Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)
Available online at www.inia.es/sjar

Spanish Journal of Agricultural Research 2007 5(4), 470-473
ISSN: 1695-971-X

Short communication. Low dietary sodium content affects the digestibility of nutrients and fattening performance in growing rabbits

S. Chamorro, M. S. Gómez-Conde, R. Carabaño and J. C. de Blas*

Departamento de Producción Animal. ETS Ingenieros Agrónomos. Universidad Politécnica. 28040 Madrid. Spain

Abstract

An experiment was conducted to study the effect of a reduction in dietary sodium content on performance and nutrient digestibility, in rabbits weaned at 25 days of age. Two diets with the same composition and only differing in the supply of sodium chloride content (0.5 or 0%) were used. A reduction on the dietary sodium content from 2.7 to 0.6 g kg^{-1} DM decreased the ileal and faecal apparent digestibility of dry matter, crude protein and the ileal apparent digestibility of every amino acid studied with the exception of the phenylalanine, and reduced daily weight gain, feed intake and feed efficiency. These results indicate that a reduction of the dietary sodium content up to 0.6 g kg^{-1} DM results excessive and insufficient to assure a correct absorption of nutrients and to maintain the growth performance in growing rabbit.

Additional key words: amino acids, faecal digestibility, feed intake, ileal digestibility, weight gain.

Resumen

Comunicación corta. Un bajo contenido de sodio en la dieta afecta a la digestibilidad de los nutrientes y a los rendimientos productivos de gazapos en cebo

Se realizó un experimento para estudiar el efecto de una reducción de sodio en la dieta de gazapos destetados a 25 días. Se utilizaron dos piensos con la misma composición y que sólo diferían en el contenido de cloruro sódico añadido (0,5 y 0%). La reducción del contenido en sodio de la dieta del 2,7 a 0,6 g kg^{-1} MS disminuyó la digestibilidad ileal y fecal aparente de la materia seca y la proteína bruta, y la digestibilidad ileal aparente de todos los aminoácidos estudiados con la excepción de la fenilalanina. También empeoró el consumo y la ganancia media diaria y la eficacia alimenticia. Estos resultados indican que una reducción de sodio de la dieta hasta 0,6 g kg^{-1} MS resulta excesiva e insuficiente para asegurar una correcta absorción de los nutrientes y para mantener los rendimientos productivos en gazapos de cebo.

Palabras clave adicionales: aminoácidos, consumo de pienso, digestibilidad fecal, digestibilidad ileal, ganancia de peso.

The relation between minerals and amino acid (AA) requirements and its influence on acid-base balance and growth performance, has been widely studied in poultry (Austic and Patience, 1988) and swine (Madubuike, 1980), whereas scarce information is available in rabbits. Dietary sodium content is essential for the absorption of luminal nutrients as glucose and amino acids, which are transported across the intestinal epithelial cell by several systems that require sodium as a co-transport (Schultz and Zalusky, 1965). The current recommendations of dietary sodium vary between 1.6 and 3.0 g kg^{-1} DM (Mateos and De Blas, 1998; Chamorro *et al*., 2007a), and are usually achieved with the addition of 5 g $kg^{-1}$of NaCl in the diet. Excess of sodium in the form of NaCl (above 10 g kg^{-1}) has been reported detrimental to growth (Harris *et al*., 1984).

The objective of the present work was to study the effect of a reduction in dietary sodium content from 2.7 to 0.6 g kg^{-1} DM in diets exceeding present recommendations in chloride and other minerals, on fattening performance and ileal and faecal apparent digestibility of nutrients.

A basal diet with a low sodium concentration (0.6 g kg^{-1} DM) and sufficient chloride content (2.7 g kg^{-1} DM) was formulated to meet nutrient recommendations

* Corresponding author: c.deblas@upm.es
Received: 28-05-07; Accepted: 15-10-07.

