SUMMARY

The demand for sea foods is increasing worldwide as it provides healthy animal protein. Among the sea foods, shellfish play a vital role in India's economy and their popularity is increasing due to their delicacy and food value. Molluscs such as bivalves and gastropods have been serving the nutritional needs of the coastal population. Next to crustaceans, gastropods form important fishery resource along the Southeast Coast of India. Most of the molluscs are good source of protein, glycogen and minerals while comparing with other animal foods. Nowadays, the economic growth leads to the extensive demand for “ready – to – cook” or ready-to-serve products which results in the development of convenience products to meet out the need of the people. In view of this increasing demand for seafood and proper utilization of all available underutilized marine resources, few value added products were developed and their shelf life was assessed and popularized.

The King abalone, Chicoreus ramosus and Conch, Hemifusus pugilinus are the important underutilized marine gastropods, fished by skin diving and landed as by catch along southeast coast of India. The meat of these gastropods is being used locally by the fisherfolk and small quantities are being exported to Southeast Asian countries. In the present study, the total landings, percentage yield of edible meat, biochemical composition, nutritional quality, development of some value added products such as pickle, soup powder, chutney powder, wafers and smoked products and their shelf life assessment and popularization of the developed products were done.

The gastropod resources are such a source yet to be explored for consumption in India. Irrespective of their export demand, the indigenous
consumption is very low attributed to the prejudice related to the people’s food habits rather than the palatability of the meat. The landing data of the gastropods *C. ramosus* and *H. pugilinus* was studied to understand the seasonal availability and percentage meat yield which determines the quality and feasibility of meat for consumption. The total annual catch of *C. ramosus* and *H. pugilinus* were 99 and 77.9 tons respectively in Tuticorin coast of Southeastern India. The percentage yield of *C. ramosus* edible meat varies from 16.26 to 9.27% and for *H. pugilinus* meat it varies from 15.10 to 8.10%.

Over the last few years, utilization of fish and shellfish for human consumption has increased world wide, primarily due to growing concern for healthy nutrition. For better utilization and processing of new resources, analysis for proximate chemical composition and nutritional components becomes a prerequisite, especially in case of new varieties of seafood. Therefore the study was carried out to understand the nutritional quality of both *C. ramosus* and *H. pugilinus* meat. The meat of *C. ramosus* and *H. pugilinus* was found to contain higher level of protein (14.35 and 6.09%) and carbohydrate contents (4.82 and 4.12%) with low fat content (2.7 and 3.0mg/g). The other parameters such as cholesterol, total free sugars, glucose and protein bound sugars were less than 1mg/g in both *C. ramosus* and *H. Pugilinus* meat samples. The presence of essential polyunsaturated fatty acids (PUFA, Weight %) such as Linoleic acid (2.62 and 2.13), Linoleaidic acid (4.00 and 3.38), Linolenic acid (1.91 and 1.08), Arachidonic acid (10.36 and 4.48) and health beneficial PUFA such as Eicosapentaenoic acid (EPA) (3.27 and 1.91) and Docosa hexaenoic acid (DHA) (3.27 and 1.91) were found in both the meat. The meat also contains vitamins like vitamin B₁ (0.12 and 0.12 mg/100g), B₂ (0.32 and 0.34mg/100g), B₆ (0.42 and 0.23mg/100g), B₁₂ (0.34 and 0.34 mcg/100g), niacinamide (1.023 and 0.014 mg/100g), folic acid (0.01 and 0.39mg/100g), Vitamin
A (1.034 and 2.07mg/100g), D (48.5 and 24.7IU), E (31.3 and 26.8mg/100g), C (56.6 and 4.45 mg/100g), and K (23.5 and 32.5 mg/100g). Biotin in both samples was below the detectable levels. Minerals such as sodium (101.54 and 101.56 mg/100g), potassium (112.4 and 112.67 mg/100g), calcium (486.5 and 435.7 mg/100g), Iron (0.97 and 0.56 mg/100g), Copper (0.12 and 0.12mg/100g) and Phosphorus (1.13 and 1.12 mg/100g) were present in both the meat samples. Trace metals such as mercury, cadmium, lead, Arsenic and Nickel were not found.

