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Modern nutrition impact on the health and life longevity of dogs and cats

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ABSTRACT - For some time the primary role of diet in supplying the nutritional and metabolic requirements has been highlighted, however, recent studies have pointed out the importance of energy and nutrients in the modulation of physiological body functions in therapeutic aid (prevention and treatment) of some diseases and promoting the well-being of the animals. The nutritional concepts are expanding and currently emphasizing the use of food as means to enhance the quality of life by improving health, reducing the risk of diseases and promoting well-being. Thus, the expectancy and quality of life for pets (regarding less susceptibility to disease and ability to maintain an active life) can be increased through nutrition, appropriate feeding management and use of functional food. So, food restriction, the use of antioxidant nutrients (like vitamins C and E, beta carotene, taurine), certain fibers and polyunsaturated fatty acids as well as the use of techniques and knowledge such as nanotechnology and nutrigenomics can promote good health and increased longevity of pets.

Key Words: caloric restriction, nutriceuticals, nutrigenomics, pets

Impacto da nutrição moderna sobre a saúde e longevidade de cães e gatos

RESUMO - Há algum tempo destaca-se o papel primário da dieta no suprimento das exigências nutricionais e metabólicas, no entanto, estudos recentes ressaltam a importância da energia e dos nutrientes na modulação de funções orgânicas fisiológicas, no suporte terapêutico (prevenção e tratamento) de algumas patologias e na promoção de bem-estar. Os conceitos nutricionais estão se expandindo e, atualmente, enfatizam o uso dos alimentos para auxiliar na qualidade de vida, melhorando a saúde, reduzindo o risco de doenças e promovendo o bem-estar. Assim, a expectativa e a qualidade de vida dos animais de companhia (relacionada à menor susceptibilidade a doenças e à habilidade em manter uma vida ativa) podem ser aumentadas através da nutrição, do manejo alimentar adequado e da utilização de alimentos funcionais. Dessa forma, a restrição alimentar, o uso de nutrientes antioxidantes (como as vitaminas C e E, o beta caroteno, a taurina), de certas fibras, de ácidos graxos poliinsaturados, bem como a utilização de técnicas e conhecimentos como a nanotecnologia e a nutragenômica, podem promover manutenção da saúde e aumento da longevidade dos animais de companhia.

Palavras-chave: animais de companhia, nutracêuticos, nutragenômica, restrição energética

Introduction

The interaction between man and pets has strengthened and it has been proved to be very beneficial to both parties. The emotional bond established with the animal has ceased to be merely a companion to become part of the family. So, animals that used to inhabit only the backyards of the houses began to live with their owner within them and within apartments (Maia et al., 2010). Scientific studies have proven that besides playing an important role in its owners' quality of life, the animals can also act as backup in tense and stressful situations, as in separations and losses of people that were close. In parallel, another concept, related to stressful and afflicted life of big cities, has grown in recent decades. The concept of physical health at all costs, with bursts of gyms and beauty centers, granted an important role for human nutritionists. While gastronomy relied on "food flavor", human nutrition began to focus on "health". Obviously these concepts were extended to pets (Saad et al., 2003).

These concepts are evident in the changes that commercial feeds have gone through in the last two decades. Up to 1990, most feeds available in the market were based only on the minimum nutritional requirements established by the National Research Council and published in 1986. These feeds presented similar nutritional compositions and

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regarded only two physiological stages: growth and adult. Currently many new niches are rising to positions of privilege in the global PET market: organic food; grain free; ingredients with quality standards for humans; natural; “super premium”; “ultra premium”; meat-based (beef centric) and protein-based (protein focused) diets, also diets in the niche: skin and hair health, intestinal health, oral health, diets for specific breeds, urinary tract health, senile animals and athlete animals (Saad & França, 2010). These new feeds reflect advances in research on pet nutrition.

According to Carciofi & Jeremias (2010), scientific research related to pet nutrition, especially in the last 10 years, no longer focus on the dichotomy, minimum needs and maximum contents, especially regarding the establishment of nutritional recommendations. Te knowledge of the minimum necessities is no longer so important and, increasingly, it is sought to understand the role of nutrition in health improvement, well-being and longevity.

The concepts of nutrition are expanding beyond the borders of survival and apetite satisfaction to emphasize the use of foods that promote well-being, health improvement and reduce the risk of disease. The understanding of how diets may maximize the expectancy and quality of life by the use of ingredients and nutrients have been sought to develop the ability to resist diseases and improve health (Carciofi & Jeremias, 2010).

