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Review

Micro- and nano-scaled materials for strategy-based applications in innovative livestock products: A review

Karna Ramachandraiah[a], Mi-Jung Choi[b], Geun-Pyo Hong[a,*]

[a] Department of Food Science and Biotechnology, Sejong University, Seoul 05006, South Korea
[b] Department of Food Science and Biotechnology of Animal Resources, Konkuk University, Seoul 05029, South Korea

A R T I C L E I N F O

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A B S T R A C T

Background: With the advent of new technologies and the emphasis on innovation, novel engineered particles are being developed that possess superior functional properties, consumer acceptance and cost effectiveness. The performance of particulate systems in animal derived foods is dependent on several factors including particle size, shape, chemical and structural properties.

Scope and approach: Micro- and nano-sized materials for the three major strategic applications in animal derived foods are discussed. Although this review describes a few examples of dairy products such as milk and cheese, it primarily emphasizes meat, poultry, fish and eggs.

Key findings and conclusions: While whole grains with large particle sizes influence gizzard growth and function, superfine powders of yeast cell wall and oolong tea have improved immune function and meat quality along with reductions in fat. As a part of a product reformulation strategy to reduce sodium, salt-loaded chitin nanofibers incorporated in seafood have resulted in enhanced saltiness. To reduce allergies associated with eggs, microparticulation of protein has been attempted but without any success. However, micro-sizing fish powder has enhanced transglutaminase (TGase) activity in surimi. In terms of storage strategy, ZnO nanoparticles loaded onto carboxymethyl cellulose film have improved color stability and water holding capacity (WHC) of pork. Other potential applications include reutilization of wastes in biodiesel production and nanoquantum dot-based lighting to improve the showcasing of meat. For the successful application of particle technologies in animal derived foods, knowledge gaps related to the toxicity of nanomaterials, commercialization challenges and negative public perception need to be addressed.

1. Introduction

With the economic development of several nations, meat, dairy and seafood markets have witnessed a great demand, which had formerly arisen largely from developed nations (Delgado, 2003). As a result, the global annual per capita consumption of meat has increased from 10 kg in the 1960s to 26 kg in 2000 and is projected to reach 35 kg by the year 2025 (FAO, 2016). Increased demand is predicted despite the perception among meat consumers, at least in the developed world, to reduce meat intake (Fiala, 2008). The negative perception of meat is attributed to the health concerns owing to its high saturated fat content and added nitrites and salts (Young et al., 2013). However, apart from being the best protein source in the human diet, meat provides numerous health benefits that include being a source of amino acids, peptides for age related muscle loss (sarcopenia), providing protein for bioactive hydrolysates, and being a source of ACE-inhibitory components, nucleotides and nucleosides (gut health), antioxidants, conjugated linoleic acid and phytanic acid. Even with such benefits, most meat research is often related to subsidence of the disease effects of meat (Young et al., 2013). Additionally, focus has been shifted from traditional supply chains to value chains that depend on the utilization of efficient technology for its success (Sosnicki & Newman, 2010). All these have led to investments in innovation by meat industries, which also must overcome negative health concerns such as colon cancer risks associated with the consumption of processed and red meats. Thus, to prevent the negative effects associated with meat, it is suggested that new additives could be utilized (Corpet, 2011).

Particle technologies have the potential to be applied in various types of industries such as chemicals, pharmaceuticals, agriculture, energy, environment, materials and food (Lee & Henthorn, 2012). The advantages of particle-based technology include improvement in functional properties, specific selectivity in chemical reactions, novel processing methods for reutilization of natural or synthetic materials, novel methods for separation and filtration, multiple functionalities in

* Corresponding author. Department of Food Science and Biotechnology, College of Life Science, Sejong University, Seoul 05006, South Korea.
E-mail address: gphong@sejong.ac.kr (G.-P. Hong).