The nutritional quality of both the meat were studied using feeding trials on albino rats. The control group rats were fed with standard casein diet. The experimental rats fed with gastropod meat test diets 1 (C. ramosus meat) and 2 (H. pugilinus meat) showed higher Protein Efficiency Ratio (PER) (0.95 and 0.77), relative growth rate (0.043 and 0.035 g/ individual) and daily growth rate (0.58 and 0.70 g/ individual) than the control diet fed rats. The average assimilation efficiency (%) for test diet 1 and 2 was 92.35 and 95.29 respectively and in the control diet it was 93.2. The blood serum of the rats fed with test diets showed a significant decrease (P<0.05) in protein level, lipid, total free sugars, Polysaccharides and protein bound sugars. The antioxidants such as superoxide dismutase, catalase, Glutathione peroxidase and GSH showed a significant reduction (P<0.05) in both test diet fed rats than the control diet fed rats. The antioxidant vitamins such as C and E indicated a significant decrease in rats fed with test diets.

Fish and shellfish are relatively perishable and their quality degrades mainly by microbial spoilage and biochemical reactions occurring during handling and storage. Icing of fish immediately after catch keeps them in acceptable condition from a few days to a couple of weeks and reduces the microbial spoilage. The study was carried out to observe the quality of fresh meat such as C. ramosus and H. pugilinus after dip treating with 2% NaCl and 0.2% citric acid and
2% NaCl + 0.2% lactic acid. The third lot was kept as control without any chemical treatment. The 2% NaCl + 0.2% citric acid dip treated samples were found to have lower TMA – N, TVB – N and FFA values than 2% NaCl + 0.2% lactic acid treated and control samples. From the organoleptic point of view, they also had a longer shelf life period.

Value addition and diversification of processed seafood is an important need in fish processing. Preference for ready-to-cook or ready-to-serve type products is on the increase. For better utilization of these protein rich marine gastropods and popularization, after the preliminary studies, various value added products such as pickles, soup powders, chutney powders, wafers, and smoked product were developed from *C. ramosus* and *H. pugilinus* meat and the shelf life of each product was assessed.

Generally the gastropod meat has different odour from other seafoods. To remove the odour, the meat was cooked for 5 minutes in equal amount of water at a pH of 5.5 (adjusted with orthophosphoric acid) and drained. Boiling and draining was repeated for three times, and the meat thus deodorized was taken out and cooled. The deodorized meat was dried, powdered and used for the preparation of soup powder, chutney powder, and wafers. For pickle and smoked products raw meat was used.

Pickled products are considered as a delicacy and have a long shelf life. Pickling protects the food and also helps to retain its wholesomeness and nutritive value for a long time. Pickling has been found to be a comparatively cheaper method of preservation and so production of ready-to-serve pickle products from gastropods appears to be one of the best methods for its economic utilization. Gastropod meat pickles were prepared by using acetic acid (Vinegar) and their shelf life was
analysed. The prepared pickles were packed in sterilized bottles, sealed and stored at ambient temperature. During storage period, both the samples were analysed bimonthly for biochemical, microbiological and sensory evaluation. The protein and lipid contents of *C. ramosus* and *H. pugilinus* meat pickles were 16.55, 8.77% and 24.8, 19.46% respectively. The pH of both pickles showed a decreasing trend and was 4.90 and 5.34 respectively at the end of the storage period of 240 days. TMA-N contents of both meat pickles were initially low such as 2.4 and 3.6mg/100g and then gradually increased to 12.84 and 14.86mg/100g during the storage period. The TVB-N content ranged from 5.2 to 24.62mg/100g in *C. ramosus* meat pickle and 7.24 to 28.45 mg/100g in *H. pugilinus* meat pickle. Pathogenic bacteria such as *E. coli*, *Salmonella* and *Vibrio* were not encountered during the entire study period. The sensory scores showed a decreasing trend but they have remained in acceptable condition during storage. The meat pickles had a good storage life period of 240 days.

