KRMIVA

DIGESTION OF STRUCTURAL SUBSTANCES IN RATITAE AND OTHER POULTRY SPECIES

PROBAVA STRUKTURNIH TVARI U NOJEVA I DRUGIH VRSTA PERADI

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SUMMARY

Ostrich and emus are the typically herbivorous animals. Only about 3% of world's bird population belong to this tropic group. Wildlife ostriches or emus also eat insecta, lizards and other small animals. Transit time of the content (chymus) through the ostrich' digestive-intestinal (DI) tract is, on average, 30-36 hrs in adult birds, depending on kind of ingested feed, even up to 48 hrs.

Ostriches have crop, but similarly to the other bird species - two-part stomach. Length of caecum (single) amounts to about 80-100 cm (in hens, geese and ducks - 10-25 cm), which gives voice to the accommodation of these birds to intake of feeds rich in structural polysaccharides fractions and their microbiological degradation in postileal part off the intestine. In comparison to the total length of the DI tract, the caecum is better developed in ostrich than, for example, in hen. Dry matter digestibility in emus vary at range of 60-68%, apparent digestibility of the cell-wall constituents (NDF) fluctuate 35-45%, hemicellulose 51-61%, ADF from -2 up to 18%, cellulose from -2,8 to 19%, lignin 4-23%. In domestical poultry species the digestibility of structural substances is lower.

Concentration of the short-chain fatty acids (SCFA), which are produced as an effect of polysaccharide fermentation amounts in the small intestine from 10 to 18 mmol/1, in the large intestine and cloaca 6-28 mmol/1 (in domestical birds these amounts to about 60 mmol/1). Molar percentage share points that the acetic acid is dominant and its quantity amounts up to 96 or 86% in the small or large intestine, respectively. Nutrients digestion and their utilization in ostriches shows the distinctly specious changeability in relation to the "performance birds" (poultry). Totally, higher extent of amino acids (AA) apparent and true availability was noted in ostriches (in mean, over 80% of true availability), while in roosters, for a lot of AA considerably lower values were obtained. True digestibility of protein amounts in ostrich to 65%, in chickens 61%, but fat digestibility, both apparent and true, was higher in chickens.

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Energetic value of some feeds, that were estimated for ostrich and roosters, differs considerably. Higher value of the true metabolic energy of feeds was estimated for ostriches than for roosters. The differences concerned examined mixture components, which indicates that the same feeds have a higher energetic value in ostrich than in roosters. This confirms the opinion that calculation of the diets using energetic values of feeds that were determined for hens, roosters ets., leads to over-estimation of energy in the diets given to ostriches.

INTRODUCTION

Ostrich and emus are the typical herbivorous animals. Only about 3% of world's bird population belongs to this tropic group. However, wildlife ostriches or emus also eat insecta, lizards and other small animals (Table 1, 2). Transit time of the content (chymus) through the ostrich' digestive-intestinal (DI) tract amounted, in dependence to age about 30-36 hrs, in adult birds, depending on kind of ingested feed, even up to 48 hours.

Table 1. Nutritional preferences and differences in the digestive tract construction in ratitae (some data adapted from Noble, 1991)

Tablica 1. Hranidbene sklonosti i razlike u izgradnji probavnog sustava u ratitima (neki podaci prilagođeni od Noble, 1991.)

