Cold Chain Business in Bangladesh to Enhance the Economic Growth of the Country

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Abstract— **This descriptive study tries to find the economic and environmental impact on Bangladesh if cold chain technology of freezing shrimp is changed from conventional mechanical block process to liquid nitrogen individual quick frozen (LN IQF) process. The study also incorporates new business opportunity of cold chain and an effective supply chain of the frozen shrimp that would enhance the export of the country. The study was conducted based on the secondary data, i.e. analysis of the literature, journals, books and different publications of the stakeholders. It is found if the conventional mechanical process is changed to Liquid Nitrogen Individual Quick Frozen (LN IQF) process then, the country could earn extra $537 million per year and that could add to the GDP of the country. This LN IQF process could produce high quality frozen shrimp and would not create any harmful gases to the environment. Also export amount from this sector would increase to $1004 million with a new business opportunity of cold chain of turnover around $27.5 million per year. Although the investment for the new business would be around $68 million, this investment cost of the LN IQF process could be recovered within two months from the extra earning of the frozen shrimps. The LN IQF would also allow the Bangladesh shrimp producers to access directly into the international shrimp market, since in the current process they have to go through the intermediate buyers to sell the frozen shrimps. This LN IQF would increase the effectiveness of the supply chain of the frozen shrimps from Bangladesh to the final consumers in the international market.**

Keywords—Cold Chain, supply chain, Liquid Nitrogen (LN), Individual Quick Frozen (IQF), new business opportunity, economic and environmental impact.

1. Introduction

Bangladesh is one of the most important suppliers of frozen shrimp in the world market. Yearly around 55000 tons (Statistical Year Book 2010, BBS) of frozen shrimp was exported from Bangladesh in the last 5 years.Apart from various species of fish, world's most favoured shrimp 'Black Tiger' (Penaeus monodon) is available in plenty in Bangladesh trawling areas and also cultivated on-shore farms.

Shrimp are highly perishable items and hence, the method of freezing and transportation is very important to ensure the ultimate quality of shrimp that reaches to the end user living in Japan, USA or somewhere in Europe or other parts of the world. A complete cold chain from harvesting to the kitchen of the ultimate consumer can only ensure the effective supply chain that satisfies customers in terms of quality. Around eighty five percent exported shrimp of Bangladesh are block frozen and remaining is air blast individually frozen.

Ammonia or CFC based mechanical refrigeration provides a good solution to the traditional block freezing at lower cost, Individual Quick Frozen (IQF) product can be produced with cryogenic freezing process using liquid nitrogen at a better production efficacy. Consumers of frozen shrimp prefer IQF rather than frozen blocks, for a very simple reason that only required quantity can be cooked without thawing the whole block. Ammonia or CFC is very harmful gases to environment where as nitrogen is an environment friendly gas.

The most important difference between mechanical or ammonia refrigeration and liquid nitrogen (LN) refrigeration comes from the quality of frozen shrimp. It has now been established beyond any doubt that cryogenic freezing with liquid nitrogen provides genuine IQF quality product, with minimal loss of product quality, dehydration, appearance, texture and organoleptic properties (Tomlins, R., 2004). As a result, most of the world's leading food processors is using liquid nitrogen freezing as their priority option for high quality, high value and low volume option.

The demand of cryogenic IQF shrimp is increasing day by day in the world market. This is considered as a value-added product and priced higher than traditionally block-frozen product. On an average export price of per Kg IQF shrimp was $18.25 and that is $8.5 of per Kg block shrimp. This means more foreign currency can be earned from the same quantity of shrimp if LN IQF process is used.

International Journal of Supply Chain Management
IJSCM, ISSN: 2050-7399 (Online), 2051-3771 (Print)

Another important factor in food freezing is the quantum of investment for freezing equipment. Cryo-freezers are much less expensive and more productive than robust mechanical freezers/ammonia refrigerator.

