ($Y$) with ($SY$), the linear function of the changeable values observed with the expected zero values. The matrix ($S$) is symmetrical and equals the total number of the variables, $N$, the rank $(N - p)$ where $(p)$ is the rank of the column $X$, with $SX = 0$ whereby follows:

$E(SY) = 0$, and the variance $V(SY) = SYS$

In the case that the values $S$ are not equal in all the repetitions, as it can happen with the number of mares in consecutive foalings, then the inversion of the probable function is not needed. Otherwise this function can be found and used in the general form of the inversion.

The values for the components of variance are as follows:

$$E(u) = G \tag{6}$$

$$V(e) = R \tag{7}$$

The co-variance of the variables indicates the following values: Cov $(u, e) = 0$, whereby the total variance is:

$$V(Y) = V = ZGZ' + R \tag{8}$$

where: $G$ – additive genetic component for the variance and co-variance of the individual property
$R$ – correlation between the variable values within the model

Average heritability values of the properties estimated in cases of consecutive foalings were calculated by means of the following formula:

$$h_n^2 = \frac{n}{1 + (n-1)\,r} \cdot h_2 \tag{9}$$

where: $n$ – foaling number
$r$ – average phenotypic correlation between individual foalings for the investigated properties
$h^2$ – individual heritability values for withers height, chest girth, and cannon bone circumference

The heritability by the intraclass correlation and the offspring on-dam regression was calculated by the following formulas:

Intraclass correlation:

$$h_0^2 = \frac{4 \cdot \sigma_0^2}{\sigma_0^2 + \sigma_p^2} = \sigma_F^2 \tag{10}$$

where: $\sigma_0^2$ – variance between sires
$\sigma_p^2$ – variance within sires

Standard error:

$$SE_{h^2} = \sqrt{\frac{2(n-1)(1-t)^2[1+(k-1)\,t]^2}{k^2\,(n-o)(o-1)}} \tag{11}$$

where: $o$ – sire number
$n$ – total offspring number
$t$ – intraclass correlation
$k$ – average offspring number for sire with an unequal offspring number

Regression:

$$h^2 = 2\,.\,b \tag{12}$$

## RESULTS AND DISCUSSION

Table I shows the heritability and the variance components between the sires, as well as the variance within sires for the morphological traits of mares and foals. These data were obtained by various methods: regression (mare – offspring), intraclass correlation and REML method for the three body measurements mentioned. Heritability of morphological traits of Lipizzaner horses in Croatia varied, depending on the trait and the method applied.

Heritability for withers height (calculated by means of intraclass correlation) was somewhat higher $h^2$ = 0.32 than the values obtained by the method of offspring on-dam regression and REML method ($h^2$ = 0.29, and $h^2$ = 0.26, respectively). The same was found for chest girth and cannon bone circumference, as can be seen from Table I. Differently from the maximum likelihood method (ML), which ignores the differences resulting from selection and other systematic influences, REML method takes those differences into account. REML is the method of restricted maximum likelihood which has the most desirable statistical properties for the estimation of variance components. The investigations conducted by means of this method re-

I. Heritability and the components of the variance between and within sires for the morphological traits of mares and foals

| Methods | Withers height | | | | | |
|---|---|---|---|---|---|---|
| | $h^2$ | $SE_{h^2}$ | $\sigma^2_{bs}$ | $SE_{bs}$ | $\sigma^2_{ws}$ | $SE_{ws}$ |
| 1. Offspring-on-dam regression | 0.29 | 0.08 | 32.31 | 10.13 | 344.17 | 13.11 |
| 2. Intraclass correlation | 0.32 | 0.12 | 44.22 | 11.10 | 371.18 | 12.37 |
| 3. REML | 0.26 | 0.07 | 45.67 | 10.05 | 409.27 | 11.45 |
| | Chest girth | | | | | |
| 1. Offspring-on-dam regression | 0.24 | 0.12 | 29.44 | 12.33 | 277.13 | 15.56 |
| 2. Intraclass correlation | 0.28 | 0.13 | 34.88 | 14.87 | 288.23 | 16.38 |
| 3. REML | 0.25 | 0.10 | 35.86 | 10.24 | 301.43 | 13.47 |
| | Cannon bone circumference | | | | | |
| 1. Offspring-on-dam regression | 0.20 | 0.10 | 28.43 | 14.31 | 267.14 | 17.14 |
| 2. Intraclass correlation | 0.23 | 0.13 | 36.17 | 13.96 | 271.10 | 16.54 |
| 3. REML | 0.16 | 0.09 | 35.98 | 12.84 | 283.56 | 12.86 |

For Tabs. I–III: $h^2$ – heritability, $SE_{h^2}$ – standard error of heritability, $\sigma^2_{bs}$ – variance between sires, $\sigma^2_{ws}$ – variance within sires, $SE_{bs}$ – standard error between sires, $SE_{ws}$ – standard error within sires

II. Heritability estimation of morphological traits of mares and foals by the method of maximum likelihood (ML)

| Traits | $h^2$ | $SE_h^2$ |
|---|---|---|
| MARES | | |
| Withers height in cm | 0.27 | 0.09 |
| Chest girth in cm | 0.25 | 0.09 |
| Cannon bone circumference in cm | 0.18 | 0.07 |
| FOALS | | |
| **At foaling:** | | |
| Withers height in cm | 0.26 | 0.10 |
| Chest girth in cm | 0.20 | 0.10 |
| Cannon bone circumference in cm | 0.22 | 0.12 |
| **At six months of age:** | | |
| Withers height in cm | 0.27 | 0.11 |
| Chest girth in cm | 0.24 | 0.12 |
| Cannon bone circumference in cm | 0.19 | 0.09 |

used various methods for the estimation of the heritabilities.

The heritability for withers height of mares (Table II) obtained by the method of maximum likelihood (ML) is 0.01 higher than the heritability estimated by the method of restricted maximum likelihood (REML). For the chest girth, the estimated heritabilities by the ML and REML method show the same value. The heritability of the cannon bone circumference of mares estimated by the ML method is 0.02 higher than the heritability estimated by the REML method. According to Rastija et al. (1995) the highest heritability value obtained by the method of correlation of the offspring of the same parent was found in foals at the age of six months. The values for withers height, chest girth, and cannon bone circumference were $h^2 = 0.80 \pm 0.25$, $h^2 = 0.30 \pm 0.16$, and $h^2 = 0.58 \pm 0.21$, respectively. Heritability values of young Finnish horses for all three

III. Average heritability for morphological traits of foals at foaling and at six months of age

| Traits | Foalings in chronological order | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 + 2 | | 1 + 2 + 3 | | 1 + 2 + 3 + 4 | | 1 + 2 + 3 + 4 + 5 | |
| | $h^2$ | $SE_{h^2}$ | $h^2$ | $SE_{h^2}$ | $h^2$ | $SE_{h^2}$ | $h^2$ | $SE_{h^2}$ |
| **At foaling:** | | | | | | | | |
| Withers height | 0.27 | 0.10 | 0.29 | 0.09 | 0.30 | 0.09 | 0.34 | 0.08 |
| Chest girth | 0.19 | 0.09 | 0.22 | 0.08 | 0.25 | 0.09 | 0.26 | 0.08 |
| Cannon bone circumference | 0.14 | 0.09 | 0.18 | 0.08 | 0.21 | 0.09 | 0.22 | 0.07 |
| **At six months of age:** | | | | | | | | |
| Withers height | 0.24 | 0.09 | 0.26 | 0.09 | 0.30 | 0.09 | 0.33 | 0.07 |
| Chest girth | 0.16 | 0.09 | 0.23 | 0.09 | 0.27 | 0.09 | 0.30 | 0.08 |
| Cannon bone circumference | 0.13 | 0.07 | 0.17 | 0.08 | 0.20 | 0.08 | 0.21 | 0.07 |

veal that in the three properties observed the variance within sires exceeded the variance between sires.

The investigations conducted by various authors indicate that there is a considerable variability concerning the estimation of heritabilities. Grundler (1977) and Grundler, Pirchner (1991) found that the average heritability for withers height was $h^2 = 0.34$. Hintz et al. (1978) estimate the heritability between $h^2 = 0.33$ and $h^2 = 0.88$ for withers height and between $h^2 = 0.12$ and $h^2 = 0.77$ for cannon bone circumference. Seidlitz et al. (1991) show the following heritabilities values: $h^2 = 0.48 \pm 0.12$ for withers height, $h^2 = 0.31 \pm 0.16$ for chest girth, and $h^2 = 0.51 \pm 0.14$ for cannon bone circumference. According to Samoré and Rosati (1995) heritability for withers height of males and females is $h^2 = 0.56$ and $h^2 = 0.49$, respectively. Heritability estimated on the basis of correlation for withers height measured by a stick is $h^2 = 0.32$, $h^2 = 0.24$ for chest girth, and $h^2 = 0.55$ for cannon bone circumference Butler and Krollikowsky (1986). Such different heritability values for the three traits are not beyond anticipation because these authors

body measurements according to Saastamoinen (1990) and Saastamoinen, Ojala (1991) were higher at advanced age. According to Klemetsdal and Wallin (1986) during the first year of the foals' life the withers height was low and it had large standard errors. According to Butler (1986) heritability for withers height and chest girth was $h^2 = 0.25$, and $h^2 = 0.27$, respectively, which corresponds to the results of our study. However, heritability values for cannon bone circumference presented by Butler (1986), $h^2 = 0.47$, exceed those obtained by our investigations. Varo (1965) claims that the heritability for cannon bone circumference is significantly lower ($h^2 = 0.13$) than the heritability for withers height ($h^2 = 0.26$) and chest girth ($h^2 = 0.23$). Accordingly, the results shown by these authors concur with the results of our investigations.

Average heritability for withers height at foaling and at six-months of age (Table III) increased along with the increase of the foaling number. For example, heritability for withers height was $h^2 = 0.27$ for the first two foalings together, and $h^2 = 0.29$, $h^2 = 0.30$, $h^2 =$

0.34 for three, four, and five consecutive foalings, respectively. The same trend was found for heritability height of chest girth and cannon bone circumference at foaling and at six-months of age, as well. This indicates that the influence of genetic factors upon the variability of the investigated morphological traits is somewhat lower at first foalings than at later ones.

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**Komise genetiky a šlechtění zvířat ČAZV**

**Sekcia genetiky, šľachtenia a chovu zvierat SAPV**

**Jihočeská univerzita, Zemědělská fakulta, České Budějovice**

pořádají 8.–10. září 1989 v Českých Budějovicích
mezinárodní vědeckou konferenci

# XVIII. GENETICKÉ DNY

Konference se koná již tradičně v pravidelných dvouletých intervalech se zaměřením na genetiku a šlechtění zvířat. Jejím cílem je soustředit nejnovější vědecké poznatky ze širokého spektra genetických disciplín od základního až po aplikovaný výzkum.

**Tematické okruhy:**

1. Molekulární genetika a cytogenetika
2. Biotechnologické metody v reprodukci a šlechtění
3. Genetika zdraví a rezistence
4. Teoretické základy genetiky a šlechtění zvířat
5. Genetika a šlechtění skotu
6. Genetika a šlechtění prasat
7. Genetika a šlechtění koní, ovcí a koz
8. Genetika a šlechtění drůbeže
9. Genetika a šlechtění ryb
10. Genetika a šlechtění ostatních druhů hospodářských zvířat
11. Genetická diverzita
12. Software v genetice a šlechtění zvířat
13. Výuka genetiky a šlechtění zvířat
14. Volná sdělení

**Výkonným předsedou přípravného výboru konference** je prof. Ing. Václav Řehout, CSc. (registrace přihlášek), Jihočeská univerzita, Zemědělská fakulta, 370 05 České Budějovice, tel.: 038/777 25 90, fax: 038/777 25 93, e-mail: rehout@zf.jcu.cz.

Abstrakty příspěvků přednesených na konferenci budou uveřejněny v čísle 9/1998 časopisu Czech Journal of Animal Science.

**Pokud máte zájem o výtisk tohoto čísla, můžete si ho do 31. 7. 1998 objednat na adrese:**

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# DAIRY AND REPRODUCTIVE PERFORMANCE OF IMPORTED HOLSTEIN CATTLE

## MLÉČNÁ UŽITKOVOST A UKAZATELE REPRODUKCE U IMPORTOVANÉHO HOLŠTÝNSKÉHO SKOTU

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**ABSTRACT:** Production traits (import to first calving period, first and second lactation milk performance, protein and fat yield) and fertility traits (calving interval, calving to first insemination interval, service period, first service conception rate, conception rate and services per conception) were analysed in imported Holstein cattle. 544 first calver cows were used for the analyses. Data were analysed by SAS/STAT® program using mixed model least squares and maximum likelihood method. A model of analysis contained effects of farm, first calving season and import to first calving period. Import to first calving period had significant effect on first lactation length, hundred days of first lactation milk performance and protein yield. Long ($P \leq 0.01$) import to first calving period was observed in farm II and III and short ($P \leq 0.01$) import to first calving period was observed in farm I. Farm II had high ($P \leq 0.01$) protein yield at hundred days of first lactation and during second lactation. Low ($P \leq 0.01$) first lactation protein yield was recorded in farm I. Farm II had high ($P \leq 0.01$) second lactation milk performance. Significantly best fertility traits were determined in farm III. Except service period first calving season had no significant effect on analysed fertility traits. Import to first calving period effect was insignificant on analysed reproductive traits. Finally, before importation of highly improved breed the preparation of farms to provide proper nutrition and management is the most important paragenetic factor.

Holstein cattle; dairy performance; fertility traits; first calving period

**ABSTRAKT:** Analýza produkčních ukazatelů (délka období od importu do prvního otelení, produkce mléka, bílkovin a tuku v první a druhé laktaci) a ukazatelů reprodukce (mezidobí, interval, servis perioda, procento zabřeznutí po první inseminaci, procento zabřeznutí celkem a počet připuštění na zabřeznutí) byla provedena u importovaného holštýnského plemene. Do analýzy bylo zahrnuto celkem 544 krav. Byl použit program SAS/STAT® (metoda nejmenších čtverců s maximální věrohodností). Model analýzy zahrnoval efekty farmy, období prvního otelení a délky období od importu do prvního otelení. Délka období od importu do prvního otelení měla průkazný vliv na délku první laktace a dále na stodenní produkci mléka a bílkovin v prvé laktaci. Nejdelší ($P \leq 0,01$) období od importu do prvního otelení bylo zjištěno na farmách II a III a nejkratší ($P \leq 0,01$) období na farmě I. Na farmě II byla zjištěna nejvyšší ($P \leq 0,01$) produkce bílkovin ve sto dnech první laktace a v laktaci druhé. Nejnižší ($P \leq 0,01$) produkce bílkovin v první laktaci byla zjištěna na farmě I. Na farmě II byla zaznamenána nejvyšší ($P \leq 0,01$) celková produkce mléka v druhé laktaci. Průkazně nejlepší hodnoty ukazatelů reprodukce byly zjištěny na farmě III. Období prvního otelení s výjimkou servis periody nemělo průkazný vliv na ostatní sledované ukazatele. Období od importu do prvního otelení nemělo průkazný vliv na ukazatele reprodukce. Ukazuje se, že nejvýznamnějším negenetickým faktorem při dovozu vysoce prošlechtěného plemene je příprava farmy na optimální výživu a náročnou organizaci chovu.

holštýnské plemeno; mléčná produkce; ukazatele reprodukce; období prvního otelení

### INTRODUCTION

The trait of primary importance in dairy cattle is obviously milk production, qualified by fat, protein and total solids (Gordon, 1993). Increasing the productive efficiency of dairy cattle populations remains an important challenge at commercial dairy farms aiming for increased productivity in milk production. The performance and/or adaptation of European (temperate) dairy breeds and their crosses under different environmental conditions have been reviewed (Bondoc et al., 1989). Because of general superiority of Holstein cattle for milk production, especially in temperate climates, in the past few years interest has focused on forming commercial dairy farms (through importation) in the Czech Republic. However, the highly commercial and specialised dairy cattle husbandry system practised in the developed West European countries may be

biologically and economically suitable in the Czech Republic.

Reproductive efficiency is a major determinant of productivity in all livestock operations and is dependent on management, nutrition and genetic factors. Ideally, the calving interval should be, on the average, one year but this can only be achieved if the traits of conception and detection of oestrus are high and the interval between parturition and first service is less than 90 days. The question of optimal calving and effects of a change of calving interval or days open are often discussed. Some studies have found short days open of 30 to 60 days to be optimal. Others have indicated intermediate optima between 90 to 120 days open (Strandberg, Oltenacu, 1989). Reproductive performance is a sensitive indicator of the level of adaptation provided that diet is adequate and proper. Consequently, reproductive efficiency must be viewed as a phenotypic expression of the interplay of genetic and environmental factors. The objective of the present study is to evaluate the productive and reproductive efficiency of imported Holstein cattle.

## MATERIAL AND METHODS

Basic data were obtained from three dairy farms located in central Bohemia. These dairy farms from 1993–1995 imported pregnant Holstein heifers from France. Farm I had 568 lactation records from 284 cows. Cows were kept indoors in stanchionless housing and offered mixed ration (30 kg corn silage, 14 kg haylage, 1 kg hay and 10 kg concentrate) twice daily. Milking is twice daily in tandem parlour.