Species Vrsta	Feed preferred in natural environment - Izbor hrane u prirodnom okolišu	Characteristic features of digestive tract - Karakteristične značajke probavnog sustava
Ostrich Noj	grass, steppe plants, herbs, small invertebrata trava, biljke stepe, bilje, mali beskralježnjaci	two-parts stomach, long intestine (14 m), very long large intestine, caecum 70-100 cm. Urine excreted separately from solid excrements from cloaca dvodjelni želudac, dugo crijevo (14m), vrlo dugo debelo crijevo, slijepo crijevo 70 d0 100 cm. Urin se izlučuje odvojeno od krutog sadržaja iz kloake
Emu - Emu	grass, herbs, fruits, invertebrata animals, feeds found in savannah trava, bilje, voće, beskičmenjaci, hrana nađena u savani	shorter intestine, in them short caeca, strong gizzard contractions kraće crijevo, malo slijepo crijevo (cekum), jake želučane kontrakcije
Kazuar	feed from the tropical rain forests, fruits hrana iz tropskih kišnih šuma, voće	short digestive tract - kratak probavni sustav
Nandu	grass, herbs, alfalfa, clover, fruits, insects, small animals (lizards etc.) trava, bilje, lucerna, djetelina, voće, kukci, male životinje, (gušteri, itd.)	long intestine, in them long caeca, urine excretion from cloaca delayed because of water absorption - dugo crijevo, dugo slijepo crijevo, izlučivanje urina iz kloake zadržavano zbog apsorpcije vode
Kiwi	feed from sub-tropical rain forests, small invertebrata animals, fruits hrana iz subtropskih kišnih šuma, mali beskičmenjaci, voće	short aesophagus, strong muscular contractions (gizzard), short caeca (about 17-19 cm), total length of digestive tract = 215-245 cm kratak jednjak, jake mišićne kontrakcije, kratko slijepo crijevo (oko 17 do 19 cm), ukupna duljina probavnog sustava 215 do 245 cm

Table 2. Ostrich' preferences for the plant that grow in african savannah
Tablica 2. Sklonosti noja za bilje koje rastu u afričkoj savani

- grass (Graminae) - trava
- leguminous plants (Leguminosae) - biljke mahunarke
- compositae (Compositae) - compositae
- green fodders rich in silicon dioxide (SiO_2) - zelena krmiva bogata silicijevim dioksidom (SiO_2)
(The plants close to the plants eaten by grant' gazelle) - (Biljke slične onima što ih jede gazela)

Table 3. Comparison of intestine length in ostrich, emu and in chickens (Scheideler and Sell, 1998)
Tablica 3. Usporedba duljine crijeva noja, emua i pilića (Scheideler i Sell, 1998.)

Part of intestine - dio crijeva	Ostrich - Noj		Emu - Emu		Chicken - Pilići	
	cm	%	cm	%	cm	%
Small intestine - Tanko crijevo	512	36.0	315	88.5	61	90.0
Caeca - Slijepo crijevo	94	7.0	12	3.3	5	7.0
Large intestine - Debelo crijevo	800	57.0	29	8.2	2	3.0

Ostrich has no crop, but similarly to the other bird species - two-part stomach. Length of caecum (single) reaches about 80-100 cm (Table 3) (in hens, geese and ducks - 10-25 cm; Jamroz et al., 1994,1995) which gives voice to accommodation of these birds to intake of feeds rich in structural polysaccharides fractions and their microbiological degradation in postileal part of the intestine. In comparison to the total length of the DI tract, the caecum and the large intestine are better developed in ostrich than, for example, in hen.

In contrast to ostrich, chickens and ducks - birds with relatively shorter intestinal tract may digest the structural substances to a limited extent. The degradation of crude fibre varies in dependance to the diet composition between 6-21% (chickens) and 1-7% (ducks). Hemicellulose is digested in 44-61% of its total amount (Table 4). In very young animals fed diets containing great amounts of barley the capacity for the NDF and hemicellulose degradation is low and varies between 15-30% (Table 5) although in other animals fed diets containing greater amounts of triticale the NSP-sugars digestibility was high and was for particular sugars as follows: for arabinose 56-63%, xylose 34-40% and mannose 64-71% that was on average, for NSP-sugars 55-61% (Table 6). These examples show the dependence of digestibility extent on diet composition and the polysaccharides content in them.

Table 4. Apparent digestibility of structural substances and SCFA production (Jamroz et al., 1994)
Tablica 4. Prividna probavljivost strukturnih tvari i proizvodnja SCFA (Jamroz i sur. 1994.)

