3.3 Nature, extent and causes of post-harvest losses in export-oriented giant freshwater prawn (*Macrobrachium rosenbergii*) market chain in Sri Lanka

KHM Ashoka Deepananda
Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Sri Lanka

AU Kuragodage
Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Sri Lanka

Asanka D Jayasinghe
Department of Limnology and Water Technology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Sri Lanka

Clive M Jones
Centre for Sustainable Tropical Fisheries and Aquaculture, College of Science and Engineering, James Cook University, Australia

Upali S Amarasinghe
Department of Zoology and Environmental Management, University of Kelaniya, Sri Lanka

Abstract

The GFP (*M. rosenbergii*) industry in Sri Lanka is vital to rural livelihoods and the national export economy. However, substantial post-harvest losses occur throughout the market chain, from harvest to export. We assessed the extent and causes of these losses for fishers and evaluated handling, grading, storage and transportation practices at each key actor stage of the market chain. GFP is primarily harvested as bycatch in gillnet fisheries that target finfish. Substantial post-harvest losses occur at the producers due to predation, physical damage, molting and delayed retrieval. Predation rates vary widely among reservoirs, reaching as high as 60.1%. Molting rates also contribute to losses, with up to 15.2% recorded at some reservoirs. Post-harvest handling practices are inconsistent; fishers generally did not grade or ice the harvests, while only 50% of local collectors employ adequate icing (with a GFP-to-ice ratio of 2:1 to 3:1), though one-third of them use minimal quantities. Central collectors and factory agents adopt better practices by implementing improved grading systems and lowering GFP-to-ice ratios to 1:1. Most of the key actors utilise insulated containers such as Styrofoam or fibre-reinforced plastic (FRP) boxes. Transportation durations range from 5 minutes to 6 hours, with rural infrastructure challenges leading to delays, which increases the susceptibility to spoilage. Exporters grade GFP based on weight and quality, primarily for chilled (60%) and frozen products. Poor handling, inadequate icing, prolonged storage and infrastructure limitations contribute to quality degradation and economic loss. This study emphasises the need for improved post-harvest management practices, including standardised grading, proper icing, infrastructure development and capacity development of key market-chain actors to minimise losses and enhance export competitiveness.

Keywords: *market chain, quality management, export market, grading, icing practices*

Introduction

The GFP (*M. rosenbergii*) industry is vital to the Sri Lankan inland fisheries sector, supporting rural livelihoods, national food security and export earnings (Jones et al. 2021; Amarasinghe et al. 2022; Digamadulla et al. 2023). However, marketing and distribution systems for GFP face several challenges, such as product quality deterioration, physical damage and logistical delays. Post-harvest loss refers to the decline in a product's quality and quantity following harvest, which impacts its marketability, shelf life and economic value. Factors such as the time elapsed post-harvest and temperature management throughout the supply chain are critical in determining the final product quality (Olafsdóttir et al. 1997; Olafsdottir et al. 2004). Studies have identified significant post-harvest losses of GFP at various handling stages, with severe quality degradation frequently occurring during transportation (Kamal et al. 2000). Moreover, delays in handling after harvest have been shown to impact product quality negatively (Rahman et al. 2001), and notable quality losses have been documented under different storage conditions. As international markets increasingly demand traceable, high-quality seafood products that meet rigorous food safety and environmental standards, it is crucial to minimise post-harvest losses and improve handling efficiency throughout the export-oriented GFP market chain in Sri Lanka (Martinsdottir et al. 2001; Paul 2014). Understanding the critical control points and loss mechanisms is vital for developing targeted interventions that enhance value retention and sustainability in the industry. Therefore, this study aims to investigate the extent and causes of post-harvest losses in Sri Lanka's GFP industry, from harvesting at reservoirs to final export. By examining practices related to handling, storage, transport and marketing, this research provides insights and practical recommendations to reduce losses, enhance product quality, and improve the global competitiveness of the Sri Lankan freshwater prawn industry.

Materials and methods

The present study, conducted from May 2022 to May 2023, examined fisher communities fishing in 22 dry zone perennial reservoirs across 9 administrative districts of Sri Lanka (Table 3.3.1). A structured questionnaire, developed and refined through preliminary surveys, was administrated in data collection, carried out through interviews, focus group discussions and key informant interviews, for which interviewees were selected employing the snowballing sampling technique (Biernacki and Waldorf 1981; Deepananda et al. 2015; Naderifar et al. 2017). Consequently, stakeholders in the GFP market chain, including fishers, collectors, factory agents, exporters and aquaculture extension officers, were identified and interviewed. The study administrated a total of 286 questionnaires to assess aspects including harvesting, post-harvest handling, pricing, transportation and market challenges. The accuracy of the collected data was validated through additional assessments and interviews with the key informants. Moreover, primary in-situ data concerning harvesting methods, post-harvest losses, storing, and export procedures were collected from key informants selected at each node of the market chain. The data collected were analysed, and the outcome was aptly presented to elucidate the post-harvest losses at each node of the GFP market chain. In this context, the currency conversions were made based on the conversion rate in February 2023, when USD1 was approximately LKR362.7.

