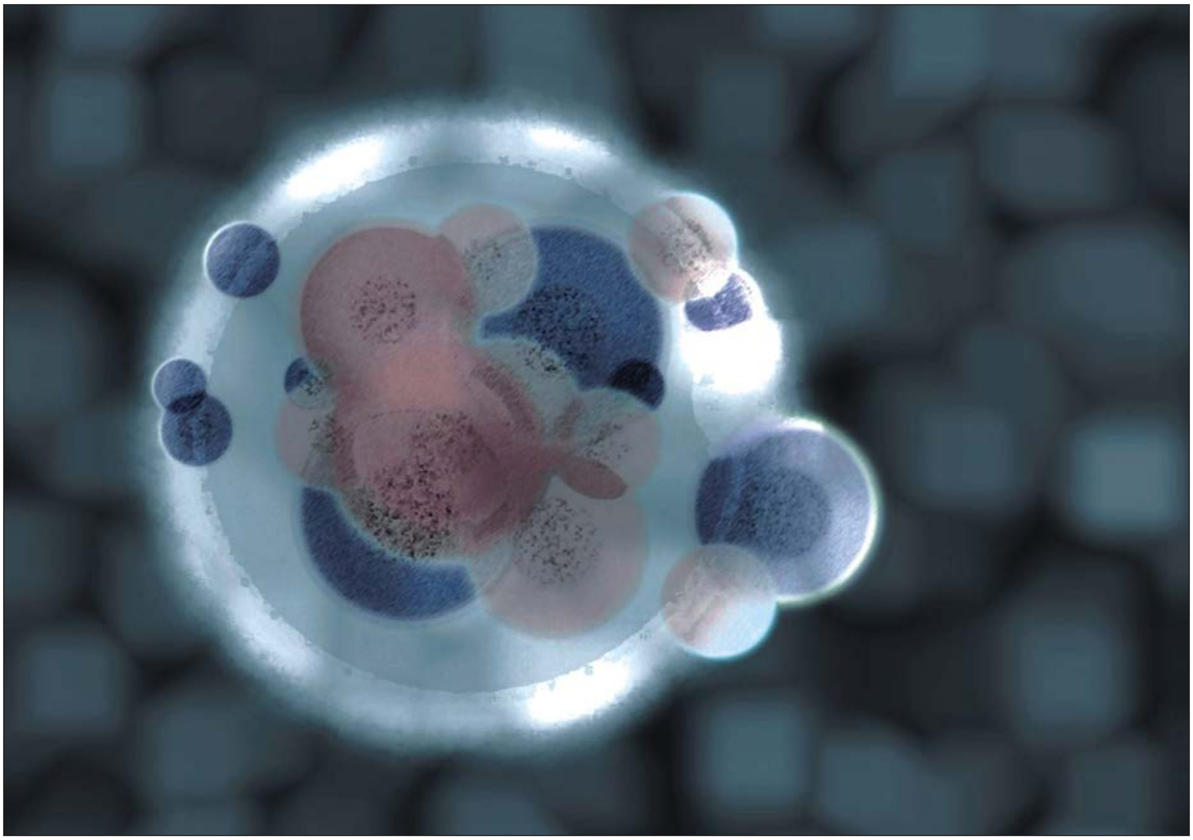

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Duck Meat Utilization and the Application of Surimi-like Material in Further Processed Meat Products

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Abstract: Poultry production has risen rapidly due to the increased consumption of further processed chicken-based products such as sausages, nuggets and burgers. This increase in poultry consumption has been dominated by chicken meat. Duck meat is also widely available but less frequently utilized in further processed products due to certain limitations of its functional properties. Nonetheless, duck meat production has increased steadily over the years. One technology that may improve the functional properties of meat is surimi processing. This specialized washing process removes undesired components (e.g., fats, blood, enzymes and pigments) and increases the concentration of myofibrillar proteins that play important roles in the functional properties of meat. The successful development of fish surimi has inspired researchers to study surimi-like material made from other animal muscle. Several researchers have tested the properties of surimi-like material made from beef, pork, chicken, mutton and sheep and reported improved qualities compared with the original (untreated) raw meats. Surimi-like material also has been used in several product formulations for nuggets, frankfurters, sausages, restructured roasts and imitation crab sticks. Therefore, it is reasonable to assume that processing duck meat into surimi-like material could improve the functional properties of duck meat and allow its application in many further processed products.

