

## THE EFFECT OF RATIO OF METABOLISABLE ENERGY, LYSINE AND THREONINE IN THE DIETS ON PERFORMANCE OF SOWS DURING THE WHOLE GESTATION PERIOD

### UTJECAJ ODNOSA IZMEĐU METABOLIČKE ENERGIJE I LIZINA TE TREONINA U OBROCIMA NA PROIZVODNE POKAZATELJE KRMAČA TIJEKOM CJELOKUPNOG GRAVIDITETA

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#### SUMMARY

The effect of the use of rations lysine:metabolisable energy and threonine:metabolisable energy in the nutrition of gestating sows during the whole gestating period was investigated. Experimental (the second group in the experiment) sows were fed during the whole gestation period experimental diet. All lactating sows were fed the same diets and all suckling piglets were also fed creep feed during the lactation period. Research was carried out on 28 sows in two treatments (13 animals in the first, control group and 15 animals in the second, experimental group) included in the experiment, on Experimental pig farm in Institute for Animal Husbandry, Zemun, Serbia. Obtained results showed that in the control group, gestating diet with lysine:ME 0.51 g/MJ and threonine:ME 0.42 g/MJ, the sows were losing 16.37% of their weight during the lactating period. During the same period the sows consumed 3.85 kg/day of feed, 9.00 piglets/litter were weaned, average weighing 7.48 kg. Average mass of the whole litter in the control group was 67.36 kg at weaning, which means that average daily gain of piglets was 204 grams. The feed intake in creep feeding was 6.45 kg/litter. The experimental group of animals fed the gestating diet characterized with lysine:ME 0.55 g/MJ and threonine:ME 0.38 g/MJ. Sows in lactation were losing only 12.72% of their own body mass which was by 22.3% less compared to the control group of animals. Feed intake in the experimental group of sows in lactation was 4.21 kg/animal, which was by 9.35% higher compared to the control group. With realized 9.73 piglets per litter at weaning and average body mass of 7.74 kg/animal, the litter weight of the experimental group was 75.34 kg which was by 11.85% better compared to the control group of animals. Average daily gain of experimental group of piglets was 213 grams i.e. the improvement by 4.41% and piglets consumed 8.23 kg of creep feed, which was by 27.60% ( $P < 0.05$ ) more of feed compared to the first, control, group of piglets. Apparent coefficients of digestibility of dry and organic matter, protein and fiber showed that the level of utilization of all tested indicators was better in the experimental diet compared to the control group at the end of the study period, i.e. 110 days of gestation.

Economic analysis of feed costs showed that the feeding of gestating and lactating sows using the trial mixtures, as well as the creep feed, increased the cost by 0.89%. However, realized value of piglets at the end of lactation showed that the piglets of the control group realized by 11.85% lower value compared to the animals

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of the experimental group. In general, the obtained results show that by correcting lysine:ME and threonine:ME ratios for the whole period of gestation, the sows have better both production performance and apparent digestibility of nutrients and the price achieved for piglets.

Key words: ratio lysine:ME, threonine:ME, whole of gestating sows, suckling piglets

## INTRODUCTION

National Research Council<sup>s</sup>-NRC (1998) in nutrient recommendations for swine suggest a fixed amount of dietary amino acids for sows during gestation, which assumes a constant demand for amino acids throughout gestation. These recommendations are based on maintenance and growth data from the 1970<sup>s</sup> and 1980<sup>s</sup>. Since that time, considerable improvements have been made through genetic selection to indicate that the amino acid requirements for gestation are greater than current NRC recommendations. During last 45 days of gestation, fetal weight increases five-fold, fetal protein increases 18 fold and mammary protein content increases 27 fold, indication that the requirements for amino acids may be greater in late gestation compared with early gestation. The threonine was the most likely amino acid to reflect the change in the whole body amino acids requirements of sow in gestation. Daily demand for threonine may change to a greater extent from early to late gestation than the requirement for lysine. Our initial studies showed that by correcting lysine:ME and threonine:ME ratios for early gestation, the first third of the gestating sows (Živković et al., 2011) and the first two third of gestating sows (Živković et al., 2013), showed better production performance, digestibility of nutrients and the price of realized suckling piglets is achieved for lactating sows.

