Effects of Dietary Yeast -Glucan Supplementation on Production Performance, Serum Biochemical Indices, and Antioxidant Capacity in Periparturient Dairy Cows (Postprint)

Authors: Gu Kuntau, Zhao Liansheng, Wang Liuxiang, Bu Dengpan, Liu Ning, Wang Jianping

Date: 2018-12-24T00:00:00+00:00

Abstract

This study aimed to investigate the effects of dietary yeast -glucan supplementation on production performance, serum biochemical indices, and antioxidant capacity in periparturient dairy cows. Forty healthy Holstein dairy cows with similar body condition score (3.63±0.06), parity (2.88±0.05), milk yield in the previous lactation [(36.86±1.06) kg/d], and expected calving date [(28±1) d] were selected and allocated to control and treatment groups (n=20 per group) using a completely randomized design. The control group was fed a basal diet, while the treatment group received a test diet supplemented with 10 g/(head · d) yeast -glucan. The experimental period lasted 49 days, including a 7-day preliminary period and a 42-day formal experimental period.

The results showed that: 1) dietary yeast -glucan supplementation significantly increased postpartum dry matter intake, milk yield, and milk protein yield ($P<0.05$), while having no significant effect on the yield and percentage of other milk components ($P>0.05$); 2) dietary yeast -glucan supplementation significantly increased postpartum serum glucose content ($P<0.05$), significantly decreased postpartum serum non-esterified fatty acids content ($P<0.05$), and tended to increase postpartum serum total protein content ($P=0.06$), with no significant effects on prepartum and postpartum serum albumin, C-reactive protein, haptoglobin, and amyloid protein contents ($P>0.05$); 3) dietary yeast -glucan supplementation significantly increased prepartum and postpartum serum glutathione peroxidase activity ($P<0.05$), and tended to decrease prepartum serum malondialdehyde content ($P=0.05$), while having no significant effects on prepartum and postpartum serum total antioxidant capacity and superoxide dismutase activity ($P>0.05$).

In conclusion, supplementation of 10 g/(head · d) yeast -glucan in the periparturient diet can increase postpartum dry matter intake, milk yield, and milk protein yield, enhance postpartum serum glucose content and serum antioxidant capacity, and reduce postpartum serum non-esterified fatty acids content in dairy cows.

Full Text

Effects of Dietary Supplementation of Yeast -Glucan on Performance, Serum Biochemical Indices and Antioxidant Capacity of Transition Dairy Cows

Gu Kuntao[1], Zhao Liansheng[2], Wang Liuxiang[3], Bu Dengpan[2], , , Liu Ning[1], Wang Jianping[1]*

[1]College of Animal Science and Technology, Henan University of Science and Technology, Luoyang 471023, China
[2]State Key Laboratory of Animal Nutrition, Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing 100193, China
[3]Lesaffre Management Co., Ltd., Shanghai 200235, China
Chinese Academy of Agricultural Sciences and World Agroforestry Centre Joint Laboratory on Agroforestry and Sustainable Animal Husbandry, Beijing 100193, China
Hunan Co-Innovation Center for Animal Production Safety, Changsha 410128, China

Abstract: This study investigated the effects of dietary yeast -glucan supplementation on production performance, serum biochemical indices, and antioxidant capacity in transition dairy cows. Forty healthy Holstein cows with similar body condition score (3.63 ± 0.06), parity (2.88 ± 0.05), previous lactation milk yield [(36.86 ± 1.06) kg/d], and expected calving date [(28 ± 1) d] were randomly allocated to control and treatment groups (n = 20 each). Cows in the control group received a basal diet, while the treatment group received the basal diet supplemented with 10 g/(head·d) yeast -glucan. The 49-day trial consisted of a 7-day preliminary period followed by a 42-day experimental period. The results demonstrated that: (1) yeast -glucan supplementation significantly increased postpartum dry matter intake, milk yield, and milk protein yield ($P < 0.05$) without affecting other milk components ($P > 0.05$); (2) supplementation significantly elevated postpartum serum glucose content ($P < 0.05$), decreased postpartum serum non-esterified fatty acid content ($P < 0.05$), and tended to increase postpartum serum total protein content ($P = 0.06$), while having no significant effects on serum albumin, C-reactive protein, haptoglobin, or amyloid A ($P > 0.05$); and (3) supplementation significantly enhanced prepartum and postpartum serum glutathione peroxidase activity ($P < 0.05$) and tended to reduce prepartum serum malondialdehyde content ($P = 0.05$), without significantly affecting total antioxidant capacity or superoxide dismutase activity ($P > 0.05$). In conclusion, dietary supplementation with 10 g/(head · d) yeast

