Carbon Footprint of IQF Peeled Tail-On Breaded Shrimp (*Litopenaeusvannamei*): How big is it compared to other aquatic products?

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Abstract

There has been an increasing interest in the connection between climate change and aquaculture which leads to the questions of greenhouse gas emissions from fisheries and aquaculture products generally. Thus, the carbon footprinting of Individually Quick Frozen Peeled Tail-On Breaded Shrimp was performed to familiarize ourselves with the carbon footprint standard based on the PAS 2050 methodology as well as to establish how high its carbon footprint value is as compared to other aquatic products both from fisheries and aquaculture systems. The system boundary included feed production, shrimp farming, processing, packaging and stopped at the factory gate. In general, the primary data of the processing plant's direct activities were gathered based on the annual production in 2011 whereas the associated background data were mainly from the national life cycle inventory databases, supplemented by the international life cycle inventory databases where necessary. Raw shrimps at the size of 55-60 (i.e. this usually equates to between 55-66 shrimps per kg) were purchased from multiple farms so primary data were collected from a random sample of associated contracting farms. At the processing stage, the input and output data were gathered from the internal data recording systems with the substitution of missing data if any. The data of primary and secondary packaging were obtained from secondary sources due to their non-significant contributions. The total carbon footprint value was 5.88 kgCO_2e per kg, mainly from the processing stage (53%), followed by the farming stage (46%). At the farm, the electricity use for aerators to maintain the oxygen level in culturing ponds over the production cycle of 75 days and the utilization of fisheries-based (i.e. fish meal and fish oil) & agriculture-based (i.e. soybean meal) feed ingredients were the major contributors, whereas the use of liquid CO_2 for freezing was the major contributor at the processing stage. Compared to other aquatic products, shrimp has a higher carbon footprint value than tilapia but lower than trout. It is worth noting that this information only indicates the impacts to climate change but not other associated impacts.

Key words: Aquatic products/ Aquaculture/ Carbon footprint/ Fisheries/ Shrimp

1. Introduction

The over-exploitation situation of wild-capture fisheries has highlighted the significance of aquaculture for fish production. As a consequence, the growth rate of the aquaculture sector is highest among the various food sectors. White-leg shrimp (*Litopenaeusvannamei*) is the main species cultured in Thailand and the most economical species; however, its potential environmental impacts have always been under criticism at the international level.

Carbon Footprint has emerged as an approach to estimate GHG emissions throughout a product's life cycle to help identifying the hot spots where improvements can made. Food and drinks have been identified as an energy-

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intensive sector contributing to GHG emissions (Mungkung et al., 2011). Recently, there has been an increasing interest in the connection between climate change and aquaculture which leads to the questions of greenhouse gas emissions from aquatic products. As a leading global shrimp producer and a major exporter, Thailand is very well aware of the development and implementation of Carbon Footprinting and Carbon Labelling for climate change mitigation as well as to anticipate trade measures.

Thus, this study was developed aiming to assess the carbon footprint values of shrimp product by using the PAS 2050 methodology (BSI, 2008); and to compare with other aquatic products to have an idea of how big its carbon footprint is.

2. Methodology

The assessment of carbon footprint is rooted in the Life Cycle Assessment (LCA) technique as described in ISO 14040 and 14044. The term "carbon footprint" is known among LCA practitioners as the value of Global Warming Potential (GWP), which is one of the environmental impact categories assessed in the scope of LCA studies. Hence, the methodology of carbon footprint is only a specific application of LCA. Even though LCA's are covered by several standards set up by the International Organisation for Standardisation (ISO 14040/44, ISO 14025 and ISO 14064), there is still controversy over the definition of methodological issues (Mungkung et al., 2010). In this connection, the Carbon Trust along with the British Standards Institution (BSI) and the Department of Environment, Food and Rural Affairs (Defra), the UK has developed a standardised methodology for calculating the carbon footprint, or GHG emissions, embodied in goods and services – the Publicly Available Specification or "PAS 2050:2008 - Specification for the assessment of the life cycle greenhouse gas emissions of goods and services" (BSI, 2008).

At this point in time when this study was conducted, PAS 2050 appeared to be the only available methodology which gave the details of carbon footprinting, so this method was selected to be used. In addition, it was based on the interest of industries to prepare themselves for responding to the market requirements on environmental product declaration including carbon labeling schemes firstly in the UK and then extending to other EU countries. In this connection, the studied product chosen here was Individually Quick Frozen Peeled Tail-On Breaded Shrimp (Figure 1), which is a value-added product exported mainly to the EU countries.