Farm II had 288 lactation records from 144 cows. Animals were kept indoors in loose housing arrangement and offered mixed ration (10 kg corn silage, 15 kg haylage, 1.5 kg hay, 7 kg corn cobs) thrice daily. Cows were grouped into three groups according to their daily milk production, i.e. ≥ 38 litres of milk per day, ≥ 27 litres of milk per day and ≥ 16 litres of milk per day. Concentrate feeding for ≥ 38 litres of milk production was 4.70 kg per day, for ≥ 27 litres of milk 2.20 kg per day and for ≥ 16 litres of milk 0.50 kg per day. The herd was milked thrice daily during first half of lactation and twice daily at second half of lactation in 4 x 5 autotandem parlour.

Farm III had 232 lactation records from 116 cows. Cows were kept indoors in stanchionless housing arrangement and offered mixed ration (30 kg corn silage, 18 kg haylage and 2 kg hay) twice daily. Concentrate feeding is according to lactation phases, i.e. 0.40 kg during the first 100 days of lactation, 0.30 kg 101–240 days of lactation and 0.10 kg until end of lactation. Milking was twice daily in tandem parlour.

Date of birth, date of import and calving date were collected from individual farms. Records of all inseminations and reinseminations of these herds were collected from the insemination files of individual farms and matched with the lactation records. Data on first and second lactation production records were obtained from official milk efficiency control. Second lactation herd production level was characterised by 305 day mature equivalent milk production.

Specific productive traits selected for analyses were import to 1st calving, period 100 days of 1st lactation milk and protein yield, 1st lactation milk, protein and fat yield, 1st lactation length and 2nd lactation milk, protein and fat yield. In order to describe first lactation herd fertility retrospectively, selected fertility traits were calving interval, calving to first insemination interval, service period, first service conception rate, conception rate and services per conception.

Observations of first calving season analyses were assigned to four seasons of the year (January to March, April to June, July to September and October to December). Import to first calving period was classified by the following method into four classes:

| | | | |
|---|---|---|---|
| $y \leq x - s$ | class 1 | ≤ 25 days | $n = 55$ |
| $x - s < y \leq x$ | class 2 | 26–64 days | $n = 263$ |
| $x < y \leq x + s$ | class 3 | 65–103 days | $n = 191$ |
| $y \geq x + s$ | class 4 | ≥ 104 days | $n = 35$ |

where: $y$ – number of days from import to first calving
$x$ – the average number of days from import to first calving
$s$ – standard deviation

Statistical analyses were done using statistical program SAS/STAT® by mixed model least squares and maximum likelihood method. Differences between least squares means for the effect of farm on production and reproduction traits were tested by Duncan's multiple range test modified by Kramar. The following statistical model was used for the analysis:

$$Y_{ijkl} = \mu + A_i + B_j + C_k + \beta(X_{ijk} - X) + e_{ijkl}$$

where:
$Y_{ijkl}$ – obtained values of observed traits
$\mu$ – overall mean
$A_i$ – effect of farm
$B_j$ – effect of first calving season
$C_k$ – effect of import to first calving period
$\beta(X_{ijk} - X)$ – regression of age at first calving
$e_{ijkl}$ – random residual

## RESULTS AND DISCUSSION

### Dairy performance

Dairy performance of imported Holstein cattle was analysed and mutually compared. The overall means and standard deviations of the traits in the analyses are presented in Table I. Import to first calving period is an interesting factor from the breeders point of view during importation of highly improved breeds, because of acclimatisation processes to the new environment. Import to first calving period had significant effects on hundred days of first lactation milk yield ($P \leq 0.05$), protein yield ($P \leq 0.01$) and first lactation days ($P \leq 0.05$) (Table II). Farm and first calving season had sig-

I. Overall means and standard deviations of production and reproduction traits

| Source of variation | | | Mean | s.d. |
|---|---|---|---|---|
| Import – 1st calving period | | (days) | 64.07 | 39.46 |
| 100 days of 1st lactation: | milk | (kg) | 2 330.62 | 481.16 |
| | protein | (kg) | 73.39 | 17.27 |
| 1st lactation: | days | | 287.46 | 23.48 |
| | milk | (kg) | 5 814.87 | 1 397.43 |
| | protein | (kg) | 189.88 | 48.76 |
| | fat | (kg) | 251.86 | 64.24 |
| 2nd lactation: | milk | (kg) | 7 938.06 | 1 442.18 |
| | protein | (kg) | 261.94 | 47.29 |
| | fat | (kg) | 366.12 | 70.31 |
| Calving interval | | (days) | 407.8 | 84.1 |
| Calving to 1st insemination | | (days) | 83.6 | 41.0 |
| Service period | | (days) | 128.6 | 82.5 |
| 1st service conception rate | | (%) | 70.7 | 31.3 |
| Conception rate | | (%) | 62.9 | 32.2 |
| Services per conception | | | 2.25 | 1.56 |

s.d. = standard deviation

nificant ($P \leq 0.001$) effects on import to first calving period. Long ($P \leq 0.01$) import to first calving period was observed in farm II and farm III and short ($P \leq 0.01$) import to first calving period was observed in farm I. Differences of import to first calving periods between farm II and III were insignificant (Table III).

Information is scarce regarding the optimum import to first calving period during importation of a highly improved breed to the Czech Republic. However, import to first calving period results of the present study do not agree with Urban (1989). The disagreement between the study of Urban (1989) and this study may be due to different number of observations. Overall, this study on 544 first calver cows suggested the need for further analysis with higher number of observations.

The mean hundred days of first lactation milk and protein yield of farm I and farm III are below mean values but farm II had above mean values (Table IV). Least squares means for the effects of farm on hundred days of first lactation milk and protein yield (Table III) show that farm II had significantly ($P \leq 0.01$) high protein production. Hundred days of first lactation protein yield differences between farm I and III were insignificant.

First calving season and import to first calving period had significant ($P \leq 0.05$) effects on first lactation length (Table II). Statistically insignificant effect of farm was determined from the assessment of the relation to first lactation length. Least squares means for the effect of farm show that all three farms had almost similar first lactation length (Table III). Many factors are involved in the increase or decrease of lactation length which might affect the total milk yield of a cow. As indicated in some recent studies short first lactation length of first calver cows is a normal physiological phenomenon. Payne (1990) deduced that first calver cows should be dried off after approximately 260 to 270 days and given 90 to 100 days dry period, i.e. they should be allowed longer dry periods than cows, where they are likely to continue to grow throughout the first

II. *F*-test values and statistical significance of farm, first calving season and import to first calving period code effects on production and reproduction traits

| Source of variation | | | Farm | 1st calving season | Import to 1st calving period code |
|---|---|---|---|---|---|
| Import – 1st calving period | | (days) | 14.85*** | 4.86*** | 199.4*** |
| 100 days of 1st lactation: | milk | (kg) | 1.76 | 4.20*** | 3.09* |
| | protein | (kg) | 20.19*** | 8.65*** | 3.89** |
| 1st lactation: | days | | 1.35 | 2.77* | 2.69* |
| | milk | (kg) | 5.22** | 9.00*** | 0.81 |
| | protein | (kg) | 18.11*** | 10.97*** | 0.90 |
| | fat | (kg) | 2.24 | 7.48*** | 0.68 |
| 2nd lactation | milk | (kg) | 3.63* | 7.13*** | 1.47 |
| | fat | (kg) | 15.24*** | 6.18*** | 1.38 |
| | protein | (kg) | 8.75*** | 6.14*** | 0.90 |
| Calving interval | | (days) | 3.51* | 1.80 | 0.27 |
| Calving to 1st insemination | | (days) | 5.04** | 1.35 | 1.92 |
| Service period | | (days) | 6.10** | 2.22* | 0.05 |
| 1st service conception rate | | (%) | 6.08** | 1.15 | 0.12 |
| Conception rate | | (%) | 10.37*** | 1.63 | 0.61 |
| Services per conception | | | 6.06** | 1.93 | 0.45 |

* $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$

III. Least squares means and standard errors for the effect of farm on production and reproduction traits

| Source of variation | | | | Farm I $n = 284$ | Farm II $n = 144$ | Farm III $n = 116$ |
|---|---|---|---|---|---|---|
| Import – 1st calving period | | (days) | $\mu$ | $66.87^{A}$ | $74.28^{B}$ | $79.73^{B}$ |
| | | | $s_\mu$ | 2.20 | 2.53 | 2.65 |
| 100 days of 1st lactation: | milk | (kg) | $\mu$ | 2 301.07 | 2 385.79 | 2 269.71 |
| | | | $s_\mu$ | 51.92 | 59.65 | 62.59 |
| | protein | (kg) | $\mu$ | $71.68^{A}$ | $81.89^{B}$ | $70.93^{A}$ |
| | | | $s_\mu$ | 1.68 | 1.93 | 2.03 |
| 1st lactation: | days | | $\mu$ | 289.62 | 285.45 | 290.11 |
| | | | $s_\mu$ | 2.69 | 3.09 | 3.24 |
| | milk | (kg) | $\mu$ | $5\ 448.22^{A}$ | $5\ 913.40^{BC}$ | $5\ 723.40^{AC}$ |
| | | | $s_\mu$ | 150.48 | 172.89 | 181.39 |
| | rotein | (kg) | $\mu$ | $174.17^{A}$ | $203.17^{B}$ | $189.51^{B}$ |
| | | | $s_\mu$ | 4.97 | 5.71 | 5.99 |
| | fat | (kg) | $\mu$ | 236.12 | 250.88 | 239.20 |
| | | | $s_\mu$ | 7.03 | 8.08 | 8.47 |
| 2nd lactation: | milk | (kg) | $\mu$ | $7\ 944.21^{a}$ | $8\ 128.05^{a}$ | $7\ 537.89^{b}$ |
| | | | $s_\mu$ | 161.67 | 185.74 | 194.87 |
| | protein | (kg) | $\mu$ | $255.12^{A}$ | $282.11^{B}$ | $252.28^{A}$ |
| | | | $s_\mu$ | 5.17 | 5.94 | 6.24 |
| | fat | (kg) | $\mu$ | 376.46 | 351.76 | 344.65 |
| | | | $s_\mu$ | 7.90 | 9.08 | 9.52 |
| Calving interval (days) | | | $\mu$ | $406.6^{a}$ | $418.5^{a}$ | $383.1^{b}$ |
| | | | $s_\mu$ | 9.8 | 11.2 | 11.8 |
| Calving to 1st insemination | | (days) | $\mu$ | $75.1^{A}$ | $90.0^{BC}$ | $76.8A^{C}$ |
| | | | $s_\mu$ | 4.7 | 5.4 | 5.7 |
| Service period | | (days) | $\mu$ | $126.4^{A}$ | $140.2^{A}$ | $95.0^{B}$ |
| | | | $s_\mu$ | 9.5 | 11.0 | 11.5 |
| 1st service conception rate | | (%) | $\mu$ | $64.5^{A}$ | $70.3^{AC}$ | $79.2^{BC}$ |
| | | | $s_\mu$ | 3.6 | 4.1 | 4.4 |
| Conception rate | | (%) | $\mu$ | $63.6^{A}$ | $51.1^{B}$ | $73.4^{C}$ |
| | | | $s_\mu$ | 3.7 | 4.2 | 4.4 |
| Services per conception | | | $\mu$ | 2.22 | 2.64 | 1.78 |
| | | | $s_\mu$ | 0.18 | 0.21 | 0.22 |

$^{A,B}$ Means denoted with different letters are significantly different at $P \leq 0.01$
$^{a,b}$ Means denoted with different letters are significantly different at $P \leq 0.05$

lactation. Zdravkovic et al. (1990) found 297 days of first lactation length in first lactating Holstein cows. Chi et al. (1994) in first lactating Holstein cows found 301 days of first lactation length, which is longer than the present study. Urban (1989) found 363 days of first lactation length in imported Holstein first calver cows ($n$ = 28) and does not agree with the present study.

First lactation milk, protein and fat yield of farm I and farm III are below mean values and Farm II had above mean values of milk, protein and fat yield (Table IV). As presented in Table II farm had significant effects on first lactation milk performance ($P \leq 0.01$) and protein yield ($P \leq 0.001$) but not on fat yield. High first lactation protein production ($P \leq 0.01$) was recorded in farm II and III but low ($P \leq 0.01$) protein yield was recorded in farm I. Pryce et al. (1997) reported 305-day first lactation milk performance of 5765 kg. Motyčka et al. (1997) found standardised first lactation production performance of 6514 kg milk, 213 kg protein and 281 kg fat in imported Holstein cows. Urban (1989) found 5313.89 kg milk and 175.59 kg fat in imported Holstein first calver cows ($n$ = 28), which is lower than the present study. Graham et al. (1991) found 6097 kg milk, 226 kg protein, 231 kg fat in first lactating Canadian Holstein cows and their finding was 282 kg milk and 36.2 kg protein higher than, and 20.8 kg fat lower than in the present

IV. Means and standard deviations of production and reproduction traits of farms

| Source of variation | | | | Farm I | Farm II | Farm III |
|---|---|---|---|---|---|---|
| Import – 1st calving period | | (days) | μ | 48.24 | 83.35 | 78.92 |
| | | | s.d. | 29.36 | 49.03 | 30.54 |
| 100 days of 1st lactation: | milk | (kg) | μ | 2 284.36 | 2 488.70 | 2 247.63 |
| | | | s.d. | 475.45 | 537.23 | 366.69 |
| | protein | (kg) | μ | 70.36 | 85.09 | 68.69 |
| | | | s.d. | 17.75 | 19.31 | 10.99 |
| 1st lactation: | days | | μ | 287.27 | 285.09 | 290.87 |
| | | | s.d. | 24.38 | 24.33 | 19.64 |
| | milk | (kg) | μ | 5 595.54 | 6 379.84 | 5 650.51 |
| | | | s.d. | 1 378.43 | 1 432.29 | 1 203.26 |
| | protein | (kg) | μ | 177.45 | 218.40 | 184.93 |
| | | | s.d. | 44.69 | 51.42 | 39.99 |
| | fat | (kg) | μ | 245.26 | 275.28 | 238.93 |
| | | | s.d. | 63.95 | 67.31 | 53.16 |
| 2nd lactation: | milk | (kg) | μ | 7 979.73 | 8 239.76 | 7 461.53 |
| | | | s.d. | 1 432.97 | 1 569.71 | 1 164.60 |
| | protein | (kg) | μ | 255.54 | 284.12 | 250.10 |
| | | | s.d. | 44.13 | 53.51 | 36.72 |
| | fat | (kg) | μ | 378.21 | 359.30 | 345.00 |
| | | | s.d. | 72.93 | 71.88 | 54.58 |
| Calving interval | | (days) | μ | 412.4 | 412.6 | 390.5 |
| | | | s.d. | 89.9 | 75.1 | 78.0 |
| Calving to 1st insemination | | (days) | μ | 81.4 | 93.3 | 76.6 |
| | | | s.d. | 37.4 | 44.0 | 43.5 |
| Service period | | (days) | μ | 134.1 | 134.7 | 107.4 |
| | | | s.d. | 86.9 | 74.5 | 77.5 |
| 1st service conception rate | | (%) | μ | 66.1 | 73.6 | 78.5 |
| | | | s.d. | 32.4 | 29.2 | 29.5 |
| Conception rate | | (%) | μ | 64.3 | 54.0 | 70.6 |
| | | | s.d. | 32.8 | 29.1 | 31.8 |
| Services per conception | | | μ | 2.24 | 2.50 | 1.99 |
| | | | s.d. | 1.59 | 1.50 | 1.53 |

study. Jairath et al. (1995) found 5155 kg milk, 162 kg protein, 183 kg fat in first lactation Holsteins and it was less than in the present study. Graham et al. (1991) found 5469 kg milk, 189 kg protein and 226 kg fat in New Zealand Holstein cows at first lactation. Their finding was 346 kg milk and 25.8 kg fat lower than the present study, but protein production was similar.

The mean second lactation milk, protein and fat yield is presented in Table I. Farm had significant effect on second lactation milk production ($P \leq 0.05$), protein ($P \leq 0.001$) and fat ($P \leq 0.001$) yield (Table II). As presented in Table III least squares means for the effect of farm show that farm III had low ($P \leq 0.05$) milk yield and farm II had high ($P \leq 0.05$) protein yield. Dairy performance differences between farm I and farm II were insignificant. In terms of fat production insignificantly high fat production was recorded in farm I. Zdravkovic et al. (1990) found 6062 kg milk and 209 kg fat yield in Holstein cows. Urban (1989) found 5321 kg milk and 190 kg fat yield in imported Holstein cows ($n = 25$). The results of both authors are lower than in the present study.

