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The Effects of Brewer's Yeast on Growth Performance, Rumen Fermentation, and Serum Antioxidant Markers in Beef Cattle

Mingming Jiang[1]*, Yanling Zheng[5], Daoping Ren[2], Qudrat Ullah[3], Muhammad Zahoor Khan[4]* and Yulin Ma[5]*

[1]Department of Animal Science and Technology, Heilongjiang Agricultural Economy Vocational College, Mudanjiang, Heilongjiang 157041, China
[2]Heilongjiang Jinxiang Biochemical Co., Ltd., Harbin, Heilongjiang 150000, China
[3]Department of Theriogenology, Faculty of Veterinary and Animal Sciences, Cholistan University of Veterinary and Animal Sciences, Bahawalpur, Punjab, Pakistan
[4]College of Agricultural Sciences and Engineering, Liaocheng University, Liaocheng 252000, China
[5]College of Animal Science and Technology, Ningxia University, Yinchuan, Ningxia 750021

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Key words
Beef cattle, Brewer's yeast, Growth performance, Rumen fermentation, Antioxidant capacity

ABSTRACT

This study aimed to investigate the impact of brewer's yeast supplementation on the productive performance, rumen fermentation, and serum antioxidant capacity of Simmental × Charolais crossbred beef cattle. Forty healthy beef cattle with same body weights (201 ± 6 kg) were randomly assigned to either a control group (CON) or a brewer's yeast (100 g/head/day) supplementation group (SC), each consisting of 20 animals. The experimental period spanned 120 days. Results revealed significant improvements in the SC group compared to the CON group. Specifically, the final body weight (P=0.043) and average daily gain (P=0.027) of the beef cattle in the SC group significantly increased, while the feed conversion ratio demonstrated a significant reduction (P=0.003). Furthermore, the rumen fermentation profile of the SC group indicated noteworthy alterations, with significantly higher concentrations of acetic acid (P<0.001), total volatile fatty acids (P<0.001), and an increased acetic acid/propionic acid ratio (P=0.021), coupled with a significant decrease in ammonia peptide nitrogen content (P<0.001). In terms of serum antioxidant capacity, the SC group exhibited significantly greater concentrations of total antioxidant capacity, total superoxide dismutase, and glutathione peroxidase compared to the control group (P<0.05). Conversely, malondialdehyde levels were significantly lower in the SC group (P<0.001). In conclusion, the incorporation of brewer's yeast into the diet of beef cattle yielded substantial improvements in growth performance, rumen fermentation characteristics, and antioxidant levels. These findings underscore the potential of brewer's yeast supplementation as a beneficial dietary strategy in enhancing the overall health and productivity of Simmental × Charolais crossbred beef cattle.

INTRODUCTION

Efficient feeding and management practices during the growth phase are pivotal in shaping production performance including the growth performance and economic returns of cattle (Ren *et al*., 2024; Khan *et al*., 2020a, b, 2022, 2023, 2024; Huang *et al*., 2023; Xiao *et al*., 2021). The evolving landscape of the beef cattle industry underscores the growing interest in precision nutrition as a means to optimize growth and health by precisely modulating nutrition at various physiological stages. Yeast cultures, recognized as probiotics rich in oligosaccharides, organic acids, vitamins, and other essential nutrients, have garnered attention in this context (Ogbuewu *et al*., 2023; Razzaghi *et al*., 2023). Various studies have highlighted their potential to enhance palatability of the diet and stimulate feed intake (Song *et al*., 2021). The ruminant's rumen, a pivotal organ for nutrient absorption and transport, is profoundly influenced by dietary components.

* Corresponding author: 15046336911@163.com, ma18810318038@163.com, zahoorcau@cau.edu.cn
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Incorporating yeast cultures into the diet at a rate of 80 g/ head day has been shown to significantly increase the cattle beef propionic acid content (Jiao *et al*., 2019). Consistently, a study by incorporating monensin into beef cattle feed to enhance the rumen environment and raise the rumen pH value, rumen acidosis can be alleviated (Simanungkalit *et al*., 2023). Numerous studies have demonstrated that brewer's yeast has the potential to elevate rumen pH, ultimately enhancing the growth performance and feed digestibility of beef cattle (Nardi *et al*., 2023; Rients *et al*., 2023). Furthermore, brewer's yeast supplementation has been associated with shifts in the microbial composition within the rumen, favoring cellulolytic and lactate-utilizing microorganisms, ultimately improving ruminal pH and mitigating sub-acute ruminal acidosis (Jiang *et al*., 2017). In beef cattle production, diets often contain a substantial proportion of concentrates, which can predispose animals to ruminal acidosis. An analogous study in beef cattle demonstrated that supplementing yeast cultures in the diet improved growth performance and rumen fermentation parameters (Geng *et al*., 2016). Despite the widespread adoption of yeast cultures in animal production, comprehensive research, particularly in the context of beef cattle, remains limited, with a paucity of studies examining their impact on antioxidant capacity. This study delves into the effects of incorporating yeast cultures into the diets of Simmental x Charolais beef cattle, evaluating their influence on growth performance, ruminal fermentation characteristics, and serum antioxidant capacity. The outcomes of this investigation aim to establish a theoretical framework for the application of yeast cultures in beef cattle nutrition, addressing both performance and health aspects.