from De Blas and Mateos (1998). Its ingredients and chemical composition is shown in Table 1. Another diet was made by adding 0.5% of sodium chloride to the basal diet, to achieve a dietary sodium content (2.7 g kg^{-1} DM) and chloride content (5.7 g kg^{-1} DM) above the current recommendation, maintaining the supply of the rest of nutrients as well as the dietary electrolyte balance (calculated as Na + K ± Cl meq kg^{-1} DM) at similar levels. The diets were pelleted and included 5 g kg^{-1} of lucerne hay marked with an indigestible marker (ytterbium) according to the procedure described by García *et al.* (1999). Experimental trials were carried using 68 New Zealand White × California mixed-sex rabbits weaned at 25 days of age. Animals were housed in wire metabolism cages measuring 250 × 600 × 330 mm in a building with heating and forced ventilation system to maintain the temperature between 18 and 23°C, and received a cycle of 12 h of light and 12 h of dark throughout the experiment. Rabbits were handled according to the principles for the care of animals in experimentation published by the Spanish Royal Decree 1201/2005 (BOE, 2005). Another 28 rabbits weighing 484 ± 11 (SE) g at 25 days of age were blocked by litter and assigned at random to the experimental diets to determine the apparent ileal digestibility (14 per diet) of DM, crude protein (CP) and AA. Twenty of them were also used to determine the faecal apparent digestibility of DM, CP and energy from 32 to 35 days of age. The faeces were collected daily and stored at –20°C, dried at 80°C during 48 h, and ground at 1 mm to be analysed. At 35 days of age, all the animals were slaughtered by cervical dislocation between 19:00 and 21:00 h. The last 20 cm of the ileum were taken and the ileal contents were removed, frozen and freeze-dried. The samples were then ground and, because of the small quantity available, they were pooled in groups of two rabbits of the same treatment to analyse CP and ytterbium. To determine the AA content of the ileal digesta, a fixed amount (0.05 g) of all the samples belonging to each treatment were pooled. Ytterbium content of experimental diets and ileal digesta were analysed to calculate apparent ileal digestibility of CP and amino acid (CP_{id} and AA_{id}) according to the following equation:

$$CP_{id} = [1 - \text{dietary ytterbium concentration} \times \text{ileal CP concentration/ileal ytterbium concentration} \times \text{dietary CP concentration})] \times 100$$

$$AA_{id} = [1 - (\text{dietary ytterbium concentration} \times \text{ileal amino acid concentration/ileal ytterbium concentration} \times \text{dietary amino acid concentration})] \times 100$$

Table 1. Ingredients and chemical composition of the basal diet 0.6 Na (g kg^{-1})

Ingredients (g kg^{-1})		Chemical composition (g kg^{-1} DM)	
Wheat	300	Dry matter (DM)	912
Wheat bran	135	Ash	63.0
Sunflower meal	50	Crude protein[a]	176
Sunflower hulls	28	Starch	220
Soya bean protein concentrate	75	Neutral-detergent fibre (NDF)	363
Apple pulp	138	Acid-detergent fibre (ADF)	185
Beet pulp	112	Acid-detergent lignin (ADL)	55.7
Wheat straw	112	Gross energy (MJ kg^{-1} DM)	19.2
Lard	22	Digestible energy (MJ kg^{-1} DM)	13.6
L-Lysine HCl 78	4.7	Sodium	0.6
DL-Methionine 99	1.8	Chloride	2.6
L-Threonine	1.8	Potassium	9.11
Calcium carbonate	10	Calcium	12.1
Sodium chloride	0	Magnesium	2.27
Vitamin/mineral premix[b]	5	Phosphorus	4.13
Lucerne hay-Yb	5		

[a] Analysed amino acid content (g kg^{-1} DM): Arginine, 9.49; Cystine, 3.22; Histidine, 3.74; Isoleucine, 5.97; Leucine, 10.7; Lysine, 10.7; Methionine, 4.85; Phenylalanine, 7.29; Threonine 7.40; Valine, 7.15; Alanine, 6.67; Aspartic acid, 13.1; Glutamic acid, 32.4; Glycine, 7.18; Proline, 9.93; Serine, 6.69; Tyrosine, 4.71. [b] Provided by Trouw Nutrition España S.A. (Madrid, Spain): Mineral and vitamin composition (mg kg^{-1} of feed): Mg, 290; Na, 329; S, 275; Co, 0.7; Cu, 10; Fe, 76; Mn, 20; Zn, 59.2; I, 1.25; choline, 250; riboflavin, 2; niacin, 20; pyridoxine, 1; phytylmetaquinone, 1; alpha-tocopherol, 13; thiamine, 1; retinol, 2.5, and cholecalciferol, 0.019.