**Reproduction performance**

Reproductive performance of imported Holstein cattle was analysed and mutually compared. Import to first calving period had no significant effect on reproduction traits (Table II), but farm had significant effect on analysed reproductive traits. Long calving intervals bring about a reduction in the number of lactations and consequently the total amount of milk produced during

a cow's reproductive life time. Milk production by dairy herds is associated with the reproductive efficiency of the animals and directly affected by the calving interval, the optimum of which is considered to be 365 days (Kourletaki et al., 1995) and 13 months in the case of primiparous cows (Genizi et al., 1992) for attaining maximum production. Pryce et al. (1997) in first calver Holstein cows reported calving interval of 391 days, which is 17 days longer than in the present study. The length of calving interval of the present study agrees with Huba et al. (1996b) but does not agree with Urban (1989). The disagreement is most probably due to a small number of observations conducted by the author.

Service period is influenced by management decision as when to commence service, the incidence of anoestrus and the efficiency of oestrus detection. A biological maximum of fertility appears to be achieved approximately 120 days after calving (Hodel et al., 1995). The calving to conception interval (service period) of this study disagrees with Moore et al. (1990), Esslemont, Peeler (1993), Eicker et al. (1996), Huba et al. (1996b) and Pryce et al. (1997) and agrees with Motyčka et al. (1997).

Estimates of mean time from parturition to first service usually are 70 to 90 days (Hillers et al., 1984; Coleaman et al., 1985). Days to first breeding (calving to first insemination interval) findings of Huba et al. (1996a) and Darwash et al. (1997) were shorter than in the present study. Days to first breeding of the present study is almost in line with findings of Faust et al. (1989), Ouweltjes et al. (1996) and Pryce et al. (1997). Butler and Smith (1989) argued that calving to first insemination interval is not a good measure of fertility of the cow, because of the large influence of the farmer. This is also the case for interval from first insemination to conception because the high producing cows are given more opportunities for reinsemination in the case of conception failure.

First service conception rate is recognised as one of the important measures of fertility and is greatly influenced by management decision when to start the breeding period after calving. The first service conception rate of this study is lower than the results of Esslemont, Peeler (1993) and Huba et al. (1996a) and higher than the results of Darwash et al. (1997) and Pryce et al. (1997).

Conception rates vary considerably between the farms, and some of the probable factors involved are quality of nutrition and management. The results of this work do not agree with conception rate findings of Moore et al. (1990) and Huba et al. (1996a). Motyčka et al. (1997) expressed the reproduction status of imported Prim Holsteins and generalised that reproduction results showed significantly greater problems of conception, but did not express them in numeric terms.

Least squares mean for service per conception of farm III was only 1.78, indicating that once the animals are detected in oestrus conception would shortly follow (Table III). Service per conception findings of Drew et al. (1982), Motyčka et al. (1995), Huba et al. (1996a, b) and Pryce et al. (1997) are lower than in the present study.

Comparing these farms, with short calving interval ($P \leq 0.05$), short service period ($P \leq 0.01$), high first service conception rate ($P \leq 0.01$), high conception rate ($P \leq 0.01$) and low number of inseminations per conception, best reproductive performance was found in farm III. It is apparent from this study that under adaptation stress reproductive performance of imported animals is satisfactory. Finally, before importation of highly improved breed preparation of farms to provide proper nutrition and management is the most important paragenetic factor.

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# VPLYV NADMERNÝCH DÁVOK HORČÍKA A PRÍDAVKOV TUKU A OLEJA DO KŔMNYCH DÁVOK NA FYZIOLOGICKÉ UKAZOVATELE V KRVI A V BACHOROVEJ ŠŤAVE HOVÄDZIEHO DOBYTKA

## EFFECTS OF SUPERFLUOUS MAGNESIUM DOSES AND FAT AND OIL ADDITIONS TO FEED RATIONS ON PHYSIOLOGICAL PARAMETERS IN THE BLOOD AND RUMEN FLUID OF CATTLE

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**ABSTRACT:** Effects of magnesite emissions on physiological parameters in the blood and rumen fluid of young bulls were studied in physiological trials on young bulls of Black-Pied breed, live weight of 400 kg, which were applied rumen cannulas. Four model feed rations, control and three experimental ones, were tested: magnesite emissions (Ú), magnesite emissions + waste fat (T) and magnesite emissions + rapeseed oil (O) at a dose of 5% of feed dry matter. A daily dose of magnesite emissions (201 g) was calculated from immission deposition per 1 $m^2$ of land area. Following addition of magnesite emissions, concentrations of soluble Mg in rumen fluid significantly increased ($P < 0.05$) within three hours from feeding, in comparison with control feed ration. Plasma magnesium showed the same tendency ($P < 0.05$). Additions of rapeseed oil and waste fat significantly increased plasma P concentration ($P < 0.001$) while Ca concentration decreased insignificantly. The additions of emissions did not have any depressive effects on total counts of infusorians. Their counts increased from 1.55 to 2.32 x $10^7$/g of rumen contents dry matter as a result of emission feeding. The addition of waste fat and rapeseed oil increased their counts to the level of control feed ration.

cattle; magnesite emissions; mineral elements; rumen fluid; blood

**ABSTRAKT:** V štyroch fyziologických pokusoch na býčkoch čiernostrakatého plemena o živej hmotnosti 400 kg ošetrených bachorovými kanylami sme sledovali vplyv magnezitového úletu na fyziologické ukazovatele v krvi a v bachorovej šťave býčkov. Testovali sme 4 modelové kŕmne dávky – kontrolnú a 3 pokusné: magnezitový úlet (Ú), magnezitový úlet + kafilerický tuk (T) a magnezitový úlet + repkový olej (O) v množstve 5 % zo sušiny kŕmnej dávky. Dennú dávku magnezitového úletu (201 g) sme vypočítali na základe analýzy imisného spádu na 1 $m^2$ plochy pôdy. Koncentrácia rozpustného Mg v bachorovej šťave pridaním magnezitového úletu významne stúpla ($P < 0,05$) 3 h po kŕmení v porovnaní s kontrolnou kŕmnou dávkou. Rovnakú tendenciu sme zaznamenali u plazmatického horčíka ($P < 0,05$). Prídavok repkového oleja a kafilerického tuku významne zvýšil hladinu P v plazme ($P < 0,001$), pričom hladina Ca poklesla nevýznamne. Prídavok úletu nemal depresívny vplyv na celkový počet infuzórií. Ich množstvo sa skrmovaním úletu zvýšilo z 1,55 na 2,32 x $10^7$/g sušiny bachorového obsahu. Prídavkom kafilerického tuku a repkového oleja sa ich počet dostal na úroveň kontrolnej kŕmnej dávky.

hovädzí dobytok; magnezitový úlet; minerálne látky; bachorová šťava; krv

### ÚVOD

Biologický význam horčíka je veľmi široký a dobre známy, zatiaľ čo mechanizmus zachovania jeho homeostázy v organizme nie je úplne objasnený. Všeobecný prehľad o metabolizme horčíka nájdeme v prácach autorov Walsera (1967) a Ebel, Günther (1980). Ako uvádza Paulov (1980), je horčík funkčným aktivátorom asi 300 enzýmov. Polovica celkovej telesnej zásoby horčíka je v kostiach (Aikawa, 1971) a jeho mobilizácia z kostí prebieha len na základe osmotickej výmeny (Vrzgula a kol., 1990). V krvi je asi tretina plazmatického horčíka viazaná na bielkoviny (Massry, 1977; Vrzgula a kol., 1990), väčšou časťou difuzibilnej frakcie je voľne ionizovaný horčík. Potreba Mg, P a Ca udávaná v rozdielnych systémoch je dobre zhodná iba pre Mg (Meschy, Guéguen, 1996). V praxi sa však stretávame s nedostatkom Mg, pričom vyšší výskyt hypomagneziémie je v intenzívnych chovoch hovädzieho dobytka a najmä u vysokoteľných kráv (Lebeda, Štourač, 1986). Jedine v oblasti Jelšavy nadbytok Mg výrazne ovplyv-

ňuje životné prostredie, organizmus zvierat a človeka (Reichrtová, 1982). Prostredníctvom krmív sa hovädziemu dobytku a ovciam podávajú nadmerné dávky Mg, ktoré spôsobujú poruchy trávenia a hnačky (Bartko et al., 1991; Bíreš et al., 1992), čo sa prejavuje horším využitím živín a poklesom úžitkovosti.

Podľa autorov Vrzgula a kol. (1990), Jenčík et al. (1992), Bíreš et al. (1992) a Pavlík et al. (1996) tieto negatívne vplyvy môžeme eliminovať skrmovaním vyšších dávok vápnika, fosforu a tuku.

Cieľom našej práce bolo stanoviť vplyv prídavku magnezitového úletu, ako aj prídavkov kafilerického tuku a repkového oleja k modelovým kŕmnym dávkam na vybrané ukazovatele v krvi a v bachorovej šťave býčkov.

## MATERIÁL A METÓDA

Do pokusu sme zaradili troch býčkov slovenského strakatého plemena o priemernej živej hmotnosti 400 kg. Zvieratá sme ošetrili bachorovými kanylami.

Zvieratám kontrolnej a pokusných skupín sme podávali dvakrát denne kŕmnu dávku tohto zloženia:

| Krmivo (kg/deň) | K | Ú | T | O |
|---|---|---|---|---|
| Kukuričná siláž | 6,5 | 6,5 | 6,5 | 6,5 |
| Lucernové seno | 3,2 | 3,2 | 3,2 | 3,2 |
| Jačmenný šrot | 0,85 | 0,85 | 0,85 | 0,85 |
| Pšeničný šrot | 0,85 | 0,85 | 0,85 | 0,85 |
| Kŕmna soľ | 0,10 | 0,10 | 0,10 | 0,10 |
| Magnezitový úlet | – | 0,201 | 0,201 | 0,201 |
| Tuk kafilerický | – | – | 0,335 | – |
| Olej repkový | – | – | – | 0,335 |

K – kontrolná KD
Ú – pokusná KD s magnezitovým úletom
T – pokusná KD s magnezitovým úletom a kafilerickým tukom
O – pokusná KD s magnezitovým úletom a repkovým olejom

Výkrmovým býčkom sme podávali na 1 kg živej hmotnosti 502 mg magnezitového úletu s obsahom Mg 346,6 g/kg. Týmto množstvom imisného úletu sme pred kŕmením posýpali predloženú kŕmnu dávku. V skupine T a O sme kŕmnu dávku premiešali s kafilerickým tukom, resp. repkovým olejom (5 % zo sušiny kŕmnej dávky).

Výživná hodnota krmív a príjem živín zvieratami sú uvedené v tab. I a II. Kŕmne dávky boli skrmované

I. Priemerný obsah živín a Ca, P, Mg (g/kg) v krmivách skrmovaných počas experimentu – Average contents of nutrients and Ca, P, Mg (g/kg) in feeds administered during the trial

| Živiny[1] | Lucernové seno[2] | Kukuričná siláž[3] | Jačmenný šrot[4] | Pšeničný šrot[5] | Kafilerický tuk[6] | Repkový olej[7] | Magnezitový úlet[8] |
|---|---|---|---|---|---|---|---|
| | v sušine[9] | | | | | | |
| Pôvodná sušina[10] | 884 | 277 | 874 | 878 | 994 | 999 | 990 |
| N-látky[11] | 191 | 96 | 128 | 114 | – | – | – |
| Vláknina[12] | 354 | 269 | 59 | 39 | – | – | – |
| Tuk[13] | 17 | 36 | 22 | 17 | 990 | – | – |
| Popol[14] | 86 | 58 | 29 | 20 | – | – | – |
| Ca | 11,68 | 4,14 | 1,00 | 0,99 | 0,66 | 0,03 | 10,42 |
| P | 3,06 | 2,13 | 3,27 | 3,13 | 0,83 | 0,42 | 0,15 |
| Mg | 2,53 | 2,47 | 1,31 | 1,27 | 0,05 | 0,04 | 346,6 |

[1]nutrients, [2]alfalfa hay, [3]corn silage, [4]barley groats, [5]wheat groats, [6]waste fat, [7]rapeseed oil, [8]magnesite emissions, [9]in dry matter, [10]original dry matter, [11]crude protein, [12]fiber, [13]fat, [14]ash

II. Denný príjem živín a Ca, P, Mg zvieratmi v g – Daily intakes of nutrients and Ca, P, Mg in g

| Živiny[1] | Lucernové seno[2] | Kukuričná siláž[3] | Jačmenný šrot[4] | Pšeničný šrot[5] | Kafilerický tuk[6] | Repkový olej[7] | Magnezitový úlet[8] |
|---|---|---|---|---|---|---|---|
| Sušina[9] | 2 832 | 1 800 | 743 | 746 | 333 | 335 | 199 |
| N-látky[10] | 541 | 172 | 95 | 85 | – | – | – |
| Vláknina[11] | 1 002 | 484 | 44 | 29 | – | – | – |
| Tuk[12] | 48 | 65 | 17 | 13 | 332 | – | – |
| Organická hmota[13] | 2 589 | 1 696 | 722 | 731 | – | – | – |
| Ca | 33,07 | 7,46 | 0,74 | 0,73 | 0,22 | 0,01 | 2,07 |
| P | 8,66 | 3,85 | 2,43 | 2,34 | 0,28 | 0,14 | 0,05 |
| Mg | 7,16 | 4,46 | 0,97 | 0,95 | 0,02 | 0,01 | 68,00 |

For 1–8 see Tab. I; [9]dry matter, [10]crude protein, [11]fiber, [12]fat, [13]organic matter

postupne tými istými zvieratami. Každý experiment mal 10dňové prípravné obdobie a 10dňové pokusné obdobie, v ktorom sme odoberali:

- na 2., 4. a 10. deň bachorovú šťavu pol hodiny pred kŕmením a 3, 6 a 9 h po kŕmení na stanovenie Ca, P a Mg
- na 2., 4. a 10. deň bachorový obsah 4 h po kŕmení na stanovenie počtu infuzórií
- na 1. a 10. deň krv pred raňajším kŕmením na stanovenie plazmatického Ca, P a Mg.

Jednotlivé ukazovatele sme stanovili takto:

- Ca, Mg, Na, K, Fe, Mn, Zn, Cu, Cr, Pb, Co (na AAS Unicam 939)
- P (spektrofotometricky, použitím molybdovanadátového činidla – spekol 11)
- bachorové protozoá sme stanovili podľa autorov Ogimot a Imai (1981)
- pH (pH-metrom HI 9321)
- $NH_3$ (mikrodifúznou titračnou metódou podľa Conwaya)
- UMK (plynovou chromatografiou na HP 5830 elektrometricky).

Výsledky sme spracovali matematicko-štatisticky pomocou programu OPEN ACCESS-II metódou jednofaktorovej analýzy rozptylu ANOVA.

## VÝSLEDKY A DISKUSIA

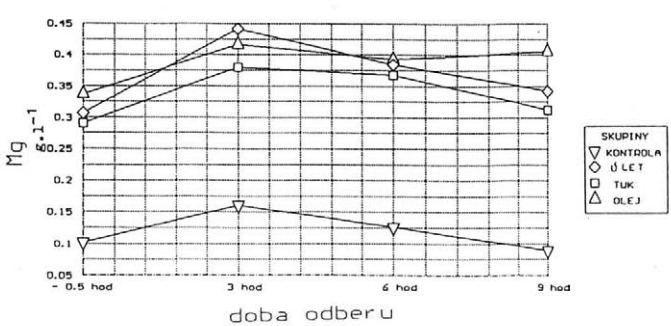
Testovaný úlet získaný pri odprašovaní elektrostatických filtrov v magnezitových závodoch mal na 1 kg sušiny toto zastúpenie: Mg 346,6 g, Fe 33,37 g, Ca 10,3 g, Mn 2,04 g, K 1,11 g, Na 0,72 g, P 0,15 g, Zn 18,45 mg, Cr 8,73 mg, Cu 6,60 mg, Pb 1,46 mg, Co 0,56 mg. Percentuálne zastúpenie hlavných zložiek úletu sa mení podľa vsádzkového materiálu. Magnezitový úlet skrmovaný v našich pokusoch obsahoval 58 % MgO, 1,4 % CaO a 4,8 % $Fe_2O_3$. Pomer Mg : Ca bol 34 : 1.

Hodnoty pH, N-$NH_3$ a UMK v bachorovej šťave sa vo všetkých skupinách pohybovali v medziach fyziologických hodnôt, ktoré uvádzajú Slanina et al. (1980). Tieto hodnoty zároveň svedčia o tom, že dané množstvo magnezitového úletu podstatne neovplyvnilo fermentačné procesy v predžalúdkoch. Vyplýva to z biogénnej povahy horčíka, jeho relatívne malej absorpcie a pomerne ľahkého a rýchleho vylučovania z organizmu. Predžalúdky sú primárnym miestom absorpcie, ktorá sa podľa autorov Greene et al. (1983) znižuje zvyšovaním koncentrácie draslíka v kŕmnych dávkach hovädzieho dobytka, avšak po „nasýtení" absorpcie Mg v bachore prebieha ďalšie vstrebávanie Mg i v tenkom čreve (Grace et al., 1974; Khorasani, Armstrong, 1992). Sodík a draslík sú pohotovejšie absorbované v porovnaní s horčíkom (Waterman et al., 1991). Koncentrácia rozpustného horčíka v bachorovej šťave sa zvyšuje s poklesom pH, čo vidieť hlavne 3 h po kŕmení (obr. 1). Prídavok magnezitového úletu s obsahom 58 % MgO ku kŕmnej dávke zvýšil nielen hladinu rozpustného Mg v bachorovej šťave, ale aj obsah plazmatického Mg (obr. 2). V krvi je 55 až 60 % plazmatického Mg vo forme voľných iónov, 6 až 13 % vo forme zlúčenín, hlavne citrátu a fosfátu, a z 32 až 34 % bielkovinových väzieb prevláda väzba na albumín (Paulov, 1980; Vrzgula a kol., 1990). Prídavkom kafilerického tuku a repkového oleja sa plazmatická hodnota Mg nezmenila.