MATERIALS AND METHODS

Experimental materials

The brewer's yeast was provided by Heilongjiang Jinxiang Biotechnology Co., Ltd. The nutritional composition of the brewer's yeast included a crude protein content of 18%, crude fat content of 4%, crude fiber content of 28%, crude ash content of 9%, and a dry matter content of 92% and the SC biological activity is 1.2 x 10^9.

Experimental design

A single-factor completely randomized design was employed in this experiment. Forty-one-year-old healthy Simmental crossbred beef cattle with a body weight of (201±6) kg were selected and randomly divided into two groups: the control group (CON; fed with basal diet) and the brewer's yeast group (SC; basal diet supplemented with 100 g of brewer's yeast). Furthermore, each group had 4 replicates, with 5 cattle in each replicate.

Experimental cattle management

The formulation of the experimental cattle diet followed the standards for beef cattle feeding (NY/T815-2004) and was prepared as a total mixed ration (TMR) for feeding. The diet formulation and nutritional levels are shown in Table I. The experimental cattle were fed three times a day and had free access to water. The experiment lasted for a total of 120 days, including an initial 15-days pre-feeding period (CON: fed with basal diet; SC: basal diet supplemented with 100 g of brewer's yeast).

Growth performance

At the beginning and end of the experiment, cattle were weighed in the morning before feed delivery, and the feed intake of both groups was recorded once a week. The average daily gain, average daily feed intake, and feed-to-gain ratio were calculated for both groups using the following formulas:

Average daily gain: (final weight-initial weight)/ number of experimental days

Average daily feed intake: total feed intake/(number of experimental days × number of cattle)

Feed to gain ratio: average daily feed intake/ average daily gain

Table I. Basal diet and nutritional levels (on a dry matter basis %).

Composition of ingredients	Contents	Nutrient levels[2]	Contents
Corn silage	40.6	Crude protein (%)	8.22
Wheat straw	18.2	Neutral detergent fibre (%)	35.64
Corn	23.8	Acid detergent fibre (%)	18.88
Soybean meal	8.5	Calcium (%)	0.75
Wheat bran	6.5	Phosphorus (%)	0.54
Sodium bicarbonate	0.4	Net Energy (MJ/kg)	6.22
Premix [1]	2.0		

1, The premix provides per kilogram of feed: VA 4,000 IU, VD 1,020 IU, VE 25 mg, iron 42 mg, copper 13 mg, zinc 55 mg, manganese 57 mg, cobalt 0.15 mg, iodine 0.23 mg, selenium 0.23 mg. 2, Nutrient levels are calculated values, the rest are measured values

Rumen fluid determination

At the end of the experiment, 100 mL of rumen fluid was collected from the oral cavity using a gastric tube type Rumen fluid sampler (MDW-15, Shanghai Sili Corporation), filtered through 4 layers of gauze, pH was immediately determined using a pH meter (SevenGo™ PH-SG2, Shanghai Zanxing Instrument Technology Co., LTD.), and then divided into 10 mL centrifuge tubes and immediately taken to the laboratory for the determination of VFA and ammonia nitrogen indicators.

Blood antioxidant indicators

On the 120th day of the experiment, 10 cattle were randomly selected from each group, and 10 mL of fasting blood was collected from the tail vein. The collected blood was centrifuged at 3000 rpm for 10 min. The supernatant was transferred to 2.0 mL Eppendorf tubes and stored at -20°C for the measurement of total antioxidant capacity (T-AOC), glutathione peroxidase (GSH-Px), catalase (CAT), malondialdehyde (MDA), and superoxide dismutase (SOD) in the serum. According to the manufacturer's instructions, a commercial colorimetric assay kit (Nanjing Jiancheng Bioengineering Institute, Nanjing, China, Kit# ab65329) was used to measure the activities of GSH-Px, SOD, T-AOC, CAT and MDA, concentrations in the serum.

Data analysis

Preliminary data organization was conducted using Excel 2007, with data presented as means. Average daily gain, average dry matter intake, and feed-to-gain ratio are statistically analyzed on a per-pen basis (n=4). Statistical analysis was performed using SPSS 24.0, with a significance level set at $P < 0.05$.

