



Consumer perceptions towards healthier meat products

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Consumer perceptions towards healthier meat products are now mainly associated with how meat is produced and processed; the physical and chemical composition; nutritional quality; sensory properties, and social, ethic, or religious aspects. The main purpose of this condensed review was to summarise the most recent studies on the consumer perceptions towards healthier meat products and contribute to a better knowledge and social awareness about the healthiness of meat products by disseminating the available information.

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Introduction

In recent decades, consumers' concerns about food quality have been increasing, particularly in relation to perceived healthiness of food. Meat products are no exception mainly after recent episodes such as Bovine Spongiform Encephalopathy (BSE), foot and mouth disease, avian influenza in poultry, or the International Agency for Research on Cancer of World Health Organization (WHO) [1] report of 2015 with meat consumption recommendations, often treated inappropriately by the media.

These episodes associated with the increase in healthier lifestyles and care for the environment are leading producers, retailers, and the meat industry to respond to consumer perceptions on the healthy quality of meat products at the time of purchase.

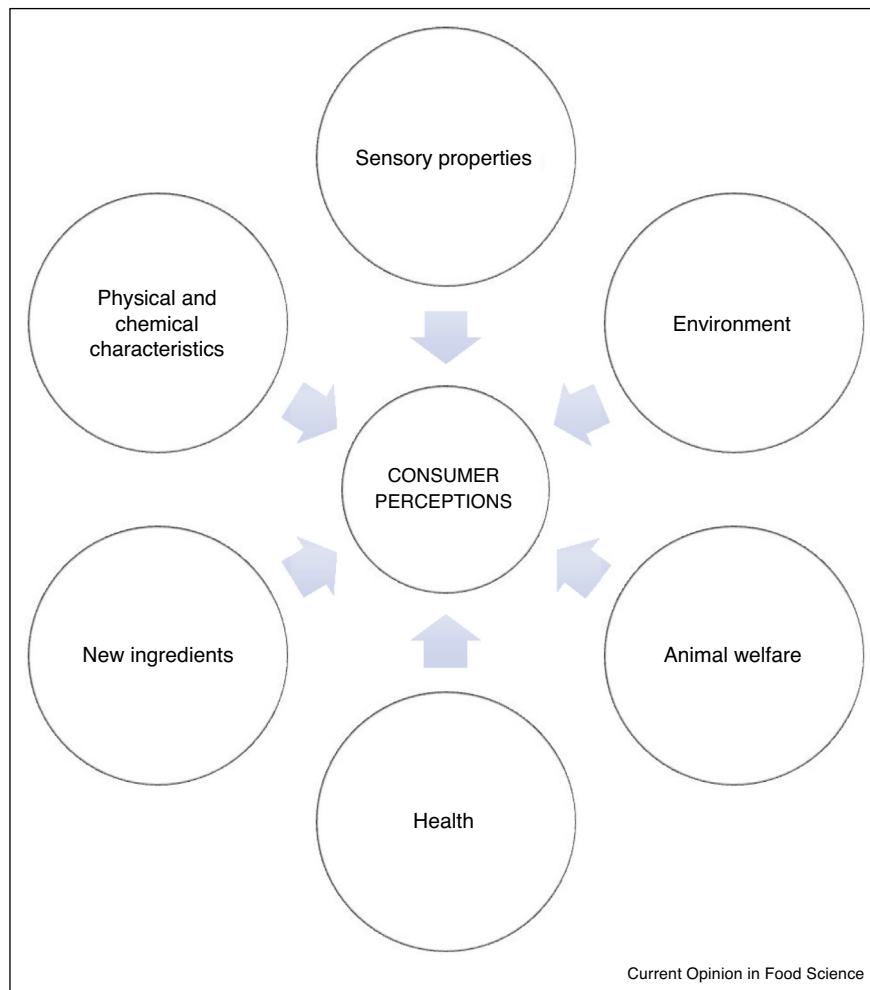
Meat products' consumption has been associated, sometimes unreasonably, with several adverse health consequences: high levels of salt and nitrites, some fibers,

