THE EFFECT OF ETHYL-ESTER OF APO-CAROTENIC ACID (CAROPHYLL YELLOW) ON HEALTH, REPRODUCTION, MORPHOLOGICAL AND BIOCHEMICAL BLOOD PARAMETERS OF GEESE

DJELOVANJE ETHYL-ESTERA APO-KAROTINSKE KISELINE (CAROPHYLA ŽUTOG) NA ZDRAVLJE, REPRODUKCIJU, MORFOLOŠKE I BIOKEMIJSKE PARAMETRE KRVI GUSAKA

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SAŽETAK

Izvršeno je ukupno 5 pokusa za koje se sumarno prikazuju rezultati. U pokusima I do IV bilo je u svakoj grupi po 280 gusaka bijele talijanske pasmine a u pokusu V bilo je 1.820 gusaka. Svaka podgrupa sadržavala je 30 do 32 guske i 6 do 8 gusana jednu do dvije godine starosti. Svaka je grupa imala 3 do 4 ponavljanja. U tijeku proizvodnje period svjetla trajao je 8 sati dnevno.

Pokusne životinje razvrstane su u pokusne grupe polovicom prosinca a period nesenja počeo je u drugoj polovici siječnja. Pokus je trajao od prvog snešenog jajeta do završetka nesivosti polovicom lipnja. U tijeku pokusa praćeni su broj i težina jaja, fertilitet i sposobnost valjenja, uzimanje hrane, mortalitet i njihov uzrok.

U periodu nesivosti guske su dobivale hranu koja je sadržavala 10% dehidrirane trave i male količine kukuruza ili je bila bez kukuruza (tablice 1, 5, 10, 15, 22). Sadržaj s. proteina bio je 15,8% u pokusu I a u ostalim pokusima varirao je od 13,3 do 13,8%. Vitamin A bio je konstantan 10.000 i.j./kg hrane. Dodavanjem premixa vitamin A se povećao od 10.000 do 25.000 i.j./kg i β-korotin od 6 do 12 mg/kg. (tablice 2, 6, 11, 16, 23). Uzimanje hrane u tijeku nosivosti kretalo se od 280-360 g (dan) guska. Količina dodanog ethyl-estera (C30) u hrani kretala se od 8 do 36 mg/kg.

Rezultati su pokazali pozitivne učinke kombiniranog dodavanja 10.000 i.j. vitamina A s 24 mg ethyl-estera na 1 kg hrane na proizvodnju jaja što iznosi 2,5 do 5,5 guščića više po nesilici u usporedbi sa samo 10.000 i.j. vitamina A. Dodavanjem 16 mg ethyl-estera + 10.000 i.j. vitamina A povećava se nesivost za 6,7% ili 2,8 guščića više po guski dok je dodavanje 8 ppm bez učinka.

U makropokusu dobar je rezultat od 50,5 guščića postignut u kontrolnoj grupi koja je dobivala hranu sa 20.000 i.j. vit. A. U tom tretmanu ako je dodano 8 ppm ethyl-estera povećao se rezultat za 10,9%, odnosno 5,5 guščića više po guski u periodu nesivosti.

Krvna slika varirala je u tijeku reprodukcijskog perioda i nije bilo utjecaja ethyl-estera na promjene vrijednosti u krvnoj slici te ukupnim bjelančevinama u krvi. Utvrđeno je povećanje transferina, bolje vezanje željeza od 18 do 22% putem TIBC transferina. Manja saturacija transferina sa željezom pokazuje visoku otpornost gusaka koje su dobivale ethyl-ester. Nije utvrđena linearna ovisnost između β-karotina u serumu i količine dodanog ethyl-estera.

Dobiveni rezultati pokazali su da u industrijskoj proizvodnji krmnih smjesa za guske nesilice treba posebnu pažnju posvetiti dodavanju krmnim smjesama ethyl-estera ili karofil-žutog i β-karotina osobito u slučajevima kada se upotrebljavaju krmne smjese bez kukuruza. Eliminacija zelene mase iz hranidbe gusaka mora se zamijeniti krmivima i dodacima koji sadrže visoke količine proridnih ksantofila naročito luteina, zeaxanthina i canthaxanthina.

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Geese – typical herbivorous birds consume considerable amounts of soft plants and roots rich in variety of carotenoids, which does not comprise vit. A. The elimination of these feeds or reduction of these doses in intensive rearing system, as well as replacement of assortment of compounds in complete feed required reconstruction of natural xantophyll contents, especially lutein, zeaxanthin and canthaxanthin in the diets (FLECHTER and HALLORAN, 1983; PAPPA et al., 1985; NEHRING and HOFFMANN, 1966). These substances, although easily absorbed, can not or can hardly be metabolized to vitamin A in the enterocytes of intestine walls of poultry. Also β-carotene is hardly converted into retinol, although it plays an important function in reproduction by stimulating progesteron production (PETHES et al., 1985; SCHWEIGERT, 1988).

Intensification of poultry production has brought about radical changes in rearing and feeding system of birds. Like other birds, geese in intensive rearing are fed with feed containg high cereals share. In the situation of maire deficiency, pastly replacement of maize rich in zeaxanthin by basley and other domestic cereals results in carotenoids shortage. Forages traditionally fed to geese in extensive rearing are replaced by dehydrated feeds of different nutritional value and carotenoid contents.

The opinions of specialists on intentionally increasing standard vit. A levels in complete feed from 10000 IU up to 20000 or even 30000 IU/kg are full of divergences (JAMROZ et al., 1979, 1985a).

The increased vit. A level in complete feed improves reproduction and hatchability, immunity of birds, lipids' metabolism, etc. (DAVIS and SHELL, 1983; HILL et al., 1961; SKLAN, 1983a, 1983b), whereas β-carotene given to layers and growing birds in different grade affected their performances (DAMRON et al., 1984; LORINCZ and LATOS, 1987; ŽARSKI et al., 1988). The mechanism of β-carotene conversion to vit. A in animals is well-known (BRUBACHER, 1975; GANGULY and SASTRY, 1985; SCHIEDT et al., 1985; SCHIEDT, 1988, 1990), but so far no data have been reported on geese, the birds naturally fed on green forages high in carotenoids.

Seven years ago, bearing in mind the peculiarity and significance of this problem in geese feeding, a research team at the Department of Animal Nutrition and Feed Management, Agricultural University in Wroclaw and Experimental Station at the Institute of Zootechnic in Koluda Wielka undertook the studies on optimal vit. A doses and carotenoid contents in the feed destined for reproductive geese.

Since the components of the complete feed manufactured at present are deficient in natural di-hydroxycarotenoids, they can be supplemented with synthetic xanthophylls or β-carotene. Ethyl ester of β-apo-carotenic acid (C_{30}) is available on market as 10% Carophyll Yellow premix (Hoffman La Roche). This substances occurring in colourful feathers of birds, citrus fruit and green forages, affects pigmentation of poultry carcass and table eggs (JANKY and HARMS, 1983; KARUSZAJEEVA et al., 1984; KOCI et al., 1974; PAPPA et al., 1985; STREIFF, 1970; TIRADO et al., 1986; TYCZKOWSKI and HAMILTON, 1986a, i b) and for this reason it was used in feeding the reproductive geese presuming that its somatic, vitamin-similar action could improve the birds performances.

