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Influence of Natural Sources of Biologically Active Substances on Livestock and Poultry Reproduction

Review Article

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ABSTRACT

Synthetic hormones and bioactive substances (vitamins, pigments and isoflavons) which have been used in the feed industry are accumulated in milk, meat and eggs. It is suspected that these are responsible for a number of side-effects such as carcinogenesis, liver and kidney damage, allergies in consumers. Furthermore the synthetic hormones, vitamins, pigments are less active than those extracted from natural sources. That is why there is a growing worldwide interest in finding new and safe biologically active substances from natural origin. The application of some natural no hormonal products increases the reproductive potential of male and female animals and poultry. These may improve gametogenesis, ovulation and sperm quality. The purpose of this overview is to present some natural sources of biologically active substances and to summarize their positive influence on reproduction in livestock and poultry.

KEY WORDS bioactive, livestock, poultry, reproduction, substances.

INTRODUCTION

One of the most important tasks of modern animal husbandry is to increase the reproductive potential of livestock and poultry (Abadjieva and Kistanova, 2011). The processes of reproduction are a result of the coordinated functions of many specialized cells, tissues and regulatory systems (Abadjieva, 2015). Reproductive failures in animals are due to various factors (genetic factors, inadequate nutrition, unsuitable breeding technology etc.). One of the main factors for improving the reproductive potential of livestock and poultry is the high-quality nutrition (Surai, 2007). In the scientific literature there have been published a lot of data about nutrition's direct influence on folliculogenesis in females and spermogenesis in male livestock and poultry (Yassein *et al*. 2011; Cordier *et al*. 2013). The inadequate nutrition leads to:

1) decreased expression of glucose transporter 3, which is of essential importance for development of embryo after its implantation.
2) decreased expression of the gene responsible for glucose transportation (SLC5A1) and ATP in the oocytes.
3) increased expression of prostaglandins and leptin from the receptors in the granulous cells (Pisani *et al*. 2008).
4) decreased quality and quantity of male and female genital cells.

Feeding forages containing high-quality proteins and fats, as well as biologically active components (vitamins, micro- and macro- elements, carotenoids and other pigments, polyphenols, furostanol saponins) in amounts required for the respective species of breeding livestock and poultry allows for stimulation of sexual functions (Surai, 2002; Surai, 2007). Biologically active substances (BAS) influence the genic expression, either via signal ways or directly.

They have the ability of regulating the growth factors and enzymes, as well as the molecules related with the apoptosic changes within the cells (Jump, 2002). BAS are assimilated in full and have a positive impact on various physiological processes, namely they:

1) have pronounced antioxidant activity.
2) take part in the detoxication of the organism and suppress degenerative processes.
3) strengthen the immune system.
4) improve the functions of particular organs and systems, among them the reproductive system.

Synthetic hormones and BAS, still used in the animal husbandry practice in many countries for stimulating the reproductive parameters, accumulate in the milk, meat and eggs. They are considered the reason for a number of side effects in people (cancer, lesions of visceral organs, allergies, and so on). Beside that, synthetically produced hormones, vitamins, pigments and other biologically active substances are many times less active than those obtained from natural sources (Topliss *et al*. 2002; Munir *et al*. 2013). There is a large interest worldwide in discovering new and safe BAS obtained from natural sources, which will substitute the synthetic hormones (Grigorova, 2014).

The aim of the current review is to present some natural sources of biologically active substances and to summarize their positive influence on reproduction in livestock and poultry. Also, it describes investigations performed by the authors of the article, and experiments performed by other researchers in this field.

