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Thermal Processing of Fishery Products in Flexible and Rigid Containers

J. Bindu[1]*, A. K. Mallick[2] and T. K. S. Gopal[1]

[1] *Central Institute of Fisheries Technology, P. O. Matsyapuri, Cochin - 682 029, India*

[2] *Export Inspection Agency, 6th Floor CMDA Tower II, Gandhi Irwin Road, Chennai - 600 008*

Abstract

Thermal processing, one of the most widely used methods for fish preservation facilitates long-term stability for a wide range of seafood products. In thermal processing, food is preserved in hermetically sealed containers in cooked form for storage at ambient temperature, without compromising on the quality. Over the years, this technology has led to the evolution of new products and packs which have been readily accepted by consumers. This article reviews the early work on thermal processing in cans, its development through various stages, the concept of retort pouches for food processing, their evolvement as containers for thermal processing, different types of packaging films used, their advantages and disadvantages, different types of fish products that were developed in retort pouches and factors affecting heat penetration rate are elaborated. The changes in nutritional quality in terms of vitamins, colour, texture and microbial quality during thermal processing are also discussed.

Key words: Thermal processing, fish, cans, retort pouch, quality changes

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* *E-mail : bindujaganath@gmail.com*

Introduction

Thermal processing is a method of preserving food by heating in sealed containers to eliminate microbial pathogens at a given time and temperature. Nicolas Appert of the late 18th century was the first one who packed food in wide mouth glass bottles, corked, heated and preserved them. However it was in 1864, that Louis Pasteur made it clear that it was the heating process that killed the micro-organisms and extended shelf-life of food. Seafood was one of the first food types to be preserved by canning (Bitting,1937; Jarvis, 1943) The Food and Agriculture Organization of the United Nations (FAO, 1973) stipulated a code of practice for canned fishery products and various factors that influence the thermal resistance of bacteria and processing conditions like pH, buffer components, ionic environment, water activity and composition of the medium required for heat treatment. World over, consumers are showing greater awareness towards packaged food as packaging provides assurance of quality and hygienic environment for food products. In case of thermal processing, packing materials are most important. Different packing materials like glass jars / bottles, tin and aluminium cans were used for thermal processing while recent materials used are polymer coated tin free steel cans (TFS) and opaque and clear retortable pouches.

Thermal processing of fish products in rigid containers

Tin plate can made of steel (98%) with tin (2%) coated on either side is the most commonly used container for canning. The base steel used is referred to as can making quality (CMQ) steel. The poor organoleptic qualities of foods packed in tin containers led to the introduction of the aluminium alloy can for packing meat and fish products as early as 1918. These cans are now extensively used in European countries because of the availability of raw material and electricity and low production cost. Tin Free Steel (TFS) is an important alternative to tin can. TFS can of different manufacturers is known under different names such as can super, Hinac coat and Hi-top. They were originally developed in Japan by electroplating cold rolled steel sheet with chromium in chromic acid. Metal cans are advantageous as packages due to availability in different sizes, their superior strength, high speed manufacturing and ease of filling and closing while the disadvantages are heavy weight, difficulty in reclosing and disposal.

In thermal processing of foods, the heat transfer mechanism is classified as convection, conduction, or combined convection and conduction heating. In case of conduction heating, the movement of heat is by direct transfer of molecular energy within solids whereas in case of convection, heat is transferred by groups of molecules or fluid bulk that moves as a result of differences in the density of the fluid. The first scientific method known as the graphical or general method for the calculation of minimum sterilization processes for canned foods was developed by Bigelow et al. (1920). Ball (1923) developed a mathematical or theoretical method for process calculations while Schultz & Olson (1940) developed a nomographic method for process determination. Stephen & Wiley (1982) compared general method and Ball's formula method for process calculation and found that Balls method was more suitable. Heat process for conduction heating of foods in retortable pouches was determined by Bhowmik & Tandon (1987) and the heat transfer coefficient for retortable pouches was worked out by Lebowitz & Bhowmik (1989). A short-cut method for the calculation of sterilization value F or conduction type heated canned foods was devised by Thijssen et al. (1978) whereas the calculation of optimum sterilization for conduction heating packs was detailed by Thijssen et al. (1980). A series of formulae for estimating thermal diffusivity in foods packed in cylindrical cans were developed by Uno & Hayakawa (1980). Problems of practical importance in thermal processing of canned foods were studied by Naven et al. (1983). A transducer was designed and tested by David & Shoemaker (1985) for directly measuring the lethality during thermal processing. Prediction of thermal processes of packaged solid-liquid food mixture was developed by Lekwauwa & Hayakawa (1986) using a computerized model.