As LN freezing systems require very small space, the processing area hygiene can also be ensured with much ease and lower cost. This will also help in solving stringent requirements on health and hygiene by European Community and US FDA.

As in other countries, production of shrimp in Bangladesh from natural sources is declining and more value can be brought only by changing the product type, such as, IQF shrimp. This will certainly add more to the economy of Bangladesh with less effort made (Ministry of Planning, 2008 & 2009).

The shrimp that is already frozen and stored in the cold room must also be transported in frozen condition to the shipping point. Here the mechanical systems used in in-transit refrigeration are not reliable. Most of the time mechanical refrigeration fails to keep the required temperature or breaks-down when it is needed most. This causes loss to the quality as the product is thawed inside the vehicle. Sometimes the product becomes unsuitable for export. This causes further loss of reliability in terms of commitment of supply.

Systems have been designed with LN, which provide highest reliability of temperature maintenance during in-transit refrigeration. There are no mechanical moving parts in the cryogenic transportation system and hence, there is no possibility of failure. The costs are within acceptable range both in terms of investment and day to day operation.

This paper encompasses the following objectives:

- To explore the contribution of exported shrimp to GD of Bangladesh

- To oversees the impact of the environment

- To find the effectiveness of the exported shrimp supply chain

2. Literature Review

A **cold chain** is a temperature controlled supply chain. An unbroken cold chain is an uninterrupted series of storage and distribution activities which maintain a given temperature range. It is used to help extend and ensure the shelf life of products such as fresh agricultural produce, frozen food, fish, chemicals and pharmaceutical drugs.

A cold chain can be managed by a quality management system. It should be analyzed, measured, controlled, documented and validated. A well-organized cold chain reduces spoilage, retains the quality of the products and guarantees a cost efficient delivery to the consumer given adequate attention to customer service.

2.1 A typical guide to the cold chain from factory to consumer

The sequence of events within a typical cold chain is illustrated in the following Figure.

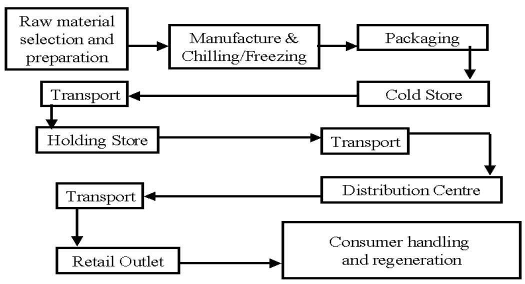

Figure 2.2: A typical cold chain

Increasingly good temperature control is being achieved throughout the cold food chains as a result of improved equipment design, quality control and heightened awareness of issues surrounding food safety and quality. However, it is important to avoid complacency and to integrate temperature monitoring as a part of the *Total Quality Management* program.

Transfer points, e.g. chiller/freezer to cold store, factory to distribution vehicle, retail cabinets to consumers' refrigerators, are well known problem areas. A useful concept is that of the 'relay system', where the baton (the food product) is transferred safely from one responsible person to another, and where a signing-over system includes information on product temperature and history. Such a system necessitates thorough education and training of staff likely to come into contact with the food product.

2.2 Cryogenic Freezing and Chilling of Food

The modern frozen food industry was founded in 1928 when contact refrigeration systems were developed by Clarence Birdseye. They were followed by mechanical air blast and cryogenic systems using both solid carbon dioxide and liquid nitrogen (Tomlin, R., 2004).

Today's foods must meet consumers' ever-changing demands for variety, convenience and preparation time savings. For this reason, food processors increasingly are relying on the efficiency and versatility of cryogenics for freezing and chilling operations. This is especially true for freezing because a cryogenic freezer can be adapted specifically to each food product while maintaining modular flexibility. Formulations, shapes, food types, handling concerns and product safety are all taken into account to achieve the highest product quality while the product temperature is rapidly and significantly reduced.

