Aquatic Food Studies 2(1), AFS105
https://doi.org/10.4194/AFS105

PROOF
REVIEW

Surimi Technology and New Techniques Used For Surimi-Based Products

Büket Buşra DAĞTEKİN[1,*]

[1]Central Fisheries Research Institute, Department of Food Technology, 61250, Trabzon/ Türkiye

How to cite

Dağtekin, B.B. (2022). Surimi Technology and New Techniques Used For Surimi-Based Products. *Aquatic Food Studies*, *2(1), AFS105*. https://doi.org/10.4194/AFS105

Article History
Received 23 May 2022
Accepted 26 July 2022
First Online 27 July 2022

Corresponding Author
Tel.: +904623411053
E-mail: buketgozu@gmail.com

Keywords
Surimi
Surimi-based products
Myofibrillar protein
Non-thermal techniques

Abstract

With growing population is in the world, food requirement of people is also increasing. Therefore, increasing of the current animal protein sources or presenting to human consumption for using different methods is of great importance. Surimi is an excellent source of myofibrillar proteins, which are preserved by cryoprotectants during long-term frozen storage. Surimi is a product obtained by mixing mechanically deboned fish meat, after washing with water and chopping, mixing thickeners such as sugar, sorbitol and polyphosphate (cryoprotectant) and preservatives from freezing denaturation, and is defined as the moist frozen concentrate of myofibrillar protein in fish meat. Surimi goods with unusual gelling capabilities and high nutritional value include fish balls, kamaboko, chikuwa, and crabstick etc. Surimi is also classified as a ready-to-eat food because it does not require any preparation before eating. Nowadays, with the increase in consumer demand for ready-to-eat foods, the concern for surimi-based products has also increased. However, long-term heat processing using in production of them, which produces a certain amount of protein breakdown, decreasing textural quality and failing to fulfil customer expectations. Texture is a significant factor in influencing the quality and acceptance of seafood and fish protein-based products. Recently, non-thermal techniques such as high-pressure processing, ultrasonication, microwave, ultraviolet, ohmic heating, is used to minimise the quality loss caused by high-temperature cooking in production surimi based products.

Introduction

In parallel with the rapid increase in the population in the world, the need for animal food is increasing. Some animal protein sources are not directly preferred by the consumer because of their appearance and taste. For this reason, it is of great importance to increase the existing animal protein sources or to offer them to human consumption by applying different methods. In recent years, scientific studies have investigated ways to benefit more from marine resources, especially fish, in solving nutritional problems (Kristinsson et al., 2003; Hsu, 2010; Chalamaiah et al., 2012; Aspevik, 2016).

Surimi is a Japanese term obtained by mixing mechanically deboned fish meat, after washing with water and chopping, mixing thickeners such as sugar, sorbitol and polyphosphate (cryoprotectant) and preservatives from freezing denaturation, and is defined as the moist frozen concentrate of myofibrillar protein in fish meat. "Crude surimi" is obtained by removing the oil and water-soluble compounds by washing the minced meat with water. Various additives (such as sugar, sorbitol and some phosphates) that prevent the denaturation of fish proteins and are called cryoprotectants are mixed with surimi, allowing the proteins to be frozen for a longer period of time without losing their functional properties (Turan et al., 2006; Kaba, 2009; Kong et al. 2016; Muriel-Galet et al. 2015; Moreno et al., 2016; Chen et al. 2019; Mi et al. 2021). Fish balls, fish sausage, kamaboko, chikuwa, and

Published by Central Fisheries Research Institute (SUMAE) Trabzon, Türkiye.

crabsticks are examples of surimi based products which are popular in China, Korea, Japan, Thailand and other Asia countries known for their distinctive gelling qualities and excellent nutritional value. Surimi is also regarded as a ready-to-eat cuisine because it doesn't require any preparation before eating (Campo and Tovar, 2008; Grete et al. 2010; Zhang et al. 2013; Yin and Park, 2015; Kong et al. 2016; Kobayashi et. al., 2017; Lin et al., 2019).

Dating back to the 19th century, surimi making was previously thought to be a method used to preserve the caught fish without becoming stale. The successful use of non-economic and less economical species as raw materials in the Far East, America and European countries, frozen surimi has a long shelf life and a very high functional protein content, various technological processes and, with the addition of additives has been developed production of surimi and surimi-based products (Çaklı and Duyar, 2001; Buyruk, 2005; Turan et al., 2006). Recently years, surimi and surimi-based products have increased in worldwide due to their higher nutritional values and harvesting about 4.79 million tons in 2018 (Fishery and Statistics, 2020). The aim of this paper is to describe the surimi production process and give information about new techniques used for surimi-based products.

Production of Surimi

Although surimi and surimi-based products have been produced and consumed in Japan for centuries, the production and consumption of surimi-based products has started recently in European and American countries. In Europe, they are produced intensively in the Netherlands, France, Italy and Belgium (Çaklı and Duyar, 2001).

For the preparation of surimi, choosing the proper and quality raw materials is crucial. A percentage of myofibrillar proteins should be about 70% in the chosen fish. When percentage of water-soluble proteins is more than this rate, this situation is caused to be less surimi yield (Bakli et al., 2020). The other criteria to consider when choosing fish species for surimi are; ability to form a solid gel structure; having a good organoleptic quality in terms of taste, odour, and appearance; having white meat; availability all year long and having an appropriate price (Altun and Yıldız, 2018).

Surimi production from lean (white meat) fish consists of mincing, filtration (washing) and stabilization stages (Figure 1). Following the mincing process, the minced meat is washed with water. With the washing process, water-soluble compounds, fat and blood are removed from the minced meat and the color and flavor quality of surimi and its gel formation ability are increased. The number of filtration cycles varies according to the type and freshness of the fish. Studies for washing show that 9-12 shakes are sufficient. For example, in two filtration cycles, 5 minutes (min) per agitation is sufficient. The moisture content of the minced meat is reduced to approximately 80-84% with the clarifier and screw press dryer. Additives called cryoprotectants such as sugar, sorbitol and polyphosphate are added to the obtained raw surimi. Generally, 4% sugar, 4-5% sorbitol and 0.2-0.3% polyphosphate are used (Hall and Ahmad, 1992). In addition, sodium tripolyphosphate, tetrasodium prophosphate, calcium compounds (calcium lactate, calcium sulfate, calcium citrate, calcium caseinate), sodium bicarbonate, monoglyceride or diglyceride are also widely used cryoprotectants (Park and Morrissey, 2000). After the additives are added, the surimi is packed in 10 kg polyethylene bags and frozen in blocks at -40°C by contact freezing method. Frozen surimi blocks are placed as two blocks in each cardboard box and stored at –25°C (Çaklı and Duyar, 2001; Turan et al., 2006).