Table 3.3.1: Details of the dry zone perennial reservoirs of Sri Lanka used for the present comprehensive study

District	Reservoir name	Reservoir category	Area at FSL (ha)	Effective area (ha)	GPS coordinates	
					Lat	Long
Anuradhapura	Nachchaduwa	Major	1,781	891	8^0 25'25.47''	80^0 48'11.58''
Hambantota	Ridiyagama	Major	871	436	6^0 20'68.02''	80^0 98'63.33''
	Weerawila Wewa	Medium	567	284	6^0 28'74.36''	81^0 23'82.85''
	Mahagalwewa	Minor	140	70	6^0 39'53.97''	81^0 03'76.10''
Kilinochchi	Iranamadu	Major	2,927	1,464	9^0 31'76.75''	80^0 44'97.85''
	Akkarayankulam	Major	809	405	9^0 29'73.48''	80^0 32'76.40''
	Puthumurippu	Minor	151	76	9^0 36'17.11''	80^0 35'43.26''
Kurunegala	Siyambalangamuwa	Medium	210	105	8^0 06'27.04''	80^0 31'78.40''
Monaragala	Muthukandiya	Medium	560	280	6^0 97'97.02''	81^0 50'32.15''
	Kiriibban wewa	Medium	375	188	6^0 37'57.99''	80^0 97'00.30''
	Urusita wewa	Medium	262	131	6^0 33'26.15''	80^0 93'36.58''
	Handapanagala	Medium	226	113	6^0 66'55.47''	81^0 15'16.60''
	Hambegamuwa	Medium	210	105	6^0 54'19.86''	80^0 95'65.25''
Mullaithivu	Vavunikulam	Major	1,275	638	9^0 08'99.70''	80^0 35'13.69''
	Muthiyankaddu	Major	1,255	628	9^0 20'15.21''	80^0 60'75.41''
Puttalam	Tabbowa	Medium	607	304	8^0 07'25.54''	79^0 95'54.42''
	Devalahandiya	Medium	257	129	7^0 78'74.86''	79^0 87'92.12''
	Karavitagaraya	Medium	256	128	7^0 56'80.43''	79^0 84'85.60''
	Vijayakatupotha	Medium	243	122	7^0 72'00.39''	79^0 89'51.42''
Trincomalee	Mahadiulwewa	Medium	543	272	8^0 60'70.43''	80^0 95'35.57''
	Wendrasanwewa	Medium	410	205	8^0 39'19.00''	81^0 00'87.70''
Vavuniya	Bogaswewa	Medium	472	236	8^0 88'66.60''	80^0 65'81.77''

FSL = Full Supply Level

Results

Harvesting practices and handling loss

GFP was primarily harvested using gillnets with a mesh size of 3.5 inches and above as bycatch from finfish fishing operations. Harvesting typically began in the evening, between 2 pm and 4.30 pm, when gillnets were set, and the catch was retrieved the following morning, between 8 am and 10 am. Harvest losses were attributed to predation, physical damage, molting and delays in retrieval. The leading causes of these losses were predation and quality deterioration, including head loss and broken appendages. Among the total GFP entangled in gillnets, the highest predation rate (60.1%) was documented at the Dewalahandiya reservoir, while the lowest (2.8%) was reported at the Ridiyagama reservoir. The percentage of GFP with head loss ranged from 0.7% (Dewalahandiya) to 5.6% (Ridiyagama), whereas appendage damage varied from 1.2% (Mahadivul Wewa) to 7.9% (Kiri Ibban Wewa) at the producer level. The proportion of molted GFP in the harvest ranged from 1.2% at Mahadivul Wewa to 15.2% at Mahagal Wewa reservoirs (Figure 3.3.1).

Market-chain structure and pricing

The post-harvest handling and marketing of GFP in Sri Lanka involved various stakeholders, including fishers, collectors, factory agents, exporters, consumers, input suppliers, support staff and regulatory authorities. As the producers, fishers sold their harvest mainly to local collectors, while smaller quantities were sold directly to central collectors or factory agents. Local collectors were crucial intermediaries between fishers and central collectors, who supplied GFP to the factory agents. Central collectors sold their stock directly to factory agents, facilitating transactions between intermediaries and exporters. Exporters, the final node in the Sri Lankan market chain, obtained GFP exclusively from designated factory agents without direct engagement with other stakeholders. Input suppliers in the GFP market chain included providers of nets and boats, as well as repair and financial services. Additionally, suppliers offered materials such as Styrofoam and FRP boxes, ice, transportation and fuel. Support staff were vital in ensuring product quality, safety and financial operations.

GFP pricing was determined by quality. Collectors purchased high-grade GFP from fishers at an average price of LKR1,800/kg (≈USD5), while lower-grade GFP was acquired at an average of LKR850/kg (≈USD 2). Higher-level market-chain actors acquired GFP from local collectors at prices ranging from LKR1,150/kg (≈USD3) for low-grade to LKR2,550/kg (≈USD7) for high-grade. Exporters obtained GFP from factory agents at LKR2,000–4,000/kg (≈USD6–11) and sold it internationally at an average price of LKR4,533–8,160/kg (≈USD12.5-22.5).

