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ANIMAL NUTRITION FOR THE HEALTH OF ANIMALS, HUMAN AND ENVIRONMENT

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ABSTRACT

Animal nutrition has pronounced direct impact not only on animal health but also indirectly through animal products on human health and through excreta on the environment. Due to increased awareness and concerns about animal health, due to increased incidence and severity of chronic non-communicable diseases in developed world that are linked to nutritional quality of (animal) food and due to increased concern about climate changes animal nutrition has gained new dimensions and additional importance. The knowledge of various factors involved became crucial for animal production in general and already gave, at least in some aspects, new importance and impulse to animal nutrition also in practice. In the review some most important effects and recent possibilities of animal nutrition to improve animal health, to improve nutritional value of animal products in regard of human health and to reduce environmental impact of animal production are discussed.

Key words: animal nutrition/ animal health / human health / environment

1 INTRODUCTION

In the last 20 years the perception of animal nutrition changed immensely. The importance of animal nutrition for animal health, animal welfare and quality of animal products from the point of nutritional value for humans came to the forefront. Nowadays perception of animal nutrition not only considers nutritional requirements and lifestyle of human individuals and populations, but also sensory and hygienic quality and safety of animal products and the impact on environment and sustainability of agriculture. Of course, also in the past, animal nutritionists paid attention to all these viewpoints, however, they were not so emphasised. Not only new findings and possibilities, but also the increased interest of the general public (consumers) enabled that these aspects came to the spotlight also in research. The intention of the review is to present important effects and possibilities of animal nutrition to improve animal health, to improve nutritional value of animal products in regard of human health and to reduce environmental impact of animal production.

2 ANIMAL NUTRITION FOR ANIMAL HEALTH

Animal health and welfare have always been a priority in animal nutrition. In the recent years, new knowledge and improved research possibilities enabled us to pay a grater regard to the effect of nutrition on animal health and benefit from it. In the last decade we witnessed the increasing research on bioactive plant metabolites present in feed and their impact on health of animals. This research was additionally promoted when Europe banned the use of nutritional antibiotics, which had an important role in animal production. Besides that, the severe EU regulations also limited the use of some other

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feed supplements (zinc oxide, copper...). It has to be mentioned that in the respect of feed additives the regulations of European Food Safety Authority (EFSA) are far stricter in comparison with the regulations in the United States or the rest of the world. All the limitations triggered a search for new possibilities how nutrition can further improve animal health and productivity. Together with the search of new, effective nutritive replacements, science and production sector make effort also to make the changes in technology and management of animal production. In this aspect the focus stands on the importance of the effect of nutrition on feed consumption, health status of the gastro-intestinal tract, function of the immune system, regulation of metabolism, prevention of negative effects of oxidative stress, removal and/or inhibition of antinutritive feed substances.

One of the basics how to preserve animal health is to meet the requirements for all nutrients. However, we still do not know enough about the requirements to say that the research in this field is unnecessary. One of such fields which need more research attention is the field of essentiality of fatty acids. Most of the official recommendations mention only the requirements for n-6 but not n-3 polyunsaturated fatty acids (PUFA). While older research did not establish any important value to n-3 PUFA, new findings show that appropriate supply of long chain n-3 PUFA to sows increases the concentration of IgG in colostrum and thus affects the activity of the immune system of piglets in the time of lactation period (Leonard *et al*., 2010).

There are also a lot of uncertainties about the recommendation amounts of some microminerals and vitamins. For example, vitamin E requirements are still insufficiently defined regarding different nutritional states (as for instance the intake of PUFA) and also regarding the function and activity of different forms or isomers of vitamin E (Voljč *et al*., 2011). This problem can be recognized also for some other vitamins and minerals.

To meet the requirements for certain nutrients, their availability has to be taken in the consideration also. With the development of feed additives with better nutrient availability animals can be better provided with nutrients, which is beneficial for their health also. Nice example are organic forms of microminerals, which do not only provide animals with nutrients because of better digestibility, but are usually less toxic and can be used in smaller amounts and thus represent less of a burden to the environment (e.g. Brennan *et al*., 2011).

The latest research has questioned the non-essentiality of some nutrients. For example glutamine and nucleotides, which are normally synthesised by the organism in sufficient amounts in normal conditions, can become essential in the situations which require higher synthesis of nucleic acids and proteins for growth and repair of certain tissues (pathological states). So the supplementation of pigs at the time of weaning with nucleotides can improve the structure, function and microbiota of the intestine, affects metabolic processes, immune system and increases productivity (Sauer *et al*., 2011).