This paper is a synthesis of long-term studies carried out by the author and her co-operators in the years 1984-1989 (JAMROZ et al., 1985b, 1987, 1990a, b).

MATERIAL AND METHODS

In total, 5 experiments were carried out; experiments I-IV were conducted on 280 geese of White Italian breed in each and experiment V was performed on 1820 birds. The subgroups consisted of 30-32 geese and 6-8 ganders, one- and two- year old. Each feeding group consisted of 3-4 replications. During the egg production the light period was provided for 8 hours a day.

The birds were divided into the experimental groups in the middle of December and the laying period was due to begin in the second half of January. The studies commenced when the first egg was laid and were finished on till the end of June.

During the entire experimental period the number and fertility and hatchability, feed intake, mortality and its causes, from 20-23 settings, were determined.

In the laying period the birds were fed by complete feed containing 10% of dehydrated grass and small amounts of maize (or without maize) (Tables 1, 5, 10, 15, 22). The concentration of crude protein was 15,8% in experiment I and varied from 13,3 to 13,8% in the remaining experiments. Standard vit. A dose was constant i.c. 10.000 IU/kg of feed.

The birds were given supplement Polfasol A in order to increase vit. A level from 10.000 to 25.000 IU/kg. The quantity of applied ethyl-ester (C_{30}) in feed ranged from 8 to 36 mg/kg and β-carotene from 6 to 12 mg/kg (Tables 2, 6, 11, 16, 23). Feed intake during the laying period ranged from 280 to 360 g/day bird.

In the months March, May and June, i.c. from peak till reduced egg production 8-10 eggs were randomly selected from each group for the determinations which included: β-carotene, retinol and ethyl-ester (C_{30}) contents of yolk by the method of liquid chromatography on the columns filled with Li-Chrosorb SI 60 um, the moving phase was composed of the mixture of heptane and n-octanole (ratio 99,6:0,4) at the flow rate of 1 ml/min. The examined compounds were detected spectrophotometrically at wavelength of 298 um.

Apart from the geese performance, the authors also focused their attention to the health of birds and their resistance to diseases, cince a favorable effect of ethyl-ester (C_{30}) supplementation on the health of geese had been observed (JAMROZ et al., 1985b, 1987, 1990a, b).

The blood for biochemical and morphological studies was collected from the wing vein of 6 birds in each trial group, three times during the laying period; thus the studies included 96 birds. The determinations in full blood comprised:

Ht-index using a microhematocrit Unipan 316 centrifuge,
morphotic elements by the Natt-Harrick method,
leucogram by the Pappenheim method.

The blood serum determinations included crude protein contents by biurette method, protein fractions by electrophoresis, transferrin using a radial immunodiffusion test made by »Mega« Biopreprarators. Fe and total iron binding capacity (TIBC) after saturation with Fe compounds using a biochemical diagnostic test of POCh Gliwice, reserve iron binding capacity (from the formula TIBC-serum Fe), transferrin saturation with

$$Fe\left(\frac{\text{serum Fe}}{\text{TIBC}} \times 100\right),$$

Cu^{2+} (using a Lachema diagnostic test), ceruplasmine (radial immunodiffusion test of f. Mega), β-carotene and retinol contents (liquid chromatography), aminotransferase activity; AspAT and AlAT (by the Reitman and Frankel method using chemotests of POCh Gliwice).

The data obtained in the morphological and biochemical studies were analyzed statistically using a variance analysis and multiplical Duncan's test.

RESULTS AND DISCUSSION

The economical system of geese feeding i.e. reduction of protein contents in the feed from standard 16% to 13,3-13,8% and dailylight program reduced to 8 hours, consequently resulted in very high egg production, i.e. 58,0 (experiment I); 69,9 (II); 67,0 (III) 66,1 (IV) and 63,3 (V) eggs per layer. Specially high egg production was recorded in experiment II in which the number of eggs per layer averaged 71,0 (Tables 2, 7, 12, 16, 23).

The increase vit. A content in complete feed from standard 10.000 to 25.000 I.U./kg, did not improve the egg production, while combined administration of vit. A (10.000 I.U.) and ethyl-ester (C_{30}) (24 mg/kg of feed) resulted in 4,7 (I); 2,8 (II) and 5,5% (III) increase in the number of eggs. However, the number of eggs recorded in group IV was only 2% lower than in the control. On the other hand, the increased vit. A content (20.000 I.U./kg) and low ethyl-ester concentration (8 ppm) improved egg production by 3,6% in comparison with the control.

The geese eggs weight did not show any differences to vit. A or ethyl ester (C_{30}) supplementation.

Ethyl-ester C_{30} supplement markedly reduced the losses in the consecutive cycles of egg hatching (Tables 3, 8, 13, 17, 23) substantially enhanced an important reproductive rate – the number of healthy goslings from a layer. Combined administration of vit. A (10.000 I.U./kg) and ethyl-ester (24 mg/kg of feed) resulted in 6% (I); 3% (III) and 17,7 (IV) increase in the number of goslings as compared witht the control group. In experiment V (20.000 I.U. of vit. A + 8 mg of ethyl-ester C_{30}/kg) the increase reached 10,9%. These data are worth noting because the number of goslings from a layer was 43, 45, 46, 49 and 56 in each experiment. Presented results therefore suggest that not only vit. A supplementation but ethyl-ester C_{30} as well as natural carotenoids affect the viability of embryos (KOETSEVELD, 1961), and consequently the number of goslings per layer.

The observations noted for all the experimental years prove that the geese given ethyl-ester C_{30} went through the laying season, so exhausting for their organisms, in very good health condition; they were active and had good appetite. No losses except for some accidental causes, were noted in females and no symptoms of clinical Neisseria sp. were observed in ganders, though this is a serious problem in geese breeding (CHIFRA and PETHES, 1987).

The appearance of the goslings from mothers fed ethyl-ester supplemented mixtures was very appealing; their beaks and feed were bright orange, besides, they were very active and lively.

These explicit, though subjective observations encouraged the authors to conduct biochemical and morphological studies on geese blood in order to determine the indices characterizing the birds' health and their immune system.

It was not evidence to indicate that the morphotic changes in the geese blood were effected by the experimental factors (Table 18). The Ht-index dropped markedly ($P<0,01$) after the laying peak. It could be suggested that its revival at the end of the laying season was due to other no- experimental factors and resulted by physiological characteristic of this period. Ethyl-ester C_{30} slightly increased the Ht-index (3-4%) irrespectively of the dosage applied.

A slightly increased (4,5-5,9%) number of erythrocytes was detected in the blood of birds fed with concentrates supplemented with 8-24 ppm of ethyl-ester, whereas the smallest number was noted in the control group ($P<0,05$). The highest number of leucocytes was found in group II but the values did not exceed the physiological standards. The numbers of leukocytes increased significantly after 5 months of laying.

The leucogram of the laying geese did not show any significant changes due to ethyl-ester supplementation, although in the course of the laying season a decreased percentage of basophils ($P<0,01$), eosinophils and neutrophils was noted together with an increasing amount of monocytes.The percentage of neutrophils was rising at the end of the laying season. The lymphocytes increased markedly during the laying peak.

