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Maturation of the intestinal digestion and of microbial activity in the young rabbit: Impact of the dietary fibre:starch ratio

T. Gidenne [a,*], L. Debray [a], L. Fortun-Lamothe [a], I. Le Huërou-Luron [b]

[a] INRA, Université de Toulouse, UMR1289, Tissus Animaux, Nutrition, Digestion, Ecosystème et Métabolisme, Chemin de Borde-Rouge-Auzeville, BP 52627, F-31326 Castanet-Tolosan Cedex, France, INPT-ENSAT, F-31326 Castanet-Tolosan Cedex, France, ENVT, F-31076 Toulouse Cedex 3, France
[b] INRA, UMR1079, Systèmes d'Elevage Nutrition Animale et Humaine, F-35590 Saint Gilles, France

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Abstract

The developmental changes of intestinal digestive potential and caecal microbial activity were described in suckling and weaned rabbits according to two feeding programmes. Two groups of thirteen litters were fed from 18 to 42 days old a "High" or a "Medium" NDF:starch ratio diet (resp. 2.7 vs 2.0, groups HL and ML) with similar protein and lipid levels, and from 42 to 70 days old the two groups were fed a "Low" NDF:starch ratio diet (1.7). From 25 to 32 days (weaning), the milk and solid feed intake were 22% and 41% higher in ML group ($P<0.05$), and the mortality by diarrhoea was 4 units lower ($P<0.01$). The whole tract digestive efficiency increased by 10% before weaning, and remained steady (organic matter) or decreased (lipids, protein) after weaning. Energy digestibility was 0.623 and 0.686 for *High* and *Medium* diets respectively. From 25 to 42 days, total enzymatic activity in intestinal content increased for chymotrypsin (5-fold, $P<0.001$), lipase (10-fold, $P<0.001$), amylase (17-fold, $P<0.01$) and maltase (11-fold, $P<0.001$), while trypsin doubled after weaning. The feeding programme only affected the amylase and maltase activities, that were higher in HL group ($P<0.05$). The volatile fatty acids concentration in the caecum was not significantly different among the groups, but it increased by 44% 10 days after weaning. The bacterial fibrolytic enzymes, increased by 30% after weaning and were similar among the two groups. The study revealed that the intestinal digestive maturation and the caecal microbial activity of the rabbit evolved markedly between 3 and 5 weeks of age, and was weakly affected when the NDF:starch ratio decreased from 2.7 to 2.0.

Keywords: Digestive maturation; Gut health; Dietary fibre; Rabbit

1. Introduction

The weaning is a critical period for the young mammals, since digestive processes are maturating intensively in association with a disruption of the feeding behaviour, and this corresponds frequently with a high sensitivity to digestive troubles. Physiological changes during this key period and relationship with digestive health are documented in some domestic species, such as the piglet where new indicators of digestive health have been proposed (Lalles et al., 2004; Montagne et al., 2007). Weaning induced both transient and long-lasting modifications of digestive characteristics in the piglet (Pluske et al., 1997; Boudry et al., 2004). Feed composition, such as dietary fibre, interacts with the digestive health of the young animal (Montagne et al., 2003) and particularly of the growing rabbit after weaning (Gidenne, 2003).

Before weaning the young rabbit is caged with its mother, and consumes a diet corresponding to nutritional needs of the doe. It was thus hypothesised that the early nutrition of the young with a diet not adapted to its needs may negatively affect its digestive maturation and could lead to a higher sensitivity to digestive troubles (Gidenne and Fortun-Lamothe, 2002). Contrary to other monogastric animals, such as poultry (Christensen et al., 2007) or piglet (Boudry et al., 2004), few studies addressed the digestive maturation of the young rabbit and the impact of nutrient intake on its health. The development of enzymatic equipment of the rabbit's pancreas starts around days 21–24 of age, regardless of the nature of diet (Lebas et al., 1971; Corring et al., 1972). According to Corring et al. (1972) and Scapinello et al. (1999)

* Corresponding author. INRA, UMR1289 TANDEM, BP52627, F-31326 Castanet-Tolosan, France. Tel.: +33 561285103; fax: +33 561285319.
E-mail address: gidenne@toulouse.inra.fr (T. Gidenne).