The objective of this paper was to evaluate the use of rations lysine:metabolisable energy and threonine:metabolisable energy in the nutrition of gestating sows during the whole gestating period.

## MATERIAL AND METHODS

Tests were performed on experimental pig farm of the Institute for Animal Husbandry, Belgrade-Zemun. The experiment included a total of 28 sows divided into two dietary treatments. Through the whole gestating period a sows were successively

introduced into the test, sows being housed in to group boxes up to 7 days before farrowing, and fed daily ration of 3.0 kg/head (Table 1). The first group was fed a mixture of standard composition with normal concentrations of lysine and threonine, 0.615 and 0.501, respectively. Sows in the experimental group received a meal with increased levels of lysine (0.735) and threonine (0.510) in the mixture. Ratio lysine:ME was + 7.8% and threonine:ME reduced 7.9% in the experimental group compared to the control mixture (Table 2). At 10 days before farrowing, sows were transferred to farrowing facility. Sows of the first, control, and the second, experimental, group were fed diets for lactating sows. During lactation sows of both groups were fed *ad libitum* with individual feeders. After farrowing, from the 10<sup>th</sup> day of age, the piglets were fed diets – pre-starter mixture of the same composition for both groups. Around 110<sup>th</sup> day of gestation, in the diets for pregnant sows, Cr<sub>2</sub>O<sub>3</sub> was included in the feed in order to examine and compare the diets using the indirect method for determining the digestibility of nutrients.

The criteria for evaluation of the results were the following indicators: body weight of sows before farrowing and weaning, feed intake in lactating sows, the number of born piglets, number of piglets weaned, the average weight of pigs at farrowing and weaning, average daily gain both of piglets and litters during lactation. Statistical analysis of growth data and digestibility coefficients was performed by classical methods of statistical analysis, analysis of variance, and the data on differences between the average values using the t-test.

## RESULTS

The experiment examined the possibility of using adequate or improved mixtures in regard to lysine and threonine in the diet for gestating sows during the whole period of gestation.

**Table 1 Scheme of the experiment**

**Tablica 1. Shema pokusa**

Group - Skupina	1 Control - Kontrola	2 Experimental - Pokus
Gestating sows, the whole gestation period – Gravidne krmače, cijeli period graviditeta		
Control mixture, kg/days/head – Kontrolna krmna smjesa, kg/dan/grlo	3.0	-
Experimental mixture, kg/days/head – Pokusna krmna smjesa, kg/dan/grlo	-	3.0
Lactating sows, during lactating period – Dojne krmače, tijekom perioda laktacije		
Control mixture, kg/days/head – Kontrolna krmna smjesa, kg/dan/grlo	Ad libitum	Ad libitum
Suckling piglets – creep feeding - Sisajuća prasad – puzajuća hranidba		
Control mixture, kg/days/head – Kontrolna krmna smjesa, kg/dan/grlo	Ad libitum	Ad libitum

**Table 2 Scheme of diets for sows during the whole period of gestation**

**Tablica 2. Pregled obroka krmača tijekom cijelog perioda graviditeta**

Group - Skupina	1 Control - Kontrola	2 Experimental - Pokus	%
ME, MJ/kg	12.04	13.13	+ 10.7
Lysine, total, %	0.615	0.735	+ 19.5
Threonine, total, %	0.501	0.510	+ 1.2
Lysine : ME	5.11	5.51	+ 7.8
Threonine : ME	4.16	3.83	- 7.9
Lysine : Threonine	100:81.5	100 :69.4	+ 14.8

