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Seminal plasma proteins and buffalo bull's fertility

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Abstract

Seminal plasma is the acellular part of the semen with composition varying among different species due to the difference in glands or type of ejaculate they have. It is basically composed of seminal plasma proteins which perform many functions, but most of them have not been studied in detail, especially the functions related to fertility regulation and fertilization. Bull fertility is an important aspect of fertilization affected by seminal plasma proteins. The present review attempts to review composition of seminal plasma of mammals, its major proteins and their functions regarding sperm function with a particular focus on its role in fertility indication in bull. Different studies on seminal plasma proteomics, beneficial as well as the harmful role of seminal plasma proteins on sperm function and fertility regulation was investigated. Most important proteins working as bull fertility markers are the osteopontin, prostaglandins D synthase and sperm adhesion 2. Of these higher amounts of osteopontin are found in bulls of higher fertility and higher amounts of sperm adhesion 2 are found in bulls of lower fertility. From these studies it is clear that seminal plasma proteins are necessary for both spermatozoa and oocytes functionality and therefore play an important role in bull's fertility as well as infertility.

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Introduction

Seminal plasma

Semen is a spermatozoa containing fluid secreted by gonads and other vesicles. It having cellular and acellular parts with acellular part commonly known as seminal plasma (WHO, 2010). Its composition varies among species, within individuals and even within ejaculates (WHO, 2010). In some species seminal plasma forms about 95-98% of the total volume of semen (Beyler *et al.,* 1982).

Origin and composition

Seminal plasma produced by accessory glands namely seminal vesicles, prostrate and bulbourethral glands is an important source of proteins, phosphatases, glycosidases, mucin and hyluronidase (Drake *et al.,* 2010). Major seminal plasma proteins inhibiting sperm motility and antibacterial activity are semenogelin I and II, lactoferrin, protein C inhibitor and fibronectin (Duncan *et al.,* 2007).

Specific hormones control the production and secretion of seminal plasma proteins which might be prostate specific antigen, prostatic acid phosphatase and cysteine rich prostate specific protein (Burden *et al.,* 2006).

Seminal plasma proteins

Seminal plasma proteins are of vascular origin in most species but may be fibronectins or sperm adhesions in ungulates like bull and buck (Kelly *et al.,* 2006; Calvete *et al.,* 2007). Basically these proteins are of three types namely fibronectins, type II modules and sperm adhesions (Kelly *et al.,* 2006).

In bull, ram and human most abundant proteins of seminal plasma are transferrin and albumin (Moura *et al.*, 2007). Peptides also forms an important part of seminal plasma in addition to proteins which may be fragment particles or peptide hormones (Duncan *et al.,* 2007). Besides structural differences, seminal plasma proteins also differ in functionality depending on their production source which are determined by difference in relative abundance as well as structure and way of expression (Calvete *et al.,* 2007).

Properties

Seminal plasma proteins forms coating layers by binding firmly on sperm surface during ejaculation (Varilova *et al.,* 2006). They are involved in maintaining viability of sperm, sperm attachment to female reproductive tract, fertilization and fertility indication (Topfer *et al.,* 2005).

They are also important in providing additional coating to premature spermatozoa by preventing exocytosis (Topfer *et al.,* 2008). Seminal plasma induces immunity in spermatozoa or early embryos in oviduct having antigen by initiating immune tolerance (Moldenhauer *et al.,* 2009).Direct relation was shown in some studies between sperm quality and season as sperm quality increased in winter and decreased in summer (Chacur *et al.*, 2011).

In contrast, some other studies showed that spermatozoa are sensitive to cold shock which affects role of seminal plasma in sperm functionality by destabilizing sperm membranes (Watson 1995). Seminal plasma of different species also differ in the form and source of proteins which might be due to the difference in different glands as well as the type of ejaculate secreted by these glands (Rodriguez *et al.,*2010).

Most important functions of seminal plasma are regulation of steps towards fertilization, capacitation, sperm reservoir in oviduct, uterine immunity regulation, transport of sperm in genital tract of female, gametes interaction and their fusion (Topfer *et al.,* 2005). Bicarbonates and zinc ions of seminal plasma regulates cell motility and chromatin stability thus maintaining sperm viability (Bjorndahl *et al.,* 2010). Bovine seminal plasma proteins (BSPs) secreted by seminal vesicles belongs to heparin binding proteins (Nauc and Manjunath, 2000).