Post-harvest handling and quality management

Grading

GFP was not graded by fishers before sale. Local collectors, except those from Ridiyagama, Hambegamuwa, Karawitagala and Urusitawewa, graded GFP at purchase. They classified GFP into grading categories: Ga (male and others), Gb (soft-shelled and others), Gc (200 g and below, soft-shelled, head-loose), and Gd (less than 100 g and soft-shelled). Central collectors, except in Karawitagala and Mahadivulwewa, graded GFP before purchase and regraded purchased GFP into grading categories such as male, female, head-loose and soft-shelled. Most factory agents classified GFP based on weight (100 g and above

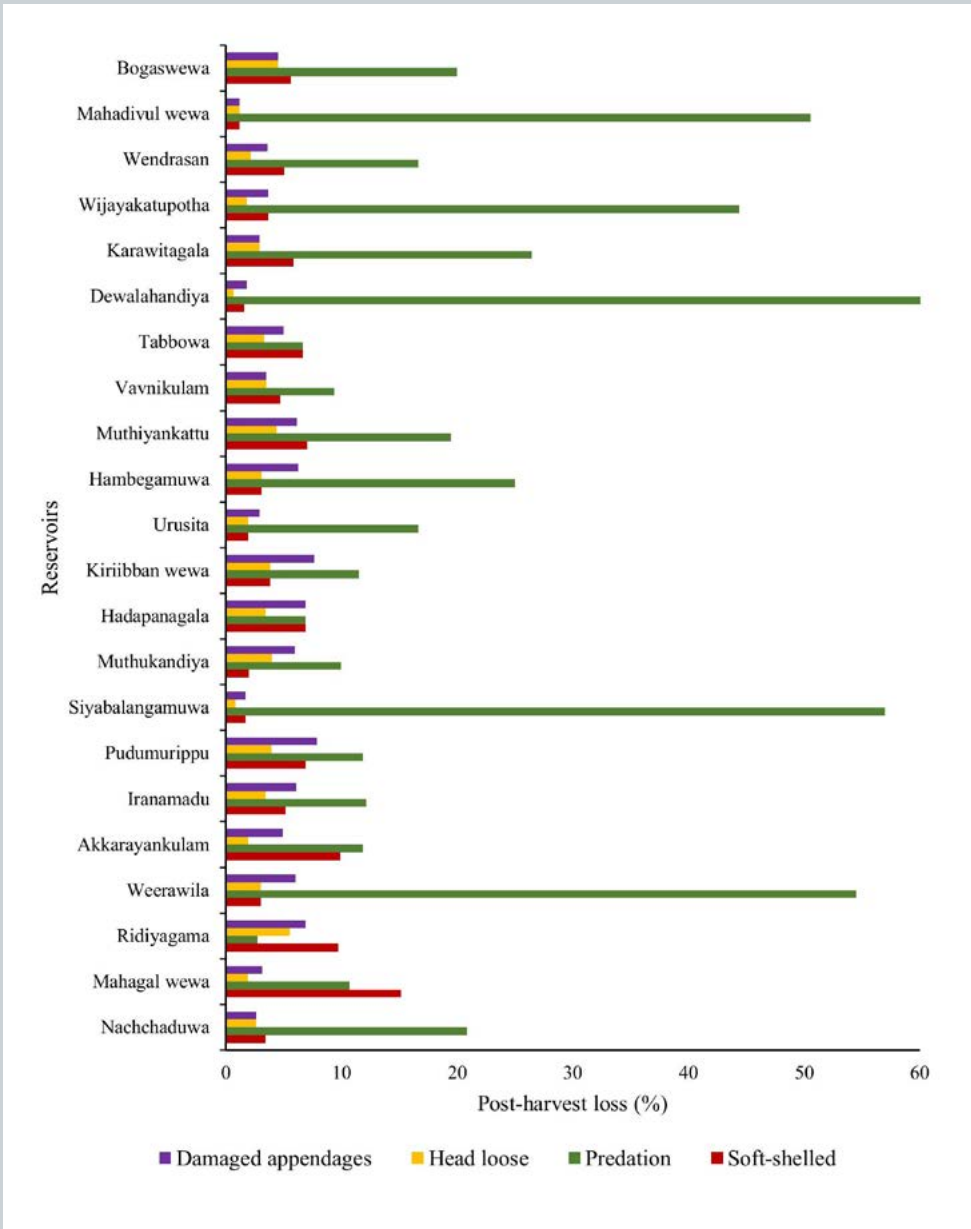

Figure 3.3.1: Harvesting and post-harvest handling losses observed in producers (fishers) at each study reservoir

or 450 g and above), while others at the Nachchaduwa, Wendrasan and Muthukandiya reservoirs employed sex (male and female) and condition-based grading (head-loose and soft-shelled). Final grading was performed by exporters within factory premises before processing, using weight and quality as the primary criteria.

