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Reviewing on Nanotechnology for Creating Antimicrobial for Chicken Feed: Max-Min Optimization Approach

A. H. Niknamfar [1*], H. Esmaeili [2]

[1]Department of Young Researchers and Elite Club, Qazvin Branch, Islamic Azad University, Qazvin, Iran.

[2]Department of Business Management, Qazvin Branch, Islamic Azad University, Qazvin, Iran.

A B S T R A C T

Nanotechnology deals with studies of phenomena and manipulation on elements of matter at the atomic, molecular and macromolecular level (rangefrom1to100nm), where the properties of matter are significantly different from properties at larger scales of dimensions. Nanotechnology is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nm where nano denotes the scale range of 10-9 and nanotechnology refers the properties of atoms and molecules measuring thoroughly 0.1 to 1000 nm. Nanotechnology is highly interdisciplinary as a field, and it requires knowledge drawn from a variety of scientific and engineering arenas. There are two main types of approaches to nanotechnology: the first approach is Top-down and another one is Bottom-up approach. The Top-down approach involves taking layer structures that are either reduced down size until they reach the nano-scale or deacon structured into their composite parts. This paper aims to deal with Top-down approach in order to utilize Biopolymer nanoparticles for Creating Antimicrobial for chicken feed so that the live average time of chicken will be increased noticeably by using max-min optimization approach. Finally, the applicability of the proposed approach and the solution methodologies are demonstrated in three steps.

Keywords: Nanotechnology, live average time, max-min approach, optimization.

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1. Introduction

Nanotechnologies hold great potential for creating new materials with enhanced properties. A number of nanotechnology-powered products are finding applications in industries, such as medical devices, imaging, sports and so on. In the future, the global economy will be increasingly influenced by nanotechnologies as more products containing Nanotechnology move from research and development into production and commerce.

Nanotechnology ("nanotech") is manipulation of matter on an atomic, molecular, and supra-molecular scale. The earliest, widespread description of nanotechnology referred to the particular

* Corresponding author

E-mail address: niknamfar@yahoo.com

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technological goal of precisely manipulating atoms and molecules for fabrication of macroscale products, also now referred to as molecular nanotechnology. A more generalized description of nanotechnology was subsequently established by the National Nanotechnology Initiative, which defines nanotechnology as the manipulation of matter with at least one dimension sized from 1 to 100 nanometers. This definition reflects the fact that quantum mechanical effects are important at this quantum-realm scale, and so the definition shifted from a particular technological goal to a research category inclusive of all types of research and technologies that deal with special properties of matter, which occurs below the given size threshold. It is therefore common to see the plural form "nanotechnologies" as well as "nanoscale technologies" to refer to the broad range of research and applications whose common trait is size. The Top-down approach involves taking layer structures that are either reduced down size until they reach the nano-scale or deacon structured into their composite parts. On the other hand, the Bottom-up approach is where materials are constructed from the atomic or molecular components. Designing at the nanoscale is working in a world where physics, chemistry, electrical engineering, mechanical engineering, and even biology become unified into an integrated field. “Building blocks” for nanomaterials include carbon-based components and organics, semiconductors, metals, and metal oxides; nanomaterials are the infrastructure, or building blocks, for nanotechnology. The last decade has seen advancement in every side of nanotechnology, such as nanoparticles and powders; nanolayers and coats; electrical, optic, and mechanical nanodevices, and nanostructure biological materials. Presently, nanotechnology is estimated to be influential in the next 20-30 years, in all fields of science and technology.

Both nanoscience and nanotechnology are the most important studies in the 21st century. Nanotechnology is a technology that can bring the precision up to nanometer-level or a predetermine dimension in size to nano-scale. Several works including the atomic and molecular structure, the nature of matter as well as their interactions and movements at nano-scale uses there features that high-tech for the service of humanity. Nano-technology has made a great influence for manufacturing industry and brought huge effects on the manufacturing methods, process‹ and so on. In the nanotechnology manufacturing that is fused nanotechlogoy with manufacturing technology, the ultimate goal is to manufacture products with specific function at nano-scale using atoms and molecules technology manufacturing, which is focused on nano-technology with manufacturing technology. Its ultimate goal is to manufacture products with specific function at nano-scale using atom and molecules as raw materials and its scope of application would be very expensive, including nano-materials technology, nano-processing technology, nano-assembly technologies‹ nano-materials, nano-assembly technologies, nano-measurement technologies‹ nano-machines and so on.