RESULTS

Beef cattle growth performance

As shown in Table II, compared to the CON group, the SC group significantly improved the final weight (P=0.043) and average daily gain (P=0.027) of beef cattle, while significantly reducing the feed-to-gain ratio (P=0.003). There were no significant differences in initial weight and average dry matter intake between the two groups (P>0.05).

Rumen fermentation in beef cattle

From Table III, it can be observed that compared to the control group, the SC group significantly increased the content of acetic acid and total volatile fatty acids (P<0.001) in the rumen of beef cattle. Additionally, the acetic acid/propionic acid ratio was significantly higher in the SC group (P= 0.021). There were no significant differences in propionic and butyric acid content between the two groups (P>0.05). The SC group also significantly reduced the content of ammonia nitrogen in the rumen of beef cattle (P<0.001).

Table II. Effects of brewer's yeast on beef cattle growth performance.

Parameters	Groups		SEM	P value
	CON	SC		
Initial weight (kg)	200.82	201.32	8.437	0.886
Final weight (kg)	310.43	331.82	6.516	0.043
Average daily gain (kg/d)	0.91	1.09	0.012	0.027
Average dry matter intake (kg/d)	7.34	7.46	0.547	0.613
Feed conversion ratio	8.07	6.84	0.243	0.003

CON, control group; SC, yeast additive group; The same applies to the table below. Average daily gain, average dry matter intake, and feed to gain ratio are statistically analyzed on a per-pen basis (n=4).

Table III. Effect of brewer's yeast on rumen fermentation in beef cattle.

Parameters	CON	SC	SEM	P-value
Acetic acid (mmol/L)	65.47	70.99	0.29	<0.001
Propionic acid (mmol/L)	14.82	15.10	0.17	0.679
Butyric acid (mmol/L)	8.33	8.41	0.07	0.416
Total volatile fatty acids (mmol/L)	56.25	59.82	0.13	<0.001
Acetic acid/Propionic acid ratio	4.42	4.70	0.05	0.021
Ammonia nitrogen (mg/dL)	8.36	7.73	0.09	<0.001

For abbreviations, see Table III.

Table IV. Effect of brewer's yeast on serum antioxidant indices in beef Cattle.

Parameters	CON	SC	SEM	P-value
MDA (μmol/L)	4.60	3.32	0.065	<0.001
T-AOC/(U/mL)	8.32	10.24	0.087	<0.001
SOD/(U/mL)	132.40	155.15	0.894	<0.001
CAT/(U/mL)	5.57	5.91	0.075	0.831
GSH-Px/(U/mL)	128.80	156.30	1.290	<0.001

MDA, malondialdehyde; T-AOC, total antioxidant capacity; SOD, superoxide dismutase; CAT, catalase; GSH-Px, glutathione peroxidase

Serum antioxidant indices in beef cattle

As shown in Table IV, compared to the control group, the SC group exhibited a significant decrease in the

content of MDA in the serum of beef cattle (P<0.001). At the same time, the SC group showed a significant increase in the levels of T-AOC, SOD, and GSH-Px in the serum of beef cattle (P<0.001). However, there was no significant difference in CAT content in the serum of the two groups (P=0.831).

DISCUSSION

This study emphasizes the importance of the growth and fattening phase in beef cattle feeding management. Brewer's yeast supplementation in cattle diets has shown significant benefits. Cattle receiving brewer's yeast exhibited a 6.4% increase in final body weight and a remarkable 16.5% surge in average daily gain, demonstrating its positive impact on growth. Additionally, the feed to gain ratio decreased by 17.9%, indicating improved nutrient utilization and feed conversion efficiency, which can benefit cattle producers economically. Brewer's yeast also plays a role in rumen health by regulating microbial populations, improving nutrient degradation, and promoting efficient nutrient absorption. It reduced rumen ammonia nitrogen content, enhanced rumen fermentation dynamics, and served as an energy source. Brewer's yeast reduced oxidative stress, indicated by a decrease in serum MDA content and an increase in T-AOC and SOD levels in cattle serum. These effects contribute to improved antioxidant capacity and overall health in cattle.

Previous research endeavors have corroborated these findings by demonstrating that the supplementation of cattle diets with 30g/day of brewer's yeast substantially amplifies the digestibility of essential constituents, including dry matter, neutral detergent fiber, and acid detergent fiber (Gao and Geng, 2022). This augmentation in digestibility may serve as a direct causal factor for the observed improvements in growth performance attributed to brewer's yeast supplementation. Analogous effects have been observed in calf feeding trials, wherein brewer's yeast supplementation precipitated noteworthy increments in average daily gain, body length, and chest circumference among the calves (Maamouri and Ben Salem, 2022). Collectively, these findings substantiate the hypothesis that the judicious inclusion of brewer's yeast within ruminant diets engenders the prospect of ameliorated growth performance. This improvement may be ascribed to the multifaceted composition of brewer's yeast, which not only furnishes an abundance of nutrients but also encompasses organic acids and digestive enzymes that orchestrate the regulation of rumen microbial populations, facilitate the degradation of nutrients within the diet, and stimulate the efficient absorption of nutrients by the rumen epithelium (Maamouri and Ben Salem, 2022; Mcfarland, 2021).

