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ECONOMIC LOSS OF FISHERIES DUE TO THE POST HARVEST QUALITY LOSS AND ASSESSMENT OF THE QUALITY LOSS IN FISH

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ABSTRACT

Fisheries play a significant role in Sri Lanka providing a 20% of the animal protein supply contributing 2.7% of country Gross Domestic Products, making opportunity for direct and indirect employment for 2.4 million people. In 2008, its contribution for the Gross Domestic Product (GDP) was 1.1% and 1.942 % in total export income from 2009 in Sri Lanka with the total production of 29,3170 metric tons. Proper handling practices, rapid chilling and proper storage of fish on boats and up to the market place ensure the quality of fish. This study attempt to investigate the qualty loss and estimate the economy loss of three fish species, namely *Katsuwonus pelamis*, *Decapterus russeli* and *Auxis thazard* from one day fishing boats. . Samples were collected from the catching point and the landing place (physically damage and non-damage fish) from 24 one day fishing boats and analysis proteolytic bacterial count. The visual observation method used to analysis physical damages throughout the value chain and the final market value was observed for damages and non-damages fish at market place. Research is revealed of the effect and the level proteolytic bacteria in the boat deck and the hand that is removing fish from the net, to the both good and damaged fish sampled at the catching site and the Landing site. Research revealed the level of the effect of the boat deck to the proteolytic bacteria in 52.9 % to the damaged fish on the boat, 44.4 % to the good quality fish kept on the deck and 27.3 % damaged fish kept on the boat deck. When the fishermen are removing fish from the net and catching the fish, research revealed that the proteolytic bacteria level of the effect to the particular fish from the hand is 36 % to the good quality fish as soon as possible catch, 13.1 % to the damaged fish as soon as possible catch, 32.1 % to the fish damaged on the boat, 30.2 % to the good quality fish sampled at the pier and 67.7 % to the damaged fish sampled at the peir. And revealed there is no significant difference of the activity of fish under chilled condition in both good and damaged sampled both at the boat and the pier. It is found as 2 - 6 % damages in *Katsuwonus pelamis* with 10 - 50 % economic loss, in *Decapterus resseli* 8 - 18 % damages with 13 % - 45 % economic loss and in *Auxis thazard* 13 % - 23 % damages with 39 % - 51 % Economic loss. Based on the information gain from this study, a comprehensive handling, processing and quality management system has been suggested to minimize the quality and economic loss for one day fishing boats.

1. INTRODUCTION

1.1. Importance of Fish as Nutrition Source

Fisheries play a major role in many countries contributing to the livelihood; food security and international trade and broad aspect of the economy. Fish is the major protein source which is provided essential proteins to human and other animals in animal husbandry with high quality and easily absorbed proteins. (Linus and Saud; 2006). Through other animal foods, like meat, milk, eggs; fish is more important than all of them, because in a unit mass of fish muscles are having relatively larger amount of proteins to other food items (Hathwar, Kumar, Modi, Narayan; 2011). Using raw fish, other by products are produced having a larger amount of proteins and in the other hand; fish is used to produce other animal foods with relatively larger amount of proteins that is essential for the better growth and better health condition of other animals.

1.2. Word Fisheries Production Trends

Global fish production increased from 40 million tons in the 1960s to nearly 101 million tons in the 2002, providing an apparent per capita supply of 16.2 kg (live weight equivalent). Particularly overall, fish provided more than 2.6 billion people with at least 20% of their average per capita animal protein intake. The share of fish proteins in total world animal protein supplies grew from 14.9% in 1992 to a peak of 16.0 % in 1996 and remained close to that level (15.9%) in 2001 (SWFA, 2000).
Demand for protein is increased with day by day with increasing of the population and with that the need of more production. To fulfill that particular need, fish are produced through the industry named fisheries and it is included both marine and inland fisheries. From recent period, aquaculture is taking a part of fulfilling above need. But yet the highest contribution is done by capture fisheries.

1.3. Capture Fisheries in Sri Lanka

Capture fisheries is playing the major role of food fish production in Sri Lanka (Table 1.1). During the last 10 years aquaculture and capture fish production has increased considerably.