Nano-technologies used in testing can open up nano-scale and atomic- scale features of ultra – precise surface. The new information, new features and new knowledge previously unknown would be discovered. Nanotechnology used in micro-machines and atomic operations can enhance the development of the integrated chip and “molecular devices” production technology.

Nanotechnology used in arrangement of atom based on requirement can produce high density disk storage, which is one hundred million times higher than the going sub-nanometer CNC molecular " processing machine tools" that could carry out the assemblage operation of atoms and molecules.

1.1. The Importance of Nanomaterials

These materials have created a high interest in recent years by virtue of their unusual mechanical, electrical, optical and magnetic properties. Some examples are given as follows:

Nanophase ceramics are of particular interest because they are more ductile at elevated temperatures as compared to the coarse-grained ceramics. Nanostructured semiconductors are known to show various non-linear optical properties. Semiconductor Q-particles also show quantum confinement effects, which may lead to special properties, like the luminescence in silicon powders and silicon germanium quantum dots as infrared optoelectronic devices. Nanostructured semiconductors are used as window layers in solar cells. Nanosized metallic powders have been used for the production of gas tight materials, dense parts and porous coatings. Cold welding properties combined with the ductility make them suitable for metal-metal bonding especially in the electronic industry.

More than 200 million broilers and layers are raised in the Palmetto State. The industry has moved toward bigger broiler farms with flocks of between 150,000 and 300,000 birds becoming common. Chickens are susceptible to disease. An illness can spread throughout facility housing. Vaccines and medications can be effective but pose risks to growers and consumers. Each flock has particular health and immunity profiles, so chicks from different breeders do not respond to vaccines and diseases. Moreover, bacteria can build up "antibiotic resistance" making the drugs less effective. For consumers, poultry can harbor bacteria, viruses and fungi that do not affect them but do cause human illnesses, especially when poultry is undercooked or mishandled during food preparation. Researchers are looking for drug-free alternatives. Clemson scientists have made a promising discovery using nanotechnology. Nanotechnology is tiny science — working with materials 1/100,000th the size of a human hair. Scientists are seeking to shrink materials down to the scale of atoms, creating particles that show promise for making better medicines, faster computers and safer foods. Jeremy Tzeng and Clemson colleagues [1-3] have built nanoparticles that mimicked the host cell surface in poultry and locked the targeted pathogens. The particles then bind together and they are purged through the bowel. Tzeng et al. [4] (Nanotechnology chicken feed) calls it "intelligent chicken feed." If we use this physical purging, physical removal, we will not use antibiotics so the chance of the microorganism becoming resistant to it is really small [4]. To protect the discovery, Clemson technology transfer officials are patenting it. Tzeng et al. [4] says that it will take more research and will test before the nanoparticle is ready to be used, but in the not-so-distant future, chickens and humans may live better lives due to intelligent chicken feed.

With consumers demanding higher quality meat products at affordable prices and growing competition, the meat production sector has witnessed an exceptional change not only in the ingredients, but also in the processing system [5]. The demand for sustainable production of meat products and emphasis on human health and wellness has further led to the growth of innovation in meat product industry [6]. Thus, expectations have risen regarding the use of ingredients and additives with improved functionality to enhance the quality and image of muscle foods [7]. Some of the most commonly used additives in meat and poultry are antioxidants (e.g., butylated hydroxytoluene [BHT], butylated hydroxyanisole [BHA] and tocopherols), binders (e.g., carrageenan, sodium caseinate), thickeners (e.g., gelatin), humectants (e.g., sodium salt, glycerine), curing agents (sodium erythorbate, sodium nitrite and nitrate), flavor enhancers (e.g., monosodium glutamate), tenderizing enzymes (bromelin, ficin and papain) and sweeteners (e.g., corn syrup) [8]. Although they are still widely used, growing health concerns has caused a shift in the focus towards the development of novel meat products with reduced amounts of saturated fat, sodium salts, color fixatives (e.g., nitrites), and cholesterols, along with increased use of ingredients which have positive effects on health. It is also expected that novel products developed with new ingredients and processing systems should possess similar gustatory, visual and aromatic effects as traditional meat products [9].