A finishing performance trial was carried using 40 rabbits (20 per diet), weaned at 25 days old and weighing 486 × 12 g. Animals were individually caged, blocked by litter and assigned at random to the experimental diets throughout a two-week period. After 39 days of age, all the animals received a commercial feed (CUNIUNIC®, NANTA, S.A.: 170 g CP, 5 g NaCl, 144 g starch, 373 g neutral detergent fibre and 49 g acid detergent lignin per kg) until they reached 56 days of age. Animals had *ad libitum* access to the feed and water throughout the whole experimental period. Feed intake, weight gain at day 14 after weaning and at the end of the experimental period were recorded.

Chemical analysis of diets and ileal digesta was performed using the procedures of AOAC (2000) for dry matter (930.15), ash (923.03), Dumas N (968.06) and starch (according to the alpha-amyloglucosidase method, 996.11). Neutral-detergent fibre, acid-detergent fibre and acid-detergent lignin were determined according to the sequential method of Van Soest *et al*. (1991). Gross energy (GE) was measured by adiabatic calorimetry. The minerals (Na, Cl, K, Ca and Mg) of the diets were determined by ion chromatography. Amino acids and Ytterbium content of diets and ileal digesta were analyzed as described by Chamorro *et al*. (2007b).

Data were analyzed as a completely randomized block design using type of diet as main effect and litter as block effect, by using the GLM procedure of Statistical Analysis Systems Institute (SAS, 1991). Weaning weight was used as a linear covariate in the growth traits analysed.

The effect of diets on the apparent ileal and faecal digestibility (AID and AFD, respectively) of nutrients is shown in Table 2. A reduction on the dietary sodium content from 2.7 to 0.6 g kg^{-1} DM decreased the AID of DM by 31% ($P < 0.001$), CP by 17% ($P < 0.01$), and that of every AA studied with the exception of the

Table 2. The effect of dietary treatments on the apparent ileal and faecal digestibility (%)

	Diets[a]		SEM[b]	P-value
	0.6Na	2.7Na		
Apparent ileal digestibility				
Dry matter	34.3	49.9	1.96	< 0.0001
Crude protein	52.7	63.5	2.20	0.009
Arginine	71.1	79.6	1.28	0.002
Cystine	42.2	57.8	2.61	0.003
Histidine	57.6	70.4	1.87	0.001
Isoleucine	58.4	69.9	1.87	0.003
Leucine	59.7	71.0	1.80	0.002
Lysine	70.7	77.6	1.36	0.008
Methionine	66.2	77.7	1.45	< 0.001
Phenylalanine	67.8	62.8	1.95	0.114
Threonine	52.5	63.5	2.20	0.009
Valine	53.2	68.0	2.04	< 0.001
Alanine	49.6	61.9	2.32	0.006
Aspartic acid	48.5	62.6	2.32	0.003
Glutamic acid	72.2	79.8	1.25	0.003
Glycine	16.3	44.3	3.61	< 0.001
Proline	64.3	74.2	1.60	0.003
Serine	51.4	64.2	2.21	0.004
Tyrosine	67.5	73.7	1.56	0.026
Apparent faecal digestibility				
Dry matter	70.4	72.9	1.0	0.077
Crude protein	82.2	84.5	0.8	0.042
Energy	71.1	73.4	0.9	0.097

[a] 0.6Na = dietary sodium content 0.6 g kg^{-1} DM; 2.7Na = dietary sodium content 2.7 g kg^{-1} DM. [b] Apparent ileal digestibility n = 7, Apparent faecal digestibility n = 10 per treatment.

Table 3. The effect of dietary treatments on finishing performance

	Diets[a]		SEM[b]	P-value
	0.6Na	2.7Na		
First 2 weeks after weaning period				
Weight gain (g d^{-1})	35.5	50.1	1.54	< 0.001
Feed intake (g d^{-1})	68.9	80.9	2.75	< 0.005
Food efficiency (g gain per g intake)	0.514	0.621	0.009	< 0.001
Whole finishing period (25-56 days)				
Weight gain (g d^{-1})	44.1	47.8	1.71	0.270
Feed intake (g d^{-1})	111	119	3.84	0.156
Feed efficiency (g gain per g intake)	0.400	0.399	0.009	0.897

[a] 0.6Na = dietary sodium content 0.6 g kg^{-1} DM; 2.7Na = dietary sodium content 2.7 g kg^{-1} DM. [b] n = 20 per treatment.

phenylalanine. Previous work (Chamorro *et al*., 2007a) reported a lower and less significant effect of a decrease of dietary sodium concentration from 2.6 to 1.6 g kg^{-1} DM on the AID of cystine, methionine, arginine, tyrosine and phenylalanine, whereas the AID of DM and CP and those of other amino acids remained unaltered. The requirements of sodium in the mucosal solution for the absorption of amino acids demonstrated in earlier *in vitro* studies (Schultz *et al*., 1966; Frizzeli *et al.,* 1973) might explain our results.

