ZAKLJUČNO POROČILO
O REZULTATIH OPRAVLJENEGA RAZISKOVALNEGA DELA NA PROJEKTU V OKVIRU CILJNEGA RAZISKOVALNEGA PROGRAMA (CRP) »KONKURENČNOST SLOVENIJE 2006 – 2013«

I. Predstavitev osnovnih podatkov raziskovalnega projekta

1. Naziv težišča v okviru CRP:

Povezovanje ukrepov za doseganje trajnostnega razvoja

2. Šifra projekta:

V4-0327

3. Naslov projekta:

Oživitev prireje kopunjega mesa z različnimi genotipi piščancev

3. Naslov projekta

3.1. Naslov projekta v slovenskem jeziku:

Oživitev prireje kopunjega mesa z različnimi genotipi piščancev

3.2. Naslov projekta v angleškem jeziku:

Revive of capon's meat production with different genotype of chickens

4. Ključne besede projekta

4.1. Ključne besede projekta v slovenskem jeziku:

kopun, genotip, prireja mesa, kakovost mesa

4.2. Ključne besede projekta v angleškem jeziku:

capon, genotype, meat production, meat quality

POVZETEK CRP PROJEKTA »OŽIVITEV PRIREJE KOPUNJEGA MESA Z RAZLIČNIMI GENOTIPI PIŠČANCEV« (V4-0327)

V projektu smo proučevali primernost treh genotipov vrste kokoši za prirejo kopunjega mesa. Vključili smo grahasti prelux (prelux-G), ki je križanec dveh slovenskih tradicionalnih pasem (slovenske grahaste kokoši in slovenske rjave kokoši), slovensko avtohtono pasmo štajersko kokoš in pasmo sulmtaler, ki je avtohtona kokoš iz doline Sulm v Avstriji. Izvedli smo tri poskuse, dva v prosti reji in enega v zaprti reji (talni reji na nastilu). V prvem poskusu smo pitali kopune v hlevu z izpustom do dveh starostih. Proučili smo pitovne in klavne lastnosti kopunov, senzorične lastnosti kopunjega mesa, kemijsko in maščobnokislinsko sestavo mesa. Če vse pomembne pitovne lastnosti izrazimo v proizvodnem indeksu so pri obeh starostih, 156 in 199 dni, po večjem oz. boljšem indeksu odstopali kopuni prelux-G. Kopune štajerske kokoši in prelux-G je smiselno pitati le do starosti 156 oz. 163 dni, kajti po tej starosti prenehajo priraščati. Tudi po klavnih lastnostih so bili v prednosti kopuni prelux-G pred kopuni drugih dveh pasem. Ker ni mogoče vseh senzoričnih lastnosti izraziti v eni številki je tudi nemogoče izpostaviti posamezni genotip po boljših ali slabših lastnostih. Ocene večine senzoričnih lastnostih in rezne trdnosti mesa so bile boljše pri mlajših kopunih. S statistično analizo smo proučili vpliv genotipa, starosti in kosa (bedro, prsa) na kemijsko sestavo (vsebnost suhe snovi, surovih, beljakovin, celokupnih maščob in surovega pepela) in maščobnokislinsko sestavo kopunjega mesa. Pri drugih dveh poskusih smo proučili vpliv različnega energijskega nivoja krme (9,40 MJ ME/kg in 12,90 MJ ME/kg) na pitovne in klavne lastnosti kopunov v dveh sistemih reje.

CRP PROJECT – ABSTRACT "REVIVE OF CAPON'S MEAT PRODUCTION WITH DIFFERENT GENOTYPE OF CHICKENS" (V4-0327)

The aim of the project was to study the suitability of three genotypes of hen for capon meat production. Barred Prelux (Prelux-G), a crossbreed of two Slovenian traditional breeds (Slovenian barred hen and Slovenian brown hen), Slovenian autochthonous Styrian hen and Sulmtaler breed which is an autochthonous breed originated in the valley Sulm, Austria. Three experiments were carried out, two free range and one in standard deep litter house. In the first experiment capons were kept free range till two different ages. Fattening and slaughtering traits of capons and sensory traits of capon meat as well as chemical and fatty acid composition of meat were studied. Summarizing the most important fattening traits in production index at ages 156 and 199 days it was observed that better index was achieved by capons Prelux-G. Styrian hen capons and Prelux-G capons ought to be fattened only till age 156 and 163 days respectively, because they ceased to grow after the mentioned age. Better slaughtering traits were found in Prelux-G capons compared to other two breeds. Like all sensory traits cannot be summarized in a single number; thus a genotype cannot be characterized by better or worse traits. Estimations of most of sensory traits and cutting strength were better in younger capons. Statistical analysis was used to determine the effect of genotype, age and part of meat (thighs, breasts) on chemical composition (contents of dry matter, crude proteins, total fats and crude ash) and fatty acid composition of capon meat. In other two experiments the effect of different energy value of fodder (9.40 MJ ME/kg and 12.90 MJ ME/kg) on fattening and slaughtering traits were studied in two systems of rearing.

5. Naziv nosilne raziskovalne organizacije:

Univerza v Ljubljani (Biotehniška fakulteta)

5.1. Seznam sodelujočih raziskovalnih organizacij (RO):

Univerza v Mariboru (Fakulteta za kmetijstvo)
Raziskovalna enota Perutnine Ptuj

6. Sofinancer/sofinancerji:

Ministrstvo za kmetijstvo, gozdarstvo in prehrano

7. Šifra ter ime in priimek vodje projekta:

8187 Antonija Holcman

Datum: 06. 10. 2008

Podpis vodje projekta:
Prof. dr. Antonija Holcman

Podpis in žig izvajalca:
Prof. dr. Andreja Kocijančič,
po pooblastilu
Prof. dr. Franci Štampar

II. Vsebinska struktura zaključnega poročila o rezultatih raziskovalnega projekta v okviru CRP

1. Cilji projekta:

1.1. Ali so bili cilji projekta doseženi?

- [x] a) v celoti
- [ ] b) delno
- [ ] c) ne

Če b) in c), je potrebna utemeljitev.

1.2. Ali so se cilji projekta med raziskavo spremenili?

- [ ] a) da
- [x] b) ne

Če so se, je potrebna utemeljitev:

2. Vsebinsko poročilo o realizaciji predloženega programa dela[1]:

Cilj projekta je bil proučiti:

- primernost različnih genotipov vrste kokoši za prirejo kopunjega mesa (pitovne in klavne lastnosti)
- kakovost kopunjega mesa (senzorične lastnosti, kemijska sestava mesa, maščobnokislinska sestava mesa)
- vpliv energijskega nivoja krme na pitovne in klavne lastnosti kopunov (v dveh sistemih reje)

Raziskovalna hipoteza:

1. Med kopuni različnih genotipov obstajajo razlike v pitovnih in klavnih lastnostih ter lastnostih kakovosti mesa. Ker je kakovost skupek različnih lastnosti so v posameznih lastnostih pričakovane razlike med genotipi.
2. Med genotipi obstajajo razlike v optimalni starosti kopunov za klanje.
3. Pri energijsko skromnejših obrokih bo potek nalaganja maščob približno enak nalaganju beljakovin (mesa), v primeru energijsko bogatejših obrokov pa se bodo bolj intenzivno nalagale maščobe, upočasnilo pa se bo nalaganje beljakovin.
   Dodatek koruznega drobljenca v zadnjem mesecu pitanja bo pripomogel k intenzivnejšemu rumenemu obarvanju kože.

Metodološko – teoretični opis:

V okviru projekta smo izvedli poskuse, v katere so bili vključeni trije genotipi kopunov:
- grahasti prelux (prelux-G), ki je križanec dveh slovenskih tradicionalnih pasem
- slovenska avtohtona pasma štajerska kokoš
- sulmtaler, ki je avtohtona kokoš iz doline Sulm v Avstriji.

Individualno označene dan stare petelinčke (117 petelinčkov prelux-G, 116 petelinčkov štajerske kokoši in 107 petelinčkov sulmtaler) smo ločeno po genotipih vselili v oddelke na testni postaji (talna reja na nastilu) za perutnino na Fakulteti za kmetijstvo v Mariboru. Pri šestih tednih starosti smo petelinčke kopunili. Pri starosti 84 dni smo kopune preselili k rejcu, ki je kooperant Perutnine Ptuj in sicer v hlev z izpustom, kjer smo jih pitali po tehnologiji proste reje. Tudi v tem hlevu so bili kopuni posameznih genotipov v ločenih oddelkih, vsak oddelek pa je imel odprtine za izhod v izpuste. Na vsakega kopuna je bilo zagotovljeno 4 m^2 s travo porasle površine. Kopune smo klali pri 163. in 198. dnevu starosti v eksperimentalni klavnici Oddelka za zootehniko.

Na ohlajenih klavnih trupih smo opravili meritve klavnih lastnosti: maso ohlajenega klasično obdelanega trupa, pH, prevodnost, barvo kože (na prsih in bedru), stehtali smo glavo, vrat, stopala, trebušno maščobo, trup za raženj, bedro, mišičnino bedra, prsi, mišičnino prsi, perutničke. Po opravljenih meritvah smo vzeli vzorec desetih klavnih trupov, obdelanih za raženj, po genotipu in jih zamrznili na -20°C do analize senzoričnih lastnosti. Opravili smo naslednje meritve in ocene senzoričnih lastnosti: maso trupa pred in po pečenju; na presnem kopunu smo ocenili mesnatost, barvo in zamaščenost; na

[1] Potrebno je napisati vsebinsko raziskovalno poročilo, kjer mora biti na kratko predstavljen program dela z raziskovalno hipotezo in metodološko-teoretičen opis raziskovanja pri njenem preverjanju ali zavračanju vključno s pridobljenimi rezultati projekta.

toplotno obdelanem kopunu pa barvo celega trupa, teksturo, mastnost in aromo kože. Ločeno po kosih (bedro, prsa) smo ocenili barvo, vonj, aromo, sočnost, mastnost, mehkobo, občutek v ustih in skupni vtis. Na presni mišičnini smo instrumentalno izmerili tudi rezno trdnost.
Iz ohlajenih klavnih trupov smo v klavnici vzeli tudi vzorce mišičnine za določitev kemijske in maščobnokislinske sestave. Po posameznem genotipu smo od desetih zaklanih trupov kopunov vzeli mišičnino enega bedra in mišičnino prsi. Tudi te vzorce smo zamrznili pri -20°C. V kemijskem laboratoriju Oddelka za zootehniko Biotehniške fakultete smo opravili kemijske analize mišičnine. Določili smo suho snov, surove beljakovine, celokupne maščobe in surovi pepel po metodah AOAC (Official Methods of Analysis) in analize maščobnokislinske sestave mišičnine s kapilarno plinsko kromatografijo.
V okviru proučevanja vpliva različnega energijskega nivoja (11 in 13 MJ ME/kg) krmne mešanice na pitovne in klavne lastnosti kopunov smo izvedli dva ločena poskusa:
1. Na Oddelku za zootehniko Biotehniške fakultete smo vselili 300 dan starih petelinčkov prelux-G v talno rejo na nastilu. Po kopunjenju smo jih razdelili v štiri skupine po 60 kopunov. Dve skupini sta bili krmljeni z energijsko bogatejšo krmo in dve skupini z energijsko revnejšo krmo. Zadnje štiri tedne pitanja smo eni skupini, ki je bila krmljena z revnejšo krmo in eni skupini, ki je bila krmljena z bogatejšo krmo, dodali po volji še koruzni drobljenec. Kopune smo klali pri 153. dnevu starosti. Postopek klanja, obdelava trupov in meritve klavnih lastnosti smo opravili po enakem postopku kot v prvem delu raziskave.
2. Na testno postajo za perutnino Fakultete za kmetijstvo v Mariboru smo vselili 300 dan starih petelinčkov prelux-G in 300 petelinčkov sulmtaler, po kopunjenju smo jih preselili v hlev z izpustom (pri kooperantu Perutnine Ptuj).
V obeh poskusih so bili kopuni krmljeni z istima krmnima mešanicama, le da so kopuni v drugem poskusu imeli na voljo dodatno še pašo.