Preservation of a stable rumen environment holds paramount importance in ensuring animal well-being and facilitating optimal growth. The composition of volatile fatty acids and ammonia nitrogen within the rumen serves as a reliable reflection of nitrogen utilization efficiency and represents a pivotal parameter for assessing rumen health. Ammonia nitrogen content within the rumen is indicative of the body's nitrogen utilization. Within the scope of this investigation, the cohort subjected to brewer's yeast supplementation exhibited a significant reduction in rumen ammonia nitrogen content, indicative of an augmented ammonia metabolism. This observation strongly implies that brewer's yeast supplementation exerts a supportive role in the synthesis of microbial proteins. Previous research has reported consistent findings, highlighting that the incorporation of brewer's yeast into dietary regimens significantly elevates rumen microbial protein synthesis (Carpinelli *et al*., 2021), in congruence with the diminished ammonia nitrogen content noted within the yeast culture-treated group.

Volatile fatty acids present within the rumen primarily serve as an energy source for the organism. Within this study, the yeast culture-treated group displayed notable elevations of 7.8% in acetic acid content and 5.9% in total volatile fatty acid content, in comparison to the control group. Comparable investigations have reported analogous outcomes, elucidating that brewer's yeast supplementation leads to a substantial increase in rumen acetic acid content (Jiao *et al*., 2019), which closely mirrors the findings of the current study. In a separate study involving lake sheep, the introduction of 10 g/(head•day) of brewer's yeast into dietary regimens resulted in a significant upsurge in rumen volatile fatty acid content (Song *et al*., 2021). These collective findings collectively underscore the proposition that the judicious addition of brewer's yeast to ruminant diets exerts a notable ameliorative impact on rumen fermentation dynamics, thereby promoting rumen health. This beneficial effect is likely attributable to the presence of beneficial microorganisms within brewer's yeast, which serves to stabilize rumen microbial populations, thereby mitigating the proliferation of detrimental bacterial species.

Excessive levels of oxygen free radicals within the organism can provoke oxidative damage, precipitating deleterious consequences. To counteract this, the body's enzymatic antioxidant system assumes a pivotal role in maintaining oxidative equilibrium by diminishing oxygen-free radical levels. The quantification of MDA content in serum serves as a reliable indicator of the extent of oxidative stress exerted upon the organism (Yuan *et al*., 2015a). Within the purview of this inquiry, the group subjected to brewer's yeast supplementation exhibited a

marked reduction in serum MDA content, indicative of brewer's yeast's capacity to mitigate oxidative stress. This observed effect can potentially be ascribed to brewer's yeast's involvement in protein synthesis, facilitated by nucleotide participation, consequently augmenting antioxidant enzyme activity within the serum and enhancing the overall antioxidant capacity of the organism (Yuan *et al*., 2015b).

Furthermore, the investigation revealed that the brewer's yeast-treated group demonstrated significantly elevated concentrations of T-AOC and SOD in the serum of beef cattle, thus contributing to an overall enhancement in the cattle's antioxidant capacity. Remarkably, analogous reports have concurred with these findings, illustrating that brewer's yeast supplementation within the dietary regimen of dairy cows engenders a noteworthy increase in serum T-AOC and SOD activity (Nocek *et al*., 2011), aligning harmoniously with the outcomes of the present study. This phenomenon can likely be attributed to the presence of bioactive substances such as mannooligosaccharides within brewer's yeast, which promote the proliferation of beneficial rumen bacteria while concurrently inhibiting the proliferation of detrimental bacterial species, consequently reducing the burden of oxidative stress upon the animal's physiological milieu.

CONCLUSION

In summary, within the confines of this controlled experimental investigation, the integration of 100 g/(head•day) of brewer's yeast into the dietary regimen of beef cattle has demonstrated significant improvements in key parameters, encompassing growth performance, rumen fermentation kinetics, and the antioxidative response. These results underscore the prospective advantages inherent in the supplementation of brewer's yeast, which may play a pivotal role in optimizing the physiological and metabolic facets of beef cattle management during these crucial developmental stages.

DECLARATIONS

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Ethical approval and IRB statement

All experiments involving animals were conducted according to the ethical policies and procedures approved by the Institutional Animal Care and Use Committee of Ningxia University, China (No. NXU-2024- 145).

Statement of conflict of interest

The authors have declared no conflict of interest.

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