2.2.1 The Freezing Process

The freezing process can be divided into three phases:

- pre-freezing
- freezing
- lowering of the temperature to the required storage temperature - typically below -10°C

Heat must be moved from the interior of the product to the surface by conduction. The heat can be removed from the surface of the product by direct contact with a cryogenic liquid such as liquid nitrogen or carbon dioxide snow.

2.2.2 Required Freezing Time

The required freezing time depends on a number of factors, the most important of which are:

- the dimension and shape of the product
- the thermal properties
- initial and final temperatures
- the temperature of the cryogenic liquid or solid
- the coefficient of heat transfer

2.3 Cryogenic Freezing with LN

Cryogenic system depends on the direct contact of liquid nitrogen or solid carbon dioxide with the food product. Liquid nitrogen boils at -196.C (-320. F) and the sublimation point of carbon dioxide is -78.5.C (-110.F) (Tomlin, R., 2004).

In the past, liquid nitrogen was unavailable and it is used to be an expensive refrigerant. Now it is available, in plenty and within acceptable price range (Tomlin, R., 2004).

In nitrogen-based systems, nitrogen, also a consumable, refrigerant is sprayed into the system as both a liquid and a vapor. As the liquid nitrogen droplets touch the product's surface, the liquid changes to a vapor that extracts heat from the food. A simultaneous distribution of nitrogen vapor throughout the freezer creates a wind-chill effect that increases the rate of freezing. Liquid nitrogen systems obtain about 50 percent of their refrigeration from the vaporization of the liquid and the other 50 percent from the cold vapor. To ensure efficient and economical use of nitrogen, the system must contain a vapor heat exchange area. In standard cryogenic freezers, liquid nitrogen is injected into a single zone, and the cold vapors are directed to the ends of the freezer to completely envelope the food product.

Systems have been designed with LN, which provide highest reliability of temperature maintenance during in-transit refrigeration. There are no mechanical moving parts in the cryogenic transportation system and hence, there is no possibility of failure. The costs are both in terms of investment and day-to-day operation.

2.4 Cryogenic Chilling with LN

The use of cryogenic systems to quickly chill products also has distinct benefits. Quick chilling of raw food products dramatically reduces food safety concerns by slowing or stalling the growth of spoilage organisms and by allowing the products to reach a safe holding temperature quickly.

For food operations that prepare products for further processing, achieving a uniform temperature throughout large transport bins can be difficult with traditional chilling methods. Installing a cryogenic system that allows for a quick, uniform chill throughout the product reduces rework, returns and product rejections.

As with freezing, cryogenic cooling offers increased cooling speed, improved quality, extended shelf life and cost savings. Whether the product is vegetables, cooked meat, fresh seafood or raw poultry, cooling with cryogenic gas is improving product handling and food safety.

2.5 Advantages of Freezing and Chilling with LN

The main benefits of cryogenic refrigeration are its high rate of temperature reduction, its flexibility, its small size and the quality it provides (Tomlins, R., 2004).

Rapid refrigeration: Liquid nitrogen produces a rapid drop in temperature, so food spends the minimum of time in the bacteriological danger zone of +60^{0}C to +5^{0}C.

Improved freezing quality: Liquid nitrogen has a retarding effect on rates of oxidation, enzyme activity and metabolic deterioration, thus conserving nutritional and vitamin properties of the food.

Reduced dehydration and minimal drip loss: weight loss from dehydration is minimized, as is the osmotic process which depletes the nutrients of delicate foods and spoils their appearance and flavor, an important cost and quality consideration for specialist food processors.

Liquid nitrogen is metered into the freezer at a rate, which matches the heat load of the food product. Coupled with the ability to control temperature and dwell time, this provides great flexibility.

Osmosis and ice crystal growth causes damage to cell walls and both are governed by the time taken to freeze the product. The quicker the product is chilled or frozen the more rapidly the effect of osmosis is arrested and ice crystals formed are smaller and more uniform, thus causing less damage to cell walls. So no loss of intercellular fluid (drip loss) is minimized when quick freezing is achieved using liquid nitrogen, as compared to mechanical/ ammonia refrigeration.