Nutrition has a great impact on health also through the effect on oxidative stress (Lykkesfeldt and Svendsen, 2007), which because of the oxidation of important biological molecules leads to the damage and dysfunction of tissues and organ systems and of course to decreased productivity. Many disease states (coccidiosis, mastitis, steatosis...) and non-optimal environment (heat stress) are also connected to oxidative stress. Thus good antioxidant protection plays a key role for insuring the health and productivity of farm animals. In the conditions when the requirements for antioxidants increase, we can meet them with the addition of antioxidant vitamins or lately we try to combat oxidative stress with plant antioxidant either in the form of adding whole plants or plant extracts. Some interesting plant extracts were also tested in our studies on pigs and poultry. For example sweet chestnut tannins, calendula extracts, mixture of spices, black currant etc. (Frankič *et al*., 2009; Frankič *et al*., 2010; Salobir *et al*., 2010; Frankič and Salobir, 2011).

Some feed sources contain also various substances that have positive effect on health. Among such substances we can find immunoglobulins, hormones, growth factors, biologically active peptides, immunomodulatory substances, lactose... For example piglets need such feed sources at the time after weaning. At that time they are physiologically relatively undeveloped and thus exposed to weaning stress that can lead to atrophy and inflammation of intestinal epithelium, maldigestion and malabsorption, bacterial translocation and disrupted microbial equilibrium in the gut. The consequences can be various infections, diarrhea and increased mortality rate (Miller and Slade, 2003). In this aspect it is also interesting to take into consideration the different ways of feeding, which can affect health condition of the intestine. Feeding of the liquid (fermented) feed is said to decrease pH in the stomach, atrophy of intestinal epithelium, the number of coliform bacteria and increases the amount of yeast in the intestine in some studies (Deprez *et al*., 1987; Canibe *et al*., 2007), but did not had any effect in other studies (Missotten *et al*., 2010).

When we talk about the effect of nutrition on health status we cannot skip the antinutritive substances in feed. Here we can talk about mycotoxins, protease inhibitors, alkaloids, glycosides, lectins, erucic acid, sinapines, tannins etc. (Mosenthin and Jezierny, 2010), which can worsen the health status of animals through their negative impact on feed intake, nutrient digestibility, microflora and health status of the intestine, organ health and function of the immune system. Their adverse impacts can be alleviated if we limit their inclusion in the diet, with different technological procedures (thermal treatment, extraction) and with feed supplements that bind or degrade these antinutritive substances (enzymes, silicates). Of course we cannot forget the plant breeding which has already lowered the amount of antinutritive substances in some plants to the level that is no longer so detrimental for health (glucosinolates, erucic acid in canola).

The knowledge on nutrients in feed has expanded in last decades. For example we know much more about the function of fibre in the intestine and its fermentation and its effect on animal health. Fibre in the nutrition of ruminants in viewed as a functional ingredient, which has a strong health effect because of its interaction with microflora. Fibre is food for microorganisms, their products of fermentation present natural environment and food for intestinal cells. After the absorption this fermentable products also enter metabolic processes. Scientists search for appropriate sources of fermentable fibre to change the microbial community in thus lower the colonization with pathogenic bacteria (Metzler-Zebeli *et al*., 2010).

To improve health status of the animals we frequently use various feed supplements. The most effective feed supplements in the past were nutritive antibiotics, the use of which was prohibited in EU in 2004. For their substitution farmers now use organic acids, probiotics, prebiotics and symbiotics (combination of pro- and pre-biotics). The action of mentioned molecules is well known and is based on the lowering of pH in the stomach, regulation of microflora in the gut, stimulation of gut and immune system function and development...

Because of the easy and quick absorption, medium chain fatty acids (MCFA) also become interesting as feed supplements in the animals with malformed intestines. They represent an interesting source of energy and inhibit the colonisation of pathogenic bacteria in the intestine. Antimicrobial action of MCFA stands on the fact that lipid membranes of microorganisms are permeable for the MCFA, what causes a decrease in intracellular pH, which is a cause of cell lysis. The problem of their application is that the animals refuse to eat them because of their bad taste. They also stimulate excretion of CCK, the hormone that signalises satiety. Because of their quick absorption in the intestine they act mostly in the stomach and the beginning of the intestine (Dierick *et al*., 2002; Messens *et al*., 2010). The problem of feed refusal is solved with the microencapsulation of MCFA (Han *et al*., 2011).