Storing

Fishers did not store their harvest, but the other key actors in the market chain stored GFP before selling. The duration of storage varied from one actor to other, and some local collectors, such as those at Ridiyagama and Tabbowa reservoirs, sold their stock within one to 2 hours, while others in reservoirs like Vavnikulam, Muthiyankattu and Iranamadu kept the GFP until the next day. At Nachchaduwa and Karawitagala, the storage duration was 2 to 3 days. Central collectors typically stored GFP for up to 2 days, while the factory agent at Dewalahandiya kept stock for up to 2 days. Exporters stored fresh (chilled) GFP for a maximum of one day, ensuring that the export process was completed on the same day as unloading. In contrast, frozen GFP was stored for up to a year until orders were received.

Local collectors primarily used a 3:1 GFP-to-ice ratio, central collectors employed a 2:1 ratio, and factory agents utilised a 1:1 ratio. Washing was conducted solely at the exporter level, where freshwater was applied for chilled products, and a chlorine bath (70 g Cl/1,000 L at 4 °C) was employed for frozen items. Local collectors predominantly stored GFP in FRP containers, with some opting for freezers or ice-filled non-functional freezers. Frozen GFP was maintained at -18 °C at export facilities, while chilled products were kept in FRP containers.

Transporting

The shortest transport time, ranging from 5 minutes to 3 hours, was recorded between fishers and local collectors, while the longest transport time of 3 to 6 hours was observed from factory agents to exporters. Local collectors dwelling near reservoirs who reach their homes within 5 to 30 minutes use motorcycles or walk as a mode of transportation. GFP was transported by central collectors using lorries within 2 to 3 hours, while factory agents at Mahagalwewa and Dewalahandiya used lorries which took 3 to 5 hours to reach the destination. The transport time between local collectors and the next node varies from 20 minutes to 6 hours, where lorries serve as the primary mode of transport. Factory agents transported GFP to exporters using lorries within 3 to 6 hours. Among the factory agents, 40.91% received salaries with commissions, while others operated independently. Most local collectors relied on Styrofoam boxes for GFP transportation. Central collectors and factory agents utilised FRP boxes for both transport and storage. The exporters packaged chilled products in Styrofoam boxes and frozen products in cardboard boxes. Table 3.3.2 summarises details on grading, storage and transportation at each node of the GFP market chain. The input and product flow, along with the extent and causes of post-harvest losses at each key actor, are depicted in Figure 3.3.2, which provides a detailed overview of the GFP market chain in Sri Lanka.

Table 3.3.2: Post-harvest handling (grading, storing and transportation) by the key actors of the export-oriented GFP market chain in Sri Lanka

Reservoir	Fishers				Local collectors				Central collectors				Factory agents				Exporters			
	Grading	Storing time (day)	Transportation to next node		Grading	Storing time (day)	Transportation to next node		Grading	Storing time (day)	Transportation to next node		Grading	Storing time (day)	Transportation to next node		Grading	Storing	Transportation to next node	
			Time (~min)	Mode			Time (~hr)	Mode			Time (~hr)	Mode			Time (~hr)	Mode			Time (~hr)	Mode
Nachchaduwa	No	On-site selling; No storing	5	F	Ga	2	2–4	L	×	×	×		Gf	0–1	3–4	L	Soft-shelled or quality and weight based	Frozen: up to 1 year; Fresh: 0–1 day	Based on destination and product type	Fresh: Air freight; Frozen: Sea freight
Mahagal wewa			180–300	L	×	×	×		×	×	×		Ge	0–1	4–6	L				
Ridiyagama			15	B	No	No	1/3	B	Gf	0–2	1–2	L	Ge	0–1	4–6	L				
Weerawila			15–20	B	Ga	1–2	2–4	L	×	×	×		Ge	0–1	4–6	L				
Akkarayankulam			20–30	B	Ga	0–1	4–6	L	×	×	×		Ge	0–1	3–4	L				
Iranamadu			15–20	B	Ga	0–1	4–6	L	×	×	×		Ge	0–1	3–4	L				
Pudumurippu			10–15	B	Ga	0–1	4–6	L	×	×	×		Ge	0–1	3–4	L				
Siyabalangamuwa			15	B	Gc	2	6	L	×	×	×		Ge	0–1	6	L				
Muthukandiya			15	B	Gc	2	3–5	L	×	×	×		Gf	0–1	4	L				
Hadapanagala			10	B	Ga	2	3–5	L	×	×	×		Ge	0–1	4–6	L				
Kiriibban wewa			60	B	×	×	×		Gf	0–1	1–3	L	Ge	0–1	4–6	L				
Urusita			150	B	No	2	2	B	Gf	0–2	1–3	L	Ge	0–1	4–6	L				
Hambegamuwa			10–20	B	No	0–1	2–3	L	×	×	×		Ge	0–1	4–6	L				
Muthiyankattu			15–20	B	Ga	0–1	4–6	L	×	×	×		Ge	0–1	3–4	L				
Vavnikulam			15–20	B	Ga	0–1	4–6	L	×	×	×		Ge	0–1	3–4	L				
Tabbowa			30	B	Gb	No	1/3	L	Gf	0–1	1–1.5	L	Ge	0–1	3–4	L				
Dewalahandiya			5–10	B	×	×	×		×	×	×		Ge	2	3–4	L				
Karawitagala			5–10	F	No	2–3	1–2	L	No	0–1	2–3	L	Ge	0–1	3	L				
Wijayakatupotha			30	B	Gd	2	1–3	L	×	×	×		Ge	0–1	2–4	L				
Wendrasan			20	B	Gb	1–2	3	L	×	×	×		Gf	0–1	4–5	L				
Mahadivul wewa			120–180	L	×	×	×		No	0–2	1–3	L	Ge	0–1	5	L				
Bogaswewa			10	B	Ga	1–2	2–4	L	×	×	×		Ge	0–1	3–4	L				