Caloric restriction and its effects on longevity of dogs and cats

The control of energy and food intake has been studied for a long time. It is known, for over 70 years, that feeding restriction (FR), when properly applied, greatly enhances the lifespan of rodents by reducing the incidence of cancer and other diseases of senility (Weindruch, 2002, apud Aquino & Saad, 2010).

The first hypothesis for the effects of feeding restriction over the development is related to growth retardation. It was believed that aging was a natural growth process and that the decrease of the energy supply could delay the development and its consequences. This hypothesis was upheld until 1980, when the Walford & Masoro research groups verified that when the restriction is limited to the period of rapid growth (six weeks to six months), it has no big effect over the animals’ lifespan and when the restriction is performed after this period, it is as effective as the one initiated in the sixth week. These studies practically contradicted the theory of growth retardation.

The hypothesis of decreased body fat percentage was established in 1960 by Berg & Simms, and attributes the longevity to a decrease in fat accumulation, especially visceral, caused by feeding restriction (Masoro, 2005). The loss of muscle mass is a characteristic of the aging process and is associated with a decrease of strength and with physical fragility. In dogs, body composition also changes with age, resulting in a decrease of lean body and bone mass and an increase in fat mass (Kealy et al., 2002).

In dogs, the body weight is positively correlated with leptin concentration and negatively correlated with ghrelin concentrations. During weight loss, there is a significant increase in ghrelin and in plasma glucose and decrease in plasma leptin and insulin, suggesting that ghrelin and leptin plays an important role in the positive or negative energy balance (Jeusette et al., 2005). The theory of reduction in body fat was not strongly supported until 1980 because at that time the effect of growth restriction on longevity was accepted.

The theory of reduced metabolic rate was proposed by Sacher in 1977, and it says that the increase in longevity with feeding restriction is due to decreased metabolic rate (Masoro, 2005). Thus, the metabolic rate was related to the mass and its decrease in larger mammals, leads to reduced longevity. However, this theory began to be criticized, as some species, such as some birds, combine high metabolic rates and long lifespan and mammals, such as some marsupials, which have lower metabolic rates and short lifespan. Within the canine species, it is noted that small-breed animals (and presumably with higher metabolic rates) live longer than large and giant breeds (Speakman et al., 2003). Speakman et al. (2003), when comparing the changes in the metabolism of three breeds, Papillon, Labrador Retriever and Great Dane, verified that the metabolic need of the smallest breed compared to the largest was 60% higher and that the life expectancy of the Papillon was about 14 years, while the Great Dane was only 8.5 years.

The theory of oxidative damage attenuation postulates that feeding restriction could act by decreasing the production of free radicals, improving the activity of the antioxidant system and the repair mechanisms or a combination of all three. Some studies have emphasized the role of restriction in decreased production of free radicals. The mechanisms by which the reduction of ROS happens are also widely discussed, but a commonly accepted explanation is that there is a decrease or loss of protons or membrane potential, which reduces the oxygen intake (Johnson et al., 2006).

Within the various mechanisms proposed to explain the effects of feeding restriction over longevity, the oxidative damage attenuation is the one that best applies to these effects, including decrease in the production of ROS, increase in antioxidant defense and maintenance of mitochondrial and microsomal membrane fluidity.

The theory of insulin-glucose system change emerged in the 1990s, suggesting that throughout life, feeding restrictions decrease plasma glucose concentration, over the 24 hours, to about 15 mg / dL and insulin concentration to approximately 50% (Masoro, 2005). Initially, attention was focused on the lifelong role of reduction of glucose levels as a factor in prolonging the lifespan, because hyperglycemia produces functional and morphological damage similar to senescence. Then, it was proposed that the enzymatic glycation and subsequent reactions with proteins and nucleic acids are involved in the aging process in a causal manner and that increased levels of glucose promote their formation. So, the restriction would increase the effectiveness of glucose, responsiveness of insulin, or both, and the decrease in glucose and insulin levels play an important role in longevity and actions related to feeding restriction (Masoro, 2005).

As for the theory of growth hormone/IGF-1 axis change, which has also been proposed in the early 1990s, by the Sonntag research group, reported that feeding restriction caused a significant decrease in plasma levels of IGF-1 in rats and mice. The potential benefits from reduced levels of growth hormone and its main mediator include reduced risk of developing cancer and insulin resistance (Bartko, 2003).