-glucan during the transition period improved postpartum dry matter intake, milk yield, and milk protein yield, increased postpartum serum glucose and antioxidant capacity, and reduced postpartum serum non-esterified fatty acid content in dairy cows.

Keywords: yeast -glucan; transition dairy cow; performance; biochemical index; antioxidant capacity

Introduction

The transition period, encompassing the three weeks before and after parturition, represents a critical phase when dairy cows undergo dramatic physiological changes from dry to lactating status and from pregnancy to non-pregnancy [1]. During this time, cows experience severe metabolic shifts, compromised immunity, reduced disease resistance, and decreased feed intake, placing them in a state of physiological stress [2]. These challenges predispose cows to various diseases including mastitis, ketosis, and metritis, which subsequently impair reproductive performance and milk production [3]. Therefore, enhancing stress resistance during the transition period is of paramount importance.

Yeast -glucan, a primary component of yeast cell walls, is a highly bioactive structural polysaccharide composed of -1,3-D-glucopyranoside repeating units linked by -1,3 and -1,6 bonds [4]. Research has demonstrated that yeast -glucan can enhance non-specific immune function, improve intestinal microenvironment, modulate gut microbiota, inhibit pathogenic bacteria proliferation, and consequently improve animal performance, stress resistance, and immune capacity [5-7]. Zhou et al. [8] reported that dietary yeast -glucan optimized intestinal microbial structure, stimulated rumen-reticulum development, and improved performance in early-weaned calves. Additionally, yeast -glucan has been shown to enhance antioxidant enzyme activities in animals. Liu et al. [9] found that -glucan supplementation increased serum glutathione peroxidase (GSH-Px) and superoxide dismutase (SOD) activities by 0.64% and 50.80%, respectively, while decreasing malondialdehyde (MDA) content by 49.81% in *Litopenaeus vannamei*. Although the efficacy of yeast -glucan as a microecological preparation has been established in monogastric animals [10], young ruminants [11], and aquatic species [6], no studies have investigated its effects on production performance, blood biochemical indices, and antioxidant capacity in transition dairy cows. Therefore, this experiment was conducted to explore these effects and provide reference data for practical application in dairy production.

Materials and Methods

1.1 Yeast -Glucan Source

The yeast -glucan used in this study was produced by Lesaffre Group (France) with the following composition: 70% -glucan, 4% protein, 2% fat, 5% mannan oligosaccharide, 5% ash, 4% moisture, and 10% other polysaccharides.

1.2 Experimental Animals and Design

A completely randomized design was employed using 40 healthy dry Holstein cows with similar body condition score (3.63 ± 0.06), parity (2.88 ± 0.05), previous lactation milk yield [(36.86 ± 1.06) kg/d], and expected calving date [(28 ± 1) d]. Cows were randomly divided into two groups of 20 animals each. The control group received a basal diet, while the experimental group received the basal diet supplemented with 10 g/(head · d) yeast -glucan. Supplementation began 21 days before expected calving, with the product sprinkled on the basal diet surface during morning feeding to ensure complete consumption. The trial lasted 49 days (7-day preliminary period + 42-day experimental period) and was conducted at Aoya Modern Dairy Farm in Dongying, Shandong Province from December 1, 2016 to January 18, 2017.

