REVIEW

GASOTRANSMITTERS IN THE REPRODUCTIVE SYSTEM: A REVIEW*

M. Šmelcová, H. Tichovská

Czech University of Life Sciences Prague, Faculty of Agrobiology, Food and Natural Resources, Department of Veterinary Sciences, Prague, Czech Republic

Gasotransmitters are small gaseous signalling molecules produced in cell metabolism. The gasotransmitter family includes nitric oxide (NO), carbon monoxide (CO) and hydrogen sulfide (H_2S). Previously, these gases were known as atmospheric pollutants with toxic impact on mammals. However, more recently it has been found that they play important roles in physiological processes such as vasodilation, transmission of nervous signal or body defence. Currently, the effect of the gasotransmitters on the reproductive system is being studied thoroughly. The research of the effect of gasotransmitters on the reproductive system in laboratory and farm animals is important not only to increase reproductive potential in farm animals, but also to utilize results of the research human reproductive medicine. It has been proven that gasotransmitters play certain roles both in the male and female reproductive systems. In males, all the three above-mentioned gasotransmitters influence for example penis erection. NO and CO exert some effects on spermatogenesis and sperm motility. In females, NO, CO and H_2S suppress contractions of uterine smooth muscle during pregnancy. NO and CO also effect the development of female gametes. This review is focused on enzymatic production of gasotransmitters and their functions in the mammal reproductive system.

gasotransmitter; nitric oxide; carbon monoxide; hydrogen sulfide; reproduction

INTRODUCTION

A well-mastered reproductive technology is one of prerequisites for success in farm animal rearing. The research in breeding and genetic improvement of farm animals is focused particularly on pregnancy diagnosis, artificial insemination, *in vitro* embryo production, manipulation with genetic material and cloning. In order to increase the efficiency of the above-mentioned biotechnological methods it is necessary to know mechanisms that regulate reproductive processes. It has been known for a long time that the reproductive processes are regulated by hormones and enzymes. However, more recently it has been shown that even much smaller gaseous molecules – gasotransmitters – are involved in the reproductive processes. The journey to investigations of gasotransmitter functions in the regulation of physiological processes was opened by the discovery of American physiologist Dr. Furchgott. In 1978 he discovered that endothelial cells produce an unknown substance that can induce vasodilation.

In 1987 this substance was determined as nitric oxide (Ignarro et al., 1987; Palmer et al., 1987). The Nobel prize in medicine and physiology for this outstanding discovery was granted to R. Furchgott, L. Ignarro and F. Murad. More recently, other gasotransmitters have been discovered, such as carbon monoxide (CO) and hydrogen sulfide (H_2S). Typically, gasotransmitters are produced endogenously and their production is controlled. They easily penetrate through biological membranes and under natural conditions they participate in biological processes by exerting action on specific biological targets (Wang, 2002). The role of nitric oxide (NO) and carbon monoxide (CO) in the reproductive system has been investigated more extensively (Buhimschi et al., 1996) and recent research has confirmed the involvement of hydrogen sulfide in the reproductive functions (Wang, 2002).

Nitric oxide (NO)

Inside cells, NO is synthesized from aminoacid L-arginine. This process is catalyzed by NO-synthase (NOS) that occurs in three basic isoforms localized in different tissues (Griffith, Stuehr, 1995). In the nerve tissue, neuronal nitric oxide synthase (nNOS) was found, endothelial NOS (eNOS) was detected in

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endothelium of blood vessels. The third isoform, inducible NOS (iNOS), was first found in macrophages and occurs mainly in the immune system (Griffith, Stuehr, 1995; Snyder, 1995).

The NOS enzymes produce different amounts of NO, depending on life conditions of cells. The synthesized NO has a short lifetime and within a few seconds (5 s) it is incorporated in other compounds. NO plays several different roles in the mammalian body – it serves as neurotransmitter, blood pressure regulator as well as one of the immune system weapons against bacterial infections, parazite infestations, tumours and inhibitor of viral replication. Its use depends on the place of its production and especially on concentrations of produced NO.

