Fish and seafood products, as well as aquatic plants are not only delicious constituents of meals and foodstuffs, but they also have a high dietary value and include beneficial amounts of protein, lipids, essential minerals and vitamins. Currently, aquaculture is the fastest growing sector in livestock production around the world. An annual increase of production during last 30 years is ± 8% (FAO, 2012). In a recent review, it has also been publicized that fish and seafood have a most important impact on global food contribute (Tacon and Metian, 2013). At present the internationally traded amount of aquatic animal food products is higher than the total traded amount of beef, pork and poultry combined (26.85 - 27.45 compared to 20.38 - 21.99 million tons in 2009 respectively) (FAO/FISHSTAT, 2012; FAO/USDA, 2012). Moreover, in several Asian and African countries, the major animal protein source is the aquatic fauna (FAO/FISHSTAT, 2012; FAO, 2001). There is no doubt that aquaculture has still a big potential to grow and to be a major contributor to feed the world of tomorrow.

Generally, aquatic animal foods have elevated protein content than most terrestrial meats. In addition, aquatic protein is very much palatable and rich in numerous essential amino acids that are inadequate in terrestrial meat proteins, as for example methionine (6.5% in fish compared to 5.7% of total essential amino acids in terrestrial meat) and lysine (19.6% in fish compared to 19.0% of total essential amino acids in terrestrial meat) (Tacon and Metian, 2013). Fish and seafood consumption as Poly Unsaturated Fatty Acids (PUFAs) has been associated to various beneficial health effects, especially with the prevention of cancer, decreased risk of coronary
heart and cardiovascular diseases, decreased inflammatory disease such as arthritis (McManus and Hunt, 2013). Traditionally, the main effects of fish consumption have been attributed to the high content of long chain omega 3 (n-3) PUFA. However, other nutrients from fish also have positive effects on human health. Beside the n-3 PUFA, fish is a major source of well-balanced amino acids, taurine and choline, the vitamins D and B12 as well as calcium, phosphorus, iodine and selenium (Sampels, 2014). Depending on the general nutrition of human population, fish also afford significant proportions of vitamin A, iron and zinc. A further noteworthy aspect is that fish in general has a significantly lower Feed Conversion Ratio (FCR) than land living animals. For example, beef cattle can have a FCR varying from 5-20 (National Research Council, 2000) while Masilko (2014) reported a FCR for carp from 2.08-2.62. A FCR from 1.6-1.8 was reported for tilapia (LEAD, 2006) and salmonids usually have a FCR around 1 (Nordgarden et al., 2003). This means more protein can be produced with a lower amount of feed with all included factors concerning feed production as energy and water use as well.

A. Fish Therapeutics

Therapy is the systematic application of remedies to cure a disease, ailment, pain or injury and the branch of science that deals with the treatment of disease or the science of healing is known as therapeutics. When food and foodstuffs are used for treating diseases owing to their medical and health benefits, they are called nutraceuticals. They include the nutrients like vitamins, minerals, fatty acids, dietary supplements, specific diets, genetically engineered foods, herbal products, processed foods, etc. The Indians, Egyptians, Chinese and Sumerians are just a few civilizations who have provided evidence suggesting that foods can be effectively used as medicine to treat and prevent diseases.
The knowledge on therapeutic values of fish dates back to several decades. Several compounds have been extracted from fish and these are employed as remedies in the medicine (Hamada and Nagai, 1995). Some of these compounds are important as tools for biochemical research or as new leads for the development of anticancer and antiviral drugs (Higa, 1996). Agosta (1996) reported that the new chemical compound derived from spiny dogfish sharks, *Squalus acanthias* (Linnaeus 1758) is one of the most promising discoveries of the 1990s that kills parasites, fungi, and bacteria. This chemical helps to prevent infections in wounded sharks, and someday it may be used for humans. Finkl (1984) refers to *Eptatretus stoutii* (Lockington 1878), and *Dasyatis sabina* (Lesueur 1824) as sources of cardiac stimulants, antitumors and analgesic agents respectively. Oily fish, like cod, herring, salmon and turbot, have great medicinal value due to the presence of n-3 PUFA. This helps the prevention of arthritis (Adeodato, 1997). The presence of an anticoagulant system in the plasma of Atlantic salmon *Salmo salar* (Linnaeus 1758) and rainbow trout *Oncorhynchus mykiss* (Walbaum 1792) has been confirmed, supporting similarities with the protein and anticoagulant system in mammals (Salte *et al.*, 1996). Tetrodotoxin (TTX), a water-soluble guanidinium derivative, is a bioactive compound produced by puffer fish that resembles procaine in its ability to inhibit transmission of nerve cell (Colwell, 1997) and when diluted, it acts as an extraordinary narcotic and analgesic agent (Bisset, 1991).

