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SERUM HORMONE CONCENTRATIONS AND PERFORMANCE OF SOWS FED ON DIETS CONTAINING PEAS

J. ANNA NIKOLIĆ*, B. ŽIVKOVIĆ**, JEVROSIMA BEGOVIĆ*, GORDANA KOSTIĆ*, JOVANKA KRSMANOVIĆ*, V. RESANOVIĆ* and M. FABJAN**

** INEP – Institute for the Application of Nuclear Energy,Banatska 31b, 11080 Zemun, Yugoslavia*
***Institute for Animal Husbandry, Autoput BG-ZG 16, 11081 Zemun, Yugoslavia*

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The effect of feeding peas at 21.4% (diet 2) and 30.9% (diet 3) of the ration in place of soyabean oilmeal and some of the maize (standard diet 1) was investigated in 15 crossbred sows divided into three groups. The isonitrogenous, isocaloric diets were offered throughout gestation and lactation and were consumed in very similar amounts.

Determination of serum hormone concentrations (triiodothyronine, thyroxine, cortisol, progesterone, insulin) as well as insulin-like growth factor-I (IGF-I) at mid and late gestation, several days after parturition and 1 day after weaning the litter indicated more intensive anabolism in the groups of sows fed peas than in the control group. Thus, alterations in the diet had little effect on thyroid and steroid hormone concentrations, whereas both preprandial insulin and IGF-I levels tended to be higher in the pea fed groups especially during lactation ($P<0.05$). The overall performance in terms of number of weaned piglets tended to be best in the group of sows fed on diet 2 which farrowed more piglets than those fed on diet 3, of greater body mass than those farrowed by the control group. Piglet losses were greatest in the control group.

As indicated by the performance and metabolic parameters examined, it seems that nutrient availability was progressively greater in the pea containing diets expressed as a slightly greater number and mass of weaned piglets in the group of sows fed on diet 2 and a somewhat greater increase in sow body mass over the whole reproductive cycle in those fed on diet 3. These tendencies were further manifested in the different peripheral serum hormone profiles found in the different groups. They need to be confirmed and elucidated in experiments with a larger number of animals.

Key words: hormones, sows, peas, performance

INTRODUCTION

Investigations on the possibility of including peas in diets for swine have shown that this feedstuff can successfully be used to replace part of the soyabean

oilmeal and maize usually present in standard mixtures for growing pigs at all stages after weaning (Živković, 1987; Živković et al., 1993; Gatel and Grosjean, 1990; Goodlad and Mathers, 1991). There is still much controversy in the scientific literature about the extent of digestion and utilisation of nutritive materials from different varieties of peas, reliable methods of measuring this and also the possible influence of both antinutritive factors in peas and the technical process of preparation on these parameters (Gdala et al., 1992; Huisman et al., 1992; Van Barneveld et al., 1994a, 1994b, 1994c). The effect of including peas in diets for gestating and lactating sows has received little attention (Skorkin, 1965; Gatel et al., 1988), particularly concerning possible changes in biochemical parameters such as peripheral serum hormone concentrations.

Therefore, the possiblity of replacing part of the conventional feedstuffs with peas in diets for sows was examined in the present investigation. A brief account of the production results has been given already (Živković et al., 1995), so this report primarily considers some possible metabolic effects associated with changes in the diet during gestation and lactation.

MATERIALS AND METHODS

Diets. The standard diet for pregnant sows was based on maize (73.7%) with supplements of wheat (5%), sunflower oilmeal (7%), minerals and vitamins (3.8%) and soyabean oilmeal (10.5%). The metabolisable energy and crude protein contents were 13.15 MJ/kg and 13.5% respectively. During lactation the protein level was increased to 15.4% by adding fishmeal (2%) instead of some of the maize. Diets 2 and 3 were formulated to be isocaloric and isonitrogenous with the standard ration. Namely, raw peas (Pisum sativum var. Junior) were included at 21.4 and 30.9% respectively in place of some maize and three-quarters or all of the soyabean oilmeal. Levels of the other ingredients were unchanged.

Animals and procedure. Blood samples were taken from 15 crossbred sows (Swedish Landrace x Yorkshire) in the morning (about 8^{00}) at about 50 and 9 days before as well as 11 and 44 days after farrowing. The sows were group fed one of the three diets (2.6 kg per sow) until about 10 days before the expected day of parturition and then individually fed (*ad libitum* during lactation) until the litter was weaned at about 43 days after farrowing. Blood samples were taken from the jugular vein before the morning feed, allowed to clot and the serum separated by centrifugation. The hormones triiodothyronine (T3), thyroxine (T4), cortisol, progesterone and insulin, as well as insulin-like growth factor-I (IGF-I), were determined as described earlier (Nikolić et al., 1994).