Under physiological conditions, NO is mostly synthetized by the isoforms eNOS and nNOS at low concentrations when NO oxidation is slow and regulative effect of NO usually prevails. NO produced particularly with the isoform eNOS is often bound to hem in enzyme guanylate cyclase which is responsible for formation of the second messenger, cyclic guanosine monophosphate (cGMP) (Denninger, Marletta, 1999). Via this pathway, NO causes relaxation of smooth muscle in blood vessels, heart muscle and striated muscle (Diamond, Blisard, 1976). The muscle relaxation is due to reduced cellular calcium concentrations caused by the action of proteinkinase G that is activated by cGMP. Interestingly, NO can cause a decrease in calcium concentrations independently of cGMP (Adachi et al., 2001).

S-nitrosyles are often formed from NO in the brain exposed to nNOS isoform. S-nitrosyles participate in the transudction of stimuli in the brain including memory processes. Furthermore, NO is involved in inflammatory processes through S-nitrosothioles as part of natural defence against pathogens, and also in the control of blood pressure in vessels (Broillet, 1999). NO alone also reduces the risk of formation of thrombi by its effect on thrombocyte aggregation, and suppresses tumour growth by inducing programmed cell death (apoptosis) (Huang, Fishman, 1996). In addition to the formation of S-nitrosyles, NO frequently modifies various proteins such as hemoproteins (Hanafy et al., 2001).

Nitric oxide in the male reproductive system

NO exerts vital effects on the hormonal regulation of male reproductive functions and is necessary for male sexual activity (Mani et al., 1994). NO influences male sexual behaviour mainly via regulation with hormones such as luteinizing-hormone releasing hormone (LHRH) (McCann, 1982), which induces spermatogenesis in males. NO stimulates the formation of LHRH by glutanylate cyclase activation. Furthermore, NO effects male behaviour by regulating male sexual hormone testosterone (Davidoff et al., 1997).

The first functions of the male reproductive system discovered included the ability to regulate penile erection (Ignarro et al., 1990). During sexual stimulation, NO is released from nerve endings and endothelial cells of penile vessels. The produced NO activates enzyme guanylate cyclase that is responsible for the synthesis of cyclic guanosine monophosphate (cGMP). This leads to increased calcium concentrations in smooth muscle cells of blood supplying arteries and cavernous bodies of penis. Consequently, these vessels increase their diameter and blood supply into erectile tissue (Gupta et al., 1995). The discovery of NO involvement in penile erection contributed to the development of first medicine against erectile dysfunctions – Viagra. Viagra induces the same response as nitric oxide, but also maintains high cGMP levels (Boolell et al., 1996). NOS enzymes are also localized in deferent ducts, urethra, accessory sexual glands and testicles (Ehrén et al., 1994). In the testicles, NOS are localized in the Leydig and Sertoli cells in humans (Davidoff et al., 1995; Stephan et al., 1995; Tatsumi et al., 1997) and pigs (Ambrosino et al., 2003). NOS was also found in sperms of all spermatogenesis stages in humans (Zini et al., 1995), pigs (Ambrosino et al., 2003) and cattle (Meiser, Schulz, 2003; Reyes et al., 2004).

Similarly to the other organ systems, the roles of NO in the male and female reproductive system depend on its concentrations. Interestingly, a small amount of NO which is synthetized in the reproductive system protects sperms from free radicals (Sioutas et al., 2008). NO at low concentrations is necessary for sperm motility in the ram (Hassanpour et al., 2007), and the addition of low NO concentrations in hamster sperm even increased sperm motility (Creech et al., 1998). On the contrary, high NO levels produced during patophysiological conditions can cause infertility because high NO concentrations decrease sperm motility (Rosseli et al., 1995). Without NO synthesis, human and murine sperms are not capable of full maturation, attachment to the egg and fertilization (Herrero et al., 1999). It has been found that in cattle NO acts through cGMP activation or through S-nitrosylation during the sperm maturation (Gopalakrishna et al., 1993). Experimental findings in pigs showed that the dietary inclusion of L-arginine (substrate for NOS) and a herbal extract simulating cGMS increased libido, concentrations of sperms in ejaculate and sperm viability (Opletal et al., 2008).