Regular fish consumption and the intake of n-3 PUFA play an important role in the primary and secondary prevention of Coronary Heart Disease (CHD) and stroke (Sidhu, 2003). Possible mechanisms involved in this protective action of n-3 PUFA relate mainly to their anti-arrhythmic, anti-thrombotic, anti-inflammatory and anti-atherogenic effects. Omega-3 PUFA also has a beneficial effect on endothelial function.
and the immune system, and can help in lowering blood pressure in hypertensive individuals (Mohanty et al., 2011).

Various studies suggest that consumption of fish or fish oil lowers risk of death due to CHD. Comparing different types of fish, lower risk appears to be related to intake of oily fish (e.g., salmon, herring, sardines), rather than other fishes (e.g., cod, catfish, halibut). Fish intake may modestly control other cardiovascular outcome. Omega-3 PUFAs influence several cardiovascular risk factors. Positive results occur within weeks of intake and may result from altered membrane fluidity and receptor responses following incorporation of n-3 PUFAs into cell membranes and direct binding of n-3 PUFAs to intracellular receptors regulating gene transcription. The heterogeneity of the effects of fish or fish oil intake on cardiovascular outcomes is likely related to varying dose and time responses of effects on the risk factors (Mohanty et al., 2011).

Consumption of fish stimulates brain development due to the presence of Docosahexaenoic Acid (DHA). It has been known since the 1960s that, DHA is one of the major components of the grey matter of the nervous system (brain) and the phospholipids of the retina of the human eye (vision). It appears to play a vital role in the development of these vital organs and systems. Therefore, the maintenance of an adequate level of DHA in both the brain and the retina is important for proper functioning of the nervous system as well as visual components. Increased blood levels of n-3 fatty acids like EPA (Eicosapentaenoic acid) and DHA is found to lower incidence of obesity thereby indicating the importance of fish oils in weight management (Micallef et al., 2009).

Regular fish intake improves the development of bones, owing to the content of vitamin D in fish. Vitamin D is essential for proper bone mineralization; its intake is
especially important for young children to prevent rickets and for elderly people, who are at risk for osteoporosis and osteomalacia. Scientific data also indicate that the consumption of fish or fish oil containing n-3 PUFAs lowers the incidence of diabetes, and appears to alleviate symptoms of rheumatoid arthritis (Sidhu, 2003).

Fish tissues constitute a potential source of anticancer molecules. For example, squalamine, an aminosterol isolated from the liver of the shark *Squalus acanthias* (Moore *et al.*, 1993), was demonstrated to be a potent inhibitor of angiogenesis and tumour growth in several animal models (Sills *et al.*, 1998). Alkylglycerols, natural ether lipids abundant in shark liver oil, were described as inhibitors of tumor vascularization (Pedrono *et al.*, 2004). Picot *et al.* (2006) demonstrated that Fish Protein Hydrolysates (FPH), obtained by controlled enzymatic hydrolysis of muscle proteins, exert a significant anti-proliferative activity on human cancer cell lines *in vitro*.

In Hyderabad, the Bathini Goud family has been administering fish medicine to lakhs of people suffering from asthma. They give the patients to swallow a 2-3 inch long murrel fish (*Channa* sp.) which carry a drop of the secret formula. The fish carrying the medicine slips down the throat easily and enters the alimentary tract clearing the mucus and phlegm which is supposed to be the contributing factor to asthma. It is administered on a particular day, Mrigashira karthi. There has been no scientific research or clinical trials under medical supervision done on this particular medicine (www.ayurvedic-medicines.org).

