

Effects of *Moringa oleifera* L. Powder Supplementation on the Reproductive Performance of Balinese Bulls

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Abstract

The reproductive performance of bulls can be improved through dietary supplementation. This study aimed to evaluate the effects of *Moringa oleifera* L. powder supplementation on the reproductive performance of Balinese bulls. The experiment employed a randomized block design with three age groups: Group 1 (G1) bulls aged 3 years, Group 2 (G2) aged 4 years, and Group 3 (G3) older than 4 years. Each group consisted of three bulls fed a basal diet consisting of fresh elephant grass (*Pennisetum purpureum*) provided ad libitum and 1 kg/head/day of rice bran concentrate, with treatments consisting of: no *Moringa oleifera* L. powder supplementation (T0), 50 g supplementation (T1), and 100 g supplementation (T2). Observed variables included sexual behavior parameters (courtship duration, time to flehmen response, libido duration, and ejaculation duration) and fertility indicators, namely conception rate (CR), services per conception (S/C), and non-return rate (NRR). The results showed that *Moringa oleifera* L. powder supplementation significantly ($P < 0.05$) affected sexual behavior parameters. However, improvements in fertility indicators were not statistically significant ($P > 0.05$). In conclusion, supplementation of *Moringa oleifera* L. powder in the diet has the potential to enhance reproductive performance of Balinese bulls, particularly by improving sexual behavior responses.

Keywords: Balinese bulls; *Moringa oleifera* L. powder; Sexual behavior; Conception rate; Services per conception

1. Introduction

Indonesia, as a tropical country, possesses diverse livestock genetic resources, one of which is the Balinese cattle (*Bos sondaicus*). Balinese cattle are domesticated descendants of banteng (*Bos javanicus*) that have long been developed in Indonesia and hold great potential as a national beef source [1]. The advantages of Balinese cattle include a high carcass percentage, reaching approximately 57%, efficient feed utilization, and strong adaptability to tropical environments and low-quality feed [2, 3]. Efforts to increase the population and productivity of cattle in Indonesia are generally carried out through two mating methods: natural mating and artificial insemination (AI). Natural mating is still widely practiced by farmers because it is relatively simple and does not require specialized technology. The success of natural mating is strongly influenced by the quality of the bull, including body condition, reproductive health, and semen quality. In natural mating systems, the reproductive behavior of the bull, particularly libido, plays an important role, as it is directly related to conception success [4]. Therefore, efforts are needed to maintain and improve reproductive performance and sexual behavior in bulls, one of which is through improved feed management.

One approach that can be applied is the provision of natural feed additives, such as *Moringa oleifera* leaf, which contains high nutritional content. *Moringa* leaves contain various antioxidant compounds, including vitamins A, C, and E, as well as other bioactive compounds such as vitamin K, B complex vitamins, beta-carotene, amino acids (alanine and arginine), flavonoids (kaempferol and quercetin), lutein, glutathione, zinc, and phenolic compounds, all of which play roles in

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enhancing metabolism and reproductive function [5]. Several studies have reported the potential of *Moringa* leaves to improve reproductive performance in males. The administration of 15% dried *Moringa* leaves in the ration increased testosterone hormone concentration, libido, and sperm motility in cattle [6]. The use of *Moringa* leaf powder up to 15% in rabbits showed no adverse effects on sperm quality [7]. Furthermore, supplementation of *Moringa* leaves up to 50% in Red Sokoto goats significantly increased sperm count [8]. However, the utilization of *Moringa* leaves as a feed additive to improve reproductive performance and sexual behavior in Balinese bulls remains limited. Therefore, this study was conducted to evaluate the effect of *Moringa oleifera* leaf powder supplementation in the diet on reproductive performance and sexual behavior of Balinese bulls.

2. Materials and Methods

This study was conducted over a period of two months, from October to December 2025, at a private livestock farm (Kaung Bali Farm) located in Tegenan, Menanga Village, Rendang District, Karangasem Regency, Bali Province, Indonesia. The area is characterized by a tropical climate, with average ambient temperatures ranging from 26 to 32°C. A total of nine healthy Balinese bulls (*Bos sondaicus*) aged over 2 years were used in this study. Age was determined based on farmer records or by examination of incisor tooth eruption in accordance with the Indonesian National Standard (SNI 7651-4:2020) [9].

Based on this classification, the bulls were divided into three age categories: Group 1 (G1, 3 years), Group 2 (G2, 4 years), and Group 3 (G3, >4 years), with three animals in each group. The experiment followed a randomized block design (RBD), with age group as the blocking factor. In addition, forty-five Balinese cows were used for natural mating. The cows were selected based on the following criteria: clinically healthy, reproductively active, exhibiting clear estrus signs, aged between 3 and 8 years, and having a Body Condition Score (BCS) of 2–3 (on a 1–5 scale).

All bulls were maintained under similar management conditions throughout the experimental period. Animals were fed a basal diet consisting of fresh elephant grass (*Pennisetum purpureum*) provided ad libitum and 1 kg/head/day of rice bran concentrate. Water was available ad libitum. The experimental treatments consisted of three levels of *Moringa oleifera* L. powder supplementation: T0 (control or without supplementation), T1 (supplementation with 50 g/head/day *Moringa* L. powder), and T2 (supplementation with 100 g/head/day *Moringa* leaf powder). The *Moringa* leaf powder was mixed with the concentrate and administered once daily in the morning feeding.

