CHANGES IN FATTY ACID PROFILE OF *TENUALOSA ILISHA* TOWARDS POLYUNSATURATION AND IMPROVEMENT OF TASTE DURING UPSTREAM MIGRATION

SUBRATO GHOSH*

The conception of superiority of taste of the highly-preferred foodfish Tenualosa ilisha which are caught from rivers in comparison to those caught from marine waters has been reviewed in this communication. High fat content in flesh of T. ilisha, relaxation of its musculatory system during its anadromous migratory route in riverine waters and conversion of saturated fatty acids in muscle to mono- and further to poly-unsaturated fatty acids have been attributed to improvement in taste of T. ilisha, which has established itself as one of the most important commercial fishes of the Indo-West Pacific region. Towards the end of this communication, the beneficial effect of T. ilisha to human health and nutrition has been discussed.

Introduction

The *Hilsa* fish, commonly known as *Ilish* in Bengali, is a popular fish in many parts of India like West Bengal, Odisha, Andhra Pradesh, Tripura, Assam, Mizoram, etc. *Hilsa* fish is the most favourite fish of all Bengalis. Each and every part of the *Hilsa* fish is a delicacy to Bengalis. Hilsa fish is a very costly fish, but Bengalis would go to any extent to taste the fish at least once or twice in a year. Hilsa fish is also associated with Bengali culture and rituals. In many parts of West Bengal, Hilsa fish is taken with *Panta Bhat* (rice soaked in water overnight) as breakfast on *Poila Boishakh* (1st day of Bengali New Year); a pair of *Hilsa* fish (*joda ilish)* is offered during the worship of Goddess of Learning (*Saraswati*). Bengalis are very fussy about its taste. In the market the first thing a Bengali would ask to the fish seller "where was this fish caught from?". It is believed that fishes caught from river water like the Ganga, the Rupanarayan, the Padma are tastier than what were caught in estuary or in marine waters like Chilka Lake. The price also varies depending on from where the fish is caught. This article presents a scientific explanation of this difference in taste.

* Fishery Field Assistant (Government of West Bengal), Kushmandi Development Block, Kushmandi, Dist. Dakshin Dinajpur, West Bengal

Postal address: 122/1V, Monohar Pukur Road, P. O. Kalighat, Kolkata – 700026, West Bengal
e-mail: subratoghosh2007@rediffmail.com

Migratory Nature of Tenualosa ilisha

The hilsa shad *Tenualosa ilisha* (Hamilton, 1822) (Clupeiformes: Clupeidae), popular as 'Ilish machh' in Bengali vernacular is the most economically-important and highly-priced finfish with heavy consumers' demand in India and Bangladesh. This fish species occurs in the foreshore areas, estuaries and freshwater rivers of the western division of the Indo-Pacific faunistic region; its marine distribution extends from Iran and Iraq in the Persian Gulf to the west coast of India in the Arabian sea, and the Bay of Bengal. In addition to western and eastern coasts of India, it is also known in the Andaman coast of Myanmar and western coasts of Thailand and Malaysia. *T. ilisha* is an anadromous species, and, although they quickly die when out of water, they are capable of withstanding a wide range of salinity and migrating great distances upstream. In West Bengal, it forms one of the lucrative

commercial fisheries of a single species; it is also the tastiest fish due to its distinctly soft oily texture and delectable flavour. Juveniles develop and grow in freshwater, but soon migrate to sea where they spend most of their life. *T. ilisha* grows in sea upto adulthood. From sea, matured fish of both sexes migrate hundreds of kilometers to freshwater environment of the river stretches *via* estuary for breeding/spawning purposes (mating, release of gametes, *i.e.,* laying eggs, birth of young ones takes place) in favourable environmental conditions and thereafter nourishment of early juveniles. They return to their original habitat after spawning till the next breeding season to come.