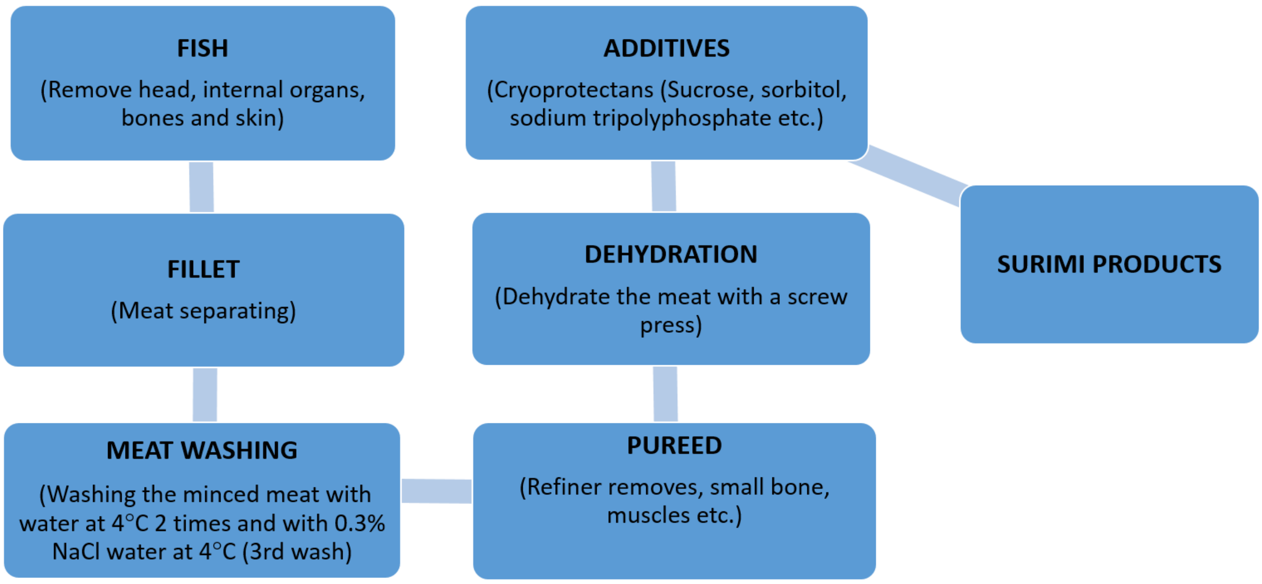

Figure 1. Surimi production process

With production of surimi from fatty (red meat) fish the only difference between surimi production method used for lean fish is the filtration (washing) stage. The filtration cycle takes place in three stages. Cycle 1: Filtration of meat four times in 0.5% sodium bicarbonate ($NaHCO_3$) solution for 20 min. Cycle 2: Filtration for 15 minutes in chilled water four times the meat. 3. Cycle: Filtration for 10 minutes in twice the meat's 0.3% salt (NaCl) solution (Turan et al., 2006; Çaklı and Duyar, 2001).

Fish Species Using For Surimi

In the production for surimi can utilise both marine and freshwater fish species. Both the light and dark fish muscles play a significant role in the production of surimi, the light muscles are more crucial for high-quality surimi due to their more stable proteins, reduced lipid oxidation, and reduced strain fluctuations. Surimi made from dark muscles, on the other hand, has a lower quality due to a larger concentration of heme proteins, lipid oxidation, proteolytic activity, and decreased protein stability (Park, 2005; Walat et al., 2022).

Numerous studies have been done to find alternative raw materials for making surimi besides the typical Alaska pollack. Several species including bigeye snapper (Park, 2005; Benjakul et al., 2004a), pacific whiting, arrowtooth flounder (Park, 2005; Uresti et al., 2006), threadfin bream (Bourtoom et al., 2009; Park et al., 2012; Nopianti et al., 2012), cod (Vareltsiz et al., 1989; Fernandez et al., 2001; Kristinsson and Hultin, 2003), lizard fish (Park, 2012; Benjakul et al., 2004b), hake (Fernandez et al., 2001), croacker (Benjakul et al., 2004b), mackerel (Eymard et al., 2005; Chaijan et al., 2006; Balange and Benjakul, 2009; Chaijan et al., 2010), sardine (Bentis et al., 2005; Chaijan et al., 2006), threadfin bream, ribbonfish, lizardfish (Muraleedharan and Gopakumar, 1998), anchovy (Kaba, 2006), thornback ray (Turan and Sönmez, 2007), and hoki (Mohtar et al., 2010) have been identified as potential raw materials. The quality of surimi made from each species of fish relies on elements such as seasonal change, eating behaviour, the pH of the water in the environment, adaptability, temperature, lipid content, sex, and spawning (Bakli et al., 2020).

However, there is a shortage of raw materials for the manufacture of surimi due to the ongoing decline in marine harvest. The recent decline in conventional surimi resources and the recent growth of the aquaculture industry globally create the possibility that freshwater fish will one day be a desirable raw material for the production of surimi (Pan et al., 2010; Bakli et al., 2020). More research has recently been done on the quality of surimi made from freshwater fish, such as silver carp (Azadian et al., 2012; Chen et al., 2020; Mi et al., 2021), tilapia (Zhou et al., 2006; Kobayashi et al., 2017), carp (Yanar and Fenercioğlu, 1999; Elyasi et al., 2010; Li et al., 2014), prussian carp (Dağtekin, 2015), grass carp (Mao and Wu, 2007).

Cryoprotectans Used in Surimi Production

Myofibrillar proteins physical, functional, and structural characteristics are effectively protected by cryoprotectants during surimi's frozen storage. Prior to freezing, cryoprotectants are added to surimi to lessen the denaturation and aggregation of the myofibrillar proteins. Among the most researched cryoprotectants used to store surimi are sucrose, sorbitol, polydextrose, lactitol, maltodextrin, litesse, sodium lactate, trehalose, and phosphates (Nielsen et al., 1994; Nopianti et al., 2010; Alakhrash et al., 2016; Park et al., 2016; Santana et al., 2017; Singh and Benjakul, 2017; Walayat et al., 2022a) . These antifreezing substances lessen viscosity, boost moisture retention, and improve protein stability when stored frozen. These cryoprotectants were picked because of their efficiency, affordability, and minimal propensity to trigger the Millard response (Kong et al., 2013).

Cryoprotectants such as sucrose and sorbitol, in general, give surimi a sweet taste and a high calorific value (Carjaval et al., 2005). As sugar and calories have become a consumer issue in recent days, many studies have been reported using other cryoprotectants with no or reduced sweetness/calorie content, such as lactitol, litesse, trehalose, sodium lactate, palatinit, polydextrose, and maltodextrin (Sultanbawa and Li-Chan, 1998; Zhou et al., 2005; Nopianti et al., 2010;).

Cryoprotectants in surimi prevent forming ice crystals which caused protein denaturation, and stabilise practical and constructional properties by bonding with protein functional groups. This situation protect mince from crystal formation, mince damage, and dehumidification also preserving actomyosin structure and inhibiting protein solubility during frozen storage (Zhang et al., 2016; Jommark et al., 2017).