Statistical analysis. The results were subjected to analysis of variance (ANOVA) in a split plot design for the factors, diet and time, using the MSTATC computer programme. The statistical significance of differences between means was assessed by calculation of the least significant difference (LSD). One outlying result each for T3, insulin and progesterone was not included in the analysis (n= 60). Missing values were calculated and the degrees of freedom for error adjusted accordingly.

RESULTS

Triiodothyronine. Serum concentrations of T3 were much lower or slightly lower than those recorded by other authors (Đurđević et al., 1992; Farmer et al. 1994; Schams et al. 1994) with large variations between animals (Figure 1a). Nine days after farrowing mean values were higher in the groups of sows fed peas than in those fed the standard diet but no differences associated with diet were detected at the other time intervals examined. Mean serum concentrations tended to be higher in midpregnancy than later on. Thus, the values found in early lactation (control group) and at weaning (diet 3) were significantly lower than those in midpregnancy respectively ($P < 0.05$). One extreme value (12 nmol/L) was excluded.

Thyroxine. No statistically significant effects of diet on serum T4 concentrations were detected (Figure 1b). The mean values decreased significantly in each group from midpregnancy to late pregnancy and then recovered somewhat during lactation. Serum T4 concentrations were higher than those of Farmer et al. (1994) but were similar to those of Schams et al. (1994) and confirmed the fall during gestation reported by Đurđević et al. (1992). In our control group of sows mean T4 concentration was still markedly lower at weaning of the litter (< 40 nmol/L) than in midgestation, whereas the recovery was faster in the groups of sows fed the pea containing diets (Figure 1).

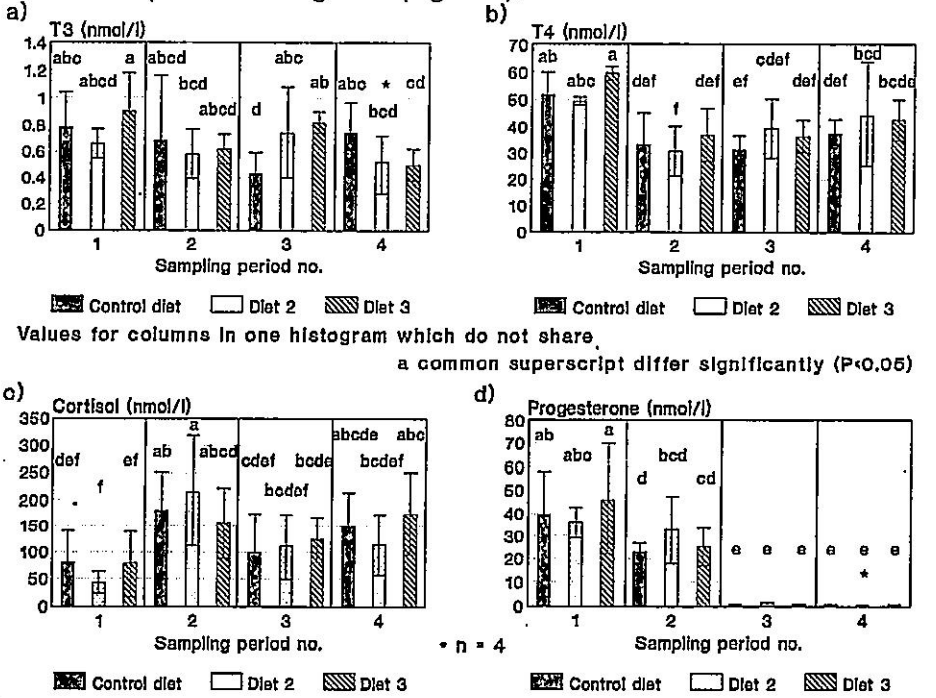

Figure 1. Peripheral serum concentrations of a) T3; b) T4; c) cortisol and d) progesterone at 51 (1) and 9 (2) days before as well as 11 (3) and 44 (4) days after farrowing in sows fed on three different diets. Diets 2 and 3 contained peas in place of some maize and soyabean oilmeal ($\bar{X} \pm SD$; $n = 5$).