Nitric oxide in the female reproductive system

Similarly to males, NO in females plays an important role in hormonal regulation of female reproductive functions. NO influences ovulation by stimulating luteinizing hormone and regulates steroidogenesis in the ovaria (Van Voorhis et al., 1995).

Nitric oxide is active both in the lower female reproductive tract and in the ovaria. NOS was found in the rat vagina where it probably influences vaginal secretion (Musicki et al., 2010). NOS enzyme was also found in the cervix of rats (Buhimschi et al., 1996), humans (Chatterjee et al., 1996) and rabbits (Batra, Al–Hijji, 1998).

Another important reproductive role of NO is the effect on uterus contractility, both during pregnancy and in pathological conditions. NO is involved in pregnancy maintenance both in laboratory (Farina et al., 2001) and farm animals such as pigs (Andronowska, Chruściel, 2008), mares (Roberto da Costa et al., 2008) and ewes (Yallampalli et al., 1994). During pregnancy, physiologically produced NO inhibits smooth muscle contractions in the uterine wall and its concentrations decrease only around parturition (Buhimschi et al., 1996). Based on these findings, a product for pregnancy maintenance in ewes was developed in the form of vaginal suppository containing NO donors (Blasi et al., 2008). NO donors help maintain pregnancy and can be used in humans, too (Yallampalli et al., 1996).

NO also induces contractions of the oviduct in humans and probably also in cattle and rats. Low NO concentrations produced in the oviduct can stimulate motility of passing sperms and protect gametes from being damaged by free radicals (Rosselli et al., 1996; Ekerhovd et al., 1997).

Nitric oxide is an important regulator of development of female gametes – oocytes. NOS enzymes were found both inside the oocyte, and in surrounding ovarian cells in laboratory rodents (Van Voohris et al., 1995; Jablonka–Shariff, Olson, 1997; Mitchell et al., 2004), cattle (Tesfaye et al., 2006; Pires et al., 2009) and pigs (Takesue et al., 2003; Tao et al., 2004, Chmelikova et al., 2009; Chmelikova et al., 2010).

Many studies have shown that NO is necessary both for the growth and subsequent meiotic maturation of the oocyte during which the oocyte reduces its genetic material (Jablonka-Shariff, Olson, 1997; Tao et al., 2004; Tichovska et al., 2011). Without functional NOS female mice have less offspring and higher mortality of newborns (Jablonka-Shariff, Olson, 1998). Nevertheless, several contrary opinions were published stating that NO inhibits proper development of oocytes in the rabbit (Yamauchi et al., 1997) and mouse (Nakamura et al., 2002; Sela-Abramovich et al., 2008). Several studies even demonstrated that high NO concentrations are toxic for oocytes on mice (Sengoku et al., 2001) and pigs (Tao et al., 2004; Tao et al., 2005). Gradually it was ascertained that like with spermatogenesis also in the development of oocytes NO plays a double role. The production of low NO concetrations is necessary for meiotic maturation, whereas high concentrations of NO can damage oocytes and impair their development (Bu et al., 2003; Tichovska et al., 2011). The mode of action of NO on the oocyte development has not been fully elucidated. It is assumed that NO acts via the cGMP cascade, like with muscle contractions (Jablonka-Shariff, Olson, 1998), or via the cascade activating kinases which are necessary for the resumption of meiotic maturation (Tranguch et al., 2003; Sela-Abramovich et al., 2008).

Interestingly, nitric oxide can launch the partenogenetic embryonal development in a mature oocyte. The oocyte can be artificially activated with this procedure which can be utilized in the animal cloning (Petr et al., 2005; Petr et al., 2010). The results published by Petr et al. (2006) showed that also the activation of porcine oocytes by an NO donor is dependant on the signalling pathway regulated by cGMP, similarly to the vasodilatation causing cascade.