Total protein content of the blood serum was found within the range of 62 to 67 g/l, albumin ranged from 32 to 35 g/l, globulin 30 g, and γ-globulin about 10 g/l (Table 19). No significant differences in geese serum protein concentration (excluding albumin) were observed in any of the feeding groups. After 2 months laying in the birds was exhibited elevated protein concentration in blood serum, but in the end of laying period it was significant decline ($P<0,01$).

Iron concentration and TIBC (transferrin) increased ($P<0,01$) after 1-2 months of laying, but the differences between the groups indicate a marked effect of ethyl-ester supplementation on biochemical blood indices (Table 20); serum TIBC was 6-8% higher in geese fed with ethyl-ester supplemented mixtures. The reserve iron binding capacity was significantly higher (18-22%) in the ethyl-ester supplemented geese ($P<0,01$) while the highest transferrin saturation with iron was observed in the control geese ($P<0,05$). As the laying period went, the higher was the numerical value characterizing this index in geese.

Variations of copper and ceruloplasmin serum contents did not suggest a definite relationship between amount of ethyl-ester supplementation and this biochemical indices. The variations were only due to the stage of egg production. The highest Cu^{2+} and ceruloplasmin level in blood serum were noted in birds of group IV (+8 ppm of ethyl-ester).

The biological function of transferrin synthetized in hepatocytes conwected with iron transportation is wider, as it plays anti microbiological role in animals' blood. The inhibitory effect of transferrin on microbial growth is more pronounced if its saturation with iron is slight (GEHRKE, 1989).

Reduced concentration of free iron ions, increased transferrin TIBC and reduced degree of its saturation with Fe^{2+} indicated better immunity of birds from the ethyl-ester *supplemented groups in comparison with the control. This* was also confirmed by higher ceruloplasmin content of geese blood in those groups. The elevated ethyl-ester doses increased the reserve iron binding capacity linearly, but decreased the degree of transferrin saturation with iron. The changes in Cu and ceruloplasmin level were irregular.

AspAT and AlAT activity in blood serum was similar in all experimental groups, although AspAT was reduced ($P<0,01$) in the fifth month of egg production. Neither the presence of ethyl-ester in concentrates nor its quantity affected aminotransferase activity.

Combined vit. A and ethyl-ester C_{30} *supplementation* did not affect the concentration of these substances in egg yolk (Table 4). However, the vit. A content of yolk increased when ethyl-ester was added to the feedstuff. Great individual variation of the discussed indices and the changes of their concentration in egg yolk during the egg production period (Tables 9,14) did not explain the relationship between the quantity of this biological active substance and retinol content of yolk.

Ethyl-ester supplementation affected significantly ($P<0,01$ and $P<0,05$) β-carotene content of the blood serum (Table 21). The linear increase in β-carotene, proportional to the ethyl-ester dose was the highest in blood serum of the geese supplemented 24 ppm of ethyl-ester, but it decreased with the decreasing supplementation. The variation in β-carotene content of blood serum were great and ranged from 0,33 to 8,72 mmol/l. Retinol content of serum was more stabile and averaged 3,20 mmol/l in all groups, excluding group II in which it was 14% lower.

Feed composition (Exp. I)
Sastav hrane (Pokus I)

Table 1 – Tablica 1

Ingredients – Krmiva		%
Ground-maize – kukuruz		30,0
Ground barley – ječam		34,0
Soybean meal – sojina sačma		18,0
Grass meal – trava		10,0
Premix Z*		0,5
Mikrofos (Mineral mixture)**		1,5
Limestone – vapnenac		6,0
Metabolizable energy (metabolička energija)	Kcal	2599
	MJ	10,8
Crude protein – s. protein	%	15,79
Crude fibre – s. vlakna	%	4,70
Lysine	%	0,76
Methionine	%	0,25
Cystine	%	0,27
Ca	%	2,74
P-inorganic	%	0,61
Average content in 1 kg: Prosječni sadržaj u 1 kg:		
– β-carotene	mg	5,07
– luteine	mg	17,50
– zeaxanthin	mg	4,62
– vitamin A	i.u.	10.000

* – Preemix Z – in 1 g: 2000 i.u. vit. A; 360 i.u. vit. D_3; 0,6 mg v it. E; 0,72 mg vit. K; 2,6 mg vit. B_2; 0,002 mg vit. B_{12}; 12 mg nicotin acid; 4,56 panthotenic acid.

** – Mikrofos – in 1 kg: 124 g P; 255 g Ca; 80 g Na; 93 g Cl; 4,0 mg Mg; 0,164 g Mn; 0,60 g Fe; 0,21 g Cu; 0,04 g Co; 1,0 g Zn; 0,02 g J.

The basicx geese performances (Exp. I)
Osnovni pokazatelji gusaka (Pokus I)

Table 2 – Tablica 2

Performances Svojstva		Trial groups / Pokusne grupe I control kontrola	II +15.000 iu vit. A/kg	III +24 ppm of ethyl-ester*
Geese body weight (kg) Težina tijela gusaka				
m – initial – početna		5,42	5,60	5,55
– final – završna		6,65	6,56	6,92
– gain – prirast		1,23	0,96	1,37
f (ž) – initial – početna		5,19	5,17	5,07
– final – završna		5,80	5,67	5,48
– gain – prirast		0,61	0,50	0,41
Eggs number of per layer		57,84	56,83	60,07
Broj jaja po nesilici	%	100,0	−1,8	+3,8
Average egg weight	g	186,7	188,7	188,2
Prosječna težina jaja	%	100,0	+1,1	+0,8
Total egg weight per layer	kg	10,80	10,72	11,31
Ukupna težina jaja po nesilici	%	100,0	−0,1	+4,7
Daily feed consumption per layer Dnevno uzimanje hrane po nesilici				
– mixture – mješavine	g	315	315	326
	%	100,0	0,0	+3,6
– crude protein – s. protein	g	49,78	49,80	51,57
	%	100,0	0,0	+3,6
– metabolizable energy	kcal	818	819	849
– metabolička energija	%	100,0	+0,1	+3,6
– Vitamin A	I.U.	6306	7885	3266
	%	100,0	+25,0	−48,2
– Apo-ester	mg	–	–	7,84

* – 24 ppm Efthyl-ester (C_{30}) = 10.000 I.U. activity of vit. A

Results of hatchability of geese eggs (Exp. I)
Rezultati sposobnosti valjenja jaja gusaka (Pokus I)

Table 3 – Tablica 3

Performances Svojstva		Trial groups Pokusne grupe I	II	III
Fertility	%	85,01	92,79	87,15
Fertilitet	%%	100,0	+9,1	+2,5
Dead embryos Uginuća embrija				
– 1st candling prvo osvjetljavanje	%	4,55	3,76	4,63
– 2nd candling drugo osvjetljavanje	%	3,10	3,56	2,41
– unhatched embryos neizvaljeni embriji	%	6,63	7,22	6,83
Hatchability of fertilized eggs Sposobnost valjenja fertilnih jaja				
– healthy goslings	%	73,46	77,74	75,09
zdravi guščići	%%	100,0	+5,8	+2,2
– weak goslings bolesni guščići	%	1,62	2,08	1,39
Number of healthy goslings per layer		42,50	44,23	45,04
Broj zdravih guščića po nesilici	%	100,0	+4,1	+6,0

The vitamin A content in the goose egg yolk (in I.U.)
Sadržaj vitamina A u žumanjku gušćeg jajeta (i.j.)

