Effects of Taurine on Semen Quality, Serum Hormone Content, and Seminal Plasma Antioxidant Capacity in Breeding Boars: Postprint

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Abstract

This study aimed to investigate the effects of taurine (Tau) on libido, semen quality, serum hormone levels, and seminal plasma antioxidant capacity in breeding boars. Twenty-four healthy adult Large White breeding boars of similar age and body weight were randomly allocated into 4 groups with 6 replicates per group and 1 boar per replicate. The groups were fed diets supplemented with taurine at levels of 0 (control), 2, 4, and 6 g/kg for a 90-day experimental period, which was divided into two phases (1–45 d and 46–90 d). The results showed that: 1) During 46–90 d, supplementation with 6 g/kg taurine significantly increased libido ($P<0.05$), ejaculate volume ($P<0.01$), and sperm motility ($P<0.05$) in breeding boars, while 4 g/kg taurine improved sperm concentration and sperm abnormality rate ($P<0.05$); 2) Compared with the control group, the 6 g/kg taurine group produced a highly significant increase in serum luteinizing hormone (LH) level ($P<0.01$) and a significant increase in testosterone (T) level ($P<0.05$); 3) During 46–90 d, 6 g/kg taurine significantly decreased seminal plasma malondialdehyde (MDA) content ($P<0.05$) and significantly increased superoxide dismutase (SOD) activity ($P<0.05$), while 4 g/kg taurine significantly increased glutathione peroxidase (GSH-Px) activity ($P<0.05$). In conclusion, long-term dietary supplementation with taurine can regulate serum hormone levels, enhance seminal plasma antioxidant capacity, thereby improving libido and semen quality in breeding boars, with an appropriate taurine supplementation level of 6 g/kg under the conditions of this experiment.

Full Text

Effect of Dietary Taurine on Semen Quality, Serum Hormone Content and Seminal Plasma Antioxidant Capacity of Breeding Boars

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Abstract

This study investigated the effects of dietary taurine (Tau) on libido, semen quality, serum hormone content, and seminal plasma antioxidant capacity in breeding boars. Twenty-four healthy adult Large Yorkshire breeding boars of similar age and body weight were randomly allocated into four groups, each comprising six replicates with one pig per replicate. The boars were fed diets supplemented with taurine at levels of 0 (control), 2, 4, and 6 g/kg for a 90-day experimental period, which was divided into two phases: days 1–45 and days 46–90. The results demonstrated: (1) During days 46–90, supplementation with 6 g/kg taurine significantly increased libido ($P<0.05$), semen volume ($P<0.01$), and sperm motility ($P<0.05$). The 4 g/kg taurine level improved sperm density and reduced sperm abnormality rate ($P<0.05$). (2) Compared with the control group, the 6 g/kg taurine group exhibited significantly elevated serum luteinizing hormone (LH) content ($P<0.01$) and testosterone (T) content ($P<0.05$). (3) During days 46–90, the 6 g/kg taurine group showed significantly decreased seminal plasma malondialdehyde (MDA) content ($P<0.05$) and increased superoxide dismutase (SOD) activity ($P<0.05$), while the 4 g/kg taurine group exhibited significantly enhanced glutathione peroxidase (GSH-Px) activity ($P<0.05$). These findings indicate that long-term dietary taurine supplementation can regulate serum hormone levels, enhance seminal plasma antioxidant capacity, and consequently improve libido and semen quality in breeding boars. Under the conditions of this experiment, the optimal dietary taurine supplementation level was 6 g/kg.