Hence, bioactive materials providing health benefits are increasingly added to food in order to treat or prevent diseases (IFIC [10]). However, there are impediments in production, storage, and distribution of food with incorporated bioactive components. Owing to the range of traditional meat products, the impediments are likely far bigger in the meat industry. A significant challenge is the low bioavailability of bioactive components when included in meat products, mainly due to relatively elevated levels of proteins, fats, and minerals. Consequently, modifications have been generated to the formulations of meat products, but these have often led to unfavorable effects, such as poor organoleptic quality, lowered capacity to retain water and poor resistance to the growth of microbes [11]. Therefore, the meat industry needs to implement and support an innovation agenda to address such challenges and ultimately improve the quality experienced by consumers [12]. Thus, nanotechnology is such process-based innovation that could have a significant impact on the food industry [13].

Nanotechnology can be referred to as an area of science and technology focused on the manufacture of nano-sized materials (less than 100 nm in diameter at least one dimension) that possess unique and novel properties, although a globally accepted definitions have not been made [14]. It also refers to the production, characterization, and manipulation of such materials [15]. The major differences between nanomaterials and bulk materials are the changes in physicochemical (e.g., porosity), optical, mechanical and catalytic properties. Other differences are also observed in strength, absorption, function, weight, and stabilization of materials [16]. All of these properties make very promising the nanotechnology, and have led to the development of many innovations in the area of food packaging [17-18]. However, when this generic technology is applied to food, the changed properties of the nanomaterials may also affect the behavior and properties of food [19]. Nonetheless, decreased use of certain food ingredients due to the improved bioavailability of functional compounds can be achieved through the use of nanomaterials [20]. Thus, it is also likely that the amounts of salt, sugar and preservatives can be reduced through the use of nanomaterials, while improving color, flavor and texture and thereby enhancing the sensory acceptance. Furthermore, the delivery and absorption of active ingredients and nutrients can be significantly improved [21]. Other benefits include targeted delivery, enhanced stability, and absorption of bioactive compounds, along with improved antimicrobial effects against pathogens in food that may be resistant to chemical antimicrobials [22].

Nanotechnology is projected to impact the food industry mainly through the creation of nano-sized materials with novel properties, the development of novel processing methods, products and improvements in food safety and biosecurity as shown in Figure 1 [23]. Strategies for the application of nanomaterials in food may be different from those employed in traditional nanotechnology [24]. Nevertheless, due to the novel properties exhibited by nanomaterials, significant beneficial changes are expected to be made in the production, packaging and distribution of many food products, including meat products [25-27]. On the other hand, this novel technology may also have the potential to cause risks to human health and the environment due to the same properties, which offered its benefits [28-29]. The perception of such risks and benefits may influence the acceptance of consumers for using this technology [30]. This review focuses on the types of nanomaterials, delivery systems and the risks associated with nanomaterials in areas of meat processing and packaging.

