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Non-meat ingredients in meat products: A scoping review

Patrick Owusu-Ansah*, Esther Kwarteng Besiwah, Ernest Bonah, Francis Kweku Amagloh

Department of Food Science and Technology, Faculty of Agriculture, Food and Consumer Science, University for Development Studies, P. O. Box TL, 1882, Tamale, Ghana

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ABSTRACT

Meat has long been known for its nutritional composition in terms of proteins. Proteins have been known to play important role in the body regarding growth, improving immune functions, making essential hormones and enzymes as well as tissue repair. This could explain why meat is being consumed by most people in all walks of life worldwide. The aim of this study was to review the literature on non-meat extenders and their functions in meat products. Data were collected from qualifying studies of databases (such as Web of Science, Google scholar, science direct, and other web platforms) and were collated, studied, and summarized. Examples of non-meat ingredients included soy protein, starch protein, milk protein, and extenders. The contributions of the non-meat ingredients were to enhance flavor and color among other functional and textural properties of the meat product. Moreover, the findings outlined that, the addition of non-meat ingredients not only improves the quality of the meat products but also reduces the cost and has beneficial health effects on consumers.

1. Introduction

The meat of domestic and wild animals described as meat has been used as food for human beings from antiquity to the present. It is processed by adding ingredients or through mechanical processes to turn into various products, e.g. sausages and burgers crafted for customers' desires. Meat is chemically composed of major components such as water, proteins, lipids, carbohydrates and many other small components such as vitamins, enzymes, pigments, and flavours (Ramalingam, Song, & Hwang, 2019). Meat products are products that are produced by subjecting fresh meat to one or more processing methods such as curing, fermentation, dehydration, comminution, or cooking (Gagaoua & Boudechicha, 2018). Its high biological values of protein, zinc, essential amino acids, vitamins and minerals make meat products particularly nutritious. However, an excessive consumption of meat products cannot be advised, especially for certain people due to their substantial fat content, since it is well known that meat contains a higher proportion of cholesterol, saturated fats, phosphate, sodium, synthetic and polyunsaturated fatty acids (Abdallah & Adam,2016). All the relative proportions of those constituents give meat its basic structure, texture, taste, colour and nutritional value (Sebranek, 2015).

Although it can be eaten raw, meat is normally eaten after it has been seasoned and cooked or processed in a variety of ways (Melgar-Lalanne, Hernández-Álvarez, & Salinas-Castro, 2019). Changing consumer demands and increasing global competition are driving innovation in meat processing. The long-standing positive consumer perception that meat and its products are very good sources of minerals, vitamins, and contain complete protein (i.e., protein that in contrast to many plant-based proteins contain all of the essential amino acids) is gradually giving way to a more negative view (Verbeke, Pérez-Cueto, Barcellos, Krystallis, & Grunert, 2010). The presence of a high level of saturated fats and cholesterol in addition to the absence of some major nutrients could be the main reason for such perception. The main drawback of meat and its products is the absence of dietary fibre and the presence of saturated fat (Kausar, Hanan, Ayob, Praween, & Azad, 2019). It is therefore needed to improve the total nutrition of meat as a whole. This can then be done by introducing non-meat ingredients that can be incorporated in the meat to boost its functional properties and nutritional value.

The benefits of inclusion of non-meat ingredients to meat are to provide flavour notes and enhance acceptability, help bind moisture through proteins (e.g., soy, dairy) and carbohydrates (e.g., starch, carrageenan), enhance freeze-thaw stability through modified starches, improve/modify texture (e.g., gelling of soy proteins, alginate), provide colour (e.g., paprika), lower formulation cost, add bulk, enhance slice ability (e.g., forming a carrageenan gel), and extend shelf life (e.g., lactic acid, spice extract) (Barbut, 2015; Mills, 2014). The incorporation of non-meat ingredients is not only necessary for nutrition but also for preventing nutrition-related disorders and for the mental-physical well-being of an individual (Kausar et al., 2019). The functional properties

* Corresponding author.
E-mail address: apatrick@uds.edu.gh (P. Owusu-Ansah).

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Table 1
Study's articles and Search string.

Identified Articles	Search String
Inclusion criteria	Meat products, meats, extenders, non-meat protein, meat nutrition.
Exclusion criteria	Reports Narratives Commentaries Essays Studies not in English language

of meat (which include gel strength, water absorption, solubility, water holding capacity), and pH have been exploited by many researchers. Aside from the nutritional contents in meat, the addition of extenders have been an issue of major concern to contemporary researchers, as far as the functional qualities is concerned (Kausar et al., 2019; Mills, 2014; Pearson, 2013; Asgar, Fazilah, Huda, Bhat, & Karim, 2010).

Extenders are included in meat products to reduce formulation costs or to contribute a variety of functions in the product with substantial protein content. The effect of an extender on formulation cost may be significant especially when it facilitates increased product yield via addition of water (Mills, 2014). Also, in meat processing, various additives such as nitrites, phosphates, and glutamate can be replaced by natural ingredients, contributing to the development of clean label strategies considering the consumer's interests (Inguglia, Zhang, Tiwari, Kerry, & Burgess, 2017).

In view of the above mentioned, this work was inspired by questions such as, "what are the advantages of meat products with non-meat ingredients and, what motivates the addition of non-meat products and extenders to the meat for consumption?"

The purpose of this scoping review is to identify and map out literature that has evaluated the inclusion of non-meat ingredients in meat products.

2. Methods

A scoping analysis was conducted on the non-meat ingredients in meat products. The approach for this scope analysis was based on the structure developed by Arksey & O'Malley (2005), and on Levac, Colquhoun, & Brien (2010) recommendations. The scoping analysis adopts a wider search strategy while at the same time allowing for reproducibility, clarity and reliability on the current literature situation. In brief, the search technique included a collection of keywords identified with the aid of a library specialist for online bibliographic search on meat, meat products, non-meat protein and extenders.

