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Meat and meat products as functional food

Maciej Ostaszewski

Student scientific club of Agricultural Engineering,
Siedlce University of Natural Sciences and Humanities, Siedlce, Poland

E-mail address: maciej.ostaszewski1@gmail.com

ABSTRACT

The work was aimed at presenting meat and its products as functional, bioactive food, which, besides nutritional value, contains additional substances intended to strengthen their health. Functional food has gained and is gaining in importance as it has a positive effect on the health of the consumer, limiting the incidence of civilization and diet-related diseases. Functional foods, in addition to meat, also include its products in which the desired content of EFAs, dietary fiber and the limited content of undesirable salts and nitrates are increased. Red meat is a very good source of bioactive ingredients, vitamins and trace elements.

***Keywords*:** red meat, functional foods, bioactive compounds, nutrition

1. INTRODUNCTION

Meat and meat products are a basic element in the human diet. They provide a series of essential substances for the human body. Thanks to this, they guarantee the proper development of the human body and limit the occurrence of diseases associated with the deficiency of ingredients in it [14]. Most consumers think that meat is a healthy and important component of the diet. Meat and meat products are an important source of wholesome, easily digestible protein in the human diet [15]. They also contain very well absorbed, hermetic iron, acids from the group of omega 3 and 6 (EFA), macroelements, micronutrients and vitamins.

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Red meat contains bioactive compounds of a pro-health nature, including linoleic acid (CLA), carnosine, coenzyme Q10, taurine, creatine, which have a beneficial effect on human health.

They help to slow down the aging process through antioxidant properties (carnosine), control the correct work of myocardium (taurine), limit the occurrence in the human body of damage caused by the toxicity of heavy metals. and also help in reducing body fat (L-carnitine) [16]. The nutritional value of meat depends on the percentage content, fat, protein, essential unsaturated fatty acids, minerals, vitamins and the ratio of fatty acids from the group n-3 to n-6. In addition, pork offal is a very good source of vitamins A, D and K and minerals, in particular well-absorbed iron, zinc and copper. The increase in consumer requirements in Europe and the change in lifestyle over the last 10 years have affected the international meat market. Consumers began to require high standards of quality and safety of products. Currently, there is an upward trend in meat consumption. Pork meat is mostly eaten in Poland, which is conditioned by tradition and eating habits. Bioactive ingredients such as linoleic acid (CLA), coenzyme Q10, carnosine, creatine, L-carnitine and lipoic acid (ALA) are present in the meat [17]. They exhibit chelating, antioxidant, buffering and anti-glycation activities. Thanks to these properties, they inhibit aging processes and counteract the development of civilization disease. In order to give the meat products the nature of healthy food, which can meet the expectations of consumers, they also increase the content of desirable ingredients, EFA, dietary fiber and reduce the content of undesirable salts and nitrates [1]. Functional food reduces the risk of civilization and diet-related diseases .

2. BIOACTIVE INGREDIENTS

The bioactive components are permitted additive substances whose planned use brings the expected results in the physiological and metabolic functioning of the human body. Red meat is a source of bioactive ingredients such as: linoleic acid (CLA), coenzyme Q10, carnosine, creatine, L-carnitine and lipoic acid (ALA) – [17].

Linoleic acid (CLA)

Table 1. CLA content in various types of meat, dairy products and egg yolk [18, 19]

Type of food product	CLA content (mg / g fat)	Type of food product	CLA content (mg / g fat)
Beef	1,2-14	Milk	2-56
Veal	2,7	Butter	1-14,3
Lamb	5,8	blue cheese	1,74-3,07
Pork	0,6	goat cheeses	1,96-2,5
Chicken	0,9	yellow cheese	0,5-6,26
Turkey	2,6	egg yolk	0,3

Linoleic acid is characterized by pro-health properties. It inhibits the development of civilization diseases. It is an exogenous compound found in meat and animal products. Most CLA is found in beef and milk. CLA is synthesized in the body of ruminants, whereas in monogastric animals it undergoes bi-boosting to saturated fatty acids. CLA in the fat component of red meat is about 1 g / 100 g, 10-46 mg / 100 g in raw meat and 30-100 mg / 100 g in cooked red meat (Table 1)