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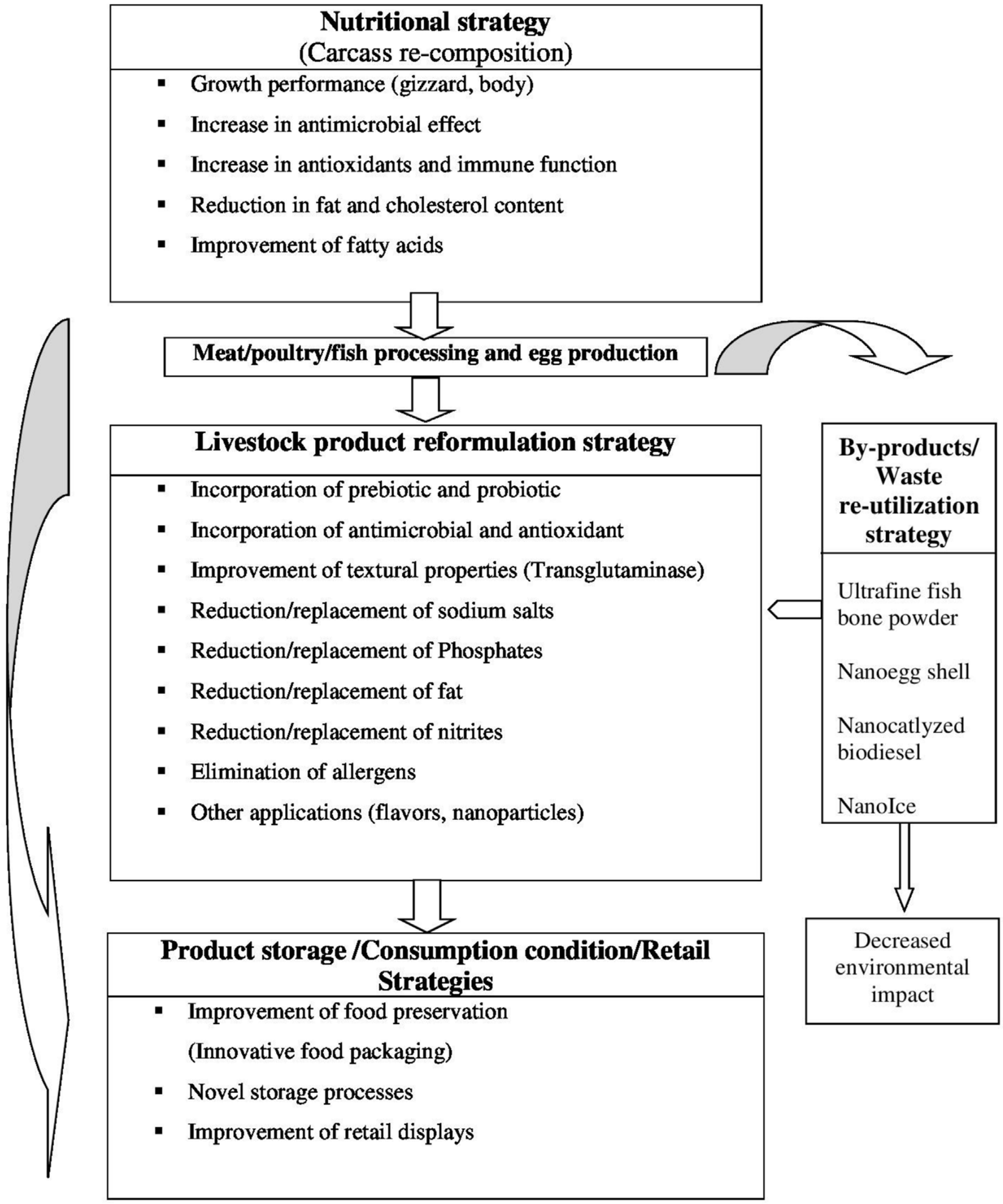

Fig. 1. Strategies for development of innovative livestock products.

composite materials, and development of new devices and equipment (Lee & Henthorn, 2012). Several methods exist for particle-size increments such as crystallization, precipitation, granulation and extrusion and for size decrements such as comminution, atomization and emulsification (Merkus & Meesters, 2014). A wide array of products makes use of various types of particulate systems. The base materials in particulate system derived products can be of natural origin such as dry powders (e.g., flour, starch, pigments, sugar) or derived through human intervention such as solid mixtures (e.g., pharmaceuticals). The production and performance of such materials is contingent upon generating particles of a certain size, shape, and composition. Therefore, it is imperative to design products with particulate systems of optimal size and shape ranges for the best performance outcomes (Merkus & Meesters, 2014).

The incorporation of novel materials for the development of innovative edible livestock products can be achieved through three major strategies as shown in the framework (Fig. 1): nutritional modification, product reformulation and storage/consumption conditions (Jiménez-Colmenero, Herrero, Cofrades, & Ruiz-Capilla, 2012). Another strategy for the application of particle technologies is the reutilization of meat/egg by-products and processing wastes. The scientific literature is replete with studies that have reviewed various types of nanoscaled materials in foods, including animal-derived. Strategies for application of ingredient systems for the development of novel meat products also have been studied (Arihara, 2006; Jiménez-Colmenero et al., 2012; Weiss, Gibis, Schuh, & Salminen, 2010). However, the studies on micro- and nanoscaled materials for strategy-based application in foods of animal sources are very limited. Investigations on microscaled materials become