During its time at sea and estuary, *T. ilisha* remains less tasty but when it enters into freshwaters, its taste and further growth increases. The *T. ilisha* of freshwater origin, like those caught from rivers Padma, Rupnarayan and Ganga (Hooghly) is tastier and delicious than those caught from the sea (Bay of Bengal) or from Hooghly-Matla estuary. The fact stands true for Godavari and other riverine *T. ilisha*. The fish is tastier just before the spawning stage than post-spawning or maturing stages. Presence of certain fatty acids like stearic acid (18:0), oleic acid (18:1n–9), and mainly poly-unsaturated fatty acids (PUFA) like linoleic acid (18:2n–6), linolenic acid (18:3n–3), arachidonic acid (20:4n–6), eicosapentaenoic acid (EPA, 20:5n–3) and docosahexaenoic acid (DHA, 22:6n–3) in flesh of *T. ilisha* make its taste unique[1].

Initial Phase of Migration

During migration, the fish is sustained by the accumulated fat in its body; they derive energy from stored food (liver and muscle glycogen). This is saturated fat; it cannot break down in the body, is collected in places in body and get stored. *T. ilisha* gains significant fat content in brackishwater environment and wide variation in fat content occurs during migration, as evidenced by the results of a study that fat content in marine *T. ilisha* was 12.4%, which increased to 17.3% in brackishwater specimens, and gradually decreased in Godavari (riverine) specimens (14.51 to 8.78%)[4] (Table-1). The fish accumulates energy reserves during its growth phase in the form of lipids, mainly as triglycerides, which are catabolized to provide the energy necessary for their anadromous migration and spawning. During monsoon and late monsoon, *T. ilisha* takes less food during its spawning period and upward migration from seawater to estuarine waters (brackishwater) and further from estuarine waters to freshwaters. Due to less intake of food, *T. ilisha* utilizes their body lipids as a source of energy. In West Bengal, it has been observed that medium

TABLE 1: Changes in the fat composition of Godavari *T. ilisha* during anadromous migration to river Godavari during June to November 2010. Values in bracket indicate fat value on dry matter basis (Source: Madhusudana Rao *et al.*, 2012)

	Marine (Bay of Bengal)	**Brackishwater (River mouth)**	**Freshwater (River Godavari)**			
	June	July	Aug	Sep	Oct	Nov
Fat content (%)	12.4 (33.97)	17.38 (46.11)	14.51 (41.02)	11.18 (33.18)	9.83 (32)	8.78 (26.32)

size group *T. ilisha* (500gm+) from Kakdwip, Dist. South 24 Parganas, a downstream station of Hooghly river had 21.0% lipid content during monsoon whereas upstream fish (collected from Tribeny, Dist. Hooghly) of similar size group had only 2-3% lipid during pre-monsoon period. Large sized fishes (800gm+) contained 14% lipids during monsoon, but fishes of same group had 7-8% lipid during pre-monsoon period. The increase in lipid content during monsoon indicates that the fishes were in mature condition[2]. Lipid composition of *T. ilisha* collected from upstream and downstream stations of Hooghly estuarine system (Hooghly river) during pre-monsoon and monsoon period[2] has been shown in Table-2.

TABLE 2: Lipid content of *T. ilisha* from downstream and upstream stations of Hooghly estuarine system during pre-monsoon and monsoon period (Source: Nath and Banerjee, 2012)

	Downstream station (Kakdwip)		**Upstream station (Tribeny)**		
	Small (200gm+)	**Medium (500gm+)**	**Small (200gm+)**	**Medium (500gm+)**	**Large (800gm+)**
Monsoon period	14.45%	20.85%	-	-	13.71%
Pre-monsoon period	-	-	1.99%	2.48%	7.82%

Under favourable climatic conditions and huge ingress of freshwater (due to monsoon rain) into estuarine and inshore waters of Bay of Bengal *via* Padma, Bhagirathi (Hooghly) and other rivers, a decrease in salinity in estuarine zone is effected; at this time secretion of Gonadotropin hormone occurs from pituitary glands of matured *T. ilisha* of both sexes, inducing and facilitating their upstream migration for breeding. Voluminous growth of maturing-turned-matured ovary takes place during this period.

