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NUTRACEUTICALS IN ANIMAL NUTRITION AND THEIR EFFECT ON SELECTED QUALITY CHARACTERISTICS OF BEEF. A REVIEW ARTICLE

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Abstract: The article discusses the importance of nutraceuticals in animal nutrition, which, on the one hand, influence their well being, and, on the other, shape the quality characteristics of beef and its taste. Nutraceuticals are very important in animal nutrition, especially when they are added to feed of pasture fattened cattle or when the cattle receives feed enriched in ingredients that modify the carcase's fatty acids profile, and, consequently, the quality beef. The most effective source of nutraceuticals with anti oxidant properties are, among others: rosemary, sage, oregano and thyme. It has been established that the use of plant extracts in animal nutrition is more effective than the use of traditional herbs, due to the fact that the extracts contain much lower concentration of volatile flavour and fragrant substances than dry or fresh plants, which is reflected in the quality of beef.

Key words: feed, plant extracts, nutraceuticals, beef, meat quality.

Introduction

Nutraceuticals are additives used in nutrition that are a source of concentrated form of a bioactive component or present the pure form of the component and are administered in a form different than food. They are used in doses exceeding those that can be obtained from normal food in order to improve animals' health. The matter is important in relation to human as well as animal nutrition. Plant materials, such as herbs, are nutraceuticals because they contain substances with multi-directional effect, e.g. antioxidant (e.g. rosemary extract), preserving (e.g. chitosan) or stabilizing (ascorbates). These substances, when used in animal nutrition, can bring the following benefits:

- they enable the modification of sensory characteristics of feed in order to create an aroma and flavour attractive for the animals – effects that can be achieved by an addition of cinnamon, cloves, cardamom, bay leaves or mint to the feed [1];
- they regulate the functions of the animals' digestive system, ensure their well-being and impact the speed and direction of metabolism inside the body. The ones worth mentioning are: turmeric, pepper, ginger, anise, mint, onion, fenugreek and cumin. The substances in these herbs influence the increase of bile acids synthesis in the liver and their release with the bile, which has a positive impact on the digestion and the absorption of lipids [2];
- they contribute to the strengthening of the immunological system of the animal (echinacea) [3];
- they lower the susceptibility to stress, which is of importance especially during weaning, change of feed, transport [4];
- they have a positive impact on the digestive tract ecosystem of animals, primarily by inhibiting pathogenic microbial growth [5];
- enable the modification and development of functional characteristics of meat material desirable by the consumers in terms of sensory and dietary qualities [6].

In these times of beef production development, rising tendencies to use plant extracts can be observed. They are a source of bio-active elements with varying effect, mostly positively influencing breeding results. The aim of this is to:

- reduce methane production in ruminants and, in this way, reduce the negative impact of breeding on the environment;
- improve production effects, such as increasing the weight gain of animals and increasing the effects of feed use with corresponding high level of animals vitality;
- support technological processes in beef processing, mostly by using their antimicrobial and antioxidant properties that impede the microbiological process of meat spoilage and lipids oxidation.

The prohibition of antibiotic use as growth stimulants introduced in 2006 contributed significantly to the greater importance of herbs in animal nutrition. Moreover, increased consumer interest in the origin and quality of meat

resulted in a much wider spectrum of research in the field of fitobiotics and other natural additives (pro- and prebiotics, organic acids).

Meat technology involves the use of numerous additives that enhance the sensory quality of the final product and support the technological process. The addition of natural materials to animal feed impacts the sensory characteristics of beef by, among others, modifying colour, flavour and aroma as well as texture; it also affects the longevity and technological yield of meat.

Characteristics of nutraceuticals used in meat cattle nutrition

Plant extracts may have a beneficial impact on the effectiveness of ruminants fattening and the reduction of the negative effect of their breeding on the environment. However, the identification of oil types and their active ingredients, finding plants that would support fermentation without the negative effect, present a challenge for the researchers. Some of the plant extracts accelerate the fermentation in ruminants. High concentration of these compounds may have a detrimental effect on the amino acids desamination and the reduction of methane production. However, long term research indicates that prolonged administration of these substances changes the direction of the fermantative microflora development, which can adapt to new conditions. Therefore, it is difficult to evaluate the real, long-term benefits of plant extracts' supplementation in ruminants' diet.

Bodas et al. [7] observed the influence of 450 types of plants as feed additives on the reduction of methane production in ruminants. The plants were added to fermented ingredients in the form of dried powder and their effect on the fermentation process, fibre digestion and methane production were studied. The examinations were performed in vitro in a vessel containing micro organisms of ruminants. The amount of produced methane and other gases, pH, the content of volatile fatty acids and the ones in dry matter were studied. Out of 450 tested plants, 35 caused a decrease in methane production by more than 15% in comparison to the control group, and 6 out of these plants reduced methane production by more than 25% without introducing any changes in digestion or influencing the overall content of gases and fatty acids. Rhubarb (*Rheum nobile*) appeared to be one of the more interesting plants that reduce methane production in ruminants. The best results in decreasing the amount of produced gases in ruminants have been achieved by the use of *Acacia Concinna* (gum arabic), garlic (*Allium sativum*), ginger (*Zingiber officinale*) and guava (*Psidium guajava*) extracts.