Taurine

It is a sulfuric amino acid formed in small quantities in the human body, from the synthesis of methionine and cysteine. Meat and animal products are a very good source of taurine as opposed to vegetable products. There are 110 mg of taurine in 100g of lamb and 77mg / 100g of beef in beef [21]. The taurine is responsible for the proper functioning of the myocardium, the nervous system, the retina of the eye and the formation of bile in the body. It reduces the risk of developing atherosclerosis by reducing blood cholesterol levels. Its deficiency causes degeneration of the myocardium (cardiomyopathy). In 100g pork there are 50-72 mg of taurine in 100g meat, beef 39-51mg / 100g and mutton 57-160 mg / 100g (Table 3).

Coenzyme Q10

Otherwise called ubiquinone. It has antioxidant properties, mainly in the lipid phase, is an electron carrier, stabilizes ion channels and cell membranes. Prevents ischemic heart disease and hypertension. Rich source of coenzyme Q10 is red meat, poultry and sea fish such as rainbow trout, pollock, Baltic herring, tuna. The daily need for coenzyme Q10 is unknown and there is no recommended consumption [20]. The richest in coenzyme Q10 are organ meats, especially pork and beef hearts (Table 2). In the case of meat, the most Q10 is found in beef (2.18-3.65 mg / 100g) then in pork (2.0 mg / 100g) and the least in mutton (1.07 mg / 100g) - (Table 3).

Table 2. The content of coenzyme Q9 and coenzyme Q10 in food [20]

Meat type	CoQ_9	CoQ_{10}
Pork heart	3.1	126.8
Beef heart	----------	113.3
Beef liver	1.4	39.2
Pork liver	1.2	22.7
Beef	0.4	36.5
Pork ham	0.9	20.00

Carnosine

It is a dipeptide built of b-alaline and histidine. It occurs in skeletal muscles and nervous tissue. Carnosine has antioxidant, chelating and buffering properties. Thanks to its chelating properties, it reduces the toxicity of ions. Carnosine combats the aging of cells. Maintaining acid-base balance by carnosine increases physical endurance by improving the strength of muscle contraction. The most carnosine is found in beef (452.6 mg / 100g) followed by mutton (251-491 mg / 100g) and the least in pork (211-419 mg / 100g) - (Table 3).

Creatine

It consists of three amino acids: arginine, glycine and methionine. It is synthesized in the liver, kidneys and pancreas. It occurs in the greatest amount in muscles and tendons. It is mainly responsible for providing energy for muscle contraction. Red meat contains an average of about 350mg / 100g of creatine. Supplementation with keratin when practicing sport competitively should be more than 15g / day [24]. Most creatine is found in the lamb (278-511 mg / 100g) then in beef (266-401 mg / 100g) and the least in pork (247-347 mg / 100g) - (Table 3).

L-carnitine

Table 3. The content of selected bioactive substances in meat of cattle, sheep and pigs [21,22]

Bioactive substance (mg / 100g)	Beef	Mutton	Pork
Carnosine	452,6	251-491	211-419
Coenzyme Q10	2,18-3,65	1,07	2,0
Creatine	266-401	278-511	247-347
taurine	39-51	57-160	50-72
L-carnitine	98-104	106-113	83,0

L-carnitine is synthesized from lysine and methionine in the brain, liver and kidneys. Although the human body is able to synthesize L-carnitine, it is 80% supplied from food. Red meat is rich in L-carnitine. It improves lipid metabolism, has antioxidant properties, increases the bioavailability of CoA, is involved in the transport of branched chain amino acids, has chelating properties and participates in the processes of detoxification of the body. The antioxidant properties of L-carnitine enable the interception of free radicals in the human body. The daily intake is 15 mg. In the diet, we usually deliver 0.3-1.9 mg of L-carnitine per kilogram of body weight, while in the vegetarian diet about 0.02 mg per kilogram of body weight. In order to satisfy it, you should consume a small amount of red meat, eg about 1/30 part of beef steak weighing 200g, compared to 27 slices of a yellow heart weighing 20g. L-

carnitine contributes to the reduction of body fat, which is beneficial for people who are slimming. It improves the tolerance of the body to glucose and increases the sensitivity to insulin. Most L-karnityny is found in the lamb (106-113 mg / 100g) then in włowinie (98-104 mg / 100g) and the least in pork (83.00 mg / 100g) - (Table 3).