Notes: Ga – male and other (female, head loose, soft shelled); Gb – soft-shelled (molted) and other (male, female, head loose); Gc – 200 g (male/female and 200 g, soft-shelled, head loose; Gd – 100 g and soft-shelled; Ge – based on quality and weight; Gf – male/female, head loose, soft-shelled; B – bike; L – lorry; F – by foot).

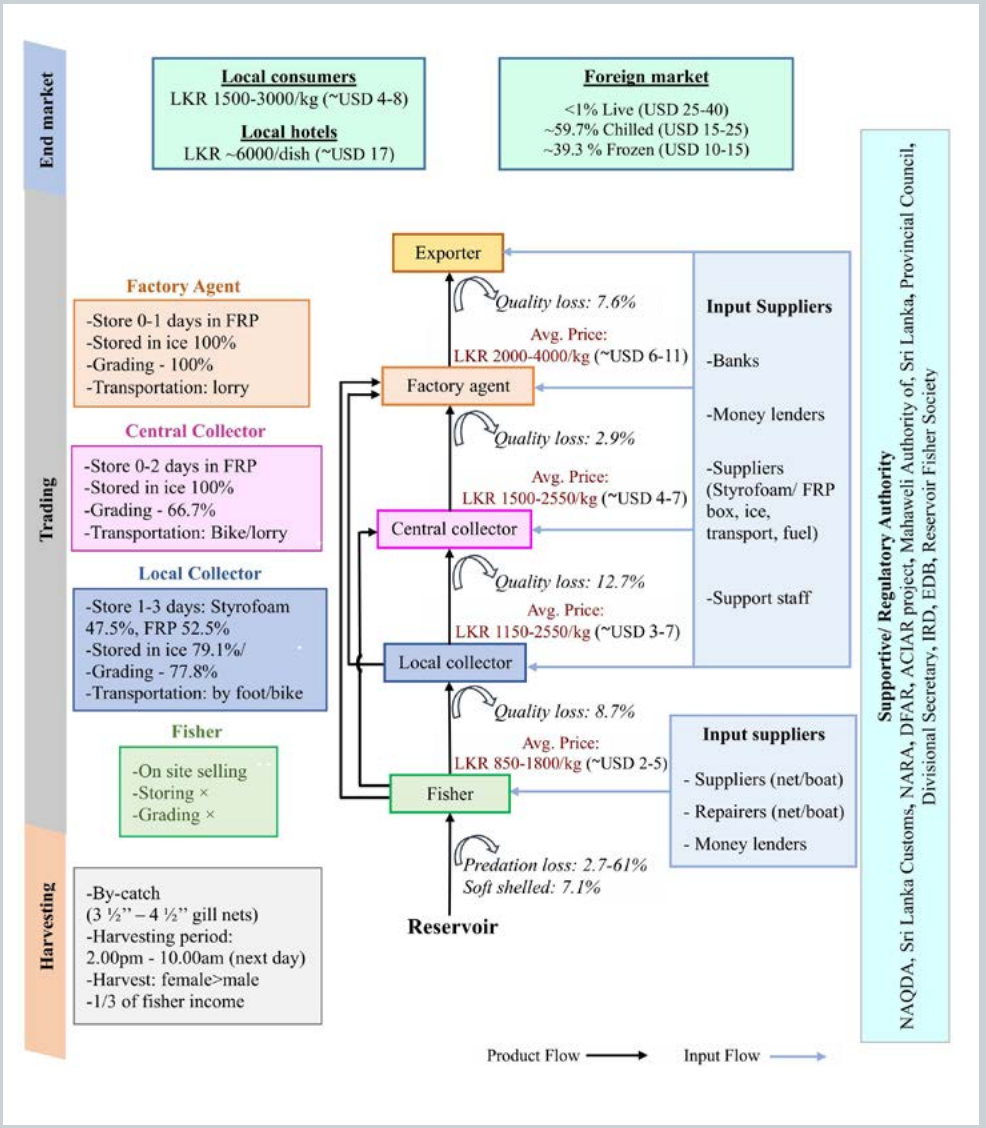

Figure 3.3.2: A detailed overview of the input and product flow, as well as post-harvest losses, at each key actor in the GFP market chain in Sri Lanka

Note: NAQDA – National Aquaculture Development Authority; NARA – National Aquatic Resources Research and Development Agency; ACIAR – Australian Centre for International Agricultural Research; IRD – Inland Revenue Department; EDB – Sri Lanka Export Development Board.