Key words: Poultry production, myofibrillar proteins, animal muscle, duck meat

INTRODUCTION

Poultry meat is very popular around the world in both developed and developing countries and its production has increased continuously in recent years. The popularity of poultry meat is due to its relatively low cost of production, rapid growth rate, high nutritional value and ability to be processed into various products, as well as the lack of cultural or religious prohibitions against its consumption (Barbut, 2002; Bilgili, 2001). Currently, the term poultry is most often used to refer to chicken. The prevalence of chicken consumption is closely related to the successful marketing of various further processed ready-to-eat chicken-based products. These products include those that were initially developed for red meat, such as sausages and burgers, as well as more recently developed types, such as nuggets. Moreover, a large number of consumers have changed their preference from red meat-based products to poultry-based products.

The production of duck meat, which is also categorized as poultry meat, has risen steadily in recent years and has become the third most widely produced poultry meat in the world after chicken and turkey. Furthermore, there has been an increase in demand for duck meat because it is no longer considered a seasonal dish and has become acceptable to eat at any time of year. This has been promoted by modern husbandry techniques that are able to supply greater quantities of duck meat (Dunn, 2008; Hird *et al*., 2005). Various breeds of duck are available. Some breeds are raised specifically for their meat, while others are kept for their egg-laying abilities (Sonaiya and Swan, 2004; Abraham and Ravindran, 2009). Nevertheless, spent egg-laying ducks can also be considered as a source of duck meat (Bhattacharyya *et al*., 2007). The availability of duck meat presents an opportunity to expand its use into many further processed meat products.

AVAILABILITY AND CHARACTERISTICS OF DUCK MEAT

The production of duck meat has been dominated by Asian countries, which supply more than 80% of the duck meat produced in the entire world. The People's Republic

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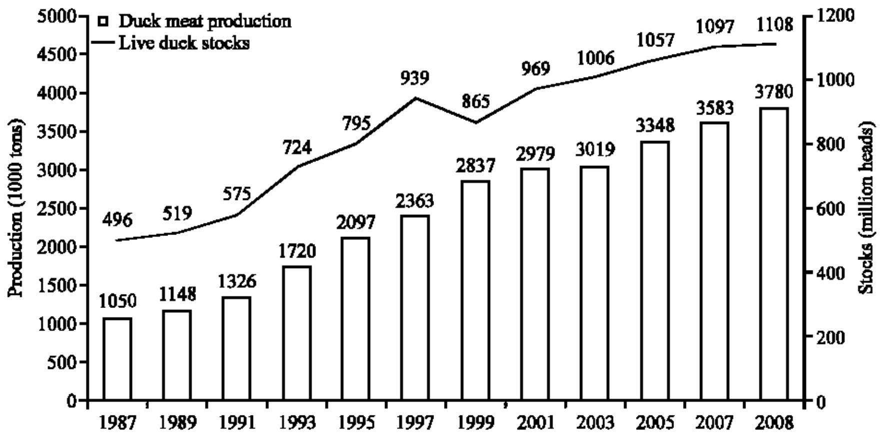

Fig. 1: World's duck meat production and live duck stocks during 1987-2008 (FAO, 2009)

Table 1: Nutritional composition of raw duck, chicken and turkey meat per 100 g (USDA, 1999)