Rezultati projekta:

Pitovne in klavne lastnosti

Rezultati prvega poskusa so pokazali, da obstajajo razlike v pitovnih lastnosti med proučevanimi genotipi. V analizo pitovnih lastnosti so bili vključeni prirasti oz. telesna masa pri 156. in 199. dnevu starosti, izkoriščanje krme in vitalnost živali. Pri 156. dnevu starosti so bili najtežji prelux-G kopuni (2,9 kg) in so porabili tudi najmanj krme za kilogram prirasta (4,8 kg krme za kg prirasta), najlažji pa so bili kopuni štajerske kokoši (2,1 kg), ki so porabili tudi največ krme za kilogram prirasta (5,6 kg za kilogram prirasta). Najvitalnejši so bili kopuni prelux-G, saj je v obdobju pitanja poginilo le 4,3 % kopunov, največji pogin pa je bil pri pasmi sulmtaler (19,1 %). Telesna masa kopunov prelux-G in štajerske kokoši se je povečevala do 156. dne starosti, v nadaljnjem obdobju pitanja, od 156. do 199. dneva starosti, je telesna masa kopunov ostala enaka. Zaključimo lahko, da je kopune prelux-G in štajerske kokoši smiselno pitati le do starosti 156 dni. Kopuni sulmtaler so sicer priraščali vse do 199. dneva starosti, ko so dosegli telesno maso 3,1 kg, vendar je tudi pri tej pasmi proizvodni indeks pri 199. dnevu starosti manjši kot pri 156. dnevu starosti. Za lažjo primerjavo gospodarske učinkovitosti posameznega genotipa namreč lahko pitovne lastnosti kopunov izrazimo v eni številki, v evropskem faktorju učinkovitosti – EEI ali proizvodnem indeksu - PI (preglednica 1). Po večjem oz. boljšem proizvodnem indeksu kopuni prelux-G odstopajo od sulmtaler in štajerske kokoši.

Preglednica 1: Proizvodni indeksi po genotipih pri dveh starostih kopunov

Genotip	Starost kopunov (dni) 156	199
Prelux-G	37	22
Štajerska kokoš	22	13
Sulmtaler	28	20

Prvo skupino kopunov smo klali pri starosti 163 dni in drugo pri starosti 198 dni. Tudi po vseh merjenih klavnih lastnosti so v prednosti kopuni prelux-G pred kopuni drugih dveh genotipov. Kopuni sulmtaler so imeli značilno najmanjšo količino trebušne maščobe, med drugima genotipoma pa ni bilo značilnih odstopanj v zamaščenosti. Čeprav dandanes v zdravi prehrani dajemo prednost pustim vrstam mesa, pa naj bi kopun vseboval več maščobe, saj ta prispeva k okusnosti mesa. Sicer pa lahko porabnik trebušno maščobo z lahkoto odstrani iz trebušne votline.
Rezultate o pitovnih in klavnih lastnosti treh različnih genotipov kopunov (»Growth rate and carcass traits in three genotypes of capons«) smo predstavili na kongresu »New perspectives and challenges of sustainable livestock farming« v Beogradu.
Z rezultati tega poskusa smo potrdili hipotezo, da med genotipi obstajajo razlike v optimalni starosti kopunov za klanje in da med genotipi obstajajo razlike tudi v pitovnih in klavnih lastnostih.

Senzorične lastnosti kopunjega mesa

Pri senzorični oceni presnih trupov je genotip značilno vplival na oceno konformacije in barvo, starost pa le na oceno konformacije. Najboljšo konformacijo so imeli kopuni sulmtaler in najslabšo kopuni pasme štajerska kokoš. Barva presnih trupov je bila najbolje ocenjena pri kopunih prelux-G, saj so bili za več kot točko bolje ocenjeni od ostalih dveh genotipov. V zamaščenosti presnih trupov se tako genotipi kot starostni skupini niso razlikovali. Na senzorične lastnosti kože je močneje vplivala starost kopunov kot genotip. Starejša skupina kopunov je imela bolje ocenjeno barvo kože in aromo, medtem ko je imela mlajša skupina bolje ocenjeno teksturo kože. Med genotipi so bile značilne razlike le pri mastnosti kože, najmanj mastno kožo so imeli kopuni prelux-G, najbolj pa kopuni sulmtaler. Ocenjevalna komisija pri mesu prsi ni zaznala razlik med genotipi pri barvi, vonju, aromi, mehkobi ter mastnosti. Kopuni prelux-G so bili od ostalih dveh genotipov boljši pri občutku v ustih, prav tako pa se je pokazal trend, da je ta genotip boljši tudi v sočnosti. S starostjo se senzorične lastnost mesa prsi niso spreminjale, izjema je bila mehkoba, kjer so kopuni starejše skupine prejeli slabšo oceno. Na mehkobo mesa beder je vplival genotip. Najbolje so bili ocenjeni kopuni sulmtaler. Pri aromi in mastnosti mesa beder se je kazal trend med genotipi. Starost je vplivala na barvo in vonj mesa beder, mlajša skupina je bila ocenjena bolje.
Pri rezni trdnosti mesa med vzorci beder in prsi ni bilo značilnih razlik. Kot značilna vpliva sta se pokazala tako genotip kot starost ter interakcija med njima. Kopuni pasme sulmtaler so imeli pri obeh starostih manjšo rezno trdnost v primerjavi s kopuni prelux-G in štajerske kokoši. Pri vseh treh genotipih je opazno poslabšanje kakovosti mišičnine s starostjo, kar kaže na to, da bi bila starost kopunov 163 dni primernejša kot starost 198 dni. Rezna trdnost mesa je bila tako pri bedrih kot prsih negativno korelirana z barvo,

vonjem in mehkobo mesa, pri prsih tudi z mastnostjo mesa, pri bedrih pa s skupnim vtisom.
Iz rezultatov proučevanj senzoričnih lastnosti mesa treh genotipov kopunov smo pripravili prispevek, ki smo ga poslali v objavo v »Acta agriculturae Slovenica« (v prilogi).

Kemijska sestava mesa

S statistično analizo smo proučili vpliv genotipa (prelux-G, sulmtaler, štajerska kokoš), starosti kopunov (163 in 198 dni) in kosa (bedra, prsa) na kemijsko sestavo kopunjega mesa. Določali smo vsebnost suhe snovi, surovih beljakovin, celokupnih maščob in surovega pepela. Genotip in starost kopunov sta statistično značilno vplivala na posamezne parametre kemijske sestave, razen genotip ni značilno vplival na vsebnost surovih beljakovin in starost na vsebnost surovega pepela. V vseh parametrih kemijske sestave so bile značilne razlike med kosoma (bedra in prsa).
Kopuni štajerske kokoši so od drugih genotipov značilno odstopali po večji vsebnosti suhe snovi in celokupnih maščobah ter manjši vsebnosti surovega pepela. V kemijski sestavi mišičnine prelux-G in sulmtaler kopunov je bila značilna razlika le v vsebnosti surovega pepela. Mišičnina starejših kopunov je vsebovala značilno več suhe snovi, surovih beljakovin in celokupnih maščob kot mišičnina mlajših kopunov. Mišičnina beder je vsebovala značilno več suhe snovi in surovih maščob ter značilno manj surovih beljakovin in surovega pepela kot mišičnina prsi.

Maščobnokislinska sestava mesa

Prav tako smo s statistično analizo proučili vpliv genotipa, starosti kopunov in kosa na maščobnokislinsko sestavo kopunjega mesa. Genotip je značilno vplival na vsoto NMK (nasičenih maščobnih kislin), ENMK (enkrat nenasičenih maščobnih kislin), VNMK (večkrat nenasičenih maščobnih kislin), na vsebnost n-3 in n-6 maščobnih kislin. V mišičnini kopunov štajerske kokoši je bil značilno manjši delež VNMK, n-3 in n-6 maščobnih kislin kot v mišičnini drugih dveh genotipov. V deležih NMK in ENMK so bile značilne razlike med vsemi tremi genotipi. Največji delež NMK in najmanjši delež ENMK je bil v mišičnini prelux-G. Najmanjši delež NMK je bil v mišičnini sulmtaler kopunov in največji delež ENMK je bil v mišičnini kopunov štajerske kokoši. Tudi starost kopunov je značilno vplivala na omenjene maščobne kisline, razen na utežni odstotek n-3 maščobnih kislin. S starostjo se je povečal delež ENMK, deleži NMK, VNMK, n-3 in n-6 maščobnih kislin pa so se zmanjšali. Med kosoma (bedra, prsa) ni bilo značilnih razlik pri utežnem odstotku vsote VNMK in n-6 maščobnih kislin. V prsih je bil značilno večji delež NMK in n-3 maščobnih kislin ter manjši delež ENMK.

Iz rezultatov analiz kemijske in maščobnokislinske sestave kopunjega mesa pripravljamo dva prispevka za objavo v tuji reviji.

Vpliv energijskega nivoja krme na pitovne in klavne lastnosti kopunov

1. Področje prehrane kopunov je zelo slabo proučeno. Iz nekaj opravljenih poskusov smo povzeli, da lahko na pitovne in klavne lastnosti kopunov vplivamo s koncentracijo beljakovin v krmi, medtem ko se vpliv koncentracije energije v krmi na klavne lastnosti v literaturi ne omenja. Zato smo v okviru tega projekta proučili vpliv energijskega (obilni/skromni) obroka na rastnost in klavne lastnosti kopunov. Poleg tega smo proučili

vpliv dodatka koruznega drobljenca na omenjene lastnosti in še zlasti na obarvanost kože, ki naj bi bila pri kopunih intenzivno rumena. Energija je poglavitna sestavina krme za kopune in je v obroku tudi najdražja. Zato je razumljivo iskanje kakšen nivo energije v krmi bi kopunom najbolj ustrezal, pri čemer naj bi bila izkoriščanje krme in klavna kakovost dobra oziroma boljša od že ugotovljene. Rezultati poskusa so pokazali, da se je izkoriščanje krme izboljšalo, medtem ko se je učinkovitost izkoriščanja energije poslabšala z višjim energijskim nivojem krme. Kopuni, krmljeni z energijsko bogatejšo krmo so bili značilno težji, težji so bili eviscerirani trupi in trupi pripravljeni za raženj, večja je bila klavnost in delež vratov, a manjši je bil delež stopal kot pri kopunih, krmljenih z energijsko revnejšimi obroki. Dodatek koruznega drobljenca v obroku je imel negativni učinek na nekatere klavne lastnosti, ki so ekonomsko pomembne, kot so masa trupa pripravljenega za peko, klavnost, delež glave, delež stopal. Pozitiven učinek je bil ugotovljen pri deležu drobovine. Vsebnost abdominalne maščobe je bila podobna pri vseh poskusnih skupinah, kljub dejstvu, da je bilo razmerje med vsebnostjo beljakovin in energije različno. Koža na prsih in bedrih kopunov, ki so bili krmljeni z obroki z večjim energijskim nivojem, so imeli večjo »a« vrednost (več rdečine), manjšo »b« vrednost (manjša rumenost) in manjšo vrednost pH kot kopuni, ki so bili krmljeni z energijsko revnejšo krmo. Dodani drobljenec v obrok je značilno vplival na povečano vrednost »b« (na večjo rumenost) in pH vrednost. Rumenost kože na prsih in bedrih je bila pozitivno korelirana s pH.

Ta raziskava je pokazala, da bi s krmljenjem kopunov z energijsko bogatejšo krmo pridobili težje spitane kopune in težje eviscerirane trupe, izboljšana bi bila klavnost. Obroki z večjim razmerjem med energijo in beljakovinami ne povzročijo večje zamaščenosti kopunov. Rezultati tega poskusa so podani v prispevku z naslovom »Effects of dietary energy density and coarsely grounded corn supplementation on growth performance, carcass traits and meat quality of capons« (priloga) in ga bomo poslali v objavo v tujo revijo.

2. Primerjava telesnih mas prelux-G kopunov, ki so bili krmljeni z istima krmnima mešanicama (energijsko bogatejšo in energijsko revnejšo krmo), vendar v različnih sistemih reje – zaprti reji na nastilu in v prosti reji (reji v izpustu) - je pokazala, da so bili težji kopuni iz zaprte reje in da se je razlika s starostjo kopunov povečevala.