Parameters - Parametri	Kind of mixture - Vrsta smjese			
	control kontrola	65% wheat pšenice	45% barley ječma	20% oats zobi
Content in mixture (%) - Sadržaj u smjesama (%)				
NDF	12.4	12.4	14.2	14.3
ADF	4.2	4.0	5.0	6.1
Hemicellulose - hemiceluloza	8.2	8.3	9.2	8.2
ADL	1.8	2.2	2.1	2.4
Cellulose - celuloza	2.4	1.9	2.9	3.7
Digestibility of the structural substances (%) Probavljivost strukturnih tvari (%)				
Chickens - Pilići				
- crude fibre - sirova vlaknina	10.9a	12.3a	21.5Aa	5.9B
- NDF	40.9aA	41.7A	42. 1A	32.7Bb
- ADF	1.4	3.5	10.3	7.3
- hemicellulose- hemiceluloza	61.4	60.1	59.6	51.7
Ducks - patke				
crude fibre - sirova vlaknina	7.4	4.2	7.6	1.1
- NDF	34.7	33.8	33.6	28.1
- ADF	2.6	1.0	2.1	7.0
hemicellulose - hemiceluloza	51.4	49.6	50.9	44.5
SCFA production in the small, caeca and large intestine (mmol/kg) Proizvodnja SCFA u tankom, slijepom i debelom crijevu (mmol/kg)				
Chickens - Pilići	173.9	211.4	232.0	209.4
Ducks - Patke	181.6	206.7	235.1	219.9

NDF - neutral detergent fibre - neutralna deterdžentna vlaknina

ADF - acid detergent fibre - kisela deterdžentna vlaknina

ADL - acid detergent lignin - kiseli deterdžentni lignin

SCFA - short chain fatty acid - kratkolančane masne kiseline

Table 5. Comparison of the structural substances digestibility and concentration of short chain fatty acids (SCFA) in different bird species (at age of 8. weeks) fed a great amounts of barley (Jamroz et al.,1995)

Tablica 5. Usporedba probavljivosti strukturnih tvari i koncentracija kratkolančanih masnih kiselina (SCFA) u raznih vrsta peradi (u dobi od 8 tjedana) hranjenih velikim količinama ječma (Jamroz i sur.,1995.)

	Chickens - Pilići	Ducks - Patke	Geese - Guske
Digestibility (%) - Probavljivost (%)			
NDF	17.8-34.5	15.6-22.4	16.7-30.0
ADF	-1.0-6.9	-2.5-7.9	-2.7-12.4
hemicellulose	27.9-52.1	26.0-32.0	29.3-41.2
Average value of digestibility coefficients (%) Prosječna vrijednost koeficijenta probavljivosti (%)			
NDF	25.7a	18.1ba	23.2b
ADF	3.3	2.8	5.9
hemicellulose	39.9a	27.8ba	34.1b
SCFA (mmol/kg)			
small intestine - tanko crijevo	10.19	11.55	17.76
caeca - slijepo crijevo	151.3	186.7	144.3
large intestine - debelo crijevo	17.4	23.8	29.3

Table 6. Apparent digestibility of sugars-NSP in different poultry species fed a great amounts of triticale (Jamroz et al., 1988) (%)

Tablica 6. Prividna probavljivost šećera -NSP u raznih vrsta peradi hranjenih velikim količinama tritikala (Jamroz i sur. 1988.) (%)

Sugars-NSP - Šećer-NSP	Chickens - Pilići	Ducks - Patke	Geese - Guske
Fructose - fruktoza	67.4a	78.4b	71.7a
Arabinose - arabinoza	56.7a	62.6b	60.5ab
Xyloza - ksiloza	34.2	40.5	39.2
Mannose - manoza	64.4a	67.6ab	71.4b
Galactose - galaktoza	59.8a	73.3b	71.9b
Average - Prosjek	54.8a	60.9b	59.8b

* estimated in 5-6 weeks of birds life - procijenjeno u 5 do 6 tjedana života peradi

The time of passage of digesta through the gastrointestinal tracts of ostrich and emus is slower than in domestic birds amounting to mean 40-48 hours, which creates valuable enviroment for degradation of structural carbohydrates. The good digestion of plant cell-wall ingredients shows perfect adaptation of these birds to the degradation of structural substances and their further conversion (Table 7 and 8).

