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ASSESSMENT OF POST HARVEST LOSS OF WET FISH: A NOVEL APPROACH BASED ON SENSORY INDICATOR ASSESSMENT

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ABSTRACT

As a very common feature of fish marketing, small-scale fisheries in tropical countries suffers from huge post-harvest loss every year. A method was proposed to quantify the post-harvest quality loss of wet fish using sensory based assessment tool. The assessments were conducted on four fish species (rohu *Labeo rohita*; Ilish *Tenualosa ilisha*, catfish *Pangasius sutchi* and tilapia *Oreochromis niloticus*) in different steps of major distribution channels in Bangladesh for a year. Sensory quality defect point data were standardized with corresponding biochemical and microbiological quality parameters through interval estimate based on regression analysis, where a "near to actual" sensory quality breaking point was found to be DP 3.3. High value of goodness of fit R^2 indicated a highly fitted regression model for all the fishes tested, with highly significant (p<0.01) estimated regression coefficients. Percent quality loss of fish at each step of distribution channel was determined using DP 3.3, constructing a (1-α) confidence interval for average percentage of defective fish. The loss assessment study indicated that fish did not lose quality during handling by the fishermen, and fish farmers or at landing centers and primary fish markets, except fresh *T. ilisha* destined for consumer market. While, *T. ilisha* used for salting during glut catch suffered substantial loss. Most of the quality losses were initiated at the transporters and commission agents, from 4% in *P. sutchi* to 11% in *O. niloticus*. When fish come to retailers, a 16% loss was recognized in *L. rohita* and *O. niloticus*, but 7% in *P. sutchi* and 9% in *T. ilisha*. Higher loss was observed in fish vendors, from 10% - 19%. Considering the retailers as the end-point stake in the fish distribution chain, study revealed the range of fish quality loss was 7-16% in four major consumed species in Bangladesh. The method was further validated in assessing the quality of 24 other major commercial fish species in different seasons and locations country-wide for two consecutive years and found identical results. The

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results suggest that the new method can be applied to any fish in quantifying the qualitative loss.

Keywords: Post-harvest fish loss, Distribution channel, Quality indicators, Qualitative loss, New loss assessment method

INTRODUCTION

The fisheries sector has acquired a unique status in Bangladesh economy contributing to the socio-cultural setting, rural employment and food and nutritional security. Because of its vast span, conducive ecological conditions and immense potential for development, the sector continues to provide direct and indirect livelihood opportunities to over 12 million people. Freshwater aquaculture has been expanding very fast, contributing from less than 20% to nearly 50% to the total fish production over a decade (DoF, 2012).

Fish provides the consumers with about 60% of their animal protein intake in Bangladesh. The average per-capita consumption of fish in Bangladesh is between 20 and 25 kg, while the world average is 13 kg (DoF, 2012). Present fish production of the country is 3.62 m MT (DoF, 2012). The country has set a target of producing 4.5 million tons of fish by the year 2019. In spite of all positive measures taken towards increment of production, post harvest loss of fish in the country is also enormous. The huge loss in fisheries exerts immense pressure on food security of the country. Although avenues exist to double the fish production, present post-harvest loss is presumed to be devastating, about 20-30% in different fish and fishery products (Nowsad, 2007), 50 % reduction of such loss can save Tk.8,000-10,000 crore per annum (Nowsad, 2010).

Preliminary research revealed a dearth of qualitative and quantitative data on post-harvest fish losses in Bangladesh. This is seen as a constraint to planning for the post-harvest sector at country level and at sector level. Previous research focused on estimation of local losses in wet fish distribution chain found about 20% of the marine fish landed in Cox's Bazar was deteriorated up to 80% of its original quality before it was loaded on the truck for distant transport (BCAS, 2003; Nowsad 2004). About 28% fish lost 60-70% of freshness quality before it reached consumers in local retail wet fish shop.

