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Original Research Article

Effects of raw material extrusion and steam conditioning on feed pellet quality and nutrient digestibility of growing meat rabbits

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ABSTRACT

This study was conducted to investigate the effects of raw material extrusion and steam conditioning on feed pellet quality and nutrient digestibility of growing meat rabbits, in order to determine appropriate rabbit feed processing methods and processing parameters. In Exp. 1, an orthogonal design was adopted. Barrel temperature, material moisture content and feed rate were selected as test factors, and acid detergent fiber (ADF) content was selected as an evaluation index to research the optimum extrusion parameters. In Exp. 2, a two-factor design was adopted. Four kinds of rabbit feeds were processed and raw material extrusion adopted optimum extrusion parameters of Exp. 1. A total of 40 healthy and 42-day-old rabbits with similar weight were used in a randomized design, which consisted of 4 groups and 10 replicates in each group (1 rabbits in each replicate). The adaptation period lasted for 7 d, and the digestion trial lasted for 4 d. The results showed as follows: 1) ADF was significantly affected by barrel temperature ($P < 0.05$); the optimum extrusion parameters were barrel temperature 125 °C, moisture content 16% and feed rate 9 Hz. 2) Raw material extrusion and steam conditioning both significantly decreased powder percentage, pulverization ratio and protein solubility ($P < 0.05$), significantly improved hardness and starch gelatinization degree of rabbit feed ($P < 0.05$). They both had significant interaction effects on the processing quality of rabbit feed ($P < 0.05$). 3) Extrusion significantly improved the apparent digestibility of dry matter and total energy ($P < 0.05$). Extrusion and steam conditioning both significantly improved the apparent digestibility of crude fiber (CF), ADF and NDF ($P < 0.05$), but they had no interaction effects on the apparent digestibility of rabbit feed. Thus, using extrusion and steam conditioning technology at the same time in the weaning rabbits feed processing can improve the pellet quality and nutrient apparent digestibility of rabbit feed.

1. Introduction

Extruded as a high temperature and short time processing technology, is widely used in food and feed processing field. Extrusion can change the nutrient content in feed, reduce the number of anti-nutritional factors, improve the hygiene condition of feed, and improve the nutrients utilization efficiency (Alonso et al., 2000; Dust et al., 2004; Decker et al., 2014). Rabbits are herbivores and monogastric animals, whose diet ingredients consist mainly of fiber feed. Gastrointestinal development of rabbits is not perfect after weaning, thus nutrient digestibility is lower, which easily causes digestion diseases. Fiber quality of dietary is very important to rabbits. The extrusion processing can effectively improve the fiber quality and increase digestibility. Therefore, the research on the application of extrusion processing technology in rabbit diet processing seems to be very important. Researches on extrusion are mainly about piglet diets and single raw material processing. These researchers found that when the material moisture content, extrusion temperature and screw speed are suitable, the starch gelatinization degree of maize can be maximized (Wang et al., 2012), and significantly improve the content of soluble fiber in soybean dregs (Jing and Chi, 2013). Sun et al. (2015) showed that low temperature pelleting after expansion improved the processing quality of weaned piglets pellet diets, and could improve the nutrient digestibility. Rojas et al. (2016) reported that

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diets of growing pigs after pelleting and extrusion can significantly improve the apparent ileal digestibility of starch and most indispensable amino acid. So far, the research and application of extrusion technology on rabbits feed processing has been rarely reported. Therefore, this study was conducted to investigate the effect of raw material extrusion and steam conditioning process on feed pellet quality and nutrient digestibility of growing meat rabbits, and to provide a reference for the rational selection of rabbit feed processing methods and parameters.

2. Materials and methods

This study was approved by the Institutional Animal Care and Use Committee of Sichuan Agricultural University.

2.1. Trial design

2.1.1. Extrusion trial design

The orthogonal table $L_9(3^4)$ was used to design an orthogonal trial with 3 factors and 3 levels. Barrel temperature (A), material moisture content (B), feed rate (C) were selected as test factors. Crude fiber (CF), neutral detergent fiber (NDF), acid detergent fiber (ADF) were selected as evaluation indexes to research the optimum extrusion parameters. The plant raw materials (maize, soybean meal, rapeseed meal, wheat bran, alfalfa meal, and peanut shells) in based diets were crushed and mixed as extrusion experimental materials according to the formula. Trial factors and levels are presented in Table 1.