Table 7. Some characteristics of ostrich digestibility (adapted from Swart et al., 1993a)
Tablica 7. Neke značajke probavljivosti u noja (prilagođeno od Swart i sur., 1993.a)

ostrich' body weight - 5 - 50 kg - tjelesna težina noja - 5 do 50 kg	
digesta passage time through the dietary tract amounted depending on body weight 21-76 hrs (mean 40,1 h)	
vrijeme prolaženja probavljene hrane kroz probavni sustav ovisno o tjelesnoj težini 21 do 76 sati (srednje 40,1 h)	
average digestibility coefficients of: - prosječni koeficijent probavljivosti:	
cell-wall NDF - NDF stijenka stanice	47%
hemicellulose - hemiceluloza	66%
cellulose - celuloza	38%

Table 8. Nutrients digestibility in young ostrich (Swart et al., 1993a)
Tablica 8. Probavljivost hranjivih tvari u mladih nojeva (Swart i sur., 1993.a)

Parameters - parametri	Body weight (kg) Tjelesna težina (kg)		
	5-10 (n=6)	15-18 (n=5)	42-50 (n=4)
Intake of feed DM (g/day) Uzimanje hrane (g/dan) ST	556	745	947
Intake of metabolizable energy (MJ/day) Uzimanje metaboličke energije (MJ/dan)	7.15	9.15	11.22
Digestibility coefficients (%) Koeficijent probavljivosti (%):			
dry matter - suha tvar	75	72	67
NDF	52	44	45
hemicellulose	69	63	66
ADF	36	26	39
cellulose	42	38	35
lignin	12	4	8
EM/EB (%)	79	75	73

The possibilities of digestion of structural substances and other nutrients and their utilization increase simultaneously with the age of birds and development of the digestive tract functional activity which affects the values of metabolizable energy from feeds and diets (Table 9). In emu, which has a shorter intestinal tract, the ability of degradation of cell-wall compounds is little higher or similar to the domestic poultry but lower than in ostrich (Table 10).

Digestibility of dry matter in emus varies from 60-68%, apparent digestibility of the cell-wall constituents (NDF) fluctuates 35-45%, hemicellulose 51-61%, ADF from 2 up to 18%, cellulose from -2,8 to 19%, lignin 4-23%.

Table 9. Crude fibre, NDF and fat digestibility in ostrich (in %) (Angel, 1993; Scheideler and Angel, 1994)
Tablica 9. Sirova vlaknina, NDF i probavljivost masnoća u noja (u %) (Angel, 1993.; Scheideler i Angel, 1994.)

Age (weeks) Dob (tjedana)	NDF	Crude fat Sirova masnoća	Value of metabolizable energy in mixture* Vrijednost metaboličke energije u smjesi*
3	6.5a	44.1a	1731a
6	27.9b	74.3b	2337b
10	51.2c	85.7c	2684c
17	58.0d	91.1d	2739cd
120	61.6d	92.9d	2801d

a,b,c,d - the data with different superscripts within a column are significantly different - značajne razlike ($P<0.05$)
* calculated on the basis of table data for hens
* izračunato na osnovi tablice podataka za kokoši

Table 10. Fibre fractions digestibility coefficients in emu (%) (Herd and Dawson, 1984)
Tablica 10. Probavljivost koeficijenata frakcija probavljivosti vlaknine u emua (%) (Herd i Dawson, 1984.)

Feed component Sastojak hrane	Diets* - obroci*			
	1	2	3	4 (contain saccharose sadrži saharozu)
Dry matter - Suha tvar	60±0.5	62±2.0	60±2.0	68±7.0
NDF	45±1.0	42±2.0	43±3.0	35±2.0
Hemicellulose	57±0.4	57±2.0	61±3.0	51±2.0
ADF	18±5.0	8±2.3	7±3.7	-2±2.1
Cellulose	19±5.0	6±2.5	10±3.0	-3±2.5
Lignin	23±8.0	14±2.0	4±5.0	13±2.0

* Diets were different on the chemical composition of components - obroci su se razlikovali u kemijskom sastavu dijelova
Body weight 28-48 kg. - tjelesna težina 28 - 48 kg

Table 11. Short chain fatty acids concentration in the emu's digesta (Herd and Dawson,1984)
Tablica 11. Koncentracija kratkolančanih masnih kiselina (Herd i Dawson, 1984.)