Conversion of Muscle Fatty Acids Towards Polyunsaturation and Change in Osmotic Balance

Fat content in *T. ilisha* decrease from the sea to brackishwater conditions, and further in the rivers. In process of migration in freshwaters, the fish show decreasing fat content with time. This is due to the consumption of enormous amount of energy during their migratory movement. Comparatively lesser fat accumulation in their body in rivers in comparison to their accumulation in marine environment makes the flesh softer. During spawning migration directed towards lower saline waters, saturated fatty acids (SFA) are converted first into mono-unsaturated fatty acids (MUFA) and then into poly-unsaturated long chain fatty acids (PUFA). In a migratory fish like *T. ilisha*, more is the upward migration towards zero salinity, more conversion into polyunsaturation takes place[3]. It is believed that more is the occurrence of polyunsaturation in lipid of *T. ilisha*, more is the development of characteristic texture and pleasant flavour in their muscle/flesh. PUFA content in *T. ilisha* has been determined to be lowest in marine specimens and highest in freshwater specimens[4]. Transformation of SFA and MUFA to PUFA is an important phenomenon that controls the unique taste of freshwater *T. ilisha*. Both lipid content and level of unsaturation of fatty acid are higher in abdominal region of the fish; this feature has been thought to be responsible for better taste of abdominal region than dorsal region[5].

From the estuarine zone, when this migratory species enters into freshwater system, changes occur in their physiological processes and muscle composition. They adjust their osmoregulatory process through kidney and gills. In order to cope up with the new environment, structure of their gill filaments changes and its permeability increases, which facilitates them to intake oxygen from freshwaters {Note: This phenomenon has been described by Dr Amalesh Chowdhury, Retd. Professor of Marine Sciences, University of Calcutta in his article on *Hilsa ilisha*, published in the Bengali Daily 'Bartaman' (supplementary pages) on 24th July, 2016 (Sunday)}. In freshwater environment, their kidney starts proper functioning and unwanted salt is extruded out. Taste of the fish changes also. In freshwater environment, due to change in osmotic balance of cells[4] from 30-35ppt salinity to 0.01ppt in complete freshwaters, fish takes more water through mouth, skin and gills to produce and excrete large volumes of urine. In this process, musculatory system of the fish gets relaxed. As the fish swims up the river, it flexes its muscles, making muscle cells softer, and, at the same time, the fat-protein intermolecular adjustment in body flesh becomes more appropriate, making it more tasty. The more it migrates through the river, more becomes the good taste. Fatter *T. ilisha* migrates faster and losses fat at a quicker rate in the rivers. In freshwaters, off-flavour gets eliminated from its body, which gets accumulated during the time when the fish grubs on muddy bottom in the sea and brackish water environment to find food (decayed organic matter, sand). In West Bengal and other places in India, *T. ilisha* ascends the waters but gets stuck in its journey due to pollution and silt load and polluted rivers, or against dams. But *T. ilisha* in Bangladesh makes a comparatively longer run upstream because of the country's less polluted rivers, thus rendering it 'improved' in terms of taste in comparison to *T. ilisha* of Indian rivers.

In a study on *T. ilisha* of Godavari river, total PUFA content showed an increasing trend with lowest in marine *T. ilisha* (11.41%) and highest in Godavari *T. ilisha* (26.87%)[4]. The SFA content was lower in Godavari *T. ilisha* (24.98%) than in brackishwater *T. ilisha* (36.76%) and marine *T. ilisha* (36.03%)[4] (Table-3). The results suggest the transformation of fat, towards PUFA, during the migration of the Godavari *T. ilisha*. The total amount of saturated, monounsaturated and polyunsaturated fatty acids of *T. ilisha* from river Godavari have been determined to be 492.22, 948.62 and 529.25mg/100gm respectively[4].

TABLE 3: Changes in the saturated and unsaturated fats during migration of *T. ilisha* from marine (Bay of Bengal) to freshwater (River Godavari) during June-November 2010 (Source: Madhusudana Rao *et al.*, 2012)

	Total saturated fatty acid (%)	Total unsaturated fatty acid (%)
Marine *T. ilisha* (Bay of Bengal)	36.03	63.98
Brackishwater *T. ilisha* (river Godavari mouth)	36.76	63.14
Godavari *T. ilisha* (River Godavari)	24.98	75.02

During monsoon, along with rapid influx of freshwater into inshore marine waters, detritus and new kind of abundant planktonic food matter enter into inshore waters. After eating these voraciously, *T. ilisha* prepares for its migration towards estuary and further into riverine freshwaters, and during which, it will take very little food. This is also thought to contribute to improvement of taste of *T. ilisha* when it is captured from rivers. Their stay in river waters imparts sweetness to the flesh and reduces its otherwise salty taste to its imperceptible point. In addition to kidney, chloride cells located in their gills also helps in

extrusion of salt from body. After spawning, when the spent fish migrates back to sea, it feeds on riverine zooplankton and phytoplankton on its way. Since the plankton resource in kind varies in different rivers, *T. ilisha* of different rivers in India may have difference in taste. Similarly the perceived taste difference between *T. ilisha* from the Bay of Bengal and the Arabian Gulf could be related to the types of food intake.