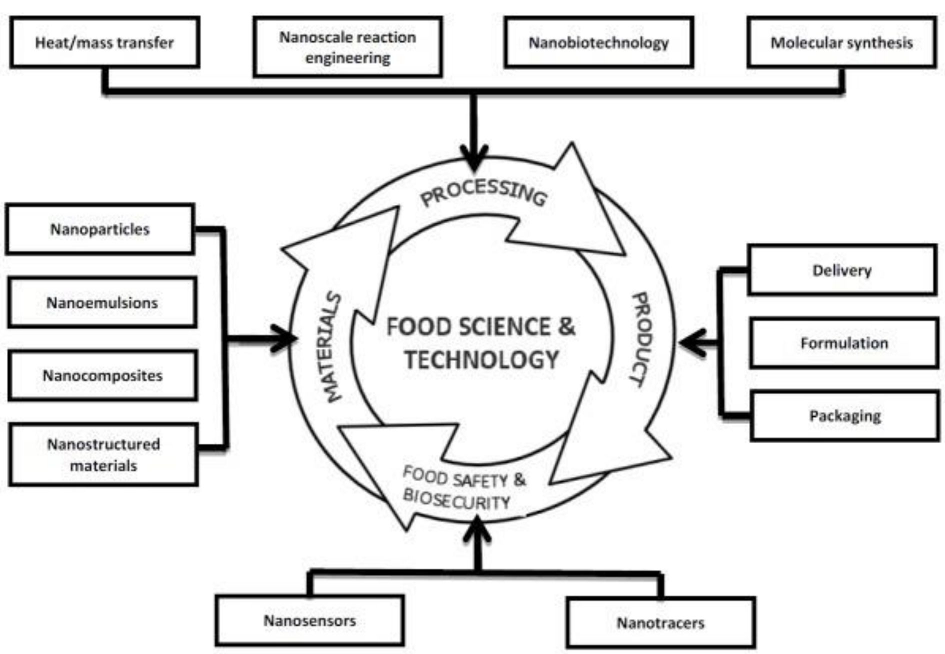

Figure 1. Application matrix of nanotechnology in food science and technology (adapted from [30]).

1.2. Chicken Feed

Chicken feed is food for farm poultry, including chickens, ducks, geese, and other domestic birds.

Before the twentieth century, poultry were mostly kept on general farms, and foraged for much of their feed, eating insects, grain spilled by cattle and horses, and plants around the farm. Grain, household scraps, calcium supplements, such as oyster shell, and garden waste often supplemented this.

As farming became more specialized, many farms kept too large flocks to be fed in this way, and nutritionally completed poultry feed were developed. Modern feeds for poultry consist of largely of grain, protein supplements, such as soybean oil meal, mineral supplements, and vitamin supplements. The quantity of feed, and nutritional requirements of the feed depend on weight and age of the poultry, rate of growth, rate of egg production, the weather (cold or wet weather causes higher energy expenditure), and the amount of nutrition the poultry obtain from foraging. This, results in a wide variety of feed formulations. The substitution of less expensive local ingredients introduces additional variations.

Healthy poultry needs a sufficient amount of protein and carbohydrate, along with necessary vitamins, dietary minerals, and an adequate supply of water. Lactose-fermentation of feed can aid in supplying vitamins and minerals to poultry. Egg laying hens require 4 grams per day of calcium 2 grams are used in the egg. Oyster shells are often used as a source of dietary calcium. Certain diets also require the use of *grit*, tiny rocks such as pieces of granite in the feed. Grit aids in digestion by grinding food as it passes through the gizzard. Grit is not needed if commercial feed is used.

The feed must remain clean and dry; contaminated feed can infect poultry. Damp feed encourages fungal growth. Mycotoxin poisoning is one of the most common and certainly most under-reported causes of toxicoses in poultry. Diseases can be avoided with proper maintenance of feed and feeder. A feeder is the device that supplies the feed to the poultry. For privately raised chickens, or chickens as pets, feed can be delivered through jar, trough, or tube feeders. The use of poultry feed can also be supplemented with food found through foraging. In industrial agriculture, machinery is used to automate feeding process, reducing cost and increasing the scale of farming. For commercial poultry farming, feed serves as the largest cost of the operation.

1.3. The Max-Min Approach

In this section, a brief review of the max-min approach is presented. The max-min approach is a solution method in decision sciences, game theory, and statistics problems that maximizes the possibility of winning in the worst-case scenario. It has been applied to solve multi-period resource allocation problems, linear multiple criteria problems [31], fair bandwidth allocation in computer network problems, water resource allocation problem [32], and waste management problem. Utilizing this approach enables manufacturers to maximize their lowest total net profit and the shortest reliability of their machines simultaneously.