Export market trends

Sri Lanka exports GFP mainly in fresh (chilled) and frozen forms. Chilled GFP makes up nearly 60% of exports, primarily to Southeast Asia. Frozen products underwent blast-freezing and were shipped to Europe and other markets. Strict quality standards, including grading based on weight and appearance, determined export viability.

Discussion

Sri Lankan reservoir fisheries operate under community-based, self-governing systems, where local fisher communities establish and enforce fishing practices to ensure the social wellbeing of the fisher communities. Although it is not a primary target species, the GFP (*M. rosenbergii*) is frequently caught as bycatch in gillnets deployed overnight. This is mainly due to GFP nocturnal and benthic behaviour, which increases its vulnerability to passive fishing gear, gillnets (Brown et al. 2010) and significantly contributes to fishers' income. The growth of GFP depends on molting, which is influenced by inhabiting environmental conditions (Aiken 1980; Boyd 1990; Dall et al. 1990). The high molting rates observed in the Mahagalwewa reservoir indicate favourable conditions for GFP growth. However, molted prawns are considered unsuitable for the export market, leading to economic losses. Conspicuously, predation and improper handling during harvesting further diminish the yield and quality of GFP. Addressing these challenges necessitates strategies to reduce predatory pressure on GFP entangled in gillnets and enhance the fisher awareness for proper post-harvest handling.

The structure of the Sri Lankan GFP market chain varies by district/reservoirs, with different numbers of intermediaries in the market chain connecting fishers to exporters. GFP is consistently supplied to exporters through factory agents, and 4 leading export-oriented market chains have been identified (authors' unpublished data). Field observations and stakeholder interviews have identified 4 primary market channels in the GFP value chain, including:

1. direct sale from fisher to factory agent
2. fisher to collector to factory agent
3. fisher to local trader to factory agent
4. fisher to local market, bypassing the export chain.

The prevalence of each channel is influenced by factors such as daily harvest quantity, the distance between the reservoir and the trader or processor, the availability of insulated transportation, and local infrastructure facilities and conditions. The study confirms that intermediaries play a crucial role in pricing and market access, while regulatory bodies ensure compliance with quality and safety standards, ensuring continued production in the long run. Furthermore, analysing these market channels offers insights into GFP distribution and stakeholder interactions. Thus, the study affirms that optimising these systems can enhance market efficiency and competitiveness and reduce post-harvest losses.

The export value of GFP in Sri Lanka demonstrates notable fluctuations over time, influenced by a combination of intrinsic biological factors and extrinsic market dynamics. A significant challenge within the GFP value chain is the dominant role played by market intermediaries, particularly collectors who represent the higher nodes of the market chain and exert substantial influence over pricing mechanisms. Fishers typically accept prices set by collectors, which

reduces their earnings. However, the study reveals that direct sales through fisher cooperatives would enhance fisher income and minimise post-harvest losses. The GFP is generally categorised into 2 primary quality grades: high and low, based on physical appearance, integrity and freshness. Quality categorisation is heavily influenced by handling procedures during harvest, packing and transportation. Poor practices such as delayed retrieval from nets, exposure to sunlight and inadequate chilling lead to physical damage, including broken appendages, soft shells from recent molting and head detachment. These conditions downgrade the product to a lower quality category, resulting in a substantial price reduction in the next node of the market chain. The resulting price gap between high- and low-quality GFP can be substantial, translating into financial losses for fishers and downstream stakeholders, including collectors and exporters. Furthermore, the diminished volume of high-grade prawns constrains the competitiveness of Sri Lankan GFP in premium international markets, where product appearance and quality are critical. As GFP is a lucrative commodity, these post-harvest losses negatively impact food security, income stability and the development of inland fisheries.

Grading responsibilities generally begin at the collector level. Local collectors, who purchase GFP directly from fishers, commonly classify GFP into 2 broad categories. The high grade consists of high-quality, hard-shelled, intact prawns, typically male individuals weighing over 100 g. These prawns are favoured by exporters for their superior appearance, meat content and durability during transport. The low grade (quality) includes prawns with detached heads (head-loose), soft shells from recent molting, broken appendages, and females, which are considered less valuable due to their fragility and reduced meat yield. Central collectors at selected reservoirs employ a more detailed grading system based on sex, head condition and molting, as mandated by factory agents. Factory agents assess GFP by quality and weight, while exporters apply their standards before sorting based on international market demand. Our findings confirm that robust grading practices from the fisher level onward through the market chain can enhance market segmentation, reduce spoilage and increase the income of each actor in the market chain. Training fishers in post-harvest handling and on-site grading can help them supply more consistent, high-quality GFP and strengthen their role in the GFP market chain.