Fat Content in T. ilisha

In total muscle nutritional composition of a fish, the more is percentage of fatty acids/fat, more becomes the taste. Taste of *T. ilisha* seems to be dependent on the fat content also. Significant differences have been found in the average value of fat in the *T. ilisha* population of river Mahanadi (19.28%), Saurashtra coast (16.73%), river Padma (14.40%), river Godavari (10.70%), river Krishna (8.50%), river Narmada (5.40%)[6]. Fat content (18.01%) of adult *T. ilisha* obtained from Kolkata markets is much high in comparison to other common fishes[7]. During July-October, fat content in *T. ilisha* (collected from Diamond Harbour in West Bengal) of 800-1000gm and 1400-1600gm sizes has been determined to be 12.56±0.83 and 17.87±0.51gm/100gm wet muscle respectively[5] (Table-4). In this study, a higher amount of PUFA (2.77gm/100gm muscle) was found in medium-sized *T. ilisha* from West Bengal coast. Fats found in riverine *T. ilisha* is of unsaturated kind, which is good for human health than saturated fat. Unlike many estuarine and freshwater fishes, *T. ilisha* is rich in oil.

TABLE 4: Seasonal variation in crude fat content of *T. ilisha* collected from West Bengal coast (Source: Mohanty *et al*., 2012)

Size and season	(gm/100gm) of wet muscle		
	July-Oct	Nov-Feb	March-June
Small (200-400gm)	9.43	6.74	7.56
Medium (800-1000gm)	12.56	8.94	9.11
Large (1400-1600gm)	17.87	11.25	14.73

Myristic acid (14:0), which is used as a common flavouring agent in food items, was found to be present as the predominant fatty acid (37.8%) in *T. ilisha*. The good flavour of the fish has been thought to be due to its high myristic acid content.

A Study in Bangladesh

T. ilisha migrates through the Padma-Meghna river systems in Bangladesh. Spatial changes in lipid (fatty acid) profiles of *T. ilisha* during its anadromous migration from the Payra river to Kirtonkhola river and Meghna river in Bangladesh during lean season was studied[8]. Among these three rivers of Bangladesh, Meghna river at Chandpur is located at a latitude between 23°12min N - 23°13min N, and is at most northward position. Payra river at Patuakhali, located between 22°15min N - 22°25min N latitudes is at most southward position, most nearer to Bay of Bengal. It was found that total SFA values were lower than unsaturated fatty acid (UFA) values; SFA content was lower in Meghna *T. ilisha* (44.57%) than in Payra *T. ilisha* (45.44%) and Kirtonkhola *T. ilisha* (46.34%). The UFA content of *T. ilisha* in three riverine regions varied significantly. Levels of MUFA content showed a gradual decrease with highest in Payra *T. ilisha* (39.44%) and lowest in Meghna *T. ilisha* (36.52%) while PUFA content showed an increasing trend with lowest in Payra *T. ilisha* (15.12%) and highest in Meghna *T. ilisha* (18.91%)[8] (Table-5). The results suggest the transformation of fat, towards PUFA, during the migration of the fish towards Meghna river and are in agreement with the fact that frequency of conversion of fatty acids in *T. ilisha* from saturation to mono-unsaturation and to poly-unsaturation is proportional to its upward migration. More the fish migrates upwards, its saturated fatty acids are converted, primarily to mono- and then to poly-unsaturated fatty acids[9]. The change in fatty acid composition of Meghna *T. ilisha* towards PUFA might be possibly a physiological mechanism to counter, *i.e*., respond to the changes in salinity of water during migration. Fat content in flesh of *T. ilisha* collected from these three different riverine landing centers is shown in Table-5. The relative percentage of fatty acids in *T. ilisha* oil collected from river Padma, Bangladesh[10] has been shown in Table-6.

