REPLACEMENT OF STARCH BY PECTIN AND CHICORY INULIN IN THE STARTER DIET OF EARLY-WEANED RABBITS: EFFECT ON GROWTH, HEALTH STATUS, CAECAL TRAITS AND VISCOSITY OF THE SMALL INTESTINAL CONTENT

VOLEK Z.[1], SKŘIVANOVÁ V.[1],MAROUNEK M.[1,2], ZITA L.[3]

[1]Research Institute of Animal Production, CZ-104 01 Prague 10, Czech Republic.
[2]Institute of Animal Physiology and Genetics, Czech Academy of Sciences, CZ-142 20 Prague 4, Czech Republic.
[3]Czech University of Agriculture in Prague, CZ-165 21 Prague 6, Czech Republic.
volek.zdenek@vuzv.cz

ABSTRACT

The aim of this study was to evaluate the effect of a higher level of dietary pectin or dietary pectin and inulin (Frutafit® IQ), as a partial replacement of starch, in the starter diet of early-weaned rabbits on growth, health status, caecal traits and viscosity of the small intestinal content. A total of 180 (60/group) and 18 (6/group) early-weaned rabbits, 21 days old at the beginning of the experiment, were used for growth performance and intestinal traits evaluation, respectively. Three experimental diets were formulated: control diet, diet P (pectin) and diet PI (pectin+inulin). The control diet (19.0% ADF, 18.6% starch, 4.3% pectins) was fed to rabbits of the 1st group from weaning to slaughter (at the age of 77 days). Diets P (20.3% ADF, 12.5% starch, 9.0% pectins) and PI (20.0% ADF, 10.3% starch, 9.0% pectins + 4% inulin) were fed to rabbits of the respective group from weaning to 42 days of age, then rabbits received the control diet till slaughter. For the intestinal measurements, rabbits were slaughtered at the age of 42 days. Rabbits fed the control, P and PI diet gained on average 43.9, 44.6 and 45.0 g/d, respectively. Corresponding feed consumption per kg of gain was 3.84, 3.57 and 3.23 kg. For the whole fattening period (from 21 to 77 d), the lowest mortality was observed in rabbits fed the PI diet (25.0, 33.3 and 43.3 % in rabbits fed the PI, control and P diet, respectively, P=0.10). Total VFA concentration in the caecum of rabbits fed diet supplemented with inulin (PI diet) was significantly higher (P=0.02) and the pH significantly lower (P<0.001) than in the caecum of others rabbits. The viscosity of the small intestinal contents was higher in rabbits fed P and PI diet than in control rabbits (P=0.10). There were no significant differences in weights of digestive organs, except for the weight of stomach, which was the lowest in rabbits fed P diet (P<0.01).

Key words: rabbit, starter diet, starch, pectin, inulin.

INTRODUCTION

Early weaning around 21–25 days might improve the corporal condition of does and allow a specific nutrition of young rabbits around weaning time (PASCUAL, 2001; XICCATO *et al*., 2004). However, mainly from a health point of view, nutritional needs of the young

rabbit require to be more fully known. One of the main problems in formulating starter diets is to find suitable sources and levels of carbohydrates. Dietary starch is incompletely hydrolysed in the small intestine of the weanling rabbits (BLAS *et al*., 1994). As a consequence, the amount of starch reaching the caecum and mortality during the post-weaning period increase with increasing dietary starch concentration (BLAS and GIDENNE, 1998). GUTIÉRREZ *et al*. (2002) tested the replacement of starch by lactose. However, the results were not favourable because incorporation of lactose into diet for early weaned rabbits causes fall in digestibility and increases mortality.

Another way of replacing starch in the starter diet of early-weaned rabbits might be through a supply of dietary pectin and inulin. GIDENNE *et al*. (2002) reported a sharp increase of bacterial fibrolytic activity between 21 and 28 days of age. After weaning the fibrolytic activity did not change significantly. In addition, supplying high quantity of digestible fibre promoted a high fermentative activity already at weaning, which might be favourable for health. There is a remarkable capacity for degrading pectins and hemicelluloses attributable to the substantial establishment of this flora compared with the cellulolytic flora (GIDENNE and FORTUN-LAMOTHE 2002). Moreover, inulin might have also positive effects on health of rabbits (FLICKINGER *et al*., 2003).