Other Additives Used in Surimi Production

In last years, researchers have investigated using different additives for developing the gel quality of surimi (Zhang et al., 2018; Jia et al., 2018). Food hydrocolloids such as carbohydrates, proteins, and peptides play an important role in the functional and mechanical stability of surimi gel. Several food hydrocolloids improve surimi gel matrix formation, modify liquid phase mobility and viscosity, and influence gel structural and textural properties. In this way, the functional and mechanical features of surimi and surimi gel have much better (Yang et al., 2014, Walayat et al., 2022a).

Carbohydrates like starch, gums, pectins, fibres etc. are affected the surimi gel matrix by interacting with myofibrillar proteins (Fan et al., 2017). These additives are protect surimi gel firmness and strength, the whiteness and thermal stability of the gel during high-temperature treatments, improved surimi gel's stability, water holding capacity and textural properties during frozen storage (Uresti et al., 2003; Cardoso et al., 2007;

Cardoso et al., 2009; Yang et al., 2014; Kong et al., 2016; Habibi et al., 2017; Walayat et al., 2022a).

Surimi's gel-forming abilities are most affected by myofibrillar protein degradation. Proteins like beef plasma protein, egg white, whey protein concentrate, and protein hydrolysates or peptides are used to prevent the textural degradation, and protect physical properties of surimi gel (Xiong et al., 2000). Beef plasma proteins are used as protease inhibitor or gelling agent in surimi gel prevented the myosin degradation during gelation process, with hold multiple polypeptides property may aid in the gelation of surimi proteins (Singh and Benjakul, 2017; Walayat et al., 2022a). Egg white is often used for influence the stretch ability and elasticity on partial heat treatments in surimi-based products. In addition to this, plays an important role in the structure of surimi gel by filling the interstitial spaces in protein network (Hunt et al., 2009; Quan et al., 2017). Whey protein concentrate increase shear strain, breaking force, and water holding capacity of surimi gel (Rawdkuen et al., 2008, Walayat et al., 2022a). Protein hydrolysates and peptides with higher content of hydrophilic amino acids are used an alternatives of other cryoprotectants, and prevented the water migration from proteins and reduced the formation of ice crystals and the loss of water from myofibrillar proteins. In addition to this with antioxidative properties improve inactivation of $Ca^{[2]+}$ATPase activity and to enhance the structural stability of myofibrillar protein during frozen storage (Zhang et al., 2002; Rawdkuen et al., 2008; Kim et al., 2010; Wiriyaphan et al., 2013).

New Techniques Used For Surimi-Based Products

The quality of protein gel used in food development depends on its functional and nutritional properties. In recent decades, there has been a growing need for protein-based products among individuals due to the increasing population (Henchion et al., 2017; Walayat et al., 2022b). Consumer demand for easy and ready-to-eat products is rising as new technologies are developed a notion that encompasses both the simplicity of preparation employed and the products' prolonged shelf-life (Espinosa et al., 2015). Most ready to eat meat products require thermal processing, which adds to favourable changes in texture, colour, taste, and odour. Despite being the most advanced process, issues such delayed heat penetration, uneven heat distribution, significant cook loss, and non-uniform texture have a detrimental influence on product quality (Khan et al., 2014). Several ready-to-eat surimi items on the market, such as fish, cooked fish ham, and fish sausages, are made by long-term heat processing, which causes some protein degradation, decreasing textural quality and failing to fulfil customer demands. Texture is an essential characteristic of seafood, and innovative processing technologies, such as non-thermal processing, should be adopted to minimise the quality loss caused by high-temperature cooking (Jadhav et al., 2021; Luo et al., 2021).

Non-thermal processing exposes food to ambient temperature for a very short amount of time, i.e., 1 min or less, resulting in improved preservation of nutrients and sensory qualities and the mouthfeel remaining intact (Birmpa et al., 2013; Koubaa et al., 2016; Pizarro-Oteíza et al., 2020). Various non-thermal food processing methods, such as high-pressure processing, ultrasonication, microwave, ultraviolet, ohmic heating have emerged in recent decades. These non-thermal treatments expose food to treatment conditions for a fraction of a second, resulting in a reduction in microbial load and an improvement in shelf-life, as well as favourable sensory and textural features (Choudhary et al., 2012; Walayat et al., 2022b).

As an emerging technology, high-pressure processing (HPP) has the potential to be applied in many sectors of food processing due to its little harm to product qualities and great effectiveness in decreasing microbial burdens, making it an efficient and eco-friendly technology (Campus, 2010). Numerous studies have recently reported the use of HPP in seafood processing, with the main focus on improving raw meat shelf-life and microbial safety, modifying functional properties of proteins, and improving texture (Ma et al., 2015; Ramirez-Suarez and Morrissey, 2006; Shi et al., 2020). HPP might modify protein structure by varying to degrees of unfolding and denaturation and changed functional qualities of protein such as coagulation, aggregation, or gelation (Ma et al., 2015). HPP has the potential to improve protein functioning and quickly adjust enzyme activity. The impact of HPP on additives and the adaptability of surimi gel has received more attention than any other sophisticated food processing advancement, including ohmic heating, microwave, ultrasonication, and ultraviolet light (Yan et al., 2020). HPP also helps to retain the textural and nutritional aspects of seafood and other meat products by preventing oxidative alterations. HPP, on the other hand, avoided oxidative alterations by increase sulfhydryl concentration and inhibite carbonyl production, resulting in improve textural qualities (Ma et al., 2015). Furthermore, depending on the operational environment, protein supply, protein stability rate, and gelling circumstances, HPP may have an impact on the textural qualities of surimi gel (Ekezie et al., 2017; Ekezie et al., 2018). HPP organises protein molecules significantly by blocking oxidative alterations that promote water holding capacity by creating hydrophobic interactions and hydrogen and disulfide binds (Guo et al., 2019).

Ultrasonication is a new non-thermal technology in the food industry, although it is already a well-established method in other industries (Chemat et al., 2011). Low frequency (16-100 kHz) and high frequency (10-1000 Wcm^{-2}) ultrasonic methods have recently been established as a quick and safe way to change protein structures, functional and physicochemical characteristics (Chemat et al., 2017). Through increasing

$Ca^{[2]+}$ATPase and sulfhydryl content, ultrasonication reduces protein oxidation (surface hydrophobicity and carbonyls) by activating hydrogen and hydrophobic interactions. As a result, gel texture and structure have become more stable (Pan et. al., 2020). When compared to covalent relationships in protein gel structure, ultrasonication increases the total of electrostatic bonds and other non-covalent connections. By adding Na_2SO_3 to the reaction mixture, this reduces the molecular weight and enhances the solubility rate by hydrolyzing disulfide bonds (Hu et al., 2013).