TABLE 5: Percentage of different fatty acids (total) in flesh of *T. ilisha* and variation in the composition of fat in flesh of *T. ilisha* collected from three riverine landing stations of Bangladesh during lean period (January-February, 2014) (Source: Moniruzzaman, 2014)

Constituents (%)	Payra River, Patuakhali	Kirtonkhola River, Barisal	Meghna River, Chandpur
SFA	45.44	46.34	44.57
UFA	54.56	53.66	55.43
MUFA	39.44	37.9	36.52
PUFA	15.12	15.76	18.91
Fat (%) in flesh of gravid *T. ilisha*	13.84	14.67	14.33

The total muscle SFA content of *T. ilisha* from Bay of Bengal has been estimated to be between 56.24-56.90%; SFA dominated the muscle fatty acid profile[11] (Table-6). In muscle tissues of *T. ilisha* from Bay of Bengal, lipid composition has been found to be 19.94±0.23% on fresh matter basis, which is 50.31% on dry matter basis. In contrast to total SFA, total MUFA content were lower in muscle tissues.

TABLE 6: Relative percentage of fatty acids in *T. ilisha* oil collected from Padma river, Bangladesh and fatty acid profile (as % of total fatty acids) in muscle tissues of *T. ilisha* collected from Bay of Bengal (Source: Munira *et al.*, 2015 and Hossain *et al.*, 2014)

	Percentage of fatty acids in *T. ilisha* oil	Fatty acid profile (% of total fatty acids) in *T. ilisha* muscle tissues
Total SFA	34.14%	56.24±0.07
Total MUFA	22.81%	27.26±0.56
Total PUFA	15.19%	14.27±0.53

Evaluation of T. ilisha as Dietary Component

Among the three types of fatty acids, SFAs and MUFAs are synthesized endogenously, but the third one (PUFAs) cannot be synthesized by humans and therefore must be obtained from the diet. The two important long chain omega-3 PUFAs EPA and DHA are important in treatment of atherosclerosis, cancer, rheumatoid arthritis and diseases of old age such as Alzheimer's disease and age-related macular degeneration. In epidemiological and clinical trials, PUFAs have been shown to reduce the incidence of coronary heart disease. Children who consume fresh, oily fish have significantly lower risk of developing asthma. DHA is proven to be essential in pre- and post-natal brain development.

In Hooghly estuarine system (Hooghly river), during monsoon, small (200gm+) and medium sized (500gm+) *T. ilisha* groups from downstream station (Kakdwip) had been observed to have 8.15 to 12.1% PUFA[2]. Total SFA was found to be maximum (49.9-57.32%) compared to total MUFA and PUFA in all groups of fishes from both upstream and downstream stations[2] (Table-7). During monsoon period, in West Bengal, large-sized group (800gm+) of upstream *T. ilisha* was found to have about 4.5% EPA and 0.8% DHA. The 0.14:1 – 0.40:1 omega-6/ omega-3 fatty acid value, recorded in *T. ilisha*, suggests that it is highly beneficial as food source to supply omega-3 fatty acid to human body[2]. Muscle tissue lipids of the fish are rich in omega-3 PUFAs, of which major portion are distributed in phospholipid fraction. In muscle tissue lipid of gravid *T. ilisha* (average wt. 806gm) collected from estuarine zone of Sundarbans, West Bengal, total SFA content has been determined to be 56.9±0.35%, total MUFA 23.7±0.16% and total PUFA 16.1±0.21%. This research[12] has also made evident the high nutritional significance of *T. ilisha* to the fish consumers.