protein with no animal origin, different fat sources, or some ingredients as additives and preservatives. Modern lifestyles also lead the meat industry to offer meat products ready for consumption that must be increasingly attractive, clean, and healthy, using and promoting new processing methods and technologies to meet new consumer expectations. The perception of physical and chemical characteristics as well as the sensory attributes, was recently studied [2^{**},3–6]. The way meat is produced has been a growing concern for consumers and environmental, social, ethical, and animal welfare attributes. Consequently, several sustainability labels have been developed, covering more or less all of these aspects. Consumer assessment of the labelling of these meats and the willingness to pay more has gained significant relevance in recent years. This is mainly in countries more committed to respectful policies for the environment and with a more enlightened consumer population that likes to be informed about these issues related to their choices. Several studies in recent years have highlighted the more relevant concerns on consumer perceptions towards a healthy lifestyle subjects such as the way meat and meat products are produced [7], concerns about animal welfare [8], sustainability and respect for the environment [9^{*},10,11] are evaluated and studied during the last 5 years. Also, consumers' perceptions of the healthiness of processed meats have been assessed in several studies [12,13^{*},14,15].

Anyway, in a study to understand predictors of consumers' purchase intention towards enriched processed meat products [12], the authors found that other factors such as general food choice motives, socio-demographic characteristics, consumer health, and the consumption of functional foods and dietary supplements in general, were not significant predictors of the purchase intention for enriched processed meat. How all these aspects can affect consumer perceptions is now a matter of the meat research teams and meat industry. Consumer perceptions towards healthier meat products are now mainly associated with how meat is produced and processed, its physical and chemical composition, their nutritional quality, sensory properties, and social, ethic, or religious aspects (Figure 1).

Considering the large volume of information in this area and the number of published works, the primary purpose of this short and condensed review was to summarize the most recent studies on the consumer perceptions towards healthier meat products and contribute to a better knowledge and social awareness about the healthiness of meat products by disseminating the available information.

Figure 1



Main factors affecting meat consumer perceptions.

Physicochemical and sensory consumer perceptions

In the last decade, public health authorities, research institutions and the meat industry have been working to improve the quality of meat products to be recognized as healthier by consumers. According to Hung *et al.* [16], a potential market for healthier meat products may offer both public health and the meat industry benefits only if the consumers accept these products. Above all, recently the meat industry has been using 3 main ways to improve the healthiness of meat products: (i) reducing fat and improving the lipid profile, (ii) reducing salt content and (iii) reduction of nitrites and nitrates. The replacement of synthetic antioxidants is also referred [17].

Reducing fat and improving the lipid profile

The partial or total substitution of animal fat by high unsaturated oils have been investigated in recent years

with the expectation to have healthier and nutritional meat processed products. However, any new manufacturing formula with these objectives will only make sense to be adopted by the meat industry if recognized and accepted by consumers. The use of microencapsulation of healthier oils to improve the lipid profile of meat products [18], and oleogels to replace saturated fat in meat products to improve their healthiness [19] were reviewed. Concerning sensory characteristics some studies referred similar scores and others a decrease in liking. If the correct hydrogel formulation is chosen sensory characteristics will not be modified [20].

Studies on the use of fat alternatives used to improve the health of different meat products are shown in Table 1. Chia, linseed, tiger nut, and olive oil emulsion gels are some of the alternatives used and their implications in consumers acceptability are referred.

Table 1

Use of fat alternatives to improve meat products healthiness and their nutritional, technological and sensory implications