Carbon monoxide (CO)

Carbone monoxide, like NO, had been considered as a toxic gas for a long time. Nevertheless, it was found that CO is also produced by the cells and at low concentrations it can act as a biological messenger, and at high concentrations it can damage tissues. The CO molecule is formed during heme degradation with specific enzyme heme oxygenase, HO (Tenhunen et al., 1969). Like NOS, HO occurs in three basic isoforms: HO1, HO2 and HO3. The cells exposed to stress synthesize enzyme HO1 that belongs to the family of heat-shock proteins which protect the cells from heat stress. HO1 caused production of CO that is able to regulate inflammatory processes to a certain extent. The reaction of CO with oxygen produces free radicals and reactive oxygen species which are utilized by macrophages for fighting bacteria (Chin, Otterbein, 2009).

The second enzyme, HO2, has been found in the endothelium of blood vessels (Zakhary et al., 1996) where synthesized CO acts as vasodilator, via the same cascade as NO (through the activation of cGMP and direct activation of potassium channels) (Koehler, Traystman, 2002). Additionally, CO can regulate vasodilatation caused by the effect of NO. Under high NO concentrations, CO acts as an antagonist of NO-cGMP cascade. On the contrary, if tissue concentrations of NO are too low, CO can more or less replace the vasodilating effect NO (Johnson, Johnson, 2003).

CO produced by this isoform is, similarly to NO, involved in neurotransmission, relax of smooth muscle, inhibition of thrombocyte clotting and prevention of programmed cell death (Soares et al., 2002;

Ryter et al., 2006). Frequently, CO forms complexes with hemoproteins such as myoglobine in muscles and cytochrome-c oxidase in mitochondria, and it can also regulate the production of NO by binding nitric oxide synthase (NOS) (Furchgott, Jothianandan, 1991; Wink, Mitchell, 1998). HO2 was the third form of the enzyme found, but its enzymatic activity is low and acts more as an oxygen transporter (Zakhary et al., 1996).

Carbon monoxide in the male reproductive system

CO, like NO, also influences many reproductive functions, from hormonal regulation to the development of germ cells. HO enzymes were found in the hypothalamic neurones (Verma et al., 1993) and produced CO is involved in the stimulation of gonadotropic hormones (Lamar et al., 1996).

The best elucidated CO function is the effect on penile erection. HO2 was found in the same tissues of penile corpus cavernosum in rats and humans as NOS (Hedlund et al., 2000; Ushiyama et al., 2004). The role of CO in the erection of penis is closely related to the role of NO (Aziz et al., 2008). Several studies have shown that CO stimulates the formation of cGMP via the same cascade as nitric oxide (Aziz et al., 2009). The close connection between NO and CO roles in the erection was demonstrated also for the action of the drug Sildenafil, and on the basis of HO1 regulation, a new therapy of erectile dysfunction was developed (Shamloul, Wang, 2006).

CO is also necessary for the ejaculaion because it causes the release of urethral muscle (Werkström et al., 1997; Burnett et al., 1998) and also influences spermatogenesis. HO1 was found in the testicles of humans and rat and in the Sertoli cells of rats, whereas sperms produce HO2 (Ewing, Maines, 1995; Middendorff et al., 2000). HO1 is active also during spermatogenesis in mice (Kurata et al., 1993). The main role of CO during spermatogenesis is sperm protection. Due to stress (e.g. heat stress), the Leydig and Sertoli cells start to produce CO that protects sperms from free radicals (Ozawa et al., 2002; Shiraishi et al., 2005). It was found that in humans HO is necessary for proper spermatogenesis and sperm motility. The lack of synthetized CO in the testicles can lead to infertility (Aziz et al., 2009).

