Effects of Dietary Artemisia argyi Leaf Powder Supplementation on Nutrient Apparent Digestibility, Nitrogen Metabolism, and Meat Quality in Growing Meat Rabbits (Postprint)

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Abstract

This experiment aimed to investigate the effects of dietary mugwort leaf powder supplementation on nutrient apparent digestibility, nitrogen metabolism, and meat quality in growing meat rabbits. One hundred and sixty 35-day-old commercial Ira meat rabbits with similar body weight were selected and randomly divided into 4 groups (40 replicates per group, 1 rabbit per replicate), and fed diets containing 0 (control group), 3% (replacing 1% peanut vine and 2% wheat bran in the control diet), 6% (replacing 3% peanut vine and 3% wheat bran in the control diet), and 9% (replacing 4% peanut vine and 5% wheat bran in the control diet) mugwort leaf powder, respectively. The preliminary period lasted 7 d, and the formal experimental period lasted 30 d. The results showed that dietary supplementation with 3%, 6%, and 9% mugwort leaf powder had no significant effects on the apparent digestibility of crude fiber (CF), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin (ADL), calcium (Ca), and phosphorus (P), as well as nitrogen intake, fecal nitrogen, urinary nitrogen, retained nitrogen, nitrogen utilization rate, and nitrogen biological value ($P>0.05$). Dietary supplementation with 3% and 6% mugwort leaf powder had no significant effects on the apparent digestibility of crude protein (CP) and digestible nitrogen in rabbit diets ($P>0.05$), but dietary supplementation with 9% mugwort leaf powder significantly reduced the apparent digestibility of CP and digestible nitrogen ($P<0.05$). Compared with the control group, dietary supplementation with 6% and 9% mugwort leaf powder significantly increased the apparent digestibility of ether extract (EE) in the diet ($P<0.05$). Compared with the control group, dietary supplementation with 3%, 6%, and 9% mugwort leaf powder significantly increased muscle drip loss ($P<0.05$), but had no significant effects on other meat quality indicators ($P>0.05$). Based on the measured indices in this experiment, the dietary inclusion level of mugwort leaf powder in

growing meat rabbits should not exceed 6%.

Full Text

Effects of Dietary Artemisia Argyi Powder on Apparent Digestibility of Nutrients, Nitrogen Metabolism and Muscle Quality of Growing Meat Rabbits

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Abstract

This experiment was conducted to investigate the effects of dietary Artemisia argyi powder on apparent digestibility of nutrients, nitrogen metabolism, and muscle quality in growing meat rabbits. One hundred sixty Hyla meat rabbits at 35 days of age with similar body weight were randomly allocated to 4 groups (40 replicates per group, one rabbit per replicate). The rabbits were fed diets supplemented with 0% (control group), 3% (replacing 1% peanut vine and 2% wheat bran in the control diet), 6% (replacing 3% peanut vine and 3% wheat bran), or 9% (replacing 4% peanut vine and 5% wheat bran) Artemisia argyi powder. The pre-test period lasted 7 days, followed by a 30-day experimental period.

The results showed that dietary supplementation with 3%, 6%, and 9% Artemisia argyi powder had no significant effects on the apparent digestibility of crude fiber (CF), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin (ADL), calcium (Ca), and phosphorus (P) ($P>0.05$). Similarly, nitrogen intake, fecal nitrogen, urinary nitrogen, retained nitrogen, nitrogen utilization, and biological value of nitrogen were not significantly affected ($P>0.05$). Supplementation with 3% and 6% Artemisia argyi powder did not significantly affect the apparent digestibility of crude protein (CP) or digestible nitrogen ($P>0.05$). However, 9% supplementation significantly reduced CP apparent digestibility and digestible nitrogen ($P<0.05$). Compared with the control group, diets containing 6% and 9% Artemisia argyi powder significantly increased the apparent digestibility of ether extract (EE) ($P<0.05$). Additionally, supplementation with 3%, 6%, and 9% Artemisia argyi powder significantly increased muscle drip loss ($P<0.05$) but had no significant effects on other muscle quality indicators ($P>0.05$).

Based on these findings, the inclusion level of Artemisia argyi powder in diets for growing meat rabbits should not exceed 6%.

Keywords: meat rabbits; Artemisia argyi powder; nutrient apparent digestibility; nitrogen metabolism; muscle quality

1.1 Experimental Animals and Management

One hundred sixty healthy Hyla meat rabbits at 35 days of age with similar body weight (half male and half female) were randomly divided into 4 groups with 40 replicates per group and one rabbit per replicate. The control group was fed a basal diet without Artemisia argyi powder, while the treatment groups received experimental diets supplemented with 0% (control), 3% (replacing 1% peanut vine and 2% wheat bran in the control diet), 6% (replacing 3% peanut vine and 3% wheat bran), or 9% (replacing 4% peanut vine and 5% wheat bran) Artemisia argyi powder. The Artemisia argyi powder was provided by Xinyang Aierkang Industrial Co., Ltd. The composition and nutrient levels of the experimental diets are shown in Table 1 .

