I. INTRODUCTION

Global total fish catch has increased from 76.7 million metric tonnes in 1984 to 90.2 million metric tonnes in 2003 (FAO, 2005). The world’s population has been increasing more quickly than the total food fish supply; as a result the average per capita fish supply has declined from 16.1 kg in 1984 to 14.3 kg in 2003. The total fish harvest has continued to increase, due to the increase in fish farm production; however, there are limitations on that source also. When looking at individual species, 69% are considered to be either fully exploited or over exploited and on the decline. Only 9% are considered to have potential for increased fishing. The stocks of many high value ground fish have decreased by 70 to 80 % in the last 20 years. To keep production up, there has been an increase in fishing effort for underutilized fish and fish from more distant oceans. Even though fish landings in the East Indian oceans have shown increase in the last 20 years, these areas are now fully exploited (Garcia and Newton, 1997).

The overall export of marine products has reached an all time peak of 1.6 billion US$ during the year 2005-06. The total exports aggregated to 5,12,164 metric tons valued at Rs.7245.30 crore. The export has shown an increase of 11.02% in quantity, 9.01% in Rupee value. European Union continued to be the largest market for Indian marine products during the year 2005-06. Its share was 26.72% in quantity, 29.46% in value followed by USA and Japan. European Union absorbed the major share of Cephalopods (MPEDA, 2005). Export of marine products from India during April, 2006 to January, 2007 aggregated to 5,02,756 tonnes valued at Rs. 6981.29 crores, recording a growth of 16% in quantity and 13% in value compared to the exports achieved during the same period in the previous year(MPEDA, 2007). China was the main importer followed by European Union and Japan with an import share of 35, 24 and 11% (in terms of quantity) respectively.

Cephalopods include squids, cuttlefish and octopus form one of the important marine fishery resources of India, ranking next only to finfish and shellfish (shrimps and lobsters). Japan is the main consumer of octopus, its prices increased sharply during 2004, exceeding US$ 12.00/kg for the larger-sized specimens. This is nearly double the price (yen) paid in 2001. The other major markets for cephalopods are Spain, Italy, Hong-Kong, France, Germany, Greece and Portugal. In recent years the increase in demand for fishery products is mainly due to increased awareness of nutritional status of fish and fishery products.

Cephalopods have received increasing importance as a marine fishery resource because of their high export value and account for 4-5% (1.13 lakh tonnes) of the total marine fish landings. Of the total cephalopod production, 82% is from west coast. In
2004 the total cephalopod production decreased by 3.85%. The cuttlefish and octopus stocks are slightly exploited along both the coasts. Along the east coast, among Octopods, *Octopus membranaceus* Quoy and Gaimard, 1832 is the most dominant followed by *Octopus dolfusi*. According to CMFRI (2005), the landings of *L. duvauceli* and *O. membranaceus* showed declining trend after tsunami.

The octopus inhabits many diverse regions of the ocean, especially coral reefs. There are about 289 different octopus species coming under the genus octopus, which is over one-third the total numbers of cephalopod species. About 38 species are known to occur in Indian seas including Andaman and Lakshdweep waters. Of these, *Octopus membranaceus*, *O. dolfusi*, *O. globosus*, and *Cistopus indicus* are most commonly occurring species and the others are *O. kibensis*, *Octopus dolfini*, *O. macropus*, *O. vulgaris*, *O. indicus*, *Berrya keralensis*, *Haplochlaena muculosa*, *O. aegina*, *Argonanta argo*, *Argonanta hians*, *O. cyaneus*, *O. varunae*, *O. tetricus*, *Berrya annae* etc. India has recorded the total export of 4111.73 tons of octopus, worth of rupees 2295.74 lakhs during the year 2003 (Table.1).

The octopus is known to make seasonal migrations which are influenced by breeding activity. They occur in shallow coastal waters in the intertidal and subtidal areas among rocks, stones or corals hiding themselves among crevices. They are exclusively carnivores, feed on crustaceans, fishes and molluscs. At present octopuses are landed mostly as incidental catches in the traditional fishing gears such as shore seines, boat seines, stake nets and hook and line and in the trawl nets. Their exploitation is still confined to the coastal waters extending to about 45 m depth zone on East and West coasts. There is a potential market for octopus because it is popular seafood and has been consumed in various forms including in raw form. The prospect of export of octopus to the foreign countries has resulted in their increased exploitation. One aspect that makes this group of species especially attractive is their short life-cycle. This is from 1 to 5 years, although in most cases the lifespan is between 8 months and a little under 2 years, so that they constitute a readily renewable resource. Such a high growth rate implies a high rate of protein replacement. The shortness of the time in which females reach sexual maturity can produce considerable changes in the muscle proteins (Mangold, 1987), a factor that is important to bear in mind when examining their behaviour in different types of processing.