Meat	Protein (g)	Fat (g)	SF (g)	MUF (g)	PUF (g)	Cholesterol (mg)	Iron (mg)
Duck meat with skin	11.49	39.34	13.22	18.69	5.08	76	2.4
Duck meat only	18.28	5.95	2.32	1.54	0.75	77	2.4
Chicken (broiler) meat with skin	19.00	15.00	4.30	6.20	3.20	75	0.9
Chicken (broiler) meat only	21.00	3.00	0.80	0.90	0.70	70	0.9
Turkey meat with skin	20.00	8.00	2.30	2.90	2.00	68	1.4
Turkey meat only	22.00	3.00	0.90	0.60	0.80	65	1.5

SF: Saturated fat, MUF: Mono unsaturated fat, PUF: Poly unsaturated fat

of China has been the top producer and exporter of both live ducks and duck meat over many years. Although France is the second-largest producer of duck meat, several Asian countries are close behind: Malaysia the third-largest, Thailand and Vietnam produce approximately as much duck meat as the United States of America. The production of live ducks has also been dominated by Asian countries. The five countries with the largest live duck stocks are China, Vietnam, Indonesia, India and Bangladesh (FAO, 2009).

Figure 1 shows the increase in world duck meat production and live duck stocks over time. The figure illustrates the threefold increase that occurred between 1987 and 2008 to achieve a total duck meat production of 3.7 million tons per year. The number of live duck stocks dropped in 1998 after reaching a peak at 1997, but have continued to increase since that time.

Duck meat has a unique combination of red meat and poultry meat characteristics. Like red meat, duck meat has relatively high fat content and levels of intramuscular phospholipids, which play a substantive role in the development of meat flavor. High levels of iron and heme pigment also make duck meat appear darker than most other poultry. Table 1 shows that duck meat with skin has distinctively higher fat and iron content compared with chicken and turkey meat. However, like chicken and turkey, duck meat is rich in unsaturated fatty acids and is thus beneficial for human health (Barbut, 2002; Baeza, 2006; Chartrin *et al*., 2006; USDA (1999).

The nutritional composition of duck meat varies depending on the breed and strain of duck. For example, Pekin duck (*Anas platyrhynchos domesticus*) meat contains more fat than Muscovy duck (*Cairina moschata*). Duck meat is also more easily influenced by the animal's diet than is chicken meat. The fatty acid content of duck meat is dominated by oleic acid ($C_{18:1}$), a monounsaturated fatty acid; palmitic acid (C_{16}), a saturated fatty acid; and linoleic acid ($C_{18:2}$), a polyunsaturated fatty acid. Some researchers have reported that duck feeds may be modified to yield duck meat that contains more unsaturated fatty acid and less saturated fatty acid. Although this improves its value for human health, the high concentration of unsaturated fatty acids makes duck meat very susceptible to lipid oxidation (El-Deek *et al*., 1997; Russell *et al*., 2003; Solomon *et al*., 2006; Woloszyn *et al*., 2006; Wang *et al*., 2009).

FURTHER PROCESSED POULTRY MEAT PRODUCTS

The increase in consumption of poultry meat was accompanied by an increase in the number of further processed products offered by industries and the growing presence of fast-food services. These trends have gradually changed the pattern of poultry meat consumption. Initially, poultry was mainly marketed and sold as whole birds, but this has been replaced by various forms of further processed ready-to-eat products. For example, in the United States, further processed products made up about 46% of the poultry meat market in 2007, compared with less than 20% in 1985; whole birds account for only 11% of the poultry meat purchased by the end consumer (National Chicken Council, 2009).

Further processing of poultry is defined as the transformation of raw carcasses into value-added, easy to prepare and convenient products. The abundant and popular ready-to-eat products that can be easily found in grocery and retail stores are classified into following categories (Baker and Bruce, 1989; Keeton, 2001; Owens, 2001; Barbut, 2002; Huda *et al*., 2010; Silva and Gloria, 2002).