Micro and macro algae

One enormous biological resource which is still insufficiently used by stock-breeders and feed producers, are micro- and macro- algae. These plants belong in the so-called functional feeds, since they contain proteins, fats and carbohydrates, and are rich with BAS: minerals, carotinoids, omega-3 and omega-6 polyunsaturated fatty acids (PUFA) etc. (Christaki *et al*. 2010; Petkov, 2011). It is proven that PUFA are precursors of arachidonic acid – a main component in the production of prostaglandins which are mediators in the process of steroidogenesis (Peiretti and Meineri, 2008). The use of even a very small amount of biomass of micro-aquatic plants strengthens the immune system of animals, thereby stimulating their growth and improving their reproductive properties (Abadjieva *et al*. 2011). In the last years, many researchers have focused their efforts to investigate the positive effects of addition of the microalgae *Spirulina platensis* (SP) on the physiological condition and the reproductive parameters in swine, sheep and cattle (Shimkus *et al*. 2008a; Shimkus *et al*. 2008b; Holman and Malau-Aduli, 2013). Shimkiene *et al*. (2010) found that pregnant sheep, receiving SP, give birth to heavier lambs compared with the sheep from the control group. Similar results published by Shimkus *et al*. (2009), obtained from experiments with pregnant pigs receiving SP with the forage. Many authors reported this nutrient's positive effects on fertilization and hatching of the eggs in laying hens receiving SP with the forage (Ross and Dominy, 1985; Inborr, 1998; Nikodémusz *et al*. 2010). Abadjieva (2015) demonstrated the positive effect of *Spirulina platensis* on the reproductive parameters in female rabbits: higher weight of their ovaries (0.199±0.002 in the experimental and 0.181±0.002 in the control group); more active involvement of the primordial follicles in the process of folliculogenesis (0.30 and $0.13\times10^{-4}/\mu m^2$ density of secondary follicles in the experimental (Figure 1) and in the control group, respectively); higher survivability of the newborns (4.14±1.06 and 2.43±1.36 of the number of two weeks old rabbits, in the experimental and in the control group, respectively).

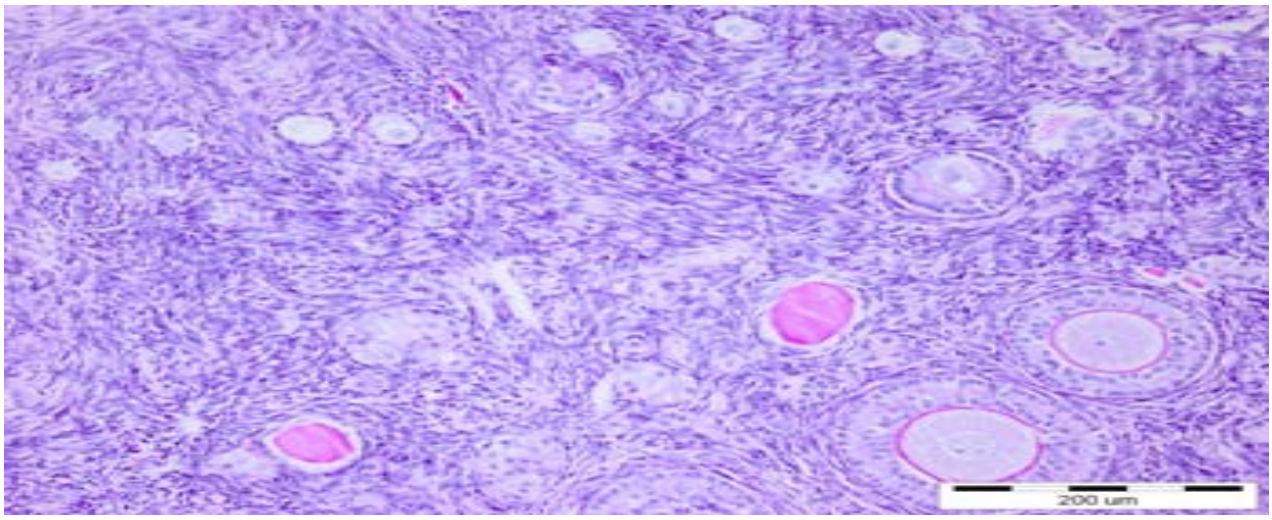

Figure 1 Microphotography of rabbit' ovary (PAS, X20): spirulina platensis provoked many primordial follicles in rabbit' ovary, including in next phases of folliculogenesis