Tudi v prosti reji so bili težji kopuni krmljeni z energijsko bogatejšo krmo kot kopuni krmljeni z revnejšo krmo. Prav tako smo pri tem poskusu potrdili, da dosežejo prelux-G kopuni večje telesne mase kot kopuni pasme sulmtaler. Tako so bili prelux-G kopuni pri 140. dnevu starosti težji od sulmtaler za 250 g, ko so bili krmljeni z energijsko revnejšo krmo in za 495 g, ko so bili krmljeni z energijsko bogatejšo krmo.

3. Izkoriščanje dobljenih rezultatov:

3.1. Kakšen je potencialni pomen[2] rezultatov vašega raziskovalnega projekta za:

- ☒ a) odkritje novih znanstvenih spoznanj;
- ☐ b) izpopolnitev oziroma razširitev metodološkega instrumentarija;
- ☒ c) razvoj svojega temeljnega raziskovanja;
- ☐ d) razvoj drugih temeljnih znanosti;
- ☒ e) razvoj novih tehnologij in drugih razvojnih raziskav.

3.2. Označite s katerimi družbeno-ekonomskimi cilji (po metodologiji OECD-ja) sovpadajo rezultati vašega raziskovalnega projekta:

☒ a) razvoj kmetijstva, gozdarstva in ribolova - Vključuje RR, ki je v osnovi namenjen razvoju in podpori teh dejavnosti;

☐ b) pospeševanje industrijskega razvoja - vključuje RR, ki v osnovi podpira razvoj industrije, vključno s proizvodnjo, gradbeništvom, prodajo na debelo in drobno, restavracijami in hoteli, bančništvom, zavarovalnicami in drugimi gospodarskimi dejavnostmi;

☐ c) proizvodnja in racionalna izraba energije - vključuje RR-dejavnosti, ki so v funkciji dobave, proizvodnje, hranjenja in distribucije vseh oblik energije. V to skupino je treba vključiti tudi RR vodnih virov in nuklearne energije;

☐ d) razvoj infrastrukture - Ta skupina vključuje dve podskupini:

- transport in telekomunikacije - Vključen je RR, ki je usmerjen v izboljšavo in povečanje varnosti prometnih sistemov, vključno z varnostjo v prometu;
- prostorsko planiranje mest in podeželja - Vključen je RR, ki se nanaša na skupno načrtovanje mest in podeželja, boljše pogoje bivanja in izboljšave v okolju;

☐ e) nadzor in skrb za okolje - Vključuje RR, ki je usmerjen v ohranjevanje fizičnega okolja. Zajema onesnaževanje zraka, voda, zemlje in spodnjih slojev, onesnaženje zaradi hrupa, odlaganja trdnih odpadkov in sevanja. Razdeljen je v dve skupini:

☐ f) zdravstveno varstvo (z izjemo onesnaževanja) - Vključuje RR - programe, ki so usmerjeni v varstvo in izboljšanje človekovega zdravja;

☐ g) družbeni razvoj in storitve - Vključuje RR, ki se nanaša na družbene in kulturne probleme;

☐ h) splošni napredek znanja - Ta skupina zajema RR, ki prispeva k splošnemu napredku znanja in ga ne moremo pripisati določenim ciljem;

☐ i) obramba - Vključuje RR, ki se v osnovi izvaja v vojaške namene, ne glede na njegovo vsebino, ali na možnost posredne civilne uporabe. Vključuje tudi varstvo (obrambo) pred naravnimi nesrečami.

[2] Označite lahko več odgovorov.

3.3. Kateri so **neposredni rezultati** vašega raziskovalnega projekta glede na zgoraj označen potencialni pomen in razvojne cilje?

Kopunje meso je nekdaj veljalo za specialiteto in je slovelo po sočnosti in okusnosti. Zaradi drage reje so kopune s tržišča izpodrinili cenejši pitovni piščanci. Dandanes pa bi lahko kopunje meso prispevalo k večji pestrosti ponudbe različnih vrst mesa. Pitanje kopunov v prosti reji (reji v izpustih) oziroma ekološki reji lahko predstavlja dopolnilno dejavnost na kmečkih gospodarstvih. Rezultati tega projekta v zvezi s pitanjem kopunov prelux-G v zaprti reji pa so pokazali, da je lahko uspešen tudi ta način reje kopunov. V preteklosti so bili znani predvsem kopuni naše avtohtone pasme štajerske kokoši. V okviru projekta smo želeli proučiti ali obstajajo bistvene (statistično značilne) razlike med kopuni jerebičaste štajerske kokoši in kopuni nekaterih drugih pasem oz. križancev. Tako smo proučili razlike med tremi genotipi in primernost posameznega genotipa za prirejo kopunjega mesa, kjer smo ovrednotili različne skupine lastnosti (pitovne, klavne, senzorične, kemijske). Ker smo v času, ko se vse bolj ceni in poudarja vrednost lokalnih pasem in lokalnih proizvodov, smo v poskuse vključili tudi slovenske tradicionalne pasme kokoši oz. njihovega križanca. Prelux-G je namreč križanec dveh slovenskih tradicionalnih pasem (slovenske rjave kokoši in slovenske grahaste kokoši). Prelux-G nesnica je priljubljena v Sloveniji predvsem v kmečkih rejah oz. rejah v manjših jatah. Čeprav je to srednje težka kokoš, so petelinčki nezanimivi za pitanje in jih je potrebno usmrtiti že takoj po izvalitvi. S kopunjenjem teh petelinčkov pri približno šestih tednih starosti pa lahko priredimo kakovostno kopunje meso. V rezultatih vseh poskusov, ki smo jih izvedli v okviru tega projekta, so se še posebej izkazali prav prelux-G kopuni. Ti kopuni so pri večini proučevanih lastnosti statistično značilno odstopali od drugih dveh pasem. V poskuse pa smo vključili še eno staro pasmo, sulmtaler. To je težki tip štajerske kokoši, ki je bil včasih razširjen v srednještajerski dolini reke Sulm (v Avstriji). Wenko (1935) je v knjigi »Kmetijsko kokošarstvo« zapisal, da je »sulmdolka« mesnata kokoš, ki je zelo požrešna in je za pašo manj prikladna. Veliko pomanjkanje krme med drugo svetovno vojno je povzročilo, da je ta kokoš izginila. Rejci v dolini Sulm želijo to pasmo ponovno oživiti in promovirati kot primerno pasmo za prirejo kopunjega mesa. Po večini lastnosti, ki smo jih proučevali v okviru projekta, se je ta pasma uvrstila med kopuni prelux-G in kopuni štajerske kokoši.

Z rezultati projekta smo odgovorili na vprašanje primernosti posameznega genotipa (prelux-G, sulmtaler, štajerske kokoši) za kopunjenje oz. prirejo kopunjega mesa. Potrdili smo hipotezo, da med kopuni imenovanih genotipov obstajajo značilne razlike v pitovnih in klavnih lastnostih, senzoričnih lastnosti in kemijski sestavi mesa.

Prav tako smo ugotovili, da obstajajo med temi genotipi razlike v optimalni starosti za klanje. Zaradi ekonomske učinkovitosti prireje kopunjega mesa ni upravičeno pitanje kopunov štajerske kokoši in prelux-G nad starostjo 156 dni oz. 163 dni.

Nekateri rezultati projekta predstavljajo tudi prispevek k izdelavi tehnologije pitanja kopunov. Tehnologija je najbolj pomanjkljiva na področju prehrane kopunov, o tem pa je tudi v literaturi zelo malo podatkov. Nekaj odgovorov v zvezi z energijskim nivojem krme smo pridobili s poskusom v okviru tega projekta.

3.4. Kakšni so lahko **dolgoročni rezultati** vašega raziskovalnega projekta glede na zgoraj označen potencialni pomen in razvojne cilje?

Rezultati raziskave v okviru tega projekta predstavljajo pomemben znanstveni prispevek na področju pitanja kopunov, prireje in kakovosti kopunjega mesa, hkrati pa imajo tudi praktično vrednost. Rezultati projekta predstavljajo namreč pomemben prispevek k izdelavi tehnologije pitanja kopunov. Pridobljeni podatki bodo lahko vključeni tudi v prehranske tablice.
V Sloveniji bi vsekakor veljalo promovirati »slovenskega grahastega kopuna«. Kopuni avtohtone pasme štajerske kokoši so se po večini proučevanih lastnosti pokazali med vsemi tremi genotipi najmanj primerni. Rezultati projekta kažejo na to, da je prelux-G kopun primeren za pitanje v različnih sistemih reje, tako v zaprti kot prosti reji. Reja kopunov je lahko dopolnilna dejavnost na kmečkih gospodarstvih, tako v manjših rejah kot tudi pri kooperantih večjih perutninarskih družb.
Pitanje kopunov oz. prireja in prodaja kopunjega mesa lahko predstavlja zanimivo tržno nišo. Potrebno bi bilo organizirati združenje rejcev kopunov, ki bi ustrezno promoviralo in tržilo kopunje meso.

3.5. Kje obstaja verjetnost, da bodo vaša znanstvena spoznanja deležna zaznavnega odziva?

- ☐ a) v domačih znanstvenih krogih;
- ☒ b) v mednarodnih znanstvenih krogih;
- ☒ c) pri domačih uporabnikih;
- ☒ d) pri mednarodnih uporabnikih.

3.6. Kdo (poleg sofinancerjev) že izraža interes po vaših spoznanjih oziroma rezultatih?

Sulmtaler Vermarktungs GmbH, Grossklein, Austria

3.7. Število diplomantov, magistrov in doktorjev, ki so zaključili študij z vključenostjo v raziskovalni projekt?

1 diploma na visokošolskem strokovnem študiju na Fakulteti za kmetijstvo Univerze v Mariboru
1 diploma (v izdelavi) na univerzitetnem študiju kmetijstva – zootehnika na Oddelku za zootehniko Biotehniške fakultete Univerze v Ljubljani
1 magistrsko delo (v izdelavi) na podiplomskem študiju Bioloških in biotehniških znanosti na Biotehniški fakulteti Univerze v Ljubljani

4. Sodelovanje z tujimi partnerji:

4.1. Navedite število in obliko formalnega raziskovalnega sodelovanja s tujimi raziskovalnimi inštitucijami.

4.2. Kakšni so rezultati tovrstnega sodelovanja?

5. Bibliografski rezultati[3] :

Za vodjo projekta in ostale raziskovalce v projektni skupini priložite bibliografske izpise za obdobje zadnjih treh let iz COBISS-a) oz. za medicinske vede iz Inštituta za biomedicinsko informatiko. Na bibliografskih izpisih označite tista dela, ki so nastala v okviru pričujočega projekta.

6. Druge reference[4] vodje projekta in ostalih raziskovalcev, ki izhajajo iz raziskovalnega projekta:

[3] Bibliografijo raziskovalcev si lahko natisnete sami iz spletne strani:http:/www.izum.si/

[4] Navedite tudi druge raziskovalne rezultate iz obdobja financiranja vašega projekta, ki niso zajeti v bibliografske izpise, zlasti pa tiste, ki se nanašajo na prenos znanja in tehnologije.
Navedite tudi podatke o vseh javnih in drugih predstavitvah projekta in njegovih rezultatov vključno s predstavitvami, ki so bile organizirane izključno za naročnika/naročnike projekta.

PRILOGE

1. Bibliografski izpisi za obdobje 2006-2008 iz COBISS-a za vodjo projekta in ostale raziskovalce

2. Prispevek z naslovom »Effects of dietary energy density and coarsely grounded corn supplementation on growth performance, carcass traits and meat quality of capons«.