The International Fisheries Research Meeting in Paris in 1991 prioritized the need of estimating post harvest fish losses, since there had been no tried and tested methods by which fish loss could be estimated (Ward 2000). Since then the development of systematic and practical tools for assessing post harvest losses and assisting users to plan mitigation measures have been the key focus in many tropical African and Asian countries, where post harvest losses are thought to be very high (Cheke and Ward 1998; DFID 2002; FAO 2000; Ward 2000; Ward and Jeffries, 2000). Over the years, many different methods of quality assessment have been developed and investigated in an attempt to determine the most suitable index for use in quality testing or loss estimation, but no single method is found appropriate or suitable completely. Usually two or more methods are applied to measure the quality of fish or fishery products (Clucas and Ward 1996; Gopakumar 2002). Ward (2000) developed a field and desk based tool to estimate post harvest fish loss in West Africa and validated it in many African and Asian countries.

Many other authors have estimated physical or quantitative (economic) loss in fish and products in narrow ranges with minimal number of species or products, for example discard of by-catch species from shrimp trawlers or loss due to insect infestations (Srinath et al., 2008; Ward and Cheke, 1997). On the other hand, there is no any holistic study on estimation of quality loss of wet fish post-mortem, though it is thought to be a loss encountering up to 40% in some developing countries (FAO 2000). Although qualitative losses in fresh fish postharvest are generally assumed to be significant, it is extremely difficult to quantify the qualitative losses.

Sensory methods are generally used at field level to assess the quality of fish, i.e., the degree of freshness is assessed based on organoleptic characteristics. These subjective judgments are made by individuals. Various numerical scoring or ranking systems have been developed to evaluate the judgments or results (Connell, 1990). We have revitalized the fish freshness assessment method (Howgate et al., 1992) in quantification of post harvest quality losses through a regression model developed to estimate the parameters of the explanatory variables. Sensory quality defect points were standardized by several chemical and microbiological quality parameters to obtain near to accurate results. The current study is an attempt of assessing post-harvest quality loss of wet fish under a holistic approach incorporating all steps of major fish distribution channels where potential loss may occur.

MATERIALS AND METHODS

Loss assessment of wet fish throughout the distribution channel

In the present experiment, based on Howgate et al. (1992), the qualitative fish freshness assessment tool was revitalized to quantify the post-harvest fish loss, while the sensory defect points were standardized by several chemical and microbiological indicators. The assessments were conducted on three aquaculture species (rohu, *Labeo rohita*; pangas catfish, *Pangasius sutchi*; and tilapia, *Oreochromis niloticus*) and one captured species (river shad ilish, *Tenualosa ilisha*), in different steps of 11 major fish distribution channels (FDC) of the country for a year covering both summer and winter months (Table 1). In every distribution step, at least five lots of same fish and 3 individual measurements for each lot were assessed. The quality defects of the same fish or same lot of fish were assessed during its movement from fish farmer/fisherman; to commission agent (CA)-1(commission agent in primary market); to transporter/wholesaler; to CA -2 (commission agent in secondary market); to retailer and vendor. Time required to move fish from harvest to retail sale in the distribution chain has been presented in table 1. Field data collectors moved along with the fish from the harvest or landing centers through these distribution steps up to retailers and/ or vendors and assessed the quality of same fish or same lot of fish through the distribution chain, using table 2. Average of all data for a single fish in each step of FDC was taken as average quality defect point, as shown in table 3.

Standardization of sensory defect point (DP) by chemico-microbiological indicators

In sensory quality defect analysis of wet fish (Table 3), sensory quality breaking point lies within the DP range of >3 to <4. The range is very wide. Therefore, a near to actual sensory quality breaking point needs to be understood to determine the percent quality loss.

In order to correlate the sensory quality breaking points, several biochemical and microbiological quality parameters of fish were assessed and in the laboratory conditions, their quality breaking points were determined corresponding to each sensory DPs. When these biochemical and microbiological quality breaking points were plotted against the sensory quality DPs, a near to accurate sensory quality breaking point was pointed out.

Fishes were purchased live, or in premium quality fresh condition as in case of *T. ilisha*, brought to the laboratory and allowed to stand at ambient temperature (28-32^{o}C) for deterioration. Samples from the spoiling fishes were collected at regular intervals in course of deterioration and several biochemical and microbiological parameters were measured corresponding to each sensory DPs. The non-protein nitrogen (NPN), total volatile base nitrogen (TVBN), protein solubility (PS), peroxide value (PV), thiobarbituric acid reactive substance value (TBA), pH and surface aerobic plate count (APC) were measured corresponding to the obtained sensory DPs. Standard methods (AOAC 2010) were followed for the estimation of biochemical parameters. The PV and TBA were determined according to the modified method of Miwa and Ji (1992).