Carbon monoxide in the female reproductive system

In female rats it was found that CO is necessary for the normal course of oestrous cycle, parturition and lactation (Alexandreanu, Lawson, 2003). CO produced in the hypothalamus inhibits oxytocine synthesis (Kostoglou-Athanassiou et al., 1996) and stimulates ovarian estradiol production. It has been proven to play an important role in the regulation of progesterone and androstenedione secretion (Alexandreanu, Lawson, 2003).

Similarly to NOS, enzymes HO1 and HO2 were found in the rat uterus (Kreiser et al., 2003). It was found that uterine HO activity increases during pregnancy. CO can suppress smooth muscle contractions, regulate blood supply to the placenta, thereby helping to maintain pregnancy (Bainbridge, Smith, 2005). In the uterine tissue CO acts either through cGMP and it can reduce oxidative stress (Cella et al., 2006). It was found that with reduced uterine CO production pathological inflammatory conditions can occur due to the action of surplus free radicals (Bainbridge, Smith, 2005).

CO also participates in the development of female gametes – oocytes. The presence of HO1 and HO2 enzymes was proven in the ovaries of rats and pigs (Alexandreanu, Lawson, 2003; Harada et al., 2004). The cells surrounding the oocyte contain HO1 and HO2. HO2 was also found in ovarian stroma (Alexandreanu, Lawson, 2003). CO is likely to regulate the development of ovarian follicles. The follicles destined to decay contain higher amounts of HO1, whereas the follicles destined for further development contain more HO2. Furthermore it was found, that in swine higher CO levels increase programmed death rate of granulous cells in the follicle (Harada et al., 2004).

Hydrogen sulfide (H_2S)

Similarly to NO and CO, hydrogen sulfide used to be regarded as toxic gas. However, since its physiological function in the brain was discovered (Abe, Kimura, 1996), hydrogen sulfide has attracted attention particularly for its potential therapeutic effect on male and female reproductive dysfunctions. Hydrogen sulfide seems to influence a number of biological targets and induces physiological processes by not yet specified mechanisms (Kimura, 2010).

In mammalian tissues, hydrogen sulfide is produced with three enzymes. In most tissues, H_2S production is governed mainly by cystathionine β-synthase (CBS) and cystathionine γ-lyase (CSE) (Wang, 2002). The third enzyme that was found to produce hydrogen sulfide in the brain is 3-mercaptopyruvate sulfurtransferase (3MPST) (Shibuya et al., 2009). These enzymes use amionacid L-cystein as substrate and produce different amount of hydrogen sulfide (Starka, 2009).

Tissue concentrations of endogenous hydrogen sulfide range from 50 μM to 160 μM. A mechanism of hydrogen sulfide degradation is necessary for maintaining adequate tissue levels. First, H_2S is oxidated to thiosulfide in mitochondria, which is later transformed to the end product sulfide. The second metabolic pathway of hydrogen sulfide is methylation with thiol

S-methylstransferase (TSMT) to methanethiol and dimethylsulfide (Furne et al., 2001). Similarly to CO and NO, hydrogen sulfide binds to hemoglobine (Starka, 2009) forming sulfhemoglobine (Wang, 2002). Furthermore, hydrogen sulfide can react with NO, producing a nitrosothiol compound which is involved in reverse regulation of NOS enzyme activity (Whiteman, 2006).

Hydrogen sulfide has been paid greater attention as signaling molecule since the discovery of its presence in mammalian tissues. Hydrogen sulfide is produced in different parts of the body, e.g. in the central nervous system (Abe and Kimura, 1996), vascular system (Zhao et al., 2001), male reproductive system (Srilatha et al., 2007), and female reproductive system (Srilatha et al., 2009).

High concentrations of endogenous H_2S in brain tissue were measured in rats, cattle and humans (Eto et al., 2002). Hydrogen sulfide, similarly to nitric oxide, belongs to molecules that participate in the transmission of information between nerve cells and is involved in the processes of memory formation and learning. It regulates membrane ion channels in brain tissue and activities of many enzymes which may influence brain activities (Abe, Kimura, 1996).