Plant resources

Another natural source of BAS is the nutrients of plant origin (mainly herbs and their extracts). They contain phytohormones - steroid glycosydes (saponins), used as a raw material for producing steroid hormones (sexual hormones, corticosteroid hormones). For the difference from synthetic hormones, phytohormonal nutrients have a wide spectrum of action: no side effects have been observed in them; they have well-balanced complex action on all metabolic processes in the organism; they stimulate the work of sexual glands, not obstructing the hormonal mechanisms of regulation (Pankiv and Litvak, 2011). The action of steroid saponins is realised mainly on cellular level, through the central nervous system and the endocrine system via stimulation of endocrine glands' functions by improving the supply of endocrine cells with energy and normalizing the synthesis of DNA and proteins (Mayorov, 2011).

Other important BAS contained in herbal products, are: alkaloids, flavonoids and tannins. Alkaloids widen the blood vessels, activate the circulation in the genitalia, which leads to an increase of sexual activity. Flavonoids decrease the viscosity of blood and prevent the formation of thrombi, while tannins have diuretic and anti-inflamatory actions. The plants *Mucina pririens* (Figure 2), *Argyreia speciosa* (Figure 3), *Anacyclus pyrethrum* (Figure 4), *Tribulus terrestris* (TT) (Figure 5), and others are used for libido improving and reproductive properties in humans, livestock and poultry (Durage, 2007).

***Tribulus terrestris* recourse**

A very popular herbal product is the extract from annual plant *Tribulus terrestris* (TT), which farmacological effect is mainly determined by the contents of steroid furostanol saponins – protodioscin and protogracylin (Asenov *et al.* 1998). Protodioscin stimulates the enzyme 5-alpha-reductase, which participates in the transformation of testosterone into dehydrotestosterone (Viktorov *et al.* 1994). The stimulating action on sertoli and germinative cells leads to higher production of spermal liquor. The Bulgarian extract from TT is with the highest contents of BAS (45% of furostanol saponins against 15-20% in the extracts from other origins), which is probably due to the favorable combination of climate, land relief and soil (Frohne, 1999). In the recent years, a number of experiments were done on livestock and poultry, with the goal of following-up the influence of this nutrient on their reproductive properties. In the application of TT, Kashamov (2007) found increased level of testosterone in blood serum of roosters and a higher percentage of fertilized oocytes and hatched chicks in hens of the sort White Plymouth Rock. The extract from *Tribulus* increases the content of testosterone in blood serum of male goats too (Sharawy *et al.* 2015). Nikolova *et al.* (2010) registered increased volume of the testicles in breeding roosters receiving 10 mg/kg/day of TT extract with the forage. The addition of 10 mg/kg/day of this nutrient into the drinking water intended for roosters had a positive impact on the quality of their sperm (Grigorova *et al.* 2008). Similar effects on the sperm quality of male goats receiving 1.5 g/day per unit of TT extract were reported by Kistanova *et al.* (2005). In the experiment with female and male rabbits (New Zealand White) receiving the Bulgarian product Vemoherb-T (dry extract from TT) in amounts of 2.5 mg/kg body weight/day for a period of 42 days, were registered larger diameters of the follicles and the oocytes (Abadjieva *et al.* 2013) (Figure 6); a full scope of follicular structures with prevailing preantral follicles (Kistanova *et al.* 2008); and a statistically significant increase of testicular weight (Abadjieva *et al.* 2015). The use of Vemoherb-T in sexually mature female rabbits in the dose of 3.0 mg/kg body weght/day for a period of 45 days before insemination, results in: higher weight of the ovary as a result of active folliculogenesis expressed in many preantral and antral follicles (Figure 7); higher density of the primary and the secondary follicles; higher survival rate of the newborns and higher weight of the pups on day 20 (Abadjieva, 2015).