Microwaves are being used more and more in cooking, blanching, rehydration, thawing, pasteurisation, baking, roasting, tempering, and drying (Puligundla et al., 2013; Guo et al., 2017; Ekezie and Cheng, 2017). Microwave processing is becoming increasingly popular due to its strong penetration ability, which results in high heating rates, significant reductions in process time, energy efficiency, and ease of operation. Because of its strong heat transfer capabilities, microwave aided conventional gelation of surimi can improve gelation and save processing time. The mechanism of microwave heating is thought to be its beneficial effect in avoiding myofibrillar protein breakdown and assisting them to assemble, which generates additional disulfide bonding via protein interactions (Liu and Lanier, 2016). When microwave heating was used in the second phase of surimi gelation, the water retaining capacity and gel strength of surimi were greatly increased. Microwave heating results in a larger degree of protein cross-linking via disulfide and non-disulfide covalent connections, which contributes to gelation. Microwave heating improves water holding capacity, which is helped by aggregation of myosin in heavy chain gel (Liang et al., 2020).

Ultraviolet technology is a low-cost, non-thermal technique. It is commonly used for food safety management because it may inactivate microorganisms by destroying their nucleic acid (Ferreiraet al., 2021). Ultraviolet irradiation can produce singlet oxygen, superoxide radicals, and hydroxyl free radicals, all of which can cause protein structure unfolding and increase protein cross-linking (Vaceket al., 2021). Furthermore, ultraviolet irradiation can disrupt original sulfide-sulfide bridges in proteins to create free-sulfhydryl, which can build new sulfide-sulfide bonds in protein molecules (Parracino et al., 2011), promoting protein cross-linking. Along with polysaccharides, UV could lead to better gel hardness, compactness and three-dimensional networks of surimi gel in comparison with control gel due to fewer increases in carbonyls and surface hydrophobicity (Jiang et al., 1998).

Ohmic heating has received a lot of attention in the last two decades for thermal processing of foods because of its fast and uniform treatment, as well as its great energy economy and mechanical simplicity. Many food procedures, including pasteurisation, dehydration, extraction, microbial inactivation, blanching, and freezing, have utilised ohmic heating (de Alwis et al., 1990; Varghese et al., 2014). Ohmic heating is a way of producing heat within food owing to electrical resistance, resulting in a reasonably linear heating rate and uniform temperature distribution. The conductivity of surimi-based paste is enough for the ohmic effect since it includes water and salts. Ohmic heating-induced gelation is highly dependent on heating parameters such as heating speed, heating time, and electrical conductivity (Van et al., 2021). Because ohmic heating transfers electrical energy to thermal energy, the temperature within the meal increases evenly and quickly (Rocha et al., 2020; Leong et al., 2022). There are less sensory alterations, less off-flavor, fewer nutritional losses, and less bioactive degradation as a result (Jafarpour and Hashemi, 2022).

Conclusion

In this review, information was given about the developments in the production of surimi and surimi-based products. Consumers who are conscious of healthy nutrition today demand that ready-to-eat foods to be healthier. In this context, it has become important to reduce the amount of salt used in the surimi sector, which has a large market in the world and is constantly developing, to use natural additives instead of chemical additives, to develop technologies that will prevent the deterioration of surimi-based products by freezing storage or heating. Thus, it will be possible to develop surimi and surimi-based products with better functional and textural properties in line with consumer demands.

Ethical Statement

There is no need for ethical declaration in this study.

Funding Information

Not applicable.

Author Contribution

BBD: *Conceptualization, Writing -review and editing*

Conflict of Interest

The author(s) declare that they have no known competing financial or non-financial, professional, or personal conflicts that could have appeared to influence the work reported in this paper.

References

Alakhrash, F., Anyanwu, U., Tahergorabi, R. (2016). Physicochemical properties of Alaska Pollock (*Theragra chalcograma*) surimi gels with oat bran. LWT Food Sci. Technol., 66, 41–47. https://doi.org/10.1016/j.lwt.2015.10.015.

Altun, B.E. and Yıldız, Z. (2018). Surimi processing technology. Acta Biologica Turcica, 31(4), 203-208.

Aspevik, T. (2016). Fish Protein Hydrolysates Based on Atlantic Salmon By-Products: Enzyme Cost-Efficiency and Characterization of Sensory, Surface-Active and Nutritional Properties. University of Bergen, PhD thesis, 86 pp.

Azadian, M., Moosavi-Nasab, M., Abedi, E. (2012). Comparison of functional properties and SDS-PAGE patterns between fish protein isolate and surimi produced from silver carp, Eur. Food Res. Technol., 235, 83–90, https://doi.org/10.1007/s00217-012-1721-z.

Bakli, S., Chowdhury, S., Nath, S., (2020). Surimi powder: Processing technology and potential application. Journal of Entomology and Zoology Studies, 8(4), 850-859.

Balange, A.K., Benjakul, S. (2009). Effect of oxidised tannic acid on the gel properties of mackerel (*Rastrelliger kanagurta*) mince and surimi prepared by different washing processes. Food Hydrocolloids, 23, 1693-1701. https://doi.org/10.1016/j.foodhyd.2009.01.007.

Benjakul, S., Visessanguan, W., Thongkaew, C., Tanaka, M. (2004a). Effect of frozen storage on chemical and gel-forming properties of fish commonly used for surimi production in Thailand. Food Hydrocolloids, 19, 197-207. https://doi.org/10.1016/j.foodhyd.2004.05.004.

Benjakul, S., Visessanguan, W., Tueksuban, J., Tanak, M. (2004b). Effect of some protein additives on proteolysis and gel-forming abilityof lizardfish (*Saurida tumbil*). Food Hydrocolloids, 18, 395-401. https://doi.org/10.1016/S0268-005X(03)00127-9.

Bentis, C.A., Zotos, A., Petridis, D. (2005). Production of fish-protein products (surimi) from small pelagic fish (*Sardinops pilchardusts*), underutilized by the industry. Journal of Food Engineering, 68, 303-308. https://doi.org/10.1016/j.jfoodeng.2004.06.003.

Birmpa, A., Sfika, V., Vantarakis, A. (2013). Ultraviolet light and Ultrasound as non-thermal treatments for the inactivation of microorganisms in fresh ready-to-eat foods. Int. J. Food Microbiol., 167, 96–102. https://doi.org/10.1016/j.ijfoodmicro.2013.06.005.

Bourtoom, T., Chinnan, M.S., Jantawat, P., Sanguandeekul, R. (2009). Recovery and characterization of proteins precipitated from surimi wash-water. Journal of LWT - Food Science and Technology, 42, 599-605. https://doi.org/10.1016/j.lwt.2008.09.001.

Buyruk, G. (2005). The sensory properties and food composition quality of surimi prepared from tilapia (*Oreochromis niloticus*). MsC Thesis, University of Çukurova, 37p.

Campo, L., Tovar, C. (2008). Influence of the starch content in the viscoelastic properties of surimi gels. Journal of Food Engineering, 84, 140–147. https://doi.org/10.1016/j.jfoodeng.2007.05.011

Campus, M. (2010). High pressure processing of meat, meat products and seafood. Food Engineering Reviews, 2(4), 256–273. https://doi.org/10.1007/s12393-010-9028-y.