Table 4 – Tablica 4

Month Mjesec	I in 1 g ug	I in 1 g I.U.	I in yolk I.U.	II in 1 g ug	II in 1 g I.U.	II in yolk I.U.	III in 1 g ug	III in 1 g I.U.	III in yolk I.U.
I	63,39	27,30	1.730,8	68,71	23,34	1.603,7	66,54	25,44	1.692,8
II	70,15	28,09	1.970,5	69,88	41,21	2.879,7	71,55	36,36	2.601,5
V	65,12	33,48	2.180,2	69,53	35,24	2.450,0	67,08	33,71	2.261,2
VI	66,80	27,63	1.845,6	63,41	35,26	2.235,8	66,73	28,80	1.921,8
$\bar{x}$	66,36	29,12	1.931,7	67,88	33,76	2.292,3	67,97	31,08	2.119,3

Trial groups – Grupe

Feed composition (Exp. II)
Sastav hrane (Pokus II)

Table 5 – Tablica 5

Ingredients Krmiva		%
Ground wheat – pšenica		36,0
Ground barley – ječam		35,6
Grass meal – trava		10,0
Soybean meal – sojina sačma		8,0
Mikrofos (Mineral mixture) – minerali		4,0
Limestone – vapnenac		5,0
Premix Z*		1,0
Vitamin B – compositum		0,1
DL-Methionine		0,2
L-Lysine		0,1
Metabolizable energy ME	Kcal/kg	2460
	MJ	10,3
Crude protein – s. proteini	%	13,50
Crude fibre – s. vlaknima	%	5,60
Lysine	%	0,67
Methionine	%	0,41
Cystine	%	0,24
Ca	%	2,52
P-inorganic	%	0,68

* – Premix Z: in Tab. 1

Design of experiment II
Plan pokusa II

Table 6 – Tablica 6

Trial groups Pokus	Standard level of vitamin A in the feed Količina vitamina A u hrani I.U./kg i.j./kg	Vitamin A supplemented as Polfasol A dodatak vitamina A putem POLFASOLA I.U./kg i.j./kg	Ethyl-ester supplementation Dodatak ethyl-estera mg/kg
I control	10.000	10.000	–
II	10.000	–	24,0
III	10.000	10.000	24,0
IV	10.000	–	36,0

The basic geese performance
Osnovni pokazatelji gusaka

Table 7 – Tablica 7

Performances Svojstva		Feeding groups – Grupe I	II	III	IV
Geese body weight (kg) Težine tijela gusaka (kg)					
m – initial – početna		6,7	6,5	6,5	5,9
– final – završna		6,1	5,9	6,3	5,9
– gain – prirast		−0,6	−0,6	6,5	0,0
f (ž) – initial – početna		6,0	5,9	5,9	5,9
– final – završna		5,4	5,8	5,7	5,7
– gain – prirast		−0,6	−0,1	−0,2	−0,2
Eggs number per layer		70,9	71,1	67,7	68,6
Broj jaja po nesilici	%	100,0	+2,8	−4,5	−3,3
Average egg weight	g	184,4	180,3	186,3	185,8
Prosječna težina jaja	%	100,0	−2,2	+1,0	+0,7
Total egg weight per layer	kg	13,07	12,82	12,61	12,75
Ukupna težina jaja	%	100,0	−2,0	−5,5	−2,5
Daily feed intake per layer	g	324	353	348	348
Dnevno uzimanje hrane po nesilici	%	100,0	+8,9	+7,4	+7,4
Per egg	g	979,4	1046,1	1084,5	1070,8
Po jajetu	%	100,0	+7,3	+11,1	+9,9

Results of hatchability of geese eggs (Exp. II)
Rezultati leženja jaja gusaka (Pokus II)

Table 8 – Tablica 8

Performances Svojstva		Trial group – Grupe I	II	III	IV
Fertility	%	91,4	90,9	90,1	92,9
Fertilitet	%%	100,0	−0,6	−0,4	+1,6
Dead embryos Mrtvi embriji					
– 1st candling% – prvo osvjetljavanje		4,96	3,95	4,18	4,01
– 2nd candling – drugo osvjetljavanje	%	3,85	3,09	2,95	3,17
Unhatched embryos Neizvaljeni embriji	%	7,92	8,54	7,26	7,75
Hatachability of fertilized eggs	%	70,2	72,1	72,3	72,2
Izvaljeno fertilnih jaja	%%	100,0	+2,7	+3,0	+2,9
Number of healthy goslings/layer		48,0	49,5	46,3	48,2
Broj zdravih guščića/nesilica	%	100,0	+3,1	−3,6	+0,4

Carotene, Vitamin A and Ethyl-ester content in the geese egg yolk (Exp. II)
Sadržaj kartoina, vitamina A i ethyl-estera u žumanjku gušćeg jajeta (Pokus II)

Table 9 – Tablica 9

Performances svojstva	Month	Trial groups – grupe I	II	III	IV
β-Carotene (μg/g)	III/IV	5,698	5,700	5,978	5,695
	VI	0,350	0,460	0,525	0,610
	VII	0,638	0,578	0,844	0,788
	$\bar{x}$	2,228	2,246	2,449	2,364
Ethyl-β-apo-carotenoate (μg/g)	III/IV	0,00	36,93	33,76	63,36
	VI	0,00	36,24	32,41	30,15
	VII	0,00	39,95	26,43	56,67
	$\bar{x}$	0,00	37,70^{L}	30,86^{Aa}	50,06^{B}
Retinol (ug/g) (I.U./kg)	III/IV	10,03	9,50	12,24	7,95
		33,43	31,66	47,46	26,50
	VI	4,32	5,10	6,15	4,30
		14,40	17,00	20,50	14,33
	VII	4,89	5,98	6,36	6,13
		16,30	19,93	21,20	20,43
	$\bar{x}$	6,41	6,86	8,92	6,13
		21,37	22,86	29,72	20,43

1 ug of Retinol = 3,333 I.U.
1 ug Retinola = 3,333 i.j.
The level of Retinol at the begining of the study was 29,25 I.U. = 8,77 μg/g
Količina Retinola na početku pokusa bila je 29,25 i.j. = 8,77 ug/g
a, b – P<0,05
A, B – P<0,01

Feed composition (Exp. III)
Sastav hrane (Pokus III)

Table 10 – Tablica 10

Ingredients Krmiva		%
Ground wheat – pšenica		36,0
Ground barley – ječam		35,6
Grass meal – trava		10,0
Soybean meal – sojina sačma		8,0
Mikrofos (Mineral mixture)		4,0
Limestone – vapnenac		5,0
Premix Z		1,0
Vitamin B-compositum		0,1
DL-Methionine		0,2
L-Lysine		0,1
Metabolizable energy	Kcal/kg	2460
	MJ	10,3
Crude protein – s. proteini	%	13,5
Crude fibre – s. vlakna	%	5,6
Lysine	%	0,67
Methionine	%	0,41
Cystine	%	0,24
Ca	%	2,52
P-inorganic	%	0,68
Vitamin A	I.U./kg	10.000
β-carotene	mg/kg	3,9
Xantophyls	mg/kg	22,2