Seafood canning in India was initially confined to shrimp processing (Varma et al., 1969) while different canned fish products were developed subsequently. Rao & Prabhu (1971) used thermocouples for determining the core temperature and rate of heat penetration and F_0 value of processes as applied to commercially packed prawns of different size grades. They concluded that the main transfer of heat to the meat is by convection in hot brine. Canning of ice-stored sardine was standardized by Madhavan et al. (1970) adopting a precooking of brined sardine for 40 min at 0.35-kg cm^{-2} steam. A new packaging medium, namely, curry was proposed as an alternative to conventional brine and oil pack (Rai et al., 1971). Canning of oil sardine in its own juice was described by Nair et al. (1974). Vijayan & Balachandran (1986) developed sardine canned in curry yielding two different tastes, one having medium pungency and the other less pungent. Canning operations for packing mackerel in the form of skinless and boneless fillets in oil were standardized by Saralaya et al. (1975). Effect of various sterilizing values on canned mackerel in natural pack and the corresponding effects on quality were studied by George (1987). Pujar (1988) studied canning of sardines in various styles to different F_0 values and recommended an F_0 value of 10 for optimum qualities. Canning of shellfishes, namely, clams in different media like oil, brine and masala were developed by Saralaya & Nagaraj (1980). Heat penetration characteristics of seerfish processed for various degrees of lethality was studied by Venkateshamurthy (1981). Canning of cultured freshwater fish (rohu) in 'natural style' was standardized by Balachandran & Vijayan (1988). Jeyasekaran & Saralaya (1991) standardized the canning procedure of white sardine in natural pack, oil and brine. Many studies were carried out to standardize the process conditions to can different fishery products in TFS cans. Mallick et al. (2006) standardized rohu curry in north Indian style in TFS cans in different media. Thermal processing of prawn kuruma in retortable pouches and aluminum cans was standardized by Mohan et al. (2006). The total process time can be reduced by rotation of thermally processed tuna in oil in aluminum cans (Ali et al., 2006). Process parameters for ready-to-eat shrimp curry and ready-to-eat squid curry in TFS cans was standardized by Sreenath et al. (2007; 2008). Maheswara et al. (2011) found TFS cans suitable for canning of little tuna in curry medium. Bread spread using crab mince in TFS cans was standardised (Biji et al., 2013) and combination meals of rice and sardine curry in high impact polypropylene trays was found acceptable upto four months of storage (Bindu et al., 2013)