For the determination of surface APC, bacteriological samples were collected in duplicate from 1.5 cm^2 area of skin at the base of pectoral fin above the lateral line of each of the fish (Nowsad et al., 2014). A 1.5 cm^2 area marked on sterile filter paper (Advantec 131, 55 mm, Toyo Roshi Kaisha Ltd. Japan) was cut-off and placed on the skin surface. A piece (1 cm x 1 cm) of sterile cotton (Cut Cotton, 4 cm x 4 cm, Tomonari Salinity Material Co. Ltd. Japan) was wet with 1.5% NaCl and the designated skin surface was wiped with a forceps. Wiped cotton was dissolved in 20 ml sterile 1.5% NaCl for 30 sec, squeezed well to drop out NaCl solution and used for second time wiping. Similar wiping of surface skin and subsequent dissolving in NaCl solution were done 5 times. The NaCl solution with collected bacterial cells was serially diluted and then pour plated in duplicate on appropriate media (poly peptone0.5%, yeast 0.3%, $MgSO_4$ 0.05%, K_2HPO_4 0.2%, KH2PO4 0.04%, agar-1.2%, NaCl 1.5% pH 7.4). The plates were incubated at 37^{o}C and APC was done up to 24 h.

RESULTS AND DISCUSSION

In order to determine a near to accurate value of sensory DP corresponding to biochemical and microbiological quality breaking points, the following steps were followed-

i. values of some important biochemical and microbiological factors related with fish quality deterioration were determined, *viz*., NPN, TVBN, PV, TBA, PS, APC and pH;

ii. a regression model was developed on the basis of model selection criteria, R^2. Here, the selected target oriented regression model to estimate the parameters of the explanatory variables was as follows-

$$Y_i = \alpha + \beta_1 NPN_i + \beta_2 TVBN_i + \beta_3 \mathrm{PV}_i + \beta_4 \mathrm{TBA}_i + \beta_5 \mathrm{PS}_i + \beta_6 \mathrm{APC}_i + \beta_7 \mathrm{pH}_i + \varepsilon_i$$

Where Y_i = quality defect point corresponding to chemical/microbiological parameters;

α = intercept greater than zero;

β_i = i^{th} regression co-efficient, i = 1 (1)7;

ε_i = random error;

iii. value of percent quality loss (L) was simulated, L (%) = 0 (0.1) 5; then different biochemical and microbiological parameters corresponding to their sensory DPs for each step of distribution were estimated;

iv. range of each biochemical and microbiological parameters for each quality grade on the basis of the former step was constructed considering non-negative non- zero values;

v. near to actual sensory breaking point for percent quality loss (L%) (Here it was DP 3.3) was determined based on individual inverse regression (Table 3).

The value of the goodness of fit R^2 lies between 0 to 1 (Table 4). Since the value of the goodness of fit, R^2 is so high, the regression model for different fishes is observed to be highly fitted and the estimated regression coefficients are significant at 1% level of significance. When the value of protein solubility (% PS) increased, on an average, the sensory DPs decreased in each fish and the quality of the fish remained in acceptance level. On the other hand, when the other quality parameters, viz., NPN, TVBN, PV, TBA, APC and pH increased, on an average, the sensory DPs also increased. So, the quality of the fish declined. This well-known phenomenon, as commonly observed during the sensory DP validation study in four fishes, is also well-supported by the present regression model (Table 4). Interval estimate between different parameters based on this regression analysis calculated a near to actual sensory defect point 3.3 (Table 5), as also discussed later, comes to a more valid and genuine quality defect, compared to the existing sensory quality analysis (Howgate et al., 1992), to quantify the quality loss of wet fish.