Cortisol. Feeding peas appeared to have no significant influence on serum cortisol concentrations, which exhibited marked differences between animals. Despite the fact that some sows had consistently low concentrations, some consistently high concentrations and some variable concentrations, a highly significant effect of sampling interval on cortisol level was found (Figure 1c). Namely, in contrast to T4, cortisol concentrations were lowest in midgestation (about 60 nmol/L) and highest just before farrowing (about 180 nmol/L), the increase being statistically significant for each group of sows. Costa and Varley (1995) found somewhat lower mean levels in early pregnancy but the values reported by Molokwu and Wagner (1973) 7 days *pre partum* were exactly confirmed by our results. Mean values fell to about 110 nmol/L in early lactation (Figure 1c) followed by a tendency to increase 1 day after weaning probably as result of stress.

Progesterone. Serum progesterone concentrations fell significantly from mid to late pregnancy except in group 2 and then drastically after parturition in all groups (Figure 1d). This confirms the findings of other authors (Costa and Varley, 1995; Molukwu and Wagner, 1973; de Passillé et al., 1993). An increased value (27.0 nmol/L) encountered in one sow from group 2 at weaning indicated a lactational oestrus. This value was excluded from the statistical analysis. Nevertheless, there appeared to be no influence of diet on serum progesterone concentrations.

Insulin. Preprandial serum insulin concentrations were low during pregnancy and tended to increase during lactation (Figure 2a). The increase was statistically significant only for the sows in group 3, which tended to have higher insulin concentrations than those in the other groups. One extreme value (97 mIU/L) found in one sow from group 2 in early lactation was excluded from the analysis. If one discounts inadvertent access to feed, imminent suckling may have been the cause. Thus, increases in insulin concentrations associated with the proximity of the piglets as well as marked differences between animals in early lactation have been described by others (Uvnäs-Moberg et al. 1984; de Passillé et al., 1993; Schams et al., 1994).

IGF – I. Serum concentrations of total IGF-I were low during gestation but markedly increased in early lactation ($P < 0.05$). The increase was greater in the sows fed on diet 3 than in those fed on the standard ration, leading to a statistically significant difference between the control group and group 3 in early lactation (Figure 2b) which persisted right through to the day after weaning. Namely, the mean serum IGF-I level in group 3 was still greater than the values during gestation 1 day after removal of the piglets at 44 days *post partum*. In general, our results confirmed those of other authors who found values of 40 – 50 mg/L in cycling sows (Claus et al., 1992), 70 – 80 mg/L in mid gestation (Lee et al., 1993) and late gestation (Farmer et al., 1994) and higher values in early lactation (Donovan et al., 1994; Schams et al., 1994). The fall from mid to late gestation observed by Lee et al. (1993) was not found here.

Body mass. The mean body mass of the sows at mating (Figure 2c) was somewhat greater in the control group than in group 2 but no significant differences between the groups were observed immediately before farrowing and when

the piglets were weaned. All except two sows (one each from the control group and group 2) exhibited gains in body mass between mating and weaning their litters. The greatest overall production (increase in body mass plus total mass of the litter at weaning) was found in group 3 (Figure 2c), although group 2 provided the greatest number and mass of weaned piglets. The body mass of the sows was somewhat greater than those of Costa and Varley (1995).