Retort pouch as a thermal processing container

The concept of pouch as a container for food packaging was developed by the US Army Natick Laboratories and a consortium of food packaging companies in the early 1960s (Herbert & Betteson, 1987). The US Military developed a packaging material made up of 75 μ vinyl / 9 μ foil / 25 μ polyester (McGregor, 1959) for use as retort pouch to test pack sliced peaches and beef steaks. In the year 1968-69 commercialization of different products like fish, ham and sausages in foil free and aluminum foil containing pouches was undertaken in Japan (Tsutsumi, 1972). The technical and commercial feasibility of using retort pouches for thermo-processed products has been proven by Hu et al. (1955) and the feasibility of retort pouches for producing different food products by Tripp (1961). The most comprehensive work on flexible packaging for thermal processed foods was done by Lampi (1977). The effect of increased over- pressure levels, entrapped air and temperature on the heat penetration rates in flexible packages was studied by Sara et al. (1989). Retort pouched products are shelf stable and ready to serve which can be used as per convenience of the consumer (Rangarao, 2002). Now retort pouches of low-acid solid foods appear to have attained some commercial acceptance and recognition for their superior quality and more convenient packaging, creating a new segment within the canned foods category (Brody, 2003). The three or four layer retort pouches consist of an outer polyester layer, a middle aluminum layer and an inner cast polypropylene layer (Griffin, 1987). Nylon is also added as an additional layer or is substituted for the aluminum layer to give additional strength in a four layer pouch. Outer polyester layer provides good mechanical resistance to the pouch, the middle aluminium foil is the barrier layer which gives the product a longer shelf life (Rangarao, 2002) and polypropylene has a high melting point and is used as the inner layer to provide critical seal integrity, flexibility, strength and taste and odour compatibility to a wide range of products. The different layers are held together with adhesives which are usually modified polyolefins such as ethylene vinyl acetate. Taylor (2004) reported the possible use of liquid crystal polymers, which have superior oxygen and water vapour barrier properties compared to other polymer films. Introduction of pouches with polyvinylidiene chloride and nylon instead of the aluminium layer tends to permit viewing of the product. These are foil free laminated materials and offer good barriers to oxygen molecules but are not complete barriers and therefore the shelf life is reduced (Jun et al., 2006). Nowadays retort pouch containing a coating of nano particles of silicon dioxide or aluminium oxide on the polyester layer in addition to the other mentioned layers are commercially available in the market. These pouches have good barrier properties and are comparable to aluminium foil pouches (Bygun et al., 2010).

Retort pouches have several advantages over traditional cans, the foremost being their shape, which increases surface area to volume ratio permitting faster rate of heat penetration to the cold point of pouches. Thus the total process time to achieve commercial sterility of the product gets reduced without over cooking the contents, resulting in tremendous energy savings. Reduction in process time also has an advantageous effect on the sensory and nutritional qualities of thermally processed products. Other advantages are light weight, cost effectiveness, ease of opening and reheating.

A review of commercial process time and temperature (Tsutsumi, 1972) indicated that Fo values suitable for commercially canned products are generally adequate for retort pouch products. Most studies conducted on thermal processing of pouches were based on conduction-heated foods. Ohlsson (1980) presented a numerical solution to heat conduction equation in one dimension to obtain an optimal temperature profile for the pouches and to achieve minimum loss in sensory and nutritional quality of the processed food., An analytical method to predict nutrient retention in conduction heating of foods in a rectangular pouch was put forward by Castillo et al. (1980). Hayakawa (1977) developed computerized models to estimate proper thermal processes of canned foods, based on the Ball formula method which can be applied to pouches subjected to thermal sterilization at a constant retort temperature. Comparisons of General and Ball formula methods were also made for pouches processed under water in a still vertical retort (Spinak & Wiley, 1982). All methods described above are applicable to rectangular/cylindrical containers. A model to evaluate thermal processing of a pouch containing conduction-heated food was developed by Tandon & Bhowmik (1986). They also developed a mathematical model to evaluate the thermal processing of a two-dimensional pouch containing conduction-heated food with hot water as the heating medium. The temperature predicted by the model compared well with the experimentally measured temperatures at the center of the pouch and the nutrient retention estimated in this model showed close agreement with experimental measurements.