As seen in table 5 also, in all four fishes studied, NPN, TVBN, PV, TBA and APC values increased but PS decreased with the increased level of sensory DPs. For teleosts of acceptable quality, the recommended value of NPN varied from 9.2 to 18.3% of the total nitrogen. A limit of 35-40 mg TVBN per 100 g of muscle is considered acceptable for good quality wet fish, while a value of 50-70 mg $100g^{-1}$ of muscle can be taken as upper limit beyond which fish is considered inedible (Gopakumar, 2002). The PV above 20 mmol kg^{-1} for any fish is considered rancid (Gopakumar 2002). For a good quality moderate lipid fish, TBA value of less than 2 mg kg^{-1} is usually accepted (Gopakumar 2002). In tropical freshwater fish, pH goes above 7.8-8.0 and in marine fish, pH above 7.7 is considered spoiled. Fish generally harbours a large population of bacteria on skin, surface, gills and in the intestine. Usually the bacterial load in fresh fish is in the range of 10^3 to $10^5/cm^2$ in the skin surface, 10^4 to 10^6 g^{-1} tissue in the gills and 10^5 to 10^8 g^{-1} in the gut contents, beyond which the fish is said to be deteriorating. Many authors opined a total aerobic plate count (APC) of 10^5 ($\log_{10}$ 5) is the upper limit beyond which the wet fish become unacceptable (Clucas and Ward, 1996; Connell, 1990; Gopakumar, 2002).

Interval estimate between different parameters based on regression analysis (Table 5) showed that the quality breaking point of NPN, as observed 19.06% in *T. ilisha*, 22.94% in *P. sutchi*, 23.0% in *O. niloticus* and 24.06% in *L. rohita*, intercepted the corresponding sensory DP 3.3 of the four test fishes. TVBN values at 64.92mg $100g^{-1}$ in *L. rohita*, 70.10mg $100g^{-1}$ in *P. sutchi*, 75 mg $100g^{-1}$ in *O. niloticus* and 108.83mg $100g^{-1}$ in *T. ilisha* crossed the respective sensory DP 3.3. The PV within the range of 26.0 - 30.0 mmol kg^{-1} in four fishes and TBA within 2.30 to 2.44 mg kg^{-1} body weight in four fishes, PS at the range from 62.96 to 66.33%, pH from 7.32 to 8.01 and APC from 4.86 to 5.1 x ($\log_{10}$ CFU/g) were observed to cross their corresponding sensory DP at 3.3. Similar phenomena can also be observed in line graphs if the chemical and microbiological parameters are plotted against their corresponding DPs. The quality cut-off points of chemical and microbiological parameters of *L. rohita* intercepted the sensory defect points at x-axis at a range between DP 3.1 and 3.6 with an average DP of 3.28 (Figure 1). Similar average DP values (DP 3.3) were also found when the line graphs of quality parameters of three other fishes (*O. niloticus, P. sutchi, T. ilisha*) were plotted against their corresponding DPs too. Thus DP 3.3 can be taken as the sensory quality breaking point at or beyond which fish is rejected.

Determination of post-harvest quality loss of wet fish

Quality loss (%) was calculated from the number of assessed cases in each step of FDCs that attained or crossed DP 3.3. The following formula was used to calculate percent quality loss of fish.

$$L\,(\%) = \frac{D_i}{N}\ X\ 100$$

L = Percent quality loss

N = Number of observed lots

D_i = Total number of calculated DP ≥ 3.3

$$D_i = \frac{d_1}{n_1} + \frac{d_2}{n_2} + \cdots + \frac{d_i}{n_i}$$

Where 'd_i' is the number of DP ≥ 3.3 in fishes in n th lots and 'n' is the number of observations in ith lot.

In order to estimate the accurate value of L (%) of different fish in different steps of distribution channel throughout the country, the following sequential steps were followed:

i. random samples with replacement for each step of distribution channel were drawn;

ii. proportion of defective fishes (DP ≥ 3.3) was calculated and converted into percentage;

iii. above 2 steps were conducted as desired level and an average percentage of defective fishes were determined;

iv. standard errors of average percentage of defective fishes in each step of distribution channel were obtained;

v. (1- α) confidence interval for average percentage of defective fishes was constructed by using the formula –

$$\bar{A}_i \pm Z_{\alpha/2}\ S.E\ (\bar{A}_i)$$

Where, $\bar{A}_i$ = average percentage of defective fishes for the i^{th} type fish, equivalent to L (%)

S.E ($\bar{A}_i$) = standard error of $\bar{A}_i$

$Z_{\alpha/2}$ = critical value of i^{th} type fish

The above steps were conducted repeatedly for each step of distribution in different distribution channels.