Simultaneously, attention was paid to the role of hydrogen sulfide in the circulatory system. Zhao et al. (2001) confirmed that hydrogen sulfide, similarly to NO, regulates contractility of blood vessels and it can reduce blood pressure. These effects of hydrogen sulfide consist in the action of smooth muscle cells (Łowicka, Beltowsky, 2007). In smooth muscle cells isolated from blood vessels, hydrogen sulfide increased permeability of K_{ATP} channels and subsequently hyperpolarized the cell membrane. Hydrogen sulfide production can enhance for instance the action of nitric oxide (Starka, 2009).

Hydrogen sulfide is able to modify activities of many enzymes. While NO can change protein activity by the S-nitrosylation process (Hanafy et al., 2001), hydrogen sulfide regulates activity of proteins by replacing the SH group with SSH group in the protein. This reaction, called sulfhydration is an important factor which controls activities of 10 to 25% proteins in the liver. By means of sulfhydration, for instance activity of enzyme glyceraldehyde 3-phosphate dehydrogenase which is included in the process of glycolysis, is rapidly increased. Sulfhydration might be an important mechanism that controls many other metabolic processes in the animal body (Mustafa et al., 2009).

Hydrogen sulfide in the male reproductive system

Hydrogen sulfide is involved in the reproductive functions, too. Enzyme expressions that regulate endogenous hydrogen sulfide production, were detected both in the male and female reproductive system. Hydrogen sulfide effects penis erection, uterus contractility and oocyte development.

For the male reproductive system attention has been paid mainly to the role of endogenous hydrogen sulfide as a substance that facilitates penis erection. According to Srilatha et al., (2006), hydrogen sulfide is involved in relaxation of smooth muscle in blood vessels which is one of the basic causes of penis erection and at the same time it exerts a positive effect on the pressure in cavernous body in primates. mRNA and enzymes CBS and CSE have been found also in human penile tissue (d'Emmanuele et al., 2009). Based on these results it is assumed that hydrogen sulfide could serve as an alternative medicine against erection disorders.

In the rat testicles a different distribution of the two enzymes was revealed: CBS is present mainly in the Leydig cells, Sertoli cells and germ cells, whereas CSE was detected only in the Sertoli cells and immature germ cells (Sugiura et al., 2005). According to the above-mentioned studies it can be assumed that hydrogen sulfide is involved in the regulation of testicle functions.

Hydrogen sulfide in the female reproductive system

Gaseous molecules NO and CO play important roles in the female reproduction physiology (Rosseli et al., 1998; Alexandreanu, Lawson, 2003). Therefore scientists have focused on the role of hydrogen sulfide in the physiology of female reproductive processes.

Patel et al. (2009) detected enzymes CBS and CSE in the uterus, foetal membrane and placenta of rats. Also in the murine ovarium a high expression of CBS in follicular cells was detected, although not in the oocytes (Liang et al., 2006). The importance of CBS enzyme in fertility was demonstrated in mice with blocked CBS gene. The mice had lower counts of developing follicles, shorter and irregular oestrous cycle (Guzmán et al., 2006). Furthermore, Liang et al. (2007) found that by suppressing CBS expression in granulous cells, meiotic maturation of the oocyte is inhibited. Unpublished experiments demonstrated that in porcine oocytes two enzymes are located: cystathionine γ-lyase (CSE) and 3-mercaptopyruvate sulfurtransferase (3MPST).

Similarly to NO and CO, hydrogen sulfide is involved in the regulation of uterine muscle contractility. Sidhu et al. (2001) demonstrated that low doses of hydrogen sulfide donor reduce uterine contractions in the rat, thereby delaying the parturition. Sulfide ions hinder the binding of oxytocine to its receptors, thereby causing suppression of uterine contractions. The blocking of oxytocine receptors by H_2S is probably the mechanism that can delay parturition pain (Hayden et al., 1989). More recently it has been found that hydrogen sulfide relaxes smooth mus-

cle of reproductive system by means of nitric oxide signaling pathway and increased permeability of K_{ATP} channels (Srilatha et al., 2009).