3. Prispevek z naslovom » Sensory traits of capon meat in three chicken genotypes«

Effects of dietary energy density and coarsely grounded corn supplementation on growth performance, carcass traits and meat quality of capons

D. Terčič[1], Milena Kovač[1] and Antonija Holcman[1]

[1]University of Ljubljana, Biotechnical Faculty, Department of Animal Science, Domžale, Slovenia

Introduction

Nowadays many, especially small poultry producers are finding success in the marketplace by jumping on two trends. One is the production of natural and organic poultry products and the other is the production and processing of specialty-type birds. Capons (castrated male chickens) produce more tender, juicier, and more flavorful meat than regular chickens (JACOB and MATHER, 2000). For this reason, they are considered a delicacy and a premium product for consumers who are increasingly willing to pay higher prices for special-quality meat. On the other hand using male layer type chicks for capon meat production may be a viable alternative to elimination of unwanted day-old cockerel chicks of the laying strains which is today a great problem for industrial hatcheries. Capons have presently only a small market but they continue to be in demand, especially for the gourmet market and in certain ethnic communities (PORTER, 2003). Producing these heavy birds requires adequate health measures, housing conditions and especially adequate nutrition to promote skeletal development, optimize live bird performance and allow the bird to express its meat yield and meat quality potential. However, as capon production is still limited to small-scale poultry producers the literature concerning capon nutrition is very scarce. Most capon diets are just modified broiler diets, with minor changes in nutrient components. One of other most important decisions for poultry nutritionist is level of the energy in the diet and its ratio to the protein. Not only is the energy level or energy:protein ratio of the diet the most crucial in terms of nutrition, but it also has the most impact on the practical application of the feed, on its cost and on the quality of carcasses (yields of edible meat, fat content) (BARTOV and PLAVNIK, 1998). In the past, the majority of capon studies was aimed to assess the effects of caponization on different production, carcass and physiological characteristics (e.g. CASON et al., 1988; TOR et al., 2002; DURAN, 2004; RAHMAN et al., 2004; CHEN et al., 2005; CHEN et. al., 2006) but according to our knowledge little research emphasis has been placed on the responses of capons to diets varying in energy density. Although WELTER (1976) studied the influence of variations in energy density on growth rates, feed efficiency and carcass yield of capons and roosters no information has been reported on the effects of different dietary energy levels on studied traits in capons. The present study was therefore carried out to evaluate the performance and carcass composition of capons at two levels of dietary energy concentration. Because a deep yellow skin carcass color is prefered it was also our objective to determine if and how inclusion of coarsely grounded corn in the last month of fattening affects growth, carcass and some meat quality variables in capons.

Material and Methods

Bird husbandry and dietary treatments

The experiment was conducted at the Department of Animal Science, University of Ljubljana, Slovenia for a period of five months in a summer season. A total of 300 vent-sexed male layer-type chicks of Slovenian provenance Prelux-G were individually identified by toe clipping, weighted and housed on wood shavings litter in an environmentally controlled room that had a temperature setpoint of 32°C. The temperature of the room was reduced by 3°C each week until 20°C was reached at 35 days of age.

At 40 days of age all birds were subjected to an overnight period of feed withdrawal and surgically castrated. The experiment was conducted in two periods: a) pre-experimental period: from 1 to 43 days of age; b) experimental period: from 44 to 154 days of age. In the pre-experimental period chicks received a standard commercial starter diet for broilers (12.60 MJ ME/kg and 22.3 % CP). At the start of the experimental period chicks were individually weighted and randomly distributed to 4 dietary treatments with 60 birds per floor pen and 1 floor pen per treatment. Dietary treatments may be defined as follows: A-diet with 9.40 MJ ME/kg and 173 g crude protein/kg, B-diet with 12.90 MJ ME/kg and 175 g crude protein/kg, C-diet with 9.40 MJ ME/kg and 173 g crude protein/kg plus supplementation of coarsely grounded corn in the last month of fattening, D-diet with 12.90 MJ ME/kg and 175 g crude protein/kg plus supplementation of coarsely grounded corn in the last month of fattening. The ME value for coarsely grounded corn was 14.02 MJ/kg. The chemical composition of experimental diets and their nutrient composition are shown in Table 1. The experimental diets were analyzed for the different macronutrients according to the Weende or proximate analysis. Feed was given to capons in the form of mash.

Table 1: Ingredient and analyzed composition of the experimental diets

	Diet	
	Low energy	High energy
Ingredients (g/100 g diet)		
Corn	26.7	52.4
Barley	8.0	5.0
Wheat offal	30.0	/
Corn gluten meal	4.1	/
Soyabean dry grain	11.8	27.8
Alfalfa	12.0	4.0
Soyabean oil	2.2	4.9
Premix	0.5	0.5
Salt	0.5	1.3
Other ingredients	4.2	4.1
Chemical composition (g/100 g diet)		
Dry matter	89.1	89.0
Crude protein	17.3	17.5
Crude fat	4.8	7.7
Crude fiber	7.4	4.1
Crude ash	5.8	5.7
Nitrogen-free extract	53.4	53.9
Starch	34.2	42.1
Sugars (saccharose)	3.5	3.8
Metabolizable energy (MJ/kg diet)	9.40	12.90
Calorie : Crude Protein ratio		
	129.7	176.0

All pens measured 3.8×4.0 m (3.9 birds per 1 m^2) and were located in the same environmentally controlled facility. Each pen contained one automatic bell drinker, two tube feeders, fresh straw and wood shavings. The temperature in the house with floor pens was around 20°C. Continuous light was given to all birds in the pre-experimental period. At 44 days of age lighting treatment of 15 hours light : 9 hours dark was initiated. Feed and water were freely available at all experimental periods. Feed consumption on a group basis and individual liveweights were recorded monthly. Mortality was recorded in groups throughout the study. FCR data were corrected for mortality.

Processing procedure and measurements

After final body weights were obtained at 153 d of age, feed was removed from birds 12 hours prior to processing. At 154 days of age all experimental animals were stunned, slaughtered, bled and plucked in the experimental processing plant. During evisceration which was performed by hand carcasses were inspected to verify complete testes removal. At the slaughter day eviscerated weight (warm) was recorded for each capon. Following overnight chilling at +4°C carcasses were weighted again to get the eviscerated weight (cold) and oven-ready weight (= cold eviscerated weight without head, neck, feet, abdominal fat and giblets). Thereafter meat quality measurements (color, electrical conductivity, pH) were made on the breasts and thighs. Color parameters (L* = lightness, a* = redness, b* = yellowness) were determined in duplicate using a CR-300 Minolta Chroma Meter (Minolta Camera Co., Osaka, Japan). All conductivity and pH measurements were conducted on the breast muscles. Two small incisions were made in the muscle, and pH was measured by inserting a probe directly into the fillet. Conductivity was determined using LF/PTSTAR (Matthäus) conductometer, pH value using Metter Toledo (MA130 Ion Meter) pH meter. Chilled capon carcasses were then dissected into head, neck, wings, feet, whole breast (breast fillets with wishbone but without skin), right leg quarter (thigh+drumstick with skin) and giblets (heart, gizzard, spleen and liver). The necks with neck skin were separated from the carcasses at the shoulder joint and from the head by a section between first and second cervical vertebra. The wings were removed from the breast by cutting through the junction of humerus and coracoid. The legs were separated from the hip joint by a cut through the junction of ilium and femur and from the feet by a cut through hock joint (tarsal joint). The breast was separated from the back at the shoulder joint and by a cut through the junction of the vertebral and sternal ribs. After standard dissection of carcasses, cut-up pieces were weighed. The ratio of these traits to cold eviscerated weight was calculated as head percentage, neck percentage, breast percentage, leg quarter percentage, abdominal fat percentage and giblets percentage. Dressing percentages were calculated either as the proportion of oven-ready weight from final live body weight (dressing percentage I), or as the proportion of eviscerated weight (cold) from final live body weight (dressing percentage II).

Statistical analysis

Analyses of variance among treatment groups were calculated using the GLM procedure of statistical package SAS/STAT (SAS Inst., Inc., Cary, NC, 2004). Differences among means ($P \leq 0.05$) were separated using the LSMEANS option of SAS software. Models used were:

$$y_{ij} = \mu + G_i + e_{ij} \qquad \text{(model 1)}$$

$$y_{ijk} = \mu + D_i + C_j + DC_{ij} + e_{ijk} \qquad \text{(model 2)}$$

Where: y was an individual observation for trait y; μ was overall mean for trait y; G_i was fixed effect of the i^{th} group (model 1); D_i was fixed effect of the i^{th} basic diet (i=low-energy, high-energy); C_j was fixed effect of the j^{th} coarsely grounded corn supplementation (j=with corn supplement, without corn supplement); DC_{ij} was interaction between basic diet and coarsely grounded corn supplementation and e was random error associated with the measurement of each individual. Results are presented in the form least square mean (LSM) ± standard error of the mean (SEM). Analysis of variance was not applied for feed intake, since it was not recorded individually. Pearson's correlation coefficients between the meat quality variables were calculated using the CORR procedure of SAS.

Results

After mortality and culling of slips (incomplete caponized male chickens) there were 166 capons remaining. The effects of dietary ME and coarsely grounded corn supplementation on growth performance, feed conversion and carcass yield parameters are given in Tables 2 and 3.

Table 2. Effects of different energy levels of basic diets and coarsely grounded corn supplementation on the performance of capons

Parameter	Experimental groups		Significance between diets with low and high level of ME	Experimental groups		Significance between diets without and with coarsely grounded corn supplementation	Significance of interaction basic diet × coarsely grounded corn supplementation
	A+C	B+D		A+B	C+D		
	low level of ME	high level of ME		without corn supplementation	with corn supplementation		
Number of animals	83	83	/	83	83	/	/
Feed intake (kg basic diet/animal)	15.80	12.53	/	15.30	13.10	/	/
FCR (basic diet : weight gain)	6.03	4.58	/	5.69	4.91	/	/
FCR (MJ ME[1] : weight gain)	63.38	65.88	/	62.18	67.05	/	/
Body weight at 43 d of age (g)	515.17 ± 5.97	514.55 ± 5.97	N.S.	519.07 ± 5.97	510.64 ± 5.97	N.S.	N.S.
Body weight at 71 d of age (g)	1293.83 ± 13.28	1325.47 ± 13.28	N.S.	1312.85 ± 13.28	1306.45 ± 13.28	N.S.	N.S.
Body weight at 99 d of age (g)	2078.58 ± 18.91	2133.53 ± 18.91	*	2111.57 ± 18.91	2100.55 ± 18.91	N.S.	N.S.
Body weight at 127 d of age (g)	2757.83 ± 20.40	2839.92 ± 20.40	**	2798.25 ± 20.40	2799.49 ± 20.40	N.S.	N.S.
Body weight at 153 d of age (g)	3137.95 ± 22.61	3229.26 ± 22.61	**	3190.57 ± 22.61	3176.64 ± 22.61	N.S.	N.S.
Average daily gain from 43 d to 153 d of age (g)	23.84 ± 0.18	24.67 ± 0.18	**	24.28 ± 0.18	24.23 ± 0.18	N.S.	N.S.
Eviscerated weight (warm) (g)	2580.72 ± 19.80	2697.49 ± 19.80	***	2640.29 ± 19.80	2637.92 ± 19.80	N.S.	N.S.
Eviscerated weight (cold) (g)	2600.12 ± 19.73	2713.01 ± 19.73	***	2668.78 ± 19.73	2644.35 ± 19.73	N.S.	N.S.
Oven-ready weight (g)	2025.87 ± 15.71	2107.99 ± 15.71	***	2090.63 ± 15.71	2043.23 ± 15.71	*	N.S.
Dressing percentage I (%)	67.57 ± 0.14	68.02 ± 0.14	*	68.48 ± 0.14	67.11 ± 0.14	***	*
Dressing percentage II (%)	86.71 ± 0.19	87.57 ± 0.19	**	87.42±0.19	86.86 ± 0.19	*	*
Head (%)	2.77 ± 0.02	2.73 ± 0.02	N.S.	2.81 ± 0.02	2.70 ± 0.02	***	***
Neck (%)	5.68 ± 0.05	5.87 ± 0.05	**	5.81 ± 0.05	5.74 ± 0.05	N.S.	**
Feet (%)	4.05 ± 0.02	3.96 ± 0.02	**	4.00 ± 0.02	4.00 ± 0.02	N.S.	N.S.
Abdominal fat (%)	4.87 ± 0.13	4.94 ± 0.13	N.S.	4.84 ± 0.13	4.97 ± 0.13	N.S.	N.S.
Giblets (%)	3.88 ± 0.04	3.81 ± 0.04	N.S.	3.70 ± 0.04	4.00 ± 0.04	***	N.S.
Leg quarter (%)	25.58 ± 0.11	25.46 ± 0.11	N.S.	25.81 ± 0.11	25.22 ± 0.11	***	*
Whole breast (%)	21.67 ± 0.10	21.67 ± 0.10	N.S.	21.58 ± 0.10	21.76 ± 0.10	N.S.	N.S.
Wings (%)	9.48 ± 0.05	9.41 ± 0.05	N.S.	9.44 ± 0.05	9.46 ± 0.05	N.S.	N.S.