Percent quality loss

The percent quality loss of four fishes in different steps of FDC have been shown in table 6. Neither of the fishes lost their quality when they were in fishermen, landing centers or commission agents in primary fish market except *T. ilisha*. A 2±0.4% and 5±2% loss in *T. ilisha* destined for consumer market as wet fish was observed in landing centers and commission agents. This might be due to unavailability of ice or transport in glut season catch. River shad is a highly oily and seasonal fish. Uddin et al. (1999) reported loss of *T. ilisha* during glut period, mainly in September- October. Glut period may persist only 1-2 weeks when schools of straddling *T. ilisha* come across the near coast off Cox's Bazar and Barguna from other parts of the Bay of Bengal. These huge catches are generally not taken care of with adequate supply of fishing boat, manpower for handling, icing, ice box and transportation. Most of such quality deteriorated *T. ilisha* are processed into dry or wet salting (Nowsad, 2010). *T. ilisha* used for salting suffered substantial loss while they were in fishermen (14±3%), landing center (43±5%) or processors (61±7%). This result supports the findings of glut period loss of *T. ilisha* as explained.

In most metropolitan cities, there are second commission agents where fish transported by the transporters/wholesalers are auctioned again to transfer fish to retailers or vendors. Most of the quality loss were found to be initiated at the transporters/wholesalers, from 4±2% in *P. sutchi* to 11±0.5% in *O. niloticus*. When the fish come to retailers, very high degree of losses, as much as 16±4% and 16±2% were recognized in *L. rohita* and *O. niloticus*, while it was 7±3% in *P. sutchi* and 9±2% in *T. ilisha*. A further extreme loss was observed in fish vendors, as much as 10-19% in 4 species. This was due to delayed selling in association with minimum use of ice in fish.

CONCLUSIONS

In existing sensory quality assessment of fish, the range of quality breaking point is very wide (>3 to <4). Therefore, a near to actual sensory quality breaking point was determined through regression analysis between several chemico-microbiological quality parameters and the corresponding sensory defect characteristics of four spoiling fishes in laboratory conditions. The regression analysis found a near to actual sensory quality breaking point, DP 3.3. High value of goodness of fit R^2 indicated a highly fitted regression model for all four fishes tested, with highly significant ($p<0.01$) estimated regression coefficients. We also calculated the estimated range of chemico-microbiological parameters for each DP by using the confidence interval. This modified method of DP 3.3 was used to calculate the percent quality loss of initially four mentioned wet fish (*L. rohita, P. sutchi, O. niloticus* and *T. ilisha*) and later, huge other commercial wet fishes in different steps of their marketing and distribution channels country-wide. The modified fish loss assessment method has been come up as a useful field tool to quantify the qualitative loss of fish post-harvest.

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Table 1. Fish distribution channels (FDC) covered in the study

Name of FDCs	Nature of fishery	Distance transported (Km)	Time required (Hr)*[1]	Month of observation	Temp range (^0C)	Species assessed
Sunamganj-Dhaka	Capture	344	12.0	Jul - Aug Nov - Jan	29-34 16-19	*L. rohita, O. niloticus,*
Barobazar Jessore – Dhaka	Culture	376	15.0	May - Jul Dec - Jan	34- 35 20-22	*L. rohita, O. niloticus,*
Mymensingh-Dinajpur	Culture	340	18.0	Aug - Sept Jan - Feb	33-36 16-18	*L. rohita, O. niloticus,* *P. sutchi*
Barobazar Jessore – Dinajpur	Culture	410	17.0	May - Jul Jan - Feb	31-35 20-22	*L. rohita, O. niloticus,*
Chittagong - Dhaka	Capture /Culture	270	14.5	Aug - Oct Feb - Mar	30-36 20-24	*T. ilisha, O. niloticus,*
Cox's Bazar - Dhaka	Capture /Culture	400	22.5	Sept - Oct Feb - Mar	34-36 20-24	*T. ilisha*
Mymensingh - Dhaka	Culture	120	9.0	Aug - Sept Jan - Feb	32-35 18-22	*L. rohita, O. niloticus* *P. sutchi*
Mymensingh-Sunamganj	Culture	440	14.5	Aug - Sept Jan - Mar	32-34 18-25	*L. rohita, O. niloticus* *P. sutchi*
Patharghata - Dhaka	Capture	320	23.0	Sept - Oct Jan	33-36 18-24	*T. ilisha*
Khulna - Dhaka	Capture /culture	335	18.0	Oct Feb	35-37 19-21	*T. ilisha, L. rohita,* *O. niloticus*
Chandpur - Dhaka	Capture	160	13.0	Sept - Feb	34-37 16-22	*T. ilisha*