2.6 Preserving the Quality of Food

Freezing

In case of freezing, the temperature of the whole product is reduced to -18.C or below. With its ability to deliver extreme cold instantly, liquid nitrogen is the perfect medium for freezing, particularly of meats, fish and confectionary products.

Chilling

In case of chilling, temperature of the product is rapidly reduced to between 0.C and +3.C. Liquid nitrogen as a means of chilling offers tangible benefits to both retailers and caterers. Rapid chilling guarantees longer shelf life for products like fresh meat and poultry, and in catering ensures that prepared snacks and meals are kept fresh and visually appealing until the moment they are consumes.

Cooling

In cooling, reduction in temperature is achieved generally not below ambient-apprx. +20.C. Liquid nitrogen is a practical and reliable means of speeding up in the in-line cooling process of hot or warm flour and sugar confectionary products. It is quick, economical and allows higher production rates to be achieved.

Gas Packaging

Gas packaging is used to maximize the shelf life of many fresh and processed foods such as meat, fish, shrimp and poultry and to ensure that they stay and look fresh throughout their distribution chain. Nitrogen in varying proposition is used extensively as part of the ‘gas mix’ in modified atmosphere gas packaging.

Figure: IQF Shrimp

2.7 Postulation

In this article we used dollar as the financial currency since it is an international currency and all over the world dollar is well know. The cost/price of some of the items (e.g. electric power cost, LN cost, etc.) are being converted from the local currency (Bangladesh Taka) to US dollar (using present conversion rate, 1 US dollar = 81 BDT). Only two companies in the world produces Cryogenic IQF machines – one is Cryoquip, USA and another is Cryolore, France. Here we took Cryoquip as the reference brand because this company currently has a trading relationship with Bangladesh. The bank interest rates, electric power rates, etc. have been assumed as the present value of the Government. The break down of the cost/price, and other details have been omitted so that the main purpose of the article (effect of using LN IQF processing in shrimp exporting) would not be distracted. In Bangladesh, there are only two geographical locations where the shrimps are frozen for exports. These two locations are Khulna and Chittagong. These two locations are very close to the sea ports of Bangladesh.

2.8 Methods of Application of Liquid Nitrogen in Freezing

Basically, there are three methods of application in Liquid Nitrogen refrigeration:

a) Spraying of the liquid directly on the product

b) Vaporizing the liquid in a forced draught which blows over the product surface, and c) Immersion of the products in the liquid nitrogen.

Anyone or combination of the methods can be used to freeze efficiently (BOC Limited, Cryo-Chem Inc)

2.9 The Most Effective IQF Methods using Liquid Nitrogen

This cryogenic IQF freezing system installation consists of a contact freezer and a post cool tunnel, connected by an insulated supply line to a liquid nitrogen storage tank located outside the building.

Electrical and pneumatic supplies and an exhaust gas vent are necessary. Water may be connected for cleaning (optional).

The IQF system comprises a contact bath freezer directly coupled to a post-cooling tunnel. The product is conveyed through the direct contact bath freezer, which imparts a crust freeze into the product prior to its transfer to the post-cool tunnel. The integrity of the product, due to its crust freeze, enables a certain amount of multi-layering to take place on the post cool tunnel belt, limited only by the production demand and temperatures required.

Product may be fed into the freezer via the entry and conveyor extension or through the top loading port, where it contacts liquid nitrogen immediately, enhancing individual quick frozen quality. The product is conveyed through the freezer on an all stainless steel belt, specifically developed for operation at -320°F (-196°C). The belt is fitted with UHMW (Ultra High Molecular Weight) inserts as standard, to reduce the amount of product debris entering the liquid bath. Debris is continuously removed by the belt. The belt is designed to operate continuously at speeds up to 60 feet per minute.