2.1. Search strategy and selection of the literature

Reviewed papers published in English language journals were collected through systematic searches using these databases: Google scholar, science web, science direct, and information web. Keywords (i.e. meat, extenders, meat/non-meat protein, and meat ingredients) were determined after an initial specific literature search and consultation with a librarian and literature review specialist. We chose to use a tightly defined search string because otherwise the various unrelated meat analogue or extrusion studies would overshadow the studies on non-meat ingredients used in meat products. The found search articles were moved to a research manager program, which omitted histories, commentaries, or certain forms of documents such as studies, and essays. Systemic reviews were also excluded; however, for additional related research, the reference lists of all qualifying ones have been carefully updated. The inclusion, exclusion criteria and the search string are shown in Table 1.

2.2. Data extraction

The information that helped answer the research questions includes the details of publishing results, the situation of choice, the study sample, the country in which the study took place, year, authors, location, type of meat products (examples of sausages, ham burgers and frankfurter), intent of the study, nature of the study, key findings and the type of provider for which the preferences were asses Extracted data were checked to ensure accuracy in advance of the quality assurance process.

2.3. Technique for literature

It listed a total of 1024 publications from the repositories, of which 394 were duplicates. When criteria for inclusion and exclusion were applied at the title and abstract level, it excluded 284 papers based on title and abstract content. For the remaining 74 posts, requirements for inclusion and exclusion were applied after a full-text screening process of 272 completed. Sixty-two percent of the included research were conducted in the last seven years of this current studies (2010–2017) and about eighty-five percent of the current study was conducted in the last decade (2015–2019). The methods and techniques used in this analysis were outlined in a review protocol. All primary work published in English, peer-reviewed journal articles, academic reports, dissertations and conference abstracts or papers were included in the scope of the review (Sivaramalingam, Young, Pham *et al.,* 2015). In the present time, the bibliographies of studies found were checked to ensure completeness of search. Strict limits were not set in the first phase of the literature search and relevant studies were collected regardless of the scope of the study. The search strategy was checked by hand-searching the reference list of relevant review articles and carefully selecting relevant primary research papers, the peer-reviewed literature on non-meat ingredient in meat product is recent and has credibility. As well, eligible articles were limited to research carried out in western countries and Africa. This was inspired by the articles and works highlighting the growing demands of consumers on the consumption of meat with their non-meat products and extenders (Kausar et al., 2019; Piñon, Alarcon-rojo, Renteria, & Carrillo-lopez, 2018;). Flow chart in Figure 1 represents study's identification and selection process.

2.4. Types of method and study design

The review team consisted of all co-authors with multidisciplinary expertise in the topic area and methodology. The review scope included all primary research published in English: peer-reviewed journal articles, research reports, dissertations, and conference abstracts or papers. Meat, in the study was defined as the flesh of an animal, typically a mammal or bird that can be consumed as food (including fish and some sea foods). Studies were strictly directed to researches in the area of food sciences and safety.

2.4.1. Overview of studies

2.4.1.1. Meats and meat products. Meat products are described as those that have modified fresh meat by any of several processing methods, including healing, comminution, dehydration, fermentation, or cooking. With the considerably high number of studies that were scrutinized, the majority of the literature focused on the importance of baseline information in meat extenders (Abdallah & Adam, 2016). This related to popular knowledge of the meat variety that exists: where they originate; how meat is processed; and to a lesser extent, minimal nutritional knowledge of the role of nutrients in meat. In particular, information helps to make informed decisions about 'good meat consumption' Mullen et al., (2017). In other words, knowledge will help individuals understand what makes meat 'clean' and 'unhealthy,' while addressing the role of meat extenders as a precursor to the ability of judging meat quality. Of the study that analysed meat products, 65 per cent of the reported findings showed

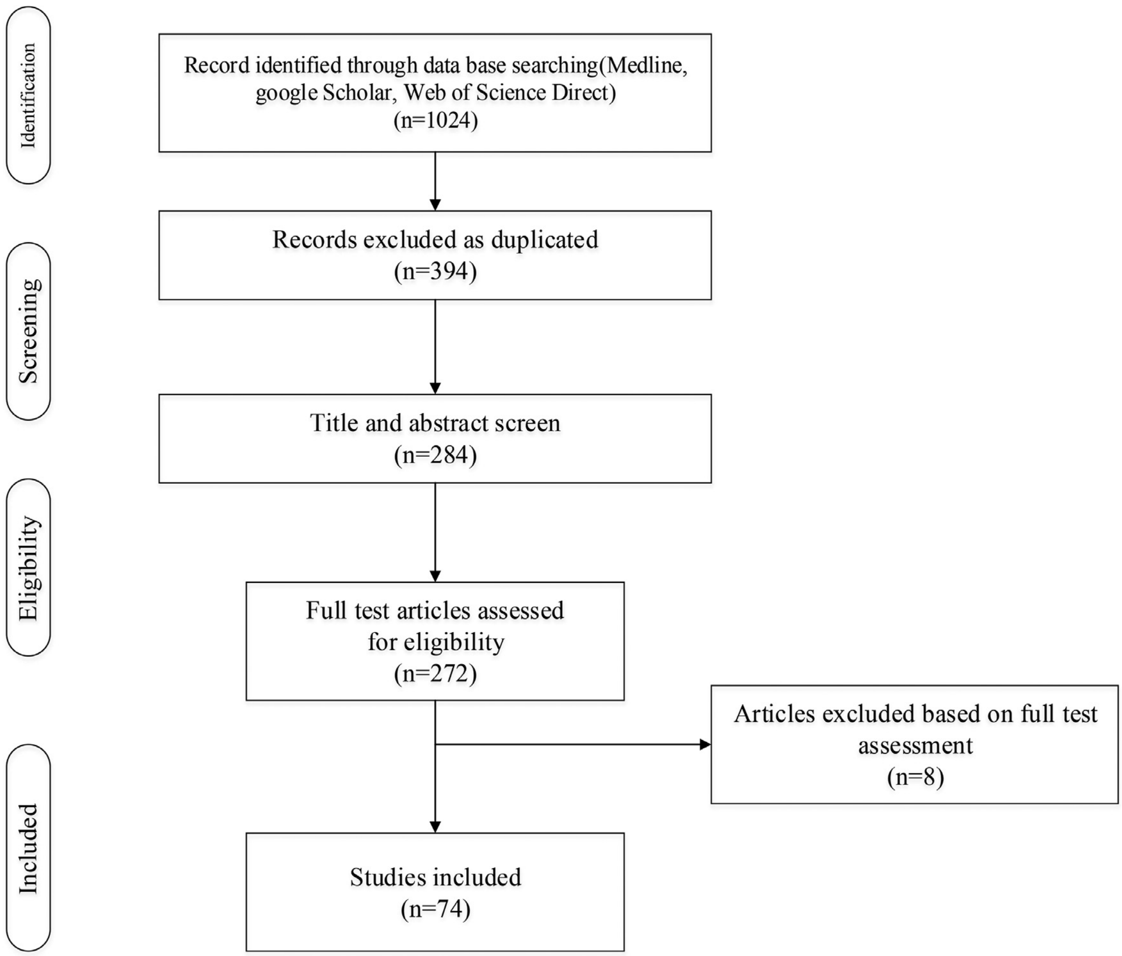

Fig. 1. Flow chart of the studies identification and selection process.