The therapeutic potential of freshwater fishes has not been given due importance, though scattered information is available on this aspect. In India, the tribes of Assam like Karbi, Damasa and Thadou use many freshwater fishes inspite of scientific evidence (Table 1). The whole fish or part of it as raw or cooked was used as a cure for various diseases or for their health benefits.
Table 1 Icthyofauna of therapeutic importance used by tribes of Assam in India

(Courtesy: Teronpi et al., 2012)

<table>
<thead>
<tr>
<th>S. No</th>
<th>Scientific name</th>
<th>Local Name</th>
<th>Tribes</th>
<th>Parts used</th>
<th>Usage</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Danio aequipinnatus</em></td>
<td>Nune</td>
<td>Karbi</td>
<td>Whole fish</td>
<td>Constant spitting</td>
<td>Boiled fish is consumed regularly</td>
</tr>
<tr>
<td>2</td>
<td><em>Monopterus cuchia</em></td>
<td>Kumchirui</td>
<td>Karbi</td>
<td>Whole fish, raw blood</td>
<td>Anemia</td>
<td>Raw blood taken orally</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Kala azar</td>
<td>Raw fish is taken orally or fresh blood is consumed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Blood entry of leech into the anus</td>
<td>Fresh raw blood is consumed to eliminate leech from rectum/ anus</td>
</tr>
<tr>
<td></td>
<td>Namna</td>
<td>Dimasa</td>
<td>Whole fish</td>
<td>Delivery weakness</td>
<td>Fish is boiled and taken to regain health</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><em>Puntius sp.</em></td>
<td>Ok- puthi</td>
<td>Karbi</td>
<td>Head</td>
<td>Night Blindness</td>
<td>Cooked head is taken regularly</td>
</tr>
<tr>
<td></td>
<td>Puthi</td>
<td>Thadou</td>
<td>Head</td>
<td>Memory</td>
<td>Boiled head is taken to improve memory</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><em>Clarias batrachus</em></td>
<td>Nagur</td>
<td>Karbi</td>
<td>Whole fish</td>
<td>Small pox</td>
<td>Cooked fish to treat small pox</td>
</tr>
<tr>
<td></td>
<td>Nagen</td>
<td>Dimasa</td>
<td>Whole fish</td>
<td>Delivery weakness</td>
<td>Boiled fish is taken regularly</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td><em>Mystus sp.</em></td>
<td>Tengera</td>
<td>Karbi</td>
<td>Whole fish</td>
<td>Small pox</td>
<td>Cooked fish to treat small pox</td>
</tr>
<tr>
<td>6</td>
<td>Hill stream fishes</td>
<td>-</td>
<td>Karbi</td>
<td>Belly</td>
<td>Sore festering wounds</td>
<td>The affected area is bandaged with belly and kept for 2-3 days</td>
</tr>
<tr>
<td>7</td>
<td><em>Channa gachua</em></td>
<td>Ok-langosa</td>
<td>Karbi</td>
<td>Bile</td>
<td>Thorn prick</td>
<td>Bile of the fish is applied to remove the thorn</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Whole fish</td>
<td>Dysentery</td>
<td>The fish is mixed with common salt and wrapped in banana leaf,</td>
</tr>
<tr>
<td>No</td>
<td>Common Name</td>
<td>Tribe</td>
<td>Part Used</td>
<td>Condition(s)</td>
<td>Method of Use</td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>-------------</td>
<td>-------</td>
<td>-----------</td>
<td>---------------</td>
<td>---------------</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td><em>Puntius</em> sp.</td>
<td>Manthu</td>
<td>Whole fish</td>
<td>Blood purifier</td>
<td>Cooked with bamboo shoot and taken to purify the blood</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(fermented)</td>
<td></td>
<td>Common cold</td>
<td>Manthu cooked with chilli and taken to cure cold</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td><em>Anguilla bengalensis</em></td>
<td>Nujung</td>
<td>Fat</td>
<td>Rheumatoid arthritis</td>
<td>Fat is applied and massaged to relief pain</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td><em>Heteropneustes fossilis</em></td>
<td>Singki</td>
<td>Brain</td>
<td>Sting by the fish itself</td>
<td>Raw brain is consumed when stung by the fish (as analgesic)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nagen</td>
<td>Whole fish</td>
<td>Delivery</td>
<td>Boiled fish is taken to regain strength</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dimasa</td>
<td>Weakness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td><em>Wallago attu</em></td>
<td>Seketa</td>
<td>Head</td>
<td>Liver tonic</td>
<td>Boiled head is taken regularly to regain and improve liver function</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td><em>Labeo pangusia</em></td>
<td>Notun</td>
<td>Flesh</td>
<td>Delivery</td>
<td>Boiled fish is taken to regain strength</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Karbi, Dimasa</td>
<td>Bile</td>
<td>Stomach ache</td>
<td>Bile is taken orally to relieve stomach pain</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td><em>Channa punctatus</em></td>
<td>Ok-meklot/Ok-borok</td>
<td>Eyes</td>
<td>Corn or clavus</td>
<td>Eyes mixed with common salt is applied to the affected part to remove corn</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ngavo</td>
<td>Whole</td>
<td>Diarrhea</td>
<td>Boiled fish is taken</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thadou</td>
<td>Head</td>
<td>Swelling of the testicle</td>
<td>Heads are tapped on the affected testicle to control swelling</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thinkha</td>
<td>Bile</td>
<td>Malaria</td>
<td>Bile is taken thrice a day till recovery</td>
<td></td>
</tr>
</tbody>
</table>
B. **Snakeheads**