*[1] "Time required" in the distribution chain was calculated from the time of harvest to retail sale

Table 2. Sensory defects and defect points (DP) for assessment of quality loss of fish [*1]

Name of fish : .... Step of distribution channel: ....

Nature of landing: …………................Location: …………………. Date:…………................

Distance from origin (km): …………..…. Ambient temp. (^{o}C): …………..…. Fish body temp (^{o}C):……………

Characteristics	Defects	DP	Given DPs in different observations														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Odor of broken neck	a. Natural fishy odor	1															
	b. Faint odor	3															
	c. Sour odor	5															
Odor of gills	a. Natural odor	1															
	b. Faint sour odor	2															
	c. Slight moderate sour odor	3															
	d. Moderate to strong sour odor	5															
Color of gills	a. Slight pinkish red	1															
	b. Pinkish red to brownish	2															
	c. Brown to grey	3															
	d. Bleached color	5															
Slime of gills	a. Thin colorless slime, filaments soft & separate	1															
	b. Sticky greenish slime, filaments separate	3															
	c. Yellowish slime, filaments attached	5															
Body slime	a. Clear, transparent, uniformly spread	1															
	b. Turbid, opaque	3															
	c. Thick, sticky, yellowish or greenish	5															
Eye	a. Bulging with protruding lens, transparent eye cap	1															
	b. Slight cloudy lens, sunken	2															
	c. Dull, sunken, cloudy, blood line/reddish cornea	3															
	d. Sunken eyes covered with yellow slime	5															
Consistency of flesh	a. Firm, elastic	1															
	b. Moderately soft & some loss of elasticity	2															
	c. Some softening of muscle	3															
	d. Limp or floppy	5															
General appearance	a. Full bloom, bright, shinning, iridescent	1															
	b. Slight dullness, loss of bloom	2															
	c. Definite dullness and loss of bloom	3															
	d. Reddish lateral line and caudal region, dull, no bloom	5															
	Average DP																
Grand average DP																	

[*1] Indicators proposed by Howgate et al (1992) were revised in the present form

Table 3. Sensory defect point (DP) and quality characteristics of fish[*1]

DP	Characteristics	Grade
<2	Excellent, highly acceptable	A
2 to 3	Good, acceptable	B
> 3 to < 4	Deteriorating, not acceptable	C
4 to 5	Spoiled, rejected	D

[*1] Howgate et al. (1992)

Table 4. Regression analysis of chemical and microbiological parameters on sensory DP

Parameters	Estimated *Regression Coefficient* for different fish[*1]			
	L. rohita	***T. ilisha***	***P. sutchi***	***O. niloticus***
NPN (% of total N)	0.107168	0.11457	0.114504	0.115587
TVBN (mg $100g^{-1}$)	0.046814	0.057856	0.06096	0.068808
PV (mmol kg^{-1})	0.082397	0.073794	0.06596	0.127616
TBA (mg kg^{-1})	0.868365	0.878568	1.007781	0.804872
PS (%)	-0.07811	-0.08222	-0.08271	-0.1256
APC (log10 CFU g^{-1})	2.610211	2.239595	1.848606	3.27139
P^H	1.376812	2.12054	1.465419	1.467721
R^2	0.910284	0.927942	0.873365	0.924027

[*1] $p< 0.01$

Table 5. Interval estimate of chemical and microbiological parameters corresponding to sensory DP