Besides the feed extracts with immunomodulatory effects scientists try to find new ways to affect the function of immune system. As for now, sea weed (laminarin) looks as a promising source of β-(1-3)/(1-6)-glucans. Feeding them to sows improves the phagocyte activity of suckling piglets at the time of weaning and improves histology of intestines (Leonard *et al*., 2010).

The field of natural feed supplements with various active molecules is becoming more and more interesting. Their effect on oxidative stress, immune response, health status of the intestine, microbial population, feed intake and productivity of animals is becoming very important (Frankič *et al*., 2008). In the human nutrition ingestion of plant food sources is recommended also because of the content of secondary plant metabolites (carotenoids, polyphenols) (DGE, 2011), in animal nutrition we still cannot find such general recommendations.

In the future we can expect development of new research possibilities, as is the development of Nutrigenomics, which will lead not only to more certain estimations of animal requirements for certain nutrients, but also the more verified data of the effects of nutrients on health and function of the organism. In the animal nutrition the feeding according to genotype might be a prospective in the future. This is a task that is much easier done with genetically very similar animals (like chicken of the same provenience) than with humans.

3 ANIMAL NUTRITION FOR HUMAN HEALTH

The effects of animal nutrition on human health is seen mostly through: i) the effect of animal nutrition on nutritional value of animal products and thus adequacy of inclusion of these products in the human nutrition, ii) the effect of animal nutrition on sensory and technological quality and microbiological stability of animal products, iii) inhibition of transfer of pathogenic/toxic feed constituents on animals and through animal products to humans. Because we have already discussed the possibilities of nutrition to prevent contamination in the first part of the paper, we will now address only on the first two points.

Humans gain a big part of nutrients from food of animal origin. From the data of European nutrition and health report (Elmadfa, 2009) we in EU consume from 23% (Greece) to 37% (France, Finland) of energy from the food sources of animal origin (Slovenia is with the 31% in the middle), what is far less in comparison with our ancestors who ingested up to 70% of energy from food of animal origin (Cordain *et al*., 2002).

With the abundance of food in the developed countries, we noticed an increase in chronic civilisation diseases. The resolution of the national programme of food policy 2005–2010 (ReNPPP, 2005) reports that 77% Slovenians have an unhealthy diet. Unhealthy diet is mostly a consequence of unhealthy nutritional habits. Let us look at the mistakes in nutrition that can lead to development of diseases: excessive energy intake, lack of energy derived from carbohydrates and excessive from fat and saturated fat, shortness of essential fatty acids (n-3 FA) or unbalanced ratio in intake of n-6 and n-3 FA, excess of cholesterol, too much sugar and easy digestible carbohydrates, shortness of fibre, too much sodium and lack of potassium, magnesium, calcium and essential microelements (Fe, Se, I, Zn), shortness of some vitamins. We can also mention the problem of shortness of secondary plant metabolites (antioxidants, phytosterols...).

The above mentioned problems are connected also with redundant and unbalanced diet, thus the new ways to improve the nutritional status of the western population are searched. One of the possibilities are functional foods which have besides the nutritional value also a positive effect on targeted physiological function, improve wellbeing and health, decrease the risk of disease development or improve quality of life by increasing physical and psychological efficiency and behavioural characteristics (Roberfroid, 2002). Functional foods of animal origin can be the ones that contain less in human nutrition unwanted substances and those that are enriched with nutrients deficient in the nutrition of population or certain groups of population (elderly, children, pregnant women...).

For the people who have inappropriate nutritional habits, the products of animal origin pose a problem mostly because of rather high cholesterol and/or total fat content. While the cholesterol content in animal products cannot be affected by nutritional means, the fat content can be easily manipulated. Errors in the nutrition of growing animals (lack of protein, excessive energy intake...) lead to excessive fat deposition. This phenomenon has a negative effect not only on the carcass composition but also on economics of production.

Considering fat as undesired led to drastic carcass fat reduction by means of animal selection and nutrition. Already in the year 2000 more than 30% decrease in carcass fat tissue content was achieved in pigs (Southgate, 2000). Higgs has concluded already in 2000 that on the basis of improvement of red meat composition in England, the fatty meat is history and that today's meat without visible fat represents a non fat food with a favourable fatty acid composition.