Keywords: taurine; breeding boar; semen quality; serum hormone; seminal plasma antioxidant capacity

Introduction

With the widespread application of artificial insemination technology in intensive pig production, semen quality in breeding boars has become increasingly critical to farm profitability. Oxidative stress (OS) is recognized as a major factor contributing to reduced semen quality, making research on antioxidant capacity in boar semen essential for reproductive performance [1-3]. Taurine (H_2N-CH_2-CH_2-SO_3H), a sulfur-containing β-amino acid existing in free form throughout the body, possesses multiple biological functions including regulation of reproductive function, immune enhancement, and antioxidant capacity [4-6]. Previous studies have demonstrated that appropriate taurine supplementation can increase relative testicular weight before sexual maturity in roosters, promote testosterone (T) secretion, stimulate germ cell development, and accelerate spermatid formation [7]. Taurine has also been shown to prevent oxidative stress induced by sodium arsenite in rats, enhance testicular antioxidant capacity, and inhibit germ cell apoptosis [8]. Furthermore, taurine improves semen preservation efficacy in various mammals [9-11]. However, no studies have investigated the effects of taurine on reproductive performance in male livestock, particularly breeding boars. This experiment was designed to examine the effects of different dietary taurine levels on libido, semen quality, serum hormone content, and seminal plasma antioxidant capacity in breeding boars, and to determine the optimal supplementation level to provide a scientific basis for taurine application in boar production.

Materials and Methods

1.1 Experimental Materials and Design Taurine used in this experiment was provided by Qianjiang Yong' an Pharmaceutical Co., Ltd., with molecular formula $C_2H_7NO_3S$, relative molecular mass of 125.15, appearing as white crystalline powder, odorless, with 98% purity.

Twenty-four healthy New American Line Large Yorkshire breeding boars aged (360\$±15)*daysandweighing*(180±\$10) kg were selected from Liaoning Debao Agriculture and Animal Husbandry Group' s Edmond Boar Breeding Farm and randomly divided into four groups, each consisting of six replicates with one pig per replicate. The groups were fed diets supplemented with taurine at levels of 0 (control), 2, 4, and 6 g/kg. All diets contained identical nutrient levels except for taurine. The basal diet composition and nutrient levels are presented in Table 1 . Experimental boars were restrictively fed 2.5 kg of diet daily, divided into two feedings at 09:00 and 15:00, with free access to water. Normal disinfection and immunization procedures were followed, and daily management practices for breeding boars were observed to monitor feeding behavior and health status. The experiment included a 10-day pre-trial period followed by a 90-day formal trial period divided into two stages: days 1–45 and days 46–90.

1.2.1 Libido Assessment Semen was collected from experimental boars strictly using the manual collection technique every three days. Following methods described by Ren et al. [12] and Estienne et al. [13], a stopwatch was used to record ejaculation reaction time and ejaculation duration.

1.2.2 Semen Quality Evaluation Semen color and odor were observed and evaluated. Semen volume, sperm density, sperm motility, and sperm abnormality rate were determined according to standard methods provided by the World Health Organization [14].

1.2.3 Serum Hormone Analysis On day 90 of the experiment, approximately 5 mL of blood was collected via ear marginal vein from fasting boars at 08:00. The blood was centrifuged at 3,000 r/min for 15 minutes, and the serum supernatant was stored at -20°C for subsequent analysis. Serum follicle-stimulating hormone (FSH), luteinizing hormone (LH), and testosterone (T) contents were measured using electrochemiluminescence immunoassay with an r-911 automatic radioimmunoassay counter (Beijing Huaying Biotechnology Research Institute).

1.2.4 Seminal Plasma Antioxidant Capacity Measurement During the final semen collection of each experimental phase (days 1–45 and 46–90), 10 mL of semen sample was retained in a glass centrifuge tube. After static sedimentation, 2 mL of the upper seminal plasma layer was collected and stored at -15°C for analysis. Total antioxidant capacity (T-AOC) was measured using colorimetric method, malondialdehyde (MDA) content was determined using thiobarbituric acid (TBA) method, superoxide dismutase (SOD) activity was measured using xanthine oxidase assay, and glutathione peroxidase (GSH-Px) activity was determined using colorimetric method. All assay kits were provided by Beijing Huaying Biotechnology Research Institute.

1.3 Statistical Analysis Experimental data were analyzed using one-way ANOVA and Duncan' s multiple comparison test in SPSS 21.0 statistical software. All data were expressed as "mean ± standard deviation." Differences were considered significant at $P<0.05$ and extremely significant at $P<0.01$.