the beneficial effects of meat product extenders; two studies findings which have had both a positive and a negative impact on the customer. According to Bender, (2011) they were favourable, since there was no proof of any meat products impacting on the quality of meat.

2.4.1.2. Meat extenders. Meat extenders are applied to meat products to minimize the cost of processing or to provide other product functions (Mills, 2014). Within this category, certain attributes such as non-meat protein (i.e. soy protein, milk protein, and starch ingredients) and fat replacers, have been found to be the most explicit food literacy attribute, referring to meat proteins used to increase cohesiveness or fat to increase emulsion stability. The use of extender ingredients improves the nutrient profile of the meat; the modification can be advantageous for low levels of protein ingredients such as soy or milk, improving the quality of proteins and also changing the protein (Kyriakopoulou, Dekkers, & van der Goot, 2018). Extenders can be applied to meat products either by direct addition to comminute meat or by injection into the muscle; another technique is by surface application in a marinade and massage method. The function of the meat extenders in the meat products mainly reduces formulation costs, increases water-binding, changes texture, enhances taste, changes appearance, changes cohesiveness, provides heat-set or cold-set gelation and improves nutrient profile. Mechanical action in the form of tumbling, massaging, or mixing is required to facilitate absorption of the extender material into the muscle surface. Extender ingredients added as larger pieces such as grits or textured flakes may be easily noticeable in the finished product (Kyriakopoulou et al., 2018). The extender ingredients typically contain little or no fat. Ability to keep water, taste, texture and visual effects of meat product extenders depend on the types and quantities of carbohydrates and proteins. The carbohydrate and protein ratios differ greatly with the source of plants used. Meat extenders, commonly milled from wheat, contains substantial amounts of starch and protein (gluten) (Ertl, Klocker, Hörtenhuber, Knaus, & Zollitsch, 2015). Ingredients high in protein such as soy protein, wheat gluten, or corn protein are also produced after further processing steps. A meat extender can therefore be generated by combining these different, distilled components with a unique set of properties that suit a particular product. The cost of such a specialized extender would, of course, be greater than that of a mere milled flour (Pearson, 2013). Types of meat extenders and their sources have been shown in Table 2.

Table 2
Types of meat extenders and their source.

Source	Extenders
Proteins	protein fractions of grains, milk, or animal products
Flour	milled whole grain or grain with seed coat or germ removed
Cellulose	long chain complex carbohydrate, dietary fibre
Dextrin	from partial cleavage of starch
Starch	starch granules fractionated from grain or tubers
Hydrocolloids	longer chain, charged side groups, high hydration
Modified starch	starch granules pre-treated to improve functionality

2.4.1.2.1. Fat replacers. Excessive consumption of fat, especially consisting of saturated and hydrogenated fat has been reported to result in adverse effects on health, having been correlated to chronic diseases like obesity, type 2 diabetes, some cancer and cardiovascular disorders. However, presence of fat in food is desirable as it improves the acceptability, palatability, textural properties, emulsion properties, etc (Yashini, Sunil, Sahana, Hemanth, & Chidanand, 2019). Hence, the need to substitute fat, using fat replacers in food. Fat replacers are simply, non-fat substances that serve as fat in a food. It is often used to substitute fat in food products and provide them with some amount of fat content. Fat replacers are used in a number of food items including frozen desserts, processed meats and cheese.

Fat replacers are grouped into fat substitutes and fat mimetics. Fat substitutes are macromolecules that have a structure similar to that of fat. They replace fat on a one-to-one, gram-for-gram basis in food. They are well known as lipid or fat-based fat replacers. They are either chemically synthesized or enzymatically derived from fats and are suitable for cooking and frying. On the other hand, fat mimetics are substances that mimic the function of fats, but cannot replace fat like fat substitutes (Yashini et al., 2019). They are well known as carbohydrates (gums, modified starch, polydextrose, etc.) or protein-based fat replacers. Fat substitutes are ingredients that are close to fats and have similar physiochemic properties and reduce calories to formulate meat and do not change the flavour, juiciness, mouth-filling, viscosity or other organoleptic and processing characteristics. Fat mimetic are substances whose chemical structures are clearly distinct from fat. They are generally based on carbohydrates and proteins (Ahmad, Ahmad, & Hussain, 2018). Fat mimetic are the ingredients most commonly used to produce emulsion-based products with reduced fat. Consumer concerns about elevated levels of fat in processed meat have resulted in enhanced demand for lean meat products. Additional economic pressure has led to the huge demand of low-fat products due to human health concerns (Yashini et al., 2019). These replacers of fat can be based on lipids, proteins or carbohydrates and can be used alone or in distinctive combinations.

