Animal Feed Science and Technology 190 (2014) 87–94

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Effects of drinking water acidification by organic acidifier on growth performance, digestive enzyme activity and caecal bacteria in growing rabbits

K.H. Zhu [a], X.R. Xu [a,*], D.F. Sun [b], J.L. Tang [a], Y.K. Zhang [a]

[a] College of Animal Sci-Tech, Northwest A&F University, Yangling 712100, Shaanxi, PR China
[b] Novus International Trading (Shanghai) Co. Ltd, Shanghai 200001, PR China

ARTICLE INFO

Article history:
Received 23 June 2012
Received in revised form 13 January 2014
Accepted 18 January 2014

Keywords:
Bacteroides–Prevotella
Drinking water acidification
Escherichia coli
Growing rabbit
Growth performance
Pepsin activity

ABSTRACT

This study investigated the effect of drinking water acidification by organic acid on growth performance, gastrointestinal enzyme activity and pH, and the proportion of selected bacterium to total bacteria in growing rabbits. Ninety-six male healthy rabbits weaned at 35 days old of age were randomly divided into four groups: control, pH 5.0, pH 4.3 and pH 3.6 groups. The control group drank groundwater with a pH of 7.3. To obtain the required pH, a commercial mixture of organic acid was added to groundwater in groups pH 5.0, pH 4.3 and pH 3.6 by 0.55 g/kg, 0.85 g/kg and 3.3 g/kg, respectively. The trial lasted for 35 days, and 6 rabbits from each group were slaughtered at the end for subsequent measurements. Acidification of drinking water did not affect diarrhoea incidence and mortality rate, but had a quadratic increasing effect on average daily gain (ADG) and final weight, and quadratic decreasing function on feed conversion ratio (FCR) ($P = 0.013$, $P = 0.007$ and $P = 0.040$, respectively), 0.85 g/kg organic acid supplementation showed maximal positive effect on ADG, final weight and FCR. Compared to control, ADG and final weight in pH 4.3 group increased by 12.9% ($P = 0.016$) and 8.3% ($P = 0.020$), respectively. The acidity of digesta in gastric fundus and gastric middle was decreased linearly ($P = 0.007$ and $P = 0.014$, respectively). Rabbits in pH 3.6 group tended to have a lower gastric middle pH than control ($P = 0.09$). Organic acid supplementation in drinking water showed a quadratic increasing effect on the activity of pepsin in the stomach ($P = 0.036$), and pH 4.3 group had highest value, which increased by 23.6% ($P = 0.06$) when compared with control. The proportions of *Escherichia coli* to total bacteria and to *Bacteroides–Prevotella* were decreased linearly ($P = 0.025$ and $P = 0.003$, respectively). Compared with control, rabbits in other three groups had lower proportions of *E. coli* to *Bacteroides–Prevotella* ($P = 0.03$, $P = 0.01$ and $P = 0.02$, respectively). The relative proportion of *Bacteroides–Prevotella* or *Lactobacillus* to total bacteria tended to increase linearly ($P = 0.09$ and $P = 0.058$, respectively). This study demonstrated that acidification of drinking water with organic acid improved part of growth performances, compensated for gastric acidity and affected microbial community structure in caecum in growing rabbits. The most appropriate pH of acidified drinking water was 4.3 in present study.

Abbreviations: ADFI, average daily feed intake; ADG, average daily gain; ADWI, average daily water intake; BW, body weights; FCR, feed conversion ratio; MCFA, medium-chain fatty acids.

* Corresponding author. Tel.: +86 29 8709 1973/+86 15091284067; fax: +86 29 8709 1973.
E-mail addresses: xuxiurong@yahoo.com, 244205036@qq.com (X.R. Xu).

0377-8401/$ – see front matter © 2014 Published by Elsevier B.V.
http://dx.doi.org/10.1016/j.anifeedsci.2014.01.014

1. Introduction

Rabbits in most farms are weaned between 4 and 5 weeks of age. Because of undeveloped gut immunity system and lack of passive immunity or medium-chain fatty acids (MCFA) protection from doe's milk (Skřivanová and Marounek, 2006; Skřivanová et al., 2008), newly weaned rabbits are susceptible to intestinal infections, which can cause high diarrhoea and mortality rate. At the same time, alteration in diet and insufficiency of digestive enzyme (Gutiérrez et al., 2003; Gomez-Conde et al., 2007) and/or stomach acid after weaning can lead to poor digestion and also an increased risk of gut disease in newly weaned rabbits (Carabaño et al., 2008). In addition, many animal farms in northwest of China use untreated groundwater with pH of 7.3 to 8.0 as animal's drinking water. Untreated underground water with high pH may aggravate the gut trouble in newly weaned rabbit by constituting an increased risk of infection with pathogens and/or reduction in gastric enzyme activity.