1.3 Diets and Management

Diets were formulated according to NRC (2001) dairy cattle standards and fed as total mixed rations (TMR). Diet composition and nutrient levels are presented in Table 1 . Cows were housed in free-stall barns with bedding and fed twice daily (07:00 and 14:00) with *ad libitum* access to water, maintaining 5-10% refusals. Postpartum cows were milked three times daily (07:00, 14:00, and 20:00) using a DeLaval PR3100HD automatic rotary milking system.

1.4 Sample Collection and Analysis

1.4.1 Feed Sampling and Analysis During the final three days of each week of the experimental period, feed offered and refused was recorded daily for each group to calculate intake. Diet and refusal samples were collected using the quartering method, dried to constant weight at 65°C in a DGG-9203A drying oven, ground through a 2-mm sieve using a RETSCH-SM100 cutting mill, and stored for dry matter (DM) analysis to calculate dry matter intake (DMI). DM, crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF) contents were determined according to Zhang [12].

1.4.2 Milk Sampling and Analysis Daily milk yield was recorded individually after calving. On the last day of each week postpartum, normal milk samples were collected and pooled in a 4:3:3 ratio (morning:afternoon:evening). A 50-mL aliquot was preserved with bronopol and immediately transported to Beijing Dairy Center for quality testing. Milk composition was analyzed using

a FOSS MilkoScan™ FT6000 analyzer. The 4% fat-corrected milk yield was calculated as: 4% FCM (kg/d) = 0.4 × milk yield (kg/d) + 15 × milk fat yield (kg/d).

1.4.3 Blood Sampling and Analysis Blood samples (10 mL) were collected from the tail vein using vacuum tubes before morning feeding on days 21 and 7 prepartum, at 2 h postpartum, and on days 3, 7, 15, and 21 postpartum. After 30 min at room temperature, serum was harvested by centrifugation at 3,000 × g for 15 min at 4°C, aliquoted into 500- L sterile tubes, and stored at -20°C. Serum total antioxidant capacity (T-AOC), SOD and GSH-Px activities, and MDA and non-esterified fatty acid (NEFA) contents were measured using kits from Nanjing Jiancheng Bioengineering Institute. Serum glucose (GLU) was determined by glucose oxidase method, total protein (TP) by biuret method, and albumin (ALB) by bromocresol green method. Serum haptoglobin (Hp), amyloid A (AA), and C-reactive protein (CRP) were measured by competitive ELISA at Beijing Huaying Biotechnology Institute.

1.5 Statistical Analysis

Data were analyzed using the PROC MIXED procedure of SAS 9.4, with results presented as least squares means. Cow was considered a random effect, and treatment a fixed effect. Multiple comparisons were performed using Duncan' s method. Significance was declared at $P < 0.05$, and trends were noted at 0.05 $P < 0.10$.

Results

2.1 Effects of Yeast -Glucan on Performance of Transition Holstein Cows

As shown in Table 3 , prepartum DMI did not differ between groups ($P > 0.05$), but postpartum DMI increased by 9.66% in the treatment group ($P < 0.05$). Milk yield was significantly higher in the treatment group (1.68 kg/d increase; $P < 0.05$), as was milk protein yield (0.09 kg/d increase; $P < 0.05$). Milk fat percentage, lactose percentage, and milk protein percentage did not differ significantly between groups ($P > 0.05$).

2.2 Effects of Yeast -Glucan on Serum Biochemical Indices of Transition Holstein Cows

Table 4 shows that serum TP and ALB contents did not differ significantly between groups ($P > 0.05$), though postpartum TP tended to be higher in the treatment group ($P = 0.06$). Postpartum serum GLU content increased by 9.43% in the treatment group ($P < 0.05$), while postpartum serum NEFA content decreased by 17.92% ($P < 0.05$). Serum CRP, AA, and Hp contents showed no significant differences between groups at either time point ($P > 0.05$).