Cardoso, C., Mendes, R., Nunes, M. L. (2007). Dietary fibers' effect on the textural properties of fish heat-induced gels. J. Aquat. Food Prod. Technol., 16, 19–30. https://doi.org/10.1300/J030v16n03_03.

Cardoso, C., Mendes, R., Vaz-Pires, P., Nunes, M. L. (2009). Effect of dietary fibre and MTGase on the quality of mackerel surimi gels. J. Sci. Food Agric., 2 (89), 1648-1658. https://doi.org/10.1002/jsfa.3636.

Carjaval, P.A., Lanier, T.C., Macdonald, G.A. (2005). Stabilization of protein in surimi. Ed: Park JW (2nd) Surimi and Surimi Seafood, CRC Press, Boca Raton F, 163-213.

Chaijan, M., Benjakul, S., Visessanguan, W., Faustman, C. (2006). Physicochemical properties, gel-forming ability and myoglobin content of sardine (*Sardinella gibbosa*) and mackerel (*Restrelliger kanagurta*) surimi produced by conventional method and alkaline solubilisation process. Journal of European Food Research Technology., 222, 58-63. https://doi.org/10.1007/s00217-005-0091-1.

Chaijan, M., Panpipat, W. and Benjakul, S. (2010). Physicochemical properties and gel-forming ability of surimi from three species of mackerel caught in southern thailand, Food Chemistry, 121, 85–92, https://doi.org/10.1016/j.foodchem.2009.12.007.

Chalamaiah, M., Kumar, B. D., Hemalatha, R., Jyothirmayi, T. (2012). Fish protein hydrolysates: proximate composition, amino acid composition, antioxidant activities and applications: A review. Food Chemistry, 135, 3020–3038. https://doi.org/10.1016/j.foodchem.2012.06.100

Chemat, F., Rombaut, N., Sicaire, A.G., Meullemiestre, A., Fabiano-Tixier, A. S., Abert-Vian, M. (2017). Ultrasound assisted extraction of food and natural products. Mechanisms, techniques, combinations, protocols and applications. A review. Ultrason. Sonochem., 34, 540–560. https://doi.org/10.1016/j.ultsonch.2016.06.035.

Chemat, F., Zill, E. H., Khan, M.K. (2011). Applications of ultrasound in food technology: Processing, preservation and extraction. Ultrason Sonochem., 18, 813–35. https://doi.org/10.1016/j.ultsonch.2010.11.023.

Chen, J., Deng, T., Wang, C., Mi, H., Yi, S., Li, X. and Lia, J. (2020). Effect of hydrocolloids on gel properties and protein secondary structure of silver carp surimi. J. Sci. Food Agric., 100, 2252–2260. https://doi.org/10.1002/jsfa.10254.

Choudhary, R., Bandla, S. (2012). Ultraviolet pasteurization for food industry. Int. J. Food Sci. Nutr. Eng., 2, 12–5. https://doi.org/10.5923/j.food.20120201.03.

Çaklı, Ş. and Duyar, H.A. Surimi Technology. E.U. Journal of Fisheries and Aquatic Sciences, 18(1-2), 255-269 (2001).

Dağtekin, B. B. (2015). Investigation of quality changes in fish fingers made from prussian carp (*Carassius gibelio*) protein isolates produced by surimi and pH shifting methods during the frozen storage, , PhD Thesis, Mersin University, 152 pp.

de Alwis, A.A.P. and Fryer, P.J. (1992). Operability of the Ohmic heating process: Electrical conductivity effects. Journal of Food Engineering, 15(1), 21–48. https://doi.org/10.1016/0260-8774(92)90038-8.

Ekezie, F.G.C., Cheng, J.H., Sun, D.W. (2018). Effects of nonthermal food processing technologies on food allergens: A review of recent research advances. Trends Food Sci. Technol., 74, 12–25. https://doi.org/10.1016/j.tifs.2018.01.007.

Ekezie, F.G.C., Sun, D.W., Cheng, J. H. (2017). A review on recent advances in cold plasma technology for the food industry: Current applications and future trends. Trends Food Sci. Technol., 69, 46–58. https://doi.org/10.1016/j.tifs.2017.08.007.

Elyasi, A., Zakipour Rahim Abadi, E., Sahari, M.A. and Zare, P. (2010). Chemical and microbial changes of fish fingers made from mince and surimi of common carp (*Cyprinus carpio* L., 1758). International Food Research Journal, 17, 915-920.

Espinosa, M.C., Díaz, P., Linares, M.B., Teruel, M.R., and

Garrido, M.D. (2015). Quality characteristics of sous vide ready to eat seabream processed by high pressure. LWT - Food Science and Technology, 64(2), 657–662. https://doi.org/10.1016/j.lwt.2015.06.027.

Eymard, S., Carcouet, E., Rochet, M.J., Dumay, J., Chopin, C. and Genot, C. (2005). Development of lipid oxidation during manufacturing of horse mackerel surimi. Journal of the Science of Food and Agriculture, 85(10), 1750-1756. https://doi.org/10.1002/jsfa.2145.

Fan, M., Hu, T., Zhao, S., Xiong, S., Xie, J., Huang, Q. (2017). Gel characteristics and microstructure of fish myofibrillar protein/cassava starch composites. Food Chem., 218, 221–230. https://doi.org/10.1016/j.foodchem.2016.09.068.

Ferreira, C.D., Lang, G.H., Lindemann, I.d.S., Timm, NdS, Hoffmann, J.F., Ziegler, V., Oliveira M.d. (2021). Postharvest UV-C irradiation for fungal control and reduction of mycotoxins in brown, black, and red rice during long-term storage. Food Chemistry, 339, 127810. https://doi.org/10.1016/j.foodchem.2020.127810.

Fernandez-Diaz, M.D., Montero, P., Gomez-Guillen, M.C. (2001). Gel properties of collagens from skins of cod (*Gadus morhua*) and hake (*Merluccius merluccius*) and their modification by the coenhancers magnesium sulphate, glycerol and transglutaminase. Food Chemistry, 74(2), 161-167. https://doi.org/10.1016/S0308-8146(01)00110-8.

Fishery and Statistics. (2020). Global aquaculture production 1950–2017 (FishstatJ). FAO Fisheries and Aquaculture Department. Rome.

Grete, L., Elinor, Y., Ragnar, L. O. and Taran, S. (2010). Thermal inactivation and growth potential of *Listeria innocua* in rehydrated salt cured cod prepared for ready-to-eat products. Food Control, 21(8), 1121–6. , https://doi.org/10.1016/j.foodcont.2010.01.006.

Guo, B., Zhou, A., Liu, G., Ying, D., Xiao, J., Miao, J. (2019). Changes of physicochemical properties of greater lizardfish (*Saurida tumbil*) surimi gels treated with high pressure combined with microbial transglutaminase. J. Food Process. Preserv., 43, e14150. https://doi.org/10.1111/jfpp.14150.

Guo, Q., Sun, D., Cheng, J., Han, Z. (2017). Microwave processing techniques and their recent applications in the food industry. Trends in Food Science, 67, 236-247. https://doi.org/10.1016/j.tifs.2017.07.007.