The pre-test period lasted 7 days, followed by a 30-day experimental period. Rabbits were housed individually in cages under natural lighting with free access to feed and water. Six days before the end of the experiment, 8 rabbits from each group were randomly selected and transferred to disinfected metabolic cages for a digestion trial. After a 3-day adaptation period, feed intake was recorded for 3 consecutive days, and total daily fecal and urine samples were collected from each rabbit and stored at 4°C after pretreatment. At the end of the experiment, after 12 hours of fasting, 8 rabbits from each group were randomly selected for slaughter and muscle quality determination.

1.2 Measurements and Calculations

Gross energy (GE) was determined using an oxygen bomb calorimeter. Dry matter (DM) content was measured according to GB/T 6435-2006. Crude protein (CP) content was determined by the Kjeldahl method, crude fiber (CF) by acid-alkali washing method, and ether extract (EE) by oil weight method. Ash content was measured by incineration method. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and lignin (ADL) were determined using the Van Soest method. Calcium (Ca) content was measured by potassium permanganate titration, and phosphorus (P) by molybdenum yellow colorimetry.

The calculation formulas for nutrient apparent digestibility and nitrogen metabolism indices were as follows:

- Apparent digestible energy = Total energy intake - Fecal energy
- Nutrient apparent digestibility (%) = 100 × (Nutrient content in diet - Nutrient content in feces) / Nutrient content in diet
- Digestible nitrogen (g/d) = Nitrogen intake - Fecal nitrogen
- Retained nitrogen (g/d) = Nitrogen intake - Fecal nitrogen - Urinary nitrogen
- Nitrogen apparent digestibility (%) = 100 × Digestible nitrogen / Nitrogen intake
- Nitrogen utilization (%) = 100 × Retained nitrogen / Nitrogen intake

- Biological value of nitrogen (%) = 100 × Retained nitrogen / Digestible nitrogen

After slaughter, the carcass weight was measured after removing skin, tail, distal parts of fore and hind legs, gastrointestinal tract, and urogenital tract. The eviscerated weight was measured after removing all viscera and abdominal fat. Foreleg muscle (boneless) and hind leg muscle (boneless) were weighed to calculate dressing percentage, eviscerated dressing percentage, foreleg muscle ratio, and hind leg muscle ratio:

- Dressing percentage = Carcass weight / Live weight before slaughter
- Eviscerated dressing percentage = Eviscerated weight / Live weight before slaughter
- Foreleg muscle ratio = Weight of two forelegs (boneless) / Live weight before slaughter
- Hind leg muscle ratio = Weight of two hind legs (boneless) / Live weight before slaughter

pH45 min: At 45 minutes post-slaughter, pH was measured at the 5th rib of the longissimus dorsi muscle using a Mettler MP120 pH meter, with the probe inserted 3 mm into the muscle.

Drip loss: At 4 hours post-slaughter, the eye muscle was cut along the fiber direction into 3 cm × 1 cm × 1 cm strips and weighed (m1). The strip was hung with a wire hook in a paper cup, the cup mouth was sealed with plastic wrap, and stored at 4°C for 24 hours. The sample was then reweighed (m2). Drip loss was calculated as: Drip loss (%) = 100 × (m1 - m2) / m1.

Shear force: Fresh longissimus dorsi muscle was stored at 0-4°C for 48 hours for aging. A thermometer was inserted into the muscle center and heated in a water bath at 80°C. Heating was stopped when the center temperature reached 60°C. The sample was trimmed along the fiber direction into cylindrical blocks (1.12 cm diameter, 3 cm thickness) and shear force (kgf) was measured using a C-LM muscle tenderness meter.

Meat color: Using a Konica Minolta CR-10 colorimeter with CIE-Lab output mode, three cuts were made on the longissimus dorsi muscle and L* (lightness), a* (redness), and b* (yellowness) values were recorded and averaged.

The apparent digestibility of nutrients in Artemisia argyi powder was determined using the substitution method, and the digestible nutrient content was calculated using the average values from the three inclusion levels.

The substitution method formula for calculating nutrient apparent digestibility in Artemisia argyi powder was:

$$D = \frac{(A - B)}{F} \times 100 + B$$

$$F = \frac{c_1 f}{c_1 f + c_0(1-f)}$$

Where: D = Apparent digestibility of a nutrient in the test feed ingredient (Artemisia argyi powder in this experiment); A = Apparent digestibility of the nutrient in the test diet; B = Apparent digestibility of the nutrient in the basal diet; F = Proportion of the nutrient provided by the test ingredient in the test diet; f = Inclusion rate of the test ingredient in the test diet; c0 = Nutrient content in the basal diet; c1 = Nutrient content in the test ingredient.