Table 1.1 Contribution of Both Fisheries and Aquaculture Sectors for Fish Production in Sri Lanka in 2009 and 2010

	Fisheries Sector			Aquaculture Sector		
	2009	**2010**	Change 2009/2010 %	**2009**	**2010**	Change 2007/2008 %
Jan	23,980	24,290	1.3%	3,260	3,250	-0.3%
Feb	24,730	26,340	6.5%	3,380	3,320	-1.8%
Mar	26,350	27,560	4.6%	3,630	3,760	3.6%
Apr	24,980	25,980	4.0%	3,140	3,690	17.5%
May	21,920	25,230	15.1%	2,960	3,270	10.5%
Jun	19,130	27,120	41.8%	2,780	3,310	19.1%
Jul	22,050	26,180	18.7%	4,380	4,490	2.5%
Aug	25,240	27,230	7.9%	5,290	6,170	16.6%
Sep	23,310	28,030	20.2%	4,970	5,420	9.1%
Oct	26,730	27,540	3.0%	3,900	4,760	22.1%
Nov	28,060			4,990		-100.0%
Dec	26,690			3,880		-100.0%
Total	**293,170**	**265,500**	-9.4%	**46,560**	**41,440**	-11.0%

Source: Ministry of Fisheries and Aquatic Resources

According to the 2010 data, the contribution of the coastal and offshore (deep sea) fisheries were 293700 tons respectively (Ministry of Fisheries: 2010). That mean, still coastal and offshore fisheries plays an important role to Sri Lankan fisheries sector. Different type of fishing crafts and various types of fishing gears are used to that purpose. Before 100 years, fishing is done by a canoe using a particular net in shore and inland water bodies (FAO; 2006). With the blue revolution, development of the science and technology is appeared to the fisheries sector and with that, modern crafts and fishing gears were introduced making for efficient and big harvest in fisheries industry in Sri Lanka.(FAO; 2006)

After the blue revolution utilization of the modern technology was increased day by day. And using boat single day boats and

multiday boats are increased day by day with using relatively larger capacity of storing fish to traditional canoes and single day boats. (Table 1.2)

Table 1.2 Utilization of Modern Crafts with Large Capacity (Ministry of Fisheries and Aquatic Resources)

Boat Type	Year		Increase/Decrease
	2004	2007	
Inboard Single Day Boats	1493	1157	-23%
Inboard Multi Day Boats	1581	2618	66%
Out-boat engine Fiberglass Reinforced Plastic Boats	11559	17835	54%
Motorized Traditional Boats	674	1854	175%
Non-Motorized Traditional Boats	15260	18206	19%
Non Mechanized Beach Seine Boat	1052	1008	-4%
TOTAL	31691	42678	35%

Data Source: Ministry of Fisheries and Aquatic Resources

With that, fishermen could involve in their industry more a in apart to the shore and the quantitative increase is shown in the harvesting in coastal and offshore with modern technology. (Table 1.3)

Table 1.3 Increase the Fish Production in Coastal and Offshore in past ten years in Sri Lanka

YEAR	FISH PRODUCTION		TOTAL FISH PRODUCTION
	COASTAL	OFF SHORE	
2000	175280	88400	263680
2001	167530	87360	254890
2002	176250	98510	274760
2003	103850	90830	254680
2004	154470	98710	253190
2005	63690	66710	130400
2006	121360	94620	215980
2007	150110	102310	252670
2008	165320	109310	274630
2009	180410	112760	293170

Data Source: Ministry of Fisheries and Aquatic Resources

1.4 Economical Contribution in Fisheries

With that, fish producing for both local and international market has started. Fisheries contribution for the economics in Sri Lanka is Rs.27016 million productions with 1.1% in G.D.P in 2008 and it has increased in to Rs.28888 million with 1.2% in G.D.P. in 2009. (CBSL, 2009) this is not in reference list. Rapid increase is obvious in fish export in Sri Lanka. (Figure 1.4) In 2009 Rs.15885 million income is earned by fish exports (Table 1.4) and it is 1.942% in total exports in Sri Lanka.