Habibi, H., Khosravi-Darani, K. (2017). Effective variables on production and structure of xanthan gum and its food applications: A review. Biocatal. Agric. Biotechnol., 10, 130–140. https://doi.org/10.1016/j.bcab.2017.02.013.

Henchion, M., Hayes, M., Mullen, A.M., Fenelon, M., Tiwari, B. (2017). Future protein supply and demand: strategies and factors influencing a sustainable equilibrium. Foods 6, 53. https://doi.org/10.3390/foods6070053.

Hsu, K. (2010). Purification of antioxidative peptides prepared from enzymatic hydrolysates of tuna dark muscle by-product. Food Chemistry, 122, 42–48. https://doi.org/10.1016/j.foodchem.2010.02.013.

Hu, H., Li-Chan, E.C., Wan, L., Tian, M., Pan, S. (2013). The effect of high intensity ultrasonic pre-treatment on the properties of soybean protein isolate gel induced by calcium sulfate. Food Hydrocoll., 32, 303–311. https://doi.org/10.1016/j.foodhyd.2013.01.016.

Hunt, A., Park, J.W., Handa, A. (2009). Effect of various types of egg white on characteristics and gelation of fish myofibrillar proteins. J. Food Sci., 74, C683–C692. https://doi.org/10.1111/j.1750-3841.2009.01354.x.

Jadhav, H.B., Annapure, U.S. and Deshmukh, R.R. (2021). Non-thermal technologies for food processing. Front. Nutr. 8, 657090. https://doi.org/10.3389/fnut.2021.657090.

Jafarpour, D., Hashemi, S.M. B. (2022). Ohmic heating application in food processing: recent achievements and perspectives. Foods and Raw Materials, 10(2), 216–226 http://doi.org/10.21603/2308-4057-2022-2-531.

Jia, R., Katano, T., Yoshimoto, Y., Gao, Y., Watanabe, Y., Nakazawa, N., Osako, K., Okazaki, E. (2018). Sweet potato starch with low pasting temperature to improve the gelling quality of surimi gels after freezing. Food Hydrocoll., 81, 467–473. https://doi.org/10.1016/j.foodhyd.2018.03.024.

Jiang, S.T., Leu, A.S.Z., Tsai, G.J. (1998). Cross-linking of mackerel surimi actomyosin by microbial transglutaminase and ultraviolet irradiation. J. Agric. Food Chem., 46, 5278–5282. https://doi.org/10.1021/jf9806614.

Jommark, N., Runglerdkriangkrai, J., Konno, K., Ratana-arporn, P. (2018). Effect of cryoprotectants on suppression of protein structure deterioration induced by freeze-thaw cycle in pacific white shrimp. J. Aquat. Food Prod. Technol., 27, 91–106. https://doi.org/10.1080/ 10498850.2017.1404532.

Kaba, N. (2006). The determination of technology and storage period of surimi production from anchovy (*Engraulis encrasicholus* L., 1758). Turkish Journal of Fisheries and Aquatic Sciences, 6, 29-35.

Khan, M. A., Ali, S., Abid, M., Cao, J., Jabbar, S., Tume, R. K., Zhou, G. (2014). Improved duck meat quality by application of high pressure and heat: A study of water mobility and compartmentalization, protein denaturation and textural properties. Food Research International, 62, 926–933. https://doi.org/10.1016/j.foodres.2014.04.006.

Kim, S. K., Wijesekara, I. (2010). Development and biological activities of marine-derived bioactive peptides: A review. J. Funct. Foods. 2(1), 1–9. https://doi.org/10.1016/j.jff.2010.01.003.

Kobayashi, Y., Mayer, S. G., Park, J. W. (2017). FT-IR and Raman spectroscopies determine structural changes of tilapia fish protein isolate and surimi under different comminution conditions. Food Chemistry, 226, 156–164. https://doi.org/10.1016/j.foodchem.2017.01.068.

Kong, B., Guo, Y., Xia, X., Liu, Q., Li, Y., Chen, H. (2013). Cryoprotectants reduce protein oxidation and structure deterioration ınduced by freeze-thaw cycles in common carp (*Cyprinus carpio*) Surimi. Food Biophys., 8, 104–111. https://doi.org/10.1007/s11483-012-9281- 0.

Kong, W., Zhang, T., Feng, D., Xue, Y., Wang, Y., Li, Z. et al. (2016). Effects of modified starches on the gel properties of alaska pollock surimi subjected to different temperature treatments. Food Hydrocolloids, 56, 20–28. https://doi.org/10.1016/j.foodhyd.2015.11.023.

Koubaa, M., Roselló-Soto, E., Barba-Orellana, S., Barba, F.J. (2016). Novel Thermal Technologies and Fermentation. In: Ojha, K., Tiwari, B. (eds) Novel Food Fermentation Technologies. Food Engineering Series. Springer, Cham. https://doi.org/10.1007/978-3-319-42457-6_8.

Kristinsson, H.G., Demir, N., Ingadottir, B., Petty, H. (2003). The functional and physical properties of protein ıngredients made from muscles of warm water fish species. Proceedings of First Joint Trans Atlantic Fisheries Technology 2003 Conference, 301-303. Iceland.

Kristinsson, H.G., Hultin, H.O. (2003). Changes in conformation and subunit assembly of cod myosin at low and high pH and after subsequent refolding. Journal of Agricultural and Food Chemistry., 51, 7187-7196. https://doi.org/10.1021/jf026193m.

Leong, S.Y., Oey, I. (2022). Application of novel thermal technology in foods processing. Foods,11(1). https://doi.org/10.3390/foods11010125.

Liang, F., Lin, L., Zhu, Y., Jiang, S., Lu, J. (2020). Comparative study between surimi gel and surimi/crabmeat mixed gel on nutritional properties, flavor characteristics, color, and texture, Journal of Aquatic Food Product Technology, 29(7), 681-692. https://doi.org/10.1080/10498850.2020.1789253.

Lin, D., Zhang, L., Li, R., Zheng, B., Rea, M. C., and Miao, S. (2019). Effect of plant protein mixtures on the microstructure and rheological properties of myofibrillar protein gel derived from red sea bream (Pagrosomus major). Food Hydrocolloids, 96, 537–545. https://doi.org/10.1016/j.foodhyd.2019.05.043.

Liu, Q., Kong, B., Han, J., Chen, Q., He, X. (2014). Effects of superchilling and cryoprotectants on the quality of common carp (Cyprinus carpio) surimi microbial growth, oxidation and physiochemical properties, LWT – Food Science and Technology, 57(1), 165-171. https://doi.org/10.1016/j.lwt.2014.01.00.

Liu, W., Lanier, T.C. (2016). Rapid (microwave) heating rate effects on texture, fat/water holding, and microstructure of cooked comminuted meat batters. Food Research International, 81, 108-113. https://doi.org/10.1016/j.foodres.2016.01.005.