Critical processing factors, which have been identified in thermal processing of retort pouches include pouch thickness, presence of residual gas, type of heating media and operating pressure (Beverly et al., 1980). Overall heat transfer coefficient from the heating medium (steam and water) to a pouch containing liquid products (curry sauce) was studied both theoretically and experimentally by Terajima (1975). The unit operations in retort pouch processing are generally compared to those of conventional canning. In traditional canning, fish is filled into metal cans or glass jars, hermetically sealed and subjected to temperatures of 121.1°C under pressure to ensure that the slowest heating point within the food reaches a pre-established time temperature integral (Brody, 2003). Successful commercialization of retort pouch in many countries (Nieboer, 1973) has instigated researchers all over the world to determine the feasibility of pouches for packing various foods. Chia et al. (1983) compared the quality of fishery products processed in cans and pouches and found that pouched products have firm texture and score higher in other sensory parameters when compared to cans. They also reported that effective chlorination and two successive pasteurization could extend the shelf life of oyster from two weeks to three months in flexible pouches. Meat, fish, poultry and vegetables in sauces, gravies and curries are the common items packed under foods covered by liquids of low viscosity. These packs are referred to as ready meals (Nieboer, 1973). Process determination for conduction-heated foods in retortable pouch was reported by Tandon & Bhowmik (1986) and Snyder & Henderson (1989) investigated the advantages of using retort pouch in replacing metal can and could observe that pouches had reduced process times. High frequency acoustic imaging system, can be used to detect defects in flexible food packages (Safvi et al., 1997). Retort pouch system requires larger investment than the canning system and with its shorter process time retort pouch processing gives better quality products. Market analysis by Sacharow (2003) in USA and Europe showed bright future for retortable pouches.

Retort pouch can withstand thermal processing and combines the advantages of metal cans and the boil-in-bags (Gopal et al., 1981). Subramanian et al. (1986) suggested indigenous packaging material as suitable for retort pouch processing. Central Institute of Fisheries Technology (CIFT), Cochin identified that three layer configuration of flexible pouch can perform the packaging function equally well as metal cans and is free from disadvantages met with them (Gopal et al., 1998; Vijayan et al., 1998). Physico-chemical properties of indigenous retort pouch are comparable with imported pouches (Vijayalakshmi et al., 2003; Ali et al.,2001). Processing of fish curry in imported and indigenous pouches of 12.5 µm polyester/12 µm aluminium foil/ 87.5 µm cast polypropylene and 12 µm polyester/ 15 µm aluminium foil/70 µm cast polypropylene carried out by Gopal et al. (2001) showed that the pouches were suitable for thermal processing. Spoilage in the flexible pouch is due to the contamination of seal area and a simple device for filling the retort pouch to obtain a clean seal area was discovered by Madhwaraj et al. (1992). CIFT has also developed and standardized a wide variety of fish curries based on different fish species and regional recipes prevalent across India. Standardization of different styles of fish curry using traditional Kerala style recipe has been reported (Vijayan et al., 1998; Gopal et al., 1998; 2002; Ravishankar et al., 2002; Manju et al., 2004). Processing conditions for rohu in curry in retortable pouch was standardised by Sonaji et al. (2002). Shelf life of black clam and ready to eat mussel in retort pouches was one year at ambient storage (Bindu et al., 2004; 2007). Dileep & Sudhakara (2007) found flexible retortable pouch as an alternative to rigid cans for processing *Aristeus alcocki*. Retort pouch processed pearl spot (*Etroplus suratensis*) was acceptable for a period of 9 months (Pandey et al., 2007) while ready-to-eat mackerel curry in Goan style (Ravishankar et al., 2008), PUFA enriched ready to serve tilapia fish curry (Dhanpal et al., 2010), *fish peera,* a traditional product from anchovies (Bindu et al., 2012) and loligo squid rings processed in curry medium (Dileep et al., 2012) were having shelf life of 12 months at ambient temperature.

Quality changes during thermal processing

Effect of high temperature on quality and nutrient retention in thermally processed food has been a major concern since the inception of canning industry. Although pouches were introduced in early 1980s, very less information is available on nutritional retention during processing. Severe heat treatment and presence of certain catalysts in fish muscle favours lipid oxidation and hydrolysis resulting in off flavors and loss of nutrients. Heat treatment triggers browning or maillard reactions which are a series of complex reactions between amino acids and sugars. Saguy & Karel (1979) investigated and developed a method for calculating optimum temperature profile as a function of time to achieve sterilization with maximum nutrient retention. Castillo et al. (1980) developed a model to predict retention of nutrients with first order kinetics of thermal degradation of foods packaged in retort pouches.