Under the prevailing situation discussed above, it is clear that the need of the better quality fish. With the quantitative increase in the harvesting and export, the production became differ in qualitative with the demand of best quality fish in both local and international market.
As a general stuff, in the market, high quality fish are selling for a good price, while low quality fish are selling for relatively lower price. But if these low quality fish came to the market as a high quality fish, economically profit will be increased. In different points of value chain, there are different practices, which is adding and losing value of fish. Through value adding as different products, economic gain is in place, while having economic loss through quality loss.

Table 1.4 Fish Export with Total Exports in Sri Lanka

YEAR	FISH EXPORT (MT)	FISH EXPORT VALUE (Rs. Million)	TOTAL EXPORT VALUE (Rs. Million)	CONTRIBUTION TO TOTAL EXPORT VALUE %
2000	11837	3782	402308.56	0.94
2005	10960	6335	619496.84	1.022
2007	15473	13560	848643.00	1.600
2008	15014	14706	885998.00	1.660
2009	13857	15885	818160.00	1.942

Data Source: Ministry of Fisheries and Aquatic Resources

1.5 Post Mortem Changes in Fish

Generally, quality is the key to successful market access, which creates increase revenue collection producers. Generally degradation of the quality of the fish will be started with taking fish away from the particular aquatic medium. Therefore, the reasons for quality deterioration leading to spoilage which is need to be determined carefully. As major ways of post mortem changes in fish are physical changes, biochemical changes and microbiological changes can be recognized (Amos; 2007). Just after death, fish started the stages of slime secretion and then rigor mortis while chemical and biological changes are taking place gradually (FAO, n.d) Slime secretion is started immediately after the death of the fish. Then muscles will be totally relaxed and the limp elastic texture persists for some certain time. Then muscles will contract. Then body is become inflexible and called it rigor mortis. (FAO; 2004)

Physical damages in fish may occur with that due to various handling, landing and storing practices. And those physical damages may effect to the other biochemical changes and microbe activities in fish muscles (FAO, n.d) In fish muscles, it is consist of various biochemical compounds like carbohydrates, proteins, lipids etc.. (FAO, n.d). Degradation of the biochemical compounds is started with enzymatic activities and microbiological activities. Microbe activities are the major parts of the fish muscles and playing a critical role of the quality of the fish (FAO, n.d).

1.6 Fish Spoilage

Spoilage and freshness are the two qualities that have to be clearly defined (singh, Danish and Saxena, n.d). A fresh product is defined as the one whose original characters remain unchanged. Spoilage therefore is the indicative of post-harvest change. This change may be graded as the change from absolute freshness to limits of acceptability to unacceptability. Spoilage is usually accompanied by change in physical characteristics. The quality changes can easily be noticed and consist of change in colour, odouror smell and texture, taste and appearance and are therefore called sensory changes. Spoilage is caused by the action of enzymes, bacteria and chemicals present in the fish. In addition, the following factors contribute to spoilage of fish.

- High moisture content
- High fat content
- High protein content
- Weak muscle tissue
- Ambient temperature
- Unhygienic handling

Fish is highly nutritive. It is tasty because of its constituents. The main components of fish are water, protein and fat. The spoilage of fish is a complicated process brought about by actions of enzymes, bacteria and chemical constituents. The spoilage process starts immediately after the death of fish. The process involves three stages:

1. Rigor mortis
2. Autolysis
3. Bacterial invasion and putrefaction

As the physical features of spoilage, the changes in color, texture, odor fish, color of eyes, color of gills, softness of muscle, and belly of a fish are obvious. In the process of fish spoilage, three major actions are occurred.

1.6.1. Enzyme action

Glycogen present in the muscle is converted to carbon dioxide and water after supply of oxygen to the cells when fish is live. After the death, the blood circulation may stop and with that oxygen supply to the cells may automatically halt (Loyd; 1992). As a result, with anoxic condition in the muscle cells, enzymes present in the muscle convert glycogen into lactic acid. The pH of the fish muscle falls with lactic acids produced in fish muscle fibers. This process is occurred until the exhausting of glycogen in muscle fibers.
Particularly this is interconnected with the process called rigor mortis (FAO; n.d.). Autolysis is occurred in muscle fibers with proteins and fats breaking down in to simple compound due to a complex series of reactions that is catalyzed by enzyme activities. Autolysis of protein starts immediately after rigor and creates favorable conditions for the growth of bacteria (FAO; n.d.). Enzymatic action also causes decomposition in the fish known as belly bursting. The belly bursting is caused by the action of digestive enzymes present in the gut of the fish.
Therefore, in order to maintain fish quality, enzyme activities should be prevented. Using low temperature is the most frequently used measure to limit enzyme activities (Huss 1994).