Alpha-lipoic acid (ALA)

Alpha-lipoic acid (ALA) also called lipoic acid (LA), is a powerful antioxidant that is soluble in water and fats. It has a wide spectrum of activity from cells, tissues to all intracellular compartments in the body. Form LA and DHLA (dihydrolipoic acid) has antioxidant activity.

DHLA is involved in the non-enzymatic regeneration of vitamin C and E. LA has chelating properties that prevent damage to the human body caused by the toxicity of heavy metals. Offal (especially beef) is a very good source of alpha-lipoic acid (Table 5). The best source of lipolysin are beef offal. Most of lipolysin from beef offal contain kidneys (2.64 μg / g) and the least lung (0.12 μg / g) - (Table 5).

Table 4. The content of lipoic acid in various species of red meat [23]

Meat	Lipoic acid content (mg / 100g)
Beef	0,02-0,04
Veal	0,01-0,02
Mutton	0,02-0,04
Pork	0,02-0,03

Table 5. The content of lipolysin in beef offal [22]

Beef offal	Lipolysin content (μg / g)
Kidneys	2,64
Heart	1,51
Liver	0,86
Lungs	0,12

The human body is able to absorb lipolysin, which in the blood is hydrolyzed to lipoic acid

3. NEW TRENDS IN CONSUMPTION MEAT- FUCTIONAL FOOD

Benefits resulting from the consumption of functional foods are: reducing the risk of development: cardiovascular diseases, neoplastic diseases, osteoporosis, civilization diseases, i.e. atherosclerosis, hypertension, obesity, diabetes [2]. Functional food is intended for people: living under stress, elderly, metabolic and digestive disorders, athletes, pregnant and lactating women and infants . The functional food market is developing in fast pace around the world. [1]. The reasons for the expansion of functional food in the XXI are: aging of societies, increase in the cost of medical and social care, an increase in the incidence of chronic diseases related to nutrition, the development of knowledge about biologically active, so-called non-nutrient food ingredients and their physiological impact on the human body, increase of consumer affluence in developed and developing countries, development of techniques and technologies of food processing, availability of nutraceuticals [15].

Modifications of meat products for health-promoting purposes:

1. Increasing the content of essential fatty acids (EFAs)
2. Reducing the salt content
3. Reducing the content of nitrates
4. Increase the content of antioxidants
5. Increase in the content of dietary fiber
6. The participation of probiotics and prebiotics [1]

Increasing the content of essential fatty acids (EFAs)

EFAs lower cholesterol and inhibit the accumulation of platelets. The change in the composition and nutritional value of meat products is obtained at the stage of slaughter animals farm and change in the recipe of products. In order to limit the share of fat in meat, selection of breeds and lines in cross-breeding is carried out and an increase in the share of LCFA in feed mixtures by the addition of linseed oil, linseed, marine algae and fish oil. This way, the fat content in the pork carcass was reduced by about 23%, and in beef by 6% [13]. The modification of the fatty acid profile in the nutritional route is mainly carried out in monogastric animals, because in PUV ruminants they are significantly degree of biohydrogenation to saturated fatty acids [12]. Feed supplementation with natural antioxidant, ie vitamin E, protects fatty acid oxidation.

In the production of meat products, the modification of the fatty acid composition is possible by introducing the vegetable fat (mixture of linseed and sunflower oil or sunflower oil) or fish, as well as microencapsulated preparations that are neutral in terms of taste and smell and reduce undesirable oxidative changes.