The quantity of GFP collected daily by local and central collectors is often minimal, discouraging central collectors and factory agents from frequent reservoir visits. Consequently, local and central collectors must store GFP within their limited storage facilities for up to 3 days until a substantial collection is received. Extended storage time at this node may result in more significant post-harvest quality loss. In some cases, factory agents and exporters store GFP for at least one day due to transportation delays. Ahmed et al. (2009) have observed that GFP traders supply their prawns directly or through agents to exporters within one to 2 days of purchase. In contrast, the present study indicates that GFP purchased by local collectors reaches exporters within zero to 6 days (excluding transportation time).

The use of ice is critical in preserving the post-harvest quality and extending the shelf life of GFP throughout the supply chain. Effective chilling through icing slows down microbial growth and enzymatic

activity, which are key contributors to spoilage in aquatic products (Tsironi et al. 2009; Wachirasiri et al. 2016). Studies have shown that maintaining an optimal ice-to-product ratio, typically between 1:1 and 1:3, can preserve sensory and microbiological quality of GFP for up to 5 days under ambient tropical conditions (Paul 2014). Although icing is commonly practiced along the supply chain, it is often overlooked at the producer level (Hassan et al. 2012). Our study reveals that only half of local collectors use sufficient ice, while a significant portion use very little. A similar scenario has been reported in Bangladesh, where many collectors utilised minimal ice during transport (Alam 2010). Proper icing dramatically influences the quality indicators, as demonstrated by Martinsdottir et al. (2001) and Paul (2014). Improving icing practices at the GFP supply chain, especially at the fisher and local collector levels, is essential for reducing post-harvest losses, maintaining product quality and meeting export market standards.

Fishers sell GFP at landing sites, while local collectors transport them using various methods, often challenged by poor rural roads. In contrast, urban-based factory agents benefit from superior transport infrastructure. The study identifies that thermal insulation is crucial for maintaining the quality of GFP during storage and transportation. Thus, most stakeholders now use Styrofoam or FRP containers, which provide better temperature control than older materials such as wood or aluminium (Quang 2005; Vyncke 1965; FAO 2003; Hassan et al. 2012).

Market fluctuations, infrastructure limitations and regulatory compliance issues impact Sri Lanka's competitiveness in global GFP markets. Improving processing techniques like individual quick freezing (IQF) and developing value-added products would enhance export potential. International buyers prioritise reliable supply, stringent quality standards, and food safety and sustainability certifications. The ability of Sri Lankan entrepreneurs to meet these demands is crucial for their competitiveness in global seafood markets. To improve its position, Sri Lanka must strengthen regulatory frameworks, enhance traceability systems and adopt environmentally sustainable practices. By focusing on certification and sustainability, Sri Lanka can improve market access and build buyer confidence, ensuring the long-term growth of the GFP industry.

Conclusion

Post-harvest loss in the Sri Lankan GFP industry is a multifaceted issue that affects the entire value chain, from harvest to export. Significant losses arise from poor handling during harvesting, inadequate icing, suboptimal storage, delayed transportation and inconsistent grading practices. Predation, physical damage, molting and the lack of immediate icing led to significant quality deterioration at the producer level. Although some storage container use and storage infrastructure improvements have been made, challenges persist, particularly in rural areas with limited road access and insufficient cold chain facilities. Furthermore, fishers have limited bargaining power and frequently rely on intermediaries, diminishing their income and undermining quality control at the source. The complex market chain, which consists of multiple intermediaries such as collectors, factory agents and exporters, introduces variability in quality management and pricing. Inconsistent grading, infrequent collection due to low daily harvest volumes, and extended storage times further deteriorate the

harvest. Although exporters maintain better quality standards, downstream inefficiencies often affect them. These cumulative losses impact not only economic returns but also food security, the sustainability of inland fisheries and the global competitiveness of the Sri Lankan GFP industry.

References

Ahmed N, Lecouffe C, Allison EH and Muir JF (2009) 'The sustainable livelihoods approach to the development of freshwater prawn marketing systems in southwest Bangladesh', *Aquaculture Economics & Management*, 13:246–269, doi:10.1080/13657300903156092.

Aiken DE (1980) 'Moulting and growth' in Cobb JS and Phillips BF (eds), *The biology and management of lobsters*, Academic press, New York.

Alam AKMN (2010) *Post-harvest loss reduction in fisheries in Bangladesh: A way forward to food security (Final report)*, National food policy strengthening programme, Department of Fisheries Technology Bangladesh Agricultural University, Mymensingh.

Amarasinghe US, Pushpalatha KBC, Wijenayake WMHK (2022) 'New paradigm for inland fisheries development in Sri Lanka: a transdisciplinary approach for addressing food and nutritional security', *Journal of the National Science Foundation*, Sri Lanka, 50:177–194, doi:10.4038/jnsfsr.v50i0.11238.