The possibility of animal nutrition in creating functional animal products is therefore seen primarily as an increase in nutrient content, which are lacking in human diet. Foods of animal origin are important in the diet because they are extremely rich in nutrients, which are lacking or have a low availability in food of plant origin. Meat is a particularly rich source of very available nutrients: essential amino acid, vitamin B12, folate and other B vitamins, iron, zinc, selenium, vitamin A, vitamin D. Moreover, in addition to meat, egg in a continental diet is the only source of n-3 and n-6 long chain polyunsaturated FA, ruminant meat also contains conjugated linoleic acid, which she attributed to anti-carcinogenic and other effects. With the help of proper animal nutrition we can enrich meat, milk and eggs with even more nutrients which are lacking in the human diet. We can reduce the proportion of harmful saturated FA, increase the proportion of favourable functional mono and polyunsaturated FA, as well as long-eicosapentaenoic (EPA) and docosahexaenoic (DHA) and the proportion of conjugated linoleic acid (CLA); we can increase levels of certain vitamins and minerals as well as content some natural plant bioactive substances.

Fat intake in humans is not only problematic in terms of quantity, but often due to excessive intake of saturated FA and insufficient intake of essential FA (especially n-3), which are also often unbalanced (too high n-6 and too little n-3) (Simopoulus, 2009). Such inadequate intakes lead to an increased incidence of cardiovascular disease, metabolic syndrome, a malfunctioning immune system, cancer, a malfunctioning nervous system and others (ADA, 2007). A functional food is therefore considered to correct these errors. The use of oils rich in unsaturated FA in animal nutrition, especially alpha linolenic acid, or with the addition of EPA and DHA can increase the content of these acids to the extent that they become a functional food according to the criteria EFSA (2005).

In addition to essential FA in the last decade much attention was attracted by the conjugated linoleic acid (CLA), especially since studies in animals have shown that CLA has anticarcinogenic, anti-atherogenic, and immunomodulatory effects. CLA is contained mainly in fat of ruminants. It is produced in the rumen by microbial modification of fats from feed and in udder from microbial modified oleic acid (vaccenic acid). The content of CLA is affected by the diet, especially by polyunsaturated FA content and the conditions in the rumen. By adding oils rich in linoleic acid (sunflower) we can significantly increase the proportion of CLA in milk (Kelly *et al.*, 1998). The addition of CLA in the feed can increase its concentration of CLA in the flesh of pigs and chickens (Smith *et al.*, 2002).

Animal foods contribute significantly to meet the requirements of people for some minerals (Ca, P, K, Fe, Zn, Se, S), where we need to emphasize high availability of these minerals from animal products for humans. The content of minerals in certain animal products was increased on purpose. Such examples are iodine and selenium, because the supply of them in some EU countries and population groups (adolescents) was deficient (Elmadfa, 2009). With the addition of iodine and selenium in the feed we can affect the concentration of iodine in milk, the eggs and also in the flesh to such an extent as to cover the needs for a much higher proportion than with normal animal products (Salobir *et al*., 2001; Surai, 2002). Similarly to the minerals this is also true for vitamins – especially B complex, as well as A and E and beta carotene (e.g. Leeson and Summers, 1997).

Of course we have to ask ourselves whether the animal created functional foods such as meat, milk and eggs actually have the impact on consumers' health. Research shows that consumption n-3 FA-enriched meat and eggs affects more favourably the fatty acid composition of blood lipids, is lowering triglycerides, and LDL and increasing HDL levels and lowering blood pressure (Oh *et al*., 1991; Stewart *et al*., 2001, Weill *et al*., 2002, Jiménez-Colmenero *et al*., 2010). The increase in the concentration of vitamin E in feed also increases its concentration not only in the flesh of animals, but also in the blood of consumers (Sandström *et al*., 2000)

Nutrient supply not only affects the nutritional value of animal products but also impacts their sensory and technological quality. The latter may also be relevant to human health as it affects the oxidative stability and microbial stability of animal products. Preventing peroxidation of fatty acids in foods with antioxidants is very important for the health of consumers as oxidized substances are harmful to health. Increasing the concentration of antioxidants in animal products to reduce the oxidative processes not only increases the stability of colour, but also reduces water drip and thus improves microbial stability and quality of meat. To protect the quality of foodstuffs of animal origin synthetic or natural antioxidants can be added to the final product itself. For fresh products, such as meat, where lipid oxidation is one of the major causes of quality deterioration during storage, we can achieve a better oxidative stability only by feeding animals with feed enriched with a reasonable amount of antioxidants. Govaris *et al*. (2004) found that oregano oil and vitamin E are more effective to delay the oxidation of minced meat when they are already added to animal feed than being added later in the product itself. Similarly, the diet has an impact on the oxidative stability of poultry meat, eggs and milk (Florou-Paneri *et al*., 2006; Voljč *et al*., 2011). It has been shown recently that the synthetic antioxidants, which are becoming more and more rejected by the consumers, can be replaced with more acceptable natural herbal preparations (Frankič and Salobir, 2011; Frankič *et al*., 2010; Frankič *et al*., 2009).