Finally, the Hormetic theory refers to the phenomenon by which deleterious environmental agents (radiation, chemical substances) change their role to play a beneficial effect when administered in low concentrations or intensity, i.e., a beneficial action resulting from the response of an organism to a stressor of low intensity. These actions include: increase in longevity, delay of deleterious effects from senescence and age-related diseases. So, caloric restriction would be a stressor of low intensity, which would act to avoid the accumulation of damages caused by endogenous and exogenous agents, increasing longevity. (Masoro, 2005).

Several beneficial effects of dietary restriction over longevity have been found in dogs. Kealy et al. (2002) evaluated the results on body composition and life expectancy of dogs, from 8 weeks of age until death, and found differences in average weight (26% lower in the group with feeding restriction) and body score (4.6 to the group with caloric restriction and 6.4 for animals that received diet *ad libitum*). The average body mass remained constant between 6 and 9 years of age for animals fed *ad libitum*, and between 6 and 11 years for animals with feeding restrictions. Between 6 and 9 years, the average lean body mass was significantly higher in animals fed *ad libitum* (AL) than in animals under controlled feeding (CF). A progressive reduction in body mass started after the 9th year, in animals under *ad libitum* feeding, but in dogs with dietary restriction it happened only after 11 years. The average percentage of lean body mass decreased significantly in both groups, from the 6th to the 12th year, but dogs with feeding restriction had always had a higher average percentage of lean body mass. The variation of fat estimated for the FR group was 10 to 22%, indicating that levels of fat below 22% represent a reasonable goal to achieve maximum quality and expectancy of life in dogs.

In a study conducted by Lawler et al. (2002), with 48 Labrador Retriever dogs, divided into two groups (control and restricted feeding), the restriction effects over longevity and chronic diseases was evaluated. It was found that 25% caloric restriction affected life expectancy (13 x 11.2 years), but not the causes of mortality.

Restriction actions on the antioxidant status of Labrador dogs could also be verified. To this end, the concentrations of serum retinol, retinyl palmitate, total vitamin A, selenium, copper, ceruloplasmin, ascorbic acid, uric acid, peroxyl radical activity and blood concentration of glutathione peroxidase were monitored over a period of six years, between the 5th and 10th year. The restriction was associated with a decrease in concentrations of retinol, vitamin E, copper and ceruloplasmin. As for the aging, it was related to the reduction of retinyl palmitate, vitamin A, vitamin E, selenium and copper and to the increase of retinol, ceruloplasmin and glutathione peroxidase (Stowe et al., 2006).

Regarding immunity, there also can be found benefits and the female immune system seems to respond better to restrictions. Labrador dogs were kept under a 25%protocol restriction, from eight weeks of age until death. The immunologic parameters were monitored from the 4th to 13th year. This related restriction slowed the decline in lymphoproliferative responses, the absolute number of lymphocytes and CD4 and CD8 related to age. There were no direct effects over phagocytic and polymorphonuclear cells, antibody production or activity of natural Killer cells. Lower proliferative responses, lower number of lymphocytes T, CD4 and CD8, lower percentages of CD8 and higher percentages of B cells have often been associated with a decrease in dogs' lifespan (Greeley et al., 2006).

The restriction also has effects over the musculoskeletal system of dogs, especially on osteoarthritis (OA). The role of obesity in the pathogenesis of this disease is complex and of great interest to veterinarians and guardians (owners), and it has a direct role in the onset and progression of this disease. The lower food intake, with the reduction of body weight and metabolic changes are beneficial to decrease the osteoarthritis or to prevent its occurrence and the reduction of clinical and pathological symptoms has been achieved by long and short term reductions in the diet (Lust, 2002).

Smith et al. (2002) conducted a study to evaluate the restriction effect over the arthritic hip manifestation and hip score. It was verified that feeding restriction had a positive effect on hip joint phenotype of Labrador dogs and that the incidence and severity of hip dysplasia and osteoarthritis were lower in animals receiving controlled feeding and persisted throughout the animal's life. With respect to the metabolism of carbohydrates, Labrador dogs were used to study the effects of dietary restriction lifelong glucose tolerance in animals from 9 to 12 years. The levels of glucose and half life, and insulin sensitivity were higher in the restricted group than in ad libitum fed (values total, and 9.10 for 11 years and lean mass) and insulin release in the final stage (of the 30 at 120 minutes) was lower. The time to onset of osteoarthritis or death was greater at lower levels of glucose and increased insulin sensitivity and food restriction was explained largely responsible for these responses and they were associated with improved quality of life and restricted dogs (Larson et al., 2003).