2.1.2. Digestion trial design

The two-factor trial design was adopted, and the experiment included 4 groups: control group, in which neither extrusion nor steam conditioning were used; treatment 1, which did not use extrusion but used steam conditioning; treatment 2, which did not use steam conditioning but used extrusion; treatment 3, in which both of extrusion and steam conditioning were used. The plant raw materials were extruded in based diets by using the extrusion process parameters which got from the extrusion experiment. The steam was added before feed pelleting was processed. Conditioning temperature was 65 °C. Four group diets were processed to be 2.5 mm diameter pellet diets. The adaptation period lasted for 7 days, and formal experiment lasted for 4 days.

2.2. Basal diet

According to the Nutrition of the Rabbit (2010) and the actual situation in China, the basal diets were formulated. The composition and nutrient levels of the basal diets are shown in Table 2.

2.3. Animals and feeding management

This experiment was started in animal nutrition institute of Sichuan Agricultural University. Rabbit cages were thoroughly cleaned and disinfected before the experiment. A total of 40 healthy and 42-day-old rabbits (20 females and 20 males) with similar weight (1,066 ± 78 g) were used in a randomized design, which consisted of 4 groups and 10 replicates in each group, 1 rabbit in each replicate. The rabbits in 4 groups were fed control group, treatments 1, 2, and 3 diets, respectively, 3 times a day (08:00, 12:00 and 18:00) during the trial period. All rabbits had free access to feed and water. Natural ventilation and lighting were used. After a 7 days adaptation period, the feces samples were collected 4 days by using total collect method.

Table 1
Factors and levels.

Levels	Factors		
	Barrel temperature, °C	Material moisture content, %	Feeding rate, Hz
1	105	12	7
2	125	14	8
3	145	16	9

Table 2
Composition and nutrient levels of the basal diet (air-dry basis).

Item	Content
Ingredients, %	
Corn	30.17
Soybean meal	7.20
Rapeseed meal	5.39
Wheat bran	20.00
Alfalfa meal	27.45
Peanut shell powder	7.10
Limestone	0.33
$CaHPO_4$	0.60
NaCl	0.50
L-Lysine-HCl	0.26
Premix[1]	1.00
Total	100.00
Nutrient levels,[2] %	
DE, MJ/kg	10.15
CP	16.12
CF	14.53
NDF	29.38
ADF	18.66
Ca	0.80
TP	0.54
Lys	0.80
Met + Cys	0.53

CP = crude protein; CF = crude fiber; NDF = neutral detergent fiber; ADF = acid detergent fiber; TP = total protein.
[1] Premix provided per kg of the diet: vitamin A, 12,000 IU; vitamin D_3, 2,250 IU; vitamin E, 24 mg; vitamin K_3, 2.25 mg; vitamin B_{12}, 0.03 mg; nicotinic acid, 45 mg; *D*-pantothenic acid, 15 mg; folic acid, 1.2 mg; Cu, 15 mg; Fe, 70 mg; Zn, 50 mg; Mn, 15 mg; I, 0.5 mg; Se, 0.15 mg; Co, 0.2 mg; choline chloride, 250 mg; diclazuril, 1 mg.
[2] The CP, CF, ADF, and NDF contents were measured values, and other nutrient levels were calculated values.

2.4. Sample collection

Extrusion materials and 4 kinds of pellet feed samples were collected by using geometric method. The digestive trial feces samples were collected 4 days. All fresh feces were collected at 07:00 every morning, and weighed after removing the rabbit hairs on the dung ball. At the end of the experiment, feces samples were collected, mixed and added with 10% HCl for chemical analyses.

2.5. Determination index and methods

2.5.1. Feed pellet quality index

The method of AOAC (2005) was used to determine the powder percentage, pulverization ratio, bulk density, hardness, and protein solubility. Starch gelatinization was determined by the method of Xiong (2000).

2.5.2. Nutrient apparent digestibility

The GE, DM, CP, ash, CF, ADF, and NDF in the samples of diets and feces were analyzed according to AOAC (2005) procedures.

2.6. Statistical analysis

The experiment data were pretreatment with Excel 2010. The orthogonal trial data were analyzed by using variance analysis method, other trial data were analyzed by using two-factor