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# Nutrition and bull fertility: A review

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#### Abstract

With the advent of artificial insemination in cow and buffalo, the need of fertile bulls with good quality semen doses get much more importance now a days. Bull fertility depends upon various factors such as genetics, environment, season and nutrition. Among these nutrition plays significant role to maximize the potential of bull fertility. Balanced nutrition during pre-weaning and post-weaning stages of male calves has a significant impact on testicular steriodogenesis and gonadotropins releasing hormone which ultimately determine the bull fertility. Hence, level of different nutritional requirement in bull at various stages and their effect on puberty, sexual maturity and fertility need to be elucidated.

Keywords: Nutrition, bull, fertility, semen quality

#### 1. Introduction

Earlier, it was said that bull is half of the herd because of its half contribution towards genetic make-up in each subsequent generation. However, now a day bulls are considered as more than half of the herd because of extensive use of frozen semen in artificial insemination. Fertility of a bull is of paramount importance for any successful breeding programme and to increase the milk production of a herd as low fertility accounts for huge economic losses to livestock farmers. It is well known that fertility is a low heritable trait and governed by many factors such as genetics, epigenetics, environment and epistasis <sup>[1]</sup>. Fertility of a bull is influenced not only by genetic make-up but also by nutrition, management, environment such as climate, stress, pollution and behaviour like experience and temperament <sup>[2, 3, 4]</sup>.

Apart from these, reproductive performance (semen quality, libido etc.) of bull is directly dependent on body vigour, physical soundness, structural conformation, masculinity and general health. The physical soundness of a bull is depends on feeding management and attainment of appropriate weight in different breeds of the bull. Thus, nutritional status of a bull is one of the main attribute in determining semen quantity and quality <sup>[5]</sup>. Moreover, under-nutrition, malnutrition or nutritional imbalance leads to reduced androgen secretion and low semen quality in adult animals. Balanced nutrition during pre-weaning and post-weaning stages of male calves has a significant impact on testicular steroidogenesis as it results in the enhanced Leydig cell functions. Moreover, bull fertility is complicated, diverse and sensitive phenomenon and no reliable fertility markers exist to predict the semen quality and bull fertility at an early age of the bull life so that rearing cost can be minimized. Multiple physiological systems in association with nutritional factors within the animal are involved *i.e.* why interaction between various nutritional factors regulating bull fertility need to be elucidated. Therefore, present review has designed to compile the information related to status of energy, protein, minerals and vitamins on attained of puberty, semen quality and fertility in bull.

#### 2. Energy and protein

Onset of puberty depends on attainment of target weight at particular age rather than age only. Further body weight along with scrotal circumference (SC) is even better criteria for judgment of superior male. So, feeding management of bulls should be directed to attain an optimum body weight along with desired SC at an earliest possible age <sup>[6]</sup>. Mandal *et al.* <sup>[7]</sup> reported that 484 Frieswal (*Holstein Friesian X Sahiwal*; having 5/8 exotic inheritance) bull calve were able to attain an average daily gain (ADG) of 512.82 g/d during the active growth phase of 13-18 months and exhibited appropriate sexual behavioural score and semen quality.

Energy level in ration has its indirect impact on testicular activities. Dietary energy up to a level accelerates pre-pubertal development but beyond a limit there are no positive effects <sup>[8]</sup>.

Feeding below the requirements for maintenance led to reductions in scrotal circumference, testis mass and the numbers of sperm in semen in sexually mature Merino rams <sup>[9]</sup>. They also reported that under-nutrition decreases sperm velocity and increases DNA damage, but has little effect on the percentages of abnormal or live sperm. Underfed rams produced sperm that had a lower curvilinear velocity (VCL), straight-line velocity (VSL) and average path velocity (VAP), than was observed in sperm from rams fed the high maintenance diets. Undernutrition would increase oxidative stress and further decrease sperm motility <sup>[10]</sup>. The higher levels of DNA fragmentation in sperm from underfed rams than in sperm from well-fed rams adds further support for our hypothesis that under-nutrition reduces sperm cell quality. The cause of the DNA damage in ejaculated spermatozoa is still not clear but two possibilities have been proposed: apoptosis during spermatogenesis and incomplete maturation during spermiogenesis. Enhancing the plane of nutrition of bull calves during the first 6 months of life will increase gonadotropin secretion and testicular development, resulting in earlier onset of puberty. Recent evidence shows that this is likely mediated through the signalling activity of peripherally derived metabolites and metabolic hormones to neuroendocrine centres within the brain and mediated by the actions of specialised neuropeptides. This leads to enhanced gonadotrophin synthesis and secretion which in turn controls testicular development and function [11].