2.4.1.2.1.1 Protein-based fat replacer

Proteins consist of amino acids linked by peptide bonds, food rich in protein usually consists of animal protein, and plant protein. Proteins offer health benefits by reducing the risk to chronic diseases to different kinds. The nutritional composition of the food is largely determined by the source protein and excess intake that occurs in the food when carbohydrates and fats are substituted. The functional properties of protein in the food system are solubility, viscosity, water binding, emulsification, gelation, fat and flavour binding, moisturizing and textured properties. Functionality of the proteins is determined by structure, methods of processing, additives and pH (Yashini et al., 2019). Protein-based fat substitution approach has been reported to be effective and is extracted from various sources of protein. When the fat is removed in meat and dairy products, the protein structure of these foods is significantly impaired and the use of protein-based fat replacers not only mimics the properties of fats but also diminishes the negative effects of protein interaction in low fat items. Protein-based fat-replacement agents places a crucial role in water emulsion fat-replacing oil (Baugreet, Kerry, Allen, Gallagher, & Hamill, 2018). The protein-based fat replacers are partially or fully digestible; in addition, the inclusion of protein-based fat replacers increases the protein content of the food. Protein-based fat replacement has some advantages in terms of flavour associations and the amount of fat replacement over carbohydrate-based fat replacement. These include enhancing consistency, nutritional value and functional properties, reducing the cholesterol level, fat content and low-fat calorie density (Öztürk-Kerimoğlu, Kavuşan, Benzer Gürel, Çağındı, & Serdaroğlu, 2021).

2.4.1.2.1.2 Plant- protein-based fat replacer

Most plant proteins are often considered as incomplete protein as they do not always contain all the essential amino acids in required proportions. Food proteins come from sources such as cereals, beans, fruits and vegetables (Kausar et al., 2019). A mixture of high amounts of plant protein, together with lower amounts of animal protein, can serve as a protein-rich human food. Furthermore, plant proteins play an essential role in replacing carbohydrates and fats. Because of the low calorie food properties of fat replacement agents, a link may exist to reduce cardiovascular problems in humans, while scientific findings are inconclusive (Yashini et al., 2019). Because of the increased consumption of non-essential amino acids, plant protein may have the potential to lower risks associated with chronic degenerative diseases. In low-fat foods, plant proteins have the ability to imitate fat properties, and hence are increasingly being used by food producers (Kyriakopoulou et al., 2018).

2.4.1.2.1.3 Animal-protein-based fat replacers

Animal proteins are total protein containing all the essential amino acids obtained from meat, dairy, fish, poultry and eggs. Their superior quality is determined by indices such as the coefficient of digestibility, biological value, and the net use of proteins and the ratio of protein production. Due to its strong functional properties such as emulsion stability, fat and flavour keeping power, foaming activity, animal proteins have the potential to replace fat. (Yashini et al., 2019).

2.4.1.2.2. Binders. Binders are substances applied to foods to thicken or strengthen the texture. Binding agents in meat products may be ingredients of animal or plant origin acting as both water and fat binder. Such substances include isolated soy protein, wheat gluten, carrageenan, gelatin and other ingredients (Kyriakopoulou et al., 2018). The concentration of the binding agents affects the characteristics of the final product, depending on the quantity added, some ingredients may act as binders and extenders, adding binders in meat products, absorbing water, improving product appearance, product quality , product preparation, health consideration and cost (Kyriakopoulou et al., 2018). The purpose of binders is not to add volume to the meat, but rather to improve meat consistency and mouth feeling. Ingredients rich in proteins have the main function of water binding and the development of protein networks, while ingredients with low to no protein levels, such as flours and starches, are typically extenders to fillers, given their water and fat binding properties through physical entanglement (Sha & Xiong, 2020). Because of its cohesive and viscoelastic nature, wheat gluten is considered a promising binder, with binding, dough forming and leavening capabilities, gluten reduces cooking losses during processing, preparation, and improves slicing properties. Due to the absence of its beany taste, soy flours, soy concentrates, and soy isolates are the most preferred. Carrageenan enhances the texture of coarse meat products such as burgers and skinless sausage products, as well as improves the quality of cooked ham slicing and reduces cooking losses (Warner, 2017).

2.4.1.2.3. Spices. Spices are plant products which are primarily used for seasoning, flavouring, and thereby improving food and beverages tastes, besides imparting distinctive flavours, spices contain antioxidant properties and through lipid oxidation inhibit the production of rancid flavours. Spices' antioxidant effects are attributed to presence of flavonoids, terpenoids, lignans and polyphenolide (Ferysiuk & Karolina, 2020). Spices extractives, such as rosemary oleoresin, can inhibit oxidative rancidity. Ginger enhance meat shelf life and black pepper extracts have been reported to be effective in reducing lipid oxidation in meats (Oswell, Thippareddi, & Pegg, 2018). Essential oils derived from spices and herbs are commonly accepted as containing the active antimicrobial compounds. Onion, garlic, cloves, cinnamon, yeast and mold hinders the development of both gram-positive and gram-negative food borne bacteria (Swamy, Akhtar, & Sinniah, 2016). And with their antimicrobial activity the spices can be effectively used as bio preservatives. Adding spices can be expected to help preserve food found in cooling temperatures, the protection of food products and their shelf life depends on the type, quantity and character of the spice added to the meat products (Munekata et al., 2020).

2.4.1.2.4. Vegetable oil. Vegetable oil are essential source of nutrition in the human diet including sunflower seeds, soybeans, palms and walnuts, and are usually used in replacing pork fats in sausages due to their natural antioxidant properties, antithrombotic and prevent low density lipoprotein oxidation (Akbar et al., 2018). Vegetable oil can be used to substitute animal fat, in particular pork fat for halal products. It can be called a meat extender because it substitutes part of the animal tissue fat to make the meat soft and juicy after heat treatment. The vegetable oil is applied to comminuted meat batters in the way as animal fat (Connor & Brien, 2016). The key constituents of oils are fatty acids, known as saturated fatty acids, monosaturated fatty acids and polyunsaturated fatty acids. These components decide the control in the human body at an optimum level of lipids, primarily low density lipid cholesterol (Elisabeta Botez, Oana V. Nistor, Doina G. Andronoiu, 2017). Partial or complete replacement of animal fat by vegetable oils in meat products can be seen as an important nutritional enhancement technique and a way of increasing oxidative stability.