The percentage of the edible portion of cephalopods is exceptionally high, between 60 and 80% of total weight, depending on species, size of specimen and sexual maturity, whereas in fish the percentage is only 40-70% (Sikorski and Kolodziejska 1986). *Octopus* is considered as a delicacy in many countries since it has a sweet, mild flavor. It is a source of easily digestible protein with a high nutritional value, which is
necessary for the building of new cells in the human body. In addition to that, it contains a spectrum of important vitamins such as thiamin, riboflavin and microelements. Octopus is an excellent source of iron, selenium and vitamin B_{12}, good source of zinc, omega-3 fatty acids, derived from EPA and DHA also.

In the octopus species both tentacles or arms and mantle are edible. In many countries, owing to the protein composition of cephalopods, they are being increasingly used for the development of new products. Octopuses are consumed in different form around the world. Number of products are being prepared from octopus all around the world viz., octopus in red wine, pickled octopus (htapothi toursi), cooking octopus in japanese style, barbecued stuffed baby octopus, baby octopus, octopus salad (Ensalada de pulpo), baby octopus with tomato and black olives, char-grilled baby octopus, octopus pie, octopus cooked in wine, octopus with smoked paprika, fried octopus, braised octopus, Greek casseroled octopus, octopus fritters, em see red octopus pasta, hockey puck octopus bites, Stanley cup octopus stew, octopus in marinara sauce, honey mustard dressing, char-grilled baby octopus, smoked octopus, pre sliced grilled octopus, octopus tidbits, chilli lemon octopus, eke takare i roto Ite akari (curried octopus in coconut sauce), octopus meze, pulpo a la gallega etc.,

There is a great scope for improving the export potential of octopus in different forms either by value addition or by traditional products. The availability of raw material is an important consideration for the industry to sustain, especially the export oriented industry. Different species are suitable for culture but the culture technology is yet be popularized.

The autolytic activity of cephalopod muscle is around six times greater than in fish muscle, in the case of octopus it can be as much as 10 times greater (Matsumoto, 1980; Jimenez and Borderias, 1983). These muscle proteases belong to the sarcoplasmic proteins of the myosystem. The thickness of the connective tissue depends on species as well as on age, sexual maturity and muscle depletion; collagen, the major component, is similarly affected by these factors in trout (Borderias and Montero, 1985). Morales et al., (2000) have reported the differences depending on anatomical location and age. The types of proteins and their functional status are the two factors that influence the most on the texture of cephalopod muscle.

Seafood quality and safety are of great concern in the present world. Most of the cephalopods that are caught are stored and marketed in their frozen state, spoilage caused by autolysis of the muscle is particularly intensive in cephalopods because of the high level of proteolytic activity in the muscle produced by their highly active metabolism (Stanley and Hultin 1984; Hurtado et al., 1999), and this favors rapid microbial growth. The spoilage of cephalopods in chilled storage is governed mainly by Gram-negative
bacteria (Paarup and Moral, 1996). In vacuum-packed samples, there are qualitative and quantitative changes due to the growth of anaerobic microbial flora as aerobic organisms are inhibited (Bahrs, 1985), and spoilage is largely dominated by Gram-positive bacteria (Stammen et al., 1990). Of the latter type, lactic bacteria are favored, to the extent that they can become the dominant flora (Leroi et al., 1996).

Freezing process can disrupt structures, as a result, enzymes from the lysosomal vesicles are released that cause proteolysis and favour the partial softening necessary for improving the quality of certain species that are unduly hard. Also, storage in this state especially for long periods, can cause protein aggregation, which, as in the muscle of other fish species, is enhanced by a number of factors such as the loss of water from tissues and the formation of formaldehyde from tri-methylamine oxide.

The texture of octopus is similar to squids and has good qualities as an edible item. Its soft texture undergoes deterioration quickly and chromatophores also change the appearance. It is observed that frozen stored squid quality often affected by alteration of proteins accompanied by loss of water holding capacity. So quick freezing of octopus, use of cryoprotectants and storage at lower temperature are important to arrest micro biological activity and biochemical changes to reduce undesirable changes in quality. The available literature on handling, processing, product development, biochemical and microbiological changes during freezing and frozen storage and quality control aspects of octopus is very scanty.

There is a need to develop suitable technology for better handling, processing, utilization and preservation to avoid post harvest losses. Hence, the objectives of present investigation are;

1. To study the chemical composition of octopus spp. (*Octopus membranaceus*).
2. To study the effect of different methods of icing on the quality of octopus during storage.
3. Studies on standardisation of coated product, smoked product and evaluation of the frozen storage characteristics and shelf lives of these products.
4. Effect of different pretreatments on the quality and shelf lives of octopus during frozen storage.