Meat product	Formulation changes	Nutritional and technological benefits	Sensory implications	Reference
Frankfurters	Emulsion gels based on soy oil as pork backfat replacers	No differences in texture, rheology, and technological properties Improved nutritional properties	Reformulated frankfurters had lower acceptability than control	[32]
Salt reduced Bologna sausage	Emulsion gel containing inulin, soy protein isolate and soybean oil as animal fat replacers	Healthier fatty acids composition	Sensory acceptable scores Flavor and aroma were reduced	[33]
Hot-dog style sausages	Pork skin-based emulsion gels with canola oil, bamboo fiber and inulin as pork backfat replacers	Physicochemical parameters not affected ω 3-PUFA and dietary fiber contents improved SFAs and ω 6/ ω 3 ratio decreased	Sensory parameters not changed	[34]
Dry fermented sausages	Inulin gelled suspension and inulin linseed oil gelled emulsion as pork backfat replacer	Different physicochemical parameters	Inulin suspension sausages had the highest overall acceptability Inulin oil emulsion had the lowest sensory scores	[35]
Beef burgers	Tiger nut oil emulsion as animal (beef) fat replacer	Reduced total and saturated fat content, increased unsaturated fatty acids	Beef fat substitution had no influence in sensory parameters acceptability Sensory differences in texture were detected with olive oil	[36]
Cooked lamb sausages	Vegetable oils (chia, linseed, olive oil) as pork backfat replacers	Nutritional indexes improved Linseed enhanced the lipid profile without changes in technological characteristics	Linseed did not change sensory characteristics	[27]
Burgers	Hydrogelled emulsion from chia and linseed oils to replace pork backfat	Technological properties not adversely affected Healthier lipid profile	Possibility of 60% pork backfat replacement with good acceptability	[37]
Dry fermented sausages	Mixture of olive and chia oil structured in oleogel or emulsion gel as animal fat replacer	No differences in technological properties and good oxidative stability after 30 days of storage Improved fatty acid profile Decrease of ω 6/ ω 3 ratio PUFA	Lower acceptability scores were attributed to sausages with fat replacer	[38]

The possibility of producing a low-fat burger with a healthy ω 6/ ω 3 PUFA ratio without affecting technological and sensory properties was indicated [21]. Chia and linseed oil microparticles showed a nutritionally favourable lipid profile but negatively influenced sensory quality suggesting caution in their use. The use of hydrogelled emulsions from chia and linseed oils showed to be a promising strategy to produce low-fat burgers with a healthier lipid profile [22], given that nutritional improvements were found with only 20% replacement of pork backfat by emulsions, and the acceptance scores and sensory profile showed a possibility of replacing up to 60% the pork backfat. However, the use of healthier oils to meat products was proved [23] to be difficult since it reduces oxidative and sensory quality. Only a small amount (10%) can be used so beef burgers had a good sensory liking and oxidative stability similar to the traditional product. On the other hand, the replacement of pork backfat by tiger nut oil, chia oil or linseed oil in deer burgers [24] improved fatty acids profile, while global acceptance was not affected by tiger nut or linseed oils. In lamb meat burgers with different formulation to replace traditional ingredients by oils and flours from nuts and seeds [25] consumers scored negatively the samples with

chia and poppy flours but gave similar ratings to pistachio and chia flour, almond oil and walnut flour, and poppy oil and almond flour formulations when compared to control. In this study consumers were segmented according to a neophobia scale and non-neophobic consumers always gave higher scores than neophobic ones.

The effect of fat replacement by oleogel (rich in oleic acid) on sausages' technological, nutritional, and sensory properties was studied [5]. The results showed that it is possible to produce Bologna-type sausages with 16–29% reduction of fat and obtaining a healthier lipid profile, without changing sensory characteristics. Beef sausages formulations were designed to be healthier by using hazelnut-based pre-emulsion systems as fat substitutes [26]. Total or partial replacement of beef fat by incorporation of pre-emulsified hazelnut oil plus hazelnut powder offered an approach to decrease saturated fats and increase unsaturated fats and a product with equivalent texture, sensory and technological quality to standard ones. Linseed oil was able to enhance the lipid profile without technological and sensory characteristics alterations [27] of cooked lamb sausages. Dry-fermented deer sausage reformulated to include soy emulsion gel [28] showed improvement in both composition and sensory quality of

the final product, suggesting that it could be an excellent strategy to enhance healthiness of fermented sausages.

Sensory analysis results of pâtés using sheep or goat meat comparing the pork fat or olive oil as fat sources were published [29]. Panellists found differences between pâtés produced with pork backfat and olive oil. However, consumers could show a preference for none of them. Micro-encapsulation of healthier oils to enhance physicochemical and nutritional properties of deer pâté [30] influenced their sensory properties. While chia and linseed encapsulated oils implied a lower acceptance score, tigernut oil was not significantly different from control, suggesting a suitable alternative for replacing pork backfat.

