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Original Research

Effects of *Lactobacillus rhamnosus* Supplementation on Growth Performance, Immune Function, and Antioxidant Capacity of Newborn Foals

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A B S T R A C T

This study aimed to explore the effects of *Lactobacillus rhamnosus* GG (LGG) supplementation on the growth performance, immune function, and antioxidant capacity of foals. Fifteen newborn foals with similar birth weight (51.67 ± 6.07 kg) and good health were randomly assigned to three groups: control group and test groups I and II, which were supplemented with 5.0×10^9 CFU/day and 1.0×10^{10} CFU/day 100211 0 0

increase the number of neutrophils, improve phagocytosis, and increase immunoglobulin expression [16].

Lactobacillus rhamnosus GG (LGG) is a gram-positive facultative anaerobic bacterium first

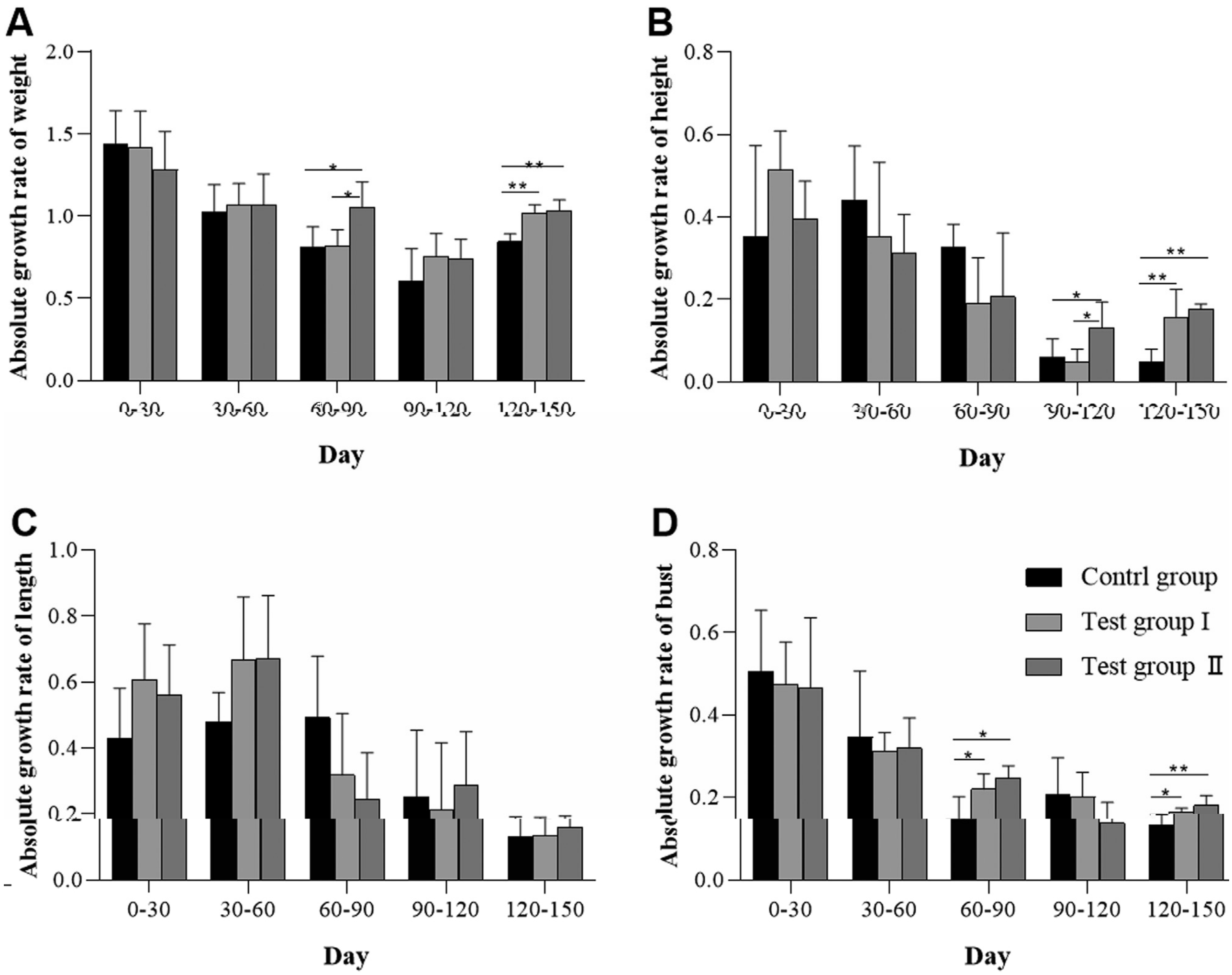
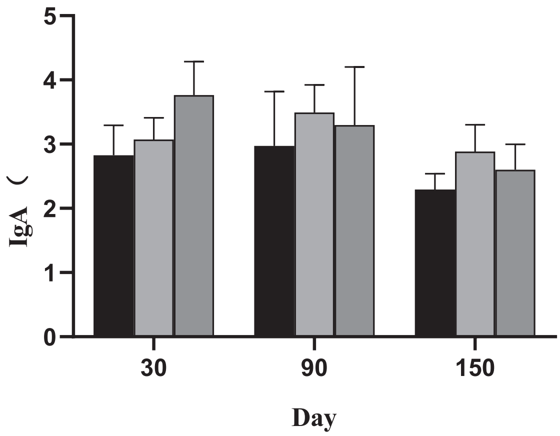


