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Impacts of Vitamins and Minerals in Animal Reproduction

Kennady Vijayalakshmy[1], Ranjeet Verma[2], Jyotsnarani Biswal[3] and Habibar Rahman[4]*

[1]*Research Officer, International Livestock Research Institute, South Asia Regional Office, New Delhi - 110012, India*

[2]*Research Scholar, Department of Animal Reproduction, Indian Veterinary Research Institute*

[3]*Scientific Consultant, International Livestock Research Institute, South Asia Regional Office, New Delhi - 110012, India*

[4]*Regional Representative for South Asia, International Livestock Research Institute, South Asia Regional Office, New Delhi - 110012, India*

***Corresponding author:** Habibar Rahman, Regional Representative for South Asia, International Livestock Research Institute, South Asia Regional Office, New Delhi-110012, India.

Abstract

Nutrition has an important impact on the reproductive performance of animals. Specific nutrients and dietary ingredients have been implicated on reproduction in animals. Essential trace minerals and vitamins play a vital role in many enzymatic and metabolic pathways that are critical for reproduction in livestock species. The conceptus relies entirely on the maternal system for a sufficient supply of trace minerals and other nutrients needed for normal development. If the supply is inadequate, growth and/or health of the conceptus can be affected adversely, and many of these effects carry over into the neonatal period. Hence, the proper supplementation of trace minerals and vitamins is highly desired to maintain normal reproductive function of the livestock. The present review aims in detailing different roles of specific vitamins and minerals in animal reproduction.

Keywords: Embryonic development; Reproduction; Supplementation; Trace minerals; Vitamins

Introduction

Inclusion of moderate quantities of vitamin and mineral supplements to the diet modulates PGF2α secretion by the uterus, enhances energy intake, enhances luteal function, affects ovarian dynamics, and embryo quality, and has desirable beneficial effects on fertility. Dietary inclusion of the supplements might enhance fertilization rate and quality embryo production in animals.

Several research studies indicate that manganese, zinc and copper are certain trace minerals which have the greater impact on animal reproduction. Zinc, copper and manganese concentrations were found to be several folds higher in conceptus than in any other reproductive tissues of the animal, that indirectly indicates that the conceptus prefers in accumulating these minerals, this action is highly important for development of conceptus, survival and growth. Furthermore, few recent results depict that increase in the biological availability of manganese, zinc and copper, by attaching to the short peptide chains (protonated trace minerals) can definitely enhance the reproductive performance in case of swine.

Mineral concentrations in case of conceptuses from female pigs that are consuming protonated trace minerals were found to be greater than those from the females that have consumed only inorganic mineral salts. Interpreting the mechanisms whereby the development and survival of conceptus are augmented by essential trace minerals that may lead to the specific feeding programs development to increase the health and number of offspring at parturition.

Vitamin A

Livestock, particularly the ruminants, tends to consume vitamin A, principally in the inactive form —Provitamin A or the carotenes, excluding when it is being fed as a supplement in case of the cereal based concentrates. Provitamin A is being converted into the active vitamin A in small intestines and along with the preformed vitamin A supplement that is being stored in the muscle, liver, milk and eggs, that is to be utilized for different functions, including those that are particularly linked with the reproductive phenomena. Reproductive disorders which are observed with vitamin A deficiency in case of farm animals mainly include low conception rate, delayed puberty, high perinatal mortality, high embryo mortality, that are resulting from blind offspring, weak offspring and reduced libido in case of male animals. Litter size during birth and weaning is a very essential economic index in case of multiparous species including pig, and various research reports exist that vitamin A is highly having a positive effect on the litter size [1,2]. The asynchrony with the early embryonic development has been found to be highly associated with the increased embryonic mortality. Vitamin A can increase the concentrations of serum progesterone on the day 3, 5 and 6 after the oestrus. Jindal et al. [3] have linked the higher levels of the progesterone during this period to increase the embryonic survival in gilts. The litter size increases in case of pigs supplemented or treated with vitamin A are primarily due to the increased embryonic survival which is mediated through an improvement in case of the early embryonic synchrony and an increased progesterone levels during the early post-ovulatory period.