Snakeheads commonly called murrels are one among the best known air breathing freshwater edible fishes of Southeast Asia. They constitute the main stay of the natural freshwater fisheries of India that fetch high price as food fish as well as in aquarium trade. They are also well known for their taste, high nutritive value, recuperative and medicinal quality. About 28 to 30 species belonging to the snakehead family Channidae are known, but few with synonymous confusion and taxonomic ambiguity. About 10 species of *Channa* have been reported in India based on morphometric and meristic characteristics (Haniffa *et al.*, 2014a). Some species that possess special features are endemic to restricted areas. These are walking snakehead-* Channa orientalis* from southern Sri Lanka, orange spotted snakehead *C. aurantimaculata* and rainbow snakehead, *C. bleheri* are reported in northern Assam. Few species are introduced ones. For example, *C. argus* was introduced to Japan and United States, *C. maculata* to Japan, *C. marulius* to United States and *C. striatus* to the islands of Indonesia, Papua, New Gunea, New Caledonia, Fiji, Hawaii, Mauritius and Madagascar (Haniffa, 2010).

Snakeheads are also referred as serpent heads because of their elongated and cylindrical bodies. Large scales present on the head are reminiscent of large epidermal scales and the cephalic plates on the head of the snakes. Moreover, the flattened head and eyes present on the dorso-lateral position on the anterior part of the head, also give snake like appearance (Haniffa *et al.*, 2014b). Species of snakeheads can be distinguished based on colouration, meristic and morphometric characteristics along with distribution of scales on underside of lower jaw and morphology of the suprabranchial organ. In India, *C. striatus, C. marulius, C. punctatus* and *C. diplogramma* fetch high price as food fish and occupy the topmost rank for their
flesh quality and taste. Murrels are carnivorous, cannibalistic and also piscivorous. They are known for their spawning behavior and parental care; at the same time, if the young ones are not separated from parents, they will become cannibalistic (Haniffa, 2010). The characteristics of the fish that make it desirable for culture include high market value, rapid growth, tolerance of high stocking density, easily adaptable to the environment, utilization of atmospheric air for respiration and ability to survive in oxygen depleted water.

Nature is a continuous source of medicines. With regard to medicinal products, plants are explored with much interest, whereas animals are poorly explored for medicinal properties despite their known ingredients for popular medicines. Some of them were recognized by current or past pharmacopoeias around the world. For instance, geekos, frogs and few insects were used in many Materia Medica; Spanish flies and leeches were listed in western pharmacopoeias and maggots in the US pharmacopoeia. For the past few decades, emphasis on marine animals like sponges and other fishes are given due importance. But freshwater animal drugs are still neglected for use as medicines just because of their complex chemical matrixes, least yield on bioactive compounds, ethical problems and at times difficulty in finding a sustainable supply (Jais, 2007). In view of this, the present investigation was carried out systematically to evaluate the therapeutic potential of selected Indian snakeheads, *Channa striatus* and *Channa marulius*.