Product conveyed through the tunnel is further frozen by a combination of the evolved gases from the contact bath freezer and if necessary by a spray of liquid nitrogen droplets. The cold gas formed by evaporation of the liquid nitrogen is circulated by vertically mounted turbulence fans. Spent nitrogen gas is removed at the off-load end and ducted to the outside air.

Product guide rails are provided to control the product on the belt. The product is conveyed through the freezers by a stainless steel mesh conveyor, sized in accordance with the type of product being processed and driven by variable speed drive. The conveyor surface projects from the post-cool tunnel at the off load end to facilitate product removal, and a scraper blade aids this process of frozen product removal from the conveyor.

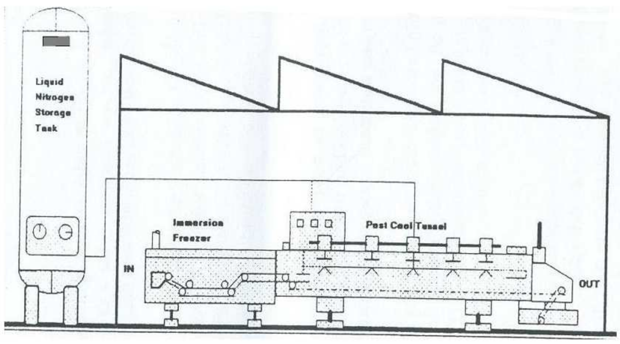

Figure: Conceptual Drawing of IQF System

Fully removable lids and a belt raising system facilitate the cleaning of the direct contact freezer, and a product debris tray is provided at the on load end. The belt

Figure: A tunnel freezer

automatically removes debris from the bath and deposits it into the tray. An easy open compartment gives access to the tray, which may be emptied from time to time during processing.

Doors are provided on the post cool tunnel to allow total access to the tunnel interior for inspection and cleaning.

Figure: IQF shrimp from freezer

Maximum efficiency is achieved when the post cool tunnel is operated with the conveyor belt completely covered to a depth commensurate with acceptable even exit temperatures. The tunnel should be operated as slowly and as warm as possible. The contact freezer belt speed should be adjusted accordingly, so as to achieve the desired product depth on the post-cool tunnel belt. The product is fed into the direct contact freezer through the top loading port, falling directly into the full width of the top loading port and be free from clumped material. The depth of liquid nitrogen should be varied to achieve the desired level of crust freeze, commensurate with the type and geometry of the product and the production rate.

Main control panels for both freezers are provided. The level control panel is located on the direct contact freezer. Both freezers carry "power" component boxes; the direct contact freezer box also contains the speed controller for varying the belt speed. Adjacent to the post cool tunnel control boxes is located the pneumatic control box which contains all the necessary components to convert the control signal of 4-20 milliampere to 3-15 pound per square inch (gauge) to operate the control valve.

Emergency stop buttons are located as required on the freezers and one is mounted on each control panel. The control temperature (set point) for the process and the process temperature are displayed on the temperature controller. The unit has a minimum of moving parts to give long, trouble-free service with a minimum of simple maintenance. (Cryo-Chem Inc.)

2.10 Some direct benefits of Liquid Nitrogen Freezing

The LN IQF process would reduce dehydration & minimal drip loss. Dehydration may be a serious factor when dealing with high value and delicate shrimp/seafood. Mechanical refrigeration (air blast IQF) can cause moisture loss of 5% to 6% and in some cases even higher. Liquid Nitrogen reduces this loss to around zero - an important economic consideration for specialist food processors.

As mentioned that osmosis and ice crystal growth causes damage to cell walls and both are governed by the time taken to freeze the product. The quicker the product is frozen the more rapidly the effect of osmosis is arrested and the ice crystals formed are smaller and more uniform, thus causing less damage to cell walls. So no loss of intercellular fluid (drip loss) is minimized when quick freezing is achieved using liquid nitrogen, as compared to mechanical/ammonia refrigeration. Typical freezing time for shrimp using Liquid Nitrogen is about 3 to 4 minutes as against 1 to 2 hours for ammonia refrigeration and 3 to 6 hours for air blast units. (Tomlins, R., 2004)

Moreover, Liquid Nitrogen IQF method does not produce any Ammonia (NH_3), Sulphur dioxide (SO_2) and other hazardous gases/materials therefore there is no chance of affecting human health (including causing cancer or detrimental effect on children).