The level of both energy and protein in diet has profound impact on reproduction. Not only excessive dietary energy/protein <sup>[12]</sup> but also low dietary energy/protein <sup>[13]</sup> adversely affects the fertility of bulls including libido. The requirement of energy and protein varies with the growing stages of bull. Low energy and protein intake result into delayed onset of puberty <sup>[14]</sup>, poor testicular development <sup>[15]</sup>, decreased thickness and diameter of seminiferous tubules <sup>[16]</sup> impaired sperm production <sup>[17]</sup> and reduced fertility <sup>[14, 18]</sup>. It has reported that restricted feeding during calf hood leads to impaired sexual development because of adverse effect on hypothalamus-pituitary-gonadal axis such as inhibition of hypothalamic GnRH pulse generator that reduced pituitary response to GnRH and altered or suppressed release of gonadotrophins, regardless of the nutrition during peripubertal period <sup>[16, 19]</sup>. In converse to aforesaid study, supplementation of high energy/protein diet during calf hood leads to faster growth, earlier onset of puberty, larger scrotal circumference, higher testicular weight and volume, increased testosterone secretion, increased IGF-I concentration, increased LH secretion, greater testicular cells proliferation and good quality semen production in mature bulls <sup>[15, 20, 21, 22]</sup>. Higher mass motility and progressive motility of spermatozoa, increased semen volume and sperm concentration has been reported following supplementation of high energy/protein diet [23] however, literatures regarding effect of plane of nutrition on above parameters are inconsistent. IGF-I regulates Leydig cell number and function whereas LH is associated with testicular cells proliferation and their enhanced function (21). Feeding of concentrate @ 1.5 kg/day to Zebu bulls in sub-humid environment over a period of 50 weeks resulted in reduction (11.40% Vs 8.3%) of abnormal sperms count as compared to control group as well within same group following supplementation <sup>[24]</sup>. High energy and low roughage diet is preferable for growing bulls but it should keep in mind that too high energy diet may result in deposition of fat in scrotum which may hampers the normal sperm production <sup>[13]</sup>.

Feeding rams on a high energy and protein diet also increases GnRH pulse frequency, but the effect fades after 3 weeks of treatment. Despite this fading of the effect, testicular mass and sperm production continue to increase for several months or at least as long as the diet is offered <sup>[25]</sup>. This finding indicates that part of the effect of diet on the testis is independent of the changes in GnRH pulse frequency. Volatile fatty acids, glucose and insulin, might be involved in the short-term effects of nutrition on the higher reproductive centres of male sheep. A role for insulin, possibly centrally synthesized, appears necessary if all the above observations are to be accommodated. Leptin alone cannot be the essential link but an interaction between Insulin and Leptin may play a permissive role, as has been suggested for the onset of puberty in rodents, humans and sheep <sup>[26]</sup>.

Kaur and Arora<sup>[27]</sup> showed the digramatic representation of effect of low proein on secetetion of LH hormone and quality of semen.



The effects of energy and/ or protein on various reproductive traits of farm animals has been reported by various workers as mentioned in table.1.

Diet	Sexual Activity	Reference
Under nutrition	Unaffected	[28]
High Energy Diet	Unaffected	[29]
Low Energy Diet	Reduced Libido	[13]
Overfeeding	Reduced Libido	[28]
Low Energy	Development of Seminal Vesicles(Ampulla, Epididymides) reduced	[30]
	Testicular Morphology(Seminiferous tubules, Tunica Dartos muscles, interstitial cells) Impaired, scrotal circumference	[31]
	Ejaculate volume reduced	[30]
	Spermatogenesis( Sperm Production reduced	[32]
	Sperm morphology Abnormal	[29]
	Epididymal Sperm Reserve Reduced	[33]
Broiler Litter (1 kg/animal/day) + Molasses(0.5kg/animal/day)+ Grazing	Reproductive performances increased, larger Scrotal circumference, higher testosterone level in Brahman bull	[34]
Low Protein	Testicular Growth Retarded	[35]
	Testicular Morphology impaired (Interstitia cell, Germinal Epithelium	[13, 35]
	Seminal Volume reduced	[13]
	Semen motility Unaffected	[35]
	Sexual Activity reduced	[13]
	Delayed Puberty	[14]
	Poor testicular development small ejaculates reduced fertility in bulls	[18]

Table 1: Effects of different level of energy and protein on reproductive traits of farm animals.