CONCLUSIONS – PERSPECTIVES

The discovery of gasotransmitters NO, CO and H_2S in mammalian tissues has brought about a revolutionary change in viewing the regulation of many physiological and patophysiological processes.

Present knowledge of the role of gasotransmitters in the reproductive system is not complete. Initially, some experiments were focused on therapeutical properties of gasotransmitters. For instance CO is regarded as potential cure for some uterine diseases and hydrogen sulfide may be used to delay parturition pain and suppress uterine contractions during difficult deliveries in farm animals. Knowledge of vasodilating effects of gasotransmitters on penis can be applied in insemination stations for male breeders having erection problems.

At present it shows that the effects of gasotransmitters on the development of gametes can be applied in biotechnologies used in farm animal rearing, which are aiming at the improvement of animal performance. Many molecular biotechnology procedures (embryotransfer, genetic manipulation, gamete cryopreservation) in the field of reproduction biotechnology require successful cultivation of gametes and this may also be favourably influenced by gasotransmitters. It has been proven that NO influences not only spermatogenesis, but also the development of female gametes. The above-mentioned studies demonstrated that also gaseous molecules CO and H_2S have a great potential to influence gamete biology.

In order to elucidate the roles of CO and H_2S in reproductive physiology, more experiments are needed in animals with blocked CO and H_2S synthetizing enzymes. It has been demonstrated that gasotransmitters have similar properties and therefore it would be suitable to focus research efforts on mutual action of gasotransmitters on gametes and reproductive organs.

In conclusion, it can be summarized that knowledge of the action of gasotransmitters and mastering of pharmacology of their formation and degradation provide basis for the therapy of many serious disease conditions.

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ŠMELCOVÁ, M. – TICHOVSKÁ, H. (Česká zemědělská univerzita v Praze, Fakulta agrobiologie, potravinových a přírodních zdrojů, katedra veterinárních disciplin, Praha, Česká republika)

Gasotransmittery v reprodukční soustavě: přehled literatury

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Gasotransmittery jsou malé plynné signální molekuly produkované během metabolismu buněk. Do rodiny gasotransmitterů patří oxid dusnatý (NO), oxid uhelnatý (CO) a sulfan (H_2S). Tyto plyny byly dříve známy jen jako součást znečištěného ovzduší s toxickými efekty na organismus savců. Později ovšem bylo zjištěno, že zastávají důležitou funkci ve fyziologických procesech, jako je vasodilatace, nervový přenos nebo obranyschopnost organismu. V současnosti je intenzivně studován vliv těchto gasotransmitterů na reprodukční soustavu. Výzkum působení gasotransmitterů na reprodukci laboratorních a hospodářských zvířat je důležitý nejen pro zvýšení reprodukčního potenciálu hospodářských zvířat, ale získané poznatky mohou být využity také v oblasti humánní reprodukční medicíny. Funkce gasotransmitterů byla prokázána jak v samčí, tak i v samičí reprodukční soustavě. U samců všechny tři gasotransmittery ovlivňují například erekci penisu, NO a CO působí na spermatogenezi a motilitu spermií. U samic NO, CO a H_2S tlumí kontrakce hladké svaloviny dělohy za březosti. NO a CO mají vliv také na vývoj samičích pohlavních buněk. Tento literární přehled je zaměřen na enzymatickou produkci gasotransmitterů a jejich funkce v reprodukční soustavě savců.

gasotransmitter; oxid dusnatý; oxid uhelnatý; sulfan; reprodukce

Contact Address:

Ing. Miroslava Š m e l c o v á , Česká zemědělská univerzita v Praze, Fakulta agrobiologie, potravinových a přírodních zdrojů, katedra veterinárních disciplin, Kamýcká 129, 165 21 Praha 6-Suchdol, Česká republika, tel.: +420 224 382 944, e–mail: smelcova@af.czu.cz