Introduction
1.0 INTRODUCTION

Tunas are among the largest and most specialized and commercially important of all fishes (Collete & Nauen, 1983). They are the fourth major internationally traded fish commodity and contribute 7.6% of the international fish trade in value terms (Thomas, 2008). The Indian Ocean contributes 19% of the world tuna catch (Pillai & Ganga, 2008). Tunas are found in temperate and tropical waters and are distributed all around the world. Tuna and related species belong to six genera of the Family Scombridae. World trends in fishing, processing and trading of tuna are influenced by a number of environmental and socio-economic factors. Fishing activities are influenced by factors such as resource availability, water temperature, current, season and operational costs, whereas processing depends on availability and quality of raw material, product formulation and product costs. The three major species of tropical tuna caught in the Indian ocean are skipjack, yellow fin and big eye. The principal markets for tuna are Japan, USA and the European Union countries. The major commodities traded are sashimi, canned, chilled, frozen and smoked products.

The contribution of India towards global production of tuna is negligible. The potential of the Indian Exclusive Economic Zone is estimated at 2.78 lakh tonnes (Pillai & Jyothi, 2007). In India, tuna fishing is in a transition stage with artisanal activity still remaining as the major production method. Though traditional fisheries for tuna existed in the Maldives and Lakshadweep Islands for more than 100 years, the industrial fishing activity in the Indian Ocean commenced only in the fifties as tuna long line fishery and was followed in the mid eighties by purse seine fishery. However the motorization of traditional crafts and adoption of new technologies for catching tuna has substantially improved the catches. In India, tuna fisheries are concentrated mainly on the coastal region while offshore tuna fishery resources are yet to be commercially exploited. The tuna exports from India have increased from 16,627 t in 2005-2006 to 23,778 t in 2006-2007. Tuna export realization grew from Rs 693.1 million in 2005-2006 to Rs 1303.8 million in 2006-2007 (MPEDA, 2007). Chilled tuna is the highest unit value earning item, while larger quantities of tuna are exported in frozen form. Major form of chilled tuna exported is whole tuna, yellow fin loins and gutted tuna.
The main internationally traded tuna forms are raw material for canning (fresh, frozen and pre-cooked loins), tuna for direct consumption (fresh, chilled and frozen) and canned tuna (solid pack, chunks, flakes and grated). Sashimi graded tuna is a delicacy in Japan and is made from extremely fresh tuna. Blue fin, big eye and yellow fin are the most preferred species for sashimi, whereas skipjack and albacore are preferred for canning. Canned products are packed in oil, brine, spring water or sauce. The principle producers of canned tuna are Thailand, USA and Spain. In 2005, 82% of tuna was consumed as canned product and 18% as fresh product. Japan consumes 78% of fresh tuna involved in the world trade. (Gopal et al., 2008)

There are numerous health benefits of eating tuna. It has high content of Omega-3 polyunsaturated fatty acids. The consumption of such fishes is believed to decrease the risk of heart diseases, reduce cholesterol, regulate blood pressure, prevent arteriosclerosis and have other health benefits. Tuna also contains minerals, such as phosphorous which is important for the nervous system and iodine which is conducive for balanced growth. It also contains vitamins like niacin and vitamin B12 for cell growth and proper metabolism of fatty acids and cholesterol. In spite of these benefits there are some risks associated with the consumption of tuna. The major risk in consumption of improperly handled tuna is histamine poisoning. Histamine is produced mainly due to the bacterial action of the amino acid histidine by the enzyme histidine decarboxylase and is correlated with temperature abuse and improper handling and storage. Another risk is the presence of methyl mercury in the tuna fish. Mercury from the environment gets converted to methyl mercury which gets absorbed into the fish. The fish tend to accumulate the mercury which is found to have a harmful effect on infant and unborn babies.

Proper handling of tuna is required to get a finished product with good quality. Tuna should be harvested with least stress to avoid the accumulation of lactic acid in the flesh so as to avoid the onset of rigor mortis and subsequent spoilage. The harvested tuna must be killed immediately and chilled onboard. Chilling may be by simple icing or using chilled seawater or refrigerated seawater. The fish should be held throughout at 0-1°C. Tuna is frozen onboard at -20 to -30°C for
canning purpose and at -50 to -70°C for raw consumption. Tuna frozen at ultra low temperatures can be stored up to 2 years without much quality changes. Value added products from tuna include Sashimi grade tuna and sushi products which fetch a very high price in the market. Sashimi grade products include tuna loins, saku block, steaks and poke cubes. Canned tuna is the major commercial tuna product which is internationally traded. In India canned tuna is produced in very minor quantities and is mainly for the domestic markets. Several dried products like ‘Mojama’ in the Mediterranean, and smoked ‘Katsuobushi’ in Japan command a high price and demand in the trade. Smoked and dried tuna called ‘masmin’ is a delicacy in the Lakshadweep islands and certain areas of the mainland. Skipjack tuna is utilized for the production of this product. Fishing and preparation of this product is the main source of livelihood for the inhabitants of these islands. Frozen products include whole tuna frozen, tuna fillets, tuna loins and precooked loins. Most of this is used for reuse in the canning industry. Other value added products from tuna include pickled tuna, tuna jerky, tuna biriyani, tuna sausage, tuna shaving, tuna paste, battered and breaded products from tuna etc. Tuna processing waste is also utilized to produce by products like protein hydrolysate, tuna silage, PUFA, tuna orbitals, tuna gelatin, tuna bone powder, tuna viscera powder, tuna skin leather etc.