2.4.1.3. Non-meat protein. In comminuted meat products, non-meat proteins are also used as alternative gelling agents to improve yield and texture by reinforcing water-binding properties. The textural properties of food proteins, such as rigidity, cohesiveness and elasticity, can be altered by modifying existing cross-links or adding new cross-links to the protein structure (Santhi, Kalaikannan, & Sureshkumar, 2017). Different non-meat proteins have been studied in the sense of the literature for their effects on textured properties of gels made from individual salt-soluble proteins and complex muscle foods such as frankfurters and bologna. The prospect of changing the functional properties of non-proteins would enhance the qualities of these ingredients used and processed in meat products. There have been a variety of studies on mediated polymerization of food proteins such as milk proteins, soybean proteins, egg proteins, chicken, gelatine and myosin. Subsequently, it has been suggested as a useful method for enhancing the texture and water-protein properties of food proteins (Raharjo & Mada, 2017). Currently, more non-meat protein sources are being explored and the functionality of their protein fractions has been examined. Research is focused on understanding the processes, structure, functional relationship of meat proteins and how they can significantly improve the quality and functionality of meat products or protein-rich food products (Kyriakopoulou et al., 2018). We may say that non-meat protein has higher proteins than meat analogues based on the results of the other studies. Non-meat protein may also have a favourable impact on texture, taste and appearance during processing. Examples of non-meat proteins ingredients includes, soy protein, starch and milk (Rubio, Xiang, & Kaplan, 2020).

2.4.1.3.1. Soy protein. A variety of non-meat ingredients can be used in meat products as extenders, but soy protein products are a good guide for learning about the effects of non-meat extenders on meat products. They are commonly used in many countries around the world, as they form substitutes for meat proteins, even in places where religion and culture prohibits the consumption of meat (Özbaş & Ardiç, 2016). The soy products come in various types and physical shapes and perform different functions. When dehulled soybeans are pressed with a solvent to extract soy oil, soy meal is given. Solvent is used to isolate soy oil. The resultant soy grits can be used or milled directly in soy flour (Mills, 2014). Soy ingredients are the most widely used as meat-extenders in meat products due to their characteristic functional properties, such as water-holding, gelling, fat-absorbing and emulsifying capacities, soymeal is the least processed soy protein commodity. Soya grits or flour contain approximately 45–50 percent protein along with carbohydrate which gives products a distinctive 'beany' taste (Kausar et al., 2019). In addition, soy proteins can have functional properties such as gelling/textural capabilities, fat emulsification, and water binding for a formulation. The preferred ingredients for obtaining the desired texture are heavily chopped meats such as meat patties, sausages, chilies, Salisbury steaks, pizza toppings and meat sauces, textured soy protein concentrate and soy flours. Soy flour is an efficient water holder but has limited protein interactions or fat emulsification due to its high protein content (Mills, 2014).

2.4.1.3.2. Starch ingredients. Specific starch can be used as extenders in meat products, starch is usually less costly than protein ingredients, and low in flavour and colour strength. Natural starches reflect carbohydrates that are found in cereal grains and tubers (Carvalho et al., 2017). They consist of two chain types of glucose, amylose, and amylopectin. The glucose chains within seeds (grains) or roots are packed into starch granules. In cold water, Starch granules are insoluble; the granules immediately swell and hydrate, and in a gelatinisation cycle, slowly create a viscous solution (Yang, Chaib, Gu, & Hemar, 2017). This process is called retrogradation, and accounts for the high water-holding capacity, decreased viscosity, and starch gelling. The process also contributes to water release and product quality loss; when unmodified starch is used in meat products it is likely to retrograde during prolonged refrigerated storage. It must therefore be emphasized that retrogradation of the starch is increased by freezing and thawing (Yang et al., 2017). Native starches are classified with cereal starches (corn, wheat, rice, and sorghum) on the basis of their properties (viscous, watery, or stringy paste and strong or weak, clear or opaque gel on cooling), as they set a strong opaque gel on cooling. Root and tuber starches (potato, cassava, and tapioca) are highly viscous and on refrigeration set to a clear, weak gel. Waxy starches (maize waxy, sorghum, rice) produce very high viscosity but do not form a rigid gel (Mbougueng, Tenin, Tchiégang, & Scher, 2015). Modified starches are used for increase meat products, cook yield, minimize purge of fluid, increase product firmness and increase slice ability. Due to the reduction in free water, overall product firmness can be increased. Certain starches can be used as fat replacers along with added water. However, starches usually do not work well with meat proteins so that they can be used to reduce rubbery character in very low-fat products (Mills, 2014). The increased fluid viscosity that the starch creates is said to lead to an oily texture during chewing, this property is a valuable replacement for fat.

2.4.1.3.3. Milk protein. Milk protein is relatively expensive, but meat processors prefer it because of its unique ability to bind with meat protein to form heat-set gels and contribute to stable emulsions (Regan, Ennis, & Mulvihill, 2014). Milk protein solids are produced from the condensed milk by extracting and drying fat. It contains about 36 percent protein including casein and lactalbumin, among others. Milk protein solids are used in meat products to enhance water keeping and reduce cook loss, thus leading to improved emulsion stability in finely comminuted products (Regan et al., 2014). For this reason, the so-called calcium-reduced milk protein is preferred for use in meat products even though it costs more. The high lactose content of milk protein contributes to the taste and texture of the finished product and may be considered undesirable in some products (Yashini et al., 2015). Milk proteins are still found widely in meat products, water-binding and viscosity, emulsification, adhesion, gelation, and organoleptic characteristics are essential functional properties of milk proteins in meat applications. In addition to the sensory properties, the milk proteins also enhance the nutritional value of the final product by means of the amino acid profile (Balestra & Petracci, 2018).

2.4.2. Qualitative studies

Some qualitative studies addressed the perceived benefits of meat products for the meat industry. Meat products can be a very interesting food carrier due to the need for developing healthier formulations such as reduced fat and fibre increasing processed meats. Some extenders could be considered as non-meat ingredients, and if well selected and properly added, based on bioactive, functional, and technological properties, they can improve the nutritional status of consumers that intake meat products in their diets (Câmara, Paglarini, Vidal, dos Santos, & Pollonio, 2020). A lot of studies report adding protein, flour, cellulose, dextrin, starch, hydrocolloids and modified starch among others as promising fat substitutes with good stability and sensorial acceptance bringing an excellent strategy for the meat industry. Besides, one of the most criticism to meat products intake expressed by the absence of extenders in their composition could be solved after reformulation by increasing of these compounds (Ahmad et al., 2018). Also, many vegetable foods that have been reported to replace raw meat in plant-based formulations are non-meat ingredients highlighting a great potential to enhance the diet of a lot of consumers that desire the sensorial experience of meat products, but do not want to eat meat (Kausar et al., 2019).