OVOCAP product

Another natural source of BAS is the patented by Kitanov (1998) product of plant origin OVOCAP for animals and birds, which has a positive influence on the reproduction. The active component of this additive is the extract of red hot pepper, containing seven alkaloids: capsaicin, dihydrocapsaicin, nordihydrocapsaicin, homocapsaicin I, homocapsaicin II, homodihydrocapsaicin I, homodihydrocapsaicin II. Tufekchiev (2006), registered OVOCAP's stimulating effect on ovaries and oviducts of pheasants. Experiments with turkeys and broiler parents receiving OVOCAP per os with the forage, demonstrate its positive influence on the reproductive system, expressed in: reduced number of unfertilized egg-cells; reduced mortality of embryos; increased number of fertilized egg-cells and increased number of hatched turkeys and chickens (Kitanov *et al.* 2003). Djorbineva *et al.* (2006) found a statistically significant positive effect of OVOCAP on fertilization and fertility of sheep intended for giving milk. The addition of this supplement to the combined forage of lactating cows of the sort American Brown Cattle results in improvement of the periods between calving and the periods of independence (Petkova *et al.* 2008).

Isoflavones

Isoflavones genistein and daidzein are non-steroid phytoestrogens isolated from soya and soy products (Kurzer and Xu, 1997).

Figure 2 *Mucina pririens*

Figure 3 *Argyreia speciosa*

Figure 4 *Anacyclus pyrethrum*

Figure 5 *Tribulus terrestris*

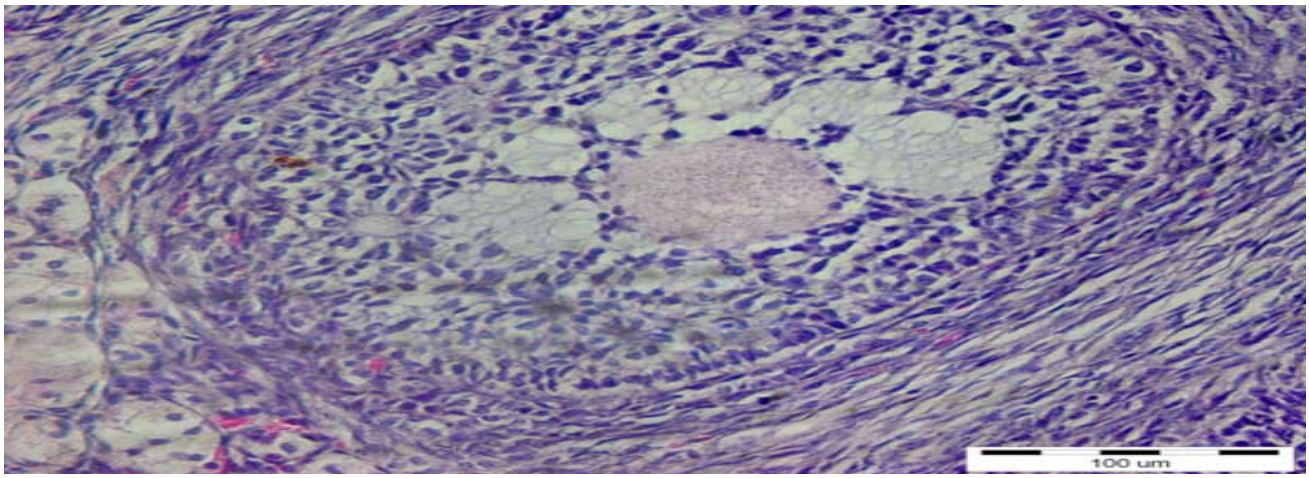

Figure 6 Microphotography of rabbit' ovary (H&E, X40): tertiary follicle in does' ovary, drunk *T. terrestris*' water solution which causes atresia (arrows), (Abadjieva *et al*. 2013)