C. **Experimental Fish: Channa marulius (Hamilton, 1822)**

**Common name:** Giant snakehead, river snakehead, large murrel, saal

**Vernacular name:** Gajal (Bengali, Oriya), Sawl (Hindi), Poochepa, Poomatta, Poolamalle (Telugu), Chengan Avuri, Poo-veeral (Tamil), Madinji, Avul Hoovinca murr (Kannada)
Scientific Position

Kingdom : Animalia
Phylum : Chordata
Sub-phylum : Vertebrata
Class : Actinopterygii
Order : Perciformes
Family : Channidae
Genus : Channa
Species : marulius

Length of head: 3.6 (3.4 to 3.9); of caudal 6.86 (6.1 to 7.5); and height of body 7.32 (7.1 to 7.5) in the total length

Eyes: Diameter 6.32 (5.8 to 6.8) in the length of head, 1.08 (1.0 to 1.2) from the end of snout and 1.56 (1.4 to 1.7) in the interorbital width. Eye lateral in position, moderate in anterior part of head, not visible from below ventral surface

Body profile: Elongated, subcylindrical anteriorly, abdomen rounded

Head: Head depressed with plate like scales, Snout somewhat obtuse. Greatest width of head 0.6 in its length. Maxilla extends half eye diameter behind orbit. Mouth opening moderate extends slightly behind the orbit. Lips moderate. Jaws equal

Teeth: Villiform in numerous rows on jaws, vomer and palate. An additional posterior row of about twelve large conical teeth on each ramus of mandible

Gill openings: Wide, membranes of the two sides connected beneath isthmus

Accessory respiratory organ: In the form of a thin bony laminae present in a cavity in suprabranchial chamber

Fins: Dorsal fin long, inserted almost above pectoral and without spine. Anal fin long but shorter than dorsal fin. Both dorsal and anal fins free from caudal. Pectoral fin
more than half the length of head, but not reaching the origin of anal fin. Ventral fin 2/3 as long as pectoral. Caudal fin rounded

**Lateral line:** Present, complete, runs straight up to 17th scale, then descends down two rows of scales and subsequently runs straight up to the centre of caudal fin

**Scales:** Scales are moderate size on the summit of head, a row of sixteen predorsal scales and a row of ten scales between the orbit and the angle of the preopercle

**Colour:** varies with the age and locality, dorsum of the body dark green; the juveniles (10 to 12 cm) with a brilliant orange band passing from tip of snout over the eyes to the tip of the caudal fin, while in the forms nearing maturity there are 4 to 5 round black blotches located along the lateral line, between the pectoral fin and the base of the caudal fin. Abdomen whitish. There is a large black prominent ocellus with orange boundary, at the upper part of base of caudal fin

**Age and Growth:** Among all murrels, *C. marulius* is the fastest growing species. Alikunhi (1953) reported that under ideal condition it may attain a size 750 mm/2.0 kg. The maximum size of giant murrel of 1000 mm/5.3 kg of nine years old has been recorded from swamp (Parameswaran, 1975). In natural habit like river, its growth has been recorded to be 1220 mm (Arumugam, 1966). In culture ponds, it grows to 34.4 mm/29.6 g per month (Murugesan, 1978). In another culture pond with abundant available food and less competition, the growth at the rate of 43-46.5 mm/month has been recorded (Murugesan and Kumaraiah, 1970). Murugesan (1978) recorded a highest growth rate of 70.1 mm/month in swampy pond. Fuller (2003) recorded total length as 183 cm weighing 30 kg. It is the fastest growing species and longevity of 9+ years has been reported (Haniffa, 2010).