[1] ME from basic diet and ME from grounded corn supplementation
*P≤0.05; **P≤0.01; ***P≤0.001; N.S.= non significant

Separate effects of basic diet and coarsely grounded corn supplementation show that live body weight at 99 d, 127 d and 153 d, eviscerated weight, oven-ready weight and dressing percentages were significantly ($P \leq 0.05$) higher in capons fed diets with high level of ME than in capons fed diets with low level of ME, however the abdominal fat percentage, head percentage, giblets percentage, leg quarter percentage, breast percentage and wings percentage were non significant ($P > 0.05$) between those two groups of capons. The body weights of the capons of the low- and high-energy groups were similar until 99 d of age, when the capons from high-energy groups (B and D) weighed 2.6 % more than capons from low-energy groups (A and C) (Table 2). The birds from high-energy groups remained heavier throughout the trial, achieving a 0.09 kg greater body weight at 153 d of age. Oven-ready weight, dressing percentages, proportion of leg quarter, giblets and head were influenced ($P \leq 0.05$) by adding coarsely grounded corn in the last month of fattening period. Coarsely grounded corn supplementation wasn't a significant source of variation for body weights at any age. No significant difference was observed for abdominal fat percentage from 9.4 to 12.9 MJ of ME/kg of diet, indicating that feeding capons with high-energy diets didn't increase the weight of abdominal fat pads. There were significant interactions between basic diet and coarsely grounded corn supplementation on dressing percentages, head percentage, neck percentage and leg quarter percentage (Table 2). Therefore, for the abovementioned traits group effects are presented in Table 3. As to dietary group, capons fed high-energy diet supplemented with coarsely grounded corn showed lower dressing percentage I, head, neck and leg quarter percentage than capons fed only high-energy diet without coarsely grounded corn supplementation (Table 3).

Table 3: Growth rate, feed consumption and carcass quality of capons fed different levels of ME

Parameter	Experimental group			
	A	B	C	D
	low level of ME	high level of ME	low level of ME + grounded corn supplementation	high level of ME + grounded corn supplementation
Number of animals	42	41	41	42
Feed intake (kg basic diet/animal)	17.12	13.44	14.52	11.65
Feed intake (kg coarsely grounded corn/animal)	/	/	2.46	2.60
FCR (basic diet : weight gain)	6.52	4.89	5.56	4.28
FCR (MJ ME[1] : weight gain)	61.30	63.06	65.42	68.66
Mortality (%)[2]	16.6	20.0	11.66	15.0
Dressing percentage I (%)	$67.99^{a} \pm 0.20$	$68.96^{b} \pm 0.20$	$67.14^{c,e} \pm 0.20$	$67.07^{d,e} \pm 0.20$
Dressing percentage II (%)	$86.72^{a} \pm 0.27$	$88.13^{b} \pm 0.27$	$86.71^{a} \pm 0.27$	$87.01^{a} \pm 0.27$
Head (%)	$2.77^{a} \pm 0.03$	$2.85^{a} \pm 0.03$	$2.78^{a} \pm 0.03$	$2.62^{b} \pm 0.03$
Neck (%)	$5.61^{a} \pm 0.07$	$6.01^{b} \pm 0.07$	$5.74^{a} \pm 0.07$	$5.73^{a} \pm 0.07$
Leg (%)	$25.68^{a} \pm 0.16$	$25.94^{a} \pm 0.16$	$25.47^{a,c} \pm 0.16$	$24.97^{b,c} \pm 0.16$

[1] ME from basic diet and ME from grounded corn supplementation

[2] included culled slips

[a,b,c,d,e] Means within rows with the same superscript letters are not significantly different ($P > 0.05$)

From 43 to 153 d, feeding the high-energy diets resulted in better feed conversion (basic feed:gain) than feeding the low-energy diets (Tables 2 and 3). In order to properly compare the utilization of diets differing in energy it is necessary to compare the efficiency of using dietary megajoules. This was done by determining the megajoule conversion ratio expressed as ME MJ/kg weight gain. The ME required per kilogram of weight gain was least for the low-energy diets and highest for the high-energy diets (Tables 2 and 3). These data indicate that the ME was more efficiently used for weight gain at both low levels of energy than at the high levels.

Supplementation of coarsely grounded corn resulted in reduced energy efficiency as compared to the diets without corn supplementation. The results of color values (lightness=L, redness=a, yellowness=b), pH and electric conductivity of the breast and/or thigh by treatment are reported in Table 4. No significant interaction was observed between basic diet and coarsely grounded corn supplementation for color, pH and conductivity values; therefore, only the main treatment effects are summarized in Table 4. Breasts and thighs from low-energy groups had lower »a« values (less red) and higher »b« values (yellower) than samples from high-energy groups. Breast fillets from low-energy groups had significantly (P≤0.01) higher pH values than fillets from high-energy groups (Table 4). The »b« values increased in both carcass cuts with grounded corn supplementation. Breast fillets from capons fed with coarsely grounded corn supplementation tended to have higher (P≤0.001) pH values than those from capons receiving mixtures without coarsely grounded corn supplementation. Dietary treatment did not affect electric conductivity. Meat pH taken on chilled breast fillets were positively correlated (P≤0.05) to three meat quality attributes: yelowness of the breast skin (R=0.15), yellowness of the thigh skin (R=0.16) and electric conductivity of breast fillets (R=0.15).

Table 4. Effects of different energy levels of basic feed mixtures and coarsely grounded corn supplementation on the meat quality of capons

Parameter	Experimental groups		Significance between diets with low and high level of ME	Experimental groups		Significance between diets without and with corn supplementation
	A+C	B+D		A+B	C+D	
	low level of ME	high level of ME		without corn supplementation	with corn supplementation	
Number of animals	83	83		83	83	
L – breast skin	70.15 ± 0.44	69.69 ± 0.44	N.S.	69.60 ± 0.44	70.24 ± 0.44	N.S
a – breast skin	-0.87 ± 0.10	-0.32 ± 0.10	***	-0.55 ± 0.10	-0.65 ± 0.10	N.S.
b – breast skin	11.36 ± 0.35	9.25 ± 0.35	***	9.08 ± 0.35	11.52 ± 0.35	***
L – thigh skin	68.89 ± 0.25	69.51 ± 0.25	N.S.	69.55 ± 0.25	68.86 ± 0.25	N.S.
a – thigh skin	1.66 ± 0.14	2.20 ± 0.14	**	1.81 ± 0.14	2.06 ± 0.14	N.S.
b – thigh skin	8.46 ± 0.31	5.61 ± 0.31	***	6.23 ± 0.31	7.83 ± 0.31	***
pH – breast	5.80 ± 0.01	5.76 ± 0.01	**	5.72 ± 0.01	5.85 ± 0.01	***
conductivity – breast (mS/cm)	8.34 ± 0.24	8.88 ± 0.24	N.S.	8.56 ± 0.24	8.66 ± 0.24	N.S.

*P≤0.05; **P≤0.01; ***P≤0.001; N.S.= non significant

Discussion

The present study was designed to provide information on the response of growing capons to dietary energy content and coarsely grounded corn supplementation under commercial housing conditions for a growing period of 43 d to 153 d of age. Investigation of the effect of dietary energy on capons has confirmed the positive effects of diets containing high energy on growth from 99 to 153 d of age and feed conversion and has shown that carcass traits and meat quality parameters also may be influenced.

Energy effects on growth, feed consumption and feed efficiency

High content of dietary energy produced faster gains than did low dietary energy. Maximum weight gain was observed in birds fed on diet containing high level of energy throughout the experiment. It was also observed that birds fed only on high-energy diet didn't gain less weights as compared to those fed high-energy diet with coarsely grounded corn supplementation in the last month of fattening. Also no difference was observed in body weight gain in low-energy diets when the low-energy diet was fortified with coarsely grounded corn during the finisher phase. Feeding the latter two diets resulted in capons nearly equal in weight.

It is not possible to state with certainty but it is very likely that capons from low-energy groups allocated nutrients of the low-energy diet less effectively into body weight because of the nutrient density of the low-energy diet. This density was too low and the capons were physically unable to consume sufficient feed and their growth was retarded. Based upon published data in broilers (WALDROUP et al., 1976; CAMPBELL et al., 1988;) it would be expected that feeding high-energy diets increases rate of gain and body weights in capons too. However, our results are difficult to compare with results from broiler studies because of differences in hormonal status of the birds, differences in the feeding periods and the energy levels fed, differences in bird ages, their genetic background etc. A trend towards decreased feed intake with increasing energy density was observed. The feed required per kilogram of weight gain was different between all diets, with the higher density diets being more efficient. Improvement in feed conversion rate of capons appears to be due to the decrease in feed intake caused by high dietary energy. Similar supporting results using broilers (HIDALGO et al., 2004; SALEH et al., 2004; LEESON et al., 1996; JACKSON et al., 1982a; DOZIER et al., 2007; GHAFFARI et al., 2007) and pekin ducks (FAN et al., 2008) were reported. Although the capons fed on low-energy diets consumed higher amount of protein due to increased feed intake, there was a significant depression in weight gain. Capons fed the high-energy diet required more megajoules per kilogram gain than did those fed low energy diet indicating that classical feed efficiency (feed:gain) in this situaiton is very misleading in defining energy efficiency. Part of the reason for the lowered energy efficiency of the capons fed the high level of ME could have been the higher energy:protein ratio of that diet. It is now well documented that dietary composition and the ratios between macronutrients have a major effect on performance and body composition of chickens (BUYSE et al., 1992; NIETO et al., 1997; COLLIN et al., 2003). To evaluate animal energy needs, a balance between dietary energy and levels of essential nutrients is desirable. This balance prevents deficiencies or excesses in nutrients that result from variation in feed consumption due to changes in dietary energy. Since protein levels were held constant, then ratios changed with energy density and, even though protein level and quality were assumed to be adequate even at the highest level of ME, there may have been an influence on the performance of the animals due to changes in these ratios.

Dietary energy and carcass characteristics

Carcasses from the capons fed the low level of ME weighed less ($P \leq 0.001$) and tended to be lower in dressing percentages ($P \leq 0.05$) than those from capons receiving higher levels of ME. Furthermore, capons fed the low-energy diets had a decreased neck percentage and an increased feet percentage relative to those fed the high-energy diets. Other carcass composition traits were similar in low- and high-energy capons. Abdominal fat (expressed either as total weight or as percentage of eviscerated weight) was not different ($P > 0.05$) in high-energy groups than that from the low-energy groups, indicating that feeding capons with high-energy diets didn't increase the weight of abdominal fat pads. This observation was not in agreement with reports from broiler studies (JACKSON et al., 1982b; SUMMERS et al., 1992; GHAFFARI et al., 2007) where diets with a high energy:protein ratio promote energy retention as abdominal fat. Abdominal and subcutaneous fat are usually considered to be waste product when birds are processed further. But in contrast, intramuscular fat could be a favorable trait since it makes some contribution to meat quality (tenderness, juiciness, flavor). However, it should be remarked that results found in broilers are not comparable with results obtained in capons since fat tended to accumulate differentially in caponized compared to non-caponized birds. In the research of TOR et al., 2002 capons showed more abdominal, intermuscular and subcutaneous fat than the cocks, both at the same slaughter age and at the same weight. The same authors also reported increased percentages of subcutaneous and intermuscular fat in capons as compared to those in cocks. Although intramuscular fat plays a major role in capon meat quality (flavor and juiciness) no estimates of its correlation with other two sources of fat (abdominal and subcutaneous) have been published. The present study indicates that a higher level of dietary energy can be fed to capons without influencing abdominal fatness.

Capons fed coarsely grounded corn-supplemented diets had similar abdominal fat percentages than capons fed unsupplemented diets. The inclusion of coarsely grounded corn did not ($P>0.05$) improve the average body weight and eviscerated weight. The lack of significant improvement in performance obtained in this study might be due to the fact that the basic feed used was rich enough in nutrient composition and therefore supported maximum performance in the last month of fattening without supplementation with coarsely grounded corn. The giblets percentage of the birds fed the grounded corn supplemented diets was superior ($P\leq0.001$) compared to the birds fed only basic diets. This unfavourable effect was achieved at the expense of decreasing oven-ready weight and dressing percentage I. Apart from the giblets and the leg quarter that were significantly affected by coarsely grounded corn inclusion, the relative weights of the other organs were not affected by the grounded corn treatment. A significant basic diet with a coarsely grounded corn interaction effects were found for both dressing percentages, head percentage, neck percentage and leg quarter percentage. Therefore, the effect of dietary treatment on carcass composition according to those traits is given group by group in Table 3. All the abovementioned carcass traits were always higher in capons fed high-energy diet throughout the experiment (group B) than in capons fed high-energy diet supplemented with coarsely grounded corn in the last month of fattening period (group D). No relevant differences between capons fed low energy diet with (group C) or without grounded corn supplementation (group A) were found, neither in dressing percentage nor in head, neck and leg percentage.