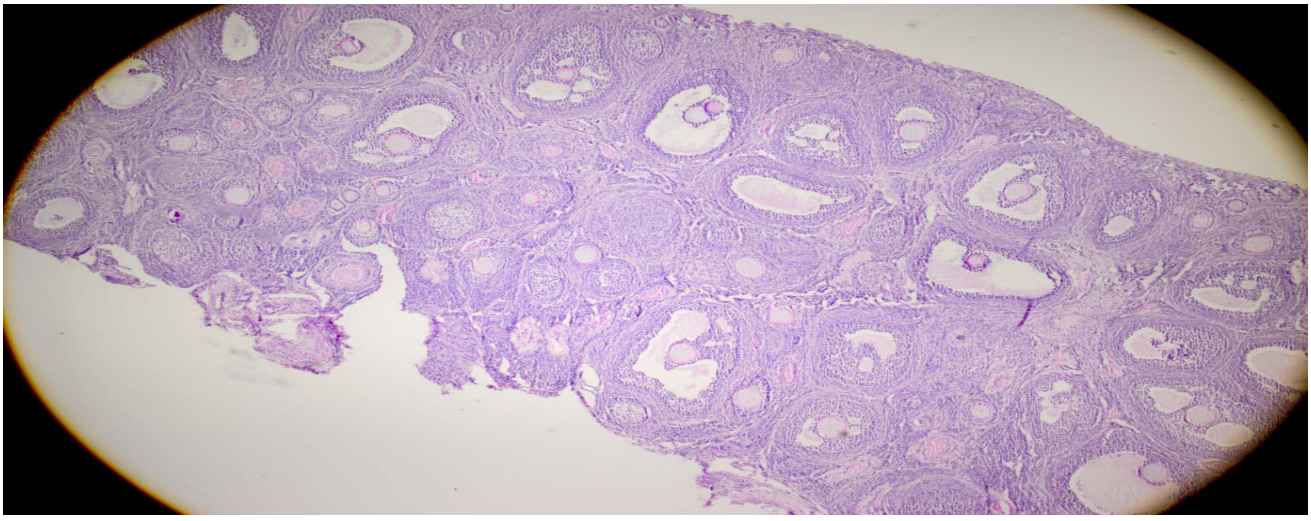

Figure 7 Panoramic microphotography of rabbit' ovary after treated with 3 mg/kg b.w. *T. terrestris* (PAS, X4): seminiferous tubule were filled with germ cells, (Abadjieva, 2015)

They have oestrogen-like bioactivity and can be used for regulation of the seasonal reproductive cycles in animals and poultry (Murkies *et al*. 1998; Wilhelms *et al*. 2006). Genistein is described as a specific inhibitor of the enzyme tyrosine-protein-kinase (Akiyama *et al*. 1987). Genistein in concentrations of 0.001^{-1} µg/mL stimulates the secretion of progesterone in cattle, and the maturation of oocytes in pigs in experiments *in vitro* (Makarevich *et al*. 1997). Gjorgovska and Filev (2013) registered increased level of testosterone in blood serum of roosters 20 weeks old, 5 days after receiving various concentrations of genistein and daidzein with the forage (300, 600, 1200, 1800 mg of forage/kg body weight).

Based on their investigations, Akiyama *et al*. (1987) and Wilhelms *et al*. (2006) came to the hypothesis that soy oestrogens have influence on the development of male sexual organs and the hormonal status of birds in the time of their growth.

Carotenoids

Carotenoids are organic pigments contained in plants and in some other photosynthesizing organisms (algae, fungi, bacteria). Around 300 species of them are known so far, classified in two groups - xanthophylls and carotenes. Some carotenoids (α-, β-, γ-carotin, β-cryptoxanthin) are provitamins of vitamin A. The positive influence of carotenoids and vitamin A on the reproduction of livestock and poultry is described by many researchers, that is – increased mobility of the spermatozoids, both of them being important in the pre- and post-embryonal phases of development (Chew, 1993; Coffy and Britt, 1993; Kolb, 1998; Surai, 2007; Trojacanec, 2013). Natural sources of carotenoids, which can be used as feed components are grass, alfalfa, various kinds of silage, grass and nettle meals, dehydrated biomass of micro- and macro- algae, dry carrot meal, pumpkins etc.

CONCLUSION

Natural sources of BAS, included in the forage in appropriate amounts, i.e. concentrations, stimulate the activity of the reproductive systems of livestock and poultry. It is clear therefore, that BAS are an alternative to synthetic hormones and synthetic biologically active substances, since they are harmless to the human beings and correspond to the modern EU requirements for quality and safe for the human health nutrients.

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