Figure 1 Individually Quick Frozen(IQF) peeled tail-on breaded shrimp

The scope of carbon footprinting was set as cradle-to-gate, as it is a product sold to retailer as a bulk pack. Thus, the system boundary included feed production, shrimp farming, processing, packaging and stopped at the factory gate, so called "Business-to-Business (B2B)" or cradle-to-gate (Figure 2). The unit of analysis (functional unit) was set as the total weight as per a sold unit (bulk pack) of 5 kg.

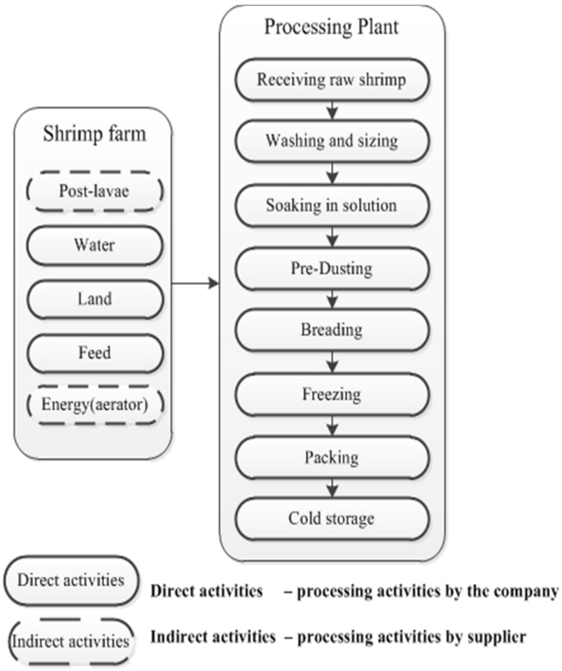

Figure 2 Scope of carbon footprinting

The required data for carbon footprinting are: activity data and emission factors. The activity data are the inputs (i.e. raw materials and energy) and outputs (i.e. product, co-product, emissions to air, water and soil) associated with each life cycle stage of the product. The activity data of the processing plant's direct activities were gathered based on the annual production in 2011. Raw shrimps at the size of 55-60 (i.e. this usually equates to between 55-66 shrimps per kg) were purchased from multiple farms; so the primary data were was collected from a random sample of associated contracting farms. The primary data of inputs and outputs associated with farming systems were then collected from the sampled farms. The collected data were: stocking density, water use, FCR (Feed Conversion Ratio), operational hours of each aerator and the horsepower of aerators and water pumps, wastewater quality and quantity and the shrimp productivity. For the feed production, the primary data associated with inputs and outputs were gathered from their main supplier due mainly to its significant contribution to the total carbon footprint. The inventory data collected were: feed ingredients, energy use, waste and the productivity. At the processing plant, the inputs and outputs were rather in order except for the electricity and energy use where only consolidated data were available that had to be shared among more than one processing line. Also, the amount of liquid CO_2 used for freezing was based on the amount to be made up in the tank per year and was shared among several frozen products.

The associated background data were mainly from the Thai national life cycle inventory databases, supplemented by the international life cycle inventory databases where necessary. At the processing stage, the input and output data were gathered from the internal data recording systems with the substitution of missing data if any. The data of primary and secondary packaging were obtained from secondary sources due to their non-significant contributions.

In this study, the environmental burdens were allocated among the harvested shrimps at the farm gate based on mass, as all the shrimps are going through the same production process regardless of size. However, the sharing of environmental burdens to the different parts of the shrimp (head, body and shell) was based on their economic value as the production of shrimp is driven by the economic values (Table 1).

Table 1 Allocation methods

Life cycle stage	Allocation method	% Allocation
Farm	Mass	Size 55-60 (86 %)
		Other sizes (14 %)
Processing plant	Economic	Body (98%)
		Shells (1%)
		Heads (1%)

As specified in PAS 2050:2011, all forms of land use change that result in GHG emissions and removals should be included in the carbon footprint of product occurring in 20 years prior to the assessment. In this case, the land use history of farms supplying shrimp raw materials were traced back from the certificate of farm registration with Department of Fisheries in the allowed areas. It was found that all farms have been practicing the farming activities for more than 20 years. Thus, it was not an issue.