Although not exactly a meat product, the use of modified starch to replace animal fat in pork liver pâtés [31] has shown an improvement in its palatability.

The impact of hedonic evaluation on beef attributes preferences, including its enrichment with $\omega 3$ and CLA fatty acids was evaluated [2**]. The hedonic assessment significantly impacted consumers' preferences with less importance on the fat content, color, and origin attributes in relation to animal diet with a special preference for $\omega 3$ enriched beef. In contrast, the preference for CLA fatty acids was not significant.

Reducing salt content

Table 2 presents studies made to evaluate the effects of salts reformulations to produce healthier products.

Using a conjoint analysis, the consumer evaluations of processed meat products reformulated to be healthier was investigated [13*]. On a base of meat products (ham, sausages, beef burgers), the authors explored the effect of the reduction or not the salt and fat, the use or not of recognized healthy ingredients like $\omega 3$, vitamin E, as well as the price and the consumer purchase intention. The price and the basic product of the meat were the most important for the consumers' purchase intention, followed by a healthy ingredient and salt and/or fat content. Ham, sausages and hamburgers with reduced salt and fat contents were the consumer's favourite. The most preferred healthier ingredient used was $\omega 3$. Overall, the meat industry results indicated that healthier reformulations improve the healthier perception of processed meat products.

The effect of fermented beetroot extracts on shelf stability of frankfurters with salt reduction was studied [39]. The panel of sensory evaluation during refrigerated storage found a decrease in the overall acceptability with the increasing of storage period. In any case, the acceptability of the product with fermented beetroot extracts was similar to the control products with no salt reduction.

The attitudes of Italian consumers towards healthier cooked ham, particularly evaluating the balance between intrinsic and extrinsic characteristics and the components or additives that could be a risk to consumers' health was investigated [14]. Results show that high salt content, nitrites, and high-fat content discourage the intention to purchase. But at the same time, it positively values taste, colour, and juiciness (attributes supposedly associated

Table 2

Reformulation strategies to produce low-salt meat products and their nutritional, technological and sensory implications

Meat product	Formulation changes	Nutritional and technological benefits	Sensory implications	Reference
Restructured cooked ham	NaCl reduction and application of ultrasounds	Ultrasounds improved physicochemical properties and did not affected oxidative stability	Sensory acceptance improvement with ultrasound application	[45]
Restructured chicken nuggets	Sodium reduction through replacement of NaCl by CaCl ₂	Physicochemical parameters were not affected Sodium was reduced and calcium increased	No sensory acceptance differences were detected	[46]
Harbin dry sausage	NaCl substitution by KCl and by KCl combined with maltodextrin, L-Lys, L-Ala, citric acid and Ca-lactato	Physical characteristics were maintained	Better sensory acceptability with 30% NaCl reduction	[47]
Frankfurters	Reduced sodium by substitution of NaCl by KCl and glycine	Texture hardness increased by NaCl	Partial replacement of NaCl by KCl had some impact on instrumental texture but not in sensory texture Overall liking score of the optimal reduced sodium (>25% reduction) not different from control	[48]
Restructured cooked hams	NaCl replaced by KCl using pale, soft and exudative meat	Ham texture profile was not affected Ham sliceability was reduced	No changes in consumers preferences were detected	[49]
Restructured cooked ham	Ultrasounds and NaCl replacement by KCl	Reduction of total fluid release Instrumental texture improved (hardness increased)	Application of ultrasounds and low sodium improved flavour and overall acceptance	[50]

with some unhealthy components), showing a certain conflict between sensory properties and health attributes. The effects of NaCl partial replacement by blends of KCl and CaCl₂ on the physicochemical, microbiological, and sensory properties of jerked beef were evaluated [40]. The results showed that adding 50% KCl may be a good strategy to reduce sodium in jerked beef.

