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FEEDING OF SPORTING DOGS
PART II. MINERALS, VITAMINS AND FUNCTIONAL ADDITIVES REQUIREMENTS

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Abstract. Sporting dog owner should realize that proper nutrition is one of the most important factors influencing the sports results achieved by the dog. In addition to the increased demand for energy and basic nutrients, particular attention should be paid to the adequate supply of vitamins and minerals, as well as dietary supplements. Therefore, the aim of the study was to characterize the importance of minerals, vitamins and functional additives in the nutrition of sporting dogs. The significant elements in the sporting dogs nutrition are calcium, phosphorus, potassium, sodium and magnesium. Micronutrients such as copper, iron, manganese, selenium and zinc are also very important. Of the vitamins in the sporting dogs nutrition, vitamins with antioxidant properties (vitamin E, vitamin C) are crucial, as well as vitamin D and B-group vitamins. Moreover, the diet of a sporting dog can also be enriched with functional additives that support the function of joints, muscles and circulatory system, as well as plants with an adaptogenic effect that improve the dog's immunity. Selecting the right amounts of individual additives so they fulfill their planned functions and are completely safe may be a problem. Since it should be remembered that both the deficiency and the excess of nutrients can be dangerous for the body.

Key words: working dogs, nutrition, active substances, adaptogens.

INTRODUCTION

In recent years, the interest in the disciplines of canine sports among dog owners has been increasing. Only in 2019, over 2 916 000 dogs participated in the competition sponsored by the American Kennel Club (2019). In many competitions, dogs do not have to meet any breed or age criteria, which allows almost all healthy dogs to participate in the sport event. Many owners decide to practice a discipline of canine sport, not knowing its rules beforehand or not realizing how the sport affects the dog's body (Baltzer 2012). Meanwhile, improper preparation of the dog for training, including an incorrectly selected diet, can lead to injuries, excluding the dog from further exercises.

The owner of a sporting dog should realize that proper nutrition is one of the most important factors influencing a dog's athletic performance. Sporting animals require special

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nutrition since the requirement for individual nutrients is definitely increased due to increased physical effort (Wakshlag and Shmalberg 2014). The best indicator of the proper nutrition of a dog is to assess the physical form, condition of the skin and coat. A properly fed dog performs its tasks much better and has more energy, so it becomes more efficient (Kazimierska and Biel 2020). In addition to the increased energy and macronutrients requirement, attention should be paid to an adequate supply of minerals and vitamins. It is also important to supplement compounds that are present in not enough levels in natural foods to fulfil the increased needs of sporting dogs. Therefore, it is worth implanting the functional additives in sporting dog's diet that may increase the dogs palmares while minimalizing the effects of exhaustion and maximizing the regeneration process of the body during rest at the same time. A well-conducted conditioning training requires supplementation to support, among others, muscle development, joint protection and regeneration, and antioxidant activity (Ostaszewski et al. 2012).

The aim of the study was to characterize the importance of minerals, vitamins and functional additives in the nutrition of sporting dogs.

MINERAL REQUIREMENT

The requirement for minerals in dogs depends on many factors, and in case of increased physical activity (as well as in case of pregnancy, growth or disease) it increases significantly. However, the nutritional guidelines (FEDIAF 2020) do not provide recommendations for sporting dogs, but only for adult dogs with division into low activity (<1 hour/day, e.g. walking on a lead) and moderate activity (1–3 hours/day, e.g. light strain). However, the correct supply of minerals is as important as the correct supply of all other nutrients. Among the elements contained in food, calcium and phosphorus and their ratio are of central importance. Exercises cause bone microdamages, and when the intensity and duration of exercise increases, the number of damage escalates, which in turn leads to bone weakening (Tomlin et al. 2000; Wrzosek et al. 2019). Exercise that overloads the osteoarticular system can lead to aseptic osteochondritis dissecans (OCD) (Slater et al. 1992). Therefore, depending on the dog's diet, additional supplementation of these elements may be mandatory. In particular, when preparing meals for dogs at home based primarily on meat, the administration of calcium supplements should be considered (Hill 2004). On the other hand, excess of dietary calcium may reduce zinc absorption, leading to zinc deficiency (White et al. 2001). Therefore, maintaining the right amount of elements is crucial to keeping your dog healthy.