1.6.4. Physical Damage

The harsh handling of fish will subject to the mechanical and physical damage, and defected of outside appearance of fish. The imporatant point of that some small cell damage and releasing the enzymes to out sides and those enzymes free to react with other substances. Mechanical damage (example damage from the net, small cut by the sharp edge of ice) may help and provide the good condition for enzymatic activities. All unconcerned fish handling may cause bruised fish. This also helps and increases the microorganism activities and enables to quicker spoilage of fish (FAO; n.d.). In general, in order to maintain the fish quality after catching, some measures for handling and preservation are needed.

1.8. Objective of the study

The objective of this study is evaluating the post-harvest quality loss and economic loss of three main fish species namely Decapterus *russeli, Auxis thazard* and *Katsuwonas Pelamis* from one day fishing boats, operating in Dondra fishing harbor.

Fish is a food source composed of high protein and proteolytic bacteria are doing a major role in reduction the quality of it increasing fish spoilage. Due to that, there are losses in both economically and nutritionally. Here expect to see the effect of proteolysis microbial activity upon good and damaged fish from different factors like fishermen hands and boat deck. Further effect of fish damage to increase the effect of spoilage due to various factors.

2. METHODOLOGY

This study was carried out to determine the effects of proteolysis bacteria to the harvested fish muscles, the rate of proteolysis bacteria activity on good quality fish and damaged fish which is damaged in various ways, economic loss due to the post-harvest quality loss, effect of the surrounding environment and fishing practices for post-harvest quality loss and effect of the proteins in fish muscles by it Proteolytic bacteria colony counts were taken using the muscle samples of *Decapterus russeli*, *Katsuwonan Pelamis and Auxis Thazard*.

Some of the days there were huge harvest and fishermen were busy with available fish load. As same as some of the days, there were turtles, rays and dolphins entangled to the net. In each and every occasion, their consideration for the quality of the harvest was different. As a result, the physical damages were happening.

2.1 Sample Collection

Fish samples were collected from single day boats which were used the gill net as the fishing gear. These samples were collected from Dondra in southern coast in Sri Lanka.

Single day boats were left from fisheries harbor on 2.00 p.m. for fishing practices of gill nets. Normally they are appeared between 2-3 rd shipping lines in the Southern region in Sri Lanka. But in some certain days delayed and not going too far away.Gill net was released to the sea between 4.00-5.00 p.m and nearly half an hour is taken to that process. And about 9.00 p.m. fishermen were started to take the net from the water and this process is taken nearly 3-4 hours. They were removing fish entangled in the net within this same time period.

Deck water samples from boat deck and hand washed water samples from the persons who are removing fish from the net was taken in to the vials before the net is taken out from the waters. Good quality fish samples and damaged fish samples were col-

lected and taken in to the ice box while they were removing the fish entangled in the gill net. And other some fish samples in both good quality and damaged were marked and kept it with other load of fish in the boat deck where all load of fish were kept. After above process finished, boat was started to leave from the fishing ground and reached to the fisheries harbor at about 6.00 a.m. Then the fish samples included good and damaged were taken in to the ice box. And some fish samples were collected and taken in to the ice box that was damaged when it was on the deck. Totally Good quality and damaged fish samples were collected from both fishing ground and the landing site. Water samples were collected in to vials from boat deck, hand washed water of fishermen were taken who was involved in taking out entangles fish from the gill net. At the landing site walked in fisheries harbor and taken the prices of *Katsuwonus pelamis*, *Decapterus resselli*, *Caranx sp., ambligaster sp.* And observations were taken in total amount of caught fish of each species when they were selling in the market and prices of both good and damaged fish.