2.4.2.1. Strengths and limitations of this scoping review. A positive point of this analysis is that it has a wide reach and aims to how non-meat ingredients are used in meat products, and what benefits they offer to humans. Throughout the whole cycle this scoping analysis used comprehensive and straightforward approaches. The search strategy included electronic bibliographic databases, the reference list of various journals, internet search engines, websites of related organizations and the other techniques to ensure a large search of the literature. A high point is the search and inclusion process, which involved the implementation of a search plan in collaboration with a librarian and literature review expert and providing reviewers for a proportion of the whole source texts. Based on the geographical reach of the included studies, it is important to note the presence of academic literature in the English language on the role of meat products. The present analysis likely has some limitations. In addition, the variety of data collection and analysis methods used in the studies under examination makes them difficult to compare and makes interpretation of the mixed results difficult. Another difficulty is to specifically identify the difference between certain extenders and compound binders aiming for proper labelling. Lastly, the application of extenders in meat products must take into account the nutritional density represented by the minimum amount to be applied for health benefits, physical-chemical stability and protection along with shelf life, sensory impacts, and cost increases resulting from this related formulation. Despite these obstacles, as the expanded meat products enter the food market, both the meat industry and the consumers would have great benefits. The interpretation of Arksey and O'Malley for scope reviews was adopted at the start of the study and was generally useful in guiding study selection. Due to the large number of appropriate references, the characterisation of the included reviews was based only on the available abstracts. Data characterisation is done using full-text documents with several scoping comments (Arksey & O'Malley, 2005). During study selection, however, some challenges were encountered with reviews which also documented processes or meanings more commonly associated with narrative, rapid, or systematic reviews. Determination as to whether comments matched the study concept of scoping analysis on meat products and extenders was based on opinions from the reviewers. On another note, the characterisation and analysis of the comments included were often subject to prejudice from the reviewers. A popular critique of the method is the lack of objective evaluation of the studies used in a scoping analysis (Levac et al., 2010). Arksey & Malley, (2005) agree that the detection of research gaps through a scoping analysis may be constrained, because the approach does not allow for the gaps arising from bad research. Advocate for an inclusive research quality evaluation using validated instruments as an additional aspect of the scoping analysis process. However (Pham, Greig, Sargeant, & Mcewen, 2015), argues that scope reviews should include all potentially applicable research, irrespective of methodological vigour, in order to provide the most detailed view of what occurs.

3. Discussion

Advancements in the production of non-ingredient meat and meat products processing and highlighted that the innovations are progressing at a growing rate. Driven by the demand for new products with new formulations, the meat industry is forced to build versatile production lines which can produce large quantities of meat products of high quality. However, there is somewhat lack of a strong scientific basis that ties newer ingredient systems to modern process operations. Analysis of the literature shows that new formulations and ingredients are frequently produced without consideration of a method and vice versa, production lines that cannot cope with potential changes in formulations with the product can be created. Ultimately, meat industry and meat scientists would need to work together more closely to close the knowledge base gap. Meat scientists play an important part in this process. They are exceptional in their ability to bridge the gaps between the various disciplines and thus help the meat manufacturing sector prosper. Extraction of data was confined to studies published in English only. This scoping review used the traditional methods of systematic review to classify, pick and synthesize findings from seventy-three studies that documented the beneficial effects of non-meat ingredients in meat products. Below we included valuable information about the results and the difference that arose from this analysis that could be applicable to the meat industry, to scholars and consumers. The findings included qualitative and quantitative studies that provided strong evidence of the addition of non-meat ingredients in meat products, nutritional results, extension use extenders, evidence of fat replacers or substitute in meat foods. Results of comparative studies indicate a wide range of possible advantages and nutritional benefits of meat products, and they must be supplied in an appropriate quantity or consistency. The introduction of non-meat ingredients in meat products can be very necessary in foods such as reduced fat and fibre growing processed meats due to the need to create healthier formulation. Some food additives or compounds could be called non-meat ingredients, and if well-chosen and properly added, based on bioactive, functional, and technical properties, they can improve the nutritional status of consumers who take meat products into their diets. In addition, by increasing these compounds, one of the most important intake of meat products represented by the absence of extenders in their composition could be solved after reformulation. Vegetables recorded to replace raw meat in plant formulations are a good source that highlights the great potential of many consumers who want to change their diets with the sensory experience of meat products. There are, however, many barriers to overcome before non-meat ingredients can be added to meat products in terms of qualitative and quantitative quantities to create successful and safer claims. The use of non-meat ingredients in meat products should be considered for the inclusion of the nutritional density specified by the minimum norm for health benefits, physical, chemical stability and protection along with shelf life, sensory impacts and cost increase resulting from this particular formulation. Given these challenges, when meat products containing non-meat ingredients reach the market, there would be great benefits for both the meat industry and the consumers. Extenders used in a particular meat product are chosen on the basis of their different functional properties, product quality, cost, taste improvement, appearance, improvement of slice capability for lunch meats, reduced cooking loss or fluid purge, modification of heat-set or cold-set gelation, fat emulsification or simply improvement of the flow capability or mixing capability of a seasoning mixture (Balestra & Petracci, 2018). Protein-based extender such as soy or milk proteins can interact with meat proteins to increase cohesiveness or fat to increase emulsion stability, starch-based extender such as corn or potato starch can increase water retention capability, but may interfere with intestinal protein interactions, thus weakening the protein matrix within the product. Extenders can be added to meat products by direct addition to comminuted meat or by injection into a compression device for intact muscle (Kyriakopoulou et al., 2018). Addition of extender ingredients improves the nutritional profile of the meat product, the adjustment can be beneficial with low consumption levels of protein ingredients such as soy or milk increasing the protein content and also adjusting the amino acid composition to boost biological value, variety of non-meat ingredients can be used as extender in meat products (Vatansever, Tulbek, & Riaz, 2020). Sources may include plant seeds, tubers, milk solids, or fermentation processes among others, in spite of their varied origins, the functional properties of most extenders are provided by their protein and carbohydrate components. The list of ingredients probe as meat extenders or substitutes includes cereal grains soy protein, milk proteins, starch, flour, gums and hydrocolloids and insulin.

