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Review paper

Meat products and functional food

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ABSTRACT

Functional food is a term for food products fortified with ingredients that possess beneficial physiological effects. Meat products are characterized by relatively high salt, fat and saturated fatty acid contents. Moreover, phosphates and nitrites are also marked as potential harmful components. Designing meat products as functional food has been associated with replacement (and/or reduction) of these components with other, especially natural, ingredients that possess beneficial effects. The development of such products poses quite a challenge since it requires the creation of a product with improved functional properties and the same sensory quality as conventional ones. Results of numerous studies into improving the nutritional properties of meat products indicate that the meat industry has responded to the changes of lifestyle and perception of food.

1. Introduction

Meat is generally a significant source of several nutrients: proteins of high biological value, and micronutrients such as iron, zinc, phosphorus, selenium and vitamin B12 (*Pereira & Vicente*, 2013; *Williams*, 2007). Fat is a great source of energy. Moreover, meat is almost an exclusive source of several bioactive compounds with antioxidative, anti-inflammatory, anti-carcinogenic and anti-atherosclerotic properties, such as conjugated linoleic acids, carnosine, anserine and taurine (*Pereira & Vicente*, 2013; *Young et al.*, 2013). Since meat as essential food needed to be preserved, ancient people developed meat products by combining different animal tissues with salt and spices, and applying early preservation techniques — drying, heating and smoking (*Kurćubić et al*., 2022). For centuries, these products have been an excellent source of protein, energy and other nutrients. However, in the last 50–60 years, fresh meat has become readily available and meat products lost their primary function and are more valuable because of their sensory properties (*Stajić & Vasilev*, 2022).

In the last third of the 20th century, it was observed that some food ingredients can have a negative effect on health (salt, saturated fatty acids (SFA)) if they are consumed in sufficient quantities. Conversely, other ingredients (antioxidants, n-3 fatty acids, minerals, vitamins) can be important in preventing or treating certain diseases (*Doyon & Labrecque*, 2008). This led to a different perception of food — the purpose of food is no longer only to satisfy hunger and provide energy and basic nutrients, but it could also be a tool that prevents the occurrence of diseases caused by changes in lifestyle and diet, and improves physical and mental health (*Siró et al.*, 2008). Therefore, the concept of "new food" appeared which later become "functional food".

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2. Functional food

In 1984, Japanese scientists first used the term "functional food" for food products fortified with ingredients that possess beneficial physiological effects (*Bigliardi & Galati*, 2013). Japan is also the first country where this field was regulated (in 1991), when the Ministry of Health introduced the regulation called FOSHU — Food for Specified Health Uses (*Iwatani & Yamamoto*, 2019). Since then, numerous definitions of functional food have been proposed — *Bigliardi and Galati* (2013) selected 39 definitions after extensive literature research. In general, functional food should be food that is part of regular nutrition and contains ingredients with a selective effect on one or more functions of the body, and the positive effects of which can be seen as physiologically functional (*Jiménez-Colmenero et al.* 2010; *Zhang et al.*, 2010).

3. Meat products as functional food

In general, meat products contain all the nutrients/compounds from meat that have a positive effect on health, although the content of some minerals, taurine, carnosine and thermolabile vitamins, can be reduced during the process of production, storage and preparation for consumption. Some compounds with a positive effect on health (e.g. bioactive peptides) and others with an adverse effect on health (e.g. biogenic amines and nitrosamines) can occur during the production process. Also, some ingredients such as salt (sodium), phosphates and nitrites, as well as SFA that fatty tissue is rich with, are correlated with a negative influence on health. A large number of research studies has investigated reduction and/or replacement of these potential harmful components.

3.1. Reduction of salt (sodium)

Salt is the most common non-meat ingredient used in meat processing. It is essential for technological and sensory properties, shelf-life and safety of meat products. Its influence depends on salt content, form of meat (whole muscle/ground), processing procedures (heating, drying, mixing/grinding) and can be summarized as: extraction and activation of myofibrillar proteins, meat emulsion formulation and stabilization, improvement of the water-holding capacity (WHC) and defining flavour (*Kurćubić et al.*, 2022). High sodium intake has been correlated with high blood pressure, while salt is the major source of sodium in meat products, in which it accounts for approximately 79% of the sodium (*Desmond*, 2006).

