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THE EFFECT OF DIET SELENIUM SUPPLEMENT ON MEAT QUALITY

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Review paper

Abstract: The health of farm animals depends on many factors and they all indicate that food plays an important role in preserving health, improving reproductive and productive characteristics and functioning of immune system. Besides numerous nutritional factors, antioxidants play a special role in the struggle for survival and good health state. An oxidative stress represents a condition induced by generating and reacting of reactive-oxygen species (ROS), and their toxic products, on different metabolic and physiological processes. The generating of ROS is induced by both endogenous and exogenous factors. In the case of the organism inability to expel the causative agents of oxidative stress they can damage cell lipids, proteins or DNA thus endangering the cell functions. Lipid peroxidation is a process which can lead to degradation of lipids and damage of cell membrane. Selenoenzyme glutathione peroxidase can protect organism from peroxidative damages, decrease the level of malondialdehyde protecting in this way a muscular tissue from oxidation. Recent research has shown that selenium has an effect of preserving sensory characteristics of meat and its texture, what is of great importance for consumers. Animal tissue incorporates supplemented selenium quickly thus it is possible to produce a selenium enriched meat and eggs. Selenium also shows positive effects on meat quality: it reduces water loss, influence the stability of colour, prolongs oxidative protection, and therefore the time of its shelf life.

Key words: selenium, glutathione peroxidase, estimation of meat quality.

Introduction

A main source of selenium for animals are vegetable mixtures in which this microelement is found in the form of selenocysteine and selenomethionine. The content of selenium in plants depends on its quantity in the soil where it is present

in the form of salts: selenites, selenates and selenides. Some regions are selenodefficient, so the plants from these regions contain insufficient quantities of selenium. Because of that the selenium can be added into diet for animals in the form of supplement – sodium selenite, selenized yeast and selenomethionine (*Sretenović et al., 2007*). The organic selenium is more deposited into the muscle tissue and animal organs than inorganic one (*Todorović et al., 1999; Kim and Mahan, 2001; Joksimović Todorović et al., 2006; Behne et al., 2009; Juniper et al., 2009*). Inorganic form of selenium has a role of prooxidant, but given in great quantities (< 5 mg/kg diet) can be very toxic (*Seko et al., 1989; Mihailović et al., 1996a,b, 1997; Todorović et al., 1998*).

Lipid peroxidation is a natural process which can cause degradation of lipids, and therefore damage of cell membrane. Malondialdehyde (MDA) is one of metabolic products of lipid peroxidation which can move lipid oxidation induced by reactive oxygen species (ROS) in tissues. Free radicals are very unsteady, reactive and able to damage DNA, proteins, lipids and carbohydrates. Damage of DNA can potentiate mutation, translator errors, inhibition of protein synthesis, whilst damaged proteins can lead to changes in transport of ions and enzyme activity. By the oxidation polyunsaturated fatty acids can change membrane structure, permeability and activity of membrane enzymes. Damage of biological molecules and numerous systems endangers the health status and production abilities in animals. The activity of selenoenzymes, glutathione peroxidase protects the organism from peroxidative damages, maintaining the content of MDA on low level. Reducing of the level of malondialdehydes and increased activity of GSH-Px in tissues are two major indicators of adequate protection of muscle tissue from oxidation and likely way of prolonging the shelf life of fresh meat (*Zhan et al., 2007*).

Water loss and meat colour are important parameters for estimation of meat quality. Organic selenium (selenized yeast) reduces water loss and can effect the stability of the colour of pork and chicken meat (*Downs et al., 2000*).

Concentration of Se and activity of GSH-Px in some organs and muscle tissue

Physiological roles of selenium are directly associated with the function of proteins whose content it is being built into via selenocysteine aminoacid. Over 30 selenoproteins are known, but a physiological role is known for only a few of them. The first discovered enzyme is glutathione peroxidase (GSH-Px) (*Rotruck et al., 1973*). Glutathione peroxidase has a role in cell defence against oxidative damages in animals catalysing reduction of hydrogen peroxides and lipid peroxidation (*Arthur, 2000; Skřivanová et al., 2007*). The activity of GSH-Px in animal blood plasma depends on the level of selenium intake (*Hassan, 1987; Todorović, 1990;*