Biernacki P and Waldorf D (1981) 'Snowball sampling: Problems and techniques of chain referral sampling', *Sociological Methods & Research*, 10:141–163, doi:10.1177/004912418101000205.

Boyd CE (1990) 'Environmental requirements' in Boyd CE (ed), *Water quality in ponds for aquaculture,* Birmingham Publishing Co, Birmingham.

Brown JH, New MB and Ismael D (2010) 'Biology' in New MB, Valenti WC, Tidwell JH, D'Abramo LR and Kutty MN (eds), *Freshwater Prawns: Biology and Farming*, Blackwell, Oxford.

Dall W, Hill B, Rothlisberg P and Sharples D (1990) *The Biology of the Penaeidae*, Academic Press, London, San Diego, New York.

Deepananda KHMA, Amarasinghe US and Jayasinghe-Mudalige UK (2015) 'Indigenous knowledge in the beach seine fisheries in Sri Lanka: An indispensable factor in community-based fisheries management', *Marine Policy*, 57:69–77, doi:10.1016/j.marpol.2015.03.028.

Digamadulla DS, Asoka JM, Jones C, Jayasinghe-Mudalige UK, Wijenayake WK, Amarasinghe US and De Croos MDST (2023) 'Appraisal of culture-based fisheries of giant freshwater prawn (*Macrobrachium rosenbergii*, De Man, 1879) in reservoirs of Sri Lanka', *Aquaculture, Fish and Fisheries*, 3:81–95, doi:10.1002/aff2.94.

FAO (2003) *The use of ice on small fishing vessels*, Food and Agricultural Organization, Rome.

Hassan MN, Rahman MM, Hossain MM, Nowsad AAKM and Hossain MB (2012) 'Post-harvest handling and marketing of shrimp and prawn in south-western region of Bangladesh', *World Journal of Fish and Marine Sciences*, 4:651–656, doi:10.5829/idosi.wjfms.2012.04.06.6594.

Jones C, Amarasinghe U, De Silva S, De Croos MDST, Digamadulla S, Jayasinghe A, Yomal GATK, Deepananda KHMA and Fleming A (2021) *Assessing production of giant freshwater prawns in reservoirs in Sri Lanka (final report)*, Australian Centre for International Agricultural Research (ACIAR), Australia.

Kamal M, Rahman MM, Yasmin L, Islam MN, Nurullah M and Mazid MA (2000) 'Studies on the post-mortem changes in shrimp and prawn during ice storage: II. Biochemical aspects of quality changes', *Bangladesh Journal of Fisheries Research*, 1:91–96.

Martinsdottir E, Sveinsdottir K, Luten JB, Schelvis-Smit R and Hyldig G (2001) *Reference manual for the fish sector: sensory evaluation of fish freshness*, QIM Eurofish, The Netherlands.

Naderifar M, Goli H and Ghaljaie F (2017) 'Snowball sampling: A purposeful method of sampling in qualitative research', Strides

in Development of Medical Education, 14:e67670, doi:10.5812/sdme.67670.

Olafsdottir G, Martinsdóttir E, Oehlenschläger J, Dalgaard P, Jensen B, Undeland I, Mackie IM, Henehan G, Nielsen J and Nilsen H (1997), 'Methods to evaluate fish freshness in research and industry', *Trends in Food Science*, 8:258–265, doi:10.1016/S0924-2244(97)01049-2.

Olafsdottir G, Nesvadba P, Di Natale C, Careche M, Oehlenschläger J, Tryggvadottir SV, Schubring R, Kroeger M, Heia K, Esaiassen M and Macagnano A (2004) 'Multisensor for fish quality determination', *Trends in Food Science*, 15:86–93, doi:10.1016/j.tifs.2003.08.006.

Paul DK (2014) *Effect of Different Ratios of Ice on Quality and Shelf Life of Cold-Water Shrimp* (*Pandalus borealis*), United Nations University Fisheries Training Programme, Iceland.

Quang NH (2005) *Guidelines for Handling and Preservation of Fresh Fish for Further Processing in Reykjavik, Iceland*, The United Nations University.

Rahman M, Yasmin L, Kamal M, Islam MN and Ochiai Y (2001) 'Quality changes in freshwater prawn *Macrobrachium rosenbergii* during ice storage', *Bulletin of the Faculty of Education*, Ibaraki University, Natural Science, 50:39–49.

Tsironi T, Dermesonlouoglou E, Giannakourou M and Taoukis P (2009) 'Shelf-life modelling of frozen shrimp at variable temperature conditions', *LWT – Food Science and Technology*, 42(2):664–671, doi:10.1016/j.lwt.2008.07.010.

Wachirasiri K, Wanlapa S, Uttapap D and Rungsardthong V (2016) 'Use of amino acids as a phosphate alternative and their effects on quality of frozen white shrimps (*Penaeus vannamei*)', *LWT – Food Science and Technology*, 69:303–311, doi:10.1016/j.lwt.2016.01.065.

Vyncke W (1965) *Temperature, packing and quality in fish market*, Fishing Handling and Preservation – Organisation for Economic Co-operation and Development, Paris.