Consider a multi-objective optimization problem involving $P\ (P>1)$ objective functions that are required to be optimized simultaneously. In this problem, $f_i(x)$; $i=1,2,...,P$ is the ***i***-th objective function, and x is defined as the feasible solution of the problem. A typical multi-objective maximization problem is defined as

$$\text{Maximize } f_1(x), f_2(x), ..., f_P(x) \tag{1}$$

As a number of objective functions in Eq. (1) may conflict with each other, a unique solution that simultaneously maximizes all the objectives does not exist. Hence, the non-dominated concept is used, in which solution x is said to dominate y , ($x \succ y$) if and only if [33]

$$f_i(x) \le f_i(y), \quad (\forall i = 1,2,\ldots,P) \text{ and} \tag{2}$$

$$f_i(x) < f_i(y), \quad (\exists i \in \{1,2,\ldots,P\}) \tag{3}$$

The prior mentioned concept provides a set of optimal solutions called Pareto-optimal solutions, which create the Pareto-front [34]. To solve the problem, the max-min solution method can be utilized to maximize the minimum (the worst) performance [35]. Note the optimal solution set provided by the max-min approach that always contains an efficient solution for the original multi-objective problem presented in Eq. (3) [36]. Suppose $y_i = f_i(x)$ for each objective functions as an individual objective function that measures the outcome. Therefore, the max-min solution of the multi-objective functions can be written as [36]

$$Max\{\min_{i=1,2,\ldots,P} \ y_i \ : \ \sum_{i=1}^{P} y_i \le b\} \tag{4}$$

Using the max-min approach, the bi-objective formulation of the problem at hand can be derived to find a fair non-dominated solution, a solution with all normalized objectives as equal as possible [35, 37]. Hence, the proposed bi-objective model including Z_1 and Z_2 is converted to a max-min problem, which the following normalizations are implemented

$$Max \quad \alpha,$$

$$\text{s.t.} \tag{5}$$

$$\alpha \le Z_1' = \frac{Z_1^{\max} - Z_1}{Z_1^{\max} - Z_1^{\min}},$$

$$\alpha \le Z_2' = \frac{Z_2^{\max} - Z_2}{Z_2^{\max} - Z_2^{\min}},$$

and Constraints (2) – (11), where $Z_i^{\max}$ and $Z_i^{\min}$ are the maximum and minimum value of the objective function Z_i (i=1,2).

Utilizing this formulation, in order to find a fair non-dominated solution for total net profit and total reliability, the manufacturer maximizes the minimum value of total net profit and total reliability simultaneously. In other words, fair non-dominated solutions with all normalized objectives are obtained as equal as possible.

2. Manufacturing Nanomaterials

Nanomaterials can be produced through the utilization of two broad approaches known as top-down and bottom-up approach. The top-down approach is mostly used for processing inorganic materials through traditional methods, such as milling, grinding, sieving, and chemical reactions [38]. Homogenization is an example of a top-down method that utilizes pressure to reduce the size of materials such as fat globules. Milling mechanically reduces the size of materials to improve their functionality [39]. The Bottom-up approach involves the assembly of smaller molecules through self-organization resulting in the formation of supra-molecular structures, which possess novel functionalities [40]. Solvent evaporation and layer by layer (lbl) deposition are examples of the bottom up approach [41], which is commonly employed in food applications using components such as phospholipids [42].

2.1. Type of Nanomaterials

The novel functions associated with nanomaterials are contingent on the type of materials and their sizes (FSAI [43]). Examples of nanomaterials that can be manufactured into one, two, and three dimensional structures are thin films, nanotubes and nanoparticles, respectively. It is not easy to classify nanomaterials due to their complex structures and diverse properties. Additionally, those structures that are produced deliberately at nanometer scale and possessed novel properties are considered as nanomaterials as opposed to those structures that may be naturally present (e.g., molecules of sugar, fat) due to conventional methods (e.g., protein nanoparticles in ricotta cheese) (HOL [44]). The general classification of nanomaterials is summarized in Table 1 .