**Table 3 Performance of sows in the experiment**

**Tablica 3. Proizvodni pokazatelji krmača u istraživanju**

Group - Skupina	1 Control* - Kontrola	2 Experimental - Pokus
Gestating sows, till 115 days – Gravidne krmače do 115. dana		
Control mixture, kg/day/head – Kontrolna krmna smjesa, kg/dan/grlo	3.0	-
Experimental mixture, kg/day/head – Pokusna krmna smjesa, kg/dan/grlo	-	3.0
Lactating sows - Dojne krmače		
Body mass of sows before farrowing, kg – Tjelesna masa krmača prije praseња, kg	268.2 <sup>a</sup>	240.3 <sup>b</sup>
Body mass of sows at weaning, kg – Tjelesna masa krmača kod odbića, kg	228.2	211.9
Losses of sows body mass, % - Gubici tjelesne mase krmača, %	16.37	12.72
Compared to the control group, % - Usporedba s kontrolnom skupinom, %	-	+ 22.3
Duration of lactation, days – Trajanje laktacije, dani	29.5	28.7
Feed intake, kg/head/days – Konzumacija hrane, kg/dan/grlo	3.85	4.21
Compared to the control group, % - Usporedba s kontrolnom skupinom, %	-	+ 9.35

\*The small letters in the row over the average values designate statistical significant difference on the level  $P < 0.05$

The results obtained (Table 3) showed that sows in the control group fed the normal farm mixture during lactation lost 16.37% of their own weight. Sows of the second, experimental, group, fed diet with the "narrower" threonine to ME ratio lost only 12.72%, which is less by 22.3% in comparison with the ratios achieved with the mixture of control diet. In terms of feed intake during lactation (Table 3) sows fed the control mixture with the normal ratio of threonine to ME resulted in average daily feed intake of 3.85 kg. Use of the corrected ratio of threonine and ME in the mixture during gestation led to increased feed intake, on average by 0.36 kg or 9.35% compared to the control mixture. Significantly ( $P < 0.05$ ) higher body weight of piglets at farrowing was recorded in the control group by about 5.64%. Body weight of piglets in the experimental group, at weaning, 0.26 kg or 3.46% expressed positive impact on gain of piglets during lactation. In terms of the number of

live born piglets in experimental group, with 11.47 animals born alive per litter, on average by 0.47 or 4.27% more than in the control group of sows. At the end of lactation, the use of the corrected ratio of threonine and ME in the second group with average body weight 7.74 kg led to improvement by 0.26 kg or 3.46% heavier than the litter of weaned piglets compared to the control group using the diet of usual composition (Table 4).

On the 110<sup>th</sup> day of gestation digestibility coefficients of studied indicators showed positive effects on all investigated parameters in sows of the experimental group (Table 5).

Economic analysis of the cost of the compared mixtures indicated the increased feed costs for gestating animals by 0.89%, for lactating sows difference was 10.83%, so consequently the experimental diet for sows and suckling piglets increased

**Table 4 Performance of suckling piglets in the experiment**

**Tablica 4. Proizvodni pokazatelji sisajuće prasadi u istraživanju**

Group - Skupina	1 Control* - Kontrola	2 Experimental - Pokus
Suckling piglets – Sisajuća prasad		
Number of farrowing piglets, head – Broj oprasene prasadi, grlo	11.00	11.47
Body weight of piglets at farrowing, kg – Tjelesna masa prasadi pri prasenju, kg	1.461 <sup>A</sup>	1.383 <sup>B</sup>
Number of piglets at weaning, head – Broj prasadi kod odbića, grlo	9.00	9.73
Compared to the control group, % -Usporedba s kontrolnom skupinom, %	-	+ 8.11
Body weight of piglets at weaning, kg – Tjelesna masa prasadi kod odbića, kg	7.484	7.743
Average daily gain, g – Prosječni dnevni prirast, g	204	213
Compared to the control group, % - Usporedba s kontrolnom skupinom, %	-	+ 4.41
Average litter weight at weaning, kg – Prosječna težina legla kod odbića, kg	67.36	75.34
Compared to the control group, % - Usporedba s kontrolnom skupinom, %	-	+ 11.85
Consumed of pre-starter, kg – Konzumacija predstartera, kg	6.45 <sup>b</sup>	8.23 <sup>a</sup>
Compared to the control group, % - Usporedba s kontrolnom skupinom, %	-	+ 27.60

\* The small letters in the row over the average values show statistical significant difference on the level  $P < 0.05$  and big ones on the level  $P < 0.01$ .