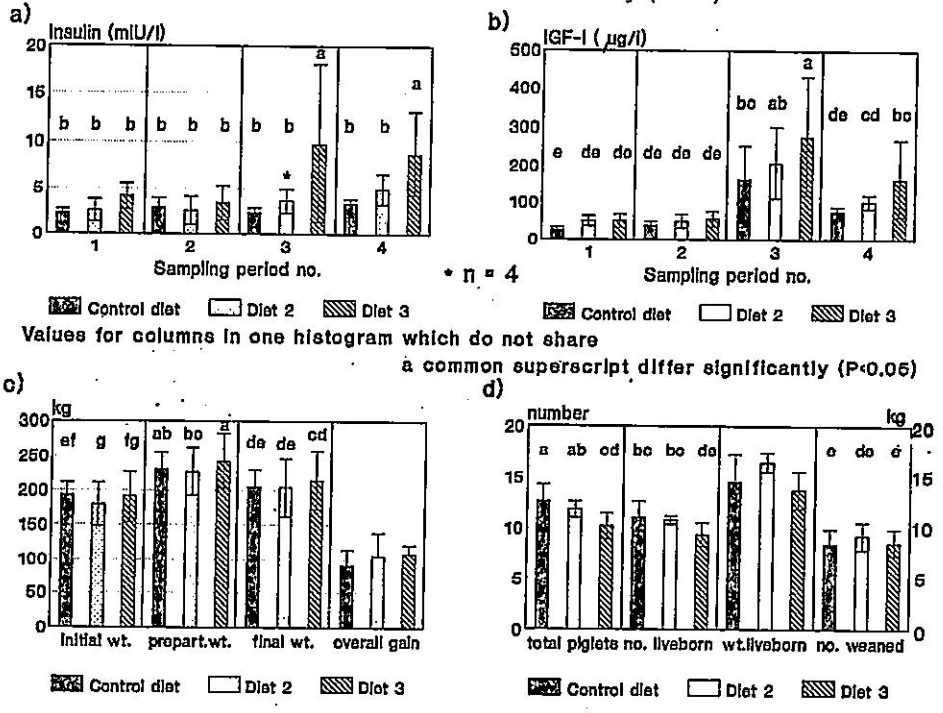

Figure 2. Peripheral serum concentrations in sows of a) insulin and b) IGF-I at 51 (1) and 9 (2) days before as well as 11 (3) and 44 (4) days after farrowing; c) body mass of the sows and overall production (litter mass at weaning + gain in body mass) and d) total number and number of liveborn piglets, their mass and the number weaned (X ± SD; n = 5). The sows (n = 15) were fed on three different diets. Diets 2 and 3 contained peas instead of soyabean oilmeal and some of the maize.

Litter size. Statistically significant differences were encountered between the control group and group 3 concerning both the total number of piglets farrowed and the number of piglets born alive (Figure 2d). Moreover, since the mean body mass of the liveborn piglets was somewhat lower in the control group than in the group fed on the diets containing peas, the total mass of the liveborn litter was greatest in group 2 (Figure 2d), although the difference was not statistically significant. Nevertheless, the lower mean birth mass in the control group may have been a contributory factor in piglet losses, because the mean number of weaned piglets was very similar for the control group and group 3 despite the difference in number of farrowed piglets.

DISCUSSION

The desired endproduct in swine reproduction is a large healthy litter of weaned piglets and a sow a favourable state to enter a new reproductive cycle. The results obtained here show that peas can be successfully used partially to replace feedstuffs such as soyabean oilmeal and maize in diets for sows, both during gestation and lactation. The best production results in terms of number and body mass of weaned piglets were obtained with diet 2 in which 75% of the soyabean oilmeal and 19% of the maize were replaced with raw peas. However, the number of sows in the groups was small and their heterogeneity in age and body mass led to large individual differences concerning most of the parameters studied. The experiment is being repeated with the same animals to determine whether the differences found between the groups were caused by the difference between the diets or due to a constitutional difference in the reproductive capacity of individual sows or even to a chance phenomenon found in a single experiment.

Nevertheless, the differences occurring in production were associated with differences in serum concentrations of the anabolic substances insulin and IGF-I. Namely, the group of sows which farrowed the smallest number of piglets had the highest final body mass and exhibited higher preprandial serum insulin concentrations and IGF-I during lactation than the other groups. It is well known that insulin directs excess units of energy towards body fat stores. On the other hand IGF-I levels tend to reflect protein anabolism i. e. direction of nutrients towards muscle, bone and eventually milk. Thus,poor growth in pea fed rats was associated with low serum levels of IGF-I and a low rate of bone protein synthesis (Martinez et al., 1993). In our experiment mean IGF-I concentrations tended to be higher in the groups of animals which showed a greater anabolic response as expressed by overall gain (litter weight at weaning plus increase in body mass).

Higher values for both insulin and IGF-I in these sows suggests better availability of both protein and energy yielding nutrients in these diets. The availability of protein from white-flowered pea varieties in pig nutrition was slightly better than that of a soyabean meal/barley based control diet (Abrahamsson et al., 1993) and was related to the amount of neutral detergent fibre present in the variety tested (Gdala et al., 1992). Huisman et al. (1992) showed that raw pea protein is almost completely enzymically digested in the small intestine of piglets. Heat treatment even at mild temperatures decreases the utilisation and availability of pea amino acids such as lysine (Van Barneveld et al., 1994b, 1994c). If this is true for soya, lysine availability might have played a role in influencing the parameters measured here, because the lysine content of the control diet was somewhat lower than that in diets 2 and 3 (Živković et al., 1995).