Results

2.1 Effect of Dietary Taurine on Libido of Breeding Boars As shown in Table 2 , dietary taurine supplementation during days 1–45 had no significant effect on libido ($P>0.05$). However, during days 46–90, boars in the 6 g/kg taurine group exhibited significantly shorter ejaculation reaction time compared with the control and 2 g/kg groups ($P<0.05$), and significantly longer ejaculation duration ($P<0.05$). These results indicate that 6 g/kg taurine supplementation significantly improved libido during the latter experimental phase ($P<0.05$).

2.2 Effect of Dietary Taurine on Semen Parameters of Breeding Boars Table 3 presents the effects on semen quality parameters. During days 1–45, the 6 g/kg taurine group showed significantly higher semen volume compared with the control group ($P<0.05$), while sperm density, motility, and abnormality rate did not differ significantly ($P>0.05$). During days 46–90, the 6 g/kg taurine group demonstrated extremely significantly higher semen volume ($P<0.01$), the 4 g/kg group showed significantly increased sperm density ($P<0.05$), and the 6 g/kg group exhibited significantly improved sperm motility ($P<0.05$). Sperm abnormality rate decreased by 6.30% with 4 g/kg taurine and by 5.95% with 6 g/kg taurine, with both groups showing significant improvements compared with the control ($P<0.05$).

2.3 Effect of Dietary Taurine on Serum Reproductive Hormone Content As presented in Table 4 , dietary taurine had no significant effect on serum FSH content ($P>0.05$). However, serum LH content in the 4 and 6 g/kg taurine groups increased by 26% ($P<0.05$) and 34% ($P<0.01$), respectively, compared with the control group. The 6 g/kg taurine group also showed a significant 22% increase in serum testosterone content ($P<0.05$).

2.4 Effect of Dietary Taurine on Seminal Plasma Antioxidant Capacity Table 5 summarizes the antioxidant capacity results. During days 1–45, no significant differences were observed in T-AOC, MDA content, or SOD and GSH-Px activities among taurine supplementation groups ($P>0.05$). During days 46–90, the 6 g/kg taurine group exhibited significantly lower MDA content ($P<0.05$) and significantly higher SOD activity compared with the control and 2 g/kg groups ($P<0.05$). The 4 g/kg taurine group showed significantly enhanced GSH-Px activity ($P<0.05$).

Discussion

3.1 Regulation of Serum Hormones by Taurine and Its Effects on Libido and Semen Quality Spermatogenesis in male animals is directly regulated by the hypothalamic-pituitary-testicular axis. Gonadotropin-releasing hormone secreted by the hypothalamus reaches the adenohypophysis via the hypophyseal portal system, stimulating FSH and LH secretion. Wells et al. [15] demonstrated that LH promotes testosterone synthesis in Leydig cells of neonatal piglets, and testosterone facilitates spermatogenesis while serving as the primary regulator of male libido and sexual function. FSH acts on the germinal epithelium of seminiferous tubules, controlling Sertoli cells and regulating spermatogenesis and maturation. Franca et al. [16] reported that FSH, as a primary mitogen, influences testicular cell proliferation in breeding boars. Estienne et al. [13,17] confirmed that LH and testosterone levels correlate positively with libido but not semen volume, whereas Bilskis et al. [18] suggested testosterone correlates positively with both libido and semen volume while correlating

negatively with sperm abnormality rate.

Taurine is the predominant free amino acid in spermatozoa, which can be obtained through the cysteine decarboxylase pathway or transported from luminal fluid via β-amino acid transport systems. Yang et al. [19] and Zhang et al. [20] demonstrated that appropriate taurine levels promote testosterone secretion from Leydig cells in adult rats and neonatal mice, respectively. Yang et al. [21] confirmed that taurine enhances libido and sexual capacity in aged male rats.