On the other hand, the energy reduction for glycemic control must be associated with the use of diets that minimize and extend the postprandial glycemic wave. Major differences in glycemic response of healthy dogs due to the consumption of isonutrient diets with different starch sources were cited by Carciofi (2008), and should also be observed when formulating diets for dogs seeking an increase in longevity.

Thus, it is observed that feeding restriction is a nutritional intervention that has proven to be effective in delaying morbidity and mortality. This was demonstrated in several species, including dogs. Even a slight degree of accumulation of body fat is enough to increase the risk of disease and early mortality. The benefit of restriction is greater when adopted in the first year of life, but if done in adulthood, it can also produce significant results. Therfore, while the benefits may come from the control of physical fitness throughout life, it is believed that the achievement and maintenance of lean body condition can be beneficial at any time. Caloric restriction is counterindicated only in the pre-weaning and in uterus. Caloric restriction of the pregnant mother may harm the health of the offspring, which may not be noticed for months or years, but may have shorter life expectancy and greater risk of developing diabetes or cardiovascular diseases in the future (Laflamme, 2002).

However, caloric restriction, after the weaning period, seems appropriate for dogs, since overweight and obesity are predisposing factors for morbidity in all races. Dogs that have scored between 4 and 5 (on a scale of 1 to 9) live 15% longer than animals with a score between 6 and 7.2. For cats, it is indicated to maintain the score of 5, to avoid the harmful effects of excess weight over the health (Laflamme, 2002).

Protein and amino acids

The protein supply is one of the most discussed topics in human and small animal nutrition. The high concentrations of this nutrient in commercial feeds and high prevalence of kidney disease in older animals lead to a debate about whether their over-consumption could predispose to kidney damage by overloading that organ, caused by a chronic increase of glomerular pressure and hyperfiltration.

Protein restriction may also decrease the generation of mitochondrial ROS and is believed to be involved in the methionine process. It is known that, for rats and mice, its reduction is involved in an increase in longevity, independently of the energy generation. The 65% decrease could lead to an increase of up to 10% in life expectancy, which would be consistent with the protein restriction of up to 40%. Methionine would reduce ROS generation, particularly of complex I, specific protein markers and instauration of cardiocytes and hepatocytes mitochondria membrane of. Excessive methionine intake could be related to increases in plasma hydroperoxide concentration, hepatic iron, lipoperoxidation, conjugated diene, it also would alter the liver antioxidant enzymes and decrease the levels of vitamin E, besides accelerating the brain aging (Pamplona et al., 2007).

Historically, it has been recommended, for dogs and cats, the provision of diets with low protein specific older animals (over what is normally adopted for maintenance) due to the risk of developing kidney disease (Williams et al., 2001). In animals that have kidney disorders, protein restriction was indicated in the loss of protein, characterized by an increase in protein / creatinine and in hypoalbuminemia. It would be an important step when there is an impairment of renal function because it would limit the actions of uremic toxin and would improve the nutritional status, but this restriction could not be severe enough to impair the palatability of the diet or to induce a negative nitrogen balance, which would lead to massive loss of muscle mass and worsening of clinical condition. However, the loss of muscle mass (which contributes only 20% of the total protein turnover for the senile and about 30% in adults) can be accelerated, contributing to a progression in the aging process in animals fed diets with low protein content. The reduction in muscle mass would be due to decrease in GH and IGF-1 secretion (Williams et al., 2001). In dogs, the supply of different protein levels (16.24 or 32%) for animals between 2 and 8 years of age, did not affect the concentration of IGF-1, but among the elderly, regardless of the protein content in the diet, that differed from most species. In addition, a quadratic effect on total body protein synthesis and in degradation was observed, depending on protein concentration in the diet, and may indicate that concentrations above 16% are not required to maintain the proper balance of nitrogen in dogs (Williams et al., 2001).

For the immune function, the branched-chain fatty acids leucine, isoleucine and valine were essential for protein synthesis and replication of lymphocytes. For humans and some animal species, this relationship is clearly established (Calder et al., 2006).