**Table 5 Digestibility of nutrients of gestating sows in the experiment, %**

**Tablica 5. Probavljivost hranjivih tvari kod gravidnih krmača u istraživanju, %**

Group - Skupina	1 Control - Kontrola	2 Experimental - Pokus
Gestating sows at 110 <sup>th</sup> days of gestation – Gravidne krmače 110. dana graviditeta		
Dry matter - Suha tvar	73.93	76.22
Organic matter – Organska tvar	76.72	77.63
Crude protein – Sirove bjelančevine	69.18	70.97
Crude fiber – Sirova vlakna	31.63	34.52

**Table 6 Economic analysis the cost of gain both sows and suckling piglets**

**Tablica 6 Ekonomska analiza troškova krmača i sisajuće prasadi**

Group - Skupina	1 Control - Kontrola	2 Experimental - Pokus
Gestating sows, whole gestation – Gravidne krmače, cjelokupni graviditet		
The cost of feed during whole gestation, % – Troškovi krmne smjese tijekom cjelokupnog graviditeta, %	100.00	100.89
Lactating sows – Dojne krmače		
The cost of feed during lactation, % - Troškovi krmne smjese tijekom laktacije, %	100.00	110.83
Suckling piglets – Sisajuća prasad		
Cost of feed, sow + suckling piglets, % - Troškovi krmne smjese, krmače + Prasad, %	100.00	134.09
RECAPITULATION - REKAPITULACIJA		
The value of realized piglets/litter, % - Vrijednost ostvarene prasadi/legla, %	100.00	104.32
Compared to the control group, % - Usporedba s kontrolnom skupinom, %	100.00	111.85

feed costs by 4.32% compared to the control diet mixture.

The value of piglets realized in the experimental group showed that by 11.85% better realization of piglets was achieved which justifies the experimental diet for gestating sows in the whole gestation period (table 6).

## DISCUSSION

A group from Germany has recently published new recommendations for swine nutrition (GfE,

2008). These recommendations suggest that amino acid requirements in late gestation are greater than in early gestation. They propose a change of diet on day 85 of gestation to accommodate the greater amino acid requirements caused by fetal growth. For example GfE (2008) suggest standardized ileal digestible lysine intake of 9.4 g/d for day 1 to 85 of gestation and 14.6 g/d for day 85 to 115. The corresponding calculated values for threonine, based on estimated amino acid ratios for sow maintenance and body protein growth are 6.6 g/d and 9.6 g/d. These recommendations should be treated with caution until they are confirmed by experimental

data. There is a great deal more to be learned about energy and amino acid requirements during different phases of gestation and lactation. As this information becomes available, it is expected to further reduce the cost of sow feeding while maintaining increasing sow productivity and longevity (Moehn at al., 2009). The above information isto develop a revised feeding program for gestating sows:

- Lower energy and lower protein intake for early gestation from day 1 to 84.
- Higher energy and higher protein diet for late gestation from day 85 to 115.

There is a potential to significantly reduce the cost of sow feeding, but current nutrient recommendations need improvement. Phase feeding, i.e. using separate diets early/mid gestation and late gestation, may save up to 5.00 \$ per sow per gestation. Using a single diet for gestation, but phase feeding at a higher level in late gestation, may save up to 3.00 \$ per sow per gestation. During late gestation and lactation, addition of free amino acids can reduce feed cost. These improvements may also increase sow productivity and longevity (Moehn at al., 2009). Current amino acid recommendations for sows are to provide a fixed amount of amino acid intake throughout gestation based on the assumption that there is a constant demand for amino acid; however, the demand for nutrients changes from maternal lean tissue in early gestation to fetal and mammary growth in late gestation. The objective of this study was to determine the threonine requirement in early (day 35 to 53 and 25 to 55 for Exp. 1 and 2, respectively) and late (day from 92 to 110 and 81 to 111) gestation using the indicator Amino Acids oxidation (IAAO) method as Amino Acid tracer. Sows were used; each sow received each of 6 diets in random order in both early and late gestation. A basic diet was formulated to contain Threonine at 60% of the 1998 NRC recommendation and 20% and 60% of the 1998 NRC for early and late gestation, respectively. Crystalline L-Threonine was added to create additional diets with approximately 10% of incremental increases in threonine. Sows were placed in respiration chambers, and expired air and blood were collected every 30 min for 5.5 h. Tracer Phenilalanine was given orally over the last 4 hours divided into eight 0.5 hours meals. Expired air and plasma were measured for  $^{13}\text{CO}_2$  enrichment and free threonine concentration, respectively. Data