Luo, H., Sheng, Z., Guo, C., Jia, R., Yang, W. (2021). Quality attributes enhancement of ready-to-eat hairtail fish balls by high-pressure processing, LWT, 147, 111658, https://doi.org/10.1016/j.lwt.2021.111658.

Ma, X., Yi, S., Yu, Y., Li, J., Chen, J. (2015). Changes in gel properties and water properties of nemipterus virgatus surimi gel induced by high-pressure processing. LWT - Food Science and Technology, 61(2), 377–384. https://doi.org/10.1016/j. lwt.2014.12.041.

Mao, L. and Wu, T. (2007). Gelling properties and lipid oxidation of kamaboko gels from grass carp (*Ctenopharyngodon idellus*) influenced by chitosan. Journal of Food Engineering, 82, 128–134. https://doi.org/10.1016/j.jfoodeng.2007.01.015.

Mi, H., Li, Y., Wang, C., Yi, S., Li, X., Li, J. (2021). The interaction of starch-gums and their effect on gel properties and protein conformation of silver carp surimi. Food Hydrocolloids, 112, 106290. https://doi.org/10.1016/j.foodhyd.2020.106290.

Mohtar, N.F., Perera, C., Quek, S.Y. (2010). Optimisation of gelatine extraction from hoki (*Macruronus novaezelandiae*) skins and measurement of gel strength and SDS–PAGE. Food Chemistry, 122, 307-313. https://doi.org/10.1016/j.foodchem.2010.02.027.

Moreno H.M., Herranz B., Perez-Mateos M., Sanchez-Alonso I. and Borderias A. J. (2016). New alternatives in seafood restructured products, Critical Reviews in Food Science and Nutrition, 56(2), 237-248. https://doi.org/10.1080/10408398.2012.719942.

Muraleedharan, V., Gopakumar, K. (1998). Preparation and properties of functional protein concentrate from Tuna (*Euthynnus affinis*). In: Fish utilization in Asia and the Pacific. Proceedings of the APFIC symposium, Beijing, 24-26.

Muriel-Galet, V., Lopez-Carballoi G., Gavara, R. and Hernandez-Munoz, P. (2015). Antimicrobial effectiveness of lauroyl arginate incorporated into ethylene vinyl alcohol copolymers to extend the shelflife of chicken stock and surimi sticks. Food and Bioprocess Technology, 8(1), 208–217. https://doi.org/10.1007/s11947-014-1391-x.

Nielsen, R., Plgott, G. (1994). Gel strength ıncreased in low-grade heat-set surimi with blended phosphates. J. Food Sci., 59, 246–250. https://doi.org/10.1111/j.1365-2621.1994.tb06940.x.

Nopianti, R., Huda, N., Fazilah, A., Ismail, N., Easa, A.M. (2012). Effect of different types of low sweetness sugar on physicochemical properties of threadfin bream surimi (N*emipterus spp.*) during frozen storage. International Food Research Journal, 19(3), 1011-1021.

Nopianti, R., Huda, N., Ismail, N. (2010). Loss of functional properties of proteins during frozen storage and improvement of gel-forming properties of surimi. As. J. Food Ag-Ind., 3(6), 535-547.

Pan, J., Lian, H., Jia, H., Li, S., Hao, R., Wang, Y., Zhang, X., Dong, X. (2020). Ultrasound treatment modified the functional mode of gallic acid on properties of fish myofibrillar protein. Food Chem., 320, 126637. https://doi.org/10.1016/j.foodchem.2020.126637.

Pan, J., Shen, H. and Luo, Y. (2010). Cryoprotective effects of trehalose on grasscarp (*Ctenopharyngodon idellus*) surimi during frozen storage. J. Food Process Preserv., 34, 715–727. https://doi.org/10.1111/j.1745-4549.2009.00388.x.

Parracino, A., Gajula, G.P., di Gennaro, A.K., Correia, M., Neves-Petersen, M.T., Rafaelsen, J., Petersen, S.B. (2011). Photonic immobilization of bsa for nanobiomedical applications: cre-ation of high density microarrays and süper paramagnetic bioconjugates. Biotechnology and Bioengineering, 108(5), 999-1010. https://doi.org/10.1002/bit.23015.

Park, J.W. (2005). Surimi and Surimi Seafood. Marcel Dekker, Inc., New York.

Park, J.W., Yongsawatdigul, J., Tadpitchayangkoon, P. (2012). Gelation characteristics of tropical surimi under water bath and ohmic heating. Journal of LWT - Food Science and Technology, 46, 97-103. https://doi.org/10.1016/j.lwt.2011.10.020.

Park, S. H., Lee, H. J., Yoon, I. S., Lee, G. W., Kim, J. S., Heu, M. S. (2016). Protein Functionality of concentrates prepared from yellowfin tuna (*Thunnus albacares*) roe by cook-dried. Process. Food Sci. Biotechnol., 25 (6), 1569–1575. https://doi.org/10.1007/s10068-016-0242-0.

Pizarro-Oteíza, S., Briones-Labarca, V., Pérez-Won, M., Uribe, E., Lemus Mondaca, R., Cañas-Sarazúa, R., et al. (2020). Enzymatic impregnation by high hydrostatic pressure as pretreatment for the tenderization process of Chilean abalone (*Concholepas concholepas*). Innov Food Sci Emerg Technol., 65, 102451. https://doi.org/10.1016/j.ifset.2020.102451.

Puligundla, P., Abdullah, S.A., Choi, W., Jun, S., Oh, S.E., Ko S. (2013). Potentials of microwave heating technology for select food processing applications - a brief overview and update. Journal of Food Processing and Technology, 4(11), 278. https://doi.org/10.4172/2157-7110.1000278.

Quan, T. H., Benjakul, S. (2017). Comparative study on the effect of duck and hen egg albumens on proteolysis and gel property of sardine surimi. Int. J. Food Prop., 20, S2786–S2797. https://doi.org/10.1080/10942912.2017.1374290.

Ramirez-Suarez, J. C., Morrissey, M. T. (2006). Effect of high pressure processing (HPP) on shelf life of albacore tuna

(*Thunnus alalunga*) minced muscle. Innovative Food Science and Emerging Technologies, 7(1), 19–27. https://doi.org/10.1016/j.ifset.2005.08.004.

Rawdkuen, S., Benjakul, S. (2008). Whey protein concentrate: autolysis ınhibition and effects on the gel properties of surimi prepared from tropical fish. Food Chem., 106, 1077–1084. https://doi.org/10.1016/j.foodchem.2007.07.028.

Rocha, R.S., Silva, R., Guimarães, J.T., Balthazar, C.F., Pimentel, T.C., Neto, R.P.C., et al. (2020). Possibilities for using ohmic heating in Minas Frescal cheese production. Food Research International., 131. https://doi.org/10.1016/j.foodres.2020.109027.

Santana, P., Zilda, D., Huda, N. (2017). Physicochemical properties of surimi powder made from threadfin bream (*Nemipterus japonicus*) with various dryoprotectants added. J. Fundam. Appl. Sci., 9, 866–874. https://doi.org/10.4314/jfas.v9i2s.54.