3. Potential Areas of Application

According to Chaudhry et al. [45], application of nanomaterials in food system is primarily seen in the production of food ingredients with nanostructure and in delivery systems for supplements and nutrients. Areas of investigation in meat product include reformulation through minimizing and modifying fat content, lowering the amount of sodium, phosphate, and nitrate, and inclusion of probiotics, prebiotics, and other materials, such as seaweed and walnut. In addition, improvement of bioavailability, formation of compounds that can promote health and reduction of unhealthy compounds are possible areas of study for the processing and storage of meat products [46].

Table 1. Types of Nanomaterials, products and application [43].

Category	Nanomaterials		Application/function	Product name	**Web address or reference**
Inorganic	Iron (Fe)		Improved bioavailability	SunActive iron (High vive fortified fruit juice)	http://www.highvive.com/sunactiveiron.htm
Nanoparticles					
	Silver (Ag)		Improved bioavailability and antimicrobial activity	Ag nanoparticles (fresh food bag)	[15]
	Iridium				
	Platinum				
	Zinc				
Organic Nanoparticles	Liposomes	Improved bioavailability	Bioactive agent.	Lypo-spheric vitamin C (Livon labs)	http://www.livonlabs.com/cgi-bin/start.cgi/liposome-encapsulated/lypo-spheric-vitamin-c.html
			Nanoencapsulation.		
			Improved solubility and bioavailability, cell-specific targeting.		
	Protein		Nanoencapsulation of hydrophobic nutraceuticals.	Casein micelle	[38]
			Improved functionalities (gelation, heat stability)		
	Polymeric		Nanoencapsulation & improved functionalities (delivery, antimicrobial)	Chitosan/β-lactoglobulin nanoparticles	[23]
Nanofibres	Globular proteins		Improved functionalities (Thermal stability, thickening agent, shelf life)	Antioxidants zein prolamine nanofibers	[30]
Nanoemulsions	Oil in water (o/w)		Nanoencapsulation and regulated release of bioactive agents and nutrients	Curcumin nanoemulsion	[33]
	Water in oil (w/o)			Ice cream (nestle)	[41]
Nanodispersions	Beta-Carotene		Improved solubility and addition levels	Beta- Carotene nanodispersions	[15]
Nanoclays	Montmorillonite (mmt)		Improved properties in packaging (barrier, thermal, durability)	Montmorillonite (mmt) nanocomposite	[13]

A wide variety of ingredients exist for potential application in meat processing (e.g., fat replacers, such as citrus fiber, soy protein concentrate, oat fiber, carrageen an, soy fiber and plasma protein). Other areas of application include modification of fat profile with chicken oil extract, flaxseed and linseed; salt reduction by utilization of edible seaweeds and apple pulp;

nitrite reduction with the use of celery and spinach juice; delivery of novel antioxidants from rosemary extract, ascorbic acid and hyssop extract, and utilization of noising, rosemary and oregano oil as antimicrobials [47]. Some of these areas may potentially benefit from the use of nanotechnology by delivery of antioxidants and antimicrobials through nano-material in processed meats [47] .However, the behaviors of both native and altered food in the assembly components need to be understood for the production of nano-materials [48].

3.1. Nanoscale Ingredients

Ingredients produced by nanotechnology can be utilized to improve taste and texture of food, and to increase the bioavailability of bioactive compounds and nutrients [49]. They can also be used to mask unpleasant flavors and odors [23]. Dry and wet milling of organic materials may result in the production of nano-sized or ultrafine powders (sizes of 100 nm to 1 μm) which can be utilized in food manufacturing at a low cost [12]. An example is nanotea (green tea), which was shown to have increased antioxidant activity due to its reduced particle size [50]. Other examples include ultrafine milled antimicrobial chitosan nano powder, with increased hypolipidemic activity, and wheat bran, with improved bioactivity [50-51]. Reducing ginger, which is sometimes used in meat as a tenderizer and extender, to micro-sized powders, was found to improve its penetrability, while also making it more soluble and dispersible than native ginger [53]. If such ingredients were further reduced to nanopowders, they may exhibit novel physical and chemical properties. Although powders with particles in nanometer range may have enormous potential, further improvements in understanding of the nature of raw materials (e.g., toughness) and advancements in equipment are required for successful application [53]. The area of nanotechnology-based ingredients is still in the nascent stage, and the extensive use of nano-sized ingredients in food is predicted with the development of other associated technologies [16].