Sodium excretion also increases during exercise (Grignolo et al. 1982). The amount of sodium in the dietary ration that will not cover the loss of this element in urine can lead to hyponatremia, especially in sled dogs making long distances (Hinchcliff et al. 1997; Hinchcliff et al. 1998), but also in dogs training agility (Rovira et al. 2007). Dogs do not use saliva electrolyte sparing mechanisms, so adequate electrolyte supplementation, including sodium, may be valuable for sporting dogs (Templeman et al. 2019).

Potassium and magnesium are also important elements in the nutrition of sporting dogs. Potassium and sodium play a key role in regulating the water-electrolyte and acid-base balance. Chronic supplementation with sodium and potassium bicarbonate improves

anaerobic capacity in human athletes (Chycki et al. 2018). Magnesium is involved in energy metabolism, circulatory and respiratory activity and muscle function. Insufficient levels of magnesium in the body can worsen exercise performance (Zhang et al. 2017).

Micronutrients such as selenium, zinc, iron, copper and manganese are also very important. During exercise, iron is critical to aerobic capacity because of its oxygen transport functions (Hinton 2014). Moreover, iron and copper participate in the process of oxidative phosphorylation, as well as in the synthesis of hemoglobin and myoglobin (Speich et al. 2001). Copper deficiency can weaken the immune and cardiovascular systems, although it is unclear whether intense exercise increases or decreases copper levels (Baydil 2013). Selenium, zinc, copper and manganese contribute to the proper function of the enzymatic antioxidant system. Thus, they prevent an excessive increase in the content of reactive oxygen species caused by exercise. Selenium is part of glutathione peroxidase (GPx), which protects cells from damage under oxidative stress caused by injury, infection or inflammation (Bulycheva and Sitnikov 2017). In turn, considering the role of zinc in antioxidant systems, such as those involving superoxide dismutase and catalase, maintaining optimal levels of zinc may be key in mediating oxidative stress in skeletal and systemic muscles (Chu et al. 2018). Sporting dogs need more zinc than non-training dogs. Therefore, it is worth remembering about raw materials rich in this element. Meat and animal offal are a rich source of zinc, as well as many other substances needed in sporting dog's diet (Biel et al. 2019).

VITAMINS

Vitamins are nutrients required by the body in small amounts, for a variety of essential processes. It should be remembered that both the deficiency and the excess of vitamins can be dangerous for the body and have long-term consequences.

Antioxidant vitamins are of key importance in the nutrition of sporting dogs. Pressures antioxidant vitamin deficiency is associated with increased oxidative stress. In sporting dogs, increased production of reactive oxygen species is observed which causes damage to cellular macromolecules. Therefore, special attention should be paid to the correct supply e.g. vitamin E, of which the concentration in the blood is reduced by exercise (Hinchcliff et al. 2000; Scott et al. 2001). Vitamin E deficiency impairs muscle endurance and changes muscle contractile properties after a long series of contractions (Coombes et al. 2002). Piercy et al. (2001) showed that low vitamin E levels in the blood plasma of sled dogs increases the risk of non-completion long-distance runs and does not affect the speed of the run at the same time. In addition, sled dogs require high-fat food, so adding E vitamin is then important in preventing unsaturated fatty acid oxidation, which is exacerbated by exercise (Bergero et al. 2004). Furthermore, the addition of vitamin E along with a high content of n–3 fatty acids may have positive effect on the joints, showing an improvement in reduced lameness in dogs (Fritsch et al. 2010; Roush et al. 2010).

Vitamin C supplementation can also have beneficial effects. Although dogs are animals that synthesize ascorbic acid (Ogawa 2008), endogenous synthesis may not fulfil the increased requirement for this ingredient throughout the season. Giving sled dogs increased doses of ascorbic acid may prevent reduction its blood levels during the racing season (Donoghue

et al. 1993). Sporting dogs also get ascorbic acid to prevent muscle damage from oxidative stress during exercise (Baskin et al. 2000). Vitamin C also influences the synthesis of L-carnitine and collagen as it is an important cofactor of reactions catalyzed by proline hydroxylase and lysine hydroxylase (Janda et al. 2015). On the other hand, an excessive intake of ascorbic acid in nutrition can adversely affect athletic performance. The research conducted by Marshall et al. (2002) showed that when greyhounds received an addition of ascorbic acid, the distance of 500 meters was covered by 0.2 seconds longer than dogs not receiving this supplement. It is worth using natural sources of vitamin C, such as rosehips, berries of sea buckthorn or indian gooseberry (Nojavan et al. 2008; Fleck et al. 2014; Jaroszewska et al. 2018).