In block freezing there might be a chance of having various kinds of germs in the frozen shrimp. This could create different types of human health hazards. However, in the LN IQF process there is no chance of having any kind of germs at all. The IQF is completely germfree process. Even if there are any kinds of germs in the raw shrimps before the freezing process, the LN IQF process entirely eradicates those germs from the shrimps. As a result, the LN IQF process is the healthiest process for freezing shrimp.

2.11 Origin and Price of the IQF system

Description	Price*
Origin: Cryoquip USA	
Contact Bath Freezer Model CBF 1810	$68000.00
Post Cool Tunnel Model PCT 2420	$78000.00
Glazer Model G 2410 Glazer	$26000.00
Total Price	$172000.00

* All prices are CIF Chittagong, Bangladesh

2.12 Batch Freezing IQF Methods using Liquid Nitrogen

The batch freezer of model BF 300 SD is a compact, low capital cost unit which enables foodstuffs to be rapidly frozen or chilled by liquid nitrogen (LN) on a batch production basis at a rate of around 200Kg/hr. This freezer is suitable for wrapped and unwrapped products and has a temperature range of +50 ^{o}F to -95 ^{o}F.

Figure: Batch freezers

The frozen product is first loaded onto the shelves of a special two part rack and dolly. When full, the dolly is wheeled to the freezer, the door is opened, and the rack pushed directly and easily into the cabinet. No foreign matter is carried into the unit. The rack is designed to standard dimensions; each tray measuring 18" x 26" and the top tray is within easy reach of personnel of average height. The rack has a 20 tray capacity.

To freeze the loaded product, liquid nitrogen is fed directly from a bulk storage vessel to special spray nozzles within the cabinet. Fans create a intensive circulation of the cold LN gas around the loaded trays to ensure even and efficient freezing. The LN gas then leaves the cabinet through exhaust ducts. A highly sensitive thermocouple is used to control the temperature during the freezing process. Freezing condition can be adjusted over a wide range.

The stainless steel construction of the cabinet permits cleaning by steam or water jet. (CRYO-CHEM INC.)

2.12.1 Origin and Price of the Batch Freezing IQF system

Origin: Cryo - Chem/Kryosprauy, USA

Price of the Batch Freezer of Model BF 300 is US$22,000.00

2.13 Liquid Nitrogen (LN) Consumption Norms

The Liquid Nitrogen consumption rate depends on:

- Initial temperature of food products
- Desired frozen food temperature
- Type of food material.

Consumption rate for shrimp freezing:

Initial Product Temperature	= 15° C (59° F)
Final Product Temperature	= - 40° C (- 40° F)
Freezing Point	= - 2.2° C (28° F)
Sp. Heat of Prawns above FP	= 0.86 BTU/Ib/o F
Sp. Heat of Prawns below FP	= 0.45 BTU/Ib/o F

Heat removal to freeze 1 lb of prawn:

Above FP (59-28) X 0.86	= 26.66 BTU/lb
Below FP (28- (-40)) X 0.44	= 29.92 BTU/lb
Latent Heat	= 119.00 BTU/lb
Total	= 175.58 BTU/lb
Add 20% process Loss	= 35.10 BTU/lb
Total	= 211 BTU/lb

1 Ib of LN can extract 165 BTU of heat

So, 1 unit of prawn will need 1.28 units of LN

That is one Kg Prawn needs 1.6 Litre of LN [1]