Design of experiment III
Plan pokusa III

Table 11 – Tablica 11

Trial groups Grupe	Standard level of vit. A in the feed I.U./kg Standardna količina vit. A u hrani i.j./kg	Vitamin A supplemented as Polfasol I.U./kg Dodani vit. A	Supplementativone – Dodatak Ethyl-ester*	β-carotene**
I control	10.000	10.000	–	–
II	10.000	–	24,0	–
III	10.000	–	–	6,0
IV	10.000	–	–	12,0

* – ethyl-ester of apocarotenal acid – Carophyll Yellow 10%; preparation made by La Roche
** – 10% Rovimix; preparation made by La Roche

The basic geese performance (Exp. III)
Osnovni parametri (Pokus III)

Table 12 – Tablica 12

Parameters Svojstvo		Trial groups – Grupe I	II	III	IV
Geese body weight (kg) Težine tijela gusaka (kg)					
m – initial – početna		6,3	6,0	6,1	6,0
– final – završna		6,1	6,1	5,9	6,0
– gain – prirast		−0,2	+0,1	−0,2	0,0
f (ž) – initial – početna		5,4	5,3	5,6	5,4
– final – završna		5,7	5,9	6,0	5,8
– gain – prirast		+0,3	+0,6	+0,4	+0,4
Number of eggs per layer		65,7	69,3	65,8	66,9
Broj jaja po nesilici	%	100,0	+5,5	+0,3	+1,8
Average egg weight	g	186,5	181,5	180,4	182,3
Prosječna težina jaja	%	100,0	−2,7	−3,3	−2,2
Total egg weight per layer	kg	12,25	12,58	11,87	12,20
Ukupna težina jaja po nesilici	%	100,0	+2,7	−3,1	−0,4
Feed intake – per head daily	g	339	351	341	349
Uzimanje hrane po grlu dnevno	%	100,0	+3,5	+0,6	+2,9
– per one egg	g	1057,8	1038,3	1062,4	1069,4
– po jajetu	%	100,0	−1,8	+0,4	+1,1

Results of geese eggs hatchability (Exp. III)
Rezultati leženja gušćih jaja (Pokus III)

Table 13 – Tablica 13

Parameters Svojstva		Trial group – grupe I	II	III	IV
Fertility of eggs Oplođena jaja	%	90,9	89,1	81,9	91,1
Dead embryos Uginuli embriji					
– 1st candling – prvo osvjetljavanje	%	7,52	7,71	8,20	7,76
– 2nd candling – drugo osvjetljavanje	%	4,54	5,01[b]	4,76	3,87 [a]
Unhatched embryos Neizvaljeni embriji	%	8,66[b]	7,13[a]	7,82	8,23
Hatchability of fertilized eggs Izvaljeno oplođenih jaja	%	74,5	75,2	74,4	75,6
Number of healthy goslings/layer		42,0	43,3	37,1	43,0
Broj zdravih guščića/nesilica	%	100,0	+3,1	−11,7	+2,4

a, b – $P<0,05$

Carotene, Vitamin A and Ethyl-ester content in the geese egg yolk (Exp. III)
Sadržaj karotina, vitamina A i ethyl-estera u žumanjku gušćeg jajeta (Pokus III)

Table 14 – Tablica 14

Parameters svojstva	Month Mjesec	Trial groups – grupe I	II	III	IV
β-Carotene (μg/g)	III/X	0,34	0,40	1,25	1,90
	V	2,05	2,76	3,23	2,93
	VII	1,89	m.d.	1,85	1,47
	$\bar{x}$	1,43	1,58	2,11	2,10
Ethyl-β-apo-carotenoate (μg/g)	III	–	16,58	–	–
	V	–	44,08	–	–
	VII	–	m.d.	–	–
	$\bar{x}$	–	30,33	–	–
Retinol (ug/g)	III	5,21	4,84	3,95	4,13
	V	3,67	2,38	2,06	2,16
	VII	1,75	m.d.	1,32	1,05
	$\bar{x}$	3,54	3,61	2,44	2,44

m.d. – missing data

Feed composition (Exp. IV)
Sastav hrane (Pokus IV)

Table 15 – Tablica 15

Ingredients Komponente		%
Ground wheat – pšenica		36,2
Ground barley – ječam		35,8
Soybean meal – sojina sačma		8,0
Grass meal – trava		10,0
Limestone – vapnenac		4,9
Mikrofos (Mineral mixture)		4.0
Premix Z*		0.5
Vitamin B – compositum		0.1
DL-Methionine		0.2
L-Lysine		0.1
Metabolizable energy ME	Kcal/kg	2741
	MJ	10,4
Crude protein – s. proteini	%	13,88
Crude fibre – s. vlakna	%	7,21
Lysine	%	0,69
Methionine	%	0,40
Ca	%	2,52
P-inogranic	%	0,69
Vit. A	I.U./kg	10.000
β-carotene	mg/kg	3,9
Xantophyles	mg/kg	22,9

The basic of geese performance
Osnovni pokazatelji

Table 16 – Tablica 16

Indices Svojstva		Groups – Grupe I – Control	II +24 mg of Apo-ester	III +16 mg of Apo-ester	IV +8 mg of Apo-ester
Geese body weight Težina tijela gusaka					
– initial	♂	6,5	6,8	6,5	6,4
početna	♀	5,2	5,7	5,7	5,4
– gain	♂	+0,5	+0,4	+0,2	+ 0,2
prirast	♀	+0,6	+0,6	+0,7	+ 0,4
Number of eggs per layer Broj jaja po nesilici		68,0	66,6	66,8	62,9
	%	100,0	−2,1	−1,8	−7,5
egg mass	g	178	179	178	178
težina jaja	%	100,0	+0,6	0,0	0,0
total egg weight	kg	12,10	11,92	11,89	11,20
per layer ukupna težina jaja/nesilica	%	100,0	−1,5	−1,7	−7,4
Feed intake on:					
day/layer	g	392	395	392	389
one egg	g	1079	1108	1099	1157

Hatchability indicates of eggs
Leženje jaja

Table 17 – Tablica 17

Indices Svojstvo		Groups – grupe Standard level of vit. A 10000 iu/kg Standardna količina vit. A 10000 i.j./kg I – Control	II +24 mg of apo-ester	III +16 mg of apo-ester	IV +8 mg of apo-ester
Fertility	%	86,3	93,6	89,6	76,8
Oplođeno jaja	%%	100,0	+8,4	+3,8	−11,0
Embryo mortality	%	17,7	9,5	12,6	9,7
in 1st and 2nd candling Mortalitet embrija kod 1. i 2. osvjetljavanja	%%	100,0	−46,1	−28,8	−45,2
Hatchability of	%	65,9	79,1	73,7	76,2
fertilized eggs Valjenje oplođenih jaja	%%	100,0	+20,0	+11,8	+15,6
Number of healthy		41,9	49,3	44,7	37,7
goslings Broj zdravih guščića	%%	100,0	+17,7	+6,7	−10,1