Thus, the aim of this study was to evaluate the effect of a partial replacement of starch by dietary pectin or pectin and inulin in the diet of early weaned rabbits on growth, health status, caecal traits and viscosity of the small intestinal content.

MATERIAL AND METHODS

Animals, diets and recordings

A total of 180 early-weaned rabbits (Hyplus®), 21-days old at the beginning of experiment, were divided into three groups. Rabbits, born in a commercial rabbitry, were kept in all-wire cages, three per cage. Three experimental diets were formulated: control diet, diet P (pectin) and diet PI (pectin+chicory inulin) (Table 1). The diets were similar in the level of crude protein, NDF and ADF, but differed mainly in the level of starch, pectins and fructans. The control diet contained more starch and less pectins than other diets. In addition, PI diet was supplemented with 4% chicory inulin by means of Frutafit® IQ (SENSUS, 4704 RG Roosendaal, The Netherlands). Frutafit® IQ is the instantized version of powdered inulin. A higher pectin content was supplied through sugar beet pulp at the expense of wheat bran content. All diets contained salinomycin (22 mg/kg), but no antibiotics.

The control diet was fed to rabbits of the 1st group from weaning to slaughter (at 77 days). P and PI diets were fed to rabbits of the respective group from weaning to 42 days of age, and then rabbits received the control diet till slaughter. Diets and water were available *ad libitum*. Consumption of feed was measured weekly per group, thus the statistical evaluation of this traits was not possible. Animals were individually weighed every week. Mortality was recorded every day; morbidity was recorded two times a week. A rabbit was considered morbid only one time. Dead animals were only

considered in mortality rate. For growth performance traits evaluation, data only from healthy rabbits were used (initial number of rabbits at weaning minus morbidity and mortality) (Table 2). Dead rabbits were examined using standard pathological, bacteriological and parasitological methods in the State Veterinary Institute of Prague.

Table 1. Ingredients (%) and chemical composition (g/kg) of control diet, P diet (pectin) and PI diet (pectin+inulin)

	Control diet	P diet	PI diet
Ingredients (%)			
Alfalfa meal	28	28	28
Extracted sunflower meal	15	15	15
Extracted soya bean meal	3	5	5
Wheat bran	26	6	6
Sugar beet pulp	0	20	20
Oats	9	10	10
Barley	15	12	8
Inulin (Frutafit® IQ)	0	0	4
Molasses	1	1	1
Vitamin supplement[1]	1	1	1
Dicalcium phosphate	0.5	0.5	0.5
Limestone	1	1	1
Salt	0.5	0.5	0.5
Composition (g/kg)			
Organic matter	839	842	837
Crude protein	185	180	175
NDF	337	350	342
ADF	190	203	200
ADL	56	52	50
Hemicelluloses (NDF-ADF)	145	150	142
Cellulose (ADF-ADL)	134	151	150
Pectins[2] (water insoluble)	43	90	90
Fructans[2]	8	4	44
Starch	186	125	103
Ether extract	30	26	25
Digestible energy[2] (MJ/kg)	10.3	10.2	10.0

[1] Per kg supplement: vitamin A-1 200 000 IU; vitamin D_3-200 000 IU; vitamin E-5 g; Vitamin K_3-0.2 g; vitamin B_1-0.3 g; vitamin B_2-0.7 g; vitamin B_6-0.4 g; niacinamide-5 g; Ca-pantothenate-2 g; folic acid-0.17 g; biotin-20 mg; vitamin B_{12}-2 mg; choline-60 g; lysine-25 g; DL- methionine-100 g; salinomycin 2.25 g.
[2]Calculated values.

Intestinal traits

A total of 18 early-weaned rabbits (Hyplus®), 21 days old at the beginning of the experiment, were used for the intestinal measurements. Rabbits were assigned at random to the three experimental diets (control, P and PI diet). Both feed and water

were available *ad libitum*. Rabbits were slaughtered at the age of 42 days (on average 1,3 kg live weight). After slaughtering, stomach, small intestine, caecum and colon were isolated by tying off with a string to prevent movement of the digesta. Digesta organs were weighed and the small intestinal and caecal contents squeezed out.