3.2. Nanoencapsulation

Most ingredients meant to serve special functions in food are not incorporated in their original form, making it necessary to modify these materials prior to use with suitable delivery systems [54]. For instance, many bioactive compounds are sensitive to temperature, oxidation, and lack of solubility in water along with preference for loci in the gastrointestinal tract for entry into the blood stream through absorption [28]. Therefore, a delivery system must transport the functional ingredient to its target while simultaneously protecting it from oxidative degradation [53]. Furthermore, the release of functional ingredients can be regulated by the strength of ions, as well as surrounding temperature and pH. It is also important that the ingredients be compatible with the qualitative aspects of foods, such as color, texture, taste, etc. Although several delivery systems exist, only few systems (e.g., association colloids, biopolymeric nanoparticles, and nanoemulsions) are likely to have a broad impact on food production [53]. Association colloids are stable systems with well-dispersed nanoparticles in the product. Micelles and reverse micelles are good examples of this type of colloidal system. In the colloidal system, the novel properties of particles (5 to 100 nm) can be delivered using materials that may be polar, nonpolar and amphiphilic, thereby improving the shelf life of food along with providing other benefits [39]. Yusop et al. [48] applied micelles to chicken breast fillets, where the use of nanoparticle paprika oleoresin as an ingredient seemed to enhance the effects of maintenance and the sensory qualities of the fillets.

Biopolymers in a nanometer scale can also be utilized to improve the shelf life of food. An example of a food-grade synthetic biopolymer is polylactic acid (PLA), which is used as a delivery system [43]. Regulated release of the functional ingredients can also be achieved using other synthetic biopolymers, such as polylactic-co-glycolic acid (PLGA) and polyethylene glycol [17]. The antimicrobial activity was enhanced when PLGA nanoparticles were used as a delivery system for phenolic compounds in cooked and uncooked chicken. Inhibition of pathogenic microorganisms, such as Salmonella Typhimurium, Escherichia coli O157:H7 and Listeria monocytogenes was found at very low concentrations of phenolics (e.g., benzoic and vanillic acids) when packaged in polylactic glycolic acid nano-particles [46]. On the other hand, a natural alternative for synthetic biopolymer, chitosan, can also be used in the encapsulation of functional compounds [53]. Abdou et al. [3] investigated the effects of antimicrobial chitosan nanoparticles on the growth of microorganisms in chicken feed, and found that the chicken feed with chitosan or chitosan edible coating showed decreased bacterial counts compared to the uncoated chicken feed and those with commercial coating, suggesting a potential extension of the shelf-life. Study of the rheological properties revealed coatings to be pseudo plastic in nature for all different concentrations of chitosan [3].

Functional compounds can be included in a droplet or any other phase of nanoemulsions such as the continuous and interfacial phases. These systems can provide a vehicle for more than one material, with activities, such as antimicrobial and antioxidant functions [51]. An example of a nanoemulsion is the nanostructured multilayer emulsion, in which the release of active ingredients is dependent on external stimulus [39]. However, the inclusion of emulsions in meat systems remains a challenge, as reported by [29]. The incorporation of a stable oil-in-water (O/W) emulsion in pork sausages was observed to cause an increase in oxidation. In a study by Joe et al. [18], a nano-emulsion made with sunflower oil was used in the processing of Indo-Pacific king mackerel steaks. They reported a decrease in the initial microbial growth up to 12 h except for the control and an increase in the shelf life of 48 h, determined organoleptically, indicating its potential use in the short-term storage of chicken products. Table 2 presents the utilization of some nanomaterials for delivery, and the improved performance of functional compounds in meat systems. Nanoemulsions and micelles are two examples of delivery system that are cost-effective and easy to produce [8]. Apart from compatibility and cost, several other disadvantages and advantages are associated with each type of delivery system for the encapsulation and regulation of the release of functional compounds [43]. Although some studies have demonstrated improved encapsulation methods, it is critical to investigate their functional efficacy of oil-in water emulsion in a complex food matrix such as meat products [23].