Packaging plays a very vital role in today’s society; it surrounds, enhances and protects the goods we buy right from processing through handling and storage to the final consumer. Food is packaged to preserve its quality and freshness, and also add appeal to consumers and to facilitate storage and distribution. Seafood scenario the world over is witnessing vast changes. Value addition and diversification to satisfy the ever changing and diverse demands from the importing countries as well as demand from urban markets are major challenges faced by the Indian fish processing industry. The consumers increasingly demand convenience food products that are of high quality, taste, appearance and nutrition. These products should be prepared with minimum preparation time and should be in the ready to cook or ready to eat forms. Increase in expendable income, increase in number of working women, awareness of the different types of convenience products and overall improvement in standards of living have contributed to this change. Technological
upgradation and value addition have been instrumental in processing several products from fish and marketing them in overseas and urban markets.

Thermal processing has been used to achieve long-term shelf stability for a wide range of seafood products and is one of the most widely used methods for fish preservation. The main objective of the thermal processing is to produce a safe and high quality fish product at a price affordable to the consumer. Thermal processing is mainly done in cans. Owing to their convenience, long shelf life and economy, canned foods form a major segment of processed food market. Nicholas Appert, a French confectioner in 1809 invented the art of thermal processing. In 1920, Bigelow and Ball presented the first scientifically based graphical method for calculating minimum process conditions for safe sterilization. In 1923, Ball developed a mathematical model for determination of sterilization process which was followed by a nomographic method for process determination by Olson in 1939. The technology has evolved over the years and currently the main focus is on increased efficiency in energy utilization and production, easy handling, more attractive packaging and better sensory quality (Durance et al., 1997). Attractive packaging materials are available to present various products. The success of thermal sterilization necessitates balancing the beneficial and destructive influence of heat on the desirable characteristics of foods. Several changes occur in food during thermal processing of which some are desirable and some are undesirable. The heat treatment destroys the pathogens and spoilage enzymes that would bring about spoilage of the fish whereas nutritional quality is brought down by processing. The surface of canned meats and other solid-packed products may be darkened by contact with the inner surface of the hot can. Studies have shown that thermal death rates of bacteria generally proceed much faster with increased temperature (Stumbo, 1973). Hence it is necessary to increase the rate of heat transfer into the food so as to reduce process time and maximize the retention of quality factors to get a good product. Thin profile utilizes the concept of larger surface area for rapid heating and cooling of foods packed in retort pouches or thin profile containers. Retort pouch packaging is of recent origin but have gained equal importance due to several reasons over the metallic cans. The retort pouch is a flexible, laminated package that can withstand thermal processing and has the
advantages of cans as well as flexible packages. The pouches show improved heat transfer and reduced process time and promote better quality. Thermal process parameters such as heating rate index (frh), heating lag factor (jch) and cooling lag factor (jcc) for the product help in determining the process time and optimal conditions for heat sterilization. However, these parameters are influenced by factors like mode of agitation, type of heating medium, temperature, rotational speed, headspace, can size and shape, product shape and size and carrier fluid viscosity (Sablani & Ramaswamy, 1995; 1996 and Ramawamy & Sablani, 1997a).

Smoking is another traditional method for preservation of fish and is widely practiced in the hilly, tribal and Lakshadweep islands of India. Major portion of the internationally traded smoked fish is prepared by cold smoking (temperature less than 30°C) by using different smoke flavourings. In tropical countries like India fish is preserved by hot smoking in traditional kilns at higher temperatures (more than 60°C). Masmin from skipjack tuna is the most important commercially available smoked fish product in India. It is the loin which is smoked and dried using coconut wood and husks. However, this product is very hard and represents a piece of wood, dry in texture due to very low moisture content. Though the product is relished by the traditional users there is a lot of inconvenience to the new consumers during usage.

Hence studies to develop an alternate product from tuna capable of storage at ambient temperature for more than a year, with convenience of use and having the same flavour of smoke of coconut husks have been attempted. Since the tuna used in the studies is yellow fin, this study will help in utilizing the smaller fish resources which otherwise will not be used as sashimi grade. The technology and trade of sashimi and chilled products from tuna is yet to catch up in the Indian sub continent, and at present the available catch can be utilized to develop value added products like smoked tuna in retortable pouches, which are ready to use and can be made readily available in the market. This is the first time that such a product has been developed in India by using locally available wood for flavour and having an extended shelf life of a year at ambient temperature.
The objectives of this study are:

1. To develop high moisture smoked tuna products with increased shelf life at ambient temperature storage.
2. To identify and standardize suitable indigenously available wood as the source of smoke flavour.
3. To identify appropriate packaging material for the smoked and thermal processed products.
4. To standardize the heat processing parameters of the product in different packing media.
5. To investigate the heat penetration characteristics of the product in different types of flexible pouches.
6. To investigate the effects of rotational speed on the heat penetration characteristics of smoked tuna products packed in different medium.
7. To investigate the effect of processing on the different smoke components during thermal processing.
8. To determine the shelf life by studying changes in biochemical, sensory and textural characteristics of the developed products during ambient (28 ± 2°C) and accelerated temperature storage (37 ± 2°C).