#### 3. Feeding Polyunsaturated Fatty Acids (PUFA's)

Like all mammalian cells, sperm have a plasma membrane that is made up of a phospholipid bilayer and this contains large amounts of PUFA's. Lipids, present in both the sperm and seminal plasma are involved not only in sperm energy metabolism, but also in many functions that lead to fertilization <sup>[36]</sup>. Semen from all domestic species contains high levels of PUFAs <sup>[37]</sup>, but the nature of lipids depends on animal species. In mammals, the fatty acid composition of sperm is characterized by very high proportions of omega-3 polyunsaturated fatty acids particularly (n-3), docosahexaenoic acid (22:6 n-3) [38]. PUFA's are involved in physicochemical modifications of the sperm head during capacitation <sup>[39]</sup> and gives fluidity to the sperm membrane to participate in the membrane fusion events that is associated with fertilization <sup>[40]</sup>. However, these PUFAs are extremely vulnerable to oxidative damage generated by reactive oxygen species (ROS) [41]. Although ROS are involved in cell signalling at low levels, excessive production of ROS can lead to oxidative stress, lipid peroxidation, DNA damage, and associated impairment of sperm function <sup>[42]</sup>. In addition, sperm have a relatively small amount of cytoplasm which contains low concentrations of antioxidants <sup>[43]</sup>. Therefore, there is a critical balance between lipids, ROS and the antioxidant system in the environment surrounding the sperm, which is required to ensure their efficient functionality. It is perhaps this complex interaction that has led to conflicting reports in the scientific literature on the relationship between the fatty acid profile of sperm and subsequent fertility. There are two main approaches to date which have been used to investigate the role of fatty acids in sperm cell function, namely: the comparison of the fatty acid profile of high and low fertility males and dietary supplementation with PUFAs to alter the milieu in which spermatogenesis occurs and therefore the composition of the sperm membrane <sup>[44]</sup>. PUFA supplements have been shown to alter the sperm fatty acid profile and sperm quality of rams <sup>[45]</sup> and bulls <sup>[46]</sup>. The sperm is very sensitive to lipid peroxidation because its plasma membrane is rich in polyunsaturated fatty acids (PUFA),

especially in the long-chain PUFA docosahexaenoic acid and docosapentaenoic acid [37]. Enrichment of the diet of rams with n-3 PUFA can alter the fatty acid profile of plasma and to a more limited extent, sperm concentration. An important positive effect of PUFA in sperm function has been attributed to its effect on fluidity of the plasma membrane <sup>[46]</sup>. Gulliver et al.<sup>[47]</sup> reviewed the role of omega-3PUFAs on reproduction in sheep and cattle and stated no published studies have specifically examined the effects of n - 3 PUFA's supplementation on male fertility and semen quality. They suggested that direct feeding studies in ruminants examining the effects of n - 3 PUFA's on male fertility are required. The concentration of these PUFA decreases with age in bulls <sup>[48]</sup> and the effect of PUFA supplementation is often positive, especially in older animals. However, the variability of its effects on semen characteristics of different mammals is surprisingly high [38]. In ruminants, PUFA may be efficient only when provided either in rumen-protected form or at very high levels in order to counteract their extensive ruminal bio hydrogenation. Generally, the ideal supplementation levels are within a narrow range because PUFA at the same time stimulate the formation of ROS and their precursor <sup>[49]</sup>. Recently, the effects of intact fish oil <sup>[50]</sup> and rumen protected fish oil<sup>[51]</sup> on the semen characteristics of rams were studied and their positive effect were reported. But, these studies were done in the physiologic breeding season. However, PUFAs are also associated with increased oxidative stress, which can reduce semen quality therefore, several mechanisms need to be considered when examining the overall effects of n - 3PUFAs on quality of semen [38]. Byrne et al. [52] reported that supplementing young postpubertal bulls (14 months) for 12 weeks with either an omega-6 (safflower oil) or an omega-3 (distilled fish oil) enriched diet altered the PUFA composition of spermatozoal cells and seminal plasma but did not lead to any appreciable improvements to the quantity or quality of fresh semen.