Table 2. Nan materials for delivery of functional ingredients in meat products.

Nanomaterial	Function of nanomaterial	Meat product	Performance in meat	Reference
Micelle (Nanoparticle paprika oleoresin)	Encapsulation of functional ingredient	Chicken breast fillet	Improved marinating performance and sensory perception	Yusop et al., 2012
Biopolymeric nanoparticle (Chitosan nanoparticle)	Antimicrobial	Chicken	Increased antimicrobial activity	Abdou et al., 2012
O/W Nanoemulsion (Sunflower oil)	Antimicrobial	Indo-Pacific king mackerel Steaks	Short lived antimicrobial	Joe et al., 2012
PLGA nanoparticles (phenolics loaded)	Antimicrobial	Raw & cooked meat systems	Efficient antimicrobialactivity	Ravichandran et al., 2011

4. Biopolymer Nanoparticles (Creating Antimicrobial for Chicken Finger)

Biopolymer nanoparticles were first designed using albumin [22] and non-biodegradable synthetic polymers, such as polyacrylamide and poly (methylacrylate) [24, 33]. The risks of chronic toxicity due to the intracellular and/or tissue overloading of non-degradable polymers were soon considered as a major limitation for the systemic administration of polyacrylamide and poly (methylacrylate) nanoparticles in humans. Consequently, the type of nanoparticles that received much attention was designed with synthetic biodegradable polymers including polyalkylcyanoacrylate, poly (lactic-co-glycolic acid) and polyanhydride. The therapeutic potential of these biodegradable colloidal systems was investigated for various applications [4].

Despite the very interesting results reported in literature, these systems may also be concerned with toxicological problems. There is another limitation for the bionanoparticle-based administration of hydrophilic molecules, such as peptides, proteins and nucleic acids (oligonucleotide and genes) which are recognized to have great potential for therapeutics. This limitation is mainly because the polymers forming these nanoparticles are mostly hydrophobic, whereas proteins, peptides, and nucleic acids are hydrophilic. This leads to difficulties for the drug to efficiently encapsulated and protected against enzymatic degradation. Therefore, the preparation of nanoparticles using more hydrophilic and naturally occurring materials has been explored.

The need for developing biodegradable nanoparticles (liposome, virus-like particle (VLP), protein, etc.) as effective drug delivery devices was felt years ago. The reason is that biopolymer nanoparticles, in addition to the general advantages of nanoparticles, offer several advantages in particular, which include the ease of their preparation from well-understood biodegradable polymers and their high stability in biological fluids and during storage. Nanoparticles made of biodegradable polymers like proteins and polysaccharides can act as efficient drug delivery vehicles for sustained, controlled, and targeted release, aiming to improve the therapeutic effects and to reduce the side effects of the formulated drugs.

4.1. Protein Nanoparticles

The first naturally occurring material used for the preparation of nanoparticles consisted of two proteins, albumin and gelatin. Among the colloidal systems, those based on proteins are very promising because they are biodegradable, less immunogenic and non-toxic. They have greater stability in vivo and during storage, they are relatively easy to prepare and to monitor size distribution, and their manufacture can be scaled up. In addition, because of the defined primary structure of proteins, the protein-based nanoparticles offer various possibilities for surface modification and covalent drug attachment.

5. Conclusions

In this paper, some applications of nanothnology have been investigated. The results showed that, it is critical to investigate some nanomaterials for delivery, and the improved performance of functional compounds in meat systems. Nanoemulsions and micelles are two examples of delivery system that are cost-effective and easy to produce their functional efficacy of oil-in water emulsion in a complex food matrix such as in meat products.

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