2.3 Effects of Yeast - Glucan on Serum Antioxidant Capacity of Transition Holstein Cows

As presented in Table 5 , serum MDA content was reduced by 29.71% prepartum and 8.54% postpartum in the treatment group, though these differences were not statistically significant (P > 0.05). Serum GSH-Px activity increased by 58.25% prepartum and 27.00% postpartum (P < 0.01). Serum T-AOC and SOD activity showed numerical increases (5.14% and 5.32% prepartum; 1.96% and 8.20% postpartum) but did not differ significantly (P > 0.05).

Discussion

3.1 Effects of Yeast -Glucan on Performance of Transition Holstein Cows

Similar to other functional oligosaccharides, yeast -glucan can promote the proliferation of beneficial bacteria such as lactobacilli while reducing pathogenic *E. coli*, thereby improving animal performance [13-14]. Zhou et al. [8] demonstrated that yeast -glucan significantly increased rumen papilla length (1,059.05 m vs. 1,521.82 m), width (392.95 m vs. 457.16 m), and mucosal thickness (1,310.77 m vs. 1,679.56 m) in early-weaned calves, promoting rumen development and microbial modulation. Wei et al. [15] reported improved daily gain and rumen microbial balance in early-weaned lambs supplemented with yeast -glucan. Dritz et al. [11] and Schoenherr et al. [14] found that 0.025% -glucan supplementation increased feed intake and daily gain in weaned piglets.

In the current study, yeast -glucan supplementation increased postpartum DMI, milk yield, and milk protein yield by 9.66%, 1.68 kg/d, and 0.09 kg/d, respectively. These improvements may be attributed to enhanced proliferation of rumen lactobacilli and cellulolytic bacteria, which improved fiber digestion and moderated postprandial pH decline, thereby stabilizing the rumen environment. Additionally, the release of flavor compounds from ruptured yeast cells may have increased palatability, stimulating feed intake and milk production. Furthermore, yeast -glucan may have improved rumen microbial protein concentration and quality, facilitating intestinal milk protein synthesis and increasing milk protein yield.

3.2 Effects of Yeast -Glucan on Serum Biochemical Indices of Transition Holstein Cows

Serum TP and ALB reflect protein absorption, synthesis, and catabolism, with normal ranges of 67.4-74.6 g/L and 29.0-36.6 g/L, respectively [16]. In this study, yeast -glucan had no significant effect on serum TP and ALB, which remained within normal ranges, consistent with Ma et al. [17]. However, the numerical increase in postpartum TP may reflect enhanced cellulolytic bacterial activity, improved fiber digestion and lactate utilization, and increased microbial protein flow to the duodenum.

Serum GLU serves as a key indicator of energy balance, with low levels signaling energy deficiency [18]. NEFA is produced from triglyceride mobilization in adipose tissue during negative energy balance, and elevated NEFA can induce oxidative stress by inhibiting GSH-Px activity and generating reactive oxygen species in mitochondria [19]. The present study showed that yeast -glucan significantly increased serum GLU while decreasing NEFA, likely due to improved antioxidant capacity and DMI, which enhanced gluconeogenesis and alleviated negative energy balance and lipid mobilization.

-Glucan can modulate the balance between interleukin-1 and its receptor antagonist, reducing acute-phase protein synthesis and associated nutrient consumption while improving performance [11,20]. Haptoglobin, amyloid A, and C-reactive protein are acute-phase proteins that change dramatically in response to stressors such as infection, inflammation, or trauma [21-22]. Lei et al. [23] reported reduced plasma Hp, AA, and CRP in beef cattle fed yeast cell wall, while Dritz et al. [11] found decreased Hp in weaned piglets supplemented with -glucan. However, the current study observed no significant effects on acute-phase proteins, warranting further investigation.