3. RESULTS

3.1 Common practices:

Single day boats are leaving from Dondra harbour at about 2.00 p.m. and return back at about 6.00 a.m. on the next day. Assumption for fish availability is making through observing the availability of fish like Dolphine, because fishers believe that Dolphines are coming to the area of rich in *Decapterus russeli* and *Katsuwonas Pelamis* etc.

3.2. Physical loss:

The physical losses were calculated based on 24 days observation one day fishing boats landed at Dondra fisheries harbours. Please note that *Auxis thazard* landing were observed only 22 days. The data are summarized and given in Table 3. 1.

Table 3.1: Landed good quality fish, bad quality fish, total harvest, % of damages (The values are given in mean±SD and the range are given in within bracket)

Fish species	Landed of good quality fish (kg/day)	Landed of bad quality fish (kg/day)	Total harvest (kg/day)	% of Damage fish/day
Katsuwonus pelamis	2967±775 (4625-1875)	149±51 (235-90)	3116±818 (4855-1965)	4.76±0.81 (6.08-2.94)
Decapterus russeli	3876±1110 (5480-2100)	621±168 (880-320)	4496±1244 (6280-2456)	14.04±2.32 (17.69-8.76)
Auxis thazard	388±99 (555-220)	81±23 (122-52)	469±117 (648-271)	17.44±2.85 (23.00-13.02)

According to the data, the highest average landed (3876 kg/day) was recorded *D. russelli* while the lower average (388 kg/day) was recorded *A. thazard*. The highest quantity wise percentage loss (17.44%/day) was recorded *A. thazard* while the minimum was recorded the *K. pelamis* (4.76%/day).

3.3. Economical loss:

During the physical damage of fish, the price was reduced and it is obvious. According to the study the economic losses were, tabulated on table 3. 2. The unit price of good quality fish and bad quality fish was significantly difference ($p<0.05$).

Table 3.2: Economic loss with the physical damages of fish

Fish species	Unit price of good fish (Rs)	Unit price of low quality fish (Rs)	Income of good fish (Rs)	Income of damage fish (Rs)	Achievable income (Rs)	% of economic loss/day
Katsuwonus pelamis	210±21 (245-170)	163±27 (210-100)	611,611±124,195 (925,500-448,350)	23,927±7,829 (39,100-10,800)	654,360±171,780 (1,019,550-412,650)	2.88
Decapterus russeli	115±12 (140-100)	82±11 (100-65)	435,318±105,095 (615,240-236,500)	50,713±14,147 (73,150-28,210)	517,040±143,060 (722,200-282,440)	6.00

Auxis thazard	173±11 (190-150)	96±8 (120-85)	66,463±15,078 (999,000-41,106)	7,673±1,849 (11,712-5,200)	81,137±20,241 (112,104-46,883)	8.63

According to the table3.2, the highest and lowest daily economic loss was recorded on *A. thazard* and *K. pelamis* and the values were 8.63% and 2.88% respectively.

4. DISCUSSION

Animal origin food, especially fish is highly perishable product due their biological composition. The spoilage of fish and fish products are always being associated with mainly chemical and biological changes happens during postharvest techniques including handling and storage. These changes are responsible in causing spoilage of the food by changing the changing the several sensory and nutritional quality of fish such as odor, taste, texture and its appearance (Shewan, 1977).
Physical damage mainly includes bruising, gaping, and mushy flesh. When compared the fish muscle with the meat of cow and pig, fish muscle tissue is fragile and is easily damaged (Steve, n.d.). Damaging fish from the fishing ground to the landing site (pier) is occurred in various ways. It is mainly occurred in, the gear types, handling at the storage and handling at the pier. When dragging the net, large number of entangled fish observed. Fish damages will be occurred due to miscellaneous reasons like water movement, way of entangled and swallowing by other marine organisms. Cuttlefish, turtles, rays and Dolphins are major species of preying these entangled fish (FAO; n.d). According to the explanations of fishermen, major predators of entangled fish are cuttlefish because at the dark time, they are attracted by the lights of the boat and with that, entangled fish are eaten by them. Here there is a good point to analyze the level of fish damages which is entangled in the gears, among the crafts using modern technology and traditional personal experiences.

