I. INTRODUCTION

In India, fisheries have always been playing a pivotal role in food and nutritional security of people especially in rural areas. It has significantly contributed towards the improvement of the nutritional status of the populations, since fish has proved as an ideal health food, which is within the reach of the common man (Ghufoorunissa, 2001). Tropical fisheries comprising of several species of fish in varying sizes impose several problems in their handling and preservation. This is one of the reasons for substantial wastage of landed wealth. The fish production in India registered an impressive growth during the last fifty years and in the year 2003-04 the total fish production was 6.67 million metric tons (CMFRI, 2004). The contribution from marine sector accounts for 3.6 mmt and remaining 3.07 mmt is from aquaculture practices. Over the years, the growth in the marine sub sector has slowed down considerably due to dependence on the wild stocks of fish, which are obviously being over exploited. It has been estimated that another 0.6-1.0 mmt can be exploited from unfished/under exploited off shore waters (Somavanshi, 1998). Based on the projected demand of 10 mmt by 2010, the deficit has to be made by other sources. It has been estimated that a large fraction of this resource (nearly 15%) is wasted, either due to discard at sea or deterioration due to spoilage. Hence to meet the increasing demand of fresh fish, one of the strategies is to minimize the wastage and use for human consumption. India has an estimated fish production potential of 8.4 million tons, of which the marine sector potential is 4.0 million tons. In India, there is also the problem of under utilization of by-catch due to lack of means of efficient utilization. The cost effective and efficient utilization of aquatic products demands proper processing and distribution. Demand for fish and fish related products are increasing day by day in India and reduction in post harvest losses can make a major contribution to satisfy this demand.

In order to improve the utilization of underutilized fisheries resources, there is a need to minimize the post harvest 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, flat-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 plasticised material, which flows downstream into extruder channel (Chiruvella et al., 1996). Basically an extruder is a pump, heat exchanger and bioreactor that simultaneously transfers, 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. Considerable progress has been made in the extrusion cooking technology with the use of cereals, oil seeds and leguminous seeds (Altschul, 1974; Kinsella, 1978).

Extrusion cooking can be carried out either in a single screw or twin-screw extruder. Twin-screw extruders are used for production of a wide variety of food products and the final quality of the end products depends on the characteristics of starch in the cereals and protein ingredient as affected by extrusion process. In extrusion process gelatinization of starch and denaturation of protein is achieved by combined effect of temperature and mechanical shear. The conversion of raw starch to cook and digestible material by the application of heat and moisture is called gelatinization (Chiruvella et al., 1996). In the conventional way of gelatinization, water is absorbed and bound to the starch molecules, which results in change in structure. During extrusion the conditions that prevail are high temperature, high pressure, high shear rate and low moisture available for starch may lead to breakdown of starch molecules to dextrins.

The advantages of extrusion process are; a) the process is thermodynamically most efficient b) high temperature short time enables destruction of bacteria and anti-nutritional factors c) one step cooking process thereby minimizing wastage d) destruction of fat hydrolyzing enzymes during extrusion process and enzymes associated with rancidity.

In order to improve the nutritional quality of the cereal based extruded products, addition of fish meat incorporation has been attempted (Choudhury et al., 1998). Use of fish mince for extrusion process started in the 1990’s basically to utilize underutilized species and fish mince recovered from filleting, canning and surimi operations (Choudhury and Gogoi, 1995). Incorporation of fish meat or hydrolysates along with cereals have been attempted to improve the nutritional quality of extrudates (Choudhury and Gautam, 1999; Choudhury and Gogoi, 1995). The advantages of developing fish based extruded product will help in supplying nutritious and balanced diet to the under-nourished people in the developing countries (Venugopal and Shahidi, 1995). To develop acceptable fish mince-
cereal based extruded products, there is a further need to understand protein-polysaccharide interaction so as to evolve appropriate unit operations for enhanced quality products.

In India, during the last decade, with increased efforts to exploit unfished waters, the catches of ribbonfish (*Trichiurus spp.*) and bull’s eye fish (*Priacanthus spp.*) have increased considerably. Together the two species accounts for 10% of total marine catch (CMFRI, 2004) and relatively sell at low price. The domestic market for ribbonfish exists both in fresh and salted-dried form. The consumer acceptance of bull’s eye fish is yet to pick up and does not attract remunerative prize. Since these two species are available at a lower price and its utilization for extrusion process will perhaps pave way for efficient utilization for human consumption.

The disposal of fish processing waste like skin, bones and viscera is gaining more attention of researchers so as to avoid environmental pollution problem. Many valuable products have been prepared from processing waste and gelatin appears to be more promising in terms of commercial viability. Gelatin is a protein derived from collagen, traditionally obtained from beef and pork skin and bones. Gelatin has been widely used for many years in desserts and meat products as well as for glue production and photographic purposes. Gelatin has played a major role in the development of colloid chemistry and the gel formation in food industry. The surface-active properties and film formation of gelatin have been studied extensively (Montero and Gomez-Guillen, 2000). The largest use of gelatin is in gel desserts. The estimated world usage of gelatin is 200,000 metric tones per year (Choi and Regenstein, 2000). Gelatin is reported to have characteristic favourable melting properties and mouth feel that are not easily mimicked by polysaccharide thickeners and stabilizers. The physical and chemical properties of gelatin depend on several factors including the method of preparation and the intrinsic properties of collagen. The traditional raw material source for gelatin preparation is bovine and porcine source. With recent outbreak of mad cow disease (Bovine Spongiform Encephalopathy-BSE), the industry is looking for alternate raw material. For different social and religious reasons porcine source as raw material also being limited. Hence utilization of fish skin and bones has a high commercial potential as a raw material for gelatin production.

With this rationale, the present investigation was aimed at evolving suitable technology for extrusion of cereal based fish mince mixture using low economic value fish
like ribbonfish and bull’s eye fish. Also, preparation of gelatin from skin of fish (bull’s eye fish) and assessing its properties has been attempted.

The objectives of the present investigation are

- To prepare extruded products of acceptable quality using selected fish species and flours from different sources such as rice, wheat and ragi using twin-screw extruder.
- Optimization of extrusion process – barrel temperature, screw speed, feeding rate and die diameter.
- Quality evaluation of extruded products by instrumental analysis.
- To understand protein-polysaccharide interaction by rheological techniques.
- Preparation of gelatin of acceptable quality from skin of bull’s eye fish (Priacanthus spp.) and assessment of rheological properties.