Vitamin content

Among water soluble vitamins, vitamin C is known to be rapidly destroyed by heat in presence of air, but it is almost totally preserved if oxygen can be removed during thermal processing. Among the B-vitamins, thiamine and folic acid are heat sensitive and are lost during canning. Loss of vitamin B_1 was up to 70% in canning. Investigations on canned tuna and mackerel showed that during 6 months storage, almost all vitamins were retained without any change, except for a considerable loss of thiamine (Komata et al., 1956). In seafoods, nutrients affected by time-temperature processes are especially vitamins B_1 and C, but loss of other B vitamins occurs. Some other water-soluble nutrients leach out into the liquids but in general, nutrient retention in canned seafood products is at an acceptable level (Pigott & Tucker, 1990). Pre-processing operations like evisceration and cleaning also contribute to loss of vitamins and diffusion of water-soluble vitamins into brine and sauce was up to 30-35% during canning (Bramsnaes, 1962). Braekkan (1962) found fairly equal values for canned and fresh products with respect to vitamin B. Canned mackerel, tuna and salmon were found to be good sources of niacin and vitamin B_6 whereas canned shellfishes showed lower values. Retention of vitamin A and C can be achieved by proper exhausting of cans before sealing. Under normal storage conditions, canned foods show excellent stability against loss of vitamins. Destruction of fat-soluble vitamins was greater for vitamin A and E, while vitamin D and K are normally stable. However, for maximum retention, storage at lower temperature is recommended. Destruction of vitamins follows a first order reaction similar to that of microbial destruction (Fellows, 1990). Thermal destruction of vitamin C in foods packed in retort pouches was reported by Ghani et al. (2002).

Protein and amino acids

Loss of protein can be due to three possible reasons which are pre-cooking, diffusion into liquid and heat destruction during thermal processing. Commercial thermal processing of canned fish products will not destroy significant amount of amino acid except cystine, which is not an essential amino acid (Dunn et al., 1949). Lepkowski (1953) reported the beneficial effects of heat treatment of fish which is due to the inactivation of thiaminase enzyme in some fishes. The effect of canning on the extractable nitrogen fractions showed that there was an increase in the total extractable nitrogen, especially in the exuded liquid (Hughes, 1961). Exposure to canning conditions does not significantly affect the dietary value of protein (Bender, 1972). Protein digestibility and available lysine are two recommended and frequently used indicators to assess the effects of heat treatment on the quality of food proteins. However, due to smaller level of available lysine in fish, the loss of lysine is less (Hurrel & Carpenter, 1977). Seet & Brown (1983) found only a small change in available lysine and protein digestibility in canned albacore subjected to heating in a batch steam retort. A kinetic model for the thermal degradation of available lysine and protein digestibility for albacore canned in oil was developed by Banga et al. (1992) which showed no significant changes in the two parameters. Even though there was a decrease in available lysine levels, it did not alter the nutritional quality of the protein mainly due to the higher levels of lysine in tuna protein. A procedure for predicting nutrient retention during thermal processing, conduction heating of foods in rectangular containers was developed by Barriero et al. (1984). Decrease in amino acids in processed food is due to the heat sensitive nature of amino acids and a reduction of about 10-20% of the amino acids in canned products was reported by Fellows (1990). Purine content of shrimp, especially adenine decreases during thermal processing (Lou, 1997). Amino acids like lysine, cystine, methionine and histidine slightly decreased, whereas aspartic acid and glutamic acid slightly increased after retort pouch processing (Mohan et al., 2006).