Reducing the salt content

Reducing the content of NaCl in meat products serves to give them health-promoting properties. Limitation of salt to the minimum quantities in which the microbiological, sensory and technological criteria of meat products will be met. The World Health Organization (WHO) recommends salt intake in the amount of 5g / day. It has been shown that it is possible to reduce the level of salt in meat products to 1.7% without changing its sensory characteristics. The above limits the necessity of using water and fat binding agents such as phosphates or soy protein preparations [3]. According to many authors, the above may occur

due to the use of other chlorides (KCl, $MgCl_2$, $CaCl_2$), as well as non-chloride salts, e.g. lactates or phosphates [4, 5]

Reducing the content of nitrates

In order to prolong durability, produce characteristic organoleptic characteristics (taste, smell, color) and inhibit the growth of pathogenic bacteria (eg Clostridium botulinum) and putrefaction in the production of meat products, the process of curing meat. It consists in using a mixture of table salt with nitrate (III) or sodium nitrate (V). Due to the high reactivity and the ability to form N-nitrosoamid, including carcinogenic N-nitroso-dimethylamine (NDMA), its use is limited. In order to inhibit the formation of N-nitrosoamid, L-ascorbic acid or L-ascorbate are used in the production. The action of L-ascorbic acid and L-ascorbate is based on the reduction of diiadium trioxide (N_2O_3) to nitric oxide by ascorbate. It is recommended to use an excess of ascorbic acid to effectively inhibit the formation of nitrosamide in the presence of oxygen. The most important lipophilic substance inhibiting nitrosation is alpha-tocopherol .

Increase the content of antioxidants

Obtaining an increased content of antioxidants in meat and meat products is possible due to the addition of vitamin E, carotenoids, plant extracts, eg tea, grapes, olives to the animal diet and during technological processes increasing the content of bioactive substances in muscle tissue. Carotenoids reduce the risk of anticancer diseases and reduce the risk of cardiovascular disease (CVD). Antioxidants of vegetable origin are obtained from such plants as: rosemary, sage, tea, soybeans, citrus fruit peels, sesame seeds, olives and grapes. They are used to inhibit lipid oxidation. Green tea extract lowers total cholesterol, increases HDL fractions and reduces lipoprotein oxidation. Extract of citrus fruits and grapes improves the circulatory system. Included in the diet of animals may also be carnitine, glutathione and carnosine, which have a positive effect on increasing the oxidative stability of meat [2].

Increase in the content of dietary fiber

Regular fiber intake provides many health benefits. Increased fiber intake lowers blood pressure, serum cholesterol, suppresses appetite, facilitates intestinal motility and slows down absorption of glucose and fats. People who consume the recommended amount of fiber, ie 30 to 40g per person per day, according to the Healthy Diet Index (HDI), are less likely to develop coronary heart disease, stroke, hypertension, diabetes, obesity and some gastrointestinal diseases. Enriching the diet of obese people significantly increases weight loss. Dietary fiber is also characterized by technological properties, e.g. the ability to maintain water, the ability to bind cations, emulsify fat, sorption capacity and increase the viscosity of the systems. The addition of fiber in the meat industry results in a better preservation of the shape of heat-treated meat products and an increase in their efficiency. The addition of dietary fiber to meat products also has a positive effect on their color. The addition of various types of fiber to meat products with a reduced fat content, reduces their brightness (L *) and the intensity of the yellow color (b *), while increasing the intensity of the red color (a *) [6]

The participation of probiotics and prebiotics

Probiotics are bacterial strains that have a beneficial effect on human health as a result of the development of a beneficial intestinal microflora. Prebiotics are food ingredients that stimulate the growth of defined groups of microorganisms, improving the functioning of the human body. Probiotic microorganisms are able to colonize the digestive system, thus limiting the adhesion of pathogenic pathogenic cells to the intestinal epithelium. Probiotics lower cholesterol levels, improve intestinal motility, stimulate intestinal epithelial reconstruction and inhibit unfavorable microflora development [11]. Meat products with the participation of probiotics have been available on the German and Japanese market since 1998 [1]. In Poland, the trend of using probiotic bacteria as an addition to meat products is growing, especially for the production of ripening meat products. Strictly maturing sausages could be the source of probiotics in the human diet, vaccinated by Bifidobacterium lactis, Lactobacillus casei, L. paracasei, L. rhamnosus [7]