Zistili sme minimálny pokles hodnôt plazmatického vápnika (obr. 2) pri pokusných kŕmnych dávkach. Malé zmeny v obsahu Ca pri vyššom príjme Mg *per os* zaznamenali Heaton a Parson (1961). Kŕmne dávky s vyšším obsahom Mg však zvyšovali vylučovanie Ca močom (Waterman et al., 1991). Najnižšiu hladinu Ca v krvnej plazme sme zaznamenali pri skrmovaní dávky s repkovým olejom, čo je možné dať do vzťahu s nižšou absorpciou Ca z krmiva v súvislosti s jeho reakciou s mastnými kyselinami pri tvorbe nerozpustných solí. Túto skutočnosť potvrdzujú aj vypočítané koeficienty stráviteľnosti Ca, ktoré sú najnižšie pri tejto diéte (7,52 %).

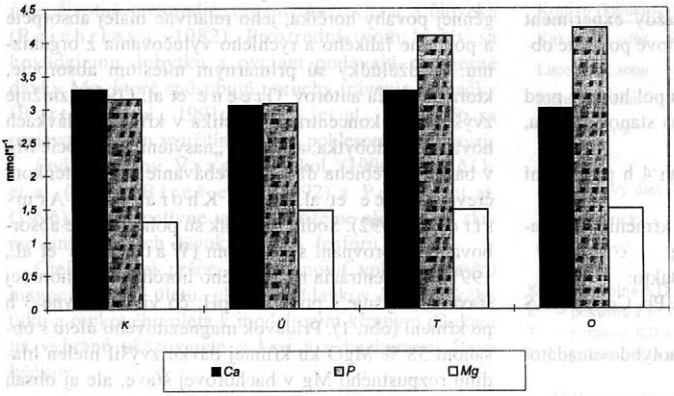
Tendencia zmien hladiny Ca v bachorovej šťave bola v priebehu sledovania takmer zhodná v skupinách K a Ú (obr. 3). Použitím kafilerického tuku a repkového oleja sa priebeh krivky zmenil – tri hodiny po kŕmení prudko klesol, hlavne s prídavkom repkového oleja.

Zistené hodnoty plazmatického fosforu (obr. 2) majú opačnú tendenciu v porovnaní s úrovňou plazmatického vápnika. Vyšší perorálny príjem Mg v pokusoch autorov Lotz et al. (1968) zapríčinil podstatný pokles fosforu. Naše výsledky korešpondujú s výsledkami au-

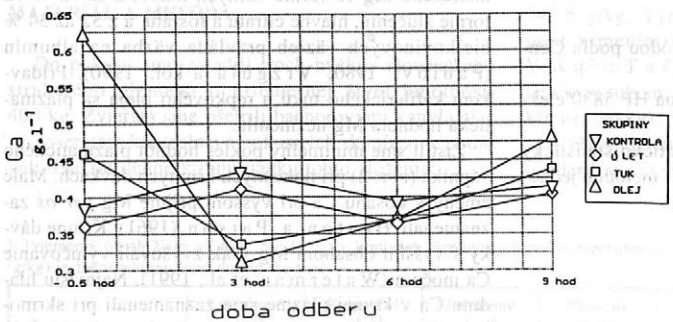



1. Zmeny hladiny Mg v bachorovej šťave býčkov – Variations of Mg concentrations in rumen fluid of young bulls

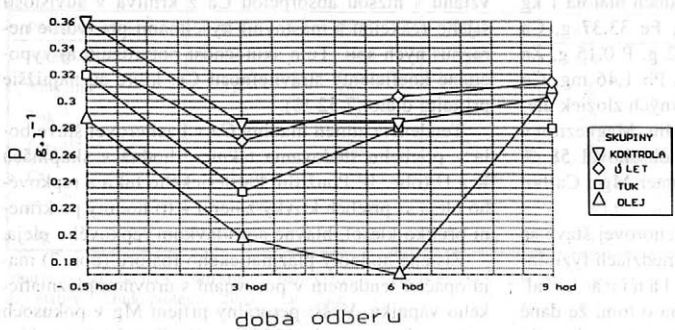
For Figs. 1, 3 and 4: doba odberu = time of collection, skupiny = groups, kontrola = control, úlet = emissions, tuk = fat, olej = oil




2. Koncentrácia Mg, Ca a P v krvnej plazme býčkov – Concentrations of Mg, Ca and P in the blood plasma of young bulls




3. Zmeny hladiny Ca v bachorovej šťave býčkov – Variations of Ca concentrations in rumen fluid of young bulls




4. Zmeny hladiny P v bachorovej šťave býčkov – Variations of P concentrations in rumen fluid of young bulls

torov Jenčík et al. (1991), ktorí okrem Ca, P a Mg sledovali u výkrmového dobytka aj ďalšie biochemické ukazovatele. Výraznejší vzostup koncentrácie P v plazme bol v skupine s repkovým olejom.

Hladiny P v bachorovej šťave býčkov (obr. 4) vykazovali značné rozdiely tiež v diétach s prídavkom kafilerického tuku a repkového oleja v porovnaní s diétami K a Ú.

Mg pôsobí synergicky s Ca, v mnohých prípadoch však je jeho antagonistom. Vyšší obsah MgO ako CaO je nepriaznivý pre odnímanie Ca bielkovinám bunkového jadra, a naopak, nadbytok CaO spôsobuje nerozpustnosť kyseliny fosforečnej a u zvierat dochádza k prejavom nedostatku.

Predpokladom využitia MgO je reakcia s $H_2O$ za vzniku $Mg(OH)_2$ v zažívacom trakte zvierat. Mg vytvára s amoniakom dobre rozpustné komplexné soli, iba pri alkalogénne pôsobiacich kŕmnych dávkach vzniká nerozpustný fosforečnan horečnato-amónny $Mg(NH_4)PO_4$.

Na základe mikrobiologického vyšetrenia bachorového obsahu sme zistili, že celkové množstvo infuzórií v kontrolnej diéte bolo 1,55 x $10^7$/g sušiny. Prídavok úletu ku kŕmnej dávke nemal depresívny vplyv na počet prvokov. Ich množstvo sa dokonca zvýšilo o 0,77 x $10^7$/g sušiny. Malé zmeny v pH, celkovej acidite, UMK a v počte infuzórií zaznamenali Slanina et al. (1969) po magnezitovom poprašku u oviec v dávke 0,34 g/kg. Rovnaké množstvo magnezitovej múčky

III. Množstvo infuzórií v bachorovom obsahu ($10^7$/g sušiny) – Infusorian counts in rumen contents ($10^7$/g dry matter)

| Býk[1] | K | | Ú | | T | | O | |
|---|---|---|---|---|---|---|---|---|
| | | $\bar{x}$ | | $\bar{x}$ | | $\bar{x}$ | | $\bar{x}$ |
| 1 | 1,48<br>1,55<br>1,62 | 1,55 | 2,40<br>2,89<br>2,32 | 2,54 | 2,29<br>1,65<br>1,64 | 1,65 | 1,88<br>–<br>1,41 | 1,65 |
| 2 | 2,14<br>2,07<br>1,71 | 1,97 | 2,61<br>3,33<br>– | 2,97 | 3,10<br>1,80<br>2,19 | 2,00 | 1,36<br>1,74<br>0,89 | 1,33 |
| 3 | 1,17<br>1,17<br>1,08 | 1,14 | 1,39<br>1,27<br>1,69 | 1,45 | 1,38<br>–<br>1,44 | 1,41 | 1,80<br>1,19<br>1,10 | 1,36 |
| $\bar{X}$ | | 1,55 | | 2,32 | | 1,68 | | 1,44 |

K – kontrola, Ú – magnezitový úlet, T – kafilerický tuk, O – řepkový olej
K – control, Ú – magnesite emissions, T – waste fat, O – rapeseed oil

[1]bull

však významne znížilo trávenie celulózy. Počty infuzórií boli podstatne nižšie ako u kontrolných zvierat. Prídavok antidot pri ich obsahu 5 % v sušine krmnej dávky redukoval počet infuzórií na úroveň kontrolnej dávky. Táto skutočnosť potvrdila, že do 5% hladiny tuku v krmnej dávke sa všeobecne jeho toxický vplyv na infuzóriá a baktérie neprejavuje. Výsledky práce poukazujú na dodnes celkom neznámy mechanizmus toxického pôsobenia nechráneného tuku na bachorovú mikroflóru. Je známe (Ossowski et al., 1996), že všetky prídavky tuku redukujú počet prvokov, ale rozdielnou intenzitou. Uvedení autori uvádzajú depresívny účinok repkového oleja na počet infuzórií. Naopak, Legay-Carmier a Buchart (1989 – cit. Valent, 1989) nezistili toxický účinok prídavku 7,9 % repkového oleja do krmnej dávky na množstvo adherentných mikroorganizmov. Nižší počet infuzórií bol v krmnej dávke s repkovým olejom (1,44 x $10^7$/g sušiny bachorového obsahu).

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# INFLUENCE OF ADDITION OF POLYENZYME PREPARATIONS INTO FEED MIXTURES ON FATTENING AND SLAUGHTERING PROPERTIES OF LAMBS

## VLIV PŘÍDAVKU POLYENZYMOVÝCH PREPARÁTŮ DO KRMNÝCH SMĚSÍ NA VÝKRMNOST A JATEČNOU HODNOTU JEHŇAT

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**ABSTRACT:** Different biostimulating substances are often used in lamb meat production as well as in other types of livestock production. The aim of this paper was to investigate effect of polyenzyme preparations Polizym$^R$ and Polizym-BX added into feed mixtures at an amount of 0.1% of the total raw material composition of mixtures on fattening and slaughtering lamb quality. Experimental lamb fattening was conducted with two control (I and III) and two experimental (II and IV) groups. First (I) and second (II) group of lambs were given feed mixture of the same composition whereas the second one was given feed mixture with added Polizym$^R$ preparation (alpha-amylase, beta-glycanase, n-protease, cellulase, and beta-glycosidase). Third (III) and fourth (IV) groups of lambs were given feed mixture 2 but the fourth group was given mixture with addition of preparation Polizym-BX (alpha-amylase, beta-glycanase, n-protease, and xylanase) with addition of quality meadow hay. Significant differences in fattening and in most slaughtering properties of lambs were determined between experimental (II and IV) and control (I and III) groups of lambs. Average daily gains with II and IV experimental group fed by addition of polyenzyme preparations were statistically very significant ($P < 0.01$) higher by 4.97, i.e. 8.83% relative to lambs of the control groups (I and III). Feed mixture conversion was better and meadow hay conversion, consumption of feed mixtures and meadow hay increased with experimental groups of lambs (II and IV). Lambs of the experimental groups (II and IV) significantly differed concerning most of slaughtering properties relative to the lambs of the control groups (I and III). Application of polyenzyme preparations Polizym$^R$ and Polizym-BX added into feed mixtures adapted to composition of feed mixtures and lambs age can be recommended on the basis of the results of investigation.

lambs; polyenzyme preparations; additive, fattening; body weights; daily gains; conversion and consumption of forage mixtures and meadow hay; slaughtering properties

**ABSTRAKT:** Při výrobě jehněčího masa i v ostatních odvětvích živočišné výroby se často používají biologické stimulační látky. Cílem této práce bylo šetření vlivu polyenzymových preparátů Polizym$^R$ a Polizym-BX přidávaných do krmných směsí v dávce 0,1 % z celkového surovinového složení směsí na výkrmnost a jatečnou hodnotu jehňat. Pokusný výkrm jehňat probíhal ve dvou kontrolních (I. a III.) a ve dvou pokusných (II. a IV.) skupinách. První (I.) a druhé (II.) skupině jehňat byla podávaná krmná směs stejného složení, přitom druhá skupina dostávala krmnou směs s doplňkem preparátu Polizym$^R$ (alfa--amyláza, beta-glykanáza, n-proteáza, celuláza and beta-glykosidáza). Třetí (III.) a čtvrtá (IV.) skupina jehňat dostávaly krmnou směs č. 2, čtvrtá skupina dostávala navíc přídavek preparátu Polizym-BX (alfa-amyláza, beta-glycanáza, n-proteáza a xylynáza) a kvalitní luční seno. Zjistili jsme významné rozdíly ve výkrmnosti a ve většině jatečných vlastností mezi pokusnými (II. a IV.) a kontrolními skupinami jehňat (I. a III.). Průměrné denní přírůstky jehňat II. a IV. pokusné skupiny byly vysoce významně vyšší ($P < 0.01$) o 4,97 kg, tj. 8,83 %, než u jehňat v kontrolních skupinách (I. a III.). V pokusných skupinách (II. a IV.) byla zjištěna lepší konverze krmiva a lučního sena a zvýšila se spotřeba krmné směsi a lučního sena. Ve srovnání s jehňaty z kontrolních skupin (I. a III.) existovaly u jehňat z pokusných skupin (II. a IV.) významné rozdíly v jatečné hodnotě. Na základě výsledků našich šetření lze doporučit přidávání polyenzymových preparátů Polizym$^R$ a Polizym-BX do krmných směsí v závislosti na jejich složení a na věku jehňat.

jehňata; polyenzymové přípravky; aditivum; výkrm; hmotnost jehňat; denní přírůstky; konverze a spotřeba pícninových směsí a lučního sena; jatečná hodnota

## INTRODUCTION

Successful lamb's meat production depends on a large number of genetic and paragenetic factors. Of paragenetic factors, food plays a special role. Production of lamb's meat mostly depends on ration price and its feeding value. In order to increase ration feeding value different enzymes have been used recently in domestic animals feeding as forage additives (Kalivoda, 1990; Matošić-Čajavec, 1987). They are mainly used at forage with substances which can hardly be decomposed, in the case when a body still does not produce its own digestive enzymes. It is also the time when the body due to different physiological conditions (incomplete digestive system development, different stress conditions) does not produce a sufficient amount of enzymes (Salobir, 1994). Use of enzyme preparations in rations for adult ruminants is limited by their fast degradation which is the result of rumen's microorganisms effect. Thus, many researchers claim that enzyme preparation application is more effective in young ruminants with still undeveloped digestive tract without enzyme system (Baran, Kmet, 1987; Kung, 1990; Dawson, 1993).

Other authors (Wójcik et al., 1973; Krempa et al., 1983; Kalous, 1989; Zubok, 1990; Bauman et al., 1994) also recorded positive effects of the enzyme preparations added into calves rations. Popov (1980), Babijchuk et al. (1981), Mamedov (1981), Galiev et al. (1982), Kaminski et al. (1983) and Eranov et al. (1988) achieved the same positive effect but with bullcalves.

This problem should be paid much more attention since lambs at the age of seventy days still have neither sufficiently developed digestive tract nor enzyme system for decomposition of nutrients from roughages.

Many authors (Gazdarov et al., 1979; Nechipurenko et al., 1981a, b; Tolokonnikov, Nikilburskij, 1982; Modyanov, Zelner, 1983; Judkins, Storbart, 1988) recorded positive effects of enzyme preparations of different composition added into lamb's feeding rations on fattened lambs properties.

The aim of this investigation was to determine the efficiency of polyenzyme preparations added into complete feed mixtures with increased share of oat, barley and wheat and reduced share of corn with qualitative meadow hay on slaughtering properties of lambs.

## MATERIAL AND METHODS

Biological investigations were carried out with 72 lambs of Würtemberg breed type after ablactation at average age of 70 days. The experimental lambs were classified into four groups of which two control (I and III) and two experimental ones (II and IV). Lambs were of the equal age, body weight, sex and origin. They were kept in the same conditions during the experiment.

The investigation was conducted according to the scheme displayed in Table I.

Considering the aim of the investigation, forages used in feed mixtures, their raw material and chemical composition (analysed according to AOAC, 1960) can be seen in Table II.

The first (I) and second (II) lamb groups were given feed mixture of the same composition – feed mixture 1. However, the second group was given feed mixture with addition of polyenzyme preparation Polizym$^R$. Third (III) and fourth (IV) group of lambs was given feed mixture 2, but the fourth group had feed mixture with added polyenzyme preparation Polizym-BX.

Polyenzyme preparations Polizym$^R$ and Polizym-BX (Krka, Novo Mesto, Slovenija) represent a stabilized enzyme complex. Composition of polyenzyme preparations can be seen in Table III.