3.3 Effects of Yeast -Glucan on Serum Antioxidant Capacity of Transition Holstein Cows

As an immunologically active polysaccharide, yeast -glucan effectively scavenges free radicals, prevents damage from hydrogen peroxide and reactive oxygen species, and enhances antioxidant enzyme activity while reducing cytotoxic effects of oxidation products, thereby protecting membrane integrity [6,24]. GSH-Px is a ubiquitous antioxidant enzyme that catalyzes hydrogen peroxide decomposition, protecting macromolecules from oxidative damage. MDA, a primary product of lipid peroxidation initiated by free radicals attacking polyunsaturated fatty acids, can cause cellular damage and reduce antioxidant enzyme activities [25-26].

Liu et al. [27] found that 400 mg/kg -glucan supplementation significantly increased plasma GSH-Px activity in weaned piglets, while Duan [28] reported improved antioxidant capacity and reduced MDA in early-weaned piglets fed 0.025% -glucan. In the present study, yeast -glucan significantly increased serum GSH-Px activity and tended to reduce prepartum MDA, effectively enhancing antioxidant capacity, decreasing lipid peroxidation, and alleviating oxidative stress in transition dairy cows.

Conclusion

Under the conditions of this experiment, dietary supplementation with 10 g/(head · d) yeast -glucan during the transition period improved postpartum dry matter intake, milk yield, and milk protein yield, increased postpartum serum glucose content and antioxidant capacity, and reduced postpartum serum non-esterified fatty acid content in dairy cows.

References

[1] Ren WQ, Zhou EY, Chang YY, et al. Causes and preventive measures of transition period diseases in dairy cows [J]. Contemporary Animal Husbandry, 2017(12): 14-16.

[2] Hao HX, Liu GL, Zhang PH. Effects of dietary selenium on performance and oxidative stress status of transition dairy cows [J]. Heilongjiang Animal Science and Veterinary Medicine, 2017(13): 40-45, 48.

[3] Greenfield RB, Cecava MJ, Johnson TR, et al. Impact of dietary protein amount and rumen undegradability on intake, peripartum liver triglyceride, plasma metabolites, and milk production in transition dairy cattle [J]. Journal of Dairy Science, 2000, 83(4): 703-710.

[4] Sun HS, Li GY. Effects of selenium polysaccharide and yeast glucan on two antioxidant enzyme activities in hemolymph of *Chlamys farreri* [J]. Chinese Marine Drugs, 2000, 19(5): 20-23.

[5] Cao JM, Wu CY, Huang YH, et al. Effects of -glucan on immune and antioxidant indices of *Lateolabrax japonicus* [J]. Fisheries Science, 2015, 34(1): 1-7.

[6] Li YJ, Cao JM, Zhao HX, et al. Research progress on the role of -glucan in nutritional physiology of aquatic animals [J]. Guangdong Agricultural Sciences, 2014, 41(21): 128-134, 143.

[7] Gu M, Ma HM, Mai KS, et al. Effects of dietary -glucan, mannan oligosaccharide and their combinations on growth performance, immunity and resistance against *Vibrio splendidus* of sea cucumber, *Apostichopus japonicus* [J]. Fish & Shellfish Immunology, 2011, 31(2): 303-309.

[8] Zhou Y, Diao QY, Tu Y, et al. Effects of yeast -glucan on gastrointestinal development in early-weaned calves [J]. Chinese Journal of Animal Nutrition, 2009, 21(6): 846-852.

[9] Liu QF, Cao JM, Huang YH, et al. Combined effects of -glucan with selenium and vitamin E on growth, serum immune and antioxidant indices and disease resistance of *Litopenaeus vannamei* [J]. Journal of Fishery Sciences of China, 2013, 20(5): 997-1006.

[10] Dritz SS, Shi J, Kielian TL, et al. Influence of dietary -glucan on growth performance, nonspecific immunity, and resistance to *Streptococcus suis* infection in weanling pigs [J]. Journal of Animal Science, 1995, 73(11): 3341-3350.