Morphological parameters indicates in blood of geese (Exp. IV)
Morfološki pokazatelji krvi u gusaka (Pokus IV)

Table 18 – Tablica 18

	Apo-ester suppl. Dodatak Apo-estera	Days of blood sampling – Dani uzimanja krvi 14.01		24.02		22.03		23.06		x̄w		
		x̄	±S	x̄	±S	x̄	±S	x̄	±S	x̄	±S	%
Haemotocrit (%)												
	0	38,60	4,04	33,60	3,03	32,60	2,06	35,40	1,29	34,93	3,47	100,0
	24	38,00	3,54	36,10	2,56	33,60	1,07	37,00	2,92	36,05	2,97	+3,1
	16	40,00	3,32	34,60	2,07	33,70	2,40	37,50	1,84	36,33	3,41	+4,0
	8	39,20	3,03	37,70	3,45	39,90	2,13	36,10	1,85	36,31	3,24	+3,9
x̄w		38,95[A]	3,03	35,50[C]	3,04	33,21[B]	1,91	36,50[C]	2,06			
Erythrocytes 10^{12}/l												
	0	3,06	0,49	2,79	0,16	2,88	0,21	2,85	0,12	2,89[a]	0,28	100,0
	24	3,14	0,27	3,01	0,29	2,98	0,22	2,98	0,26	3,02	0,25	+4,5
	16	3,12	0,29	2,93	0,22	3,02	0,11	3,02	0,20	3,02	0,21	+4,5
	8	2,93	0,27	3,23	0,67	3,05	0,34	3,02	0,15	3,06[b]	0,39	+5,9
x̄w		3,07	0,32	2,99	0,40	2,97	0,23	2,97	0,19			
Leukocytes 10^9/l												
	0	14,40	2,30	15,40	3,05	14,20	2,79	19,60	2,88	15,81	3,39	100,0
	24	14,60	2,30	19,00	5,24	15,00	4,15	17,60	3,91	16,48	4,17	+4,2
	16	14,60	3,36	17,40	4,51	16,80	2,64	16,60	2,41	16,38	3,22	+3,6
	8	14,20	1,92	16,20	1,30	15,30	2,81	16,80	5,40	15,62	3,14	−1,2
x̄w		14,45[a]	2,33	17,00[b]	3,78	15,33[a]	3,10	17,65[c]	3,72			
Leucogram % Basophils	0	5,80	2,59	3,40	1,52	3,80	0,98	3,40	1,14	4,10	1,81	100,0
	24	7,20	2,59	4,20	1,10	4,20	1,72	2,80	1,48	4,57	2,32	+3,8
	16	6,40	2,30	2,60	0,55	3,70	1,37	2,80	1,10	3,86	2,03	−5,9
	8	6,40	1,52	4,20	1,10	3,80	0,75	3,00	1,87	4,33	1,77	+5,6
x̄w		6,45[A]	2,16	3,60[B]	1,23	3,87[B]	1,19	3,00[B]	1,34			
Eosinophils	0	1,80	0,84	1,60	0,55	1,33	0,52	2,20	1,30	1,71	0,84	100,0
	24	1,40	0,55	1,60	0,89	1,33	1,03	1,60	0,55	1,48	1,23	−13,5
	16	1,60	0,55	1,40	0,55	1,67	0,52	2,00	0,71	1,67	0,58	−1,8
	8	2,60	0,89	1,40	0,55	1,33	0,82	1,60	0,55	1,71	0,84	0,0
x̄w		1,85	0,81	1,50	0,61	1,42	0,72	1,85	0,81			
Neutrophils	0	33,40	1,14	35,00	1,87	31,40	6,25	40,40	3,36	34,86	4,99	100,0
	24	36,60	4,72	30,00	3,81	29,30	2,94	39,80	5,02	33,71	5,93	−3,3
	16	30,80	7,26	36,40	6,80	33,80	2,93	38,20	5,63	34,76	6,01	−0,3
	8	28,80	2,17	30,60	2,88	29,50	4,68	44,80	3,96	33,24	7,45	−4,7
x̄w		32,40	5,10	33,00	4,82	31,00	4,52	40,80	4,89			
Monocytes	0	1,00	0,00	1,00	0,00	1,50	0,55	1,00	0,71	1,14	0,48	100,0
	24	1,20	1,10	1,20	0,45	1,20	0,41	1,20	0,45	1,19	0,60	+4,4
	16	1,00	0,71	1,20	0,45	1,50	0,55	1,00	1,00	1,19	0,68	+4,4
	8	1,40	0,55	1,60	0,89	1,40	1,15	1,20	0,45	1,38	0,59	+21,0
x̄w		1,15	0,67	1,25	0,55	1,38	0,53	1,10	0,64			
Limphocytes	0	58,00	2,92	59,00	2,24	62,00	5,25	53,00	4,06	58,19	4,92	100,0
	24	53,60	4,16	63,00	2,74	64,00	3,46	54,80	5,17	59,10	6,04	+1,5
	16	60,20	6,61	58,40	6,02	59,00	2,42	56,00	4,85	58,52	4,97	+0,5
	8	60,80	1,92	62,20	3,27	64,00	5,29	49,40	3,58	59,33	6,80	
x̄w		58,15[A]	4,88	60,65[A]	4,08	62,33[B]	4,45	53,30[C]				

Protein fractions in blood serum of geese (Exp. IV)
Protein u serumu krvi gusaka (Pokus IV)

Table 19 – Tablica 19

	Apo-ester suppl. Dodatak Apo-estera	Days of blood sampling – Dani uzimanja krvi 14.01		24.02		22.03		23.06		x̄w		
		x̄	±S	x̄	±S	x̄	±S	x̄	±S	x̄	±S	%
Total protein g/l	0	53,26	7,10	67,96	5,88	75,72	13,12	51,84	6,79	62,20	13,06	100,0
	24	61,96	10,18	72,06	8,05	75,44	4,36	45,76	5,33	63,80	13,62	+2,5
	16	55,14	6,22	72,80	6,11	74,90	10,53	59,98	10,17	65,71	11,60	+5,6
	8	60,76	8,92	74,10	12,28	72,43	6,35	60,54	6,51	66,96	10,40	+7,6
x̄w		57,78^{A}	8,46	71,73^{B}	8,13	74,62^{B}	8,62	54,53^{A}	9,27			
Albumins g/l	0	32,54	2,11	33,60	4,82	38,46	6,72	26,31	5,59	32,73^{a}	6,47	100,0
	24	35,74	3,23	36,66	3,36	38,57	2,18	22,17	2,88	33,29	7,19	+1,7
	16	33,02	1,97	39,76	4,70	37,90	5,47	29,45	4,96	35,03	5,850	+7,0
	8	36,16	2,45	40,94	5,36	36,87	3,03	29,98	3,44	35,99^{b}	5,28	+9,9
x̄w		34,37^{A}	2,81	37,74^{A}	5,15	37,95^{A}	4,38	26,98^{B}	5,14			
Globulins g/l	0	20,72	8,98	34,36	4,00	37,26	6,52	25,52	1,13	29,47	7,03	100,0
	24	26,16	7,44	35,40	5,50	36,86	2,13	23,58	2,42	30,50	7,40	+3,5
	16	22,12	5,88	33,04	2,64	37,01	5,08	30,59	5,45	30,69	7,19	+4,1
	8	24,60	10,51	33,16	7,86	35,56	3,34	39,76	3,27	31,02	7,64	+6,2
x̄w		23,40^{A}	7,93	33,93^{B}	4,94	36,67^{B}	4,26	27,61^{A}	4,52			
Gamma globulins g/l	0	7,56	1,39	10,24	0,81	13,08	2,41	10,52	1,50	10,35	2,51	100,0
	24	8,23	0,86	10,26	1,90	10,18	0,83	9,48	1,37	9,54	1,46	−3,9
	16	7,90	1,33	11,15	2,63	11,97	1,48	10,55	0,47	10,39	2,20	+0,4
	8	8,54	1,50	10,49	2,04	10,28	1,47	10,82	1,67	10,03	1,79	−3,1
x̄w		8,06^{A}	1,25	10,53^{B}	1,85	11,38^{B}	1,96	10,34^{B}	1,33			