As observation in this research too, when sample collection is occurred, there were many turtle and ray entangling of who came around the gill net to pray entangled fish. Most of surrounding entangled fish with turtle and ray entangled were damaged, as a result of praying entangled fish by particular turtle, cuttlefish or ray. In the other hand, since one day boats are not using modern technologies like GPS and radio phone systems, they are assuming fishing grounds using shipping lanes and places which Dolphins are available. Using Dolphins, fishermen assume about places where the food chain is available with different fish species. According to that, there is an another point which can decide about the particular fishing ground with relatively higher predator pray relationship, which is having more potential to damage entangled fish to be damaged.

According to my observation when number of fish, entangled in the net reached it maximum capacity, there is a potential to damage the small fish surrounded by the large fish through thrashing due to the heavy weight. Same results were revealed by Amos, 1997 in the research, conducted in Uganda. In his findings he revealed the other potential source of damage upon the gear type. Fishing gears like gill net, has a huge potential to damage fish, because since entangling, fish struggle to release and damages are happen due to that struggles. As the same time, the amount of fish damaging will be depended upon the person who is dragging the net using right safety methods. More experienced persons and persons who are using right technique are dragging and removing fish minimizing fish damages. At that time, I observed experienced persons were trained unexperienced persons to drag the net explaining right techniques to minimize the number of fish damages. Further Amos, 1997 also revealed these facts according to the research conducted in Uganda and Iceland.

Inside the boat, when a large load of fish is on the deck, there is a potential to damage. Storage conditions are mainly affected to that. Mostly this phenomenon is occurred in both single day and multiday boats with huge load of different kinds of fish in ice storages. Inside the tank or the deck, fish stored in the lower layers are damaged most of the times. This is occurred to both large and small fish. Mostly at the boats, fish are thrown to the deck quickly, by fishermen when large amount of fish are entangled in the net. Particularly in a moment like this, they are hurry and keeping fish on the deck without any proper way. Due to that, fish may wound and skin damages will be occurred when fish is fallen on the boat deck. Nature of the deck will be key factor of determining the level of damage.

At the pier, may have some damages when removing fish from the deck or tank and keeping on the jetty. Through this process of fish taking from catching site to the pier, relatively larger damages are occurred at the catching site and at the deck. With the damage, considerable economic loss is occurred to the fishermen.

Further researched are needed to see in-depth study of fish damaging from fishing ground and reduce the damaged.
Research revealed that the 4.76% average damage per day in the total fish harvest of *K. pelamis* making economically 2.88% loss per day related to the achievable income of this amount of fish if it is in good quality. In *D. russelli*, the 14.4% per day average damage related to the total harvest is reported and with that damage, was given 6% per day economic loss related to the achievable income of this amount of fish if it is in good quality. In *A. thazard*, 17.44% per day average damage related to the total har-

vest is reported and with that damage, was given 8.63% per day average economic loss related to the achievable income of this amount of fish if it is in good quality. Especially *A. thazard* damages are relative to higher to above mention other two species.

When we seek at *A. thazard* and *K. pelamis*, these varieties most important species in both local and international markets. In year 2000, Sri Lanka exported 11837t bringing 402308.56 million rupees and in year 2009, the amount of exports were increased in to 15014t bringing 885995 million rupees valued foreign income to the country. In comparison between export markets, economic loss might be larger than this analysis. Through further more researchers can be found root causes and methods can be used to reduce this economic loss. Further in here analyzed and discussed in the angle of economic only. But in nutritional and food safety aspect, further more analyzes and findings may continue. According to an assessment which is done by FAO, Ghana, .Kenya, Mali, Tanzania and Uganda re the countries of having huge loss due to physical damage and quality deterioration. It is $3,000,000- $ 6,000,000 loss per year.

5. CONCLUSIONS

According to the findings, there was a considerable quality loss in the hand of nutritionally and in the other hand economically, due to miscellaneous handling practices of fish. Here described regarding only a one fisheries harbour and as a world, there is a considerable quality loss and economic loss. Rectification actions through further research might make solution to avoid that damage increasing food security saving valuable protin source.

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