This study provides the first evidence that 6 g/kg dietary taurine increases serum LH and testosterone contents in breeding boars and significantly improves libido and semen quality during days 46–90. The significant elevation of serum LH and testosterone is consistent with findings in male rats by Yang et al. [22]. However, the improvements in semen quality differ from those reported in adult rats, possibly due to variations in experimental animals and methodologies. In addition to regulating testosterone, taurine may influence sexual behavior by modulating FSH and LH, which are closely associated with prostaglandin F2α secretion [13], thereby affecting semen quality. The relationship between serum FSH, LH, and testosterone levels with libido and semen quality aligns with findings by Yan et al. [23]. The significant improvement in semen quality during days 45–90 with appropriate taurine supplementation conforms to spermatogenic cycles, though the underlying mechanisms of taurine's action on reproductive hormones require further investigation.

3.2 Influence of Taurine-Enhanced Antioxidant Capacity on Libido and Semen Quality Oxidative stress is considered a primary factor reducing semen quality. The sperm membrane contains high levels of unsaturated fatty acids, and the sperm tail is rich in mitochondria, making them highly susceptible to reactive oxygen species (ROS) attack. ROS can damage sperm membrane fluidity, impair mitochondrial function, inhibit enzymes related to sperm motility, and cause DNA base modifications, strand breaks, and chromatin cross-linking, ultimately accelerating sperm apoptosis [24-25]. Total antioxidant capacity (T-AOC) reflects the compensatory ability of the antioxidant system to external stimuli and the metabolic status of free radicals, serving as an important indicator for evaluating antioxidant defense capability. MDA, the primary metabolite of lipid peroxidation induced by ROS, can disrupt sperm membrane permeability and integrity, affecting sperm motility and acrosome reaction. Its concentration indirectly reflects the severity of ROS attack on cells. SOD is the most important antioxidant enzyme, while GSH-Px is a selenium-containing antioxidant enzyme. Both enzymes mitigate oxidative damage to sperm membranes and improve semen quality, playing crucial roles in maintaining free radical metabolic balance. Their activities indirectly reflect the capacity to scavenge ROS.

This study evaluated taurine' s effects on seminal plasma antioxidant capacity by measuring T-AOC, MDA content, and SOD and GSH-Px activities, and analyzed its impact on libido and semen quality. Previous in vitro and in vivo

studies have demonstrated that taurine alleviates oxidative stress and toxic damage in liver, kidney, and myocardial cells while inhibiting apoptosis. Das et al. [8] and Aly et al. [26] proved that taurine prevents reductions in testicular mass, sperm production, and sperm motility induced by sodium arsenite and endosulfan in rats, enhancing testicular antioxidant capacity and ameliorating OS-induced decreases in SOD and GSH-Px activities. The current results indicate that during days 46–90, 6 g/kg taurine significantly increased seminal plasma SOD activity, enhanced GSH-Px activity, and significantly reduced MDA content, thereby improving overall antioxidant capacity and significantly enhancing libido and semen quality. These findings are consistent with previous research on taurine' s antioxidant effects and semen quality in rats and other animals [26-27]. Although T-AOC did not differ significantly between taurine groups and the control, it showed an increasing trend with taurine dosage, consistent with findings by Yang et al. [28] in rats of different ages, though this may also relate to incomplete antioxidant capacity measurements. This study provides the first confirmation of taurine' s alleviating effect on oxidative stress in breeding boars, with results generally consistent with reports of dose-dependent antioxidant capacity.

Conclusion

This study demonstrates that long-term dietary taurine supplementation in breeding boars enhances libido and improves semen quality, with effects becoming significant after at least 45 days of supplementation. Taurine promotes the secretion of FSH, LH, and testosterone, thereby increasing their serum concentrations. Additionally, taurine elevates seminal plasma T-AOC, reduces MDA content, and enhances SOD and GSH-Px activities, collectively improving seminal plasma antioxidant capacity. Under the experimental conditions described herein, the optimal dietary taurine supplementation level is 6 g/kg.

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