**Distribution:** Freshwater river, ponds, channels, lakes, paddy fields, swamps and grassy tanks
**India**: West Bengal, Madhya Pradesh, Punjab, Haryana, Odisha, Karnataka, Kerala, Ahmedabad, Uttar Pradesh, Bihar and Tamil Nadu

Sri Lanka, Pakistan, Bangladesh, Thailand and China

**D. Experimental Fish: Channa striatus (Bloch, 1793)**

**Common name**: Striped snakehead, shol

**Vernacular name**: Shol, Gajal (Bengali), Moral, Sowra, Saur (Hindi), Sola, Shulo (Oriya), Sohr (Marathi), Veral, Karupu veral (Tamil)

**Scientific Position**

- **Kingdom**: Animalia
- **Phylum**: Chordata
- **Sub-phylum**: Vertebrata
- **Class**: Actinopterygii
- **Order**: Perciformes
- **Family**: Channidae
- **Genus**: Channa
- **Species**: striatus

**Length of head**: 3.55 (3.5 to 3.6); of caudal 6.75 (6.5 to 7.0); and height of body 7.6 (7.1 to 8.1) in the total length

**Eyes**: Diameter 8.45 (7.8 to 9.0) in the length of head, 1.65 (1.5 to 1.8) from the end of snout and 2.0 (2.0 to 2.1) in the interorbital width. Eyes lateral, moderate in anterior part of head, not visible from below ventral surface

**Body profile**: Elongated, subcylindrical anteriorly, abdomen rounded

**Head**: Head depressed with plate like scales, snout somewhat obtuse. Mouth opening wide, maxilla reaching to below hind border of eye or even eye diameter behind. Lower jaw longer. Lips moderate
**Teeth:** In lower jaw with an inner conical row, palatine with cardiform teeth

**Gill openings and Accessory respiratory organ:** Similar to *Channa marulius*

**Fins:** Dorsal fin long, inserted almost above pectoral and without spine. Anal fin long but shorter than dorsal fin. Both dorsal and anal fins free from caudal. Ventral fin 3/4 as long as pectoral. Caudal fin rounded

**Lateral line:** Present, complete, curves downwards below 12th dorsal ray or 16th to 17th scales

**Scales:** Large, irregular shaped on the summit of head. A row of 18 to 20 predorsal scales and a row of 9 scales between the orbit and the angle of the preopercle; 7 rows between the lateral line and dorsal fin

**Colour:** Dark greyish or blackish dorsally, depending on the environment, yellowish white beneath, cheeks and lower surface of the mouth spotted with grey or black. Transverse bands of grey or black descend from the sides to the abdomen. Ventral and anal fins greyish

**Distribution:** Freshwater rivers, ponds, channels, lakes, paddy fields, swamps and grassy tanks

**India:** Freshwaters throughout the plain

Sri Lanka, Pakistan, Bangladesh, Thailand, Burma, Philippines, Malaysia and China

**Age and Growth:** Maximum length of 100 cm and weight of 3 kg have been reported (Haniffa, 2010).

**E. Therapeutic Uses of Channids**

*Channa striatus* is highly valued for its medicinal properties. Of the many types of fishes in Malaysia, only the Malaysian Channidae (including *C. micropeltes*, *C. striatus* and *C. gachua*), the mudskipper, *Periophtalmus* sp., and the freshwater eel, *Monopterus albus* (Abdullah et al., 2010) are known to be used in traditional Malay
medicine. Other Southeast Asian communities like the Thais, Vietnamese and Cambodians as well as the Chinese also use *C. striatus* for the treatment of diseases. The popularity of *C. striatus* as a therapeutic agent is related to folk belief for its efficacy in treating wounds, relieving pain and boosting energy in the sick and elderly people. Mothers recuperating from normal or caesarean delivery and patients recovering from surgical operations are routinely and customarily advised to eat meals containing *C. striatus*. Among the Malays, such meals come in the form of curried, spiced, fried or roasted fish, playing the role of functional foods which provide health benefit beyond basic nutrition. Other forms such as broth or a tonic of *C. striatus* extracts are quite popular. The energy-restoring properties of *C. striatus* are also recognized in Malay society who consume it for recovery from minor to major illnesses as well as a diet supplement for elderly people. The therapeutic properties of *C. striatus* are listed below

**E.1 Wound Healing Property**

The wound healing properties of *C. striatus* (Haruan) are attributed to its fatty acid and amino acid composition. Haruan’s mucus and tissue extracts are found to contain high amount of amino acids especially glycine and arachidonic acid. These two are reported to promote wound healing by initiating collagen synthesis and re-epithelialisation in damaged tissues. Hence, haruan extracts are recommended for postoperative wound healing as well as post pregnancy rehabilitation (Gibson, 1983). Haruan is known to produce PUFA which regulate prostaglandin synthesis inducing wound healing (Zuraini *et al.*, 2006).