Mihailović et al., 1991). Thus the activity of GSH-Px in animal blood plasma is a reliable indicator of selenium status, but only on optimal and sub-optimal levels. Depending on the form of selenium, when increasing over necessary levels, the activity of enzymes shows the effect of plateau, so that a higher levels of Se, lead to no further increase of activity (*Joksimović Todorović and Jokić, 2005; Joksimović Todorović et al., 2005*). Five forms of this enzyme have been defined, and they are called family: 1. cytoplasmatic – reduces hydrogen peroxide and peroxides of free fatty acids, 2. gastrointestinal – can be found in the cells of intestinal epithelium, 3. plasmatic – reacts with hydrogen peroxides, fatty acids hydroperoxides, phospholipid hydroperoxides, and has an important role in antioxidative processes in blood plasma, 4. phospholipid hydroperoxide glutathione peroxidase – reduces phospholipids and cholesterol hydroperoxides and its reduced activity leads to increased sensibility to oxidative stress and 5. glutathione peroxidase 6 – found in olfactory epithelium and embryonal tissue. They are present in almost all cells of organism, but their distibution into tissue can manifest certain variations. Certain factors: an individual, age, sex, season and cyclic changes can control the activity of enzymes, while lately there has been some talk about genetic regulation.

Certain swine organs (kidney, liver, spleen) have fifteen times greater activity of GSH-Px than muscle tissue or diaphragm (*Daun and Åkesson, 2004*). However, in beef treated by the same levels of Se, the activity of this selenoenzyme was three times lower. The activity of GSH-Px in organs and muscle tissue in pigs reaches plateau at 0.2 mgSe/kg diet (*Lei et al., 1998*). This shows that adding of selenium into animal diet is an important factor of control of the activity of GSH-Px, however the response can be modulated by specific factors of tissues. The localization of selenium in each tissue is complex. Total selenium is found in soluble and insoluble form. Greater activity of GSH-Px in swine than in bovine organs show that both forms of selenium (soluble and insoluble) are more deposited in selenoenzyme swine organs. In bulls the concentration of Se in meat is increasing from 0.107 μg/g to 0. 223 μg/g when 4 mg Se daily is added into diet for thirty days (*Simek et al., 2002*). Se-yeast supplementation to the diet of calves for veal production at a level of 0.5 mg/kg increased Se levels in muscle and increased GSH-Px activity in muscle and liver (*Skřivanová et al.,* 2007). Chicken meat shows different content of Se. In chicks inorganic selenium is deposited in muscle tissue in very little quantites, and because of that a commercial success can be attained by selenized yeast (*Arnold et al., 1973*). The effect of adding selenium into chicks diet is associated mostly with its participation in preserving antioxidative system of cells.

In gilts fed different levels of organic selenium - 0, 0.3 and 0.6 mg/kg diet, the highest content of selenium is found in kidneys, followed by liver and heart, while the lowest one is found in leg and neck musculature, what can be seen in records shown in Table 1 (*Joksimović Todorović et al., 2006*). In the liver the concentration

of selenium was 3-4 times lower, and in heart musculature even up to 6 times lower than in kidneys. The concentration of selenium in leg and neck musculature was two, that is, three times higher in gilts fed 0.3 and 0.6 mg Se/kg diet in relation to control group. These results are in harmony with the results obtained by other authors (*Mahan et al., 1999; Pavlata et al., 2001; Yaroshenko et al., 2004*).

Table 1. Effects of different dietary levels of selenium on its concentration in some tissues, mg/kg

Tissues	Group					
	Control (0mgSe/kg food)		I (0,3 mgSe/kg food)		II (0,6 mgSe/kg food)	
	mg/kg	%	mg/kg	%	mg/kg	%
Kidney	1.23	100	1.26	102	1.38	112
Liver	0.337[a]	100	0.424[ac]	125	0.511[c]	151
Heart	0.180[a]	100	0.224[ac]	124	0.313[c]	173
Leg musculature	0.093[a]	100	0.191[ac]	206	0.260[c]	279
Neck musculature	0.090[a]	100	0.164[ac]	182	0.216[c]	290

Differences between a and b statistically highly significant ($P<0.01$)

Marounek et al. (2009) added into hare diet 0.40 mg/kg sodium selenite, selenized yeast or selenized algae. The concentration of selenium in sirloin, musculature of hind limbs and liver was the highest in the group of hares fed diets supplemented by selenoized yeast, and lowest in the group fed supplement of sodium selenite. The concentration of selenium in meat in all trial groups was a few times lower than the concentration determined in liver and hair.