TABLE 7: Percentage of SFA, MUFA and PUFA in different weight groups of *T. ilisha* collected from upstream (Tribeny, Dist. Hooghly) and downstream (Kakdwip, Dist. 24 Pgs. South) stations of Hooghly estuarine system (Hooghly river) during pre-monsoon (March-May) and monsoon period (July-September) (Source: Nath and Banerjee, 2012)

	Pre-monsoon period			Monsoon period		
	Upstream station			Upstream station	Downstream station	
	Small	Medium	Large	Large	Small	Medium
SFA (%)	55.8	50.74	49.92	53.01	52.7	57.32
MUFA (%)	29.05	30.9	34.05	36.7	34.7	34.73
PUFA (%)	14.7	17.5	12.7	10.1	12.1	8.15

At ICAR-CIFRI, Barrackpore and other ICAR institutions, among 39 foodfishes studied, *T. ilisha* was found to contain the highest amount of fat with 42.8% total SFA, 30.6% MUFA and 22% PUFA[13]. Omega-3 fatty acid content was found to be 14.2% in this fish. In terms of human health, *T. ilisha* is an important foodfish owing to its high PUFA content. The medium-sized *T. ilisha* (38.98±1.77cm; 800-1000gm) has been found to contain the highest amount of unsaturated fatty acids and lowest amount of SFA. It is best in terms of PUFA content (22.11%)[5] (Table-8), omega-3:omega-6 ratios (2.62) and EPA+DHA content (11.83%) and on the basis of fatty acid profiles, medium-sized *T. ilisha* is best followed for human health and nutrition[5]. Omega-3 fatty acid and EPA+DHA content of *T. ilisha* (14.04% and 11.83%) is higher than

TABLE 8: Total fatty acid composition of different size groups of *T. ilisha* (Source: Mohanty *et al.*, 2012)

	Percentage of total fatty acid		
	Small size	Medium size	Large size
Total saturated fatty acid	44.64±0.09	42.82±0.07	57.99±0.15
Total MUFA	31.60±0.19	35.36±0.20	27.59±0.18
Total PUFA	23.78±0.08	22.11±0.25	14.75±0.39
EPA + DHA (%)	10.90±0.03	11.83±0.09	10.24±0.57

that of another important marine fish Indian mackerel[5]. The significance of *T. ilisha* in our health and nutrition is compared to that of Atlantic salmon, another economically important foodfish of the world. A common version of the different kinds of saturated and unsaturated fatty acids has been presented in Table 9a and Table 9b respectively.

TABLE 9A: Examples of saturated fatty acids (Source: Wikipedia, Free Encyclopedia; https://en.wikipedia.org/wiki/Fatty_acid)

Sl. No.	Common name of fatty acid	No. of Carbon atoms (C) : No. of double bonds (D)
1.	Caprylic acid	8:0
2.	Capric acid	10:0
3.	Lauric acid	12:0
4.	Myristic acid	14:0
5.	Palmitic acid	16:0
6.	Stearic acid	18:0
7.	Arachidic acid	20:0
8.	Behenic acid	22:0
9.	Lignoceric acid	24:0
10.	Cerotic acid	26:0

Conclusion

As fishes like *T. ilisha*, *Sardinella longiceps* are very rich in EPA and DHA, these fishes can serve as natural dietary supplements for both EPA and DHA in many clinical conditions like asthma, lung disease, prevention of heart disease, high cholesterol, high blood pressure, certain inflammations of digestive system, rheumatoid arthritis, bipolar disorder[13]. Although *T. ilisha* is a fatty fish containing cholesterol, it may reduce blood cholesterol levels in hypercholesterolemic subjects. Oil of *T. ilisha* has a potential benefit in the treatment of cardiovascular diseases (CVD) and has a role in reducing the risk of CVD-associated hepatic complications[10].

We find that in addition to deliciousness and culinary excellence, *T. ilisha* is also esteemed from nutritional point of view. During June-July 2016, smaller-sized *T. ilisha* were available in the retail markets of Kolkata city for Rs. 400-450/kg, while price of the larger fish (600-800gm) was Rs. 500-550/kg. The above-mentioned fishes were commercially caught and landed at Namkhana and Diamond Harbour marine fishing harbours, located in southern part of Dist. 24 Pgs. South and at Digha mohona marine fishing harbour, located in coastal zone of Dist. East Midnapore, West Bengal. But had the fishes been caught from river Rupnarayan and landed at nearby Kolaghat station of the river in Dist. East Midnapore, price of the larger specimens would have surely been a minimum of Rs. 800/kg in Kolkata markets. Price of *T. ilisha* caught from rivers is definitely much higher than those caught from marine or estuarine areas; the difference in price is attributed, mainly