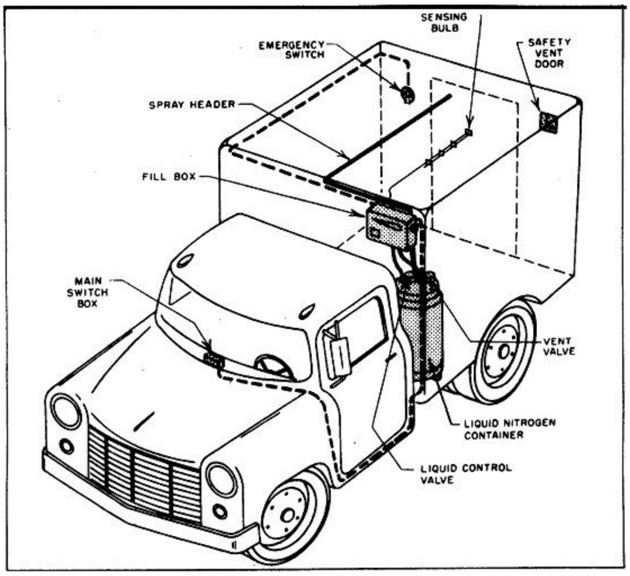

Figure: Conceptual Drawing of in-transit refrigeration System

2.14 Cost of Freezing

Initial investment of liquid nitrogen freezing system (IQF) is lower than that of other system, but operating cost for liquid nitrogen system is higher than that of mechanical system/ammonia refrigeration system, which may cover by no loss of product weight and differential price. Loss of product weight is very high in case of mechanical system.

Quality of frozen shrimp from liquid nitrogen freezing system is much better than that from mechanical system/ammonia refrigeration system. As a result, selling price of IQF shrimp from liquid nitrogen system is higher than block frozen or IQF from ammonia refrigeration system. [2]

Description	Amount
1. Price of Freezer	*$172,000.00*
2. Production Rate (Kg/Hr)	500
3. Cost of LN ($/Litre)	0.30
4. Power Cost ($/kWh)	0.07
5. Power Requirement (kW)	10
6. Hours of operation/month	400
7. LN consumption: Litre LN/Kg Shrimp	1.6

Costs:

Fixed Costs:

1. Interest on Capital @ 14%: $/month	2,007.00
2. Depreciation (Life 25 yr): $/month	574.00
3. LN Tank rent: $/month	350.00
Total Fixed Cost: $/Month	**2931.00**

Operating Cost:

1) Power: $/month	280.00
2) LN Cost: $/month	96,000.00
Total Operating Cost: $/month	**96,280.00**

Unit Cost:

Fixed: $/Kg Shrimp	0.015
Operating: $/Kg Shrimp	0.48
Total unit cost: $/KG Shrimp	**0.495**

Therefore, cost of freezing of per KG IQF shrimp is approximately $0.5 (Tk.41.00)

3. Methodology

The analysis of this descriptive study was based on secondary data, including online databases, digital libraries, books, journals, conference papers, etc. Data were collected from different journal, literature, statistical year book and annual report of the stakeholder. Extensive research papers of academicians and practitioners on cold chain are evolved from renowned international journals from FDA, European Union, IEEE, BFEEA, Bureau of Statistics, Bangladesh, etc.

4. Discussion

Since Bangladesh is exporting yearly 55,000 metric tons of block frozen shrimps at an average rate of $8500 per ton (Annual Report 2010, BFEEA) therefore, we are earning (8,500 x 55,000) $467 million. Average global price of IQF shrimp is $18250 per ton. So if the freezing process were changed from the block freezing to LN IQF process then Bangladesh would earn (18,250 x 55,000) $1004 million from shrimp export. That means there would be a direct increase of GDP of $537 (1004-467) millions or around $44.7millions per month.

Moreover, this LN IQF process would decrease the pollution of environment that harms to the human health.

Simply, because of there would be no emission of CFC or ammonia from the process.