	Jejunum Jejunum	Large intestine and cloaca Debelo crijevo i kloaka
SCFA content (mmol/1)	14.3(10.6-17.9)	17.4(6.1-28.1)
Molar share (%) Masivni dio (%)		
- acetic acid - octena kiselina	91.6	86.5
- propionic acid - propionska kiselina	1.8	1.2
- butyric acid - maslačna kiselina	6.6	12.3

Characteristic is the very high intestinal concentration of short chain fatty acids (SCFA) which in domestic birds amounts in whole intestine about 170 - 220 mmol/kg of chymus (Table 5). The amounts of SCFA in the small and large intestine are quite similar in domestic bird and in emus (Table 5 and 11).

In caeca, part of the intestine where intensive microbiological degradation and fermentation of structural polysaccharides take place, the concentration of SCFA in domestic poultry varied between 140 - 190 mmol/kg content (Table 5), however in ostrich chickens it amounted 130 mmol/kg of the intestine content (Figure 1). The main differences regarding the SCFA con-centration lie in their amount in the large intestine. In young chickens, ducks and geese this concentration is about 40 - 50 mmol/kg (Jamroz et al., 1994, 1995) and in ostrich between 140 - 190 mmol depending on the place of the large intestine where the measurements were taken (Figure 1).

The degree of absorption and utilization of short chain fatty acids in energy balance in birds organism are not well recognized yet, although the metabolizable energy density in the diets estimated in different species of birds and presented in table 12 shows higher AME density determined for feeds given to ostrich than those given to cockerels. For these species of birds the greatest ME - value for tested grains and dried lucerne was estimated, this values being about 20 - 25% higher than in cockerels. The results of investigations by Farrell et al., (2001) (Table 13) in which better digestibility of dry matter

from different diets was determined in ostrich, confirm the higher EM - density of diets in ostrich, about 22-30% higher than in cockerels (Table 13).

These essential differences concerning examined feed components indicate that the basic feeds - grains have higher EM - density for ostrich.

It has a practical implications in calculation of energy density in feed mixtures for ostrich. The use of tabular energy values of feeds determined for hen or chickens (Recommendation for Poultry Nutrition, 1996) leads to over - estimation of energy density of diets given to ostriches. This may have distinct consequences for the health and performance of the ostrich.

To present day, the completed tables of energety value of feed for ostrich have not been elaborated requiring the necessity for using tables concerning domestic birds.

Figure 1. Short chain fatty acids concentration (mmol) in gastro-intestinal tract in very young ostrich (Swart et al., 1993b)

Slika 1. Koncentracija kratkolančanih masnih kiselina (m/mol) u probavno-crijevnom sustavu vrlo mladog noja (Swart i sur., 1993.b)