Polyenzyme preparations were in a powdery form. Due to more uniform mixing and arranging of active ingredients, a pre-mixture with vitamin-mineral addition was prepared in advance. Enzyme activity in the analyzed preparations is maintained for a year at storage in dry and dark place at temperature by 25 °C. The stability of vitamin-mineral mixture and feed mixture does not change for at least two months. Activity loss at pelleting temperatures (80–90 °C) is negligible. Optimal pH for enzyme effect from the preparation is from 5 to 6.5. Optimal concentration of enzyme preparations in feed mixtures was according to the manufacturer's recommendation. Polyenzyme preparations activity was checked after manufacturer's methodology prior to their usage.

The lambs were weighed at the beginning of the experiment, on 20th day and at the end of the experiment (40th day) when consumption and conversion of feed mixtures and meadow hay were calculated per groups.

Ten lambs (5 males and 5 females) were chosen from each group by the method of random sample

I. Experiment scheme

| Groups | Control (I) | Experiment (II) | Control (III) | Experiment (IV) |
|---|---|---|---|---|
| Type of mixture | complete forage mixture (1) | complete forage mixture (1) + enzymes | complete forage mixture (2) | complete forage mixture (2) + enzymes |
| Quantity of mixture and meadow hay | *ad libitum* | *ad libitum* | *ad libitum* | *ad libitum* |
| Number of animals | 18 | 18 | 18 | 18 |
| Fattening duration (days) | 40 | 40 | 40 | 40 |
| Sex ratio (m : f) | 50 : 50 | 50 : 50 | 50 : 50 | 50 : 50 |

II. Ingredients and chemical composition of feed mixtures and chemical composition of meadow hay for lamb fattening (%)

| Forages | Feed mixture 1 | | Feed mixture 2 | | Meadow hay |
|---|---|---|---|---|---|
| | groups | | groups | | |
| | I | II | III | IV | |
| Corn | 25 | 25 | 31 | 31 | |
| Oat | 16 | 16 | 16 | 16 | |
| Barley | 20 | 20 | – | – | |
| Wheat | – | – | 20 | 20 | |
| Wheat bran | 5 | 5 | – | – | |
| Sunflower meal | 19 | 19 | 18 | 18 | |
| Soybean meal | 12 | 12 | 12 | 12 | |
| Limestone | 1 | 0.9 | 1 | 0.9 | |
| Salt | 0.5 | 0.5 | 0.5 | 0.5 | |
| VAM (vitamin, antibiotic and mineral mixture) | 1.5 | 1.5 | 1.5 | 1.5 | |
| Polizym$^{R}$ | – | 0.1 | – | – | |
| Polizym-BX | – | – | – | 0.1 | |
| Total | 100 | 100 | 100 | 100 | |
| Water | 11.45 | | 11.50 | | 10.35 |
| Crude proteins | 18.65 | | 18.98 | | 10.58 |
| Crude fats | 3.72 | | 3.33 | | 3.06 |
| Crude ash | 5.67 | | 6.03 | | 7.50 |
| Crude fibre | 7.49 | | 6.76 | | 31.29 |
| Calcium | 1.72 | | 1.76 | | 1.07 |
| Phosphorus | 0.57 | | 0.61 | | 0.33 |
| Oat feeding unit (kg) | 1.06 | | 1.08 | | 0.32 |

III. Composition of polyenzyme preparations (per gram of product)*

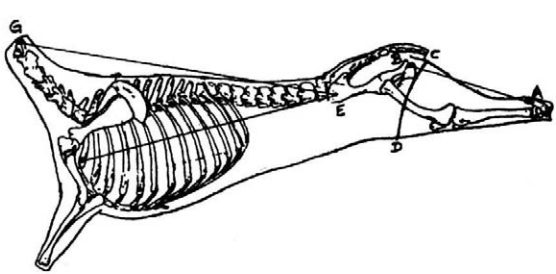
| Type and enzyme activity | Polizym$^{R}$ | Polizym-BX |
|---|---|---|
| Amylase AU (amylase units) | 150.000 | 8.000 |
| Glycanase BGU (β glycanase units) | 400 | 800 |
| Protease PU (protease units) | 140.000 | 3.000 |
| Cellulase FPU (filter units) | 50 | – |
| Glycosidase BGU (β glycosidase units) | 4 | |
| Xylanase XU (xylanase units) | – | 20.000 |

* Minimal activity was declared in harmony with declared expiry date

which were slaughtered at the end of fattening. Warm carcass weight with viscera, edible viscera weight (heart, lungs, liver and spleen) were determined after performed slaughtering processing of carcasses (within 60 minutes). Weight of cold carcass with viscera was determined after 24 hours of cooling at a temperature of +4 °C in the ham depth. Meat utilization was calculated on the basis of body weight before slaughtering and weight of warm carcasses with viscera. Cooling loss was calculated on the basis of warm carcass weight with viscera and weight of cold carcass with viscera.

Slaughtering quality indicators of lamb carcasses (carcass length, ham length, ham circumference and ham index was calculated on the basis of ham circumference and its length) were measured after lamb carcass processing on slaughtering line according to Fig. 1.

Of the indicators of lamb carcass slaughtering quality which were estimated by subjective method, conformation and carcass covering with fat tissue including




1. Measuring scheme of indicators of lamb carcass slaughtering quality

A – B = ham length (*tuber calcanei – tuberculum ossis ischii*)
C – D = ham circumference (the widest part)
E – G = length of carcass (*os pubis* – atlas)
E – F = length of carcass (*os pubis* – first rib)

kidney fat were analysed. They were evaluated according to Živković et al. (1981) using points from 1 to 5 (mark 1 = poor, mark 2 = sufficient, mark 3 = good, mark 4 = very good and mark 5 = excellent).

Statistical processing was carried out according to Hadživuković (1973).

## RESULTS AND DISCUSSION

Average lamb body weight and daily gains can be seen in Table IV. Starting lamb body weights within and between the groups were fairly equal. Thus, analysis of variance did not show any statistically significant differences between groups.

Body weights measured on 20th day of the experiment in experimental group II of lambs which received feed mixture with addition of polyenzyme preparation Polizym$^R$ were statistically significantly ($P < 0.05$) higher by 1.96% relative to lambs of control group I. On the other hand, body weights in lambs of experimental group IV which received feed mixture with addition of polyenzyme preparation Polizym-BX were statistically significantly ($P < 0.01$) higher by 2.64% than in lambs of control group III.

Differences between final body weights were also statistically significantly ($P < 0.05$) higher by 1.92% in lambs of experimental group II in relation to lambs of control group I. Body weights in experimental group IV were statistically significantly ($P < 0.01$) higher by 2.80% relative to lambs of control group III.

Gazdarov et al. (1979) obtained better results by 0.58% and 6.9% in lambs receiving feed mixtures with addition of enzyme preparation combination (Amylosuptilina and Pectofoetidina) whereas Nechipurenko et al. (1981b) had better results by 5.13% and 7.14%.

Lambs of experimental groups II and IV obtained statistically significantly ($P < 0.01$) higher daily gains measured on 20th day of the experiment by 8.18% and 13.25% relative to lambs of control groups I and III.

Differences between daily gains measured on 40th day were higher by 1.81% in lambs of experimental group II relative to the lambs of control group I but they were not statistically significant. Daily gains of the lambs of experimental group IV were statistically significantly ($P < 0.05$) higher by 4.58% relative to the lamb of control group III.

Average daily gains (measured from 1st to 40th day) were statistically significantly ($P < 0.01$) higher by 4.97% and 8.83% in lambs of experimental groups II and IV receiving feed mixtures with addition of polyenzyme preparations Polizym$^R$ and Polizym-BX relative to lambs of groups I and III.

IV. Average body weights and daily gains

| Indicators | Statistical parameters | Groups | | | | Significance of differences | |
|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | I : II | III : IV |
| Initial body weight (kg) | $\bar{x}$ | 16.25 | 16.26 | 16.06 | 16.06 | ns | ns |
| | $s$ | 0.64 | 0.67 | 0.49 | 0.59 | | |
| | $Vk$ | 3.94 | 4.12 | 3.05 | 3.67 | | |
| Body weight 20th day (kg) | $\bar{x}$ | 21.40 | 21.82 | 20.82 | 21.37 | * | ** |
| | $s$ | 0.62 | 0.50 | 0.56 | 0.48 | | |
| | $Vk$ | 2.90 | 2.30 | 2.70 | 2.25 | | |
| | % | 100.00 | 101.96 | 100.00 | 102.64 | | |
| Final body weight 40th day (kg) | $\bar{x}$ | 26.62 | 27.13 | 25.72 | 26.44 | * | ** |
| | $s$ | 0.64 | 0.52 | 0.58 | 0.70 | | |
| | $Vk$ | 2.40 | 1.92 | 2.26 | 2.65 | | |
| | % | 100.00 | 101.92 | 100.00 | 102.80 | | |
| Daily gains by 20th day (g) | $\bar{x}$ | 257.44 | 278.55 | 235.22 | 266.39 | ** | ** |
| | $s$ | 8.70 | 16.37 | 5.70 | 18.13 | | |
| | $Vk$ | 3.38 | 5.88 | 2.42 | 6.81 | | |
| | % | 100.00 | 108.18 | 100.00 | 113.25 | | |
| Daily gains by 40th day (g) | $\bar{x}$ | 261.11 | 265.83 | 244.78 | 256.00 | ns | * |
| | $s$ | 7.66 | 9.27 | 9.00 | 18.06 | | |
| | $Vk$ | 2.93 | 3.49 | 3.68 | 7.05 | | |
| | % | 100.00 | 101.81 | 100.00 | 104.58 | | |
| Average daily gains from 1st to 40th day (g) | $\bar{x}$ | 259.28 | 272.16 | 240.00 | 261.19 | ** | ** |
| | $s$ | 4.97 | 8.01 | 5.70 | 11.30 | | |
| | $Vk$ | 1.92 | 2.92 | 2.38 | 4.32 | | |
| | % | 100.00 | 104.97 | 100.00 | 108.83 | | |

ns – non significant; * $P < 0.05$; ** $P < 0.01$

Gazdarov et al. (1979) achieved daily gain increase by 5.5% to 13.9%. On the other hand Nechipurenko et al. (1981b) obtained daily gain increase from 10.1% to 10.55. Modyanov and Zelner (1983) recorded daily gain increase by 11.7% to 14.1% and 13.5% to 15.6% with addition of enzyme preparations (Amylorisin and Glukavomorin) into lambs' rations.

Obtained daily feed consumption and conversion (feed mixtures and meadow hay) is shown in Table V. Lambs of experimental group II and IV measured on 20th day of the experiment had better appetite by 3.9 and 7.8% whereas those measured on 40th day of the experiment had better appetite by 1.2 and 2.4% relative to lambs of control groups I and III.

Average consumption of feed mixtures measured from 1st to 40th day was also higher by 2.4% i.e. 4.9% with lambs of experimental group II and IV receiving feed mixtures with addition of polyenzyme preparations (Polizym$^R$ and Polizym-BX) in relation to lambs of control group I and III.

Judkins and Storbart (1987) achieved similar results with lambs fed by addition of enzyme preparation Vitaferm. They determined digestion rate increase by 9% in lambs of the experimental groups. Nechipurenko et al. (1981a) also obtained similar results.

Average meadow hay consumption which was measured from 20th to 40th day increased in lambs of experimental groups II and IV by 15.4 and 17.9%, 9.1% relative to lambs of control groups I and III.

Average daily meadow hay consumption measured from 1st to 40th day was higher in lambs of experimental groups II and IV by 13.8 and 16.7% in reference to lambs of control groups I and III.

Lower consumption of feed mixtures 1 and 2 by 3.6 and 3.1%, 0.6% measured on 20th and 40th day was obtained by lambs of experimental groups II and IV which received feed mixtures with addition of polyenzyme preparations (Polizym$^R$ and Polizym-BX) relative to lambs of I and III control group.

Also, better feed mixture conversion measured from 1st to 40th day by 1.9 and 1.8% was achieved by the lambs of experimental groups II and IV relative to lambs of control groups I and III.

Gazdarov et al. (1979) recorded better feed conversion by 0.7% and after 1st and 15th week of the experiment by 13.55 and 12.01% in the investigations with lambs after 3rd week of the experiment. Investigations of Modyanov and Zelner (1983) also showed better feed conversion by 7.1 to 9.8% and 4.1 to 7.9% whereas with Nechipurenko et al. (1981b) it was by 5.9 to17.6% depending on the experiment length.

Conversion of meadow hay measured on 20th and 40th experiment day increased by 6.9 and 6.0%, 5.6 and 5.1% relative to the lambs of control groups I and III with lambs of experimental groups II and IV.

Average obtained conversion of meadow hay measured from 1st to 40th experiment day was also higher by 6.1 and 5.6% with lambs of experimental groups II and IV receiving feed mixtures with addition of polyenzyme preparations (Polizym$^R$ and Polizym-BX) relative to lambs of control groups I and III.

Average body weight of lambs before slaughtering, carcasses weight, meat utilization, cooling loss and weight of edible viscera can be seen in Table VI. Lambs of experimental group II which received addition of Polizym$^R$ had statistically significant ($P < 0.05$) higher body weight before slaughtering, warm carcass weight with viscera and weight of cold carcass with viscera relative to lambs of the control group I. Lambs of experimental group IV which received mixtures with addition of Polizym-BX had statistically significantly

V. Average daily feed consumption (kg/day) and conversion (kg/kg)

| Indicators | Statistical parameters | Groups | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | I | | II | | III | | IV | |
| | | mixture | meadow hay | mixture | meadow hay | mixture | meadow hay | mixture | meadow hay |
| Feed consumption by 20th day | $\bar{x}$ | 0.78 | 0.26 | 0.81 | 0.30 | 0.77 | 0.28 | 0.83 | 0.33 |
| | % | 100.0 | 100.0 | 103.9 | 115.4 | 100.0 | 100.0 | 107.8 | 117.9 |
| Feed consumption from 20th to 40th day | $\bar{x}$ | 0.86 | 0.33 | 0.87 | 0.36 | 0,85 | 0.33 | 0.87 | 0.36 |
| | % | 100.0 | 100.0 | 101.2 | 109.1 | 100.0 | 100.0 | 102.4 | 109.1 |
| Feed consumption from 1st to 40th day | $\bar{x}$ | 0.82 | 0.29 | 0.84 | 0.33 | 0.81 | 0.30 | 0.85 | 0.35 |
| | % | 100.0 | 100.0 | 102.4 | 113.8 | 100.0 | 100.0 | 104.9 | 116.7 |
| Feed conversion by 20th day | $\bar{x}$ | 3.03 | 1.02 | 2.92 | 1.09 | 3.22 | 1.16 | 3.12 | 1.23 |
| | % | 100.0 | 100.0 | 96.4 | 106.9 | 100.0 | 100.0 | 96.9 | 106.0 |
| Feed conversion from 20th to 40th day | $\bar{x}$ | 3.28 | 1.25 | 3.26 | 1.32 | 3.45 | 1.36 | 3.43 | 1.43 |
| | % | 100.0 | 100.0 | 99.4 | 105.6 | 100.0 | 100.0 | 99.4 | 105.1 |
| Feed conversion from 1st to 40th day | $\bar{x}$ | 3.16 | 1.14 | 3.09 | 1.21 | 3.34 | 1.26 | 3.28 | 1.33 |
| | % | 100.0 | 100.0 | 98.1 | 106.1 | 100.0 | 100.0 | 98.2 | 105.6 |