Each LN IQF machine can produce 2,400 tons/year and each machine costs $172,000. Therefore, we would need around 23 such LN IQF machines, total cost of which would be around (23 x 172,000) $3.98 million. For producing the Liquid Nitrogen for the purpose of LN IQF process, there would be total ten 30TPD (tons per day) factories needed. At present BOC have two such factories. So, there would be eight more such factories have to be established. To establish one such factory would cost $8 millions. Consequently there would be additional investment of (8 x 8) $64 million for Liquid Nitrogen production facilities. As a result total additional investment cost would be around (64 + 4) $68 million. This initial investment could be recovered from the extra earning (i.e. $44.7 million per month) within two months by exporting LN IQF shrimps.

Therefore there is a huge opportunity to do cold chain business. If all the exported shrimp would be IQF, then total freezing cost is (55000* 1000* $0.5) = $27.5 million. So there is business opportunity of around $27.5 million dollar.

The LN IQF process would improve the quality of the exporting frozen shrimps a lot and consequently Bangladesh's exporting frozen shrimps would gain superior reputation in the global market. Furthermore, The process would abolish the intermediate buyers of frozen shrimps from Bangladesh and this would provide us to do the direct marketing of the frozen shrimps to the world markets. So the there will be a significant increase in efficiency of the supply chain of frozen shrimp export.

5. Conclusion

In the proposition for LN IQF shrimp processing system, it is required to establish additional eight LN factories with capacity of 30TPD and 23 LN IQF processing centres. The detailed analysis (technical, financial, etc.) of implementing the LN factories is not included in this paper since this is out of the scope of this article. It is recommended here that the implementation of LN factories and the LN IQF system would be done by the shrimp exporters association of Bangladesh, as they hold the primary responsibility including profits for the individual shrimp exporters.

Therefore, Bangladesh shrimps producers should convert their conventional block freezing process to the LN IQF process and consequently this could contribute to the GDP extensively. The computation that has been done in this paper would contribution $537 million per year to the GDP of the country. Furthermore, there would be a Multiplier effect on the economy of the country. Moreover, additional quality, environmental improvement, new business of cold chain, new employment and other benefits could be achieved through this LN IQF process.

References:

1. Tomlins, R., *"Cryogenic Freezing and Chilling of Food,"* BOC GASES, UK, 2004
2. BOC Limited, *"The Element of Freshness – Nitrogen technology from harvest to table"*, BOC SDD 186, UK
3. CRYO-CHEM INC., "Kryospray – Liquid Nitrogen/Liquid Carbon Dioxide", Cryo-Chem Inc., USA
4. Bangladesh Frozen Food Exporter Association, *"Annual Diary"*, BFFEA, Dhaka, 2010
5. Ministry of Planning, *"Fact Book – India*", 2008 & 2010
6. *Willem A. H. Asman, Mark A. Sutton & Jan K. Schjørring,* "Ammonia: emission, atmospheric transport and deposition", USA, 2006
7. *Statistical Year Book 2010, Bangladesh Bureau of Statistics*
8. *Application of Cryogenics and Industrial Gases, Cryogenic Engineering Centre, Indian Institute of Technology*
9. *T.K. Goswami, M.R. Ravindra, T.K. Nayak, "*Time-Temperature Relationships For Iqf Shrimp With Liquid Nitrogen And Its Quality Assessment", Journal of Food Process Engineering, Dept. of Agricultural & Food Eng., IIT Kharagpur, India, 2007
10. *K.T. Rajkowski*, "Effect of individual quick freezing (IQF) on Salmonella recovery and texture of shrimp", 2nd International Congress on Seafood Technology (ICST 2010) May 10 – 13, 2010 Anchorage, AK.,Volume #36, P.1.
11. *Smelting Solution, BOC Technology, May 1998, I*ssue number 7.
12. *A.A M. Hatha, N Paul, B Rao*, "Bacteriological quality of individually quick-frozen (IQF) raw and cooked ready-to-eat shrimp produced from farm raised black tiger shrimp (*Penaeus monodon*)", Food Microbiology, Volume 15, Issue 2.