Sexual behavior observations were conducted during natural mating periods using direct visual observation. Each bull was exposed to estrus cows, and behavior responses were recorded using a stopwatch. The observed parameters were defined as follows: Courtship duration (s): time from first approach to mounting attempt; Time to flehmen response (s): interval between initial exposure to the female and the display of flehmen behavior; Libido duration (s): time from initial sexual interest until successful mounting; and Ejaculation duration (s): time from mounting to ejaculation. All observations were carried out by the same trained observer to minimize subjective bias.

Fertility performance was evaluated based on natural mating outcomes. Each bull was allowed to mate with estrus cows with five replications. The following parameters were calculated: Conception Rate (CR, %): percentage of cows that became pregnant from the total number of inseminated/mated cows; Service per Conception (S/C): number of mating services required to achieve one pregnancy; and Non-Return Rate (NRR, %): percentage of cows that did not return to estrus within a specified period after mating. Pregnancy diagnosis was determined based on non-return to estrus and confirmed by field observation.

Data were analyzed using analysis of variance (ANOVA) based to the randomized block design. The statistical model included treatment as the main factor and age group as the blocking factor. When significant differences ($P < 0.05$) were detected, Duncan's Multiple Range Test was applied for multiple comparisons among treatment means [10]. All statistical analyses were performed using standard statistical software.

3. Results and Discussion

3.1. Sexual Behavior of Balinese Bulls

The sexual behavior parameters observed in this study included courtship duration, time to onset of flehmen response, libido duration, and ejaculation duration. The results showed that dietary supplementation with *Moringa oleifera* leaf powder significantly affected ($P < 0.05$) all observed parameters (Table 1).

Table 1 Mean sexual behavior parameters of Balinese bulls supplemented with *Moringa oleifera* L. powder

Parameter (second)	Treatment ¹⁾			SEM ²⁾
	T0	T1	T2	
Courtship duration	19.00 ^{b3)}	14.33 ^a	11.33 ^a	1.045
Time to flehmen response	21.33 ^c	16.33 ^b	11.67 ^a	0.609
Libido duration	32.67 ^c	25.67 ^b	20.00 ^a	1.171
Ejaculation duration	52.33 ^b	49.00 ^b	44.33 ^a	0.933

Notes: Different superscripts within the same row indicate significant differences ($P < 0.05$).

Overall, all parameters showed a decreasing trend with increasing levels of *Moringa oleifera* L. powder supplementation. Courtship duration, time to flehmen response, libido duration, and ejaculation duration were reduced in T1 and T2 compared to the control (T0). This reduction indicates improved responsiveness and efficiency of sexual behavior in the bulls. The improvement in sexual performance is likely associated with the rich nutritional and bioactive composition of *Moringa oleifera* leaves, including proteins, vitamins (A, C, and E), minerals (particularly zinc), and antioxidant compounds. These components, in turn, are known to enhance metabolic activity, maintain reproductive cell integrity, and support hormonal balance. Adequate nutrition plays a crucial role in stimulating testosterone synthesis, which directly regulates libido and sexual activity in males [4,11]. Furthermore, antioxidants present in *Moringa oleifera* leaves help mitigate oxidative stress, thereby optimizing reproductive system function [12]. Consequently, reduced oxidative stress is particularly important in maintaining normal physiological processes related to reproductive behavior. Therefore, supplementation with 100 g/head/day *Moringa* L. powder (T2) exhibited the most favorable effects in improving the efficiency of sexual behavior in Balinese bulls.

3.2. Fertility Performance of Balinese Cattle

Fertility performance was evaluated based on conception rate (CR), services per conception (S/C), and non-return rate (NRR). The statistical analysis indicated that *Moringa oleifera* L. powder supplementation had no significant effect ($P > 0.05$) on these parameters (Table 2).

Table 2 Mean fertility performance of Balinese bulls supplemented with *Moringa oleifera* L. powder

Parameter	Treatment ¹⁾			SEM ²⁾
	T0	T1	T2	
Conception Rate	93.33 ^{a3)}	93.33 ^a	100.00 ^a	6.086
Service per Conception	1.08 ^a	1.08 ^a	1.00 ^a	0.076
Non Return Rate	93.33 ^a	93.33 ^a	100.00 ^a	6.086

Notes: Values within the same row with identical superscripts are not significantly different ($P > 0.05$).

Although no statistically significant differences were observed, a consistent numerical improvement in reproductive performance was observed with supplementation levels. The highest CR and NRR values (100%) were recorded in T2, compared to 93.33% in T0 and T1. Additionally, S/C values indicated greater efficiency in T2 (1.00) compared to T0 and T1 (1.08). This positive trend may be attributed to the nutritional and bioactive compounds present in *Moringa oleifera*, such as proteins, vitamins, essential minerals (zinc and selenium), and antioxidants, which are known to enhance sperm quality and support spermatogenesis. Phytochemical compounds such as flavonoids and phytosterols also contribute to maintaining sperm membrane integrity and improving fertilization capacity [13].

In addition to nutritional factors, the age of the bulls—within their productive phase—likely contributed to the overall optimal reproductive performance observed in this study. Thus, although statistical significance was not achieved, *Moringa* supplementation demonstrates promising potential in improving reproductive efficiency in Balinese bulls.

4. Conclusion

Supplementation with *Moringa oleifera* leaf powder enhanced the efficiency of sexual behavior in Balinese bulls and exhibited a positive trend in improving fertility performance. Supplementation up to 100 g/head/day may serve as a natural feed additive to support reproductive performance in Balinese cattle.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors declare no conflict of interest.

Statement of ethical approval

The experimental use of nine Balinese bulls and forty-five Balinese cows was reviewed and approved by the Animal Ethics Committee of the Faculty of Veterinary Medicine, Udayana University.

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