A, B, C $P<0,01$
a, b $P<0,05$

Concentration and indicates of Fe and Cu administration (Exp. IV)
Koncentracija i parametri Fe i Cu (Pokus IV)

Table 20 – Tablica 20

	Apo-ester suppl. Dodatak Apo-estera	Days of blood sampling – Dani uzimanja krvi										
		14.01		24.02		22.03		23.06		x̄w		
		x̄	±S	x̄	±S	x̄	±S	x̄	±S	x̄	±S	%
Fe µmol/l	0	18,26	3,06	28,78	3,17	34,82	1,19	32,47	8,68	28,58	7,91	100,0
	24	19,06	3,49	27,12	0,81	29,93	4,50	26,26	6,47	25,59	5,72	−10,5
	16	17,48	3,88	27,32	2,49	31,94	2,98	34,60	6,09	27,84	7,43	−2,6
	8	20,79	3,27	27,52	5,61	28,25	2,01	31,93	3,10	27,12	5,36	−5,1
x̄		18,90^{A}	3,39	27,68^{B}	3,25	31,24^{C}	3,69	31,32^{C}	6,39			
TIBC µmol/l	0	41,92	6,71	56,19	13,20	62,79	3,07	54,60	14,06	53,88	12,27	100,0
	24	49,50	8,64	78,01	6,12	58,43	3,61	46,31	8,61	58,06	14,23	+7,7
	16	45,53	6,37	69,94	8,45	59,24	2,65	59,34	6,91	58,51	10,68	+8,6
	8	44,67	7,48	68,56	4,76	57,78	5,54	57,05	8,63	57,01	10,51	+5,8
x̄		45,40^{A}	7,30	68,17^{B}	11,36	59,56^{C}	3,62	54,32^{C}	10,91			
TIBC-Fe µmol/l	0	23,66	9,46	27,41	11,19	27,97	2,49	22,13	10,63	25,29	8,76	100,0
	24	30,43	10,34	50,30	6,03	28,49	3,52	20,05	6,58	32,32	13,09	+27,8
	16	28,05	5,09	42,62	8,09	27,30	3,73	24,74	6,43	30,68	9,08	+21,3
	8	23,87	7,86	41,04	10,77	29,53	4,00	25,12	6,67	29,85	7,04	+18,0
x̄		26,50^{A}	8,27	40,34^{B}	9,74	28,33^{A}	3,30	23,00^{A}	7,44			
$\frac{Fe}{TIBC} \times 100$	0	45,19	13,39	52,66	8,68	55,52	2,12	60,55	14,13	53,48	11,36	100,0
	24	39,77	10,62	34,86	1,72	51,14	5,99	57,10	11,34	45,72	11,88	−14,6
	16	38,38	7,10	39,43	4,88	53,97	5,22	58,31	7,67	47,52	10,71	−11,9
	8	47,68	10,59	39,93	6,42	49,03	4,25	56,52	5,95	48,29	8,95	−9,5
x̄		42,75^{A}	10,54	41,72^{A}	8,74	52,42^{B}	4,97	58,12^{B}	9,56			
Cu µmol/l	0	2,57	1,53	9,99	2,07	6,84	1,75	4,58	2,06	6,00	3,31	100,0
	24	2,48	1,14	10,90	2,77	3,00	0,87	4,47	2,00	5,21	3,85	−13,2
	16	2,28	0,57	10,50	1,83	5,10	0,87	4,03	0,91	5,48	3,32	−8,7
	8	3,31	1,53	10,90	3,20	5,58	1,60	5,02	1,26	6,20	3,46	+3,3
x̄		2,66^{A}	1,22	10,57^{B}	2,35	5,13^{C}	1,88	4,53^{C}	1,54			
Ceruloplasmine	0	17,77	6,19	39,99	9,94	40,70	6,30	27,42	6,61	31,47	11,90	100,0
	24	26,86	7,01	44,48	4,35	40,70	6,43	27,42	3,44	34,86	9,50	+10,8
	16	27,18	16,65	44,59	5,62	41,02	2,42	28,27	5,86	35,27	11,62	+12,1
	8	25,06	8,44	56,39	5,65	42,41	1,74	23,27	3,06	36,78	14,77	+16,9
x̄		24,22^{A}	10,35	46,36^{B}	8,78	41,20^{B}	4,41	26,60^{A}	4,99			

A, B, C $P<0,01$
a, b $P<0,05$

Aminotransferase activity, level of beta-carotene and vit. A in blood serum (Exp. IV)
Aktivnost aminotransferase, razina β-karotina i vitamina A u serumu krvi (Pokus IV)