TABLE 9B: Examples of unsaturated fatty acids (Source: Wikipedia, Free Encyclopedia; https://en.wikipedia.org/wiki/Fatty_acid)

Sl. No.	Type	Common name of fatty acid	No. of Carbon atoms (C) : No. of double bonds (D)	n - x or omega - x nomenclature ('x' denotes position where double bond is located on Carbon - Carbon bond)
1.	MUFA	Myristoleic acid	14:1	n-5
2.		Palmitoleic acid	16:1	n-7
3.		Sapienic acid	16:1	n-10
4.		Oleic acid	18:1	n-9
5.		Elaidic acid	18:1	n-9
6.		Vaccenic acid	18:1	n-7
7.		Erucic acid	22:1	n-9
8.	PUFA	Linoleic acid	18:2	n-6
9.		Linoelaidic acid	18:2	n-6
10.		Alfa-linolenic acid	18:3	n-3
11.		Arachidonic acid	20:4	n-6
12.		Eicosapentaenoic acid	20:5	n-3
13.		Docosahexaenoic acid	22:6	n-3

to the taste of the fish. Thus, both in taste and price, every year, during monsoon and post-monsoon, riverine *T. ilisha* positions itself at a superior level than marine *T. ilisha* in the feelings of both commercial fishermen and city fish lovers. ❐

References

1. B. P. Mohanty, S. Das, U. Bhaumik and A. P. Sharma, *Bull. ICAR-Central Inland Fisheries Research Institute, Barrackpore, India*. **171**, 1-38 (2011).
2. A. K. Nath and B. Banerjee, *Indian J. Fish.,* **59(2)**, 141-146 (2012).
3. L. J. Magnoni, D. A. Patterson, A. P. Farrell and J. M. Weber, *Can. J. Fish Aquat. Sci.* **63(8)**, 1822-1829 (2006).
4. B. Madhusudhana Rao, L. N. Murthy, S. Mathew, K. K. Asha, T. V. Sankar and M. M. Prasad, *Indian J. Fish.* **59(1),** 125-132 (2012).
5. B. P. Mohanty, P. Paria, A. Mahanty, B. K. Behera, S. Mathew, T. V. Sankar and A. P. Sharma, *Natl. Acad. Sci. Lett*. **35(4)**, 263-269 (2012).
6. T. V. R. Pillay and H. Rosa, *FAO Fish. Biol. Synopsis* **25**, 1-65 (1963).
7. S. L. Chondar, Biology of Finfish and Shellfish (SCSC Publishers, Howrah, p10-27, (1999).
8. S. M. Moniruzzaman, MS Thesis, Department of Biochemistry and Molecular Biology, Bangladesh Agricultural University, Mymensingh (Dec 2014).
9. K. A. M. Nowsad, B. P. Mohanty, M. E. Hoq and S. Thilsted, *Proc. Regional Workshop on Hilsa: Potential for Aquaculture, Dhaka*. 1-40 (2012).
10. S. Munira, M. Asaduzzaman, M. Sohanur Rahman, M. M. Rahman, M. Hasan, S. Biswas, M. Islam, M. A. Mamun, M. M. H. Khan, M. M. Rahman, M. R. Karim and M. A. Islam, *Biol Med (Aligarh)* **7(5)**, (2015), doi: 10.4172/0974-8369.1000254.
11. M. A. Hossain, S. M. Almatar and A. A. Al-Hazza, *Indian J. Fish.,* **61(2),** 58-66 (2014).
12. M. Pal, T. Mukhopadhyay and S. Ghosh, *J. Aq. Food Prod. Tech*., **20(2)**, 160-171 (2011).
13. B. P. Mohanty, S. Ganguly, A. Mahanty, T. V. Sankar, R. Anandan, K. Chakraborty, B. N. Paul, D. Sarma, J. S. Dayal, G. Venkateshwarlu, S. Mathew, K. K. Asha, D. Karunakaran, T. Mitra, S. Chanda, N. Shahi, P. Das, Md. S. Akhtar, P. Vijayagopal and N. Sridhar, *BioMed Research International*, **2016**, 1-14 (2016), Article ID 4027437.