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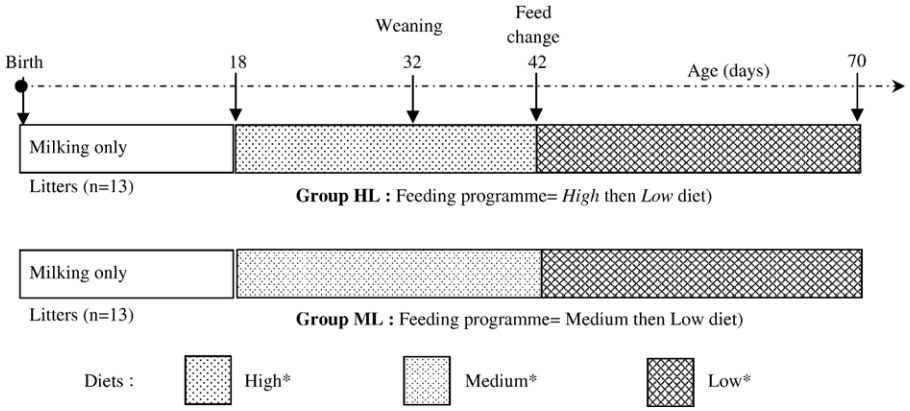

Fig. 1. Feeding programmes for young rabbits according to the experimental groups.*: NDF:starch ratio = 2.7, 2.0, 1.7 resp. for High, Medium and Low diets (see Table 1). From 18 to 32 days of age, young rabbits were milked and also have access to solid feed (*High* or *Medium* diet).

ontogenic factors seem to be more involved than nutritional factors in the development of intestinal maltase activity and of pancreatic amylase activity. In return, the nutritional needs of the growing rabbit after weaning were more documented. It was demonstrated that the fibre intake greatly favours the resistance to the digestive troubles (Bennegadi et al., 2001), while the starch intake has a weak effect (Gidenne et al., 2005a). To our knowledge, few studies investigate the digestive maturation of the rabbit around weaning, using a comprehensive approach from intestinal enzyme potential to whole tract digestive efficiency and health.

Therefore, the present study aimed to quantify changes in intestinal digestive processes and microbial activity and their relationship with digestive health, in the young rabbit around weaning with a dietary model having varying fibre:starch ratio. We also assessed the digestive adaptation of the young to a feed change.

2. Materials and methods

2.1. Experimental design and animals (Fig. 1)

Two groups of thirteen litters from primiparous female rabbits (*Cuniculus*) (hybrid INRA line A2066 × A1077) were fed from 18 days to 42 days, a "High" or a "Medium" fibre: starch ratio diet (groups HL and ML respectively, Fig. 1), and from 42 to 70 days the two groups were fed a "Low" fibre: starch ratio diet (Table 1). Litters were equalised at birth (day 0) to 9 pups and were kept at a temperature of 19 °C +/− 2 °C and under a 7:00–19:00 lighting schedule. The litter size was maintained constant until 18 days by replacing dead rabbits using a young similar in age and body weight from replacement litters. Rabbits weaned at day 32 were fed ad libitum. The diets used in the present experiment were similar to those reported in Debray et al. (2002), but ingredients and chemical composition of diets are reminded in Table 1. The "High" fibre:starch ratio diet fitted with nutritional recommendations for young rabbits (Gidenne and Fortun-Lamothe, 2002), the "Medium" diet fitted with recommendations for reproducing does (Xiccato, 1996), and the "Low" fibre:starch ratio diet (Table 1) fitted with recommendations for finishing growing rabbits (Gidenne, 2000). Diets were given as pellets of 3 mm diameter and 6–12 mm long, and no antibiotics were added to the feeds or in the drinking water during the whole experiment. From days 18 to 32, females were fed ad libitum the same feed than their litter. Females were remated 11 days after parturition. Animals were handled according to the care of animals in experimentation, in agreement with European legislation (European Union, 2003).

Young rabbits were caged with their mother in metabolism cages and freely suckled from birth to 21 days of age. Up to 18 days of age, young could also access the female solid food, but their intake remains very limited (Gidenne and Lebas, 2006). At 21 days, youngs were caged separately from their mother in order to measure the diet digestibility before weaning. From this moment, suckling was ensured by moving the does in the litter cage during 5–10 min every morning (8–9:00, until weaning 32 days). Milk intake was determined daily by weighing does before and after suckling, since females nurse their litter only a few minutes, once a day (Gidenne and Lebas, 2006). After weaning, 4 rabbits per litter were kept in metabolism cage for digestibility measurements, while the four others were caged in a standard wire net cage for further digesta sampling, at 42 and 52 days of age. Live weight was recorded individually at the beginning and at the end of each period of digestibility measurement (see following section). Feed intake was measured daily during each period of digestibility measurement, and at 58, 65 and 70 days of age.

Mortality was checked daily, while morbidity was assessed weekly through an individual control of all clinical signs of digestive troubles, such transitory diarrhoea, presence of mucus in excreta, abnormal behaviour. Animals having an abnormally low weight (under 3 SD below the mean of the group) were also accounted as morbid. Health risk index was calculated as the sum of morbid and dead animals.

2.2. Digestibility measurement

Digestibility of diets was measured at four periods of age, by recording the feed intake and by collecting the whole quantity