were analyzed using a 2-phase nonlinear mixed model. The overall litter size and litter weight were 13.5 (3.1 and 20.5 kg), respectively. Based on IAAO, the threonine requirement in early gestation was 6.1 g/d. In late gestation, the threonine requirement based on IAAO was 13.6 g/d and 12.3 g/d). Based on plasma threonine, the threonine requirement in early gestation was 7.0 g/d and 3.9 g/d. In late gestation, the threonine requirement based on plasma was 10.5 g/d. There was a linear response to increasing threonine intake in late gestation in Exp. 1. Feeding a single amount of amino acids throughout gestation results in overfeeding amino acids in early gestation and underfeeding amino acids in late gestation. The two-fold increase in threonine requirement in the last third of gestation suggests that phase feeding sows in gestation will more closely meet the demands for nutrients and that the requirement for essential amino acids in gestating sows should be re-evaluated in early and late gestation separately (Levesque et al., 2011). The researchers, Ewan at al. (1999) weighed the sows at breeding, pre-farrowing, within 24 hours after farrowing and on days 7, 14 and 21 during lactation and weaning, they also adjusted litter sizes to at least 10 pigs per litter within three days of farrowing. Individual pigs were weighed at birth and on days 7, 14 and 21 days of lactation and weaning. Bell (2011) state why it is necessary to pay attention to the energy, lysine and threonine needs in sows. The author notes that phase feeding regime of sows can save up to \$ 12 per sow per year and thus increase its productivity and uterine space is not associated with the embryonic mortality normally observed before day 30 but after day 30 it may be a factor in fetal death when large numbers of fetuses are present or when uterine space is limited (Webel and Dziuk, 1974). The quality of produced milk and piglet growth were investigated in three groups of lactating Large White sows fed three mixtures containing different levels of lysine, threonine and crude protein. Piglets were weighed immediately after delivery and then in weekly intervals. At the age of 21 days the litter weight was the highest in group B (67.96 kg;  $P < 0.05$ ), i.e. in the group with the highest dietary content of amino acids. An increased level of dietary amino acids became evident in milk at the first milk sampling (i.e. three days after delivery), when the lysine and threonine content in milk was significantly the highest in group B (lysine 11.96 g/16 g N; threo-

nine 6.72 g/16 g N;  $P < 0.05$ ). The level of amino acids in milk and the differences between groups diminished in the following samplings. The changes of crude protein in milk were similar (Bojčukova and Kratký, 2006). Beaulieu et al. (2008) mention that improved ileal digestibility of amino acids in gestating sows is probably due to restricted feed intake and Dourmad and Etienne (2002) indicate that the optimal standardized digestible threonine:lysine ratio appears to be about 1:0.71 for multiparous gestating sows. Lysine requirements at two stages of gestation were estimated in adult sows that had been fed either low or high lysine diets in the previous lactation period. Sows fed low lost more weight during lactation than sows fed high levels. Also, sows fed low level diet had more days of anestrus than sows fed high levels. There were no differences, however, in litter weight gain of sows fed low levels and high levels. Estimates of gestation lysine requirements for sows fed low level were 9.6 and 12.2 g/d for early gestation and late gestation, respectively. The plasma urea nitrogen technique did not accurately or precisely estimate the lysine requirement of the sows fed the high level diet in lactation (Sparks and Zimmerman, 2012).