1.3 Data Processing and Analysis

Data were analyzed using the General Linear Model (GLM) procedure in SAS 9.1.3 software, and Duncan' s multiple range test was used for pairwise comparisons. Results are expressed as means and root mean square error (R-MSE). $P < 0.05$ was considered statistically significant.

2.1 Nutritional Components and Value of Artemisia Argyi Powder

As shown in Table 2 , Artemisia argyi powder contained 91.56% DM, 10.35% ash, 15.70% CP, 7.29% EE, and 16.64% CF. The NDF, ADF, and ADL contents were 34.32%, 28.87%, and 7.09%, respectively. Calcium and phosphorus contents were 1.19% and 0.28%, respectively, with a gross energy of 17.62 MJ/kg. The digestible DM, ash, CP, EE, CF, NDF, ADF, ADL, Ca, and P contents were 40.95%, 1.73%, 6.81%, 6.00%, 2.46%, 4.86%, 10.64%, 1.90%, 0.46%, and 0.12%, respectively. These results indicate that Artemisia argyi powder has relatively high ether extract and ash contents, but low digestible dry matter and particularly low digestible crude protein content.

2.1.1 Effects of Artemisia Argyi Powder on Apparent Digestible Energy and Nutrient Digestibility in Growing Meat Rabbits

As shown in Table 3 , dietary supplementation with 3%, 6%, and 9% Artemisia argyi powder had no significant effects on the apparent digestibility of CF, NDF, ADF, ADL, Ca, and P ($P>0.05$). Compared with the control group, 9% supplementation significantly reduced the apparent digestibility of CP and energy ($P<0.05$), while 3% and 6% supplementation had no significant effects ($P>0.05$). Supplementation with 6% and 9% Artemisia argyi powder significantly increased the apparent digestibility of EE ($P<0.05$), but 3% supplementation had no significant effect ($P>0.05$).

2.1.2 Effects of Artemisia Argyi Powder on Nitrogen Metabolism in Growing Meat Rabbits

As shown in Table 4 , dietary supplementation with 3%, 6%, and 9% Artemisia argyi powder had no significant effects on nitrogen intake, fecal nitrogen, uri-

nary nitrogen, retained nitrogen, nitrogen utilization, or biological value of nitrogen (P>0.05). While 3% and 6% supplementation did not significantly affect digestible nitrogen or nitrogen apparent digestibility (P>0.05), 9% supplementation significantly reduced both parameters (P<0.05).

2.1.3 Effects of Artemisia Argyi Powder on Muscle Quality of Growing Meat Rabbits

As shown in Table 5 , dietary supplementation with 3%, 6%, and 9% Artemisia argyi powder had no significant effects on foreleg weight, foreleg muscle ratio, hind leg weight, hind leg muscle ratio, eviscerated dressing percentage, shear force, pH45 min, lightness, or redness values (P>0.05). However, drip loss was significantly reduced (P<0.05).

3 Discussion

3.1 Nutritional Components and Value of Artemisia Argyi Powder Artemisia argyi is nutritionally rich, containing volatile oils, flavonoids, polysaccharides, proteins, minerals, vitamins, and amino acids. In this experiment, Artemisia argyi powder contained 17.62 MJ/kg gross energy, 91.56% DM, 15.70% CP, 7.29% EE, 1.19% Ca, 0.28% P, 10.35% ash, 16.64% CF, 34.32% NDF, 28.87% ADF, and 7.09% ADL. The digestible DM, CP, EE, Ca, P, ash, CF, NDF, ADF, and ADL contents were 40.95%, 6.81%, 6.00%, 0.46%, 0.12%, 1.73%, 2.46%, 10.64%, 4.86%, and 1.90%, respectively. These findings indicate that Artemisia argyi powder is intermediate between energy feed and roughage, with relatively high ether extract and ash contents but low digestible dry matter and particularly low digestible crude protein. Therefore, excessive inclusion of Artemisia argyi powder in diets may negatively affect crude protein apparent digestibility and consequently impact daily weight gain. Variations in feed ingredient variety, harvest time, storage methods, and processing techniques may lead to differences in measured values.