Fig. 1. Effect of supplementary LGG feeding on foal growth. (A) is the daily average body weight increase, (B) is the daily average body height increase, (C) is the daily average body length increase, and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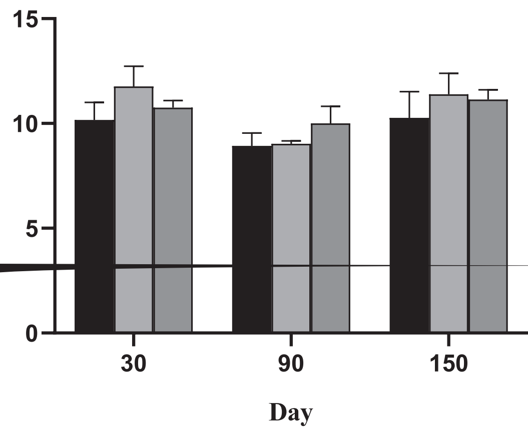
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bacterial structure of LGG can also enhance intestinal development in animals. In the present study, newborn foals were supplemented with LGG. LGG did not significantly alter the growth of young foals initially. However, the daily gains in weight, height, and chest circumference significantly increased with time. This finding may be attributed to the LGG count and duration of LGG colonization and function in the animals' gastrointestinal tract.

Newborn foals obtain their immunoglobulins mainly through breast milk, which contains a high concentration of IgA and IgG. Most of the IgA remains in the intestinal mucosa to strengthen its immunological barrier function, whereas IgG enters the bloodstream through the small intestinal wall to participate in humoral immunity. Studies have shown that adding LGG to infant food can effectively improve the immunoglobulin content in blood. Yan et al. [27] found that LGG gavage can effectively promote mouse growth and significantly improve IgA production. In the present study, supplementary LGG feeding could effectively increase plasma IgA and IgG levels in foals, particularly at 30 and 150 days. High dose LGG could more effectively increase IgA and IgG plasma levels and improve the humoral immunity of foals.

Grabig et al. [28] found that supplementation with probiotics can effectively increase the expression of TLR4, which activates MyD88 and NF-κB signaling to increase the expression of proinflammatory factors. Yoo et al. [29] reported that some bacteria produce SCFAs by fermenting carbohydrates to regulate host immune cells and provide a carbon source for colon cells. Studies have shown that lactic acid bacteria and their cell wall components can act on human peripheral blood mononuclear cells and promote TNF-α, IL-6, and IL-10 secretion, thereby enhancing immunity. For instance, Miettinen et al. [30] showed that LGG can act on cytokines in animal blood and promote TNF-α, IL-6, and IL-10 production, which can alleviate immune system disorders caused by the intake of pathogenic bacteria. Other studies have shown that LGG can inhibit inflammatory responses. For example, LGG can inhibit the signal transduction of lipopolysaccharide receptor TLR4, p65/NF-kB, p38/MAPK, and ERK1/2 and downregulate TNF-α and IL-6 through TLR4 and TLR9 expression to reduce the inflammatory response [31–34]. Zhang et al. [35] showed that adding LGG to the diet of weaned piglets can inhibit the increase in IL-6, IL-1β, and TNF-α expression caused by *Escherichia coli* and reduce the inflammatory response of piglets. Additionally, Pena et al. [36] cultivated intestinal mouse microorganisms in vitro and showed that LGG can act on macrophages and inhibit TNF-α secretion to alleviate and prevent intestinal inflammation; however, the effect on IL-10 was not significant, and the mechanism by which LGG acts on macrophages remains unclear. In the present study, LGG promoted the inflammatory response of foals in the early stage of the study, increasing IL-6, IL-1β, and TNF-α secretion. In later stages, LGG inhibited the expression of proinflammatory factors and upregulated IFN-γ to reduce the inflammatory damage to cells. Wu [37] proposed that probiotics may act as microbial antigens in the underdeveloped digestive tract of young animals, stimulate the regulation of intestinal mucosal immunity, promote the expression of TLRs, and stimulate the production of downstream cytokines. Wu [37] demonstrated that LGG stimulated the innate immunity of foals when they were young, improves their defense against pathogens, and inhibited the inflammatory response caused by pathogens at the age of 150 days.

Animals contain a high concentration of unsaturated fatty acids, which are susceptible to free radical damage, thus producing cytotoxic peroxides [38]. In the normal state, the free radicals in the body are balanced, but when stimulated by drugs, inflammation, and emotional tension, the level of free radicals increases markedly, causing damage to animal cell structure and organs. T-AOC reflects the body's ability to compensate for external stimuli and the strength of the body's free radical metabolism [39]. SOD eliminates the toxicity of superoxide anion, protecting cells from oxidative damage [40]. CAT can decompose hydrogen peroxide in the body and prevent the formation of free radicals. GSH-Px is an important enzyme for scavenging organic hydroperoxides that replaces catalase and scavenges hydrogen peroxide in tissues with low catalase concentration. MDA, a product of free radical-induced lipid peroxidation, exhibits cytotoxicity and genotoxicity

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