Se – meat quality

Meat is a good source of selenium for people although its content varies depending on geographical origin of meat and selenium supplement into animal diet (*Sretenović et al., 2012*). Se supplement in diet improves meat juiceness and softness, reduces the content of fat and water loss, and odour (*Cole, 2000*). Also, *Choct et al. (2004)* confirmed that organic selenium reduces water loss in meat. On the contrary, *Miezeliene et al. (2011)* did not determine this effect of selenium in chicken meat what is probably the result of applying of different methods. These authors confirmed significant effect of different levels of supplemented selenium (0.15 and 0.50 mg/kg) on brightness and colour of fresh and defrosted chicken meat.

pH of meat is one of the significant factors which can affect the water loss. Low pH reduces the ability of muscle proteins to bind water, reduces negative

electrostatic aversion between filaments, the space between them is being reduced what leads to shrinkage of myofibrils. The integrity of the membrane of muscle cells is being deteriorated and therefore its semipermeability (*Ashgar et al., 1991*) as well. The quantity of water loss depends on the level of lipid peroxidation (*Macit et al., 2003*). A slight increase of pH value affects the activity of GSH-Px and decreases the content of malondialdehyde, and therefore a water loss in the loins musculature, in the groups of piglets treated with selenomethionine (*Zhan et al., 2007*). However, there are some discrepancies among certain authors. *Mahan et al. (1999)* point to the fact that organic selenium has no effect on the quality of pig meat, whilst the inorganic Se has a harmful effect. These discrepancies between authors regarding the effect of Se on the quality of meat could be a consequence of supplementation of different levels of Se or ignorance of halothane genetic status in piglets.

However, research of *Zhan et al. (2007)* shows that adding 0.3 mgSe/kg diet in the form of selenomethionine in piglets, stabilizes better a pink colour of meat than the same quantity of Na-selenite. The colour of meat depends on pH or on the content of myoglobines (*James et al., 2002*), and also on the oxidation of myoglobines into metmyoglobines. Supplementation of Se in diet has no effect on the content of myoglobines, however it moderately increases pH value, significantly increases the activity of GSH-Px and reduces the level of MDA in muscle tissue. Selenomethionine is an efficient "collector" of strong oxidant peroxinitrites, which produce nitrogen oxides and superoxides. It provides efficient protection for biomolecules against oxidations and nitrite reactions.

Baowei et al. (2011) confirmed that adding of different levels of selenized yeast into diets for geese (0.1, 0.3 and 0.5 mg/kg) improved significantly the quality of breast musculature by the reduction of water loss, increased toughness of musculature and increase in the content of myoglobines. These authors established that adding selenoized yeast in the quantity of 0.3 mg/kg diet is an optimal dose for adequate antioxidative protection in geese. Also, *Perić et al. (2009*) established that supplement of selenized yeast into broiler diets led to lower water loss in meat.

Conclusion

In difference to inorganic selenium, organic selenium is deposited more effectively in tissues. It provides antioxidative protection, preserves the integrity of cell membranes, reduces water loss in fresh meat during thermal processing and is a stabilizator of meat colour. This shows that organic selenium provides quality meat, has an effect on freshness and therefore prolongs shelf life of meat. Chicken meat enriched with selenium can satisfy 50% needs for selenium in humans by consuming 100 g daily. Selenium both improves the health of animals and provides quality meat for consumers.

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Efekat dodavanja selena u hranu na kvalitet mesa

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Rezime

Zdravlje životinja zavisi od brojnih faktora, a sve ukazuje da hrana ima važnu ulogu u očuvanju zdravlja, poboljšanju reproduktivnih i proizvodnih karakteristika i funkcionisanju imunskog sistema. Pored brojnih hranidbenih faktora, antioksidansi imaju posebnu ulogu u borbi za opstanak i dobro zdravstveno stanje. Oksidativni stres je stanje izazvano stvaranjem i reagovanjem reaktiv-oksigen vrsta (ROS) i njihovih toksičnih produkata na različite metaboličke i fiziološke procese. Stvaranje ROS izazivaju endogeni i egzogeni faktori. Ukoliko organizam nije u stanju da otkloni uzročnike oksidativnog stresa oni mogu da oštete ćelijske lipide, proteine ili DNA, a time da ugroze funkcije ćelija. Lipidna peroksidacija je proces koji dovodi do degradacije lipida i oštećenja ćelijske membrane. Selenoenzim glutation peroksidaza štiti organizam od peroksidativnih oštećenja, smanjuje nivo malondialdehida i na taj način štiti mišićna tkiva od oksidacije. Izučavanja poslednjih godina ukazuju da selen utiče na očuvanje senzornih karakteristika mesa i njegove teksture, što je od velikog značaja za konzumente. Životinjsko tkivo brzo inkorporira dodati selen i tako je moguće proizvesti selenom obogaćeno meso i jaja. Selen ispoljava pozitivne efekte i na kvalitet mesa: redukuje gubitak tečnosti, utiče na postojanost boje, produžava oksidativnu zaštitu, a time i vreme njegove upotrebe.

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