Table 6. Some commercial examples of probiotic products [8]

Brand name	Description	Producer
Actimel	Probiotic drinking yogurt with L. casei Imunitass1 cultures	Danone, France
Activia	Creamy yogurt containing Bifidus ActiRegularis1,	Danone, France
Gefilus	A wide range of LGG products	Valio, Finnland
Hellus	Dairy products containing Lactobacillus fermentum ME-3	Tallinna Piimato¨o¨ stuse AS, Estonia
Jovita Probiotisch	Blend of cereals, fruit and probiotic yogurt	H&J Bruggen, Germany
Pohadka	Yogurt milk with probiotic cultures	Valasˇske´ Mezirˇı´cˇı´ Dairy, Czech Republic
ProViva	Refreshing natural fruit drink and yogurt in many different flavours containing Lactobacillus plantarum	Ska˚ ne mejerier, Sweden
Rela	Yogurts, cultured milks and juices with L. reuteri	Ingman Foods, Finland
Revital Active	Yogurt and drink yogurt with probiotics	Olma, Czech Republic
Snack Fibra	Snacks and bars with natural fibers and extra minerals and vitamins	Celigu¨ eta, Spain
SOYosa	Range of products based on soy and oats and includes	Bioferme, Finland

	a refreshing drink and a probiotic yogurt-like soy–oat product	
Soytreat	Kefir type product with six probiotics	Lifeway, USA
Yakult	Milk drink containing Lactobacillus casei Shirota	Yakult, Japan
Yosa	Yogurt-like oat product flavoured with natural fruits and berries containing probiotic bacteria (Lactobacillus acidophilus, Bifidobacterium lactis)	Bioferme, Finland

4. EXAMPLES OF FUNCTIONAL FOOD PRODUCTS

Table 7. Prominent types of functional food [9, 10]

Type of functional food	Definition	Example
Altered products	A food from which a deleterious component has been removed, reduced or replaced with another substance with beneficial effects	Fibers as fat releasers in meat or ice cream products
Enriched products	A food with added new nutrients or components not normally found in a particular food	Margarine with plant sterol ester, probiotics, prebiotics
Fortified product	A food fortified with additional nutrients	Fruit juices fortified with vitamin C
Enhanced commodities	A food in which one of the components has been naturally enhanced through special growing conditions, new feed composition, genetic manipulation, or otherwise	Eggs with increased omega-3 content achieved by altered chicken feed

5. THE MARKET OF FUNCTIONAL FOODS

The value of the global enriched food market (in minerals, vitamins and other nutrients) is estimated at USD 258.8 billion (including the functional one at USD 129 billion). In 2020, according to forecasts, it can grow up to 377.8 billion dollars.

The Asian functional products market is worth USD 51 billion (40% of the global market). Almost 33 percent. goes to the US market and 20 percent - to Europe, mainly to Great Britain, France and the Netherlands.

Due to demographic trends (in 2020 there are to be 723 million people in the world aged 66 and over), functional products that delay the effects of aging and strengthen the structure of bones and joints are becoming popular. It is mainly about products enriched with omega acids (their market is expected to double in the coming years) and functional chocolate. According to analysts, the sales of bitter chocolate in 2016-2021 will increase by 27%, mainly due to increased awareness and pro-health effects of polyphenols.

Among the Asian countries, India is still a small but growing market. According to Frost & Sullivan's estimates, the sales of functional foods are expected to grow at a rate of 17.1 per cent. annually to reach 4 billion dollars in 2020. This food is mainly for city dwellers.

6. CONCLUSIONS

1) The consumption of meat in the world and in Europe is growing, considering the increasing number of human populations in the world.
2) Meat is a source of bioactive compounds such as taurine, carnosine, coenzyme Q10, creatine and linoleic acid (CLA), which have pro-health properties.
3) The highest L-carnitine content is found in meat products
4) Functional food is a rapidly growing trend considering the development of civilization and diet-related diseases.