VI. Lamb body weights before slaughtering, carcass weights and meat utilization of the slaughtering

| Indicators | Statistical parameters | Groups | | | | Significance of differences | |
|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | I : II | III : IV |
| Body weight before slaughtering (kg) | $\bar{x}$ | 25.92 | 26.41 | 25.25 | 26.06 | * | ** |
| | $s$ | 0.49 | 0.50 | 0.48 | 0.57 | | |
| | $Vk$ | 1.89 | 1.89 | 1.90 | 2.19 | | |
| Weight of warm carcass with viscera (kg) | $\bar{x}$ | 14.30 | 14.67 | 13.72 | 14.37 | * | ** |
| | $s$ | 0.38 | 0.37 | 0.39 | 0.38 | | |
| | $Vk$ | 2.66 | 2.52 | 2.84 | 2.64 | | |
| Meat utilization of warm carcass with viscera (%) | $\bar{x}$ | 55.17 | 55.55 | 54.33 | 55.14 | ns | * |
| | $s$ | 1.48 | 2.13 | 0.99 | 1.53 | | |
| | $Vk$ | 2.69 | 3.83 | 1.82 | 2.76 | | |
| Weight of cold carcass with viscera (kg) | $\bar{x}$ | 14.05 | 14.40 | 13.46 | 14.10 | * | ** |
| | $s$ | 0.28 | 0.27 | 0.31 | 0.27 | | |
| | $Vk$ | 1.99 | 1.88 | 2.30 | 1.91 | | |
| Cooling loss (%) | $\bar{x}$ | 1.74 | 1.83 | 1.89 | 1.87 | ns | ns |
| | $s$ | 0.58 | 0.48 | 0.53 | 0.72 | | |
| | $Vk$ | 33.33 | 26.23 | 28.04 | 38.50 | | |
| Weight of edible viscera (kg) | $\bar{x}$ | 1.56 | 1.65 | 1.50 | 1.78 | ns | * |
| | $s$ | 0.33 | 0.48 | 0.23 | 0.31 | | |
| | $Vk$ | 21.15 | 29.09 | 15.33 | 17.42 | | |

ns – non significant; * $P < 0.05$; ** $P < 0.01$

VII. Indicators of slaughtering lamb carcass quality

| Indicators | Statistical parameters | Groups | | | | Significance of differences | |
|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | I : II | III : IV |
| Length of carcass (cm): | | | | | | | |
| – *os pubis* – atlas | $\bar{x}$ | 78.50 | 79.60 | 75.20 | 77.60 | ns | ns |
| | $s$ | 2.95 | 4.03 | 5.57 | 4.53 | | |
| | $Vk$ | 3.76 | 4.06 | 7.41 | 5.84 | | |
| – *os pubis* – first rib | $\bar{x}$ | 63.60 | 64.30 | 62.60 | 65.60 | ns | ns |
| | $s$ | 3.50 | 4.08 | 4.53 | 4.77 | | |
| | $Vk$ | 5.50 | 6.35 | 7.24 | 7.27 | | |
| Ham measures (cm): | | | | | | | |
| – ham length (*tuber calcanei – tuberculum ossis ischii*) | $\bar{x}$ | 26.60 | 27.30 | 26.80 | 27.40 | ns | ns |
| | $s$ | 1.99 | 1.43 | 1.51 | 1.70 | | |
| | $Vk$ | 7.48 | 5.24 | 5.63 | 6.20 | | |
| – ham circumference (the widest part) | $\bar{x}$ | 28.70 | 28.90 | 28.10 | 28.20 | ns | ns |
| | $s$ | 1.90 | 1.22 | 1.58 | 2.18 | | |
| | $Vk$ | 6.62 | 4.22 | 5.62 | 7.73 | | |
| Ham index (%) | $\bar{x}$ | 92.68 | 94.47 | 95.38 | 97.74 | ns | ns |
| | $s$ | 4.87 | 5.95 | 5.69 | 7.51 | | |
| | $Vk$ | 5.25 | 6.30 | 5.97 | 7.68 | | |
| Carcass estimation (1–5): | | | | | | | |
| – conformation | $\bar{x}$ | 3.90 | 4.30 | 3.90 | 4.20 | ns | ns |
| | $s$ | 0.74 | 0.82 | 0.74 | 0.92 | | |
| | $Vk$ | 18.97 | 19.07 | 18.97 | 21.90 | | |
| Caracass covered by fat tissue + kidney fat | $\bar{x}$ | 4.30 | 4.10 | 3.90 | 4.20 | ns | ns |
| | $s$ | 0.82 | 0.74 | 0.74 | 0.63 | | |
| | $Vk$ | 19.07 | 18.05 | 18.97 | 15.00 | | |

ns – non significant

($P < 0.01$) higher body weight before slaughtering, warm carcass weight with viscera and weight of cold carcass with viscera relative to lambs of the control group III.

Values of meat utilization of warm carcass with viscera and weight of edible viscera were not statistically different with lambs of experimental group II and lambs of control group I whereas the same values with lambs of experimental group IV were statistically significantly ($P < 0.05$) higher relative to lambs of control group III.

Values of the cooling loss were fairly equal with experimental and control groups.

Similar results were obtained by Nechipurenko et al. (1981b) when they recorded higher meat yield with lambs of the experimental groups with addition of enzyme preparation Pectofoetidin.

Indicators of slaughtering quality of lamb carcasses can be seen in Table VII. Indicators of slaughtering quality of lamb carcasses were somewhat more favourable for lambs of experimental groups II and IV relative to lambs of control group I and III. However, they were not statistically significantly higher.

## CONCLUSION

On the basis of polyenzyme preparations Polizym$^R$ and Polizym-BX in mixtures for lamb fattening the following conclusions can be drawn:

Average daily gains were statistically very significantly ($P < 0.01$) higher by 4.97 and 8.83% with experimental groups II and IV received addition of polyenzyme preparations relative to lambs of control groups I and III.

Average consumption of feed mixtures and meadow hay was increased by 2.4 and 13.8% i.e. 4.9 and 16.7% whereas average feed conversion was better by 1.9 and 1.8%. Average conversion of meadow hay was increased by 6.1 and 5.6% with lambs of experimental groups II and IV in relation to lambs of control groups I and III.

Body weight before slaughtering, warm carcass weight with viscera and cold carcass weight with viscera were very significantly ($P < 0.01$) higher with lambs of experimental group IV whereas these values with lambs of experimental group II were statistically significantly higher ($P < 0.05$) in reference to the control groups.

Meat utilization of warm carcass with viscera and weight of edible viscera were statistically significantly ($P < 0.05$) higher with lambs of experimental group IV whereas these values with lambs of experimental group II were also higher but not statistically significant in relation to the control groups.

Values of cooling loss as well as indicators of slaughtering quality of lamb carcasses were roughly equal with lambs of experimental and control groups.

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# THE EFFECT OF *BACILLUS SP.* BASED PROBIOTIC PREPARATIONS IN DIETS WITH DIFFERENT PROTEIN CONTENTS ON PERFORMANCE AND NITROGEN METABOLISM IN CHICK BROILERS*

## VLIV PROBIOTICKÝCH PREPARÁTŮ NA BÁZI *BACILLUS SP.* VE SMĚSÍCH S RŮZNOU HLADINOU N-LÁTEK NA UŽITKOVOST A METABOLISMUS DUSÍKU U KUŘECÍCH BROJLERŮ

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**ABSTRACT:** The objective of an experiment *in vitro* was to determine the activity of proteolytic enzymes produced by *Bacillus* C.I.P. 5832, an active ingredient of probiotic preparation PACIFLOR, and by *Bacillus subtilis* CCM 2216, an active ingredient of probiotic preparation AVIBION. Proteolytic activity of *Bacillus* C.I.P. 5832 and *Bacillus subtilis* CCM 2216 microorganisms was determined in relation to cultivation time in acid, neutral and alkaline media. The highest proteolytic activity was recorded in medium with pH = 7.0 in both cases, the two time curves being linear from the 72nd hour of cultivation. Proteases produced by *Bacillus* C.I.P. 5832 tolerate alkaline medium better (pH = 8.2) than do the proteolytic enzymes produced by *Bacillus subtilis* CCM 2216, and their activity is higher in acid medium (pH = 5.8). The effects of both preparations used in diets with different protein contents were determined in a trial *in vivo*, as exerted on broiler performance with respect to N output in droppings. An extensive comparative feeding trial was conducted on 480 sexed chick broilers of ROSS hybrid. A metabolic trial included 48 cockerels in total, four individuals per balance cage from the 21st day of age. Chicks received BR1 feed mixtures (starters) from 1st to 21st days of age, and BR2 feed mixtures from 22nd to 42nd days of age. The comparative feeding trial was a three-factor one, with replications according to the design f A – probiotic preparations (3) x f B – diets with different protein contents (2) x f C – sex (2) x (40) for growth, f A (3) x f B (2) x f C (2) x (4) for feed consumption. The metabolic trial was a two-factor one according to the design f A (3) x f B (2) x (2). The effect of *Bacillus* C.I.P. 5832 bacteria ($a_1$ +4.47%) on chick weight at 21 days of age was highly significant ($P < 0.01$) while the effect of *Bacillus subtilis* CCM 2216 bacteria ($a_2$ +1.70%) was significant ($P < 0.1$) if compared with the control ($a_0$). Chicks receiving BR1 feeds with a protein content of 24.31% ($a_0$) had the live weight higher by 14.23% at 21 days of age ($P < 0.01$) than chicks receiving BR1 feeds with a protein content of 20.85%. Significantly higher live weight was recorded at 35 days of life in groups of chicks receiving BR2 feeds with *Bacillus sp.* based probiotic preparations. Higher live weight of chicks on average for the groups ($a_1$, $a_2$) was determined at the end of trial (+2.47% and +2.00%, resp.), but the value was not at a significance level. Highly significantly higher live weight of chicks ($P < 0.01$) was also determined in the second period of feeding BR2 feeds with a higher content of proteins ($a_0$). Substantial positive effects of Bacillus sp. bacteria application on chick weight were observed in chicks receiving BR1 and BR2 feeds with lower contents of proteins (groups $a_1b_1$, $a_2b_1$). *Bacillus* sp. based probiotic preparations significantly ($P < 0.1$) decreased BR1 mash consumption in the production period from 1st to 21st days of chick age. The lower content of proteins in BR1 feeds resulted in the highly significantly higher feed consumption per 1 kg of weight gain ($b_1$ +9.18% against $b_0$). There was no statistically significant difference between the groups of chicks receiving feeds containing *Bacillus sp.* based preparations and the control. On the contrary, chicks receiving BR2 feeds with lower contents of proteins ($b_1$) had the significantly ($P < 0.05$) lower feed consumption per 1 kg of weight gain in the production period from 22nd to 42nd days in comparison with the groups of chicks receiving higher contents of proteins ($b_0$). Total feed consumption did not show any statistically significant difference in any of the parameters under observation. Total feed consumption was found to be lower on average in chicks receiving diets containing *Bacillus sp.* based probiotic preparations, mainly in feeds with lower protein contents. Average nitrogen retention was insignificantly higher in diets containing *Bacillus sp.* based probiotic preparations ($a_1$, $a_2$) if compared with the control group ($a_0$). This difference was in the relative range of +5.5%. A slight decrease in average nitrogen retention was determined in diets with lower protein contents. A substantial increase in nitrogen retention was observed in groups of chicks receiving a higher content of proteins in BR2 feeds containing *Bacillus sp.* based probiotic preparations ($a_1b_0$, $a_2b_0$). The lowest average nitrogen retention was determined in the control group ($a_0b_0$) – higher content of proteins without any probiotic additives. The groups ($a_0b_1$, $a_1b_1$, $a_2b_2$) showed higher nitrogen retention than the control ($a_0b_0$) +3.50–+4.44%, but the probiotic preparations were not found to influence retention. The groups of chicks receiving *Bacillus sp.* based probiotic preparations ($a_1$, $a_2$) had by 5.81–6.31% lower N output per 1 kg of weight gain. But this difference was just at a significance

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level. The groups of chicks receiving BR2 feeds with lower protein contents ($b_1$) had by 13.31% lower N output in droppings in comparison with the groups receiving feeds with higher protein contents ($b_0$). The difference between the groups was statistically significant at ($P < 0.05$). The substantially lower N output than in the control ($a_0b_0$) in droppings of chicks receiving *Bacillus* sp. based probiotic preparations was determined in groups ($a_1b_0$ and $a_2b_0$), in BR2 feeds with higher protein contents. The effect of *Bacillus sp.* applied to diets with lower protein contents on this parameter was much higher.

proteolytic activity; *Bacillus* C.I.P. 5832; *Bacillus subtilis* CCM 2216; chick broilers; growth; feed consumption; nitrogen retention, nitrogen output in droppings

**ABSTRAKT:** Předmětem pokusu *in vitro* bylo stanovení aktivity proteolytických enzymů, produkovaných *Bacillus* C.I.P. 5832, které tvoří účinnou složku probiotického preparátu PACIFLOR, a *Bacillus subtilis* CCM 2216, tvořícího účinnou složku probiotického preparátu AVIBION. Hodnoty proteolytické aktivity mikroorganismů *Bacillus* C.I.P. 5832 a *Bacillus subtilis* CCM 2216 stanovené v závislosti na době kultivace v kyselém, neutrálním a alkalickém prostředí jsou uvedeny v tab. II. Závislost proteolytické aktivity *Bacillus* C.I.P. 5832 na době kultivace v prostředí při pH 5,8, 7,0 a 8,2 je znázorněna na obr. 1. Stejná závislost pro *Bacillus subtilis* CCM 2216 je patrná z obr. 2. Nejvyšší proteolytická aktivita byla v obou případech naměřena v prostředí o pH = 7, obě časové závislosti mají od 72. hodiny kultivace lineární charakter. Proteázy tvořené *Bacillus* C.I.P. 5832 lépe tolerují alkalické prostředí (pH = 8,2) ve srovnání s proteolytickými enzymy tvořenými *Bacillus subtilis* CCM 2216, které jsou aktivnější v slabě kyselém prostředí (pH = 5,8). V pokusu *in vivo* byl stanoven účinek obou preparátů aplikovaných do krmných směsí s různou hladinou N-látek na užitkovost brojlerů s ohledem na množství dusíku vylučovaného v exkrementech. Byl uspořádán rozsáhlý krmný srovnávací a bilanční pokus se 480 sexovanými kuřecími brojlery hybrida ROSS. V bilančním pokusu bylo umístěno celkem 48 kohoutků od 21. dne věku po 4 kusech v jedné bilanční kleci. Od 1. do 21. dne věku přijímala kuřata směsi BR1 a od 22. do 42. dne věku směsi BR2. Krmný srovnávací pokus byl uspořádán jako třífaktoriální s opakováním podle vzorce f A – probiotické preparáty (3) x f B – směsi s rozdílnou hladinou N-látek (2) x f C – pohlaví (2) x (40) pro růst, f A (3) x f B (2) x f C (2) x (4) pro spotřebu směsí. Bilanční pokus byl veden jako dvoufaktoriální podle vzorce f A (3) x f B (2) x (2). Hmotnost kuřat (tab. III) v 21. dni věku byla vysoce průkazně ($P < 0,01$) pozitivně ovlivněna použitím bakterií *Bacillus* C.I.P. 5832 ($a_1$ +4,47 %) a průkazně ($P < 0,1$) použitím bakterií *Bacillus subtilis* CCM 2216 ($a_2$ +1,70 %) oproti kontrole ($a_0$). Kuřata krmená směsmi BR1 s hladinou 24,31 % N-látek ($a_0$) měla v 21. dni věku o 14,23 % vyšší hmotnost ($P < 0,01$) než kuřata krmená směsmi BR1 s 20,85 % N-látek. Průkazně vyšší hmotnost ($P < 0,1$) byla zaznamenána i v 35. dni věku u skupin kuřat krmených směsmi BR2 s preparáty na bázi *Bacillus sp.* Průměrně vyšší hmotnost kuřat skupin $a_1$, $a_2$ byla zjištěna i na konci pokusu (+2,47 %, resp. +2,00 %), avšak zde nebyla již zjištěna statistická průkaznost. Vysoce průkazně vyšší hmotnost kuřat ($P < 0,01$) byla zjištěna i ve druhém období výkrmu směsmi BR2 s vyšší hladinou N-látek ($a_0$). Rozdíl mezi skupinami $a_0$ a $a_1$ byl však na konci pokusu nižší než v případě výkrmu směsmi BR1, a to o 7,62 %. Výraznější pozitivní efekt aplikace bakterií *Bacillus sp.* na hmotnost kuřat byl zjištěn u kuřat krmených směsmi BR1 a BR2 s nižší hladinou N-látek (tab. IV, skupiny $a_1b_1$, $a_2b_1$). Probiotické preparáty na bázi *Bacillus sp.* průkazně ($P < 0,1$) snížily spotřebu směsí BR1 v 1.–21. dni věku kuřat (tab. V). Nižší hladina N-látek ve směsích BR1 měla za následek vysoce průkazně ($P < 0,01$) vyšší spotřebu směsí na 1 kg přírůstku ($b_1$ +9,18 % oproti $b_0$). V období výkrmu směsmi BR2 nebyl zjištěn statisticky významný rozdíl mezi skupinami krmenými směsmi s preparáty na bázi *Bacillus sp.* a kontrolou ($a_0 = a_1 = a_2$). Naopak kuřata krmená směsmi BR2 s nižší hladinou N-látek ($b_1$) měla ve 22.–42. dni věku průkazně ($P < 0,05$) nižší spotřebu směsí na 1 kg přírůstku oproti skupinám kuřat krmených směsí s vyšší hladinou N-látek ($b_0$). Celková spotřeba směsí nevykazovala statisticky významný rozdíl v žádném ze sledovaných ukazatelů. Průměrně nižší celkovou spotřebu směsí měla kuřata krmená směsmi, do kterých byly aplikovány probiotické preparáty na bázi *Bacillus sp.*, zejména ve směsích s nižší hladinou N-látek (tab. VI). Průměrná retence N-látek (tab. VII) byla u směsí s probiotickými preparáty na bázi *Bacillus sp.* neprůkazně vyšší ($a_1$, $a_2$) oproti skupině $a_0$ (rozdíl +5,5 %). U směsí s nižší hladinou N-látek byl zaznamenán nepatrný pokles průměrné retence. Výrazné zvýšení retence N-látek bylo zaznamenáno u skupin $a_1b_0$ a $a_2b_0$ (tab. VIII). Nejnižší průměrná retence N-látek byla však zjištěna u kontrolní skupiny ($a_0b_0$) – vyšší hladina N-látek bez probiotických aditiv. U skupin $a_0b_1$, $a_1b_1$, $a_2b_2$ byla zaznamenána vyšší retence N-látek oproti kontrole $a_0b_0$ (+3,50 až +4,44 %), avšak nebylo zde zjištěno ovlivnění retence probiotickými preparáty. U skupin kuřat, jimž byly aplikovány probiotické preparáty na bázi *Bacillus sp.* ($a_1$, $a_2$), byl zaznamenán o 5,81–6,31 % nižší podíl vyloučeného N na 1 kg přírůstku (tab. IX). Tento rozdíl se však pohyboval pouze na hranici statistické průkaznosti. Skupiny kuřat, jimž byly podávány směsi s nižší hladinou N-látek ($b_1$), měly v exkrementech o 13,31 % nižší podíl N oproti skupinám s vyšší hladinou N-látek ve směsích ($b_0$). Rozdíl mezi skupinami byl statisticky významný ($P < 0,05$). Výrazně nižší podíl dusíku vyloučeného v exkrementech kuřat byl zjištěn u skupin $a_1b_0$ a $a_2b_0$. *Bacillus sp.* aplikovaný do směsí s nižší hladinou N-látek tento ukazatel ovlivnil mnohem výrazněji (tab. X). Nižší množství dusíku vyloučeného v trusu kuřat krmených směsmi s probiotickými preparáty na bázi *Bacillus sp.* naznačuje, že i použitím vhodných biologických preparátů v krmných směsích lze přispět ke snížení zátěže životního prostředí dusíkatými látkami.

proteolytická aktivita; *Bacillus* C.I.P. 5832; *Bacillus subtilis* CCM 2216; kuřecí brojleři; růst; spotřeba směsí; retence dusíku; vylučování dusíku exkrementy

## INTRODUCTION

Reduction in N amounts getting to the soil via animal excrements is one of the requirements for environment protection improvement. This is the reason why research is aimed at ways of avoiding a decrease in animal performance, and at ensuring better utilization of proteinaceous components ingested. Besides studies of the effect of so called Ideal Protein it is possible to use existing probiotics which contain stabilized bacterial strains of the genus *Bacillus* as active ingredients that produce proteolytic enzymes at the spot of their action, i.e. in digestive tracts of animals.