3.2. Conclusion

In conclusion the addition of non-meat ingredients as an excellent source of high-quality proteins can be used as meat substitutes or protein expanders in meat products. To satisfy the requirements of customers and suppliers, the percentage of replacement must be examined with due consideration for research effects at the technical, nutritional and sensory levels for each specific combination of replacer and meat product. Non-meat ingredient are mainly protein-based ingredients and their inclusion in meat products offer several benefits such as, enhancing flavour, improving and stabilizing colour, increasing shelf-life, and water-holding capacity among others. They affect varying sensory qualities of processed meat products such as texture, juiciness and colour; the overall acceptance of the non-meat ingredients added to meat products has increased positively. The findings of this study suggest the possible use of fat replacement agents in comminuted meat products to enhance or change the functional and textural properties of certain food proteins. Therefore, the use of non-meat ingredients creates new possibilities to increase the shelf life and variety of functional properties in meat systems or manufacturing.

Authors' Contributions

Patrick Owusu-Ansah: Methodology, writing – original draft. Esther Kwarteng Besiwah: Methodology, writing – original draft. Francis Kweku Amagloh: Validation, Conceptualization, Methodology. Ernest Bonah: Methodology, writing – review and editing.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Abdallah, Y., & Adam, Y. (2016). Sudan University of Science and Technology College of Graduate Studies Nutritional Value and Microbiological Quality of (Agashi) ڈ ٹ چ ڤ ڈ ڈ ميظعلا هللا قدصـ ةيلآا ةعقاولا ةروسـ).

Ahmad, S., Ahmad, R. S., & Hussain, M. B. (2018). Nutritional Composition of Meat Rabia. In M. S. Arshad (Ed.), *Meat Science and Nutrition* (pp. 1–18). Croatia: intec open. 10.5772/intechopen.77045.

Akbar, A., Imran, A., Anil Kumar, A., Anand, M., Arome Ataguba, G., Banavara, D., & Datta, A (2018). *By-Products and their Utilization*. John Wiley & Sons Ltd All A.K. Anal. 10.1002/9781118432921.

Arksey, H., & Malley, L. O. (2005). Scoping studies: Towards a methodological framework. *Social Research Methodology*, 19–32.

Asgar, M. A., Fazilah, A., Huda, N., Bhat, R., & Karim, A. A. (2010). Nonmeat protein alternatives as meat extenders and meat analogs. *Comprehensive Reviews in Food Science and Food Safety, 9*(5), 513–529. 10.1111/j.1541-4337.2010.00124.x.

Balestra, F., & Petracci, M. (2018). Technofunctional ingredients for meat products: Current challenges. Sustainable Meat Production and Processing. Elsevier Inc. 10.1016/B978-0-12-814874-7.00003-1.

Barbut, S. (2015). *The Science of poultry and meat processing*. New York: A. Gordon C. E. J. Briskey, Ed..

Baugreet, S., Kerry, J. P., Allen, P., Gallagher, E., & Hamill, R. M. (2018). Physicochemical characteristics of protein-enriched restructured beef steaks with phosphates, transglutaminase, and elasticised package forming. *Journal of Food Quality 2018*. 10.1155/2018/4737602.

Bender, A. (2011). *Meat and meat products in human nutrition in developing countries* (4th editio). Pearson and Dutson A. B, Ed.. 10.13331/j.1541-4337.2010.00126.

Câmara, A. K. F. I., Paglarini, C., de, S., Vidal, V. A. S., dos Santos, M., & Pollonio, M. A. R. (2020). Meat products as prebiotic food carrier. *Advances in Food and Nutrition Research, 94*, 223–265. 10.1016/bs.afnr.2020.06.009.

Carvalho, G. R. De, Maira, T., Milani, G., Righetti, N., Trinca, R., Nagai, L. Y., & Carla, A (2017). Textured soy protein , collagen and maltodextrin as extenders to improve the physicochemical and sensory properties of beef burger. *Food Science and Technology, 37*(1), 10–16.

Connor, T. P. O., & Brien, N. M. O. (2016). Fat Replacers. *Meat Science, 12*(3), 1–5. 10.1016/B978-0-08-100596-5.00648-X.

Botez, Elisabeta, Nistor, Oana V., Andronoiu, Doina G., G, D. M., & I, O. G (2017). Meat Product Reformulation: Nutritional Benefits and Effects on Human Health Elisabeta. *Functional Food - Improve Health through Adequate Food Fund, 12*(14), 7–19.

Ertl, P., Klocker, H., Hörtenhuber, S., Knaus, W., & Zollitsch, W. (2015). The net contribution of dairy production to human food supply: The case of austrian dairy farms. *Agricultural Systems, 137*, 119–125. 10.1016/j.agsy.2015.04.004.

Ferysiuk, K., & Karolina, M. W. (2020). Reduction of Nitrite in Meat Products Through the Application of Various Plant-Based Ingredients.

Gagaoua, M., & Boudechicha, H. (2018). Ethnic meat products of the North-African and Mediterranean countries: an overview. *Journal of Ethnic Foods*. 10.1016/j.jef.2018.02.004.

Inguglia, E. S., Zhang, Z., Tiwari, B. K., Kerry, J. P., & Burgess, C. M. (2017). Salt reduction strategies in processed meat products – A review. *Trends in Food Science and Technology, 59*, 70–78. 10.1016/j.tifs.2016.10.016.

Kausar, T., Hanan, E., Ayob, O., Praween, B., & Azad, Z. (2019). A review on functional ingredients in red meat products. *Bioinformation, 15*(5), 358–363. 10.6026/97320630015358.

Kyriakopoulou, K., Dekkers, B., & van der Goot, A. J. (2018). Plant-based meat analogues. Sustainable Meat Production and Processing. Elsevier Inc. 10.1016/B978-0-12-814874-7.00006-7.

Levac, D., Colquhoun, H., & Brien, K. K. O. (2010). Scoping Studies : Advancing the Methodology Scoping studies : advancing the methodology. *Implementation Science*, 1–10 March 2015. 10.1186/1748-5908-5-69.