The consumers perception towards traditional frankfurters and frankfurters with healthy attributes was found out [41] and conclusions were that consumers are willing to substitute a product in traditional frankfurter with a healthier option. It was suggested that among the options that appeared to be more promising for the development and commercialization in the meat industry were the frankfurters with reduced sodium and fat. The role of consumers' culinary skills on purchasing cues of pork, with emphasis on niche demands (outdoor husbandry and/or certified organic), was assessed in cross-country regions of Spain (Catalonia and Aragon) and Portugal (North) in a study [42]. Credence cues of pork claiming health issues (absence of antibiotics and hormone residues) rather than consumers' culinary skills defined the willingness to pay for niche pork in these regions.

Looking at non-sensory factors underlying consumers' perception of smoked bacon [43], it was found that healthiness was the most important factor, followed by the context of consumption and convenience. Results may help the meat industry launch products with a greater chance of success in the market. The Spanish consumer knowledge and perceptions of quality parameters in minced meat products, as well as the most relevant aspects considered to accept or reject these products was examined [44]. Results confirm that colour and appearance of the products were very important for consumers. The unpackaged beef-pork meat was perceived as more natural, but fattier and less healthy. The chicken-turkey meat was associated with health and low-fat, but also with dislike.

Reducing of nitrites and nitrates

The use of nitrate, nitrite, associated with the salt are the main ingredients used to cure and preserve meat products. In the last decade, public health authorities, research institutions, and meat industry have been working reduce or even replace nitrite in meat products around the world.

The implications of the use of nitrate or nitrite as cure ingredients on public health as well as the sensory properties mainly the flavor perceived by consumers are very well known and described by the scientific literature. However, consumer perceptions of meat products in which nitrite or nitrate has been reduced or replaced by other ingredients are not as well known.

Table 3 shows studies about products reformulations to improve healthiness in meat products by changing the use of nitrites and nitrates.

The problem of nitrite reduction in meat products is a matter of interest to the entire meat industry and should be a subject of study from the production and processing of products to the final consumer. A study [51] was set up to explore, compare and integrate stakeholder and consumer reactions towards innovative processed meat products reducing nitrite and added phytochemicals. They found that consumers' concerns were mainly laid on the resulting products' taste, healthiness and shelf-life. The consumer attitude and purchase intention towards processed meat products with a reduced level of nitrite and natural compounds added was evaluated [16]. The authors verified that the consumers from Netherlands, Italy, and Germany generally had limited knowledge about nitrite being added to meat products and with favourable attitudes and purchase intentions towards the new processed meat products. Consumers from Italy and Germany had a lower level of purchase intention compared to Belgium.

The acceptance and preference by consumers for meat products with replacement of nitrite by natural products instead of using chemical compounds have increasingly been studied in recent years. The possibility of the use of beetroot powder in sucuk, a fermented beef sausage, was evaluated [52] as an alternative of the nitrite and the sensory panel evaluated this product during storage and no differences were found in relation to the control product containing nitrite as preservative. Moreover, at the beginning of storage, the overall acceptability of the product with beetroot was better evaluated by the taste panel.

In the same way of using natural ingredients as nitrite alternatives, some authors [53] tested the effects of using powder from different plant and fruit extracts on microbiological and physical-chemical attributes in sausages. In the sensorial evaluation by a semi-trained panel, the tasters gave the best scores for sausages treated with natural curing products compared to the other treatments. However, purple sweet potato powder had a negative sensory impact on the evaluation of sausages while sausages treated with powdered celery showed the best scores for sensory evaluation.

Other authors [54] evaluated the effect that radish powder and chitosan (a polysaccharide derived from chitin of crustaceans) exert on the physicochemical, microbiological and sensory aspects during processing and storage of fermented-cooked sausages. Results showed the possibility to replace the nitrite by radish powder with microbiological safety. Sensory evaluation was made by 124 tasters, aged between 18–55 years old, and the tasters found that the overall

Table 3**Formulations changes to reduce the use of nitrites in meat products and their health technological advances and sensory implications**