Paciflor (PRODETA VANNES, FRANCE) is an important probiotic preparation containing spores of a specified strain *Bacillus* as an active ingredient; the strain is kept in the Collection of Pasteur's Institute (C.I.P.) under No. 5832. It belongs to the species *Bacillus cereus* (Michard, Levesque, 1989). This probiotic is an antidiarrheal agent and is applied in human medicine. The preparation was studied with respect to its use as a biological growth stimulator, and most studies confirmed this effect: Nguyen et al. (1988a, b), Nguyen (1990), Roberton (1991, 1992), Kumprecht, Zobač (1996), etc.

Preventive antidiarrheal probiotic containing *Bacillus subtilis* CCM 2216 is manufactured in the Czech Republic; it is an active ingredient of probiotic preparations Avibion and Selbion (manufactured by BIOVETA, s.r.o., Ivanovice in Haná). Krupková and Harnach (1987, 1990) published the results describing applications of these preparations in animal nutrition.

The objective of an experiment *in vitro* was to determine the activity of proteolytic enzymes produced by *Bacillus* C.I.P. 5832, which is an active ingredient of the probiotic preparation PACIFLOR, and by *Bacillus subtilis* CCM 2216, which is an active ingredient of the probiotic preparation AVIBION. The effects of both preparations used in feeds with different protein contents were determined in a trial *in vivo*, as exerted on broiler performance with respect to N output in droppings.

## MATERIAL AND METHODS

These probiotic preparations were used in both trials:

a) PACIFLOR – manufactured by PRODETA Vannes, France
b) AVIBION – mfd by BIOVETA, Ivanovice in Haná, CR.

Proteolytic activity of both microorganisms was determined in an experiment *in vitro* in relation to cultivation time. Microorganisms were cultivated under constant conditions: temperature 37 °C, cultivation time 24–192 hours, pH – 5.8; 7.0; 8.2.

Formulation of culture media:

**pH = 5.8** – 1.25 g lactose, 2 g sucrose, 1.25 g glucose, 5 g casein, 23.4 g $NaH_2PO_4$, 3 ml 20% NaOH, filled up with distilled $H_2O$ to 500ml volume

**pH = 7.0** – 1.25 g lactose, 2 g sucrose, 1.25 g glucose, 5 g casein, 6.8 g $NaH_2PO_4$, 3 ml 20% NaOH, filled up with distilled $H_2O$ to 500ml volume

**pH = 8.2** – 1.25 g lactose, 2 g sucrose, 1.25 g glucose, 5 g casein, 6.8 g $NaH_2PO_4$, 4 ml 20% NaOH, filled up with distilled $H_2O$ to 500ml volume

Casein was the only source of proteins in all culture media. The media were sterilized in an autoclave for 20 minutes at 110 °C. *Bacillus* C.I.P. 5832 obtained from Paciflor preparation was inoculated to sterilized medium pre-heated to 37 °C. Agar-inoculated *Bacillus subtilis* CCM 2216 (supplied by Bioveta Co.) was re-inoculated to liquid medium under the same conditions. Samples were taken from both groups in 24-hour intervals in the period of 24–192 hours to determine proteolytic activity. Proteolytic activity (casein units/g) was determined by biuret reaction (Slavík, Smetana, 1952). Determination was performed in a culture medium in which casein at a concentration complying with the methodology was used as the only source of proteins. Casein splitting with proteolytic enzymes and the reaction of its products soluble in trichloroacetic acid with biuret reagent under blue-violet coloration underlie the principle of the method.

To achieve the goal set up in a trial *in vivo*, extensive comparative feeding and metabolic trials were conducted on sexed chick broilers of ROSS hybrid supplied by Líhně kuřat Mach Co. (Mach Chick Hatcheries Co.), Litomyšl, CR. A feeding trial involved 480 straight-run chicks in total (240 cockerels and 240 pullets), kept in cages with ten birds each, males and females separately, in an experimental house of Research Institute of Animal Nutrition at Pohořelice. A metabolic trial was conducted on 48 cockerels from the 21st day of age, housed in balance cages with four birds each. Chicks received BR1 feeds from 1st to 21st days of age, and BR2 feeds from 22nd to 42nd days of age. Tab. I shows the formulation and nutrient contents of basic feeds BR1 and BR2. Comparative feeding trial had a three-factor design with replications according to the design f A (3) x f B (2) x f C (2) x (40) for growth, f A (3) x f B (2) x f C (2) x (4) for feed consumption. The metabolic trial was a two-factor one according to the design f A (3) x f B (2) x (2).

Factor design was as follows:

f A – probiotic preparations
- $a_0$ – feeds without *Bacillus sp.*
- $a_1$ – feeds with *Bacillus* C.I.P. 5832 (10 g Paciflor/100 kg feed, 1 g Paciflor – 1 x $10^{10}$ *B.* C.I.P. 5832
- $a_2$ – feeds with *Bacillus subtilis* CCM 2216 (100 g Avibion/100 kg mixture, 1 g Avibion – 1 x $10^9$ *B. subt.*)

f B – feeds with different contents of proteins
- $b_0$ – 24.31% protein – BR1
  – 20.85% protein – BR2
- $b_1$ – 20.16% protein – BR1
  – 18.22% protein – BR2

I. Formulation and nutrient contents in feeds BR1 and BR2

| Ingredient | Feed mixtures | | | |
|---|---|---|---|---|
| | $b_0$ | | $b_1$ | |
| | BR1 | BR2 | BR1 | BR2 |
| | per cent | | | |
| Fish meal | 5 | 1 | 1 | 1 |
| Meat-bone meal | 3 | 2 | 1 | 1 |
| Yeasts | 1 | 1 | 1 | 1 |
| Soybean meal | 25 | 25 | 25 | 19 |
| Corn | 40 | 40 | 46 | 47 |
| Wheat | 21 | 26 | 21 | 26 |
| [1)]Biovitan BR1 1% | 1 | – | 1 | – |
| [2)]Biovitan BR2 Super | – | 1 | – | 1 |
| [3)]Mineral feeding supplement 2 SP | 4 | 4 | 4 | 4 |
| Total | 100 | 100 | 100 | 100 |
| Dry matter | 89.34 | 89.21 | 89.15 | 89.18 |
| Proteins | 24.31 | 20.85 | 20.16 | 18.22 |
| Fat | 2.75 | 2.52 | 2.55 | 2.60 |
| Fibre | 3.19 | 3.35 | 3.25 | 3.08 |
| Ash | 7.40 | 6.74 | 6.69 | 6.46 |
| Nitrogen free extract | 51.69 | 55.75 | 56.50 | 58.82 |
| Metabolizable energy in MJ/kg | 11.60 | 11.62 | 11.74 | 11.94 |

[1)] 1 kg of biofactor supplement BR1 contains: vitamin A 1 000 000 I.U., vitamin $D_3$ 200 000 I.U., vitamin $K_3$ 200 mg, vitamin E 1 500 mg, vitamin $B_1$ 200 mg, vitamin $B_3$ 400 mg, vitamin $B_6$ 400 mg, vitamin $B_{12}$ 2 mg, niacin 3 500 mg, folic acid 50 mg, calcium pantothenate 1 000 mg, cholinechloride 25 000 mg, methionine 50 000 mg, anhydrous sodium sulphate 150 000 mg, halofungion 300mg, Neox 20 000 mg, feeding meal ad 1 kg

[2)] 1 kg of biofactor supplement BR2 contains: vitamin A 800 000 I.U., vitamin $D_3$ 80 000 I.U., vitamin $K_3$ 200 mg, vitamin E 1 500 mg, vitamin $B_2$ 280 mg, vitamin $B_{12}$ 2 mg, methionine 50 000 mg, anhydrous sodium sulphate 150 000 mg, Monensin 10 000 mg, Neox 20 000 mg, feeding meal ad 1 kg

[3)] 1 kg of mineral feeding supplement MKP 2 SP contains: mineral supplement MD II – 10%, feeding calcite 29%, dicalcium phosphate 39%, wheat meal 17%, feeding salt 5%

I kg of mineral supplement MD II contains: ferrosulphate 140 000 mg, copper sulphate 14 000 mg, zinc oxide 25 000 mg, manganese oxide 29 500 mg, potassium iodide 150 mg, cobalt sulphate 150 mg, Magnovit (70% MgO) 379 000 mg, sodium selenate 100 mg, Siloxid 5 500 mg, feeding wheat meal ad 1 kg

f C – sex

$c_0$ – cockerels

$c_1$ – pullets

Chick weight in g was determined by weighing at 1, 21, 35 and 42 days of life as a part of the comparative feeding trial. Feed consumption in kg per 1 kg weight gain was recorded continually. Metabolic experiment was aimed at N retention from 22nd to 42nd days of life as well as at N output in droppings. Chemical analyses of feeds and droppings were performed pursuant to methodology established by the standard CSN 46 7007 (1973). Temperatures and relative atmospheric humidity in an experimental hall were adjusted in keeping with the standard for chick broiler fattening, illumination was continuous, water and feed intake *ad libitum*. Data were processed by multifactorial analysis of variance (Snedecor, Cochran, 1969).

## RESULTS

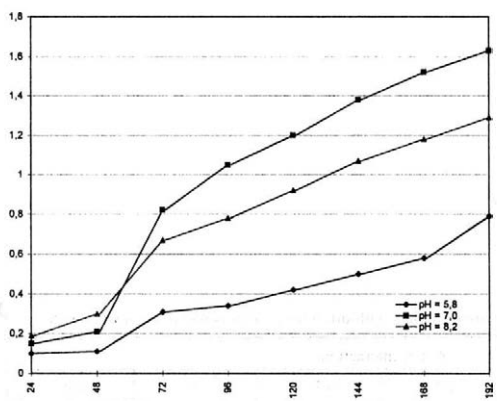
Tab. II shows the values of proteolytic activity of *Bacillus* C.I.P. 5832 and *Bacillus subtilis* CCM 2216 microorganisms determined in relation to cultivation time in acid, neutral and alkaline media. Fig. 1 shows the curve of proteolytic activity of *Bacillus* C.I.P. 5832 as related to cultivation time in media with pH values 5.8, 7.0 and 8.2, the same relationship for *Bacillus subtilis* CCM 2216 is plotted in Fig. 2. The highest proteolytic activity was recorded in medium with pH = 7.0 in both cases, the two time dependences have a linear course from the 72nd hour of cultivation. Proteases produced by *Bacillus* C.I.P. 5832 tolerate alkaline medium (pH = 8.2) better than proteolytic enzymes produced by *Bacillus subtilis* CCM 2216, which show higher activity in slightly acid medium (pH = 5.8).

The effect of these preparations was examined in feeds for chick broilers with different protein contents in the following trials *in vivo*.

Tab. III shows the effect of *Bacillus sp.* based probiotic preparations and the effect of feeds with different protein contents on chick weight, Tab. IV shows the interaction of the effect of *Bacillus sp.* based probiotic preparations applied to feeds with different protein contents.

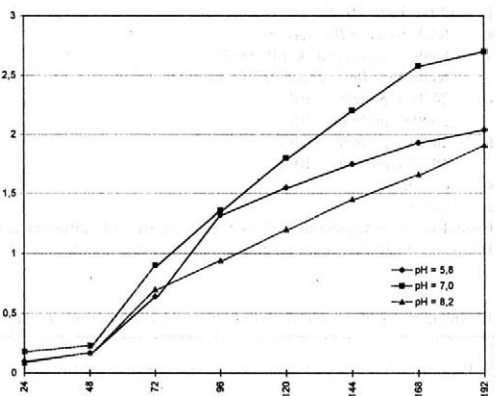
II. Determination of proteolytic activity of *Bacillus* C.I.P. 5832 and *Bacillus subtilis* CCM 2216 microorganisms in relation to cultivation time in acid, neutral and alkaline media

| Hours | *Bacillus* C.I.P. 5832 | | | *Bacillus subtilis* CCM 2216 | | |
|---|---|---|---|---|---|---|
| | protease activity (cas.u./g) | | | protease activity (cas.u./g) | | |
| | pH 5.8 | 7.0 | 8.2 | pH 5.8 | 7.0 | 8.2 |
| 24 | 0.10 | 0.15 | 0.19 | 0.10 | 0.18 | 0.09 |
| 48 | 0.11 | 0.21 | 0.30 | 0.17 | 0.23 | 0.17 |
| 72 | 0.31 | 0.82 | 0.67 | 0.64 | 0.90 | 0.70 |
| 96 | 0.34 | 1.05 | 0.78 | 1.32 | 1.36 | 0.94 |
| 120 | 0.42 | 1.20 | 0.92 | 1.55 | 1.80 | 1.20 |
| 144 | 0.50 | 1.38 | 1.07 | 1.75 | 2.20 | 1.45 |
| 168 | 0.58 | 1.52 | 1.18 | 1.93 | 2.58 | 1.66 |
| 192 | 0.79 | 1.63 | 1.29 | 2.04 | 2.70 | 1.91 |




1. Proteolytic activity of *Bacillus* C.I.P. 5832

x-axis – hours, y-axis – casein units/g




2. Proteolytic activity of *Bacillus subtilis* CCM 2216

x-axis – hours, y-axis – casein units/g

Chick weight at 21 days of age was highly significantly ($P < 0.01$) positively influenced by the use of *Bacillus* C.I.P. 5832 bacteria ($a_1$ +4.47%) and significantly ($P < 0.1$) influenced by the application of *Bacillus subtilis* bacteria ($a_2$ +1.70%) in comparison with the control ($a_0$). Chicks receiving BR1 feeds with a protein content of 24.31% ($a_0$) had the live weight higher by 14.23% at 21 days of age ($P < 0.01$) than the chicks receiving BR1 feeds with a crude protein content of 20.85%. Significantly higher live weight ($P < 0.1$) was recorded at 35 days of age in the groups of chicks receiving BR2 feeds with *Bacillus sp.* based probiotic preparations. Higher live weight of chick groups on average ($a_1$, $a_2$) was determined at the end of the trial (+2.47% and 2.00%, resp.), but the difference was not statistically different. Highly significantly higher chick weight ($P < 0.01$) was determined in the second period of feeding BR2 feeds with increased contents of proteins ($a_0$). The difference between the groups $a_0$ and $a_1$ was however lower, by 7.62%, at the end of the trial than in the case of BR1 feeds.

Higher positive effects of *Bacillus sp.* bacteria on chick weight were determined in chicks receiving feeds BR1 and BR2 with lower contents of proteins (Tab. IV, groups $a_1b_1$, $a_2b_1$).