4 ANIMAL NUTRITION FOR ENVIRONMENTAL HEALTH

Food effects the environment not only through the excretion of urine, faeces and gas, but also through the feed production. The latter does not only include the production of feed directly, but also environmental pollution through transportation, through the production and distribution of fertilizers, protective equipment, and the work involved... Here we will discuss only the direct impacts of feed. Diet plays in this respect a key role. A possible way to influence or reduce pollution is to precisely cover the nutrient requirements of animals and use the feedstuff, feedstuff combinations and feed additives that improve the availability of nutrients from feed or change the conditions in the gastrointestinal tract in a manner that enables reduced emissions into the environment.

Prerequisite to accurately meet the requirements of animals is to know precisely the needs of the animals, the content of the nutrients in the feed and their availability. This includes knowing all of the criteria described for types, categories, genders, and production methods, technologies, environment, etc. We must realize that not only the excess, but also the lack of nutrients increases the secretion of substances into the environment. Lack of nutrients, which would cause 10% slower growth rate would for instance in fattening pigs increase feed consumption for approximately 10 kg due to higher maintenance needs and would increase secretion of substances into the environment for at least about 5%. Good production results indicate, therefore, less environmental pollution. In this case, we ignored the difference in emissions from feed production, which are especially in grazing, smaller.

To accurately meet nutrient requirements, like stated before we need to know not only the nutrient content of feed, but what is much more difficult, the availability of nutrients. Systems that take into account the net nutrient or energy availability have a significant advantage. When protein is considered, additional consideration needs to combine certain essential amino acids and total nonessential amino acids. Current systems generally follow a (true) digestibility method, but not the efficiency rate of the absorbed nutrients. Systems used now to assess the energy and nutritional value, are significantly more accurate and thus environmentally friendly than the old systems. This is very obvious with the protein supply. Thus, for example in pigs, the old system based on digestible protein in combination with an average biological value of diet provided for the size and composition of weight gain required substantially higher safety adding than current system of standardized true ileal digestibility of amino acids (GfE, 2005; Mosenthin *et al*., 2007). The new system allows the use of compound feed with 30–40% smaller amount of crude protein than the old system.

In dairy cows, the progress in protein evaluation systems (system of metabolisable protein) and optimization in composing daily rations improved the efficiency of protein utilisation. This leads to a reduction in emissions of nitrogen and allows the monitoring of emissions of nitrogen in the environment by measuring the amount of urea in milk (van Duinkerken *et al*., 2011). In addition to excretion of substances into the environment via urine and faeces, became in ruminants the emission of greenhouse gases more and more important. Due to fermentation in the rumen produce ruminants large amounts of not only CO_2 but also methane.

Significantly lower excretion occurred in the case of phosphorus with the introduction of available or digestible phosphorus in poultry or pigs. The use of such systems can fully exploit also the use of certain feed additives like phytase. Excretion of nutrients in the environment can be reduced by using sources of nutrients with higher availability or by the use of feed additives that increase the availability of nutrients. Among the latter belong the enzymes for degradation of starch polysaccharides, proteins, phytic acid bound phosphorus etc. The use of digestible phosphorus and addition of phytase can to improve the digestibility of plant phosphorus to the extent that the use of inorganic phosphates is minimized or even not necessary. By this, the excretion of phosphorus into the environment may be reduced by 40% (in pigs). New insights about the requirements, the availability of phosphorus from various sources, use of phytase, etc., have resulted in reduction of phosphorus levels in feeds for pigs in European countries. In the future, there is also the possibility of using genetically modified plants, which will contain a smaller percentage of phytic acid-bound phosphorus (Flachowsky and Aulrich, 2002).