When discussing the nutrition of sporting dogs, vitamin D should also be mentioned, since it is essential for regulating calcium uptake and the deposition of this mineral in the bone matrix (Quarles et al. 1985; Hazewinkel and Tryfonidou 2002). To meet vitamin D requirements, dog's diet must be supplied with vitamin D, because they are solely dependent on vitamin D intake (How et al. 1994). The additional supply of vitamin D can help to postpone the beginning of osteoarthritis (Clements et al. 2006). However, it should be remember that most commercial foods contain at least twice the minimum requirement of dog for vitamin D, which is 63.90 IU per 100 g of dry matter. Using additional sources of it with commercial products or giving the dog unbalanced home meals may lead to its hypervitaminosis and, among others, related disorders of Ca and P homeostasis (Haussler et al. 2013; Tebben et al. 2016).

In the nutrition of sporting dogs, the proper supply of B vitamins is also important, which as precursors of coenzymes, regulate the course of many metabolic processes. The requirement for vitamins B1 and B6 may increase with the increase in energy and protein intake, and their insufficient supply may contribute to lower performance in sports, and also cause heart disorders (McDowell 1989).

FUNCTIONAL ADDITIVES

Food supplement is foodstuff which is: the supplement of a regular diet; concentrated source of vitamins, minerals or other substances, single or complex, indicating nourishing or another physiological effect; placed on the market in the form that allows dosage, in the form of: capsules, tablets, pills and other similar forms, sachets of powder, ampoules of liquid, drop dispensing bottles and other similar forms of liquids or powders intended to be consumed in small, measured amounts of units, may not have the properties of a medicinal product within the meaning of pharmaceutical legislation (Act of August 25, 2006). In the nutrition of sporting dogs, it seems more appropriate to define "functional additives", which besides food supplementation may help in the treatment of certain ailments. They should only be an addition to dog's balanced, complete diet, not its basis.

One of the nutrients that can profitably affect the achieved sports performance is glutamine. Glutamine is involved in nitrogen storage and transport. It also regulates the carbohydrate metabolism. Adding glutamine to sporting dog's diet may prevent reduction of blood glucose levels during exercise. It causes an increased release of glucose from the liver and stimulates its use by skeletal muscle (Iwashita et al. 2005).

Another compound popular among athletes is creatine. The creatine molecule is the basic energy vector in muscle cells. During exercise, a significant increase in creatinine activity is observed in dogs (Vlasakova et al. 2017; Leggieri et al. 2019). Creatine is a supplement with scientifically proven efficacy (Aktas et al. 1995; Lowe et al. 1998). The use of creatine supplements can improve skeletal muscle strength and increase lean body mass. It can also speed up muscle recovery after exercise.

In the nutrition of sporting dogs, it is also worth considering adding the preparations containing free amino acids, which have a positive effect on nitrogen metabolism. Leucine (Leu), isoleucine (Ile) and valine (Val) are three branched chain amino acids (BCAAs) that are widely used as dietary supplements for professional athletes. Studies in beagle dogs showed that BCAAs were well absorbed with a significant increase in plasma concentration and no drug accumulation in the body (Wang et al. 2015). The use of BCAAs before exercise saves muscle proteins, and after exercise shows a strong anti-catabolic effect. Consumption of BCAAs may therefore play a beneficial role in improving exercise performance (Hormoznejad et al. 2019).

The BCAA-leucine derivative, i.e. the short-chain fatty acid β-hydroxy-β-methyl-butyrate (HMB) plays an equally important role in the nutrition of sporting dogs. During intensive training, HMB counteracts muscle damage, minimizes protein reduction, and helps muscle tissue repair. Due to its strong anti-catabolic and anabolic effects, it is mainly used in strength sports. When used regularly, it prevents the breakdown of muscle protein and reduces the LDL-cholesterol fraction (Durkalec-Michalski et al. 2017).