#### 4. Effect of minerals

Minerals are important for all physiological processes in animals including reproduction. Micro minerals play important role in maintaining the reproductive status of breeding bulls. Improvement in the sperm production and fertility has been achieved following the supplementary feeding of micronutrients such as copper, cobalt, zinc and manganese <sup>[53]</sup>. Additionally, Mg, which is present in semen at a high concentration is a crucial element in cell physiology. Mg might play a role in spermatogenesis and sperm motility and it is a marker of the secretions of the seminal vesicles and acts as an intracellular Ca antagonist <sup>[54]</sup>.

Calcium is required in many physiological processes as a regulator in all living cells, including sperm cells. Spermatozoa are highly differentiated cells with the plasma membrane being the major cellular component, involved in diverse and complex functioning of the sperm cell to achieve fertilization. Many of these functional processes are made effective by the transport of ions across the plasma membrane through ion channels with various types of Ca channels being the most studied in the sperm behaviour <sup>[55]</sup>. Ca triggers the acrosomal reaction in mammalian spermatozoa, and there is substantial evidence that Ca is differentially involved in sperm motility, depending on the stage of sperm maturation <sup>[56]</sup>. Calcium present in the seminal plasma of buffalo bulls plays an important role in preserving spermatozoa motility and viability as well as antioxidant status by protecting the sperm cells oxidative damage <sup>[57]</sup>. On the other hand, negative correlation between the calcium content in the seminal plasma and spermatozoa motility was found in bovine semen<sup>[58]</sup>.

The presence of Mg is necessary for capacitation, hyper activation and acrosome reaction of spermatozoa <sup>[59]</sup>. Studies have shown that the Mg level in the seminal plasma increases with sperm concentration but has no significant relationship with sperm motility <sup>[60]</sup>. On the other hand, positive effects of Mg on the motility, morphology and concentration of spermatozoa were reported Marzec-Wróblewska *et al.* <sup>[61]</sup>. Kaludin and Dimitrova <sup>[62]</sup> found a direct proportional correlation between Mg content and ram spermatozoa motility.

Tumenbaevish *et al.* <sup>[63]</sup> revealed that the S - containing compounds increases the motility and survivability of the absolute rate of cryopreserved spermatozoa. in contrary, spermatogenesis was affected in the testes of male rats after  $SO_2$  administration due to structural and functional changes of the testicular tissue together with disturbances in the hypothalamic pituitary testicular axis <sup>[64, 65]</sup>.

Selenium is important for normal spermatogenesis and largely component of seleno-proteins phospholipid as а hydroperoxide glutathione peroxidase (PHGPx/GPX4) and Seleno-protein V. Most of the selenium found in the testis is associated with PHGPx/GPX4. It serves as a powerful antioxidant protecting cells from oxidative stress. PHGPx also appears to be involved as a structural protein to provide normal sperm motility [66]. It has also been shown that a variant to this protein is necessary for normal chromatin condensation and subsequent normal spermatozoa head formation. Selenium is linked to male fertility [67] and maintains immune cells at proper functional state [68] and enhances testicular function. Both deficiency and excessive selenium have been demonstrated to be detrimental to normal spermatogenesis <sup>[69]</sup>. Under summer conditions increasing the level of Se from 70 to 230 ug/kg ration had favorable effect on sperm resistance. Similarly the addition of 160 ug Se/kg

dry feed in the form of sodium selenite to the daily diet of young bulls, which contain basic selenium level of 70 ug/kg dry feed had resulted in increased quantities of forward motile cells and decreased quantities of non-motile cells [70]. Sodium selenate at 0.1 ppm of dry matter in rations of rams has been reported to be associated with a significant increase in scrotal length and circumference [71]. In male Baladi goats, feed supplemented with 0.15 ppm organic Se resulted in a significant increase in testosterone secretion compared to that found in a control group fed basal diet only <sup>[72]</sup>. In general, vitamin E has been observed to have synergistic effects with Se. Ali *et al.*<sup>[73]</sup> observed that vitamin E plus Se improved the reproductive performance of rams compared to vitamin E supplementation alone. The Se supplimented animals utilized Se for synthesis of selenoproteins in testis and epididymis. The principal selenoproteinin testis is phospholipid hydroperoxide glutathione peroxidase (GPx4 or PHGPx), expressed primarily in sperm [74]. Se is incorporated into selenocysteine (SeCys), also known as the twenty-first amino acid, which contains Se instead of sulphur and is an integral component of all selenoproteins in their active sites <sup>[75]</sup>. SeCys is delivered to the testis by plasma selenoprotein P [76]. Selenoprotein P uptake occurs in sertoli cells within testis by a member of thelipoprotein receptor family, apolipoprotein E receptor-2 (ApoER2), thereby transporting Se from blood to spermatogenic cells to support spermatogenesis <sup>[77]</sup>. Further, it was reported that sodium selenite supplementation in culture medium up to 0.50 mg/L enhanced Sertoli cell viability and upregulated anti-inflammatory cytokines and blood-testis barrier proteins [78].