The salt content in s formulation depends on the type of meat product: usually 1–2% in burger type products, 1.8–2.5% in emulsion-type sausages, 2–3% in cooked ham, 2.5–3% in dry-fermented sausages (>3.5% after drying), >3% in dry-cured meats (>4.5% after drying). The literature data indicate that salt reduction to about 1.7% in emulsion-type sausages (without phosphates added) and to 2.3% in fermented sausages can be reached without major adverse effects on products (*Corral et al.*, 2013; *Stajić et al.*, 2022). The major impact of salt on WHC came from the Cl^- anion (*Petit et al.*, 2019); therefore, reduction of the salt content in meat products has limitations. For example, salt levels above 1.3% (with added phosphates) are needed to obtain a stable meat emulsion (*Vasquez Mejia et al.*, 2019). Another possible course of action is the reduction of the sodium content by replacing salt with other chloride salts (KCl, $CaCl_2$, $MgCl_2$) which also has limitations, because the salty taste of salt mainly comes from the Na^+ cation (*Petit et al.*, 2019), and the use of other chloride salts can alter taste — e. g. use of KCl and $MgCl_2$ leads to bitterness (*Corral et al.*, 2013). Therefore, the partial replacement of NaCl with other chloride salts and combining it with compounds/ingredients that enhance salty taste and/or mask bitter taste could be good solution (*Inguglia et al.,* 2017). Different commercial mixtures consisting of sodium salt mixtures and lysine, arginine, K-lactate, glycine, yeast and mushroom extracts have been developed with the aim of reducing the sodium level and overcoming/masking technological and sensory defects (*Kurćubić et al.*, 2022).

3.2. Replacement of phosphates

Phosphates are very important for meat products because they increase the swelling of meat fibres (WHC), promote solubilization of myofibrillar proteins, bind metal ions, and reduce viscosity of meat batters (*Sebranek*, 2009). Therefore, phosphates are of great significance for technological properties of emulsified-type sausages and whole-muscle brine-injected meat products. The reduction of the phosphate content was not in focus (as much as salt and fat reduction) because the content/addition of phosphates to meat products is limited by regulations — 8 g/kg product of total phosphorus (as

P_2O_5) in Serbia, and 5 g/kg product of added phosphates in the EU. However, due to a change in P/Ca ratio in dietary intake and the increase of consumer demand for the "clean label" products, several research studies have been conducted to examine phosphate replacement, especially in emulsion-type sausages. The phosphate reduction was based on: i) replacement with natural mineral-based ingredients e.g. calcium powders originating from shells, eggs and algae (*Bae et al*., 2017; *Stajić et al.*, 2020); ii) replacement with natural ingredients that can bind water and emulsify fat, e.g. dietary fibre and heteropolysaccharides (*Câmara et al.*, 2020; *Powell et al.*, 2019; *Stajić et al.*, 2022); iii) reduction by application of alternative processing techniques e.g. ultrasound (*Pinton et al.*, 2019).

Natural calcium powders increase pH values and, therefore, contribute to proper processing yield, while on the other hand, they alter colour and texture properties (*Bae et al.*, 2017; *Stajić et al.*, 2020). Dietary fibre contains soluble and insoluble fibre and so has gel-forming ability, water-binding capacity and oil-binding capacity (*Tungland & Meyer*, 2002). However, due to differences in the amount of soluble and insoluble fibre, different impacts occur that are amount- and product-dependent. Lower emulsion stability was obtained when phosphates were replaced with 0.3–0.6% of wheat, maize, pea, potato and 0.5–1% of citrus fibre (*Powell et al.*, 2019; *Stajić et al.*, 2022). However, this was not significant in all treatments, and similar processing yields compared to controls were obtained in treatments with 0.6% of wheat, maize and pea fibres and 0.75% of citrus fibre. Application of ultrasound for 18 minutes can be used in processing emulsion-type sausages with 50% of reduced phosphates. These strategies have certain limitations; however, they offer great potential to multi-ingredient phosphate replacement strategy.

3.3. Nitrate replacement/reduction

Nitrites are ingredients that have multiple effects in meat systems: antimicrobial effects (particularly on neurotoxin-producing *Clostridium botulinum*), pink colour and aroma formation and lipid oxidation delay (*Alirezalu et al.*, 2019). However, nitrites also participate in the creation of carcinogenic N-nitrosamines, whose content is in correlation with the content of nitrites (*Alirezalu et al.*, 2019). Nitrites are usually added in amounts of 100–150 mg/kg depending on regulations. The main part of this amount is needed for *C. botulinum* control, while about 25 mg is needed for colour formation (*Sindelar & Milkowski*, 2012). Therefore, the strategy for nitrite reduction (and thus N-nitrosamine reduction) includes the introduction of ingredients that exhibit antimicrobial and antioxidant activity. In the research of *Kurćubić et al.* (2014), nitrite was replaced with ethanol extract of *Kitaibelia vitifolia* in effective concentration of 12.5 g/kg of the initial batch of dry-fermented sausages. The results indicate the great antimicrobial and antioxidative potential of *K. vitifolia* ethanol extract during production and cold storage. Also, colour, taste and overall acceptability were not affected. In frankfurter-type sausages, *Alirezalu et al.* (2019) obtained promising results in terms of antimicrobial and antioxidant effects and sensory properties of frankfurter-type sausages during cold storage (45 days at 4°C) when replacing nitrite with 1% of chitosan and 0.2% of ε-polylysine (both in combination with a 500 ppm mixture of green tea, stinging nettle and olive leaves extracts).