Medium chain triglycerides (MCTs) improve the dog's endurance under sustained effort. Although it is believed that dogs, especially sprinters, should get low-fat diet due to the risk of excessive fat storage, the inclusion of MCTs in a dog's diet improves muscle strength and endurance (Panchal et al. 1998). Interestingly, these acids do not require the participation of pancreatic lipase in digestion and enter the liver through the portal vein, which accelerates their availability as a source of energy for cells (Rutz et al. 2004). MCTs are therefore an easily digestible and quickly available source of energy for the dog.

The underestimated functional additives are supplements that ensure adequate microflora of the gastrointestinal tract (pro- and prebiotics), stimulating local and general immunity. Probiotics are live microorganisms which – when administered in appropriate amounts – have beneficial health effects, while the group of prebiotics includes compounds such as beta--glucan, inulin, fructo-oligosaccharides and lactulose. Healthy, well-functioning digestive tract is the basis for use and then process the energy contained in the food (Wernimont et al. 2020). Therefore, it can also affect dog's athletic performance.

In addition to supplementation for support the functionality of the joints, muscles and circulatory system, it is also important to ensure the proper functioning of the immune system in sporting dogs. Trainings and competitions often take place in unfavorable weather conditions, which requires strengthening the immunity of the sporting dog participating in them. Various plant additives and herbal preparations consisting of the so-called adaptogenic plants (adaptogens) are used to this end, supporting the dog's body overloaded with physical effort.

The most popular adaptogenic raw materials of natural origin in sporting dogs are guarana (*Paullinia cupana*) and ginseng (*Panax ginseng* C.A. Mey) extracts. They belong to the complex of stimulating herbs that support both physical and mental activity. They reduce the feeling of exhaustion, improve concentration and the ability to adapt to physical exertion. Studies in mice showed that supplementation with mountain ginseng extract improves exercise performance and energy use, and reduces fatigue-related parameters (Ma et al. 2017).

It is also worth mentioning the plant that is just gaining popularity in Europe. It is *Schisandra chinensis* (Turcz*.)* Baill., a species of plant in the Citrine family. Schisandra extract has a long history as a medicinal herb in traditional Asian medicine. Traditionally, it has been used in the treatment of diseases of the reproductive, digestive and respiratory systems as well as in states of exhaustion and weakness of the body (Panossian and Wikman 2008). The positive effect of schizandra on the immune system is associated with the enhancement of the phagocytic activity of macrophages, the intensification of haemolysis and an increase in lymphocyte transformation (Chen et al. 2012; Zhao et al. 2013). In addition, it also increases endurance and physical work capacity, as well as blood pressure control and improvement of metabolic indicators (Bae et al. 2012; Song et al. 2015). In animal studies, supplementation with Schisandra extract had a beneficial effect on muscle strength and lactate levels (Kim et al. 2018). Therefore, it can be successfully used as a supplement for the diet of a sporting dog.

Another plant with an adaptogenic effect is *Leuzea carthamoides* (Wild.) Iljin, a herbaceous perennial belonging to the *Asteraceae* family. Naturally, it occurs in Asia and Europe. The tradition of its medicinal use in folk medicine in Siberia, China, Tibet and Mongolia dates back over 5,000 years and includes the treatment of kidney and lung diseases, hepatitis and tonsillitis (Lotocka and Geszprych 2004). Currently, thanks to the compounds it contains, it is used as an aid in the states of chronic fatigue, weakness, reduced immunity and functional disorders of the nervous system. Pharmacological studies in humans have shown an increase in fitness and physical capacity after the use of extracts from the root of *Leuzea carthamoides* (Azizov et al. 1997). Moreover, herbal products based on *Leuzea carthamoides* exhibit antimicrobial (Janovská et al. 2008), antioxidant (Timofeev et al. 2006; Biskup et al. 2013) and adaptogenic (Todorov et al. 2000) properties and stimulate overall protein synthesis (Le Bizec et al. 2002). Extracts of *Leuzea carthamoides* roots stimulate the body after physical exertion and strengthen resistance to long-term stress, and therefore can be a valuable addition to the diet of a sporting dog.