Dietary energy and meat quality

Skin color of chickens is a matter of preference, with customers in different parts of the world preferring one color over the other. This variation is mainly based upon the background and experience of the consumers (HENCKEN, 1992; WILLIAMS, 1992). In many parts of the world consumers prefer yellow-skinned birds because a bright yellow or yelloworange pigmentation is often associated with health (MEJIA and GONZALEZ, 1988). This coloration can be achieved readily with alfalfa and corn-based diets, since these diets contain ample amounts of xanthophyll pigments. Because of that yellow skinned capons were used and diets were altered during the last 4 weeks of the fattening period by increasing the xanthophyll-containing coarsely grounded corn to induce the necessary yellow pigment in the skin and fat. In respect to capons fed low-energy diets, capons fed high-energy diets produced ($P\leq0.01$) breast and thigh skin higher values of redness, lower values of yellowness and lower pH. Calculated xanthophyll content in alfalfa with 22 % crude protein was 330 mg/kg while in corn it was 17 mg/kg. Higher alfalfa percentage in low energy diets was probably the main reason for higher yellowness of breast and thigh skin in those groups. FLETCHER et al. (1985) and SAYLOR (1986) reported that natural sources of xanthophyll differed in their ability to pigment egg yolk and the skin of broilers. Alfalfa meal contains several types of xanthophylls, but the one of greatest abundance and importance is lutein, which tends to impart a yellow color, whereas corn and corn gluten meal contain primarily zeaxanthin, which tends to impart an orange-red color. According to expectations the breast and thigh skin harvested from diets with coarsely grounded corn supplementation gave yellower pigmentation ($P\leq0.001$) than skin obtained from capons fed basic diets without coarsely grounded corn supplementation. YANG and CHEN (1993) reported that ground chicken meat with high pH was yellower in color than meat with low pH. In our study, the Pearson's correlation coefficients between »b« color readings and pH of breast fillets were positive (breast: $R=0.15$; thigh: $R=0.16$) and significant ($P\leq0.05$). Thus, as the pH increased, the yellowness values increased. YANG and CHEN (1993) observed also significant correlations between the other color measurements (lightness, redness) and pH which were not found in our study. Basic diet by grounded corn interaction was not significant in any color reading, pH or conductivity. Thus, capons in low-energy groups responded similarly to coarsely grounded corn supplementation as capons in high-energy groups.

Summary

This research was carried out to evaluate the effects of feeding diets containing two levels of metabolizable energy (A = low-energy diet; B = high-energy diet) and supplemental corn (C = diet A plus coarsely grounded corn in the last month of fattening; D = diet B plus coarsely grounded corn in the last month of fattening) on the capons growth and carcass characteristics. A total of one hundred and sixty six 43-days old capons of a layer-type chicken were randomly allocated to four dietary treatments (A, B, C, D). The birds were raised in groups in commercial housing conditions and were fed the experimental diets for a 110-day period during which data were obtained on feed intake, live body weight and FCR. At the end of the feeding trial, all birds were sacrificed to evaluate meat quality and carcass traits. Feed efficiency improved while energy utilization efficiency worsened with increase in dietary energy levels. Capons fed high-energy diet had heavier final body weight ($P \leq 0.01$), eviscerated and oven-ready weight ($P \leq 0.001$), higher dressing and neck percentage ($P \leq 0.01$) but lower feet percentage ($P \leq 0.01$) than capons fed low-energy diets. There was no effect of dietary energy on the whole breast and leg quarter percentage. The effect of the coarsely grounded corn supplementation in the last month of fattening period was not pronounced on the growth performance characteristics since the ration formulated was adequate to support the growth of the birds without the addition of grounded corn. However, some carcass traits of economic importance such as oven-ready weight, dressing rates, head %, and leg % were negatively affected from supplemental corn containing basic diets. Giblets % was positively ($P \leq 0.001$) affected by corn supplement to basic diet. Increased energy density tended to increase abdominal fatness only slightly, and the significant differences in live weight were not offset by adverse effects on fatness. Abdominal fat content was similar among dietary treatments despite the fact that ratio of protein to energy was not maintained at fixed level. The breast and thigh skin of the capons on the diets containing high level of ME had a higher »a« value (more red) ($P < 0.001$), lower »b« value (less yellow) ($P \leq 0.001$) and lower pH value ($P \leq 0.01$) than the capons receiving low-energy diets. Coarsely grounded corn supplementation resulted in a significant ($P \leq 0.001$) increase in »b« and pH values. Yellowness of breast and thigh skin were found to correlate positively to pH. In summary, this study shows that meat production from capon will be improved in form of higher body weight gains, eviscerated carcass weights and dressing rates by increasing energy levels in the diet. It also shows that diets containing large energy:protein ratios do not promote high rates of abdominal fatness in capons.

Key words

Capons, energy levels, growth, carcass traits

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SENSORY TRAITS OF CAPON MEAT IN THREE CHICKEN GENOTYPES

Špela MALOVRH[a)], Katarina HRIBERŠEK [b)], Dušan TERČIČ[c)], Božidar ŽLENDER [d)] and Antonija HOLCMAN[e)]

[a)] Univ. of Ljubljana, Biotechnical Fac., Zootechnical Dept., Groblje 3, SI-1230 Domžale, Slovenia, Ph.D.
[b)] Same address as [a)], graduate student
[c)] Same address as [a)], Ph.D., M.Sc.
[d)] Univ. of Ljubljana, Biotechnical Fac., Dept. of Food Science and Technology, Jamnikarjeva 101, SI-1000 Ljubljana, Slovenia, Prof., Ph.D., M.Sc.
[e)] Same address as [a)], Assoc. Prof., Ph.D., M.Sc., e-mail: antonija.holcman@bfro.uni-lj.si.

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SENZORIČNE LASTNOSTI MESA KOPUNOV TREH GENOTIPOV

ABSTRACT

Capons of three genotypes (Barred Prelux, Sulmtaler, Styrian hen) were fattened outdoors and slaughtered at two ages (163 and 198 days). Cockerels were caponised at age 47 days and at age 84 days were moved to grower houses with free access to pasture. Animals had ad libitum access tofood and water. Ten carcasses of each genotype and age were sampled at slaughter for sensory analysis. The four trained panellist assessed three traits of raw carcasses on scale 1-5 and 19 traits on roasted carcasses on scale 1-7. Shear force was measured on cooled meat slices by Instron apparatus. Statistical analysis was performed by MIXED procedure in SAS/STAT. Age at slaughter affected eight, genotype five and interaction between age and genotype three sensory traits. Share force differed among genotypes and it got worse at older age. Any of three genotypes was not superior in most of sensory traits. Thus, decision which genotype to fatten and how long depends on preferences and importance of certain sensory traits by consumers.

Key words: capon / genotype / meat / sensory traits

IZVLEČEK

Kopune treh genotipov (grahasti prelux, sulmaler, štajerska kokoš) smo pitali v izpustih in zaklali pri dveh starostih (163 in 198 dni). Petelinčke smo kastrirali pri starosti 47 dni in jih pri starosti 84 dni preselili v hlev z izpustom. Živali so imele krmo in vodo po volji. Po deset trupov vsakega genotipa in starosti smo ob zakolu vzorčili za senzorično analizo. Štiri usposobljeni ocenjevalci so na presnih trupih ocenili tri lastnosti (skala 1-5) in na pečenih trupih 19 lastnosti (skala 1-7). Reznost smo merili na ohlajenih rezinah mesa z aparatom Instron. Za statistično obdelavo podatkov smo uporabili proceduro MIXED v SAS/STAT. Starost ob zakolu je vplivala na osem, genotip pet ter interakcija med starostjo in genotipom na tri senzorične lastnosti. Rezna trdnost se je med genotipi razlikovala, poslabšala pa se je s starostjo. Noben od genotipov ni najboljši v večini senzoričnih lastnosti, zato je odločitev, kateri genotip kopunov bi bil najprimernejši, odvisna predvsem od želja in pomembnosti senoričnih lastnosti s strani porabnikov.

Ključne besede: kopun / genotip / meso / senzorične lastnosti

INTRODUCTION

Meat of capons was already in the past appreciated type of meat. The capon meat is known to be tender, juicy and tasty. These characteristics are result of higher content of intramuscular fat as well as greater deposition of fat bellow skin and in abdominal cavity in capons compared to pullets and cockerels (Cason at al., 1988, Tor et al., 2002). Razingar (1932) wrote that roasted meat of capons is the best and the taste of capon meat surpasses all others. It was known that Napoleon requested roasted capons and especially of our autochthonous breed – Styrian hen. Nowadays, the capon meat is valued in Mediterranean countries, as speciality is acknowledged in France in Italy, as well as in United States (Cvrtila et al., 2007).

The age of animal has important effect on sensory traits of meat (Remignon and Culioli, 1995, Večerek et al., 2004). Juiciness and tenderness of muscle fibres worsen with age, while the intensity of aroma increases (Remignon and Culioli, 1995). According to literature, recommended age at which caponisation of cockerels should be performed varies, as well as optimal age of capons at slaughter (Cason et al., 1988). The optimal age of caponisation and slaughter age of capons are dependent on production type and breed.

In the studies where sensory traits of meat of cockerels and capons were compared, the results showed that capon meat is more tender, while the meat of cockerels is more tough (Mast et al., 1981). Garcia et al. (1995) depicted no differences in aroma of cooked meat of breast and thigh in capons. Small differences were assessed in thigh meat, which had less tender muscle fibres and better juiciness as a consequence of higher fat content.

The rearing conditions affect sensory traits of capon meat to a smaller extent. Garcia et al. (1995) did not notice any difference in sensory traits of capon meat reared in indoor or outdoor system. However, current consumers in many places prefer meat from animals reared outdoors.

New animal products are researched and rearing systems which are friendly to animals and environment are studied nowadays. The autochthonous and traditional breeds are under preservation schemes, as well. Thus, the meat quality of three genotypes of capons reared outdoors was investigated. In the experiment, capons of two autochthonous breeds (Styrian hen and Sulmtaler) and hybrid Barred Prelux (crossbreed between two Slovenian traditional breeds of laying hens) were included. The Styrian hen is autochthonous breed in Slovenia and Austria, while Sulmtaler is autochthonous breed in Austria. The goal of the paper is to present results of sensory analysis of meat of capons slaughtered at two ages.

MATERIAL AND METHODS

Animals, rearing and slaughtering conditions

The experiment started with housing of one day old cockerels of three genotypes: 116 birds of Styrian Hen (a Slovenian autochthonous breed), 117 birds of Barred Prelux (a layer-type Slovenian hybrid), and 107 birds of Sulmtaler (an Austrian breed). After hatching, chickens were sexed and cockerels were individually marked by toe punching and weighed. They were housed in a light tight facility in three separate floor pens. Pens were littered by wood shavings. Cockerels were reared upon standard technology for broilers. Cockerels were caponised at age of 47 d. At age of 84 d, they were moved to separate grower houses with free access to pasture, where all prescribed conditions for free-range rearing were met.

Cockerels were fed *ad libitum* with commercial diets – complete feeding mixture for chickens (21.0% crude proteins, 13.28 MJ ME/kg) for the first 4 wk. From 5 wk until the end of experiment, they received complete feeding mixture for pullets (14.8% crude proteins, 11.21 MJ ME/kg). Water for drinking was freely available all the time.

At two ages (163 days and 198 days), random sample of 30 capons per genotype was weighed and slaughtered. Birds were fasted overnight before the slaughter. Carcass measurements were taken on cold carcasses. Ten carcasses of each genotype and age were frozen until assessment of sensory traits.

Sample preparation and sensory assessment

The panel consisted of four trained individuals. At the beginning, the panellists assessed raw chicken carcasses for conformation, surface colour and subcutaneous fattiness on scale from 1 to 5 (Table 1). Higher score signifies better quality for conformation and colour, while optimal value for subcutaneous fattiness is in the middle of the scale. After that, the whole carcasses were roasted in the oven at the temperature 190°C and moisture 30% without spices until the temperature in the middle of the carcass reached 85°C.