Concerning energy availability, ileal starch digestibility in pea containing diets was similar (92%) to that of barley and soyabean meal (Abrahamsson et al., 1993). In the rabbit ileal starch content dropped significantly in the order maize, peas, barley, maize starch (Gidenne and Perez, 1993), suggesting that pea starch is more extensively hydrolysed in the small intestine than maize. The residues entering the large intestine are metabolised by bacteria leading to volatile fatty acid rather that glucose production. If this was the case in our sows, it may provide

an explanation for the higher insulin concentrations found in the sows fed peas, which were included in the diets in place of both maize and soyabean oilmeal. Most studies on starch digestibility in peas have been made on cooked seeds (e. g. Würsch et al., 1986), whereas it seems that the critical factor for rapid digestion in the small intestine by α-amylase appears to be fine grinding i. e. rupture of the cells allowing immediate peptidic digestion of the protein between the starch granules inside the cells. Heating, especially of whole seeds, leads to partial swelling within the cells and possible extended retrogradation (insolubilization) of amylose. Thus, heat treatment of peas at increasing temperatures from 110^0 to 165^0 C linearly depressed diet energy digestibility in pigs (Van Barneveld et al., 1994a). Moreover, Goodlad and Mathers (1991) found that the digestibility of non-starch polysaccharides of raw peas in pigs was considerably greater than that of wheat. In this experiment overall feed consumption per sow was slightly lower for diet 2 (528.5 kg) and diet 3 (526.6 kg) than for the control diet (540.9 kg) indicating better utilization (Živković et al., 1995).

At the present time no explanation can be offered for the difference in total number of farrowed piglets between the groups of sows fed 21% (diet 2) and 31% (diet 3) peas in the ration. However, concerning piglet losses, low milk production immediately after parturition has been suggested as the most common cause of piglet deaths during the first few days. Higher concentrations of progesterone and lower concentrations of preprandial insulin in sows with large litters immediately *pre partum*, accompanied by a delayed rate of fall in progesterone levels during the first 48 h *post partum* were associated with poor piglet performance, possibly due to delayed lactogenesis (de Passillé et al., 1993). This may have been the reason for the greater losses occurring in the control group in this study and requires further investigation.

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KONCENTRACIJA HORMONA U SERUMU I PROIZVODNI REZULTATI KOD KRMAČA HRANJENIH OBROCIMA SA GRAŠKOM

J. ANNA NIKOLIĆ, B. ŽIVKOVIĆ, JEVROSIMA BEGOVIĆ, GORDANA KOSTIĆ, JOVANKA KRSMANOVIĆ, V. RESANOVIĆ i M. FABJAN

SADRŽAJ

Izvršen je ogled u kome su tri grupe od pet krmača hranjene obrocima u kojima je udeo graška, umesto dela kukuruzne prekrupe i sojine sačme (standardni obrok, grupa 1), bio 21.4% (obrok 2) i 30.9% (obrok 3). Obroci, koji su imali gotovo iste količine sirovih proteina i energije, davani su u toku cele gestacije i laktacije i bili podjednako konzumirani od strane životinja.

Koncentracije hormona (trijodotironin, tiroksin, kortizol, progesteron i insulin), kao i insulinu-sličnog faktora rasta-I (IGF-I) u perifernom serumu određene su u sredini i na kraju gestacije, nekoliko dana posle prašenja i 1 dan posle zalučenja prasadi. Dobijeni rezultati ukazali su na intenzivniji anabolizam u grupama krmača koje su dobile grašak, što je naročito bilo izraženo u toku laktacije ($P<0.05$). Proizvodni rezultati, uzeto kao broj zalučenih prasadi po krmači, pokazali su tendenciju da budu povoljniji u grupi krmača koja je dobila obrok 2. Naime, one su oprasile veći broj prasadi od krmača koje su dobijale obrok 3 i prasad su imala veću telesnu masu od onih oprašenih od strane krmača kontrolne grupe. Gubici živorođenih prasadi su bili najveći u kontrolnoj grupi.

Na osnovu rezultata performansa i metaboličkih pokazatelja, izgleda da je iskoristivost hranljivih materija obroka bila veća u obrocima koji su sadržali grašak, što je dokazano nešto većim brojem i telesnom masom zalučenih prasadi kod grupe krmača hranjenih obrokom 2 kao i većim prirastom sopstvenog tela u toku celokupnog ciklusa reprodukcije kod grupe krmača hranjenih obrokom 3, u poređenju sa kontrolnom grupom. Nađeni profili hormona u serumu tih životinja idu u prilog ove pretpostavke koju treba potvrditi i bolje objasniti detaljnijem istraživanjem na većem broju životinja.