Studies conducted by McCarty et al. (2001), to determine the effect of diets containing 18-34% protein and age over glomerular mesangium area or over the thickness of basal glomerular membrane in older uninephrerectomized dogs, verified that there were no effects of protein, but of age over these variables. However, as these measurements demanded the sacrifice of animals a very small number was used (5 older dogs and 5young dogs), what resulted in reduction in capability to detect statistical differences. Nevertheless, significant effects of age were found, raising these measurements. Finco (2000) evaluated the effects of two isocaloric diets, with the same mineral content and moderate (15% in dry matter) or high (31% in dry matter) protein content for dogs. Thus, it was verified that the protein is not related to the degree or progression of proteinuria.

Regarding amino acids, it is worth noting the role of taurine in retarding the aging process. Taurine is one of the most abundant amino acids in mammals and are particularly found in the brain, heart and skeletal muscle. Quantitatively, the largest response of taurine is its conjugation with bile acids in the liver, but it also involves combining a large number of compounds that increase the hydrophilicity for excretion (e.g. xenobiotics). The taurine is involved in fetal development, growth, neuromodulation, sensory organs, heart function, osmoregulation, emulsification of fat, a function of neutrophlia, immune response, it acts as an antioxidant in bile acid and xenobiotic conjugation, it also function as an anticonvulsant (NRC, 2006).

So, currently, in dogs and cats nutrition, there is a great controversy regarding the protein's role in longevity. The supply of protein and amino acid concentration slightly above the minimum required to maintain muscle mass, proper functioning of the immune system and other bodily functions seems to be cautious and beneficial.

Functional foods

In general, functional foods or nutriceuticals are seen as health promoters and may be associated with decreased risk of some chronic diseases. So, dog and cat nutrition has been aiming, as human nutrition, at the incorporation of functional substances in food for dogs and cats. A lot of research has been developed to evaluate the effects of soluble and insoluble fiber, natural antioxidants and polyunsaturated fatty acids in health and longevity of pets (Saad et al., 2003)

Soluble and insoluble fiber

Soluble fibers act as substrates for fermentation in the colon by altering its microbiota and physiology. They are also a thickening agent and this property tends to increase the bolus viscosity, decreasing the rate of gastric discharge and causing an impact on satiety and food intake. Therefore, in the proximal gastrointestinal tract, soluble fiber modify satiety, metabolism of carbohydrates (reducing the glycemic response), and of lipids and may be important in controlling obesity and diabetes (Aquino & Saad, 2010).

The fructooligosaccharides, which have prebiotic action, increase the concentration of short chain fatty acids, as acetic, propionic and butyric acids. The effect of intestinal acidity is an increase in the number of intestinal microorganisms, however this increase works selectively. Beneficial bacteria such as Bifidobacteria and *Lactobacillus*, are resistant to acid environment, while harmful bacteria such as *Clostridium, E. Coli, Listeria, Shigella, Salmonella* and others, are sensitive to this environment. According Beynen (2003), in an essay on FOS, two studies on dogs have shown that ingestion of these oligosaccharides increased the number of *Lactobacilli* and *Bifidobacteria* in the feces. In one of the studies, the diet contained 1% FOS isolated from the chicory root and in the other dogs received orally, gelatin capsules containing two grams of FOS. Similar results with lactosucrose are cited by Finke (2003), in which there was verified an increase in *Lactobacillus* and *Bifidobacteria* and a decrease of *Clostridium* in the feces of dogs and cats receiving 1.5 g of the substance and 0.175, respectively (Saad et al., 2003).

Other oligosaccharides that interest nutrition of dogs and cats are the mannan oligosaccharide (MOS), derived from the walls of yeast (dry extract of *Saccharomyces cerevisiae* fermentation). The MOS showed the ability to modulate the immune system and intestinal microbiota, they bind to a wide variety of mycotoxins and also they preserve the integrity of intestinal absorption surface. The pathogenic bacteria colonize the gastrointestinal tract attach to the surface of epithelial cells and prevent infection and necessary to inhibit the pathogenic linkage process. The MOS block the adherence of pathogenic bacteria by occupying the sites of epithelial cells on the intestinal mucosa, where they could get attached to (Saad et al., 2003).

Essential fatty acids

About lipids, although the practical application of essential fatty acid supplementation in veterinary medicine is based on the treatment of skin diseases it is known today that these nutriceuticals has been widely used to treat joint problems and cardiovascular diseases, and probably many other applications will be discovered in the near future.

