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REVIEW

Laser researches on livestock semen and oocytes: A brief review

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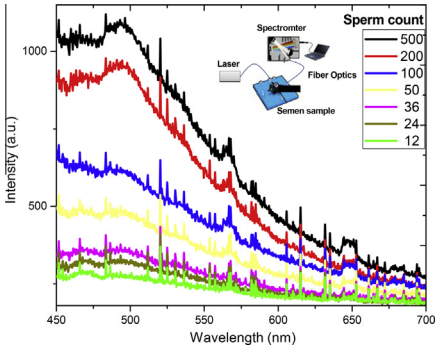
GRAPHICAL ABSTRACT



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ABSTRACT

This article presents a brief review of the past and present literature pertinent to laser effects on sperm motility parameters, improvement of oocyte maturation and characterization of semen in livestock. The aim was, on one hand, to make the readers aware of such knowledge and on the other hand to trigger the interest of the animal reproduction scientific community in attempting some laser techniques that have not yet been fully exploited in the field of artificial insemination. With respect to the conventional methods, laser is a more sensitive and less costly technology that can be used for improving artificial insemination and embryo production system. Since 1980s, laser treatment came on the biological samples scene; its applications have continuously been developed thereafter. Exploitation of laser light by various researchers for improving the reproductive efficiency of sperm cells and the maturation rate in different livestock is

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Maturation
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demonstrated herein. Laser irradiation, in principal, can increase the production of adenosine triphosphate (ATP) and consequently increases the energy provided to the cell. Since sperm motility and oocyte maturation depend on the energy consumption, an increase in the energy supply to the cells will be of great importance. In addition, the authors also discuss the use of laser spectrochemical analytical techniques, such as laser induced breakdown spectroscopy (LIBS) and laser induced fluorescence (LIF), in characterization of semen samples.

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Introduction

Over the past two decades, the assisted reproductive technologies (ARTs), namely artificial insemination (AI), *in vitro* maturation (IVM), *in vitro* fertilizations (IVF), intracytoplasmic sperm injection (ICSI), and somatic cell nuclear transfer (SCNT), for different species have been evolved effectively [1–6].

Artificial insemination offers many advantages to commercial livestock production and is routinely used in several domestic animals such as cattle, sheep and horses [7]. The technique represents a very important and a promising issue to increase animal production. Improvement of sperm motility is expected to have direct qualitative and quantitative impacts on AI of livestock. As it is well known, the role of a spermatozoon is to deliver the male's genetic material to the oocyte during fertilization; consequently motility is considered as one of the most important parameters. For motility, spermatozoa require development of a tail (flagellum). Mammalian sperm is characterized by the fusion of mitochondria in a mitochondrial sheath located around the apical portion of the tail. In different species [8] a direct relationship between motility and mitochondrial activity was shown.

Evaluation of oocytes quality is of high importance, since improvement of maturation rate represents the corner stone of the above mentioned technologies. Many researchers conducted experiments and suggested procedures for improving oocytes maturity using different types of media such as a basal medium (M199) [9], and DMEM/F12-based media [10] and/or different incubation times [11,12]. The success of *in vitro* produced embryo depends on the quality and competence of gametes involved in oocyte maturation, fertilization, and early embryonic development.

During the last two decades of the 20th century, the effects of laser on biological tissues have been studied widely [13–17]. It has been clearly demonstrated that low level laser irradiation, also known as photobiomodulation, has pronounced biological effects. Laser irradiation of fibroblasts [18], and other biological structures, such as the neuromuscular junction [19] are some examples of such biological application of lasers. In addition of studying the cells' response to laser light irradiation, recent studies dealt with laser effects on spermatozoa [20–23], and oocytes [24,25]. The positive effects of low level laser irradiation include the increase of cellular metabolism and improvement of structural characteristics, as has been confirmed in the literature [13,26,27].

Many studies have focused on utilization of laser effect on sperm motility parameters. Notwithstanding, there have been very few studies concerning the effects of laser on oocyte maturation. Over the last couple of years there has been an exponential growth in the areas of utilization of lasers (pulsed or continuous wave (CW)) which is reflected by an increasing number of publications, and thus its utility as an assisting technology has been proved. Below, a summary is presented of literature pertinent to the effect of laser irradiation on improving AI, oocyte maturation, and embryo production system in domestic animals.

Laser and improvement of sperm parameters

Sperm consists of a head containing condensed DNA, followed by a short neck (midpiece) containing mitochondria and a thin tail (flagellum) responsible for motility [11,25]. The spermatozoon motility depends on energy supply. Both of energy metabolism in mitochondria and the motility system of the cells are involved in the activation of the sperm flagellum. ATP on the other hand can be produced by mammalian spermatozoa via both of aerobic and anaerobic glycolysis [28-30]. Previously published works showed the potential of low-power laser irradiation of spermatozoa in increasing their motility and raising the ATP amount in cells. The first paper published on this topic was that of Goldstein [31]. Thereafter, it has been clearly evidenced that He–Ne