Antibiotics are often added to feed after weaning till 8 weeks of age in order to prevent enteric diseases and reduce high economic losses. Because increasing worries with food safety led consumers to oppose the usage of antibiotics in animal feeds, various feed additives have been developed as alternatives to dietary antibiotics. Organic acid is one of these alternatives because of its effect on compensating for gastric acidification and inhibition of pathogenic bacteria in the gastro-intestinal tract (Roselli et al., 2005; Pettigrew, 2006), and it has been increasingly used to control post-weaning diarrhoea in piglets, where it already has had considerable success (Partanen and Mroz, 1999; Tsiloyiannis et al., 2001; De Busser et al., 2011), and its application in rabbits appears interesting. But scientific data concerning their effect on rabbit's gut microflora population, mucosal immunity and growth performance are few and often contradictory (Falcao-e-Cunha et al., 2007). Scapinello et al. (2001) and Michelan et al. (2002) found that the inclusion of 1.5% of fumaric acid in the feeds of growing rabbits tended to improve both the daily weight gain and the feed efficiency, but the differences were not statistically significant. Cesari et al. (2008) reported acidified diet significantly lowered feed conversion rate and increased daily weight gain in growing rabbits. In a study of Skřivanová and Marounek (2002), the inclusion of 0.5% of caprylic acid reduced post-weaning mortality without affecting any other performance trait.

Acidifier added to diet raises several problems, including machine corrosion, moisture absorption and acid volatilization during the process of granulating or storing. Addition of organic acids *via* drinking water can avoid these problems. More recently, researchers investigated the effect of addition of organic acids in drinking water on reduction the *Escherichia coli* load in nursery pigs (De Busser et al., 2011) and inhibition of transmission of *Campylobacter* among broilers (van Bunnik et al., 2012). No studies have investigated the effects of organic acids supplemented *via* the water in either the newly weaned rabbits or growing rabbits. Because of the peculiar digestive physiology of the rabbit, it can be hazardous to simply extend the conclusions of studies in pig or poultry to rabbit (Falcão-e-Cunha et al., 2007). The purpose of this study was to investigate the effect of acidification of drinking water by commercial blend of organic acid on lowering the gastric pH and consequently, stimulating the digestive enzyme activity and defending bacterial colonization of the gastrointestinal tract in newly growing rabbits raised in northwest of China.

2. Materials and methods

2.1. Experimental diets

The diet based on corn, alfalfa meal and soybean meal was formulated to meet all the essential nutrient requirements of growing rabbits (De Blas and Mateos, 2010). Ingredient and chemical composition are shown in Table 1. The diet was pelleted and animals were given *ad libitum* access to feed.

2.2. Animals and experimental design

Forty-eight selected litters of neonatal commercial American Rex rabbits in a farm were identified at birth. During the pre-weaning period, health status of all litters was monitored. The neonatal rabbits were given free access to creep feed (meal form) without antibiotics or probiotics from 20 days of age. At weaning, at 35 days of age, 96 male healthy rabbits from the monitored litters were selected for the 35-day trial. Initial weight of the 96 rabbits was 534 ± 8.8 g.

Animals were assigned at random to four groups, balanced for weight and litter origin, and each group was assigned to one of four treatments. The four treatments were control group, pH 5.0 group, pH 4.3 group and pH 3.6 group. Rabbits in control group drank groundwater with a pH of 7.3. The pH of drinking water for other three groups was 5.0, 4.3 and 3.6, respectively. To get the required pH, a commercial liquid organic acidifer (containing a mixture of formic acid, acetic acid and ammonium formate) was added to groundwater by 0.55 g/kg, 0.85 g/kg and 3.3 g/kg, respectively. The pH of the drinking water was measured twice a week and adjusted if needed.

Each rabbit was housed individually after weaning. The cage was made of galvanized wire with a bamboo flooring. The size of the cage is 70 cm × 50 cm × 40 cm. Manual feeder and semiautomatic drinker were set for each rabbit. Feed and drinking water consumption were measured every day and added up at the end of the trial. Drinking water was not chlorated during the trial. The local temperature dropped gradually from 24/13 °C to 16/9 °C from the beginning to the end of the trial.