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Effects of Dietary Neutral Detergent Fiber on Production Performance, Serum Biochemical Parameters, and Reproductive Hormone Indices in Lactating Does (Postprint)

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Abstract

This experiment aimed to investigate the effects of dietary neutral detergent fiber (NDF) on production performance, serum biochemical parameters, and reproductive hormone indices in lactating does. One hundred pre-partum Ira meat rabbits were randomly divided into 4 groups with 25 replicates per group and 1 rabbit per replicate. Each group (Groups A, B, C, and D) was fed diets with NDF levels of 24%, 27%, 30%, and 33%, respectively. The experimental period lasted 28 days. The results showed: 1) The average daily gain of does in Group C was significantly lower than that in the other three groups ($P<0.05$); the average daily feed intake of does in Group D was significantly higher than that in the other three groups ($P<0.05$), the lactation capacity of Group C was significantly lower than that of the other three groups ($P<0.05$), and the individual weaning weight of kits in Groups C and D was significantly higher than that in Groups A and B ($P<0.05$). 2) Serum total protein, albumin, and globulin contents in Group B were significantly higher than those in Group D ($P<0.05$), serum insulin content in Group C was significantly higher than that in Group A ($P<0.05$), and no significant differences were observed among groups in serum triglyceride, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, and very low-density lipoprotein cholesterol contents ($P>0.05$). 3) Serum luteinizing hormone, progesterone, estradiol, prolactin, and follicle-stimulating hormone contents in Groups B and C were all significantly higher than those in Groups A and D ($P<0.05$). Based on comprehensive analysis, it is concluded that under the conditions of this experiment, dietary NDF level can affect the production performance and serum reproductive hormone contents of lactating does, and also has certain effects on serum biochemical indices; the appropriate dietary NDF level for meat rabbits during lactation is 24%~27%.

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Full Text

Effects of Dietary Neutral Detergent Fiber Level on Performance, Serum Biochemical Indices, and Reproductive Hormones in Lactating Rabbits

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Abstract: This experiment investigated the effects of dietary neutral detergent fiber (NDF) level on production performance, serum biochemical parameters, and reproductive hormone indices in lactating rabbits. One hundred pregnant Ira rabbits were randomly allocated to four groups with 25 replicates per group and one rabbit per replicate. Groups A, B, C, and D were fed diets containing 24%, 27%, 30%, and 33% NDF, respectively. The experimental period lasted 28 days. The results showed: (1) Group C had significantly lower average daily weight gain in does compared to the other three groups ($P<0.05$). Group D exhibited significantly higher average daily feed intake than the other groups ($P<0.05$), while Group C had significantly lower lactation capacity ($P<0.05$). The weaning weight of kits in Groups C and D was significantly higher than in Groups A and B ($P<0.05$). (2) Serum total protein, albumin, and globulin concentrations in Group B were significantly higher than in Group D ($P<0.05$). Serum insulin concentration in Group C was significantly higher than in Group A ($P<0.05$). No significant differences were observed among groups in serum triglycerides, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, or very low-density lipoprotein cholesterol ($P>0.05$). (3) Serum luteinizing hormone, progesterone, estradiol, prolactin, and follicle-stimulating hormone concentrations in Groups B and C were significantly higher than in Groups A and D ($P<0.05$). These findings indicate that dietary NDF level influences the production performance and serum reproductive hormone concentrations of lactating rabbits, with modest effects on serum biochemical indices. Under the conditions of this study, the optimal dietary NDF level for lactating meat rabbits is 24%–27%.

Keywords: NDF; lactating rabbits; performance; biochemical indices; reproductive hormones

Dietary fiber plays a unique role in the healthy growth of rabbits, with appropriate fiber levels enhancing production performance. Previous studies on crude fiber nutrition in rabbits [1–3] have shown that crude fiber analysis underestimates the total plant cell wall content in feed, yielding results that do not accurately reflect total fiber content. Consequently, detergent fiber analysis has gained widespread attention in recent years, though research has primarily focused on growing meat rabbits [4–5] rather than lactating does. This study examined the effects of dietary neutral detergent fiber (NDF) level on production

performance, serum biochemical parameters, and reproductive hormone indices in lactating rabbits to determine optimal NDF levels and provide a reference for improving reproductive performance and establishing feeding standards for lactating rabbits in China.

Experimental Animals and Management

One hundred multiparous pregnant Ira does (provided by Anqiu Lvzhou Rabbit Industry Co., Ltd.) of similar parity and good health status were selected. The rabbit housing, cages, feeders, and waterers were cleaned and disinfected before the experiment. During the trial, rabbits were fed manually at 08:00 and 17:00 daily, with free access to feed and water. Natural lighting and ventilation were provided, and the rabbitry was disinfected every 3–5 days. The health of does and kits was closely monitored throughout the experimental period, and detailed records were maintained.