*Bacillus sp.* based probiotic preparations significantly ($P < 0.1$) decreased the consumption of BR1 feeds in the feeding period from 1st to 21st days of chick age (Tab. V). A lower protein content in BR1 feeds resulted in significantly higher ($P < 0.01$) feed consumption per 1 kg of weight gain ($b_1$ +9.18% against $b_0$). No statistically significant difference between the groups receiving diets with *Bacillus sp.* based preparations and the control ($a_0 = a_1 = a_2$) was determined in the period of feeding BR2 feeds. On the other hand, chicks receiving BR2 feeds with lower protein contents ($b_1$) had significantly ($P < 0.05$) lower feed consumption per 1 kg weight gain in the feeding period from 22nd to 42 days in comparison with the groups of chicks receiving diets with higher protein contents ($b_0$). None of the studied parameters of total feed consumption showed any statistically significant

III. The effect of *Bacillus sp.* based preparations and feeds with different protein contents on chick weight

| Parameter | Unit | Probiotic preparation (A) | | | Proteins (B) | | Sex (C) | |
|---|---|---|---|---|---|---|---|---|
| | | $a_0$ | $a_1$ | $a_2$ | $b_0$ | $b_1$ | $c_0$ | $c_1$ |
| Chick number | number | 160 | 160 | 160 | 240 | 240 | 240 | 240 |
| Weight on day 1 | g | 52 | 52 | 53 | 53 | 52 | 53 | 52 |
| Weight on day 21 | g | $646^{A,1}$ | $675^{B}$ | $657^{AB,2}$ | $710^{A}$ | $609^{B}$ | $686^{A}$ | $633^{B}$ |
| S.D. | g | ± 97 | ± 96 | ± 87 | ± 81 | ± 77 | ± 95 | ± 84 |
| Index | % | 100.00 | 104.49 | 101.70 | 100.00 | 85.77 | 100.00 | 92.27 |
| Weight on day 35 | g | $1\ 471^{1}$ | $1\ 515^{2}$ | $1\ 493^{1,2}$ | $1\ 572^{A}$ | $1\ 415^{B}$ | $1\ 566^{A}$ | $1\ 421^{B}$ |
| S.D. | g | ± 195 | ± 188 | ± 194 | ± 171 | ± 179 | ± 193 | ± 161 |
| Index | % | 100.00 | 102.99 | 101.50 | 100.00 | 90.01 | 100.00 | 90.74 |
| Weight on day 42 | g | 1 941 | 1 989 | 1 980 | $2\ 048^{A}$ | $1\ 892^{B}$ | $2\ 077^{A}$ | $1\ 863^{B}$ |
| S.D. | g | ± 262 | ± 242 | ± 232 | ± 227 | ± 236 | ± 245 | ± 190 |
| Index | % | 100.00 | 102.47 | 102.00 | 100.00 | 92.38 | 100.00 | 89.70 |

Legend for Tabs. III–X:
$a_0$ – feeds without *Bacillus sp.*
$a_1$ – feeds with *Bacillus* C.I.P. 5832
$a_2$ – feeds with *Bacillus subtilis* CCM 2216
$b_0$ – 24.31% proteins – BR1
– 20.85% proteins – BR2
$b_1$ – 20.16% proteins – BR1
– 18.22% proteins – BR2
$c_0$ – cockerels
$c_1$ – pullets
Capital letters designate the values highly significantly different at $P < 0.01$
Digits designate the values significantly different at $P < 0.1$

IV. Interactions of the effect of *Bacillus* sp. based probiotic preparations used in diets with different protein contents on chick weight

| Parameter | Unit | A x B interactions | | | | | |
|---|---|---|---|---|---|---|---|
| | | $a_0b_0$ | $a_1b_0$ | $a_2b_0$ | $a_0b_1$ | $a_1b_1$ | $a_2b_1$ |
| Chick number | number | 80 | 80 | 80 | 80 | 80 | 80 |
| Weight on day 1 | g | 53 | 52 | 53 | 52 | 53 | 53 |
| Weight on day 21 | g | 700 | 722 | 706 | 591 | 628 | 609 |
| Index I | % | 100.00 | 103.14 | 100.86 | 84.43 | 89.71 | 87.00 |
| Index II | % | 100.00 | 103.14 | 100.86 | 100.00 | 106.26 | 103.05 |
| Weight on day 32 | g | 1 562 | 1 579 | 1 573 | 1 380 | 1 451 | 1 412 |
| Index I | % | 100.00 | 101.09 | 100.70 | 88.35 | 92.89 | 90.40 |
| Index II | % | 100.00 | 101.09 | 100.70 | 100.00 | 105.14 | 102.32 |
| Weight on day 42 | g | 2 039 | 2 051 | 2 055 | 1 842 | 1 926 | 1 906 |
| Index I | % | 100.00 | 100.59 | 100.78 | 90.34 | 94.46 | 93.48 |
| Index II | % | 100.00 | 100.59 | 100.78 | 100.00 | 104.56 | 103.47 |

difference. Total feed consumption was on average lower in chicks receiving feeds with *Bacillus sp.* based probiotic preparations, mainly if applied to feeds with lower protein contents (Tab. VI).

Tab. VII shows nitrogen retention in relation to probiotic preparations containing *Bacillus sp.* and in relation to protein content in BR2 feeds; Tab. VIII documents nitrogen retention in diets with different protein contents in which Bacillus sp. based probiotic preparations were used (A x B interaction). Average nitrogen retention in feeds with *Bacillus sp.* based probiotic preparations was insignificantly higher ($a_1$, $a_2$) than in the control group ($a_0$). This difference was within a relative range +5.5%. A slight decrease in average retention was recorded in diets with lower protein contents. It is evident from Tab. VIII that a substantial increase in nitrogen retention was observed in the groups of chicks receiving higher protein contents in BR2 feeds containing *Bacillus sp.* based probiotic preparations ($a_1b_0$, $a_2b_0$). The lowest average nitrogen retention was determined in control group ($a_0b_0$) higher protein content without probiotic additives. The groups ($a_0b_1$, $a_1b_1$, $a_2b_2$) showed higher nitrogen retention than the control ($a_0b_0$) +3.50 to +4.4%, but retention

V. The effect of *Bacillus sp.* based probiotic preparations and different dietary protein contents on feed consumption in kg per 1 kg of weight gain

| Parameter | Unit | Probiotic preparation (A) | | | Proteins (B) | | Sex (C) | |
|---|---|---|---|---|---|---|---|---|
| | | $a_0$ | $a_1$ | $a_2$ | $b_0$ | $b_1$ | $c_0$ | $c_1$ |
| Group number | number | 16 | 16 | 16 | 24 | 24 | 24 | 24 |
| BR1 feed consumption | | | | | | | | |
| Days 1–21 | kg | 1.651[1] | 1.607[2] | 1.628[1,2] | 1.557[A] | 1.700[B] | 1.623 | 1.634 |
| S.D. | kg | ± 0.111 | ± 0.077 | ± 0.084 | ± 0.033 | ± 0.074 | ± 0.116 | ± 0.061 |
| Index | % | 100.00 | 97.33 | 98.61 | 100.00 | 109.18 | 100.00 | 100.68 |
| BR2 feed consumption | | | | | | | | |
| Days 22–35 | kg | 2.173 | 2.189 | 2.163 | 2.204[a] | 2.146[b] | 2.173 | 2.176 |
| S.D. | kg | ± 0.131 | ž 0.076 | ± 0.076 | ± 0.092 | ± 0.094 | ± 0.116 | ± 0.074 |
| Index | % | 100.00 | 100.74 | 99.54 | 100.00 | 97.37 | 100.00 | 100.14 |
| BR2 feed consumption | | | | | | | | |
| Days 22–42 | kg | 2.316 | 2.307 | 2.306 | 2.360[a] | 2.258[b] | 2.303 | 2.316 |
| S.D. | kg | ± 0.133 | ± 0.096 | ± 0.086 | ± 0.102 | ± 0.081 | ± 0.117 | ± 0.093 |
| Index | % | 100.00 | 99.61 | 99.57 | 100.00 | 95.68 | 100.00 | 100.56 |
| Total feed consumption | | | | | | | | |
| Days 1–35 | kg | 1.953 | 1.936 | 1.944 | 1.924 | 1.965 | 1.940 | 1.948 |
| S.D. | kg | ± 0.085 | ± 0.049 | ± 0.049 | ± 0.055 | ± 0.064 | ± 0.074 | ± 0.050 |
| Index | % | 100.00 | 99.13 | 99.54 | 100.00 | 102.13 | 100.00 | 100.41 |
| Total feed consumption | | | | | | | | |
| Days 1–42 | kg | 2.104 | 2.076 | 2.097 | 2.097 | 2.088 | 2.088 | 2.097 |
| S.D. | kg | ± 0.085 | ± 0.062 | ± 0.048 | ± 0.074 | ± 0.059 | ± 0.075 | ± 0.058 |
| Index | % | 100.00 | 98.67 | 99.67 | 100.00 | 99.58 | 100.00 | 100.43 |

Capital letters designate the values highly significantly different at $P < 0.01$
Small letters designate the values significantly different at $P < 0.05$
Digits designate the values significantly different at $P < 0.1$

was not found to be influenced by probiotic preparations. Tab. IX shows the effect of *Bacillus sp.* based probiotic preparations and different protein contents in BR2 feeds on N output in droppings per 1 kg of weight gain. The groups of chicks receiving *Bacillus sp.* based probiotic preparations ($a_1$, $a_2$) had N output per 1 kg of weight gain lower by 5.81–6.31%. This difference was at the level of statistical significance.

The groups of chicks receiving lower protein contents in BR2 feeds ($b_1$) showed N output in droppings by 13.31% lower than the groups with higher protein contents in diets ($b_0$). The difference between the groups was statistically significant at $P < 0.05$.

The effect of *Bacillus sp.* based probiotic preparations on N output in droppings is documented mainly in Tab. X showing the values of N output for chicks receiving diets with higher and lower protein contents, and with *Bacillus sp.* based probiotic preparations (A x B interactions).

Substantially lower N output in droppings of chicks receiving *Bacillus sp.* probiotic preparations than in the control ($a_0b_0$) was determined in the groups ($a_1b_0$ and $a_2b_0$) on diets with higher protein contents. The effect of *Bacillus sp.* applied to diets with lower protein contents as exerted on this parameter was much higher.

## DISCUSSION

As indicated by the experimental results, protein contents in BR1 feeds (starters) as well as in BR2 feeds for broiler production have dominant effects on growth rate and feed consumption per 1 kg of weight gain and on total utilization of N uptake. In the first stage of feeding, the effect of protein content 23–24% in BR1 feeds on chick growth is positive, and is important with respect to the good nutrition condition of chicks in the following period. Protein content in BR2 feeds should be below 20% at a medium energy level in the period from 21st day of age. The parameters of chick weight and feed consumption were better in the feeding period from 21st to 42nd day, when BR2 feeds with protein content 18.22% and 11.94 MJ/kg were used than in the case of BR2 feeds with protein content 20.85% and 11.62 MJ/kg. Nitrogen retention was significantly influenced by protein content in BR2 feeds, the effect of the latter parameter on N output in chick droppings was highly significant. These results are generally well-known. But the objective of the trial was to find other ways of improving utilization of proteins ingested in feed, and of reducing N output in chick droppings. Probiotic preparations, with their increasing number every

VI. Interactions of the effect of *Bacillus* sp. based probiotic preparations used in diets with different protein contents on feed consumption in kg per 1 kg of weight gain

| Parameter | Unit | A x B interactions | | | | | |
|---|---|---|---|---|---|---|---|
| | | $a_0b_0$ | $a_1b_0$ | $a_2b_0$ | $a_0b_1$ | $a_1b_1$ | $a_2b_1$ |
| Group number | number | 8 | 8 | 8 | 8 | 8 | 8 |
| BR1 feed consumption | | | | | | | |
| Days 1–21 | kg | 1.573 | 1.541 | 1.557 | 1.730 | 1.673 | 1.698 |
| Index I | % | 100.00 | 97.97 | 98.98 | 109.98 | 106.36 | 107.95 |
| Index II | % | 100.00 | 97.97 | 98.98 | 100.00 | 96.71 | 98.15 |
| BR2 feed consumption | | | | | | | |
| Days 22–35 | kg | 2.190 | 2.236 | 2.185 | 2.156 | 2.141 | 2.140 |
| Index I | % | 100.00 | 102.10 | 99.77 | 98.45 | 97.76 | 97.72 |
| Index II | % | 100.00 | 102.10 | 99.77 | 100.00 | 99.30 | 99.26 |
| BR2 feed consumption | | | | | | | |
| Days 22–42 | kg | 2.367 | 2.355 | 2.358 | 2.264 | 2.259 | 2.253 |
| Index I | % | 100.00 | 99.49 | 99.62 | 95.65 | 95.44 | 95.18 |
| Index II | % | 100.00 | 99.49 | 99.62 | 100.00 | 99.78 | 99.51 |
| Total feed consumption | | | | | | | |
| Days 1–35 | kg | 1.921 | 1.924 | 1.926 | 1.983 | 1.949 | 1.961 |
| Index I | % | 100.00 | 100.16 | 100.26 | 103.23 | 101.46 | 102.08 |
| Index II | % | 100.00 | 100.16 | 100.26 | 100.00 | 98.29 | 98.89 |
| Total feed consumption | | | | | | | |
| Days 1–42 | kg | 2.106 | 2.076 | 2.108 | 2.103 | 2.076 | 2.086 |
| Index I | % | 100.00 | 98.58 | 100.09 | 99.86 | 98.58 | 99.05 |
| Index II | % | 100.00 | 98.58 | 100.09 | 100.00 | 98.72 | 99.19 |

VII. The effect of *Bacillus sp.* based probiotic preparations and different dietary protein contents on nitrogen retention

| Parameter | Unit | Probiotics | | | Proteins | |
|---|---|---|---|---|---|---|
| | | $a_0$ | $a_1$ | $a_2$ | $b_0$ | $b_1$ |
| Number of determinations | number | 12 | 12 | 12 | 18 | 18 |
| N retention | % | 44.54 | 47.02 | 47.01 | 46.96 | 45.42 |
| S.D. | % | ± 3.36 | ± 5.67 | ± 3.87 | ± 4.89 | ± 3.94 |
| Index | % | 100.00 | 105.56 | 105.55 | 100.00 | 96.72 |

VIII. Interactions of the effect of *Bacillus sp.* based probiotic preparations used in diets with different protein contents on nitrogen retention

| Parameter | Unit | A x B interactions | | | | | |
|---|---|---|---|---|---|---|---|
| | | $a_0b_0$ | $a_1b_0$ | $a_2b_0$ | $a_0b_1$ | $a_1b_1$ | $a_2b_1$ |
| Number of determinations | number | 6 | 6 | 6 | 6 | 6 | 6 |
| N retention | % | 43.73 | 48.79 | 48.35 | 45.35 | 45.26 | 45.67 |
| Index I | % | 100.00 | 111.57 | 110.56 | 103.70 | 103.50 | 104.44 |
| Index II | % | 100.00 | 111.57 | 110.56 | 100.00 | 99.80 | 100.71 |

year, are mostly used as a preventive agent against intestinal diseases. Most of these preparations stimulate growth and improve feed conversion. *Bacillus sp.* based preparations used in our trial contributed to higher chick weight and moderately lower feed consumption per unit of weight gain, which is in agreement with our previous results (Kumprecht, Zobač, 1996), and with results reported by Nguyen et al. (1988a, b) and Nguyen (1990).

Proteolytic activity of the bacterial strains under study was demonstrated in relation to pH value and application time by trials *in vitro* (Figs. 1 and 2). The highest values in units of activity were recorded at pH 7 in both strains, the lowest values at pH 5.8 in *Bacillus* C.I.P. 5832 and at pH 8.2 in *Bacillus subtilis* CCM 2216. It is possible to state that both strains can produce proteases in the digestive tract medium from duodenum to large intestine.

IX. The effect of *Bacillus sp.* based probiotic preparations and different dietary protein contents on N output in droppings per 1 kg of weight gain in broilers

| Parameter | Unit | Probiotic preparations (A) | | | Proteins (B) | |
|---|---|---|---|---|---|---|
| | | $a_0$ | $a_1$ | $a_2$ | $b_0$ | $b_1$ |
| Number of determinations | number | 12 | 12 | 12 | 18 | 18 |
| N output per 1 kg of weight gain | g | 36.975 | 34.642 | 34.825 | 38.011[a] | 32.950[b] |
| S.D. | g | ± 5.307 | ± 6.049 | ± 6.276 | ± 6.973 | ± 2.752 |
| Index | % | 100.00 | 93.69 | 94.19 | 100.00 | 86.69 |

Small letters designate the values significantly different at $P < 0.05$

X. Interactions of the effect of *Bacillus sp.* based probiotic preparations used in diets with different protein contents on N output in chick droppings per 1 kg of weight gain

| Parameter | Unit | A x B interactions | | | | | |
|---|---|---|---|---|---|---|---|
| | | $a_0b_0$ | $a_1b_0$ | $a_2b_0$ | $a_0b_1$ | $a_1b_1$ | $a_2b_1$ |
| Number of determinations | number | 6 | 6 | 6 | 6 | 6 | 6 |
| N output per 1 kg of weight gain | g | 40.400 | 36.633 | 37.000 | 33.550 | 32.650 | 32.650 |
| Index I | % | 100.00 | 90.68 | 91.58 | 83.04 | 80.82 | 80.82 |
| Index II | % | 100.00 | 90.68 | 91.58 | 100.00 | 97.32 | 97.32 |

Comparison of data obtained both *in vitro* and *in vivo* after applications of *Bacillus* C.I.P. 5832 as well as *Bacillus subtilis* CCM 2216 bacteria to diets shows a striking agreement of data on higher nitrogen retention as well as on N output in droppings of chicks from experimental groups.

Lower N output in droppings of chicks receiving diets with *Bacillus sp.* probiotic preparations indicated that the use of appropriate biological preparations in diets can contribute to a decrease in the environmental nitrogen load.

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