3. Results

Figure 3 shows the result of carbon footprinting. The total carbon footprint value was 29.40 $kgCO_2e$ per bulk pack or 5.88 $kgCO_2e$ per kg, which is mainly from the processing stage (53%) followed by the farming stage (46%). At the farm, the electricity use for aerators to maintain the oxygen level in culturing ponds over the production cycle of 75 days and the utilization of fisheries-based (i.e. fish meal and fish oil) & agriculture-based (i.e. soybean meal) feed ingredients were the major contributors, whereas the use of liquid CO_2 for freezing was the major contributor at the processing stage.

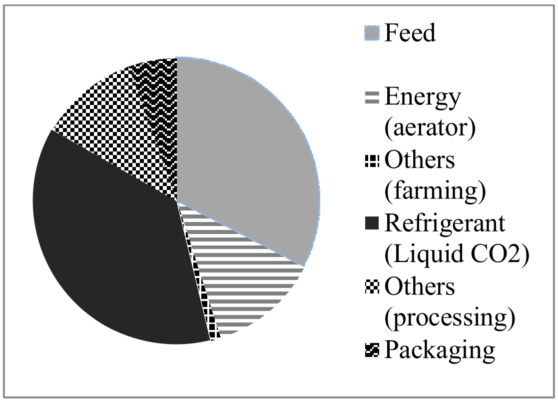

Figure 3 Total carbon footprint value and contribution analysis results

4. Discussion

The functional unit (i.e. unit of carbon footprint analysis), as suggested in ISO 14044 to reflect the measureable performance of product, has been under debate among various practitioners and has not yet been settled – mass, protein content, energy contents or nutritional levels are some of the options being considered. At this stage, using the standard weight of shrimp product as one kg is most reasonable from the industry's perspective. However, the functional unit was an issue when comparing the carbon footprint values of shrimp with other aquatic products. The proposed functional units previously debated are: total weight, edible protein, amount of omega 3 or all kinds of available nutrients (Mungkung and Gheewala, 2007).

Hence, a sensitivity analysis using different functional units was performed. It should be noted here that the comparison of carbon footprint values were at the farm-gate level as the various processed products are rather different and cannot be compared as such. It was found that the carbon footprint value of Thai shrimp was twice as high as Thai tilapia, lower than Chinese shrimp and almost equal to French troutbased on a mass basis (Table 2). The results also showed the same trend when using edible protein as the functional unit. When using the amount of omega 3 as the functional unit, the carbon footprint value of Thai shrimp was almost the same as Thai tilapia and Indonesian tilapia, 3 times higher than French trout and nearly 10 times higher than Norwegian salmon.

Table 2 Comparing the carbon footprint values of shrimp with other aquatic products based on different functional unit (total weight, edible protein, amount of omega 3).

Aquatic product	CF values ($kgCO_2e/FU$)		
	250 g (total weight)	**100 g (edible protein)**	**3 g (omega 3)**
Thai shrimp (this study)	1.10	2.17	5.95
Chinese shrimp[1]	1.32	2.60	7.15
Indonesian tilapia[2]	0.57	0.95	6.08
Thai tilapia[3]	0.55	0.92	5.84
French trout[4]	1.13	2.20	2.02
Canadian salmon[5]	0.82	1.65	0.76
Norwegian salmon[6]	0.75	1.51	0.70

Note: [1]Ling et al. (2011), [2]Pelletier and Tyedmers (2010), [3]Tessa and Mungkung (2011), [4]Papatryphon et al. (2007), [5]Pelletier et al. (2009), and [6]Ellingsen et al. (2009)

5. Conclusion

Farming is the key stage significantly contributing to GHG emissions, followed by the processing plant. Electricity use for aerators and the utilization of fisheries-based (i.e. fish meal and fish oil) & agricultural-based (i.e. soybean meal) feed were the major contributors at the farm level, whereas the use of liquid CO_2 for freezing was the major contributor at the processing level. With respect to product comparison, it is obvious that the results of the study are sensitive to the choice of functional unit, which in turn is dependent on the purpose of study and intended application of results. The unit of carbon footprint analysis could be a specific weight of whole body/specific parts, edible protein content, energy content or nutrient level depending on the grouping of products with similar characteristics and through the stakeholder consultation process, or specified in the Product Category Rules (PCR) which define the specific requirements of carbon footprinting.

6. Acknowledgement

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