Plant extracts present anti-microbiological properties, also in relation to some pathogens. It is unknown whether these pathogens can immunize against the active ingredients in plants. The effect of different plants varies depending on their chemical composition, therefore, it is difficult to determine a definitive positive or negative effect on the animals' welfare. The antibacterial mechanism of nutraceuticals in herbs and seasoning plants is very difficult to establish during *in vivo* studies due to extremely complex correlations of the microorganism population in the digestive tract of ruminants and the interaction between the active ingredients of herbs and spices, and other nutrients.

Castillo et al. [8] demonstrate the possible prebiotic effect of certain plants, e.g. a mixture of cinnamon aldehyde, capsaicin and carvacrol increases the number of lactic acid bacteria and leads to the modification of the digestive tract bacteria population of the animal.

The most common use of plant extracts is related to their antioxidant properties. They are added to feed, but also used in culinary (fresh) beef processing as inhibitors of lipid oxidation processes (minced meat) and as additives that prevent or inhibit unfavourable sensory changes during the thermal processing of meat [9].

Antioxidant properties of active elements in herbs and spices are related to the content of phenolic substances (flavonoids, tannins, phenolic acids, phenolic terpenes) and certain vitamins (E, C and A). The herbs rich in phenoles with antioxidant properties include: rosemary, thyme, oregano, sage, green tea, camomile, gingko, dandelion and calendula [10].

Gladine et al. [11], however, indicate that the extracts with the most efficient antioxidant properties are: sage, oregano, calendula, grape, rosemary and citrus extracts. On the one hand, extracts of these herbs protect the feed from oxidation processes during storage and, on the other hand, they improve the quality of meat obtained from animals fed with feed enriched with these extracts. The most popular is the rosemary extract, the source of carnosol and carnosic acid, that has received a status of a natural preservative with E 392 symbol. The primary antioxidant substances in rosemary and sage are carnosol and carnosic acid. In the case of thyme, the primary antioxidant element is p-cymene-2,3-diol.

The alternative for the additives in the feed as well as meat industry may be sedge (*Carex distachya*) extracts, which are naturally rich in antioxidants. Methanol extracts form the root of this plant contain antioxidant substances with properties similar to ascorbic acid, alpha-tocopherol and synthetic BHT, and their use has been considered useful in impeding oxidation processes during meat storage. The extracts of this plant can also be used as alternatives for synthetic antioxidants, such as butylated hydroxyanisole (BHA) and butylated hydroxytoluen (BHT). The plant contains at least 16 poliphenolic compounds, including se-

ven different ligants, four phenylethanoids, three resveratrol derivatives: glucoside, secoiridoid and monolignol [12].

Plant nutraceuticals in animal feed in relation to some of the quality characteristics of beef

Production technologies and feeding systems of cattle for fattening are determined by the higher and higher clients' expectations for good quality beef. Nutritionists suggest the need for increased consumption of unsaturated fatty acids from PUFA n-3 group. According to the recommended dosage specified by organisations for nutrition (Scientific Review Committee (Canada) or British Nutrition Foundation) [13, 14], an average Polish diet includes insufficient amounts of these acids.

One of the actions aimed at increasing the content of fats rich in PUFA n-3 in food is increasing their content also in beef. The literature indicates that the easiest manner of raising the content of n-3 fatty acids (content modification) in beef is feeding the cattle on pastures [15]. One of the more economically effective ways to improve the dietary (health-promoting) properties of beef is a modification that entails an increase in roughage and decrease in concentrates in the feed during the finishing period of cattle feeding. Such action results in the improvement of the EUFA content in the fat tissue, followed by an increase of linolenic acid (C18:3 n-3) and decrease of linoleic acid (C18:2 n-6) content. A special role in this matter can be assigned to the feed obtained from permanent pastures, especially grass and other plants occurring in the meadow and pasture sward. However, in order to provide natural protection of the polyunsaturated fatty acids in the feed before they become biohydrogenated in rumen, it is recommended to use whole oilseeds (like rapeseed, flax) in the feed of ruminants, which retain the fat inside and protect it from the rumen microflora [16].

Moreover, fairly good results can be achieved with providing feed enriched with extruded flax seeds [17]. In comparison to intense feeding, the meat of young bulls fed in a medium intensive manner can be characterised by a higher content of PUFA n-3 and of the sum of CLA isomers sought after in the human diet, as well as a more favourable ratio of PUFA n-6 to n-3 and a lower content of total cholesterol [18].

The modification of the fatty acids composition can be also achieved by adding various plant materials in the form of unprocessed herbs or in the form of extracts containing nutraceutic substances isolated from the herbs to the feed. On the one hand, they affect the quality properties (organoleptic and physiochemical) of the final product (meat), on the other hand, they become a measure to assess their health improving properties. The use of nutraceuticals in the production or processing of meat is still quite questionable, e.g. in relation to the amount, the manner and the form of placing them in the product, i.e. during the life stock production or during the beef processing stage.