Mbougueng, P. D., Tenin, D., Tchiégang, C., & Scher, J. (2015). Effect of Starch Type on the Physicochemical and Textural Properties of Beef Patties Formulated with Local Spices. *Food Science and Technology, 3*(2), 33–39. 10.12691/ajfst-3-2-2.

Melgar-Lalanne, G., Hernández-Álvarez, A. J., & Salinas-Castro, A. (2019). Edible Insects Processing: Traditional and Innovative Technologies. *Comprehensive Reviews in Food Science and Food Safety, 18*, 1166–1191. 10.1111/1541-4337.12463.

Mills, E. (2014). meat extenders. *Meat Science, 1*, 1–6. 10.1016/B978-0-12-384731-7.00108-2.

Mullen, A. M., Álvarez, C., Zeugolis, D. I., Henchion, M., O'Neill, E., & Drummond, L. (2017). Alternative uses for co-products: Harnessing the potential of valuable compounds from meat processing chains. *Meat Science, 132*, 90–98. 10.1016/j.meatsci.2017.04.243.

Munekata, P. E. S., Rocchetti, G., Pateiro, M., Lucini, L., Domínguez, R., & Lorenzo, J. M. (2020). Addition of plant extracts to meat and meat products to extend shelf-life and health-promoting attributes: an overview. *Current Opinion in Food Science, 31*, 81–87. 10.1016/j.cofs.2020.03.003.

Oswell, N. J., Thippareddi, H., & Pegg, R. B. (2018). Practical use of natural antioxidants in meat products in the U.S.: A review. *Meat Science, 145*, 469–479. 10.1016/j.meatsci.2018.07.020.

Özbaş, Ö. Ö., & Ardiç, M. (2016). Dietary Fibers as Functional Ingredients in Meat Products. *Harran Üniv Vet Fak Derg, 5*(2), 184–189. Retrieved from http://dergipark.gov.tr/download/article-file/308568.

Öztürk-Kerimoğlu, B., Kavuşan, H. S., Benzer Gürel, D., Çağındı, Ö., & Serdaroğlu, M. (2021). Cold-set or hot-set emulsion gels consisted of a healthy oil blend to replace beef fat in heat-treated fermented sausages. *Meat Science, 176* February. 10.1016/j.meatsci.2021.108461.

Pearson, A. M. (2013). Extenders and Substitutes. *Biological Science, 26*(4), 249–256.

Pham, M. T., Greig, J. D., Sargeant, J. M., & Mcewen, S. A. (2015). A scoping review of scoping reviews : advancing the approach and enhancing the consistency. *Research Synthesis Methods*, 1–15 January 2014. 10.1002/jrsm.1123.

Piñon, M. I., Alarcon-rojo, A. D., Renteria, A. L., & Carrillo-lopez, L. M. (2018). Microbiological properties of poultry breast meat treated with high- intensity ultrasound, 1–6. https://doi.org/10.1016/j.ultras.2018.01.001

Raharjo, S., & Mada, U. G. (2017). Meat Products. *Meat Science* October. 10.1002/0471238961.1305012019030813.a01.pub2.

Ramalingam, V., Song, Z., & Hwang, I. (2019). The potential role of secondary metabolites in modulating the flavor and taste of the meat. *Food Research International, 122*, 174–182 November 2018. 10.1016/j.foodres.2019.04.007.

Regan, J. O., Ennis, M. P., & Mulvihill, D. M. (2014). Milk proteins. Handbook of hydrocolloids. Woodhead Publishing Limited. 10.1533/9781845695873.298.

Rubio, N. R., Xiang, N., & Kaplan, D. L. (2020). Plant-based and cell-based approaches to meat production. *Nature Communications, 11*(1), 1–11. 10.1038/s41467-020-20061-y.

Santhi, D., Kalaikannan, A., & Sureshkumar, S. (2017). Factors influencing meat emulsion properties and product texture: A review. *Critical Reviews in Food Science and Nutrition, 57*(10), 2021–2027. 10.1080/10408398.2013.858027.

Sebranek, J. G. (2015). An Overview of Functional Non-Meat Ingredients in Meat Processing. *The Current Toolbox An Overview of Functional Non-Meat Ingredients in Meat Processing : The Current Toolbox, 6* 5 of 6.

Sha, L., & Xiong, Y. L. (2020). Plant protein-based alternatives of reconstructed meat: Science, technology, and challenges. *Trends in Food Science and Technology, 102*(May), 51–61. 10.1016/j.tifs.2020.05.022.

Sivaramalingam, B., Young, I., Pham, M. T., Waddell, L., Greig, J., Mascarenhas, M., & Papadopoulos, A. (2015). Scoping review of research on the effectiveness of food-safety education interventions directed at consumers. *Foodborne Pathogens and Disease, 12*(7), 561–570. 10.1089/fpd.2014.1927.

Swamy, M. K., Akhtar, M. S., & Sinniah, U. R. (2016). Antimicrobial properties of plant essential oils against human pathogens and their mode of action: An updated review. Evidence-Based Complementary and Alternative Medicine, 2016. 10.1155/2016/3012462.

Vatansever, S., Tulbek, M. C., & Riaz, M. N. (2020). Low- and High-Moisture Extrusion of Pulse Proteins as Plant-Based Meat Ingredients : A Review, 65(4).

Verbeke, W., Pérez-Cueto, F. J. A., Barcellos, M. D. D., Krystallis, A., & Grunert, K. G. (2010). European citizen and consumer attitudes and preferences regarding beef and pork. *Meat Science, 84*(2), 284–292. 10.1016/j.meatsci.2009.05.001.

Warner, R. D. (2017). *The Eating Quality of Meat — IV Water-Holding Capacity and Juiciness*. https://doi.org/10.1016/B978-0-08-100694-8.00014-5

Yang, Z., Chaib, S., Gu, Q., & Hemar, Y. (2017). Impact of pressure on physicochemical properties of starch dispersions. *Food Hydrocolloids, 68*, 164–177. 10.1016/j.foodhyd.2016.08.032.

Yashini, M., Sunil, C. K., Sahana, S., Hemanth, S. D., & Chidanand, D. V. (2019). Protein-based Fat Replacers – A Review of Recent Advances Protein-based Fat Replacers – A Review of Recent Advances. *Food Reviews International*, 1–27. 10.1080/87559129.2019.1701007.