The *C. ramosus* and *H. pugilinus* meat were cleaned, deodorized, dried and pulverized and the powdered meat was used for the preparation of soup powder. The developed soup powder were packed in pouches made of HMHD, 12μ PET laminated with 50μLDPE, 12μ PET laminated with BOPP and 12μ PET laminated metallised BOPP. The protein and lipid contents of *C. ramosus* and *H. pugilinus* meat soup powder were observed as 8.26, 7.42 % and 6.2 and 6.84% respectively. The vitamin contents such as vitamin B₁ (0.109 and 0.145 mg), vitamin B₂ (0.305 and 0.231 mg), vitamin B₆ (0.34 and 0.206 mg), vitamin B₁₂ (0.267 and 0.87 mg), niacinamide (1.034 and 0.034 mg), folic acid (0.0134 and 0.24 mg), Vitamin C (55.6 and 4.12 mg), A (1.012 and 1.45 mg), D (40.45 and 23.12 IU), E (27.8 and 19.23 mg) and K (26.23 and 29.34 mg) were present in both soup powders. The minerals and trace metals such as sodium (89.45 and 99.34 mg), potassium (100.78 and 67.67
mg), calcium (420.45 and 498.56 mg), iron (0.45 and 0.34 mg) and phosphorus (1.01 and 0.67 mg) were present in both the soup powder. During storage period, the biochemical composition and the quality parameters such as biochemical, microbiological and organoleptic characters were analyzed. The Free Fatty Acid (FFA) level of *C. ramosus* soup powder was low (0.017) in the initial period in laminated and HMHD pouches. It was then gradually increased to 0.084, 0.79, 0.88 and 0.112 (% oleic acid) at the end of the storage period. In *H. pugilinus* soup powder, the FFA level reached a maximum level of 0.076, 0.098, 0.084 and 0.110 % of oleic acid respectively. The maximum TMA – N levels for *C. ramosus* soup powder was 9.48, 9.28, 9.81, and 16.2 mg/100g respectively and for *H. pugilinus* 9.43, 9.86, 11.26 and 15.8 mg/100g respectively in laminated and HMHD pouches at the end of the storage period. The TMA – N levels in HMHD pouches reached the unacceptable levels (15mg/100g) after 240 days storage. The Total Volatile Base Nitrogen (TVB – N) content of *C. ramosus* soup powder increased from an initial level of 4.12 mg/100g to 21.4, 19.7, 20.32 and 30.94mg/100g in 60, 120, 180 and 240 days respectively during storage. In *H. pugilinus* soup powder, the TVB-N content was found to increase from the initial level of 3.3mg/100g to 20.96, 21.3, 21.66 and 32.92 mg/100g. The TVB-N values were well within the acceptable levels (30mg/100g) after 240days of storage in laminated pouches only. The pathogens such as *E. coli*, *Salmonella* and *Vibrio* were not found in any of the samples during storage. The Total Plate Count (TPC) count showed little bit variations during storage and were found to decrease from an initial value of 56 to 64, 58, 62, 74x10² CFU/g in *C. ramosus* and 48 to 49, 57, 58, 62 X10² CFU/g in *H. pugilinus* soup powder packed in the 12µ PET laminated with 50µLDPE, 12µ PET laminated with BOPP, 12µ PET laminated metallised BOPP and HMHD pouches after 240 days storage. The soup powders packed in laminated pouches showed good mean scores
and better shelf life for a period of 240 days compared to soup powder packed in HMHD polythene pouches, having shelf life of 180 days.

Chutney powder is a ready-to-serve product used as a side dish with Idli or dosai in South India. Chutney powder was developed by incorporating the meat powder with skinned black gram and other ingredients. The chutney powder was packed and stored in sterilized glass bottles at ambient temperature. The chutney powder prepared using *C. ramosus* and *H. pugilinus* meat was rich in protein (9.30, 7.48%) and low in lipid contents (2.58, 2.1%). The carbohydrate content of meat chutney powders was 11.9 and 9.62% respectively. The quality of the product was assessed bimonthly. During the storage period, the pH of both chutney powders showed a decreasing trend (5.2, 5.8) from the initial pH of 6.2 and 6.96. The moisture content of both chutney powders were initially low and gradually increased during storage period from 0.7 to 6.5% and 0.85 to 7.34% respectively. The TMA-N and TVB-N values were 13.71, 20.92 and 15.20, 21.24 (mg/100g) respectively at the end of the storage period. Pathogenic bacteria such as *Vibrio*, *Salmonella* and *E. coli* were not detected in both samples throughout the storage period. The Total Plate Count (TPC) showed a gradual increase from the initial level of 65x $10^2$ to 236 $10^2$ and 98.6 $10^2$ to 248.3 $10^2$ in both chutney powders during the storage period. The organoleptic characteristics of both chutney powders showed a decreasing trend but remained in good condition till the end of the storage period. Both the products had a shelf life of 300 days during storage at ambient temperature.