Lipids and fatty acids

Lipid composition of marine fish is highly unsaturated and hence oxidation during storage and processing is likely to occur, leading to quality loss (Pearson et al., 1977). However, normal processing procedure such as canning is unlikely to affect the nutritive value of oils adversely (Tarr, 1962). Lipid changes in cooked freshwater fish are least in fillets with high levels of lipids (Mai et al., 1978). An increase in peroxide value has been observed in canned seafood (Tanaka & Taguchi, 1985) while a decrease in thiobarbituric acid value for shrimp, rainbow trout and Alaska Pollock was reported (Chia et al., 1983). Heating processes in canning had little effect on fat and cholesterol contents (Hale & Brown, 1983). Study on the effect of pre-cooking on lipid classes at different loci of albacore found that there was an increase in polyunsaturated fatty acids (PUFA) and a decrease in saturated and mono unsaturated fatty acid (MUFA) contents (Gallardo et al., 1990). Frying of tilapia fillets prior to canning lead to release of moisture from the meat into oil, leading to hydrolysis to form free fatty acids, diglycerides, monoglycerides and glycerol (Shiau & Shue 1989). A general reduction in lipid content of canned and cooked samples with significant increase in free fatty acid (FFA) and phospholipids was noticed during canning of tuna while PUFA content did not vary with cooking or storage (Aubourg et al., 1990). A similar study on sardines by Ruiz-Roso et al. (1998) showed a good deal of loss of fat during pre-cooking. Fatty acids were differently affected, with saturated fatty acid (SFA) and n-3 PUFA content increasing and a marked decrease in the MUFA and n-6 PUFA. Following sterilization there is an intake of fat from the filling oil to fish and consequently an increase in lipid content in fillets. During storage, a decrease in SFA and MUFA and an increase in n-3 PUFA and constancy in n-6 PUFA were noticed. (Siriamornpun et al., 2008). Thermal processing resulted in an increase in free fatty acid content and in secondary oxidation in oil and brine canned sprat (Mahmood & Masoud, 2012).

Organoleptic quality

When subjected to industrial heat treatment, a loss in weight of fish muscle was observed and this was attributed to denaturation (Tarr,1941). Excessive heating of little tuna produced a toughening of texture (Jarvis, 1952). The breakdown of phospholipid and the production of free fatty acids in fish fillets were found to have a good relationship between protein denaturation and taste panel assessment of texture (Olley et al., 1969). Toughness and hardness are probably the most critical textural attributes in meat and seafood products and these depend on the connective tissue consisting mainly of collagen that is responsible for tensile strength and the myofibrils, consisting of myosin and actin (Martens et al., 1982). Opacity of fish flesh increases during cooking due to thermal denaturation and precipitation of sarcoplasmic proteins (Aitken & Connell., 1979). At about 60°C collagen fibers become solubilised and thus the textural changes in fish muscle at higher temperature are related to thermal denaturation of myofibrillar proteins. Protein content primarily influences strain properties while moisture content has primary effect on rigidity (Hamann, 1983). In shrimp, texture toughens during initial stages of heating but softens in the later stages (Ma et al., 1983). Tanaka et al. (1985) found that the quality of canned mackerel processed at different temperatures but receiving equal lethality gets affected and the fish subjected to higher temperature during processing tends to have a tougher texture. Lerchenfeld (1981) investigated different cooking times and temperature and found that toughening of texture was more at 65°C when compared to 100°C. A direct relation between sensory perception of toughness and instrumental shear force was seen in canned shrimp (Ma et al., 1983). Karl & Shrieber (1985) reported an excellent correlation between maximum shear cell force and first–bite hardness and structure retention during mastication for canned fish fillets. Unless supported by sensory texture evaluations, instrumental methods are of limited use and are of value only to processors and researchers for studying textural changes (Aitken & Connell, 1979). Products processed in pouches were superior to canned products with regard to texture hardness and overall acceptability (Mohan et al., 2006). Textural quality of canned skipjack tuna was better in cans subjected to rotation (Martin et al., 2008). For mahseer curry in pouch, the sensory characteristics showed a decrease in flavour scores after nine months of storage due to softening of muscle (Bindu et al., 2011). Sensory and instrumental characteristics indicated a Fo value of 7 as optimum for thermal processed crab kofta (Abhilash et al., 2013).