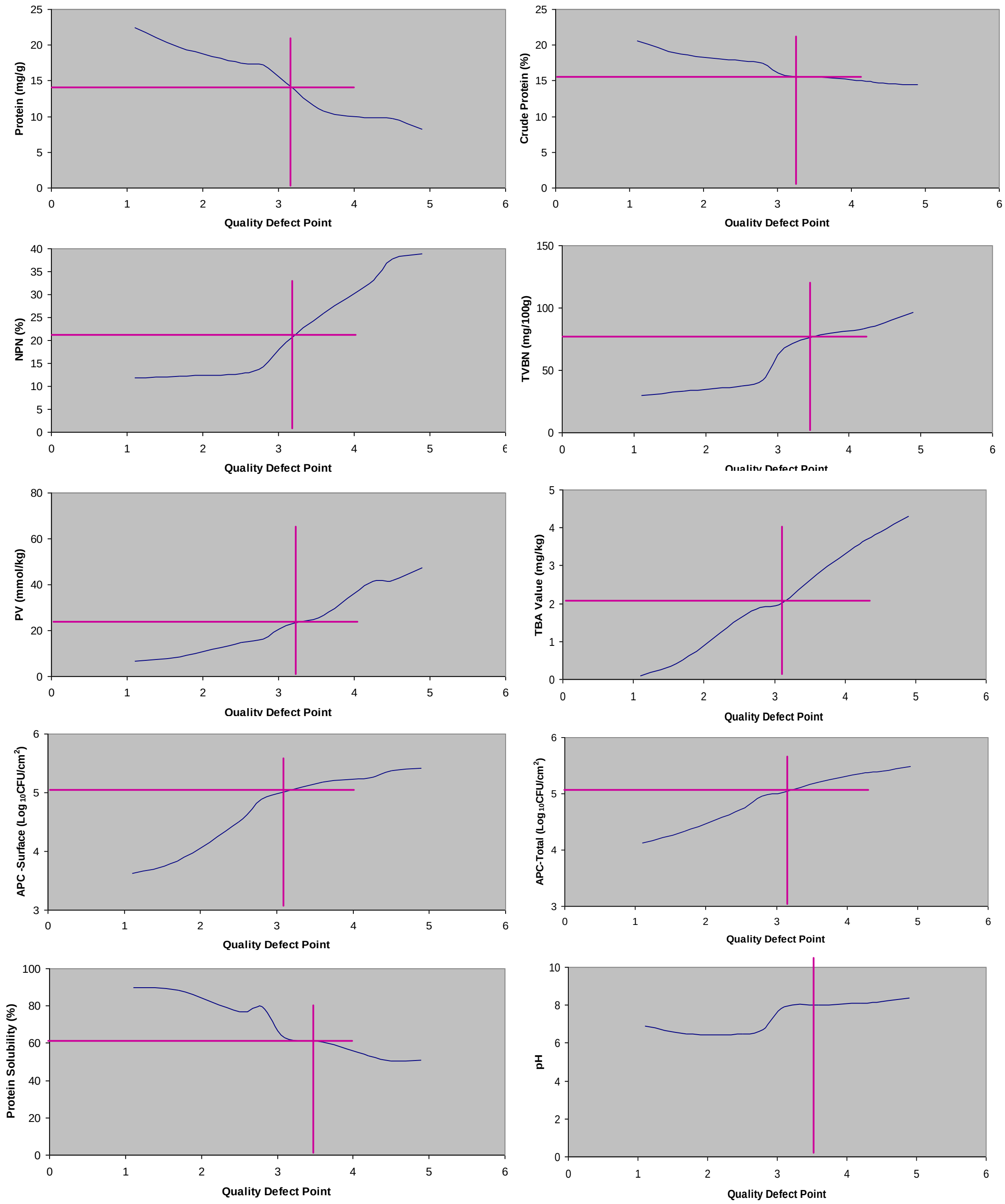
Name of fish	NPN (%)	TVBN (mg 100 g^{-1})	PV (mmol kg^{-1})	TBA (mg kg^{-1})	PS (%)	APC (log_{10}	pH	Sensory DP	Grade points
L. rohita	0.17-12.52	0.54-37.62	0.2-10.58	0.05-0.85	105.76-	3.22-4.16	5.78-6.80		
T. ilisha	0.19-9.96	137.15-120.84	0.64-12.72	0.01-0.95	99.02-	3.78-4.48	5.96-6.74	up to2	
P. sutchi	0.47-13.4	19.7-48.26	1.18-10.99	0.01-1.01	102.2-	2.89-4.03	6.22-7.03		A
O. niloticus	0.57-12.18	27.78-55.36	3.42-13.88	0.03-0.81	92..89-77.8	3.95-4.49	6.08-7.02		
L. rohita	13.00-	39.50-57.12	11.70-22.07	0.96-1.98	81.86-	4.20-4.66	6.85-7.33		
T. ilisha	10.61-	119.99-112.26	13.82-23.70	1.05-2.01	77.17-	4.52-4.86	6.78-7.95		
P. sutchi	14.08-	49.76-63.28	12.39-24.99	1.10-2.00	81.71-	4.09-4.63	7.08-7.46	>2 to 3	B
O. niloticus	12.96-	56.81-69.88	14.40-19.39	0.94-2.12	77.01-	4.52-4.78	7.07-7.50		
L. rohita	21.00-	59.07-76.63	23.22-33.57	2.10-3.12	69.91-	4.71-5.15	7.38-7.86		
T. ilisha	17.13-	111.40-103.68	24.80-34.68	2.11-3.05	66.24-	4.90-5.23	7.19-7.56		
P. sutchi	20.89-	64.78-78.31	26.40-39.00	2.09-2.99	71.46-	4.69-5.23	7.50-7.89	3> to 4	C
O. niloticus	20.70-	71.33-84.39	19.94-24.90	2.25-3.42	69.06-	4.80-5.06	7.56-8.01		
L. rohita	24.06	64.92	26.67	2.44	66.33	4.86	7.54		
T. ilisha	19.06	108.83	28.09	2.43	62.96	5.01	7.32		
P. sutchi	22.94	70.10	30.00	2.30	64.00	5.10	7.89	3.3[*1]	C[*1]
O. niloticus	23.00	75.00	26.00	2.40	64.00	4.90	8.01		
L. rohita	29.00-	78.00-98	34.71-46.21	3.2-4.37	57.97-	5.20-5.64	7.90-8.45		
T. ilisha	23.64-	102.82-94.24	35.79-46.75	3.16-4.21	55.31-	5.27-5.64	7.60-8.01		
P. sutchi	27.69-	79.81-84.83	40.40-54.41	3.09-4.08	61.21-	5.29-5.88	7.93-8.36	>4 to 5	D
O. niloticus	28.44-	85.85-100.36	25.45-30.96	3.55-4.86	61.12-	5.09-5.38	8.06-8.55		