Formed (restructured) products, which may be produced by combining cut muscles with a ground or emulsified myofibrillar protein binder and a chilled brine and converted into frozen form. These products include burgers and patties.

Emulsified (comminuted) products composed of water, protein and salt; some products also contain added fat or starch. These substances are mixed in order to reduce particle size and to obtain a homogeneous mass of meat batter. This category includes sausages (frankfurters and bologna) and meatballs.

Coated (breaded) products, which account for a large portion of the growth in further processed poultry products over previous decades. The production of these nuggets involves particle size reduction, blending, forming, coating and cooking.

The quality of the raw material plays a significant role in the quality of the final products. Sensory and functional properties are of particular importance for the final quality of further processed products. Sensory properties include color, flavor, texture, oxidation stability and losses. Functional properties include emulsification capacity, meat-binding properties, water-binding properties, adhesion (for breaded products), meat yield, cooking losses and moisture, fat and protein contents (Barbut, 2002; Erdtsieck, 1989; Petracci and Baéza, 2009). Bhattacharyya *et al*. (2007) conducted a study to compare sausages made from chicken meat and duck meat. Duck sausages had lower emulsion stability and cooking yield compared with chicken sausage as a result of their high fat content and lower water-retention capacity. As reported by Biswas *et al*. (2006), patties made from duck meat also had lower emulsion stability and cooking yield compared with chicken patties. Other researchers reported duck meat had higher cooking loss percentage, less lightness and more redness in color properties compared with chicken meat (Alvarado and Sams, 2000; Ali *et al*., 2007; Huda *et al*., 2008). These indicate that further research may improve the quality of further processed products made with duck meat.

FISH SURIMI

The term surimi was originally used in Japan to refer to a water-washed muscle protein extract produced from fish, usually mechanically recovered fish slurry. The washing process removes fats, water-soluble sarcoplasmic proteins (including enzymes and pigments), blood and metal ions and increases the concentration of salt-soluble myofibrillar proteins that have useful functional properties with respect to product texture (Sultanbawa and Li-Chan, 1998; Yang and Froning, 1992).

One important quality of surimi is its ability to form a gel. Gel breaking force, deformation and gel strength are all influenced by the proportion of myofibrillar proteins; generally, an increase in protein concentration will increase gel forming ability. However, the presence of undesirable components remains after the washing process cause unintended effects on surimi quality, e.g., inhomogeneity and granularity. In addition to improving gel-forming ability, the washing process is required to produce brighter, whiter surimi. This obviates the need for extra coloring agents during the production process, thus reducing costs. In the past, surimi was made only from underutilized fishes to enhance their value. Surimi can be widely utilized as a raw material in the production of various further processed meat products, such as kamaboko (traditional Japanese fish gel), seafood analogues, fish balls, fish ham and fish sausages (Babji *et al*., 1995; Boran and Köse, 2007; Larkin and Sylvia, 1999; Mizuta *et al*., 2007; Sultanbawa and Li-Chan, 1998; Yang and Froning, 1992). Currently, most of fish balls and fish crackers manufacturer in Malaysia are using surimi as raw material for their products (Huda and Ismail, 2009; Huda and Ariffin, 2010).

Surimi can be kept in frozen form for months. In order to prevent protein denaturation during freezing and frozen storage, some cryoprotectants are usually added to surimi. Many studies have reported the use of various cryoprotectants, such as sucrose-sorbitol, polydextrose, trehalose, lactilol and other polyols (sugar alcohol). Commercial surimi preparations use a sucrose-sorbitol combination mixed with sodium tripolyphosphate (Herrera and Mackie, 2004; Zhou *et al*., 2006). Cryoprotectants is not only able to prevent protein denaturation during freezing and frozen storage, but also during drying process (Huda *et al*., 2000). Surimi powder produced also showing higher protein quality (Huda *et al*., 2001).