They are actively involved in binding to phosphatidylcholine, plasminogen and sphingomyelin on sperm surface thus initiating capacitation by interacting with heparin and high density lipoproteins (Vadnais *et al.,* 2010).

Bovine seminal plasma proteins (BSPs)

Bovine seminal plasma proteins (BSPs) forming 70% of bovine seminal plasma are mostly heparin binding proteins secreted by seminal vesicles (Nauc and Manjunath 2000). They are having factors for useful or harmful sperm function (Moldenhauer *et al.,* 2009). Bovine seminal plasma proteins (PSPs) are important in increasing motility of sperm by stabilizing sperm membranes in bull and stallion (Avila *et al.,* 2011). Structural changes have been observed in porcine seminal plasma proteins by heparin binding proteins thus affecting capacitation, recognition of zona pellucida and fertilization (Vadnais *et al.,* 2010). Non heparin binding proteins shows a protective function to spermatozoa by binding to its surface and prevent not only exocytosis but also premature capacitation of sperm (Caballero *et al.,* 2008). One of the seminal plasma protein is fibronectin 2 that binds to phospholipids and phospotidyl choline of sperm membrane (Ekhlasi *et al.,* 2005).

Seminal plasma proteins and fertility

Many studied have been conducted to show the relation of seminal plasma proteins to fertility (Milardi *et al.,* 2012). Correlation between seminal plasma proteins and fertility has been studied in cow bull, stallion, boar, ram and goat (Jobim *et al.,* 2005).Some studies using gel electrophoresis in bull, stallion, boar and human showed that seminal plasma proteins are good markers of fertility (Novak *et al.,* 2010). Low or high fertility association has been shown in studies on some seminal plasma proteins like osteopontin (OPN) prostaglandin D synthase (Cancel *et al.,* 1999). It was observed that bulls of higher fertility contains higher amounts of osteopontins than less fertile bulls (Mccauley *et al.,* 2001).Heparin binding proteins have fertility associated antigen (FAA) and 9% more fertility was found in FAA positive bulls than the negative ones (Bellin *et al.,* 1998). Low litter size was observed in mice on the removal of seminal vesicles which might be due to the infertility caused by absence of seminal plasma proteins. Similarly, sub fertility of an animal could be improved by adding spermatozoa from a fertile semen sample (Mccauley *et al.,* 2001).

Some seminal plasma proteins acts as fertility indicators in bulls like osteopontin, prostaglandin D synthase and Sperm adhesion 2. Of these osteopontin directly helps in binding of sperm to oocyte and early development of embryo as is highly acidic. It indirectly affects fertility when it binds to integrin receptors present on epithelial surface by preventing bacterial infections (Brown *et al.,* 1992).

Prostaglandin D synthase (PGD) also associated to fertility is encoded by a gene present on chromosome 6 (Gerena *et al.,*2000).It indirectly helps male genital organs in up taking retinoids which are important in cells growth, differentiation, and spermatogenesis and sperm integrity (Koubova *et al.,* 2006). Sperm adhesion 2 (sperm adhesion Z13) is encoded by gene on chromosome 26 in bovid and is negatively associated to fertility as its higher amounts were observed in bulls of lower fertility (Moura *et al.,* 2006).

Harmful effects of seminal plasma proteins

Harmful effects of seminal plasma has also been observed in addition to their useful role in relation to sperm viability and motility (Iwamoto, 1993). Some seminal plasma proteins prevents interactions of proteins with acidic polysaccharides on binding in bull and stallion (Liberda *et al.*1998). Seminal plasma proteins present in primary secretions increases sperm survival as compared to the last segments of ejaculates which shows negative effect on sperm survival in boars and human (Rodriguez *et al.,* 2009).

Conclusion

Seminal plasma proteins play a role in sperm motility, viability and interaction with female genital tract as well as oocyte in bovine. They also provides signals for immune system of female by sperm modulation or rejection thus affecting the intrinsic fertility of male, female or both. Most importantly these proteins act as biomarker candidates for sperm fertility and sterility. On the whole seminal plasma proteins can be used as important indicators for fertility in bull as higher amounts of seminal plasma protein are found in fertile as compared to non-fertile bull and removal of seminal plasma leads to infertility. So, the fertility indication in bull by seminal plasma proteins could be helpful in increasing the fertility as well as higher reproduction rate and thus the improvement of the farm industry.

Conflict of interest

The author declare that there is no conflict of interest in this review article.

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