Wafers are ready-to-cook products that can be used as side dish for meals after frying it in edible oil. Wafers were prepared by mixing the meat powder with corn flour, green chilli paste and other ingredients. The prepared product was dried, packed and stored in laminated pouches at ambient temperature. The quality parameters such as biochemical, microbiological and organoleptic characteristics
were analysed bimonthly. The initial moisture content of *C. ramosus* and *H. pugilinus* wafers were 1.92 and 1.36% respectively and it gradually increased to 6.80 and 6.44% after 240 days of storage at ambient temperature. The FFA values of both wafers reached to a maximum level of 0.088 and 0.120 (% oleic acid) at the end of the storage period. TMA-N values of both wafers increased from 1.64 to 14.3 mg/100g and 1.56 to 14.22 mg/100g, which were within the limit of recommended value (10-15mg/100g) for fish and fishery products. At the end of the storage period, the TVB – N level reached a highest level of 21.82 and 22.6mg / 100g in *C. ramosus* and *H. pugilinus* wafers respectively. The percentage of linear expansion of wafers ranged from a minimum of 37.84 and 3.8.45% to a maximum of 43.86, and 42.74% respectively. The percentage weight of both wafers was found to decrease from an initial value of 12.88 and 11.62 % to 6.21 and 6.35 % after 240 days of storage period. The presence of pathogenic bacteria such as *E. coli*, *Salmonella* and *Vibrio* were not encountered in both wafers during storage. The TPC level both wafers increased from 24 to 84 x 10² (CFU/g) and 26 to 96x10² (CFU/g) respectively during storage. The organoleptic scores were decreased gradually but the overall sensory scores were well within the acceptability limit during storage. The meat wafers packed in laminated pouches were found to have a shelf life of 240 days.

The smoked products from *C. ramosus* and *H. pugilinus* meat were developed using conventional vertical type smoking kiln. The good quality smoked meat was collected from the kiln, dried, packed and stored at ambient temperature. The stored smoked products were drawn bimonthly and biochemical, microbiological and organoleptic characteristics were analyzed. The protein and lipid contents of *C. ramosus* and *H. pugilinus* smoked meats were 11.84, 8.96% and 2.88, 3.04% respectively. The pH levels of both meats were ranged from
6.58 to 5.87 during the storage at ambient temperature. The initial percentage of moisture content of both smoked meats was 2.28 and 2.7% and it reached at a maximum level of 8.26 and 12.26% respectively. The TMA-N and TVB-N levels of both meats increased from 2.28 to 12.86, 4.55 to 20.28 mg/100g and 2.6 to 13.58 21.24mg/100g respectively. The TPC of C. ramosus and H. pugilinus meats were increased gradually from the initial count (42 x 10^2 and 46 x 10^2 CFU/g) and it reached to a maximum count of 94 x 10^2 CFU/g and 104 x 10^2 CFU/g at the end of the storage period. The sensory scores of C. ramosus and H. pugilinus remained within the acceptability limit throughout the storage period. The overall acceptability of both smoked meats ranged from 8.8 – 7.8 during the storage period. They had a good shelf life period for 180 days at ambient temperature.

The prepared ready-to-serve products from C. ramosus and H. pugilinus were popularized among the people in non-coastal and coastal areas and school children. This study was undertaken to disseminate the nutritive information and delicacy of the gastropod meats and to create awareness about these protein rich marine resources to the people. The popularization program was carried out in a non-coastal urban area (Trichy town) and coastal villages of Tuticorin (Vellapatti and Thirespuram) and three schools (two in Kanyakumari district and 1 in Tuticorin). For the people from urban and coastal areas, 50 taste panelists were selected. Products such as pickle, soup powder, chutney powder and wafers were given to taste and a questionnaire to fill in. Taste panelists were also selected with different age groups from the two schools in Kanyakumari district such as L, M. S. girl’s higher secondary school, Neyyoor (Age group 13 and 15) and St. Mary school, Manalikarai (Age group 13 and 15) and Subbaiya Vidayalaya school (Age group 15 only) from Tuticorin town. A total of about 50 people in each group were given samples to taste and a questionnaire to fill in. The sensory judgments of all the
products prepared from both the animals were carried out by serving each product to the taste panelists. The score scale was ranged from 1 to 9 and it was assumed that a score of 8 – 9 indicated ‘very good’, 7 – 8 ‘good’, 6 – 7 ‘fair’, 5 – 6 ‘not bad’ and 4–5 to be ‘bad’ (unacceptable). All products were very well accepted by the consumers.

The present study revealed that the products developed have good storage life, nutritive value and also received good response from the people of non coastal and coastal area and school children through popularization program. Based on the response in popularization programme, it is also hoped that the pickle followed by wafers, chutney powder, and soup powder would surely be included as a regular diet of different sector of the public. Thus, the study had proven that this under utilized and protein rich gastropod resource could find a place in the domestic market on par with other sea foods.