Table 2: Previous studies about surimi-like material and its quality improvement

Type of meat	Fat removed (%)	Increasing in textural properties (%)	Increasing in Lightness (%)	Source
Spent hen surimi	79.64	36.62	46.17	Nowsad *et al.* (2000a)
Broiler surimi	76.66	33.16	32.93	Nowsad *et al.* (2000b)
Sheep surimi	89.68	33.10	63.48	Antonomanolaki *et al.* (1999)
Mutton surimi made from hand deboned meat	98.79	NA	NA	McCormick *et al.* (1993)
Mutton surimi made from mechanically deboned Mutton meat	94.44	NA	NA	McCormick *et al.* (1993)
Mechanically deboned chicken meat surimi	NA	NA	16.80	Babji *et al.* (1995)
Mechanically deboned chicken meat surimi washed with 0.5% NaCl	NA	NA	16.39	Babji *et al.* (1995)
Mechanically deboned chicken meat surimi washed with 0.5% $NaHCO_3$	NA	NA	24.69	Babji *et al.* (1995)

NA: Not available

PREVIOUS SURIMI-LIKE MATERIAL STUDIES

Based on the very successful application of surimi in fish industries, there have been considerable efforts to use this technique with other animal muscle. These products have been called surimi-like material or washed meat. As fish surimi was made from underutilized fishes, surimi-like materials have generally been produced from low value or unpopular meat sources, such as spent hen and beef heart. However, many studies have investigated the functional properties of surimi-like material made from a number of meats, including beef, pork, mutton, sheep meat, broiler and mechanically deboned chicken meat (Antonomanolaki *et al*., 1999; Babji *et al*., 1995; Jin *et al*., 2007; McCormick *et al*., 1993; Nowsad *et al*., 2000a; Park *et al*., 1996; Parkington *et al*., 2000; Srinivasan and Xiong, 1996; Wang *et al*., 1997; Yang and Froning, 1992).

As shown in Table 2, previous studies of washed meat (surimi-like material) demonstrated lower fat content and improved lightness (color) and textural properties compared with raw (unwashed) meat. Surimi washing processes successfully removed more than 90% of the fat content in mutton. This is especially important as modern consumers prefer meat with less fat (Colmenero, 1996; Farhat, 2009). Furthermore, a nearly 30% improvement in textural properties has been achieved in spent hen, broiler and sheep surimi. The lightness value of sheep surimi was also drastically increased, by 63%.

Because surimi-like materials are prospective raw ingredients for many further processed products, several studies have focused on surimi shelf life and cryoprotection. In particular, a combined sucrose and sorbitol cryoprotectant has been able to maintain some of the quality attributes of chicken surimi during the freezing process and in frozen storage (Kijowski and Richardson, 1996; Nowsad *et al*., 2000b).

APPLICATIONS OF SURIMI-LIKE MATERIALS

The use of surimi-like material as substitute ingredient has been reported in previous publications. Perlo *et al*. (2006) reported that washed chicken meat may be used as a substitute ingredient in chicken nuggets for up to 40% of the meat in the formulation. Another study showed that spent hen surimi can replace around 40-60% of the meat in sausage formulations (Jin *et al*., 2007).

Although surimi-like material can be used in large proportions in product formulations, some research has shown that optimum results can be reached with lower proportions of surimi. Desmond and Kenny (1998) found that the optimum frankfurter formulation contained 7-10% beef heart surimi. Similarly, McCormick *et al*. (1993) described good results when 5% of restructured roast meat formula was replaced with mutton surimi. Jin *et al*. (2009) reported optimal results for imitation crab sticks using 5.5-11% spent hen surimi as a substitute ingredient.

CONCLUSION

The increase in duck meat production and trends toward the greater consumption of further processed meat products present the opportunity to develop more products that use duck meat as a raw material. High-quality further processed meat, particularly emulsified meat products, can only be made from meat with specific functional properties. The processing of duck meat into a surimi-like material is one promising strategy to improve its functional properties and allow its incorporation into many kinds of further processed meat products.

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