The right side of roasted capons was cat for sensory assessment, while left side was stored in the refrigerator until the next day when the shear force was measured. After roasting, the breast skin and meat of breast and thigh were assessed (Table 1). These traits were scored on scale from 1 to 7. Traits like texture of skin or tenderness of meat have optimal value in the middle of the scale, while others have better quality at higher scores. The colour, texture, fattiness and flavour were assessed in skin, while colour, smell, flavour, juiciness, tenderness, fattiness, and mouth feeling were assessed separately in breast and thigh meat. Coded representative samples were offered to panellists.

Shear force was measured across the muscle fibres with Instron apparatus. Cooled breast and thigh meat was cat into 1 cm thick slices. The speed of the blade was 5 cm/min and the passage ob blade through sample slice was 9.4 mm. Measurements were performed in six repetitions per sample slice.

Table 1. Subjective scored sensory traits with corresponding scales
Preglednica 1. Ocenjevane senzorične lastnosti s pripadajočim razponom ocen

Part	Trait	Scale
Raw carcass	Conformation	1 (poor) – 5 (excellent)
	Skin colour	1 (pale) – 3 (optimal) – 5 yellowish-pink
	Subcutaneous fattiness	1 (too little) – 3 (optimal)– 5 (too much)
Breast skin	Colour	1 (pale, bluish) – 7 (proper yellow)
	Texture	1 (fragile)– 4 (optimal) – 7 (gummy)
	Fattiness	1 (fatless) – 7 (fatty)
	Flavour	1 (poorly expressed)– 7 (fully expressed)
Meat of breast and thigh	Colour	1 (pale) – 7 (uniform, optimally brown-pink)
	Smell	1 (poor, uncharacteristic) – 7 (typical, well expressed)
	Flavour	1 (poorly expressed)– 7 (fully expressed)
	Juiciness	1 (very dry) – 7 (very juicy)
	Tenderness	1 (very tough) – 4 (optimal) – 7 (very tender, decomposing)
	Fattiness	1 (fatless) – 7 (fatty)
	Mouth feeling	1 (rough structure)– 7 (gentle, fine structure)
	Overall score	1 (unacceptable) – 7 (excellent)

Table 2. Descriptive statistics for sensory traits
Preglednica 2: Opisna statistika senzoričnih lastnosti

Part	Trait	Mean	SD	Min.	Max.
Raw carcass	Conformation	3.17	0.66	2.0	5.0
	Skin colour	3.15	0.82	2.0	5.0
	Subcutaneous fattiness	3.43	0.66	1.5	5.0
Breast skin	Colour	6.02	0.47	4.5	7.0
	Texture	4.40	0.66	2.0	6.0
	Fattiness	2.68	0.69	1.5	5.0
	Flavour	5.37	0.53	3.5	6.5
Breast meat	Colour	5.75	0.54	3.0	6.5
	Smell	5.58	0.36	4.5	6.5
	Flavour	5.49	0.38	4.5	6.5
	Juiciness	4.54	0.96	2.0	6.5
	Tenderness	4.09	0.62	2.5	6.0
	Fattiness	1.27	0.39	1.0	3.0
	Mouth feeling	3.72	0.83	2.0	6.0
Thigh meat	Colour	5.68	0.44	4.5	7.0
	Smell	5.68	0.33	5.0	6.5
	Flavour	5.64	0.37	4.5	6.5
	Juiciness	5.23	0.70	2.5	6.0
	Tenderness	3.84	0.45	2.5	5.0
	Fattiness	2.24	0.57	1.0	5.0
	Mouth feeling	5.08	0.56	3.5	6.0
	Overall score	5.42	0.36	4.5	6.5

Statistical analysis

Statistical analysis was performed by the MIXED procedure in the SAS/STAT (SAS Inst. Inc, 2002). The restricted maximum likelihood method was used. Statistical model for all traits included fixed effects of age at slaughter (A_i) and genotype (G_j). The interaction between age and genotype (AG_{ij}) was included for smell and fattiness of brest meat and colour of thigh meat on the basis of preliminary analysis. Because all panellists did not attend all assessment events, the effect of panellist was not included in the model. However, the panellists showed heterogeneous variances for most of sensory traits, thus heterogeneous residual variance structure among panellists was assumed. The models written in scalar notation were following:

$$y_{ijk} = \mu + A_i + G_j + e_{ijk} \quad \ldots(1)$$

$$y_{ijk} = \mu + A_i + G_j + AG_{ij} + e_{ijk} \quad \ldots(2)$$

The model for sheare force (3) included the additonal effect of body part (breast, thigh; P_k). The repeatability model was used because six measurements were taken on each sample slice.

$$y_{ijkl} = \mu + A_i + G_j + P_k + AG_{ij} + e_{ijkl} \quad \ldots(3)$$

The Tukey-Kramer adjustment for multiple comparison of differences between pairs of levels for effects with more than two levels was used wherever the effect was siginficant.

RESULTS AND DISCUSSION

The difference between age at slaughter of two groups was 43 days. Age significantly affected the conformation of raw carcasses, colour and texture of roasted breast skin, smell and tenderness of roasted breast meat, as well as colour, smell and juiciness of roasted thigh meat. The genotype had significant effect on conformation and skin colour of raw carcasses, fattiness of roasted breast skin, mouth feeling of roasted breast meat and on tenderness of roasted thigh meat. The effect of genotype was close to significant for eight traits. The interaction between age and genotype was significant for three traits only: smell and fattiness of roasted breast meat and colour of roasted thigh meat.

Table 3. Souces of variability and significance of effects (p-values) for sensory traits
Preglednica 3. Viri variabilnosti in statistična značilnost vplivov (p-vrednosti) za senzorične lastnosti

Part	Lastnost	Age	Genotype	Age x genotype
Raw carcass	Conformation	0.0015	<0.0001	-
	Skin colour	0.1887	<0.0001	-
	Subcutaneous fattiness	0.3255	0.1206	-
Breast skin	Colour	0.0134	0.1645	-
	Texture	0.0002	0.0608	-
	Fattiness	0.3105	0.0001	-
	Flavour	0.0351	0.0607	-
Breast meat	Colour	0.0941	0.5823	-
	Smell	0.0075	0.2903	0.0263
	Flavour	0.2835	0.1127	-
	Juiciness	0.1192	0.0595	-
	Tenderness	0.0330	0.2696	-
	Fattiness	0.1063	0.0871	0.0139
	Mouth feeling	0.5019	0.0032	-
Thigh meat	Colour	<0.0001	0.3081	0.0291
	Smell	<0.0001	0.8440	-
	Flavour	0.2391	0.0513	-
	Juiciness	0.0317	0.1452	-
	Tenderness	0.0554	0.0014	-
	Fattiness	0.2059	0.0578	-
	Mouth feeling	0.0620	0.0603	-
	Overall score	0.1675	0.0553	-

Age effect

Age at slaughter had significant effect on eight sensory traits (Table 4). Panellists assessed conformation of raw carcasses of both age groups close to average score (3.04 and 3.27). The older capons had better conformation for 0.23 points. The older group showed more intensive yellow colour of roasted breast skin, the difference was 0.15 points. The texture of breast skin was closer to optimal in older group. Better smell of roasted breast and thigh meat was found in younger group. Both differences were small (0.12 and 0.19 points) but significant. Capon slaughtered at younger age showed also better tenderness of breast meat for 0.16 points and juiciness of thigh meat for 0.13 points. Altogether, five of eight traits, where differences between age groups were recognised, were assessed better in younger capons. There was no effect of age

on aroma, fattiness and mouth feeling of both breast and thigh meat, as well as on overall score (Table 3).

Table 4: Least square means (LSM) and estimated differences with standard errors (SE) and siginficance for age effect on sensory traits

Preglednica 4: Ocenjene srednje vrednosti (LSM) in razlike s standardnimi napakami (SE) in značilnostjo za vpliv starosti pri senzoričnih lastnosti

Part	Trait	LSM ± SE		Difference* ± SE	p-value
		Age 163 d	Age 198 d		
Raw carcass	Conformation	3.04 ± 0.05	3.27 ± 0.05	-0.23 ± 0.07	0.0015
Breast	Colour	5.97 ± 0.04	6.12 ± 0.04	-0.15 ± 0.06	0.0134
skin	Texture	4.47 ± 0.05	4.21 ± 0.05	0.26 ± 0.07	0.0002
Breast	Smell	5.62 ± 0.03	5.50 ± 0.03	0.12 ± 0.05	0.0075
meat	Tenderness	4.12 ± 0.05	3.96 ± 0.05	0.16 ± 0.08	0.0330
Thigh	Colour	5.75 ± 0.04	5.53 ± 0.04	0.21 ± 0.05	<0.0001
meat	Smell	5.80 ± 0.03	5.61 ± 0.03	0.19 ± 0.04	<0.0001
	Juiciness	5.56 ± 0.04	5.43 ± 0.04	0.13 ± 0.06	0.0317

*Difference is expressed as LSM for age 163 d minus LSM for age 198 d / Razlika je predstavljena kot LSM za starost 163 d minus LSM za starost 198 d

Genotype effect

The panellists recognised differences among genotypes for five sensory traits. Differences are presented for these traits (Tables 5 and 6). Sulmtaler capons were assessed the best for conformation of raw carcasses, while capons of Styrian hen were the worst (Table 5). Barred Prelux capons had for 0.41 points better conformation in comparison with capons of Styrian hen and for 0.41 points worse conformation in comparison with Sulmtaler capons. Difference between Sulmtaler capons and capons of Styrian hen was 0.83 points. Large differences were estimated between genotypes for colour of raw carcasses. Barred Prelux capons were for 1.18 points better compared to Sulmtaler capons and for 1.42 points better than capons of Styrian hen. Difference between Sulmtaler capons and capons of Styrian hen is smaller (0.24 points). Differences among genotypes for fattiness of raw carcasses were not significant.

Table 5. Least square means and differences with standard errors (above diagonal) between genotypes and statistical significance (below diagonal) for two traits of raw capon carcasses

Preglednica 5. Ocenjene srednje vrednosti in razlike s standardnimi napakami (nad diagonalo) med genotipi ter statistično značilnostjo (pod diagonalo) pri dveh lastnostih presnih trupov

Genotype	LSM ± SE	Genotype		
		Barred Prelux	Sulmtaler	Styrian hen
		Conformation		
Barred Prelux	3.15 ± 0.06		-0.41 ± 0.09	0.41 ± 0.09
Sulmtaler	3.57 ± 0.06	<0.0001		0.83 ± 0.09
Styrian hen	2.74 ± 0.06	<0.0001	<0.0001	
		Skin colour		
Barred Prelux	4.02 ± 0.06		1.18 ± 0.09	1.42 ± 0.09
Sulmtaler	2.84 ± 0.06	<0.0001		0.24 ± 0.09
Styrian hen	2.60 ± 0.06	<0.0001	0.0180	

LSM – least square mean / ocena srednje vrednost, SE – standard error of estimate / standardna napaka ocene

The panellist recognised difference (-0.42 points) between Barred Prelux and Sulmtaler capons for fattiness of roasted breast skin (Table 6). Difference between Sulmtaler capons and capons of Styrian hen was close to significant. The best score for mouth feeling of roasted breast meat was given to Barred Prelux capons (3.81 points). They were significantly better for 0.25 points from Sulmtaler capons and for 0.37 points from capons of Styrian hen. Difference between the last two was not significant for mouth feeling of roasted breast meat.