Shi, L., Xiong, G., Yin, T., Ding, A., Li, X., Wu, W., et al. (2020). Effects of ultra-high pressure treatment on the protein denaturation and water properties of red swamp crayfish (*Procambarus clarkia*). LWT - Food Science and Technology, 133, 110124. https://doi.org/10.1016/j.lwt.2020.110124.

Singh, A., Benjakul, S. (2017). Effect of serine protease ınhibitor from squid ovary on gel properties of surimi from ındian mackerel. J. Texture Stud., 48, 541–549. https://doi.org/10.1111/jtxs.12262.

Sultanbawa, Y. and Li-Chan, E.C. (1998). Cryoprotective Effects of Sugar and Polyol Blends in Ling Cod Surimi During Frozen Storage. Food Research International, 31(2), 87-98. https://doi.org/10.1016/S0963-9969(98)00063-5.

Turan, H. and Sönmez, G. (2007). Changes in the quality of surimi made from thornback ray (*Raja clavata*, L. 1758) during frozen storage. International Journal of Food Sciences and Nutrition, 58(7), 557-566. https://doi.org/10.1080/09637480701343762.

Uresti, R., López-Arias, N., González-Cabriales, J., Ramirez, J., Vázquez, M. (2003). Use of amidated low methoxyl pectin to produce fish restructured products. Food Hydrocol., 17, 171–176. https://doi.org/10.1016/S0268-005X(02)00049-8.

Uresti, R.M., Velazquez, G., Vázquez, M., Jose, A., Ramirez, J., Torres, A. (2006). Effects of combining microbial transglutaminase and high-pressure processing treatments on the mechanical properties of heat-induced gels prepared from arrow tooth flounder (*Atheresthes stomias*). Food Chemistry, 94, 202-209. https://doi.org/10.1016/j.foodchem.2004.11.005.

Vacek, J., Vostalova, J., Papouskova, B., Skarupova, D., Kos, M., Kabelac, M., Storch, J. (2021). Antioxidant function of phytocannabinoids: Molecular basis of their stability and cytoprotective properties under UV-irradiation. Free Radical Biology and Medicine, 164, 258-270. https://doi.org/10.1016/j.freeradbiomed.2021.01.012.

Van, Y.N. Ngan, N.H., Okazaki, E. (2021). The effect of heating factors on the properties of heat-induced surimi gel under ohmic heating. Can Tho University Journal of Science 13(2), 32-42. https://doi.org/10.22144/ctu.jen.2021.028.

Vareltsiz, K., Zetou, F., Soultos, N. and Tsiaras, I. (1989). Use of hake (*Merluccius merluccius*) surimi in a frankfurter formulation. International Journal of Food Sci. and Tech., 24, 277-281. https://doi.org/10.1111/j.1365-2621.1989.tb00645.x.

Varghese, K.S., Pandey, M.C., Radhakrishna, K.,Bawa, A.S. (2014). Technology, applications and modelling of ohmic heating: A review. Journal of Food Science and Technology, 51(10), 2304-2317.

Walayat, N., Liu, J., Nawaz, A., Aadil, R.M., López-Pedrouso, M., Lorenzo, J.M. (2022b). Role of food hydrocolloids as antioxidants along with modern processing techniques on the surimi protein gel textural properties, developments, limitation and future perspectives. Antioxidants, 2022, 11, 486. https://doi.org/(10.3390/antiox11030486.

Walayat, N., Xiong, H., Xiong, Z., Moreno, H. M., Nawaz, A., Niaz, N. and Randhawa, M. A. (2022a). Role of cryoprotectants in surimi and factors affecting surimi gel properties: A review, Food Reviews International, 38(6), 1103-1122, https://doi.org/10.1080/87559129.2020.1768403.

Wiriyaphan, C., Chitsomboon, B., Roytrakul, S., Yongsawadigul, J. (2013). Isolation and ıdentification of antioxidative peptides from hydrolysate of threadfin bream surimi processing byproduct. J. Funct. Foods, 5(4), 1654–1664. https://doi.org/10.1016/j.jff.2013.07.009.

Xiong, Y., Lou, X., Wang, C., Moody, W., Harmon, R. (2000). Protein extraction from chicken myofibrils irrigated with various polyphosphate and NaCl Solutions. J. Food Sci., 65, 96–100. https://doi.org/10.1111/j.1365-2621.2000.tb15962.x.

Yan, B., Jiao, X., Zhu, H., Wang, Q., Huang, J., Zhao, J., Cao, H., Zhou, W., Zhang, W., Ye, W., et al. (2020). Chemical interactions involved in microwave heat-induced surimi gel fortified with fish oil and its formation mechanism. Food Hydrocoll., 105, 105779. https://doi.org/10.1016/j.foodhyd.2020.105779.

Yanar, Y., Fenercioğlu, H. (1999). The utilization of carp (*Cyprinus carpio*) flesh as fish ball. Journal of Veterinary and Animal Sciences, 23, 361-365.

Yang, Z., Wang, W., Wang, H., Ye, Q. (2014). Effects of a highly resistant rice starch and pre-incubation temperatures on the physicochemical properties of surimi gel from grass carp (*Ctenopharynodon idellus*). Food Chem., 145, 212–219. https://doi.org/10.1016/j. foodchem.2013.08.040.

Yin, T., and Park, J. W. (2015). Optimum processing conditions for slowly heated surimi seafood using protease-laden Pacific whiting surimi. Lebensmittel-Wissenschaft und - Technologie- Food Science and Technology, 63, 490–496. https://doi.org/10.1016/j.lwt.2015.02.033.

Zhang, B., Fang, C.D., Hao, G.J., Zhang, Y.Y. (2018). Effect of kappa-carrageenan oligosaccharides on myofibrillar protein oxidation in peeled shrimp (*Litopenaeus vannamei*) during long-term frozen storage. Food Chem., 245, 254–261. https://doi.org/10.1016/j.foodchem.2017.10.112.

Zhang, L., Xue, Y., Xu, J., Li, Z. and Xue, C. (2013). Effects of high-temperature treatment (100ºC) on Alaska Pollock (*Theragra chalcogramma*) surimi gels. Journal of Food Engineering 115 (1):115–20. https://doi.org/10.1016/j.jfoodeng.2012.10.006.

Zhang, S., Marini, D. M., Hwang, W., Santoso, S. (2002). Design of nanostructured biological materials through self-assembly of peptides and proteins. Curr. Opin. Chem. Biol. 6 (6), 865–871. https://doi.org/10.1016/s1367-5931(02)00391-5.

Zhou, A., Benjakul, S., Pan, K., Gong, J. and Liu, X. (2006). Cryoprotective effects of trehalose and sodium lactate on tilapia (*Sarotherodon nilotica*) surimi during frozen storage. Food Chemistry, 96: 96–103. https://doi.org/10.1016/j.foodchem.2005.02.013.