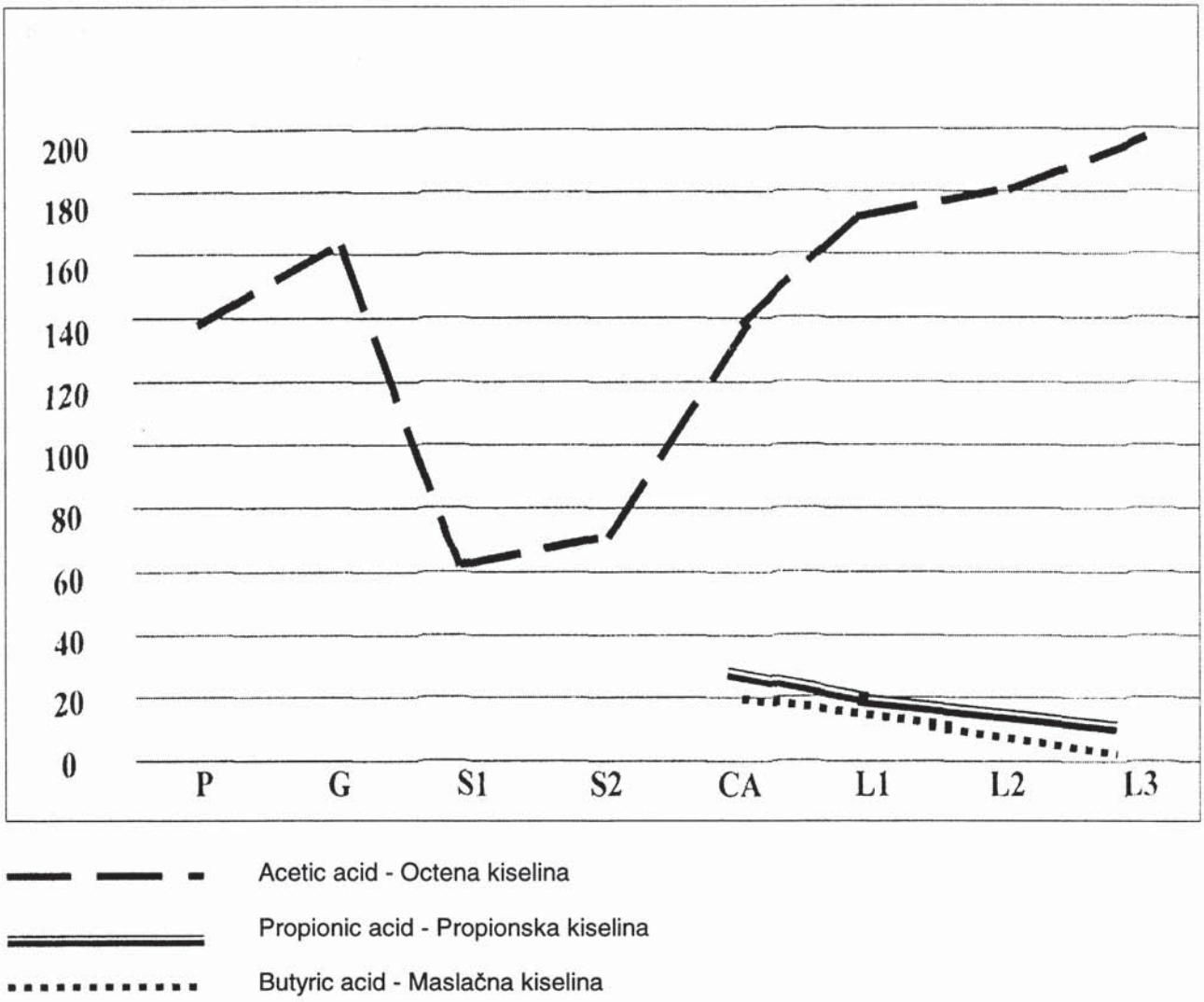

Table 12. Energetic value of some feeds given to birds
Tablica 12. Energetska vrijednost nekih krmiva davanih peradi

	AME* MJ/kg	AME** MJ/kg		AMEn** MJ/kg		TME*** MJ/kg		TMEn** * MJ/kg	
		ostrich noj	cock pijetao	ostrich noj	cock pijetao	ostrich noj	cock pijetao	ostrich noj	cock pijetao
Barley - ječam	11.85	14.55	11.13	14.21	11.06	13.92	11.57	13.92	11.33
Oats - Zob	10.75	12.97	10.49	12.65	10.48	12.50	10.63	12.27	10.63
Maize - Kukuruz	13.75	15.00	14.57	14.89	14.42	15.22	14.22	15.22	14.07
Triticale - Tritikale	12.60	13.16	11.55	12.60	11.443	13.21	11.82	13.21	11.82
Alfalfa (dried) Lucerna (sušena)	5.45!	9.27	-	8.74	-	9.26	-	8.59	-

* according to the Recommendations of poultry nutrition, 1999 - prema Preporuke za hranidbu peradi

** according to Cilliers et al.,1997 - prema Cilliers i sur., 1997.

*** according to Cilliers, calculated regression - prema Cilliers i sur., 1997.

Table 13. Apparent digestibility of dry matter (%) and value of the metabolizable energy in diets (MJ/kg DM) (Farrell et al. 2001)
Tablica 13. Prividna probavljivost suhe tvari (%) i vrijednost izmjenjive energije u obrocima (Farrell i sur., 2001.)