[*1] = near to accurate sensory DP and quality grade

Table 6. Percent quality loss of fish in different steps of fish distribution channel

Fish	Month of observation	Distance of consumer market (km)	Quality Loss (%)						
			Fishermen/ Farmer	Landing centre	CA- 1	Transporter/ Wholesaler	CA – 2	Retailer	Fish vendor
T.ilisha (used as wet fish)	Aug- Oct Feb-Mar	160 - 400	-	2±0.4	5±2	-	7±2	9±2	19±4
T.ilisha (used in salting)	Sep- Oct	40 - 120	14±3	43±5	-	-	61±7[*1]	-	-
L. rohita	May- Oct Nov-Feb	120- 440	-	-	-	4±2	6±0.4	16±4	19±3
O. niloticus	May- Oct Nov-Feb	120 - 440	-	-	-	5±2	11±0.5	16±2	13±2
P. sutchi	Aug-Sep Jan-Mar	340 - 440	-	-	-	-	4±2	7±3	10±4

[*1] Loss found with the processors



Determination of post-harvest quality loss

NPN = non-protein nitrogen; TVBN = total volatile base nitrogen; PV = peroxide value; TBA = thiobarbituric acid reactive substance value; APC = aerobic plate count

Figure 1. Relation between biochemical and microbiological quality deterioration and sensory quality defect points of *L. rohita*