**E.2 Anti-nociceptive Property**

The anti-nociceptive property of *C. striatus* is thought to be due to its glycine and arachidonic acid constituents which are known to be involved in the anti-
nociceptive pathway (Kapoor et al., 2006). Extracts of *C. striatus* have superior anti-nociceptive properties compared to other extracts from other Channidae (Hasan, 2005) and work in a concentration dependent manner (Zakaria, 2005a) in a wide range of temperatures and pH (Dambisya et al., 1999). The extracts also enhance the activity of other anti-nociceptive agents such as morphine (Jais et al., 1997) suggesting a possible interaction with the opioid receptor.

**E.3 Anti-inflammatory and Antipyretic Properties**

The anti-inflammatory effect of *C. striatus* extracts in both acute and chronic inflammation appears to be better than that of other Channidae (Somchit et al., 2004; Hasan, 2005). A further test on this property was done using aqueous and lipid based extracts of *C. striatus* (Zakaria et al., 2008). Given the possible anti-inflammatory property of *C. striatus* extract, its use in treating diseases with an inflammatory component has been explored in the amelioration of osteoarthritis (Michelle et al., 2004; Saffar et al., 2011). They found evidence which signifies reduction of soft tissue swelling and synovial inflammation and significant improvement in the density of PGP 9.5-immunoreactive nerve fibres in the synovial membrane of the osteoarthritis joints in rats. Thus, *C. striatus* may have a role in the treatment of joint diseases with a clearer inflammatory component such as rheumatoid arthritis. The anti-inflammatory property may also be the reason behind the observable antipyretic activity of the aqueous extract (Zakaria et al., 2008). This anti-pyretic activity, however, is absent in the lipid-based extracts which suggest that the anti-pyretic compound may have been a polar based, water soluble substance.

**E.4 Antioxidant Properties**

Fish in general are an important source of antioxidant and haruan is one of the major freshwater fishes to have antioxidant activity, contributed by the amino acids
and fatty acids. Murrels produce more of lipophilic antioxidants which effectively act against the oxidation of omega-3 (Dahlan-Daud et al., 2010). The amino acids are known to have significant antioxidant properties as synergists or primary antioxidants and are believed to be important metal chelators with significant potential in linoleic acid and methyl esters of linoleic acid system.

Galla et al. (2012a) evaluated the functional and in vitro antioxidant properties on the bioactive roe protein hydrolysates prepared from Channa striatus (CRPH) and Labeo rohita (LRPH). The degree of hydrolysis was 28.41% at 60 min in Channa and 18.85% in Labeo roe concentrates at 90 min. The yields of protein hydrolysates were 24.15% and 12.45% for Channa and Labeo roe protein concentrates, respectively. The protein content was identical (58%) in both roe protein hydrolysates. Protein solubility in Channa was higher (90.48%) when compared to Labeo (50.6%) at pH 12. Higher oil absorption capacity and foam stability were observed in CRPH and higher emulsifying capacity was found in LRPH. Smaller peptides of 12 kDa were noted in both CRPH and LRPH. In vitro antioxidant activity was higher in CRPH than in LRPH as seen from DPPH radical scavenging and ferric reducing power.

In another study, Galla et al. (2012b) reported that Channa striatus Roe Protein Concentrate (CRPC) and Lates calcarifer Roe Protein Concentrates (LRPC) yielded 20.7% and 22.5% respectively. Protein content of concentrates was found to be 90.2% (Channa) and 82.5% (Lates). Protein solubility was 3.93–54.6% and 1.6–55.5% in Channa and Lates concentrates. SDS–PAGE revealed that protein bands at 95 and ~30 kDa were predominant. Sorption isotherms indicated both roe protein concentrates are hygroscopic. Water absorption, oil absorption, foam capacity, stability and emulsifying capacity were found to be higher in CRPC than in LRPC.
Antioxidant activity determined by the radical scavenging activity and ferric reducing power was higher in CRPC.