The lower ileal DM and CP digestibility in low sodium diets in the present study was partially compensated by a higher microbial caecal digestion. Accordingly, AFD of DM, CP and energy were closer than AID values between diets, although differences still reached a level of significance lower than 10%.

The effect of the dietary treatments on finishing performance is shown in Table 3. During the first two weeks after weaning, when rabbits received the experimental diets, a decrease of dietary sodium content from 2.6 to 0.6 g kg^{-1} reduced daily weight gain ($P < 0.001$), feed intake ($P < 0.005$) and feed efficiency ($P < 0.001$), by 30, 15 and 17% respectively.

The results of this study indicate that a reduction on the dietary sodium content up to 0.6 g kg^{-1} DM result excessive and insufficient to assure a high absorption of nutrients and to maintain the growth performance in growing rabbits.

References

AOAC, 2000. Official methods of analysis (17th ed). Association of Official Analytical Chemists, Washington, D.C.

AUSTIC R.E., PATIENCE J.F., 1988. Undetermined anion in poultry diets: Influence on acid-base balance, metabolism, and physiological performance. Crit Rev Poult Biol 1, 315-345.

BOE, 2005. Royal Decree 1201/2005. Sobre protección de los animales utilizados para experimentación y otros fines científicos. Boletín Oficial del Estado nº 252. pp. 34367-34391.

CHAMORRO S., GÓMEZ-CONDE M.S., CENTENO C., CARABAÑO R., DE BLAS J.C., 2007a. Effect of dietary sodium on digestibility of nutrients and fattening performance in weaned rabbits. World Rabbit Sci 15, 141-146.

CHAMORRO S., GÓMEZ-CONDE M.S., PÉREZ DE ROZAS A.M., BADIOLA I., CARABAÑO R., DE BLAS J.C., 2007b. Effect on digestion and performance of dietary protein content and of increased substitution of lucerne hay with soya-bean protein concentrate in starter diets for young rabbits. Animal 1(5), 651-659.

DE BLAS J.C., MATEOS G.G., 1998. Feed formulation. In: The nutrition of the rabbit (De Blas J.C., Wiseman J., eds). Commonwealth Agricultural Bureau, Wallingford, UK. pp. 241-253.

FRIZZELI R.A., NELLANS H.H., SCHULTZ S.G., 1973. Effects of sugars and amino acids on sodium and potassium -influx in rabbit -ileum. J Clin Invest 52, 215-217.

GARCÍA J., CARABAÑO R., DE BLAS J.C., 1999. Effect of fiber source on cell wall digestibility and rate of passage in rabbits. J Anim Sci 77, 898-905.

HARRIS D.J., CHEEKE P.R., PATTON N.M., 1984. Effect of feeding various levels of salt on growth performance, mortality and feed preferences of fryer rabbits. J Appl Rabbit Res 7, 117-120.

MADUBUIKE F.N., 1980. Nutritional interrelationships of minerals and basic amino acids in growing pigs. PhD thesis. Cornell University, Ithaca, NY, USA.

MATEOS G.G., DE BLAS J.C., 1998. Minerals, vitamins and additives. In: The nutrition of the rabbit (De Blas J.C., Wiseman J., eds). Commonwealth Agricultural Bureau, Wallingford, UK, pp 145-175.

SAS, 1991. SAS/STAT® User's guide (Release 6.03). SAS Institute Inc., Cary, NC, USA.

SCHULTZ S.G., ZALUSKY R., 1965. Interactions between active sodium transport and active amino-acid transport in isolated rabbit ileum. Nature 205, 292-294.

SCHULTZ S.G., FUISZ R.E., CURRAN P.F., 1966. Amino acid and sugar transport in rabbit ileum. J Gen Physiol 49, 849-866.

VAN SOEST J.P., ROBERTSON J.B., LEWIS B.A., 1991. Methods for dietary fiber, neutral detergent fiber and non starch polysaccharides in relation to animal nutrition. J Dairy Sci 74, 3583-3597.