Analytical methods and statistical analyses

Feed samples were air-dried at 105 ^{o}C to constant weight to estimate the dry matter concentration. Protein and fat concentrations were determined employing the Kjeltec Auto 1030 Analyser and Soxtec 1043 from Tecator AB (Sweden), respectively. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined according to the sequential procedure of VAN SOEST *et al*. (1991), using Fibertec 2010. Water insoluble pectins and digestible energy were calculated from tables of ingredients (MAERTENS *et al*., 2002), as well as fructans (KNUDSEN, 1997). Starch was measured polarimetrically (Ewers procedure). Volatile fatty acids (VFA) in the caecal contents were determined in diluted samples by titration, after steam distillation. Viscosity of the small intestinal contents was measured using Visco Tester VT6L (ThermoHaake, Karlruhe, Germany).

The statistical analysis of the data was performed by one-way analysis of variance by the GLM procedure of SAS (SAS Institute Inc., Cary, NC). Sheffe test was used for mean comparison where appropriate. Data on mortality and morbidity were analysed using the χ^2 test. The statistical significance was declared at $P<0.05$.

RESULTS AND DISCUSSION

In accordance with the objectives of the formulation, the three experimental diets were similar in their levels of NDF, ADF and CP (Table 1), but differed in the level of starch. Starch was partially replaced by dietary pectin or dietary pectin and chicory inulin in the P and PI diet, respectively.

There were no significant differences among groups in the performance traits (Table 2). Rabbits fed the control, P and PI diet gained on average 43.9, 44.6 and 45.0 g /d, respectively. Corresponding feed consumption per kg of gain was 3.84, 3.57 and 3.23 kg. Morbidity was not significantly affected by dietary treatments. For the whole fattening period, the lowest mortality ($P=0.10$) was observed in rabbits fed diet supplemented with inulin (PI diet). The average high mortality rate was due to mixed bacterial infection (mainly *Escherichia coli* and *Clostridium perfringens*). Most of the rabbits died between 30 and 42 days of age.

Similarly, GIDENNE and FORTUN-LAMOTHE (2001) reported that early-weaned rabbits (23 days) were more susceptible to a colibacillosis after weaning. After starter period (21 – 42 days of age), a slightly higher mortality and morbidity were observed in rabbits fed the P and PI diet, respectively, than in rabbits fed control diet. This might be caused by the change of diet. GUTIÉRREZ *et al*. (2002) observed increased incidence of mortality during the week following the change from the starter diet to the fattening feed.

Table 2. Performance traits and health status of rabbits

	Control diet	P diet	PI diet	R.M.S.E[1]	P-level
Rabbits, n	33	26	35		
Live weight (g)					
after weaning (21 d)	481	487	484	19.3	NS
before slaughter (77 d)	2942	2986	3006	306.4	NS
Weight gain (g/d)					
21 – 42 day of age	40.0	41.9	42.3	9.6	NS
43 – 77 day of age	46.3	46.2	46.6	6.7	NS
whole period	43.9	44.6	45.0	5.5	NS
Feed conversion (kg/kg)					
21 – 42 day of age	2.48	1.94	1.68	-	-
whole period	3.84	3.57	3.23	-	-
Mortality % (n)					
21 – 42 day of age	31.7 (19)	36.6 (22)	23.3 (14)	-	NS
whole period	33.3 (20)	43.3 (26)	25.0 (15)	-	0.10
Morbidity % (n)					
21 – 42 day of age	8.3 (5)	10.0 (6)	8.3 (5)	-	NS
whole period	11.6 (7)	13.3 (8)	16.6 (10)	-	NS

[1]Root mean square error NS, Not significant

There were no significant differences in the weights of digestive organs, except for the weight of stomach, which was the lowest in rabbits fed the diet P (P<0.01) (Table 3).

Table 3. Weight of digestive organs, total caecal concentrations of volatile fatty acids (VFA), pH, and intestinal viscosity of rabbits at 42 days of age

	Control diet	P diet	PI diet	R.M.S.E	P-level
Full organ weight (g)					
Stomach	73.8[a]	47.8[b]	71.2[a]	8.6	<0.01
Small intestine	65.8	83.6	62.0	14.6	0.08
Caecum	106.8	106.8	108.0	16.8	NS
Colon	83.9	87.8	76.0	13.5	NS
Small intestine					
Viscosity (mPa/s)	492	2240	1812	1118.2	0.10
Caecum					
Total VFA (mmol/l)	77.2[ab]	60.0[a]	93.4 [b]	16.2	0.02
pH	5.9[a]	6.2[a]	5.6[b]	0.2	<0.001

[ab]Values in the same row with unlike superscript differ significantly (P<0.05)
NS, Not significant

