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Emerging Technologies in Fish Processing

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Abstract

Health, nutrition and convenience are the major factors driving the global food industry. Fish products have attracted considerable attention as a source of protein, vitamins, minerals, fats and rank third among the food categories with fastest overall growth worldwide. As fish is highly perishable, proper processing and packaging helps in maintaining the quality of fish.

Introduction

Consumers demand high quality processed foods with minimal changes in nutritional and sensory properties. Alternative or novel processing technologies are being explored and implemented to provide safe, fresher-tasting, nutritive foods without the use of heat or chemical preservatives. Recent developments have improved techniques in handling, product development, packaging, preservation and storage. To consumers, the most important attributes of a food product are its sensory characteristics. A goal of food manufacturers is to develop and employ processing technologies that retain or create desirable sensory qualities or reduce undesirable changes in food due to processing.

Sea foods are highly perishable and usually spoil faster than other muscle foods. Freshly caught fish undergoes quality changes as a result of autolysis and bacterial activity. Extent of these changes with time determines shelf life of the product. Proper storage conditions are essential to prevent the spoilage of fish and fishery products. Many emerging technologies have the potential to extend the shelf life.

Bio-Preservation

Bacteriocins are a heterogeneous group of antibacterial proteins that vary in spectrum of activity, mode of action, molecular weight, genetic origin and biochemical. Various spices and essential oils have preservative properties and have been used to extend the storage life of fish and fishery products. Natural compounds such as essential oils, chitosan, nisin and lysozyme, bacteriocins have been investigated to replace chemical preservatives and to obtain green label products (Stiles and Hastings, 1991).

Application of Enzymes

Enzymes have been used for the production of various cured and fermented fish products from centuries. Because of their appreciable activity at moderate temperature, products and process have emerged that utilizes enzymes in a deliberate and controlled fashion in the field of food processing. Cold active enzymes including elastase, collagenases, chymotrypsin extracted from Atlantic cod were used in various food processing applications. The other applications of cold active enzymes include caviar production, extraction of carotenoprotein *etc*. Treatment with protease under mild treatment conditions extending for a few hours can result in the recovery of the proteins from fish frame or shrimp shell waste. The role of transglutaminase in surimi production is well established. The gel strength of surimi can be improved by the application of extracellular microbial transglutaminase. Lipase extracted from *Pseudomonas* sp. can be used to produce PUFA enriched cod liver oil. Enzymatic de-skinning of fish fillets was done by partial denaturation of skin collagen using a gentle heat treatment followed by immersion in enzyme solution for several hours at low temperature (0 °C to 10 °C). De-skinning of tuna, Herrin, Squid were also carried out by using different enzyme technology (Haard and Simpson, 1994).

Sous-Vide Cooking

Sous vide or vacuum cooked food is defined as raw materials or raw materials with intermediate foods that are cooked under controlled conditions of temperature and time inside heat stable vacuum pouches. Sous vide cooking differs from traditional cooking methods in two fundamental ways: the raw food is vacuum sealed in heat stable, food grade plastic pouches and the food is cooked using precisely controlled heating. Vacuum sealing has several benefits. It allows heat to be efficiently transferred to the food. It increases the food's shelf life by eliminating the risk of recontamination during storage. It inhibits off flavors from oxidation and prevents evaporative losses of flavor volatiles and moisture during cooking and reduces aerobic bacterial growth. Sous vide products are cooked at 65 °C to 95 °C for a long period of time. After cooking the products are cooled and kept under chill storage. The main factors which determines the microbial safety of sous vide products are intensity of heat used for cooking, cooling time and temperature, control of chilled storage temperature (Church, 1998).

Extrusion

In order to improve the utilization of underutilized fisheries resources, there is a need to minimize the postharvest losses, develop innovative processing technologies and utilize processing waste for industrial and human use. One such technology, which will be suitable for utilization of low value fish or by catch, is extrusion technology. Use of fish mince with cereals for extrusion process will enable production of shelf-stable products at ambient temperature. Extrusion cooking is used in the manufacture of food products such as ready-to-eat breakfast cereals, expanded snacks, pasta, fat-bread, soup and drink bases. The raw material in the form of powder at ambient temperature is fed into extruder at a known feeding rate. The material first gets compacted and then softens and gelatinizes and/or melts to form a plasticized material, which flows downstream into extruder channel. Basically an extruder is a pump, heat exchanger and bio-reactor that simultaneously transfer, mixes, heats, shears, stretches, shapes and transforms chemically and physically at elevated pressure and temperature in a short time. At times, the extrusion cooking process is also referred as High Temperature Short Time process. In extrusion process gelatinization of starch and denaturation of protein ingredient is achieved by combined effect of temperature and mechanical shear. The conversion of raw starch to cook and digestible materials by the application of heat and moisture is called gelatinization. During extrusion the conditions that prevail are high temperature, high shear rate and low moisture available for starch may lead to breakdown of starch molecules to dextrins.