3.4. Fat reduction and/or improvement of fatty acids profile

Fatty tissue is essential for the quality of meat products. This is especially significant in meat products where fatty tissue is ground together with meat, mixed with non-meat ingredients (salt, additives, spices), and subjected to different procedures (drying, fermentation, grinding, emulsification) to produce fermented sausages, emulsion-type sausages or burgers/patties (*Kurćubić et al.,* 2022). The fat content of these products can be up to 50% in dry-fermented sausages and up to 30% in emulsion-type sausages and burgers/patties (*Kurćubić et al.,* 2022). Moreover, animal fat is rich in SFA and has a low content of n-3 polyunsaturated fatty acids (PUFA). Recommendations of the World Health Organization (WHO) from two decades ago emphasized that the amount of fat in total daily energy intake should be in the 15–30% range, SFA < 10% and n-3 PUFA 1–2%. Strategies include reduction of the amount of fatty tissue and/or partial to total replacement with non-lipid replacers or oils rich in PUFA (*Kurćubić et al.,* 2022). The reduction of the amount of fatty tissue has limited effects because this reduces the acceptability of fermented sausages (*Liaros et al.,* 2009) and burgers (*Heck et al.,* 2019). A partial replacement of fatty tissue with non-lipid fat replacers (inulin, cereal, and fruit fibre) can be a strategy to improve the quality of low-fat meat products

(*Bajcic et al.*, 2023; *Kurćubić et al.,* 2020). However, this only reduces the intake of energy which originates from fat — the FA profile can be changed only by introducing oils rich in PUFA (especially n-3 PUFA) into the formulation of meat products (*Kurćubić et al.,* 2022). On the other hand, oils rich in PUFA (e.g. grapeseed, flaxseed, fish, algae and their combinations) are more susceptible to lipid oxidation, and therefore, these oils need to be stabilized (cannot be added in liquid form) before application (*Stajić & Vasilev*, 2022). Oils were immobilized and stabilized in emulsions, double emulsions, gel-like matrixes (hydrogel, oleogel, oil-bulking, structured emulsions) and encapsulated by different encapsulation techniques — spray-drying, electrostatic extrusion, etc. (*Stajić & Vasilev*, 2022). The immobilization technique together with oil type, amount of fat replacement, and the principle of fat replacement (with same amount of oil (later stabilized) or with the same amount of substitute which consists of immobilized oil) influence the technological and sensory properties of modified meat products (*Stajić et al.*, 2018; *Stajić et al.*, 2020). Nutritional properties depend on the amount of fat replacement and oil fatty acid profile.

3.5. Meat products as sources of dietary fibre

As mentioned above, food could also be a tool that prevents the occurrence of diseases. Meat products are not a source of dietary fibre, however, so cold hybrid meat products, made by combining two or more types of meat with plant proteins and other non-meat ingredients, have found their place on the market (*Galanakis et al.*, 2021). Hybrid meat products have a potential advantage over plant-based meats, because they provide the familiar meaty taste and texture while containing plant-based ingredients that can contribute to a healthier and sustainable diet (*Grasso & Javorska*, 2020). They can offer a broader range of flavours and textures while reportedly having significantly lower greenhouse gas emissions when compared to all-meat products (*Baune et al.,* 2021).

The percentage of plant ingredients (legumes, grains, fruits and vegetables) in these products can be from 10% to 50%. By definition, they are not added as extensions but as part of the product constituents (*Grasso & Javorska*, 2020). Ingredients like soy, wheat, starch and fibre have been used in the meat industry for their functional properties (emulsification, water binding/holding and gelling) and to save costs (*Singh et al*., 2008; *Asgar et al.*, 2010). The conceptual difference between hybrid and traditional meat products is that plant-based ingredients are used not only for economic and technological purposes, but also for improving health claims, lowering the environmental impact and decreasing meat consumption (*Grasso,* 2020; *Talens et al.*, 2022). A market research study showed that a third of consumers are flexitarians, which means that although they eat meat, they regularly avoid it on certain days (*Grasso and Jaworska*, 2020). Therefore, hybrid meat products could create new business opportunities for the meat industry, as they fulfil the growing flexitarian consumer needs.

4. Conclusion

Results of numerous studies into improving the nutritional properties of meat products indicate that the meat industry has responded to the changes of lifestyle and perceptions of the food. Meat products with reduced sodium and fat contents and improved fatty acid profiles have been developed. Moreover, natural replacers for synthetic and potentially harmful ingredients have been introduced. The development of such products poses quite a challenge since it requires the creation of a product with improved functional properties and the same sensory quality as conventional ones. New research is being carried out with the aim of optimizing the developed products in order to provide the necessary sensory quality in addition to further improving the nutritional properties.

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