Regulation of the fatty acids composition in beef by means of adequate animal nutrition, increases the susceptibility of lipids to peroxidation, which results in the reduction of meat's durability. It is a known fact that the substrates initiating oxidation in the process of peroxidation are PUFA fatty acids. The lipid profile of beef fat and the speed of oxidation products accumulation may have a significant impact on the sensory quality of beef, its aroma in particular, as the final products of lipids' oxidation are responsible for the rancid flavour and aroma of stored meat [19]. Hence, the need to perform actions that would protect beef and the fat in it against oxidation [10].

Antioxidants in the feed in relation to lipids oxidation processes in beef

Substances with antioxidant properties occurring naturally in various plant materials have been positively accepted as additives in meat production due to their potential health and safety benefits, higher than in synthetic preservatives, like butylated hydroxyanisole (BHA) and butylated hydroxytoluen (BHT). According to current trends, synthetic antioxidants in feeds are being replaced with natural additives, such as alpha tocopherol (vit E), ascorbates or linolic acid (CLA). Furthermore, the addition of different natural plant extracts is being taken into consideration. They are a source of poliphenolic compounds with strong antioxidant effect and could be used in feed as an alternative for synthetic substances.

Technological procedures related to the limiting of oxidation changes in meat fat, irrespective of its origin, are of such importance due to the fact that the primary (peroxides) as well as the secondary (mostly aldehydes) fat oxidation products are very reactive and easily react with almost all food components. This applies in particular to meat proteins, the nutritional value of which is determined by the quantitative and qualitative content of amino acids and their susceptibility to hydrolysis with digestive enzymes. The reduction of digestibility of amino acids takes effect as a result of cross-linking bonds in protein-lipid complexes as well as the reaction between the amino acids functional groups and fat oxidation products. It relates especially to the amino, sulphydryl and hydroxyl groups [20].

The lipid profile of beef fat and the formation and accumulation of lipid oxidation products during meat storage significantly affects its sensory quality. As a result of lipids' oxidation in meat, numerous compounds appear, that are responsible for the development of rancid, unwanted scent and flavour, not accepted by the consumers. The substrates initiating the reaction of lipids' oxidation in the process of

peroxidation are PUFA fatty acids [19] and the speed of lipids' oxidation products increases especially in the presence of high concentration of dioxide [21].

Regardless of the flavour and aroma deterioration, lipids' oxidation in meat has an adverse effect on its colour, texture, nutritional value and food security [22]. One of the methods that minimize the oxidation processes of lipids in beef is the use of plant extracts or other antioxidants in cattle nutrition, especially when the cattle is fed with feed rich in PUFA fatty acids or when they are pasture fattened [23].

The most commonly used antioxidants in feeds are tocopherols [24]. Vitamin E, when administered to animals, especially in the form of DL-alpha-tocopherol acetate, effectively limits lipids' oxidation and prolongs meat longevity. Furthermore, it indirectly inhibits the colour change in meat [25]. The action mechanism of vitamin E involves the termination of lipid peroxidation processes in cell membranes and preventing the formation of fatty acids peroxides. Therefore, the addition of vit E to meat not by means of feed, but as an ingredient of culinary meat is not as efficient as feed supplementation. In the latter case, alpha-tocopherol does not get incorporated directly into cell membranes, where the lipid oxidation process is initiated. The addition of vit E to animal feed brings other benefits as well. It significantly reduces the leakage of meat juices. An increase in the content of vit E in feed results in a significantly longer meat storage time.

The increase in the content of vit E in feed, and, subsequently in meat, has a significant effect on the colour stability of beef due to a, higher than in other meats, content of mioglobin in muscles [26]. Concurrently, various studies indicate that a high level of vit E added to feed rich in PUFA is insufficient [27]. Hence, a widespread interest in antioxidants of plant origin [28]. Beneficial results can be observed when feed gets supplemented with a mixture of vit E and plant extracts rich in poliphenols (PERP) obtained from, among others, rosemary (*Rosemarinus officinalis*), grapes (*Vinis vitifera*), citrus (*Citrus paradisi*), or calendula (*Calendula officinalis*), which can ensure adequate protection against lipids' oxidation [29].

Summary

The fundamental objective of beef production is to obtain a product with characteristics desired and accepted by the consumer. The quality of beef can be improved by the use of various plant additives – nutraceuticals in beef. They are bioactive substances with multi-directional effect. Literature analysis leads to the following observations:

1. Nutraceuticals used in animal nutrition have an impact on animals welfare as well as ensure that the meat presents expected sensory and health-promoting properties.
2. In these times of beef production development, rising tendencies to use plant extracts can be observed. They are a source of nutraceuticals mostly with antioxidant properties that influence the quality and longevity of beef.
3. Plant extracts with high antioxidant potential should find an application as feed additives, especially when cattle is pasture fattened or fed with feed enriched with ingredients modifying the fatty acids profile of beef.
4. The use of plants in animal nutrition in the form of extracts is more effective than traditional herbs or spices due to the standardised content of active substances in extracts and also to the much lower concentration of volatile flavours and aromas that in the case of natural unprocessed herbs affect the flavour-fragrant profile of meat.

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