Vitamin E and selenium

A strong relationship always tends to exist between selenium and vitamin E. Both of them mainly function as the cellular antioxidants that helps to protect cells from certain harmful effects of hydrogen peroxide and certain other peroxides formed out of fatty acids. The main function of Selenium is that it acts as a component of the cytosolic GSH-Px, that helps to reduce peroxides level, whereas vitamin E tends to function as a specific lipid-soluble antioxidant in case of cell membrane. GSH-Px generally tends to destroy the peroxides before they tend to attack cellular membranes, whereas vitamin E acts within the cell membrane which is preventing the auto-oxidation i.e., chain reactive of the membrane lipids. Impairment in the reproductive performance in case of both males and females of all the farm animal species has been found to be attributed to a selenium deficiency. Reproductive disorders in case of cattle are linked to the selenium deficiency are intermittent, , delayed conception, fragile or silent heat periods, poor fertilization, development of cystic ovaries [4], reduction in sperm motility, uterine motility reduction, mastitis development [5], and fetal membrane retainment (RFM) [6,7]. The RFM incidence is very high and the deficiencies of selenium and vitamin E tends to constitute the most important nutritional cause. Crucial effects of the dietary selenium deficiencies were observed on various reproductive events starting from onset of the heat through rate of conception to the milk production and performance of the off springs.

Copper and molybdenum

It is always better to consider copper and molybdenum together, for the reason that because of the well-known interactions between two elements. Interactions which may lead to the impaired utilization of copper. Thiomolybdates are found to be formed in case of rumen following certain reactions between the molybdenum and sulfur (sulfide). Thiomolybdates, consecutively, react with copper to form the insoluble copper thiomolybdate, that is unavailable to cattle. The copper-molybdenum-sulfur complex is one among the limiting interactions that is affecting the copper utilization, and it also the leading cause behind the secondary copper deficiency which is in presence of adequate dietary copper content, as combatted to a primary copper deficiency that is arising from inadequate dietary copper content. With reference to Phillipo et al. [8], copper reserves in case of dairy heifers were found to be depleted following the high molybdenum and iron intake. Certain antagonistic relationships which may decrease the copper bioavailability can lead to secondary deficiencies, impaired reproductive efficiency and sub-clinical symptoms are copper-zinc, copper-iron, and copper-phytate complexes. This susceptibility to biologically unavailable complexes formation is very much responsible for the higher incidence of syndromes of copper deficiency, particularly with the grazing ruminants. The reproductive disorders that are associated with copper deficiency in case of grazing ruminants includes abortion and foetal resorption; delayed or depressed oestrus tends to cause low fertility; long post-partum return to oestrus period; embryonic mortality and infertility associated with anoestrus [4]. The requirement of molybdenum in case of animals are found to be extremely low, and these requirements are always likely to be met readily by the provision of normal diets, and to the extent that out of unequivocal evidence of the molybdenum deficiency in case of ruminants that is unrelated to copper is always found to be extremely rare. Otherwise, many of the reports suggested that copper deficiencies syndromes are generally secondary deficiencies that are relating to the higher molybdenum concentration [8]. Certain reproductive disorders that are reported including sterility and decreased libido in case of bull calves that is caused by damage of tissues and reduction in spermatogenesis (Thomas and Moss, 1951); reduced conception rate, delayed puberty, anoestrus and embryonic mortality [8] and a reduction in the ovulatory peak of LH in case of animals supplemented with molybdenum, to the extent that the exogenous LH tends to spike the peak that had no effect on the conception rates of the animals. Hence it is concluded that the effects arise out of molybdenum may also be mediated by an interference with the secretion of certain ovarian steroids, otherwise by the feedback of the steroids on hypothalamo-pituitary system.