Recently, it was discovered that by altering the proportion and intake of polyunsaturated fatty acids (PUFA) omega3 and omega6 in the diet, it is possible to modulate and control the severity of diseases, particularly those related to inflammatory processes (Bauer, 2008).

The influence of essential fatty acids in the control of inflammatory processes has been studied because of the ability of these compounds to be incorporated into the cell membrane and act as substrate for eicosanoid metabolism, resulting in the production of eicosanoids with low inflammatory potential (Vaughn & Reinhart, 1996). The type of eicosanoid that is synthesized depends on the type of fatty acid released into the cell membrane. Omega 6 acids, such as arachidonic acid, are triggered by cyclooxygenase and lipoxygenase enzymes to produce two series: series of prostaglandins and thromboxane from series 2 and 4 of leukotriene. In contrast, omega 3 acids, such as eicosapentaenoic acid, are metabolized primarily by lipoxygenase to the series 3 of prostaglandins and thromboxane and series 5 of leukotriene. Eicosanoids derived from fatty acids omega6 are pro-inflammatory, immunosuppressive and act as powerful mediators of inflammation in hypersensitivity reactions type I (Vaughn & Reinhart, 1996).

The therapeutic potential of polyunsaturated fatty acids lies in the ability of these fatty acids to compete with each other for the same enzymatic pathways involved in the synthesis of eicosanoids. Since there is no interconversion between omega3 and omega6 fatty acids, they are incorporated into the cell membrane phospholipids depending on its dietary concentration (Reinhart, 1996) and, once released by PLA2 (phospholipase A2), they will compete for the cyclooxygenase (CO) lipoxygenase (LO). This balance will determine the production of more or less inflammatory mediators (Vaughn & Reinhart, 1996).

The manipulation of the daily levels of omega 6 acid to omega 3 acid has the potential to change the concentrations of these acids in the tissue and finally an effect on the inflammatory response. The amount of omega 3 and 6 series fatty acids in the body is a reflection of the quantity offered in the diet, also altering the omega fatty acid concentrations on the skin (Reinhart et al., 1996).

Natural antioxidants

The oxidative reactions typically occur in the process of obtaining energy by the cells (respiratory chain) and constitute a defense mechanism against invading microorganisms, however this action is nonspecific and may harm its own cells. To avoid this undesirable effect, the organism has a complex antioxidant system, which includes enzymes and free radical neutralizing substances. On the other hand, when the antioxidant defenses are overwhelmed by internal or external factors, there is an imbalance between production and neutralization of oxidizing agents and their effects, resulting in oxidative stress with damage to cellular components and eventually causing mutations, neoplasm changes, loss of function and death of the cell. In addition to endogenous and exogenous factors involved, antioxidants from food sources contribute to the balance of intrinsic antioxidant system by increasing the defense capability of the cells (Saad et al., 2003).

According to an essay by Aquinas & Saad (2010), vitamin E is the major lipid-soluble antioxidant in plasma, erythrocytes and tissues and serves to eliminate free radicals, preventing oxidation of polyunsaturated fatty acids (PUFAs), in proteins of membrane and nucleic acids (NRC, 2006). The beta carotene could act reducing oxidative damage by enhancing the proliferative response of lymphocytes B and T, stimulating the effect functions of cells and the antitumor capacity of natural Killer cells and increasing the production of certain interleukins (Bendich, 1989). The ascorbic acid neutralizes reactive oxygen and nitrogen involved in the oxidative damage on lipids, proteins and nucleic acids. Under experimental conditions, ascorbic acid supplementation has been associated with reduced lipid DNA damage and oxidation of protein (NRC, 2006).

Besides their individual effects, dietary antioxidants may act synergistically. This is the case of vitamin C, which enhances the antioxidant effect of vitamin E by recycling tocopherol after its use in the neutralization of peroxide radicals. However, this effect was only observed *in vitro*, not being clearly demonstrated in vivo. On the other hand Vitamin E also protects the beta-carotene from oxidation. It was observed that a combination of both vitamins inhibit lipid peroxidation induced by peroxide radicals in the liver of rats (Saad et al., 2003).

The action of antioxidants over the immune response of dogs and cats has been evaluated by several researchers. Many studies on humans have shown the beneficial effects on the immune response of supplemental antioxidants in the diet. According to Koelsch (2003) kittens supplemented with a cocktail of antioxidants (a combination of alpha-tocopherol, taurine, lutein and carotenoids) have developed a humoral immune response to feline herpesvirus significantly higher when compared to the control group without supplementation. After a booster vaccination, antibody production was consistently higher in the group of kittens fed the cocktail of antioxidants.