Concentrations of VFA in the caecal contents were significantly higher (P=0.02) and the pH significantly lower (P<0.001) in rabbits fed diet supplemented with inulin (PI diet) than in the others rabbits. Similarly, ZDUNCZYK *et al*. (2004) observed a significant drop of pH in the caecal digesta of rats fed diet supplemented with preparations of inulin and lactulose. The viscosity of the small intestinal content was higher in rabbits fed P and PI diet than in control rabbits (P=0.10). This may be the reason of increased mortality of rabbits fed the diet P, as in piglets weaned at 21 d of age the increase of viscosity of the intestinal contents encouraged proliferation of haemolytic *E. coli* in the small intestine and colonization of *Brachyspira pilosicoli* in the large intestine (HOPWOOD *et al*., 2002). Inulin addition seems to reduce this undesirable effect.

CONCLUSIONS

It can be concluded that *i*) growth of rabbits was not significantly affected by dietary treatments used in this study, *ii*) the partial replacement of starch by dietary pectin in the starter diet did not improve the health of rabbits, *iii*) diets with high pectin content raised viscosity of the small intestinal content, and *iv*) the addition of inulin positively affected some physiological variables of the caecum of rabbits and decreased mortality.

ACKNOWLEDGEMENT

This study received financial support from the Czech Science Foundation (project No. 523/03/D011).

REFERENCES

BLAS E., GIDENNE T. 1998. Digestion of starch and sugars. In: *The Nutrition of the Rabbit*. (Edit. De Blas, J.C., Wiseman, J.), CABI, Wallingford, pp.17-38.

BLAS E., CERVERA C., FERNANDEZ-CARMONA J. 1994. Effect of two diets with varied starch and fibre levels on the performance of 4-7 weeks old rabbits. *Wld Rabbit Sci*. **2** (4), 117-121.

FLICKINGER E. A., VAN LOO J., FAHEY G. C. 2003. Nutritional responses to the presence of inulin and oligofructose in the diets of domesticated animals. A review. *Crit. Rev. Food Sci. Nutr.* **43** (1): 19-60.

GIDENNE T., FORTUN-LAMOTHE L. (2001). Early weaning: effect on performance and health. *Proceedings of the second meeting of workgroups 3 and 4, COST Action 848, 29-30 June, Gödöllö, Hungary*, **44**.

GIDENNE, T., FORTUN-LAMOTHE, L. 2002. Feeding strategy for young rabbits around weaning: a review of digestive capacity and nutritional needs. *Anim. Sci*. **75**: 169-184.

GIDENNE T., JEHL N., SEGURA M., MICHALET-DOREAU B. 2002. Microbial activity in the caecum of the rabbit around weaning :impact of a dietary fibre deficiency and of intake level. *Anim. Feed Sci. Technol*. **99**: 107-118.

GUTIÉRREZ I., ESPINOSA A., GARCÍA J., CARABAÑO R., DE BLAS, J.C. 2002. Effect of levels of starch, fiber, and lactose on digestion and growth performance of early-weaned rabbits. *J. Anim. Sci.* **80**: 1029–1037.

HOPWOOD D.E., PETHICK D.W., HAMPSON D.J. 2002. Increasing the viscosity of the intestinal contents stimulates proliferation of enterotoxigenic *Escherichia coli* and *Brachyspira pilosicoli* in weaner pigs. *Br. J. Nutr.* **88**: 523–532.

KNUDSEN K.B.E. 1997. Carbohydrate and lignin contents of plant materials used in animal feeding. *Anim. Feed Sci. Technol*. **67**: 319–338.

MAERTENS L., PEREZ J.M., VILLAMIDE M., CERVERA C., GIDENNE T., XICCATO G. 2002. Nutritive value of raw materials for rabbits: EGRAN Tables 2002. *Wld Rabbit Sci*. **10** (4): 157–166.

PASCUAL J.J. 2001. Early weaning of young rabbits: A review. *Wld Rabbit Sci*. **9** (4): 165-170.

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

XICCATO G., TROCINO A., SARTORI A., QUEAQUE P.I. 2004. Effect of parity order and litter weaning age on the performance and energy balance of rabbit does. *Livest. Prod. Sci*. **85**:239-251

ZDUNCZYK Z., JUSKIEWICZ J., WROBLEWSKA M., KROL B. 2004. Physiological effects of lactulose and inulin in the caecum of rats. *Arch. Anim. Nutr*. **58** (1): 89-98.