Finally, it is worth mentioning the mushrooms found in the mountainous regions of Asia – *Cordyceps sinensis* (Berk.). This species is considered an important medicinal mushroom in traditional Chinese medicine and is used for its properties, mainly to improve health, longevity and sports strength. *Cordyceps sinensis* L. has a wide-ranging health effect, in particular, characterized by high antioxidant activity (Nie et al. 2013), which modulates the immune response (Kuo et al. 2001), reduces the proliferation of cancer cells (Kuo et al. 1994), improves liver function (Manabe et al. 2000), reduce plasma cholesterol (Koh et al. 2003), and protects the kidneys (Zhu et al. 1998). It has also been found that it affects better endurance (Chiou et al. 2000). In human athletes, *Cordyceps sinensis* L. showed improvement

of the cardiovascular response in healthy runners (Nagata and Tajima 2000). Studies in rats have also shown an improvement in exercise endurance through the activation of skeletal muscle metabolism regulators and a coordinated antioxidant response (Kumar et al. 2011). However, despite some benefits, there is insufficient evidence for a role of *Cordyceps sinensis* L. supplementation in athletic performance, including a lack of studies evaluating the effects of supplementation on a sporting dog. It should be remembered that when taken in high doses it can cause stomach problems and diarrhea, so it's important to establish a safe dosage and duration of supplementation for sporting dogs before considering it as an ergogenic.

SUMMARY

Appropriate diet plays an important role in achieving full athletic potential and in preventing injuries in active dogs. The nutritional requirements of sporting dogs are usually much higher than that of dogs with standard physical activity and depends on the type and intensity of the work performed. That goes for not only increased demand for energy and macronutrients, but also to the higher requirement for minerals, vitamins and functional additives. They support, among others, the functionality of joints, muscles and the circulatory system, aerobic capacity, prevent the negative effects of increased oxidative stress, also regulate the carbohydrate metabolism and nitrogen metabolism, and adaptogenic plants strengthen the dog's immunity. The problem may be choosing the right amounts of individual additives so they fulfill their planned functions and be completely safe. It should be remembered that both the deficiency and excess of any nutrients can be dangerous for the dog’s body.

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ŻYWIENIE PSÓW SPORTOWYCH CZ. II. ZAPOTRZEBOWANIE NA SKŁADNIKI MINERALNE, WITAMINY I DODATKI FUNKCJONALNE

Streszczenie. Właściciel psa sportowego powinien zdawać sobie sprawę z tego, że prawidłowe żywienie jest jednym z najważniejszych czynników wpływających na wyniki sportowe osiągane przez psa. Oprócz zwiększonego zapotrzebowania na energię i podstawowe składniki pokarmowe szczególną uwagę należy zwrócić na odpowiednią podaż witamin i składników mineralnych, a także suplementów diety. Dlatego celem pracy była charakterystyka znaczenia składników mineralnych, witamin i dodatków funkcjonalnych w żywieniu psów sportowych. Do pierwiastków mających znaczenie w żywieniu psów sportowych zalicza się wapń, fosfor, potas, sód i magnez. Niezwykle ważne są również mikroelementy, takie jak miedź, żelazo, mangan, selen i cynk. Z witamin w żywieniu psów sportowych kluczowe znaczenie mają te o działaniu antyoksydacyjnym (witamina E, witamina C), a także witamina D oraz witaminy z grupy B. Ponadto dietę psa sportowego można wzbogacić również o dodatki funkcjonalne, wspierające

funkcjonalność stawów, mięśni oraz układu krwionośnego, a także rośliny o działaniu adaptogennym, wzmacniające odporność psa. Problem może stanowić dobranie odpowiednich ilości poszczególnych dodatków, tak aby spełniały swoje zaplanowane funkcje oraz by były całkowicie bezpieczne. Należy bowiem pamiętać, że zarówno niedobór, jak i nadmiar składników odżywczych może być niebezpieczny dla organizmu.

Słowa kluczowe: psy pracujące, odżywianie, substancje aktywne, adaptogen.