Nanotechnology

The incorporation of bioactive compounds or functional foods, nutriceuticals and vitamins, probiotics, peptides, antioxidants, among others, in feeding systems, provides a simple way to develop new functional foods that can have physiological benefits or reduce the risk of disease (Chen et al., 2006). Therefore, new and emerging technologies such as nanotechnology, have the potential to improve the field of nutritional science, aiding discovery, development and distribution of several intervention strategies to improve health and reduce risks and complications of diseases. Among the areas that would most benefit from emerging technologies there is the identification of action sites (molecular targets) for bioactive components of food (including bioactive components essential and nonessential) in order to optimize health (Ross et al., 2004).

Nanotechnology is a term used to describe the production and use of very small particles (nanoparticles, usually below 100 nanometers) to produce new structures (nanoforms) and materials (nonmaterial) that may have a wide variety of applications such as medicine, engineering, food, animal production and biotechnology (FSAI, 2008).

Mammalian cells normally have between 10,000 to 20,000 nm in diameter, so the use of nanoscale compounds (with at least one dimension < 100 nm) are beneficial taking into account that they can penetrate into cells and organelles and interact with DNA and proteins (Srinivas & Srivastava, 2002). Thus, nanotechnology is showing a great potential to improve the effectiveness and efficiency of destinations for nutriceuticals and bioactive components of functional foods to improve human health, as well as protect the stability of micronutrients and bioactive compounds during processing, storage and distribution through the body, which may likewise improve food quality and its functionality (Chen et al., 2009).

Functional lipids, such as carotenoids, phytosterols, omega 3 fatty acids, natural antioxidants and numerous other compounds are widely used as active ingredients in various food products. Most functional lipids are practically insoluble in water or show very low solubility. The solubility of lipids in the formulation of functional foods is an important factor for the food industry. Furthermore, functional lipids with low water solubility can be prone to a low bioavailability. Thus, the development of new functional materials is one of the major areas in the food industry that will probably be significantly enhanced by the development of nanotechnology (Moraru et al., 2003).

Nutrigenomics

Advances in nutrition science are aiming their attentions at how nutrients affect gene expression at cellular level, whether or not specific nutrients. The major concern in modern times is the increase in elderly population both in humans as in pets. But along with this increase in longevity, it is verified a parallel growing manifestation of diseases such as obesity, cancer, cardiovascular disease, osteoporosis, diabetes and several other chronic inflammatory diseases in animals and humans. As well as hereditary metabolic diseases that affect dogs and cats specifically. Applications in the field of nutrition and genetics together are being tested as nutrigenetic and nutrigenomic and others concepts, so such diseases can be prevented through feeding, and therefore improve health and quality of life of animals and humans (França &Saad, 2008).

The concept of interaction gene/diet describes the modulation of the effect of a dietary component over a specific phenotype (e.g., plasma lipids concentration, obesity and glycemia) by a genetic polymorphism. Alternatively, this concept refers to the modification of diet, to the effect of genetic variable in phenotypic characteristics. It is known that diets that are rich in carbohydrates and lipids are linked to obesity, mellitus insulin non-dependent diabetes and hyperlipidemia. The components of the diet may alter the genomic expression in a direct or indirect manner. Thus, the nutrients at the cellular level can: act as ligands to activate the transcription factors that promote the synthesis of receptors; be metabolized by primary or secondary metabolic pathways, and thereby alter the concentration of substrates or intermediates; and influence positively or negatively signaling pathways. Therefore understanding of the role of nutrients in the stability of DNA, repair and in the different processes of gene expression has recently become more prominent in nutritional science (França & Saad, 2008).

Final Considerations

Unlike farm animals such as birds and pigs, which usually have a short life, defined by indices of food conversion and economic factors, it is expected from researches on pet nutrition to go beyond setting minimum nutritional levels, it is also expected to promote an increase in the lifespan of the animal, in addition to maintaining optimal health. This requires a clear understanding of which inferences of nutritional science about the numerous physiological and metabolic mechanisms related to longevity and health. To this end, knowledge about antioxidant systems and oxidative metabolism, as well as the association of nutrition with the techniques and knowledge such as nanotechnology and genetics may be of primary importance in defining new directions in modern pet nutrition.

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