Radio Frequency Thawing

Radiofrequency thawing is similar to microwave ovens where fish products passing through the oven (heater), are subjected to a direct or volumetric heating process in the form of a radio frequency (RF) energy source. The RF heating process depends upon the ionic conductivity of the material being heated. Radio-frequency thawing systems are also available, where the frozen product is placed between two parallel electrodes and alternating radiofrequency energy is applied to the electrodes. Temperature rise within the product is relatively uniform, the degree of uniformity being dependent on the size and composition of the product. It is suggested that 5 cm blocks of fish can be thawed rapidly. However, radio frequency treatments have more promising attributes for processing seafood. At the lower frequencies of RF, penetration of the RF energy into foods is much greater and enables the temperature of blocks to increase from –20 °C to –2 °C or 0 °C. Radio-frequency systems are available in both batch and continuous methods. Batch RF systems operate from 40 kg-h^{-1} to 350 kg-h^{-1} while continuous RF systems can operate from 900 kg-h^{-1} to 3000 kg-h^{-1}.

Infrared and Radiofrequency Processing Technologies

Electromagnetic radiation is a form of energy that is transmitted through the space at an enormous velocity (speed of light). The heat generation in material exposed to EMR could be due to vibrational movement (as in case IR) or rotational movement (as in case of RF and MW) of molecules. Application of EMR heating is gaining popularity in food processing because of its definite advantages over the conventional processes. Faster and efficient heat transfer, low processing cost, uniform product heating and better organoleptic and nutritional value in the processed material are some of the important feature of EMR processing. In conventional heating system like hot air heating, the heat is applied at the surface which is carried inwards through conduction mode of heating. In case of EMR/dielectric heating, the waves can penetrate the material to be absorbed by inner layers. The quick energy absorption causes rapid heat and mass transfer leading to reduced processing time and better product quality. The main advantage of electromagnetic heating over conventional electric and gas oven based heating is its high thermal efficiency in converting the electrical energy to heat in the food. In ordinary ovens, a major portion of the energy is lost in heating the air that surrounds the food, fairly a good amount escapes through the vent, besides being lost through the conduction to the outside air. In contrast, almost all the heat generated by electromagnetic radiations, which reaches the interior of the oven, is produced inside the food material itself. According to the reports the energy efficiency of EMR based systems is 40% to 70%, as compared to approximately 7% to 14% in case of conventional electric and gas ovens.

Infrared (IR) Radiation

In the electromagnetic spectrum, IR occupies the region between visible and microwave radiation and has wavelength in the range of 0.78 µm to 1000 µm. Infrared radiation is broadly classified into near infrared (NIR), mid infrared (MIR) and far infrared (FIR) radiation. While NIR is suitable for HTST processes, FIR is employed for surface heating. Hybrid drying involving MIR and hot air are reported to be suitable for drying of high moisture materials.

The major advantages of IR heating are: i) versatility for any heating applications, ii) energy efficiency of properly designed IR heating system compared to conventional processing, iii) efficient heat transfer to the food material reducing the processing time and energy cost, iv) air inside the chamber is not heated, consequently ambient temperature may be kept at normal levels, v) heating is more uniform than in conventional methods because of simultaneous heating of surface and inner layers, vi) damages to the food product during heating is less due to uniform and controlled heating, vii) retention of nutrients and organoleptic properties, and viii) easy accommodation of IR heating with convective, conductive, and microwave heating making it ideal for hybrid processes. Some of the limitations of IR heating are; it is essentially a surface heating process, thus making it unsuitable for heating material requiring deep heat penetration and high heat insulating materials, since radiation is emitted in straight lines form the source or reflector, the shape of the object to be treated is also an important factor and clean metal surfaces are difficult to heat, especially if they are bright and polished.

Conclusion

Aquatic foods play a vital role in addressing issue of Food & Nutritional security. Product diversification, value addition, increasing exports and reducing post-harvest losses can contribute to economic growth and to reduce hunger in the world. Consumers demand high quality processed products with minimal changes in nutritional and sensory properties. Emerging thermal and non-thermal processing technologies will help in extending shelf life, maintain or improve sensory and nutritive properties, ensures safety, increases convenience, reduce waste, facilitate exports/ cross-boundary trade and most importantly increases economic value.

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