Zinc

Zinc which is a component of different metallo-enzymes and it is associated with several enzymatic reactions associated with protein synthesis, nucleic acid metabolism and carbohydrate metabolism. Hence, it is highly essential in cells like gonads, where active growth and division are taking place. Consequently, reproductive functions are seriously impaired by zinc deficiency, and spermatogenesis and the development of primary and secondary sex organs in the male, and all phases of the reproductive process in the female from oestrus through pregnancy to lactation, may be affected. A reduction in testicular size was observed in bull calves fed a zinc deficient diet for 13 weeks, the detrimental effects of a dietary zinc deficiency in farm animals on feed consumption and various phases of the reproductive cycle in the female, perhaps through its involvement in steroidogenesis [9] and carbohydrate and protein metabolism.

Iodine

Iodine deficiency is portrayed by numerous reproductive problems in case of adult females that includes abortion, fetal resorption, suppressed estrus, irregular estrous cycles and stillbirths.

Manganese

A deficiency of Manganese will end up in impaired reproduction and poor growth, which is depicted by testicular atrophy in case of males Short et al. [10], ovulation impairment in case of females and decline in litter size with ataxic, weak piglets. Manganese transport is expedited by α2-macroglobulin that tends to occur rapidly to wide range of tissues where it is concentrated in the cell's mitochondria. The tissue that is highly reactive to dietary intake of Manganese is bone, which it is critical for chondroitin sulfate formation as a factor of mucopolysaccharides in the organic bone matrix. Therefore, Manganese may play a major role in bone formation of fetus during organogenesis. Numerous findings have revealed that Manganese can cross the placenta into the fetus and storage of Manganese in fetus appears to be maternal dietary intake dependant. Out of the three key isozymes of Super Oxide Dismutase (SOD) found in humans, one is Manganese - SOD, that is found in the mitochondria Studies through working with fibroblast cell line revealed that cellular differentiation can be stimulated by Manganese - SOD, and cellular differentiation is an essential mechanism that is particularly necessary during early fetal development. Furthermore, bovine embryos preimplantation were revealed to transcribe and explicit the Manganese - SOD under culture conditions. Other functions endorsed to Manganese include it actions as a cofactor for an enzyme that it converts mevalonic acid to squalene and it can stimulate the synthesis of cholesterol. Squalene is the precursor in case of steroid hormone production; thus, Manganese tends to have a role in initiation of estradiol secretion by conceptus which acts as the signal for pregnancy recognition in case of pigs. Alternatively, Manganese play a crucial role in the progesterone secretion because of the Manganese concentrations in case of CL of the ewes that is increased between the 4 and 11 days and the sub-optimal progesterone concentration has been found to be implicated as a cause for the early embryonic loss.

Control of early embryonic mortality by nutritional manipulation

Optimum provision of the specific nutrients as per the requirements (the under nutrition as well as over nutrition has to be taken care off), inclusion of the dietary protein not greater than 17-19% Crude Protein; the balanced nutrition has to be provided to the animals depending upon their requirements either it may be a maintenance, gestational, etc. Supplementation with adequate quantity of mineral mixture and provide the area specific mineral mixture (Specific minerals deficient in that particular area). Restriction of the grazing animals into the field that has poisonous plants (Kale, *Veratrum califonicum*) which causes the embryonic mortality. Restricted supply of the estrogen containing plants such as the Red clover (*Trifolium pretense*), subterranean clover (*Trifolium subterranean*), Barley grain (*Hardeum vulgare*), Oat grain (*Avena sativa*) etc that can disturb the hormone balance leads to early embryonic mortality.

Conclusion

Nutrition play important role in all physiological functions of the body either directly or indirectly. Impaired nutrition directly has deleterious effects on reproductive performance of animals. If proper nutrition is provided to the livestock, this ultimately helps in improved production and reproductive functioning of the animal. Proper supplementation of vitamins and minerals are highly recommended and desired to have a desired impact on animal reproduction and productivity. At the same time, excess supplementation of trace minerals and vitamins is also not recommended since it can cause some deleterious effects out of over supplementation and toxicity.

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