Colour

Degradation of red colour is an important change taking place during processing and storage of fish and fishery products. The first quality impact by which consumers take a decision to purchase a product is its appearance. Among them, colour is very important and the most common type of discolouration are pigment degradation, browning reactions such as the Maillard reaction and oxidation of ascorbic acid (Mauron, 1981). Free ribose accounts for much of the Maillard type of reaction when fish is heated in presence of carbohydrates (Tarr, 1958). However, excessive heating produces considerable loss in the quality and organoleptic properties of foods (Hayakawa & Timbers, 1977). Thermal processing of different types of fishery product including shrimp in retort pouches and cans showed a lesser change in colour in retort pouch products than in canned products (Chia et al. 1983). Furthermore, these changes may be due to longer processing time employed for canned products to get equal lethality. Tanaka & Taguchi (1985) noticed higher intensity of browning of liquids of canned sardines processed for longer time. Retention of total colour can be used as a quality indicator to evaluate the extent of deterioration due to thermal processing. Salmon muscle colour whiten in the first 10 min of treatment followed by browning as heating progressed (Kong et al., 2007). Changes in colour and overall acceptability were superior in retort pouch products (Mohan et al., 2006). High temperature short time processing is favourable for retaining the colour of retort pouched fish products.

Microbial Safety of thermal processed products

Microbial spoilage in thermally processed food takes place due to several reasons, the important among them being, inadequate pre-processing, under processing, inadequate cooling and leaker infection (Frazier & Westhoff, 1998). Low acid foods are thermal processed to ensure commercial sterility. For maintaining sterility, primarily the container should be hermetically sealed and the seal integrity should be guaranteed (Lopez, 1987). Adequate thermal process lethality to kill the target organism should be given and the temperature at the cold spot which is the most inaccessible part of the food should be recorded by heat penetration (Banga et al., 1991). Time and temperature studies depend on characteristics of the product and container, geometry of the package and the type of heating medium. A hygienic post-process treatment should be carried out and the products should be stored adequately. The water used for cooling should always be chlorinated so that it is not a source of contamination. Thermal processed products should be stored at ambient temperature much below 30°C in order to prevent the outgrowth of thermophilic spores which may have survived the processing. The effect of storage temperature and storage time also are very important for fish products preserved in sauces which are acidic in nature and have corrosive action on the containers used (Lopez, 1987). Safety of a sterilization process can be evaluated according to the lethality achieved and the microbiological risk alteration of the target microorganisms that survive the thermal treatment (Akterian et al., 1997). Heat processing or sterilization is the most critical step during the manufacture of canned products that ensures the sterility of the product (Aubourg, 2001).

Conclusion

Thermal processing, one of the most widely used methods for fish preservation has been used to preserve wide range of seafood product. Processes have evolved over years and the current focus is on optimization of production and saving of time and energy to produce a safe fish product with superior sensory and nutritional quality at a price affordable to the consumer. A Number of factors are taken into account before designing the process since several desirable and undesirable changes may occur during processing. Destruction of microorganisms takes place at a faster rate at higher temperature and hence it is necessary to optimize the rate of heat transfer and to reduce process time thereby maximizing nutritional quality. Factors affecting heat penetration include type of container, filling medium, constituents of the product, size of the container, temperature of heating, type of retort, whether rotating or stationery etc. Cans owing to their convenience, long shelf life and economy form a major segment of processed food market in the international trade and in the recent past, thin profile containers like the retort pouches have gained equal or more importance over metallic cans. Flexible and laminated retort pouch that can withstand thermal processing have advantages of both cans and flexible packages. In view of a fast growing domestic market for convenience products, the future lies bright for thermal processing as people highly prefer ready to serve products with minimum input of time and effort. Further research can be oriented towards new materials, processes and machinery which would ensure steady supply of thermal processed products in the national and international markets. Water immersion retorts which give better contact with the container resulting in products with superior sensory and nutritional attributes and microwavable pouches and thermoformed containers that offer convenience of use are few such areas to be explored.

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