### CONCLUSIONS

In general, the obtained results show that the use of experimental mixture for gestating sows, during whole of gestation, based on ratios lysine and threonine versus ME can be recommended in the nutrition of gestating sows. More research will be needed to establish threonine and lysine requirement for other essential amino acids separately for different phase of gestation.

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## SAŽETAK

Ispitivano je djelovanje primjene omjera lizin:metabolička energija i treonin:metabolička energija u prehrani krmača za trajanja graviditeta. Pokusne krmače (druga skupina u pokusu) hranjene su tijekom graviditeta pokusnim krmnim smjesama. Sve dojne krmače hranjene su istim krmnim smjesama, a sva sisajuća prasad je prihranjivana tijekom laktacije. Istraživanje je provedeno na ukupno 28 krmača u dva tretmana (13 životinja u prvoj kontrolnoj skupini i 15 životinja u drugoj pokusnoj skupini) na pokusnoj farmi svinja Institutu za stočarstvo u Zemunu, Srbija. Dobiveni rezultati pokazuju da su tijekom graviditeta u kontrolnoj hranidbi pri kojoj je omjer lizin:ME iznosio 0,51 g/MJ, a treonin:ME 0,42 g/MJ krmače gubile 16,37% na težini za vrijeme laktacije. U istom razdoblju krmače su konzumirale 3,85 kg krmne smjese/dan, a 9,00 praščića/leglo odbijeno je sa 7,48 kg prosječne tjelesne težine pri odbiću. Prosječna težina čitavog legla u kontrolnoj skupini iznosila je 67,36 kg kod odbića, što znači da je prosječan dnevni prirast praščića iznosio 204 g. Konzumacija krmne smjese je kod prihranjivanja iznosila 6,45 kg/leglo. Pokusna skupina krmača hranjena je tijekom graviditeta obrocima kod kojih je omjer lizin:ME iznosio 0,55 gr/MJ, a treonin:ME 0,38 g/MJ. Krmače su tijekom laktacije gubile samo 12,72% vlastite težine, što je 22,3% manje u usporedbi s kontrolnom skupinom krmača. Konzumacija krmne smjese u pokusnoj skupini krmača tijekom laktacije iznosio je 4,21 kg/životinja, što je 9,35% više u usporedbi s kontrolnom skupinom. S ostvarenih 9,73 praščića po leglu kod odbića, prosječne tjelesne težine 7,74 kg/životinja, težina legla u pokusnoj skupini bila je 75,34 kg, što je 11,85% bolje u usporedbi s kontrolnom skupinom životinja. Prosječan dnevni prirast pokusne skupine praščića iznosio je 213 g, što je poboljšanje od 4,41% a praščići su potrošili 8,23 kg kod prihrane, što je značajnih 27,60% ( $P < 0,05$ ) više hrane u usporedbi s kontrolnom skupinom praščića. Koeficijenti probavljivosti suhe i organske tvari, proteina i vlakana pokazali su da je razina iskorištenja svih testiranih pokazatelja bila bolja u pokusnoj krmnoj smjesi u usporedbi s kontrolnom skupinom na kraju ispitivanja, tj. 110 dana graviditeta. Ekonomska analiza troškova hrane pokazuje da je hranidba krmača u graviditetu i laktaciji pokusnom krmnom smjesom kao i prihranjivanje povećala troškove krmnih smjesa za 0,89%. Međutim, ostvarena vrijednost praščića na kraju laktacije pokazala je da su praščići kontrolne skupine ostvarili 11,85% niže vrijednosti u usporedbi sa životinjama u pokusnoj skupini. Općenito, dobiveni rezultati pokazuju da korekcijom omjera lizin:ME i treonin:ME za cijelo vrijeme graviditeta krmače ostvaruju bolje proizvodne pokazatelje i očito bolju probavljivost nutrijenata i ostvaruju bolju cijenu praščića.

Ključne riječi: omjer lizin: ME, treonin: ME, graviditet krmača, sisajuća prasad