Experimental Design and Diets

A single-factor repeated design was employed. Experimental rabbits were randomly divided into four groups with 25 replicates per group, one rabbit per replicate, housed individually. Groups A, B, C, and D received diets with NDF levels of 24%, 27%, 30%, and 33%, respectively. The experimental diets were introduced 10 days before parturition and continued until weaning at 28 days postpartum. All diets were formulated according to NRC (1977) [6] requirements for lactating rabbits, with NDF levels adjusted according to experimental design while maintaining similar concentrations of other nutrients. Dietary composition and nutrient levels are presented in Table 1 . All experimental diets were processed into pellets 4–6 mm in diameter.

Measurements and Methods

Production Performance Indices

Litter size, number of live-born kits, individual birth weight, litter birth weight, doe weight at parturition, and doe weight at weaning were recorded. Lactation capacity [7], individual weaning weight, litter weaning weight, weaning survival rate, average daily gain, and average daily feed intake were calculated.

Serum Sample Collection and Storage

On day 21 of lactation, 8–10 does per group were randomly selected for blood collection (10 mL) from the ear vein after overnight fasting. Samples were centrifuged at 3,000 r/min for 10 minutes, and the supernatant was stored at –20 °C.

Serum Biochemical Indices

Serum total protein (TP), albumin (ALB), globulin (GLB), urea nitrogen (UN), total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol

(HDLC), low-density lipoprotein cholesterol (LDLC), and very low-density lipoprotein cholesterol (VLDLC) were measured using commercial kits from Nanjing Jiancheng Bioengineering Institute according to the manufacturer' s instructions on a Hitachi 7020 automatic analyzer. Serum glucose (GLU) concentration was determined using a portable Roche glucometer.

Serum Reproductive Hormone Indices

Serum insulin (INS), luteinizing hormone (LH), progesterone (P), estradiol (E2), prolactin (PRL), and follicle-stimulating hormone (FSH) concentrations were determined by radioimmunoassay using kits from Tianjin Jiuding Medical Bioengineering Co., Ltd. Frozen serum samples were thawed at room temperature, pretreated according to the manufacturer' s instructions, and analyzed using a gamma counter (DPM-96).

Routine Index Determination

Routine indices were measured according to *Feed Analysis and Feed Quality Detection Technology* [8].

Statistical Analysis

Data are expressed as mean ± standard error. Analysis of variance was performed using SPSS 13.0 software, and significant differences were tested using Duncan' s multiple comparison test.

Effects of Dietary NDF Level on Production Performance of Lactating Rabbits

The effects of dietary NDF level on production performance are shown in Table 2 . No significant differences were observed in doe weaning weight among groups ($P>0.05$). Group C had significantly lower average daily gain in does compared to the other three groups ($P<0.05$). Group D exhibited significantly higher average daily feed intake than the other groups ($P<0.05$), while Group C showed significantly lower lactation capacity ($P<0.05$). The individual weaning weight of kits in Groups C and D was significantly higher than in Groups A and B ($P<0.05$). No significant differences were detected in litter weaning weight among groups ($P>0.05$). Weaning survival rate showed a declining trend, with Group A significantly higher than the other three groups ($P<0.05$), though no significant differences were observed among Groups B, C, and D ($P>0.05$).

Effects of Dietary NDF Level on Serum Biochemical Indices of Lactating Rabbits

The effects of dietary NDF level on serum biochemical indices are presented in Table 3 . Serum TP, ALB, and GLB concentrations increased initially and then decreased with rising dietary NDF levels, peaking in Group B, which was significantly higher than Group D ($P<0.05$). Group A had the highest serum

UN concentration, while Group D had the lowest, though differences among groups were not significant (P>0.05). Serum GLU and TC concentrations also showed an initial increase followed by a decrease, with Group B highest and Group D lowest, but without significant differences among groups (P>0.05). Serum INS concentration in Group C was significantly higher than in Group A (P<0.05), with no significant differences from other groups (P>0.05). No significant differences were observed among groups in serum TG, HDLC, LDLC, or VLDLC concentrations (P>0.05).

Effects of Dietary NDF Level on Serum Reproductive Hormone Indices of Lactating Rabbits

The effects of dietary NDF level on serum reproductive hormone indices are shown in Table 4 . Dietary NDF level exerted varying effects on hormones, with concentrations initially increasing then decreasing, peaking in either Group B or C. Groups B and C had significantly higher serum LH, P, and E2 concentrations than Groups A and D (P<0.05). Serum PRL and FSH concentrations in Groups B and C were significantly higher than in Groups A and D (P<0.05), while Group D was also significantly higher than Group A (P<0.05).