3.2 Effects of Artemisia Argyi Powder on Nutrient Apparent Digestibility and Nitrogen Metabolism in Growing Meat Rabbits Dietary Artemisia argyi powder supplementation can improve nutrient digestibility and promote growth in meat rabbits. Gao et al. reported that adding 0.5% and 1.0% Artemisia powder to rat diets significantly increased total protease, pancreatic lipase, and pancreatic amylase activities in small intestinal chyme, thereby improving protein digestibility and promoting animal growth. Kim et al. studied the effects of adding 3%, 5%, and 10% dried Artemisia to sheep diets on nutrient apparent digestibility, finding that 5% supplementation significantly increased DM apparent digestibility and total digestible nutrient (TDN) content compared with the control group, along with significantly higher CP and CF apparent digestibility. However, in growing meat rabbits, 9% Artemisia argyi powder supplementation significantly reduced CP and energy apparent digestibility, while 6% and 9% supplementation significantly increased EE appar-

ent digestibility, and 3%, 6%, and 9% supplementation had no significant effects on CF, NDF, ADF, ADL, Ca, and P apparent digestibility. These discrepancies may be attributed to differences in experimental animal species. Additionally, the high CF content in Artemisia argyi powder increases the proportion of indigestible components in the diet, reduces apparent digestible energy concentration, and increases digestive tract burden due to bulk expansion, leading to insufficient energy intake. High CF content also increases parasympathetic nerve excitability, accelerating intestinal motility and reducing retention time in the cecum, which impairs crude fiber digestion by large intestinal microbes and compromises digestion and utilization of other nutrients. The significant increase in EE apparent digestibility at high inclusion levels may be related to the abundant arginine content in Artemisia, as studies have shown that EE apparent digestibility increases initially then decreases with increasing dietary arginine levels.

Digestion and metabolism trials are essential for studying protein balance in animals. Ingested nitrogen is either retained for protein synthesis or excreted as metabolic products, constituting a dynamic nitrogen balance system. Fecal and urinary nitrogen represent two loss pathways, with fecal nitrogen being the unabsorbed portion of dietary protein that is significantly affected by dietary protein level. In this experiment, Artemisia argyi powder supplementation at 3%, 6%, and 9% did not significantly affect nitrogen metabolism, possibly because it did not significantly affect NDF, ADF, and CF apparent digestibility, which are positively correlated with nitrogen metabolism.

In summary, after multiple physical grinding processes, Artemisia argyi powder contains increased impurities. At 9% inclusion level, growing meat rabbits showed significantly lower CP and energy apparent digestibility compared with the basal diet, resulting in lower digestible energy. Therefore, the inclusion level of Artemisia argyi powder should not be too high, with 6% being recommended.

3.3 Effects of Artemisia Argyi Powder on Muscle Quality of Growing Meat Rabbits Artemisia argyi powder possesses both nutritional and health-promoting functions. Gao et al. reported that Artemisia argyi powder supplementation in broiler diets did not significantly affect slaughter performance or meat quality. Similar results were observed in this experiment, where 3%, 6%, and 9% supplementation had no significant effects on foreleg weight, foreleg muscle ratio, hind leg weight, hind leg muscle ratio, or eviscerated dressing percentage.

Meat quality reflects consumption performance and potential value, commonly evaluated by carcass quality, color, flavor, tenderness, water-holding capacity, and juiciness. In experiments, pH, meat color, drip loss, and shear force are frequently used indicators. This experiment showed that Artemisia argyi powder supplementation significantly affected muscle drip loss. Muscle contains approximately 75% water, which moves from intrafibrillar spaces to intercellular spaces after slaughter, with some being lost. This lost water contains diluted

sarcoplasmic proteins, leading to nutrient loss. Meat with high drip loss tends to have lighter color, poorer tenderness and flavor, and greater loss of flavor compounds, resulting in reduced yield, economic losses, and compromised packaging appearance. The significant reduction in drip loss observed with Artemisia argyi powder supplementation suggests potential nutrient loss in rabbit meat.

Rabbit meat quality is largely determined by nutrition, though different nutrients affect different quality parameters. Carrilho et al. fed 5- to 8-week-old rabbits diets with different CF levels (14.3%, 18.0%, and 20.5% DM basis) and decreasing digestible energy levels (9.3, 9.1, and 8.0 MJ/kg), followed by a finishing diet until slaughter, and found no significant differences in physical meat quality (pH, color, water-holding capacity, and toughness) or sensory quality among dietary treatments. In this experiment, 3%, 6%, and 9% Artemisia argyi powder supplementation had no significant effects on shear force, pH45 min, lightness, or redness values, indicating minimal impact on muscle quality. These findings are consistent with results from poultry studies.

4 Conclusion

Artemisia argyi powder is nutritionally intermediate between energy feed and roughage. Dietary supplementation with 3-6% Artemisia argyi powder has minimal effects on nutrient apparent digestibility and nitrogen metabolism, making it a viable feed ingredient for meat rabbits. However, the inclusion level should not exceed 6% in diets for growing meat rabbits.

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Note: Figure translations are in progress. See original paper for figures.