E.5 Antimicrobial Property

Most *C. striatus* fillet extracts have no antibacterial function. Several exceptions include an ethanol extract against *Staphylococcus aureus* (Jais *et al*., 2008) and an acidic extract against *Klebsiella pneumoniae, Pseudomonas aeruginosa* and *Bacillus subtilis* (Wei *et al*., 2010). Skin mucus and intestinal mucus extract of *C. striatus* on the other hand show antibacterial activity against *Aeromonas hydrophila* and *Pseudomonas aeruginosa* (Dhanaraj *et al*., 2009). Anti-fungal activities of haruan extract have only been demonstrated by an ethanolic fillet extract against *Neurospora crassa, Aleurisma keratinophilum* and *Cordyceps militaris* (Jais *et al*., 2008). The same extract also inhibits *Botrytis pyramidalis* and *Paecilomyces fumosa-roseus* on a short term basis. Haniffa *et al.* (2013) reported that *C. marulius* methanolic extract was found to inhibit *Shigella boydii* and *S. aureus* whereas *C. striatus* methanolic extract inhibited *Shigella dysentriae*.

E.6 Cardiological Effects

Fish oil supplementation is now widely regarded as an effective preventative measure against cardiovascular problems. Italian researchers for example report that fish oil supplementation could be useful in preventing post-operative atrial fibrillation (Calo *et al*., 2005). In *C. striatus*, the skin extract called Shol Fish Skin Extract (SFSE) has been found to contain potent active compound, Cardiotoxic Factor II (CTF-II) (Karmakar *et al*., 2002), with hypotensive effect and cardiotoxic property that influence the increase in cardiac marker enzyme Creatine Phosphokinase (CPK) and Creatine Phosphokinase-MB (CPK-MB) values (Karmakar *et al*., 2004). Characterization of protein hydrolysates from muscle and myofibrillar samples of
C. striatus showed different kinetic and proteolytic activities (Ghassem et al., 2011a), and the result led to isolation of Angiotensin Converting Enzyme (ACE) inhibitory peptides with high ACE inhibitory activity, further supporting the use of C. striatus as a functional food and preventative medicine in hypertensive patients.

E.7 Haemotological Effect

The CTF-II factor found in SFSE also has blood-modulating properties. This factor could induce a decrease in haemoglobin, total RBC, WBC and platelet count (Karmakar et al., 2004).

E.8 Neurology and Neurophysiology

The skin extract of C. striatus (SFSE) could initiate apnoea and irreversible blockade of nerve-muscle preparation (Karmakar et al., 2002) and influence the serotonergic receptor system and hence, its possible role as an anti-depressant (Saleem et al., 2010 and 2011) is evident. It is also able to exert positive changes in the regenerative potential of neurons involved in traumatic injury as observed by neurite outgrowth and multipolarity of cells which took place in phaeochromocytoma PC12 cells treated with Haruan Therapeutic Extract (HTE) (Shafri et al., 2011). These findings open up the possibility of using C. striatus extract as a regenerative and restorative agent for treating damage to many types of organs.

F. Significance of the study

The therapeutic value of C. striatus is explored to a greater extent in south East Asian countries. In India, the uses of this species are still unknown, but this fish is being consumed for its taste and few intramuscular spines. Moreover, the medicinal properties of Indian C. striatus are still unexplored and only the growth studies are common. In Malaysia, haruan based drugs have been developed and there are four groups of OTC products formulated namely, personal cares, health foods, health spa
and medicated cream. Some of these especially tonic, softgel capsule and medicated cream are in clinical trials (Jais, 2007).

On the other hand, the medicinal values of the giant murrel *C. marulius* are unknown even in Malaysia and other Asian countries where the therapeutic uses of *C. striatus* are quite commonly known. There are no scientific reports on the therapeutic values of *C. marulius* or its traditional use till date. In India, the medicinal and nutritional properties of murrels are not familiar and hence, the present study was carried out to assess the therapeutic values of two Indian snakeheads *Channa striatus* and *Channa marulius* with special reference to wound healing, inflammation, arthritis, depression, ulcer, hepato-, nephro- and cardioprotective activity *in vivo*. 