Such reduction of the nutrient requirements as it is the case for protein and phosphorus in addition to the direct effect of reducing the excretion of nitrogen and phosphorus in the environment has an impact also on reducing emissions due to lower demand for production of soybeans, which affects the emissions of greenhouse gases such as CO_2 (Garnett, 2009). Agriculture contributes 10–12% of anthropogenic (from human activities) greenhouse gas emissions, while contributing 50% of anthropogenic methane, which has 25-fold greater ability to trap solar heat as CO_2. Because of microbial fermentation, ruminants contribute to one third of anthropogenic methane production and represent from environmental point of view at least a virtual problem. Besides that they are losing 6–10% of energy of feed and therefore require more feed, which is also an environmental problem (Eckard *et al*., 2010). Because the diet impacts the microbial fermentation and thus the production of methane, it also in this respect effects the environment. The factors that affect methane production (by Eckard *et al*., 2010):

- The quality of feed. Fermentation of grass with more sugars and less fibre and fermentation concentrate may produce less methane than fermentation of fibre-rich feed. In addition, feed high in energy increases feed intake in ruminants and reduces dwell time in the rumen, thus reducing methane emissions. Improved feed quality therefore leads to lower production of methane per unit of output, not only due to lower synthesis of methane, but also because of increased productivity of animals, which reduces the proportion of feed for maintenance or in other words lowers "the methane excretion for maintenance."
- The content of secondary plant metabolites and fats in feed. Some plants contain substances that modify rumen fermentation in a manner that animals may produce less methane (condensed tannins, saponins...). Also the fat content in the feed affects the production of methane, thus increasing the fat in the feed to the upper limit of 6–7% can reduce methanogenesis. This reduction is a result of the impact of fat on: i) reduction of fibre fermentation, ii) reduction of dry matter intake, iii) inhibition of methanogenic bacteria and protozoa and iiii) inhibition of biohydrogenation (limited effect).
- Feed additives. Enzymes for degrading non-starch polysaccharides improve the digestibility of fibre and reduce the excretion of methane due to the changed ratio in acetate and propionate formation. Some varieties of yeast stimulate acetogenesis and thus dispose H_2 which is required for the synthesis of methane. Also adding dicarboxylic acids (e.g. fumarate) for the conversion to propionate consumes H_2 and thus reduces the possibility of methane formation.
- Manipulation of fermentation in the rumen. Using a variety of "chemical" substances that affect the microbial community in the rumen fermentation in the rumen may be changed or managed in a way that can reduce methane production and increase the reductive acetogenesis where the end product from CO_2 and H_2 is acetate and not methane. This could reduce greenhouse gas emissions and improve energy efficiency of feed utilization. Procedures, which are mostly still in their infancy are for example: vaccination against methanogenic bacteria, use of specific bacteriophages and bacteriocins, use bromochloromethane and chloroform, and the use of nutritive

antibiotics (monensin ...), but only in countries where the use is still permitted.

Also the use of more available forms of added nutrients, especially microminerals can lead to reduction of burdens on the environment. A nice example of this is zinc. Large quantities of zinc, a 100-fold greater than the requirements, in the form of zinc oxide are used to reduce the incidence and severity of diarrhoea in weaned piglets. Since this practice is questionable from the standpoint of sustainability and maintaining circuit of substances, is banned in the EU. The EU the upper limit of Zn content in feed for piglets is only 250 mg/kg instead of required 1500–2000 mg Zn (Hill *et al*., 2001). This amount, however, does not have the desired effect. Microencapsulated preparations of zinc oxide, which should give the same results at tenfold lower concentration than required, appeared on the market. Microencapsulation protects the zinc oxide from stomach acid, which usually converts it to inactive zinc chloride. This is the reason why unprotected forms need to be added in such large quantities. Using microencapsulated preparation has the advantage also because it does not interfere with the absorption of copper which is worsened if the large quantities of Zn are used. Similarly, the minerals in cheated form can be regarded as environmentally friendly, as their requirements are lower due to better digestibility and availability what also leads to less negative interactions in the absorption.

Reduced losses in storage and preservation of the feed may also contribute to reduction of the excretion of substances into the environment (due to deterioration or poor quality of silage ...). Also controllers which minimize scattering of feed and advanced control techniques in feeding can also help. Good and current adjustments in feed composition to meet requirements of growing animals contribute great extent to lowering the excretion of substances into the environment. For example, in pigs this is certainly technically easiest to reach with liquid feeding, with which we can alter the nutrient content of virtually every subsequent feed, which is of course not always necessary.

5 CONCLUSION

From this review we can see that nutrition affects health of animals through many levers, it affects human health through nutritional and hygienic quality of animal products and affects the environment through the excretion of digested and indigested matter. In the future we can expect new findings, which will improve the effect of nutrition on animals, humans and environment.

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