	Emu - Emu				Osrtich - Noj		Cockerels -Pjetlići	
	11kg(n=5) 4.5 weeks - tjedana		21 kg (n=4) 9.0 weeks - tjedana		10 kg (n=5) 4.5 weeks - tjedana		n=6 adult - odrasli	
	DM - ST	AME	DM - ST	AME	DM - ST	AME	DM - ST	AME
Basal diet (BD) Osnovni obrok (OO)	79a	15.6a	74a	14.9a	96a	18. 3a	73a	14.9a
BD + wheat 20% OO + pšenica 20%	64b	12.8b	72ab	14. 5a	93a	17.8a	69b	14.1b
BD + dried alfalfa 20% OO + suha lucerna 20%	65b	12.8b	54b	11.1b	94a	18.2a	69b	14.0b
BD + rhodes grass 20% OO + višegodišnja trava za suha područja 20%	62b	12.3b	64c	12.8c	85b	16.1b	65c	13.1c
BD + wheat straw 20% OO + slama pšenice 20%	65b	12.8b	64c	12. 8c	84b	16.3b	61d	12.6d

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SAŽETAK

Noj i emu su tipične životinje - biljojedi. Samo 3% svjetske populacije ptica pripada ovoj tropskoj skupini. Međutim, divlji nojevi i emui također jedu kukce, guštere i druge male životinje. Vrijeme prolaženja sadržaja u želucu probavljene hrane kroz probavno-crijevni sustav (DI) noja iznosi u prosjeku, ovisno o vrsti unesene hrane, oko 30 do 36 sati, u odraslih ptica čak i do 48 sati.

Noj nema voljku, ali slično drugim vrstama peradi ima dvodjelni želudac. Duljina slijepog crijeva iznosi oko 80 do 100 cm (u kokoši, gusaka i pataka 10 do 25 cm), što pokazuje prilagodbu ove peradi uzimanju hrane bogate frakcijama strukturnih polisaharida i njihovoj mikrobiološkoj razgradnji/raspadanju u postilealnom dijelu crijeva. U usporedbi s čitavom duljinom probavno-crijevnog sustava (DI) slijepo crijevo je bolje razvijeno kod noja nego, na primjer, u kokoši. Probavljivost suhe tvari u emua varira od 60 do 80%, prividna probavljivost sastavnih dijelova stijenke stanice (NDF) kreće se od 35 do 45%, hemiceluloze od 51 do 61%, ADF-a od -2 do 18%, celuloze od -2.8 do 19% a lignina od 4 do 23%. U domaće peradi probavljivost strukturnih tvari je niža.

Koncentracija kratkolančanih masnih kiselina (SCFA) što nastaju kao učinak fermentacije polisaharida u tankom crijevu iznosi od 10 do 18 mmol/1 (u domaćih ptica 60 mmol/1), u debelom crijevu i kloaki 6 do 28 mmol/1. Masivni postotni udio pokazuje da je octena kiselina dominantna a njezina količina iznosila je do 96 ili 86% u tankom odnosno debelom crijevu. Probavljanje hranjivih tvari i njihovo iskorištavanje u nojeva pokazuje izrazitu promjenljivost vrste u odnosu na perad. Ukupno, veća količina amonokiselina (AA), prividna i prava, dostupnost zabilježena je u nojeva (u prosjeku preko 80% prave dostupnosti), dok su u pijetlova dobivene znatno niže vrijednosti mnogih aminokiselina. Prava probavljivost bjelančevina iznosi u noja 65%, u pilića 61%, međutim, probavljivost masnoća, prividna i prava, viša je u pilića.

Energetska vrijednost neke hrane procijenjene kod noja i pijetlova znatno se razlikuje. Viša je vrijednost prave metaboličke energije hrane procijenjena kod nojeva nego u pijetlova. Razlike se odnose na ispitivane sastavne dijelove krmnih smjesa, što upućuje da ista hrana ima višu energetsku vrijednost kod nojeva nego kod pijetlova. Ovo potvrđuje mišljenje da izračunavanje energetske vrijednosti hrane u obroku za kokoši, pijetlove itd. dovodi do prevelike procjene energije u obrocima za nojeve.