References

[1] Arihara K. Strategies for designing novel functional meat products. *Meat Science,* (2006), 74, 1, 219-229

[2] Jimenez-Colmenero Functional foods based on meat products. In: Handbook of food products manufacturing. Ed. Y. Hui. Wiley, New York: (2007) ,989-1116.

[3] Ruusunen M., Pualanne E., Saltiness of coarsely ground cooked ham with reduced salt content. *Agricultural and Food Science,* (2001), 10, 27-32

[4] Ruusunen M., Puolanne E. Reducing sodium intake from meat products. *Meat Sci.* (2005), 70, 531-541

[5] Desmond E. Reducing salt: a challenge fot the meat industry. *Meat Sci.* (2006) 74, 188-196

[6] Biswas A.K., Kumar V., Bhosle S., et al., Dietary fibers as functional ingredients in meat products and their role in human health. *Int J Livest Prod,* (2011), 2(4), 45-54.

[7] Työppöne, Petäjä e., Mattila-Sandholm, Bioprotectives and probiotics for dry sausages. *Int. J. Food Microb.* (2003), 83: 233-244.

[8] Siro, Istvan, et al. Functional food. Product development, marketing and consumer acceptance—A review. *Appetite* 51.3 (2008) 456-467.

[9] Spence, Joseph T. "Challenges related to the composition of functional foods." *Journal of Food Composition and Analysis* 19 (2006): 4-S6

[10] Kotilainen, Liisa, et al. Health Enhancing Foods. Opportunities for Strengthening the Sector in Developing Countries. Agriculture and Rural Development. The World Bank. Discussion Paper 30, 2006.

[11] Lourens-Hattingh, Analie, and Bennie C. Viljoen. Yogurt as probiotic carrier food. *International dairy journal* 11, 1-2 (2001): 1-17.

[12] Van Soest, PJ van, J. B. Robertson, and B. A. Lewis. "Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition." *Journal of dairy science* 74.10 (1991): 3583-3597.

[13] Wood, J. D., et al. Fat deposition, fatty acid composition and meat quality: A review. *Meat science* 78.4 (2008) 343-358.

[14] Jiménez-Colmenero, Francisco, José Carballo, and Susana Cofrades. Healthier meat and meat products: their role as functional foods. *Meat science* 59.1 (2001) 5-13.

[15] Pereira, Paula Manuela de Castro Cardoso, and Ana Filipa dos Reis Baltazar Vicente. Meat nutritional composition and nutritive role in the human diet. *Meat Science* 93.3 (2013) 586-592.

[16] Williams, Peter. "Nutritional composition of red meat. *Nutrition & Dietetics* 64 (2007) 113-119.

[17] Salminen, S., et al. Functional food science and gastrointestinal physiology and function. *British journal of nutrition* 80.S1 (1998) 147-S171.

[18] Korhonen, Hannu J. Bioactive components in bovine milk. *Bioactive components in milk and dairy products* (2009) 15-42

[19] Rainer, Lisa, and Cynthia J. Heiss. Conjugated linoleic acid: health implications and effects on body composition. *Journal of the American Dietetic Association* 104.6 (2004) 963-968.

[20] Mattila, Pirjo, and Jorma Kumpulainen. Coenzymes Q9and Q10: contents in foods and dietary intake. *Journal of Food Composition and Analysis* 14.4 (2001) 409-417.

[21] Purchas, R. W., Rutherfurd, S. M., Pearce, P. D., Vather, R., & Wilkinson, B. H. P. (2004). Concentrations in beef and lamb of taurine, carnosine, coenzyme Q10, and creatine. *Meat Science*, 66(3), 629-637.

[22] Schmid, A. (2009). Bioactive substances in meat and meat products. *Fleischwirtschaft*, 89(7), 83-90.

[23] Satoh, Soichiro, et al. Selective and sensitive determination of lipoyllysine (protein-bound α-lipoic acid) in biological specimens by high-performance liquid chromatography with fluorescence detection. *Analytica chimica acta* 618.2 (2008) 210-217.

[24] Williams, Peter. Nutritional composition of red meat. *Nutrition & Dietetics* 64 (2007) 113-S119.