Meat product	Formulation changes	Health technological advances	Sensory implications	Reference
'Sucuk' a Turkish fermented beef sausage	Use of beetroot powder as nitrite alternative	Increasing the a* outcome in a desired red color during storage	Sensory evaluation scores of samples with beet root powder were comparable to those of control with nitrite	[52]
Sausages	Natural curing agents as nitrite alternative	Protection from quality deterioration during storage. To ensure microbiological safety. The effectiveness of Celery powder as alternative to nitrite	Sausages treated with paprika powder and blueberry powder were the best evaluated	[53]
Fermented cooked sausages	Use of chitosan and radish powder to replace synthetic nitrite	Improve the microbiological stability	Overall acceptability was influenced	[54]
Frankfurter-type sausages	ϵ -polylysine (ϵ -PL) or ϵ -polylysine nanoparticle (ϵ -PLN) combined with plants extracts	Improve shelf life	Sausages formulated with ϵ -PLN had higher sensory properties	[55]
Beef burger	Use of quinoa and buckwheat flour in a functional formulation to replace soy protein and bread crumb	New meat products with pseudo-cereals with high quality plant protein and improved shelf life	Burgers with quinoa and buckwheat flours had higher sensory acceptance than burger with soy protein	[56]

acceptability was influenced by the inclusion of radish and chitosan in fermented cooked sausages and globally all attributes evaluated have lower scores than the control, including the purchase intention. The authors concluded the necessity for further studies to improve sensory attributes.

The use of specifically extracts of plants in combination with the ϵ -polylysine (ϵ -PL) or ϵ -polylysine nanoparticle (ϵ -PLN) as alternative to the nitrite was studied [55] in frankfurter sausages. The results show a great antimicrobial and antioxidant potential of this ingredient. The sensory panel of consumers found that color and acceptability was higher in the control with nitrite in comparison with the ϵ -PL and ϵ -PLN treatments. Results also showed that sausages treated with ϵ -PLN had higher sensory attributes in relation to ϵ -PL sausages.

In many of the studies carried out to find solutions for the reduction or even replacement of nitrite and nitrate in meat processing, they did not find clear and objective answers to the sensations perceived by consumers. The sensory studies included trained or semi-trained panels and not consumer study designs with representativeness of the different age groups, sexes and socio-economic groups, and it was often not possible to obtain statistically valid conclusions.

Conclusions and future trends

Meat and meat products, just like the other sectors of the food industry, are in continuous challenge trying to identify factors that influence consumers' perceived healthiness. Which meat products can be considered healthy? Is the question that researchers and industry must answer towards the consumers. The incorporation of healthier

ingredients, natural antioxidants, modified fat profiles (lower saturated fats, cholesterol, and higher polyunsaturated fats), and salt and nitrite reduction will remain subjects to be investigated to which the meat industry must adapt and improve. However, many of the studies cited in this review on consumer perceptions of these products are based on consumer panels with trained or semi-trained panellists' who respond to stimuli such as color, odor, texture or taste not corresponding to the real opinions of global consumers whether they like or dislike, whether they are available to buy it or willing to pay more for it. Therefore, more studies to find the consumer perceptions and their willingness to the inclusion of ingredients that promote the reduction or substitution of salt and nitrite will be a priority in the near future.

Priority should be given to assessing the effect of adding functional ingredients on the physical, chemical and sensory characteristics of meat products whenever improve their nutritional and health qualities. Direct use of natural antioxidants as well as some functional nutrients in processing the meat products can negatively affect sensory taste. For this reason, it makes sense to promote the use of active packaging films using active coatings or microencapsulation and nanoencapsulation technologies to enable the introduction of natural antioxidants to produce healthier products, improving sensory attributes. Studies assessing the consumer perceptions for these products will be required to give indications to meat industry. The production of ready-to-eat meat products will also increasingly be an offer in the meat industry in the future, should work out increasing its attractiveness and healthiness. Technological innovations can be important, as long as they are viable and are accepted by consumers as healthy. The

healthiness is a constant challenge in meat processing research and consumption future trends.

Conflict of interest statement

Nothing declared.

CRedit authorship contribution statement

Alfredo Teixeira: Supervision, Writing - original draft, Writing - review & editing. **Sandra Rodrigues:** Writing - original draft, Writing - review & editing.

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