Bertrand and Vladesco<sup>[79]</sup> were the first to notice presence of Zn (zinc) in semen. Since that time a large number of researchers studied the role of this essential trace element in male reproduction. Prostatic fluid, seminal plasma, spermatozoa and prostate tissues are known to contain the largest amount of Zn among all biological fluids and tissues of the body. Zinc is mainly bound with the outer dense fibres of the sperm tail where it binds with the sulfhydryl (-SH) groups of cystiene by forming Zn-mercaptide complexes and protects the outer dense fibres from premature oxidation <sup>[80]</sup>. Thus, the element Zn has motility-modulating properties and the removal of Zn from the outer dense fibres is a mandatory step in epididymal maturation of spermatozoa. Zinc also influences motility of spermatozoa as it controls the energy utilization through ATP system involved in contraction and regulation of phospholipid energy reserves [81]. Saleh et al. [82] reported that Zn controls the motility of goat sperms by influencing development of flagellar system of sperm tail. Zinc localizes in the sperm middle piece in association with lipoprotein fraction suggests that Zn is involved in catabolism of lipid, which is the principle source of energy required for movement of spermatozoa. Zinc possesses anti-oxidative properties and acts to reduce the reactive oxygen species produced by defective spermatozoa as well as leucocytes and hence increase fertility [83]. Zn elicit anti-oxidative property mainly by two mechanisms, either by decreasing susceptibility of specific SH groups to oxidation or competing with prooxidant metals (i.e. Cu and Fe) for binding sites, thus decreasing ability to transfer electrons in the particular environment [83]. It has also been demonstrated that Zn peroxidation lipid through inhibition inhibits of phospholipase. High concentration of Zn in the spermatozoa is essential for viability and fertility of the buffalo bull <sup>[84]</sup>. Some important enzymes of spermatozoa are Zn metalloenzymes like sorbitol dehydrogenase, lactate dehydrogenase, alkaline phosphatase, etc. These enzymes become dysfunctional when Zn is deficient [85]. It plays a fundamental role in the production of many sex hormones including testosterone and gonadotrophin releasing hormone in man and animals. Zn stimulates leydig cells of testis to produce testosterone. It is localized in golgi complex or secretory vesicles of interstitiotrophs (IT), folliculotrophs (FT) and lactotrophs (LT) of pituitary gland. Thus, it seems that this element plays an important role in production and secretion of FSH, LH and prolactin and these in turns, regulate testosterone production [85]. Zinc supplementation (Zn sulfate) at the rate of 40 ppm of diet for 150 days in Murrah buffalo bulls (Bubalus bubalis) has not shown any effect on sperm morphometry [86]. Addition of 150 ppm Zn as zinc sulphate and 50 ppm Se as sodium selenate in male bucks diet increased semen volume, progressive motility, sperm count, percent live spermatozoa, acrosomal integrity and hypo-osmotic swelling responding spermatozoa and decreased abnormal spermatozoa after 60 days of experiment <sup>[87]</sup> in Barbari bucks. Ghorbani et al. <sup>[88]</sup> observed that the male reproductive performance, sperm concentration, total sperm number, progressive sperm motility and mass motility were positively affected by the combination of Se and Zn (40 mg/kg Zn plus 0.3 mg/kg Se) than their individual (0.3 mg/kg Se and 40 mg/kg Zn) supplementation in rams for 120 days.