Table 6. Least square means and differences between genotypes with standard errors (above diagonal) and statistical significance (below diagonal) for traits of roasted skin and meat

Preglednica 6. Ocenjene srednje vrednosti, razlike med genotipi s standardnimi napakami (nad diagonalo) in statistično značilnostjo (pod diagonalo) pri lastnostih pečene kože in mesa

Genotip	LSM ± SE	Genotype		
		Barred Prelux	Sulmtaler	Styrian hen
		Fattiness of roasted breast skin		
Barred Prelux	2,41 ± 0,07		-0,42 ± 0,10	-0,20 ± 0,10
Sulmtaler	2,83 ± 0,07	<0,0001		0,22 ± 0,09
Styrian hen	2,60 ± 0,07	0,1420	0,0532	
		Mouth feeling of roasted breast meat		
Barred Prelux	3,81 ± 0,08		0,25 ± 0,11	0,37 ± 0,11
Sulmtaler	3,56 ± 0,07	0,0649		0,13 ± 0,10
Styrian hen	3,43 ± 0,07	0,0022	0,4293	
		Tenderness of roasted thigh meat		
Barred Prelux	3,72 ± 0,05		-0,24 ± 0,15	-0,12 ± 0,15
Sulmtaler	3,96 ± 0,05	0,0008		0,12 ± 0,15
Styrian hen	3,84 ± 0,05	0,1610	0,1546	

LSM – least square mean / ocena srednje vrednosti, SE – standard error of estimate / standardna apaka ocene

Genotype by age interaction

Three sensory traits were influenced by interaction between genotype and age (Table 3): smell and fattiness of roasted breast meat and colour of roasted thigh meat (Table 7). The most important difference in all three traits is between age groups within Sulmtaler breed. The age at slaughter within genotype does not influence so much on these traits in capons of Barred Prelux and Styrian hen (Figure 1, a-c). Capons of Sulmtaler were superior in smell of roasted breast meat and colour of roasted thigh meat at age of 163 d compared to other two genotypes. They had also fatter breast meat, but at later age differences between genotypes disappeared.

The shear force had lower values in younger groups of capons in all the genotypes and it get worse by age (Figure 1d, Table 8). However, there were great differences among genotypes. The greatest change to worse was in Barred Prelux capons (7.5 N) and the smallest in capons of Styrian hen (2.0 N). The change of shear force in Sulmtaler capons was 3.5 N. The shear force for Sulmtaler capons at age 198 days did not differ from shear force for both other genotypes at age 163 days. Regarding this trait, Sulmtaler capons can be fattened to older age compared to the other two genotypes, while for Barred Prelux capons, the shorter fattening is recommended. The age at slaughter does not influence on shear force in capons of Styrian hen up to 198 days.

Table 7: Least square means and differences between levels of interaction genotypes by age with standard errors (above diagonal) and statistical significance (below diagonal) for three sensory traits

Preglednica 7: Ocenjene srednje vrednosti, razlike med nivoji interakcije genotipa in starosti s standardnimi napakami (nad diagonalo) ter statistično značilnostjo (pod diagonalo) pri treh senzoričnih lastnostih

				Genotype x age			
G x A	LSM ± SE	1 x 1	1 x 2	2 x 1	2 x 2	3 x 1	3 x 2
				Smell of roasted breast meat			
1 x 1	5.52 ± 0.06		0.01 ± 0.08	*-0.23 ± 0.08*	0.06 ± 0.08	-0.07 ± 0.08	-0.01 ± 0.08
1 x 2	5.51 ± 0.06	1.0000		*-0.24 ± 0.08*	0.05 ± 0.08	-0.08 ± 0.08	-0.02 ± 0.08
2 x 1	5.75 ± 0.05	*0.0448*	*0.0423*		*0.29 ± 0.07*	0.16 ± 0.07	*0.22 ± 0.07*
2 x 2	5.46 ± 0.05	0.9716	0.9895	*0.0016*		-0.14 ± 0.07	-0.07 ± 0.07
3 x 1	5.60 ± 0.05	0.9372	0.9083	0.2860	0.4558		0.07 ± 0.07
3 x2	5.53 ± 0.05	1.0000	0.9999	*0.0370*	0.9360	0.9515	
				Fattiness of roasted breast meat			
1 x 1	1.04 ± 0.04		-0.03 ± 0.05	*-0.16 ± 0.05*	-0.00 ± 0.05	-0.02 ± 0.05	-0.01 ± 0.05
1 x 2	1.07 ± 0.04	0.9920		-0.13 ± 0.05	0.03 ± 0.05	0.01 ± 0.05	0.02 ± 0.05
2 x 1	1.19 ± 0.03	*0.0114*	0.1343		*0.16 ± 0.05*	*0.14 ± 0.04*	*0.15 ± 0.05*
2 x 2	1.04 ± 0.03	1.0000	0.9919	*0.0079*		-0.02 ± 0.05	-0.01 ± 0.05
3 x 1	1.06 ± 0.03	0.9976	1.0000	*0.0252*	0.9976		0.01 ± 0.05
3 x2	1.05 ± 0.03	0.9999	0.9991	*0.0176*	0.9999	0.9999	
				Colour of roasted thigh meat			
1 x 1	5.61 ± 0.06		0.04 ± 0.08	-0.27 ± 0.09	0.11 ± 0.09	-0.14 ± 0.09	0.06 ± 0.09
1 x 2	5.57 ± 0.07	0.9976		-0.31 ± 0.09	0.07 ± 0.09	-0.18 ± 0.09	0.02 ± 0.09
2 x 1	5.88 ± 0.06	0.0345	0.0096		0.39 ± 0.09	0.13 ± 0.09	0.33 ± 0.09
2 x 2	5.49 ± 0.06	0.7974	0.9659	0.0004		-0.26 ± 0.09	-0.06 ± 0.09
3 x 1	5.75 ± 0.06	0.6045	0.3319	0.7112	0.0501		0.20 ± 0.09
3 x2	5.55 ± 0.06	0.9867	1.0000	0.0043	0.9893	0.2215	

LSM – least square mean / ocenjena srednja vrednost lastnosti, SE – standard error of estimate / standardna napaka ocene, G –genotype / genotip (1 – Barred Prelux / grahasti prelux, 2 – Sulmtaler / sulmtaler, 3 – Styrian hen / štajerska kokoš), A – age / starost (1 – 163 d, 2 – 198 d)

Table 8: Least square means and differences between levels of interaction genotypes by age with standard errors (above diagonal) and statistical significance (below diagonal) for shear force (in N)

Preglednica 8: Ocenjene srednje vrednosti, razlike med nivoji interakcije genotipa in starosti s standardnimi napakami (nad diagonalo) ter statistično značilnostjo (pod diagonalo) pri rezni trdnosti (v N)

				Genotype x age			
G x A	LSM ± SE	1 x 1	1 x 2	2 x 1	2 x 2	3 x 1	3 x 2
1 x 1	19.0 ± 0.53		-7.5 ± 0.75	2.4 ± 0.75	-1.1 ± 0.75	-2.5 ± 0.75	-4.6 ± 0.75
1 x 2	26.5 ± 0.53	<0.0001		9.9 ± 0.75	6.4 ± 0.75	4.9 ± 0.75	2.9 ± 0.75
2 x 1	16.6 ± 0.53	0.0236	<0.0001		-3.5 ± 0.75	-5.0 ± 0.75	-6.0 ± 0.75
2 x 2	20.1 ± 0.53	0.7032	<0.0001	0.0003		-1.5 ± 0.75	-3.5 ± 0.75
3 x 1	21.6 ± 0.53	0.0148	<0.0001	<0.0001	0.3714		-2.0 ± 0.75
3 x2	23.6 ± 0.53	<0.0001	0.0035	<0.0001	0.0003	0.0912	

LSM – least square mean / ocenjena srednja vrednost lastnosti, SE – standard error of estimate / standardna napaka ocene, G –genotype / genotip (1 – Barred Prelux / grahasti prelux, 2 – Sulmtaler / sulmtaler, 3 – Styrian hen / štajerska kokoš), A – age / starost (1 – 163 d, 2 – 198 d)

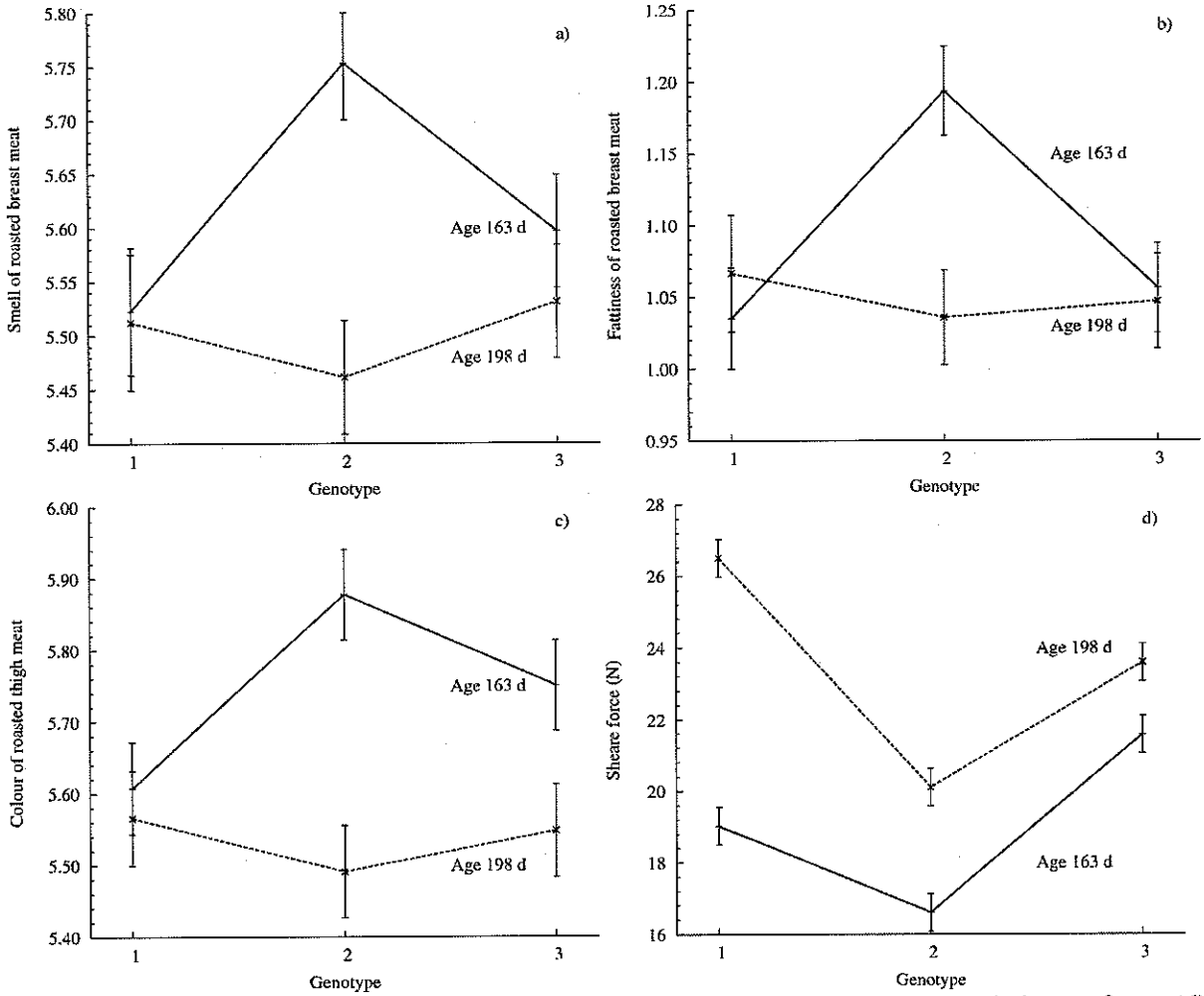

Figure 1. Interaction between genotype and age in the sensory traits (a-c) and sheare force (d)
Slika 1. Interakcija med genotipom in starostjo pri treh senzoričnih lastnostih (a-c) ter rezni trdnosti (d)

CONCLUSIONS

Age at slaughter significantly affected eight sensory traits. Conformation of raw carcass and colour and texture of roasted breast skin were better at older age, while texture of roasted breast skin, smell of roasted meat, colour and juiciness of roasted thigh meat were better in younger age. Additionally, shear force got worse at older age at slaughter.

There were eight sensory traits where the effect of genotype was close to significant: texture and flavour of roasted breast skin, juiciness of roasted breast meat, flavour, fattiness and mouth felling of roasted thigh meat, as well as overall score. Differences between capons of Barred Prelux, Sulmtaler and Styrian hen were significant in five traits: conformation and skin colour of raw carcasses, fattiness of roasted breast skin, mouth felling of roasted breast meat and tenderness of roasted thigh meat.

Thus we can conclude that decision which genotype and at which age to slaughter is the most suitable for capon production depends on which sensory traits are more important or actually which sensory traits are more important for consumers.

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