Table 21 – Tablica 21

	Apo-ester suppl. Dodatak Apo-estera	Days of blood sampling – Dani uzimanja krvi 14.01		24.02		22.03		23.06		x̄w		
		x̄	±S	x̄	±S	x̄	±S	x̄	±S	x̄	±S	%
Creatinocinase I.U.	0	22,08	13,03	35,56	5,71	34,78	10,20	33,73	2,28	31,54	9,87	100,0
	24	24,58	11,61	40,23	11,22	36,95	5,10	27,89	2,82	32,41	10,25	+2,7
	16	31,80	12,76	47,91	21,40	36,52	9,52	31,56	2,63	36,95	14,06	+17,1
	8	35,82	8,08	48,41	18,72	36,08	7,47	28,39	4,13	37,18	12,54	+18,9
	x	28,57^{A}	12,00	43,03^{B}	15,30	36,08^{b}	7,67	30,39^{A}	3,70			
AlAT I.U.	0	16,03	1,60	17,70	1,62	15,86	1,96	15,65	6,59	16,31	3,43	100,0
	24	15,86	1,68	20,04	1,32	16,86	1,12	18,26	5,88	17,76	3,33	+8,9
	16	16,36	0,95	16,53	1,10	15,70	2,61	14,78	5,64	15,84	3,01	−2,9
	8	16,03	1,82	16,62	1,52	16,70	3,18	16,52	6,45	16,47	3,48	+1,0
	x̄	16,07	1,43	17,72	1,94	16,28	2,21	16,30	5,80			
AspAT I.U.	0	53,77	4,48	60,12	7,09	50,60	2,87	11,19	2,09	43,92	20,14	100,0
	24	54,61	3,99	75,15	14,75	52,60	2,88	9,35	1,24	47,93	25,60	+9,1
	16	54,78	4,33	65,46	3,99	50,41	2,30	12,02	1,12	45,67	20,92	+4,0
	8	56,28	5,07	62,79	6,10	52,10	3,64	10,68	2,79	45,46	21,31	+3,5
	x̄	54,86^{A}	4,21	65,88^{B}	10,07	51,43^{A}	2,88	10,81^{C}	3,09			
β-carotene mmol/l	0	1,10	0,50	0,98	0,84	0,36	0,11	0,33	0,19	0,69	0,59	100,0
	24	1,07	0,59	8,72	3,79	1,41	0,66	1,10	1,11	3,08	3,83	446,3
	16	1,07	0,29	6,15	1,75	0,80	0,42	0,74	0,40	2,19	2,50	317,4
	8	1,15	0,37	3,99	1,00	0,78	0,44	0,57	0,38	1,62	11,53	234,8
	x̄	1,10^{A}	0,42	4,96^{B}	3,54	0,84^{A}	0,57	0,68^{A}	0,65			
Retinol umol/l	0	2,94	0,67	4,09	0,79	3,16	0,53	2,57	0,43	3,19	0,81	100,0
	24	2,96	0,66	2,86	0,66	2,88	0,63	2,13	0,87	2,70	0,74	−13,9
	16	2,92	0,60	2,94	0,49	3,72	1,35	3,26	1,33	3,21	1,00	+0,6
	8	2,92	0,47	2,87	0,35	3,88	1,52	3,14	0,62	3,20	0,90	+0,3
	x̄	2,94	0,56	3,19	0,76	3,41	1,09	2,77	0,93			

A, B, C $P<0,01$
a, b $P<0,05$

Feed composition (Exp. V)
Sastav hrane (Pokus V)

Table 22 – Tablica 22

Ingredients Krmiva	%	
Grains mixture – mješavina žitarica		39,48
KB-2 mixture		37,00
Soybean meal – sojina sačma		8,00
Grass meal – trava		10,00
Mineral mixture MMD – mješavina minerala		3,20
Limestone – vapnenac		1,40
Salt – sol		0,40
Polfasol AD_3E		0,02
Premix Z		0,05
Metabolizable energy	Kcal/kg	2410
	MJ	10,08
Crude proteini – s. proteini	%	13,82
Crude fibre – s. vlakna	%	6,67
Lysine	%	0,69
Methionine + Cystine	%	0,54
Ca	%	2,70
P-inorganic	%	0,80
Vitamin A	I.U./kg	20.000

The basic indicates of geese performance
Osnovni pokazatelji

Table 23 – Tablica 23

Parameters Svojstva		Trial groups – Grupe			
		Vit. A 20000	Ethyl-ester +8 ppm	+16 ppm	+24 ppm
		I	II	III	IV
Number of geese – broj gusaka		336	325	333	332
Number of gander – broj gusana		98	94	96	95
Mortality and – mortalitet i		8	7	8	4
elimination – izlučenje	%	1,84	1,67	1,86	0,93
Average laying rate	%	40,70	42,68	40,39	40,28
% nesivosti	%%	100	+4,9	−0,8	−0,99
Number of eggs – broj jaja		63,41	65,72	62,40	62,03
per layer – po nesilici		100,0	+3,6	−1,6	−2,2
Results of hatchability: Rezultati valjenja					
Number of settings eggs broj sakupljenih jaja		21089	21443	20342	20415
Fertiled eggs oplođena jaja	%	97,5	98,0	98,3	98,0
Share of dead embryos 1st and 2nd candling Uginuli embriji 1. i 2. osvjetljavanje	%	4,76	3,69	4,44	4,61
Unhatched eggs neoplođena jaja	%	11,47	8,44	9,40	10,41
Hatchability of izvaljeno od					
– settings eggs – od snešenih jaja	%	80,27	84,55	83,37	81,98
– fertiled eggs	%	82,31	86,25	84,84	83,60
– od oplođenih jaja	%%	100,0	+4,8	+3,1	+1,6
Number of healthy goslings per layer	%	50,47	56,01	51,40	50,41
Broj zdravih gušćića po nesilici		100,0	+10,9	+1,8	−0,1

The comparison of results in all experiments„
Usporedba rezultata svih pokusa

Table 24 – Tablica 24

Exp. Pokus	Vitamin A I.U./kg of feed	Dodatak ethyl-ester supplementation ppm	Number of goslings per layer broj guščića po nesilici	In comparison to the control group (in %) u usporedbi s kontrolnom grupom
I	10.000	24,0	45,05	+6,0
II	10.000	24,0	46,03	−3,6
	–	24,0	49,50	+3,1
III	10.000	24,0	43,0	+3,1
IV	10.000	24,0	49,30	+17,7
V	20.000	24,0	50,40	−0,1
	20.000	8,0	56,01	+10,9

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SUMMARY

The results of experiments indicate positive effect of combined application of 10.000 I.U. vitamin A with 24 mg ethyl-ester per 1 kg of feed (on air dry matter basis) on egg production which resulted in 2,5-5,5 goslings more from layer as compared with birds given 10.000 I.U. vit. A/kg only. The dose of 16 ppm ethyl-ester + 10.000 I.U. vit. A enhanced productive results by 6,7% (2,8 goslings from geese) while the addition of 8 ppm appeared to be ineffective.

In the field trial good productive result – 50,5 goslings from layer, was noted in the control group fed concentrate mixture contained 20.000 I.U. of vit. A/kg. In these treatment addition of 8 ppm ethyl-ester increased results by further 10,9% i.e. by 5,5 from one geese and more stable run of laying period was observed. (Fig. 1).

The blood morphology indices varied during reproductive season and no effect of ethyl-ester addition was noted. Similarly, level of total protein and its fractions were not influenced by applied supplements and were related to the stage of laying period only.

The higher level of transferrins, better iron binding capacity by TIBC transferrins (by 18-22%), lower transferrin saturation with Fe indicated of higher resistance in geese given ethyl-ester. This is in agreement with findings of MAZURKIEWICZ et al. (1990) who found the increase of cell resistance in cocks fed concentrate mixtures with high level of vit. A supplemented by carotenoides. The important role of retinol in the immune system was earlier shown by DAVIS and SELL (1983).

No explanation can be given for linear relationship between β-caroten in the serum and amount of supplemented ethyl-ester.

In the available literature there is no evidence for conversion to β-caroten in geese, however its cumulation in the serum could be affected by ethyl-ester (GANGULY and SASTRY, 1985). No similar relation have been observed for retinol concentration in the serum. A high pro-vitamin activity (1:0,40-0,44 in re-count of molar activity) of ethyl-ester, similar to that of vit. A acetat, indicated results of WEISER et al. (1989), however these findings concerned rats – all phagig mammals. In herbivorous birds another activity of ethyl-ester C_{30} can be expected.