Iron is one of the most abundant mineral nutrients in the organism and plays a critical role in the synthesis of nucleic acids and proteins, electron transport, cellular respiration, proliferation and differentiation [89] all of which are intimately related to spermatogenesis and spermatozoa metabolism (90). Three mammalian gene expressions are directly regulated by iron, two of which have an impact on male reproduction. The protein kinase C-beta, a member of the protein kinase C family has been localized in human semen and associated with flagellar motility [91]. The mitoferrin gene product and other proteins involved in iron metabolism showed enriched expression in the testes suggesting that mitochondrial iron metabolism plays a role in spermatogenesis <sup>[92]</sup>. The importance of iron in male fertility has been shown in various in-vivo and in-vitro studies. It was only iron from all the bulk elements evaluated in the seminal plasma of Nili-Ravi bulls, which was significantly and positively correlated with sperm motility [90].

A number of human and animal studies have demonstrated that Cu has direct and positive effects on semen quality parameters. Akinloye et al. [93] showed that Cu had significant positive effects on semen volume. Abdul-Rasheed <sup>[94]</sup> noted a significant decrease of Cu levels in the seminal plasma of azoospermic patients, leading to a concomitant decrease in the SOD activity and a higher risk of oxidative stress. Wong et al. <sup>[60]</sup> demonstrated a weak but significant positive correlation between blood Cu and sperm motility. Further, it was reported a positive correlation between the Cu concentration in bovine blood plasma, sperm count and progressive motility <sup>[95]</sup>. In vitro addition of low concentrations of CuSO4 to a semen extender improved the total antioxidant capacity of the ejaculate of water buffaloes. The in-vitro presence of copper improved the antioxidant capacity of the semen samples [96]. Feeding of organic Zn and Cu to growing male goats advanced onset of puberty and improved quantitative and qualitative semen characteristics. Organic Cu had a significant effect on overall performances of bucks as compared to Zn alone or Zn and Cu in combination [97].

Manganese is an activator of enzyme systems in the metabolism of carbohydrate, fats, protein and nucleic acids <sup>[98]</sup>. Manganese appears to have a vital role in reproduction. It is necessary for cholesterol synthesis <sup>[99]</sup>, which in turn is required for synthesis of the steroids, estrogen, progesterone and testosterone. Insufficient steroid production results in decreased circulating concentrations of these reproductive hormones resulting in abnormal sperm in males.

# 5. Effects of Vitamins

#### 5.1 Vitamin A

Classic symptoms of vitamin A deficiency include inhibition of spermatogenesis, reduction in testicular size and decline in testicular steroidogenesis <sup>[100]</sup>. In the male, vitamin A deficiency is associated with degeneration of testicular germinal epithelium, resulting in either reduction or cessation of spermatogenesis <sup>[101]</sup>. Bulls fed diets deficient in vitamin A have delayed puberty, reduced libido and reduced spermatogenesis <sup>[30]</sup>.

## 5.2 Vitamin E

Effect of vitamin E occurs directly or indirectly on the regulation of intra-testicular factors which regulate specific steps of germ cell development <sup>[102]</sup>. Velasquez-Pereira et al. <sup>[103]</sup> reported that bulls fed with 14 mg free gossypol per kg body weight had a lower (P < 0.05) percentage of normal sperm than those supplemental with vitamin E along with gossypol. Likewise, sperm production per gram of parenchyma and total daily sperm production were higher (P<0.05) when gossypol-treated animals also received vitamin E. Bulls receiving gossypol exhibited reduced sexual activity (P>0.05) than bulls in other treatments. So, it can be inferred that vitamin E is effective in reducing gossypol toxicity for male cattle. Hong et al. [104] reported that vitamin E supplementation increases serum as well as testis concentration of vitamin E and thus enhance the ability of testicular tissue to combat oxidative stress. Erdinç et al. [105] proposed that vitamin E supplementation to the ration could improve fertility of the flock.

### 6. Conclusion

Fertility of breeding bulls is the key factor in sustainable cattle production and development programmes. Besides general management, feeding management is the key factor in production of a good bull. The important phases in bull feeding are preweaning nutrition, postweaning nutrition, conditioning prior to breeding season, breeding season and post breeding season. Optimum feeding programme and plane of nutrition during these phases is important not only to maintain bull in physically sound condition but have the impact on secretion of gonadotropins and consequently sexual development in bulls. Thus, adequate level of energy, protein, mineral and vitamins during different stages of growth and reproduction is of paramount importance to maximize the fertility potential of bull.

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