[11] McKee C, Eicher S, Johnson T. Ascorbic acid and a beta-glucan product *Saccharomyces cerevisiae* influence dairy calf well-being [J]. Journal of Dairy Science, 2000, 83(Suppl. 1): 134.

[12] Zhang LY. Feed Analysis and Quality Testing Technology [M]. 3rd ed. Beijing: China Agricultural University Press, 2007: 56-56, 67-78.

[13] Pan SD, Li XJ, Bian LQ, et al. Effects of yeast -glucan on intestinal microflora in weaned piglets [J]. Feed Industry, 2012, 33(12): 21-23.

[14] Schoenherr WD, Pollmann DS, Coalson JA. Titration of MacroGard-TM-S on growth performance of nursery pigs [J]. Journal of Animal Science, 1994, 72(Suppl. 2): 57.

[15] Wei ZH, Li C, Li FD, et al. Effects of yeast -glucan on performance and feeding behavior of early-weaned lambs [J]. Acta Prataculturae Sinica, 2013, 22(4): 212-219.

[16] Wang L, Lü YY, Cheng ZW, et al. Effects of compound yeast culture on performance, nitrogen excretion and blood biochemical indices of dairy cows [J]. Acta Prataculturae Sinica, 2015, 24(12): 121-130.

[17] Ma T, Tu Y, Zhang NF, et al. Effects of dietary yeast -glucan on nutrient digestibility and serum profiles in pre-ruminant Holstein calves [J]. Journal of Integrative Agriculture, 2015, 14(4): 749-757.

[18] Shao W, Zhao YK, Zhang XX, et al. Effects of probiotics on performance and serum biochemistry of Xinjiang Holstein cows [J]. Feed Industry, 2015, 36(17): 47-50.

[19] Guo YM, Yan SM. Induction of oxidative stress by non-esterified fatty acids and its mechanism in dairy cows [J]. Chinese Journal of Animal Nutrition, 2017, 29(5): 1469-1474.

[20] Eurell TE, Bane DP, Hall WF, et al. Serum haptoglobin concentration as an indicator of weight gain in pigs [J]. Canadian Journal of Veterinary Research, 1992, 56(1): 6-9.

[21] Ebersole JL, Cappelli D. Acute-phase reactants in infections and inflammatory diseases [J]. Periodontology 2000, 2000, 23(1): 19-49.

[22] Li HY, Zhong RZ, Fang Y, et al. Research progress on application of acute-phase proteins in animal health monitoring [J]. Heilongjiang Animal Science and Veterinary Medicine, 2015(15): 68-71.

[23] Lei CL, Dong GZ, Jin L, et al. Effects of dietary supplementation of montmorillonite and yeast cell wall on lipopolysaccharide adsorption, nutrient digestibility and growth performance in beef cattle [J]. Livestock Science, 2013, 158(1/2/3): 57-63.

[24] Tang MY, Lin DM. Research progress on application of yeast cell wall polysaccharides in feed [J]. Feed and Animal Husbandry, 2016(3): 44-48.

[25] Lei JL, Wu SQ, Wang LL, et al. Comparative study on serum GSH-Px, SOD, and MDA in transition dairy cows [J]. China Dairy Cattle, 2008(6): 38-43.

[26] Cheng Y. Effects of yeast culture on immune function, antioxidant capacity and performance of dairy cows with subclinical mastitis [D]. Master' s thesis. Hohhot: Inner Mongolia Agricultural University, 2007.

[27] Liu JY, Wang Y, Mao JX, et al. Effects of dietary -glucan supplementation on growth performance, intestinal development and immune function in piglets [J]. Chinese Journal of Veterinary Science, 2017, 37(11): 2197-2205.

[28] Duan LJ. Effects of -glucan on performance and immune function of early-weaned piglets [D]. Master's thesis. Shenyang: Shenyang Agricultural University, 2006.

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