Effects of Dietary NDF Level on Production Performance

Previous research has demonstrated that dietary fiber has dual nutritional effects on rabbit production performance, with fiber content being particularly critical–insufficient fiber can cause severe digestive diseases. Rabbit reproductive performance is also affected by dietary fiber level. Dou et al. [9] and Tian [10] reported that higher dietary fiber levels can increase litter size in does. As an important component of carbohydrates, appropriate dietary NDF levels can improve feed intake and digestibility in herbivorous livestock, benefiting animal health and production performance.

In this study, dietary NDF level did not significantly affect litter weaning weight, while individual weaning weight increased with rising NDF levels, showing certain differences. Three possible explanations exist: first, individual weaning weight is related to litter size and milk yield; second, feeding management techniques may influence results; and third, dietary factors can affect doe reproductive performance. Wang et al. [11] reported that appropriate dietary fiber levels can improve reproductive performance in does while also playing important roles in growth, intestinal motility, chyme passage rate, nutrient absorption, reduction of enteritis and enterotoxemia, and decreased mortality. Whether higher dietary NDF levels can further increase individual and litter weaning weights requires additional investigation.

NDF primarily comprises cellulose, hemicellulose, and lignin, representing structural carbohydrates in feed that reflect characteristics of feed mastication and digestion. High dietary NDF levels can stimulate increased gastrointestinal motility in does, accelerating feed passage through the digestive tract and reducing

intestinal retention time, thereby impairing nutrient digestion, absorption, and utilization and consequently increasing feed intake. This study demonstrated that phenomenon, showing increased feed intake and decreased body weight (relative to initial weight) with rising dietary NDF levels, indicating that lactating does possess self-regulating mechanisms for feed intake and nutrient allocation. Gidenne et al. [12] investigated the effects of 19% and 31% dietary NDF levels on pre- and post-weaning young rabbits.

Effects of Dietary NDF Level on Serum Biochemical Indices

Serum TP represents the sum of ALB and GLB. ALB, synthesized by the liver, serves as a nutrient carrier, maintains plasma osmotic pressure, and provides a protein source for tissue repair and energy. GLB, secreted by plasma cells, reflects immune status [13]. Serum TP, ALB, and UN are accurate indicators of protein and amino acid metabolism and hepatic and renal function, representing protein digestion, absorption, and synthesis to some extent [14]. In this study, serum TP and ALB concentrations increased significantly when dietary NDF level reached 27% (Group B), with relatively low serum UN concentration in this group, suggesting improved protein utilization at this NDF level.

Glucose absorption, transport, and metabolism represent a dynamic equilibrium, with GLU concentration reflecting energy metabolism status. Martinez et al. [15] reported that increasing dietary crude fiber from 50% to 60% significantly decreased serum GLU concentration, with a declining trend in serum INS. Serum GLU concentration in meat rabbits decreased gradually with increasing dietary NDF level [16]. Yang [17] found that appropriate fiber levels can reduce serum GLU concentration and stabilize serum INS. The present findings are generally consistent with these results, showing an initial increase followed by a decrease with rising dietary NDF levels. Excessively high NDF levels reduced serum GLU and INS concentrations, though differences were not significant, suggesting regulatory mechanisms. Blood TC is the most important sterol compound and an indicator of blood lipid status. TG primarily transports fatty acids bound to ALB to other tissues for utilization. Kanjanapruthipong et al. [18] found that dietary NDF level did not significantly affect serum TG and TC concentrations in dairy cows at peak lactation. This study yielded consistent conclusions, showing no significant differences in serum TG and lipid concentrations among groups, though a decreasing trend was observed, related to energy metabolism and regulatory control in livestock. Similar conclusions were reported by Hou [19] in studies with high-yielding dairy cows.

Effects of Dietary NDF Level on Serum Reproductive Hormone Indices

LH, produced by the pituitary gland, stimulates ovarian estrogen secretion, with either excessive or deficient levels impairing conception rates. P, a natural progestogen secreted by the ovarian corpus luteum, is essential for reproduction. E2, primarily secreted by mature ovarian follicles, promotes and regulates normal

development of female reproductive organs. PRL stimulates mammary gland development and lactation. FSH primarily promotes follicular maturation and development [20]. Serum LH, P, E2, PRL, and FSH are the main reproductive hormones in lactating animals, with their concentrations generally reflecting reproductive hormone secretion status and reproductive capacity. This study demonstrated that dietary NDF level exerted varying effects on reproductive hormones, with 27% and 30% NDF levels (Groups B and C) showing significantly higher concentrations than the other two groups. Excessively high dietary NDF levels were detrimental to lactation, while appropriate NDF levels favored reproductive hormone secretion and improved reproductive performance in lactating does.

Dietary NDF level influences production performance and reproductive hormone concentrations in lactating rabbits while modestly affecting serum biochemical indices. Comprehensive analysis suggests that the optimal dietary NDF level for lactating meat rabbits is 24%–27%.

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