

**Quality of Shrimp (*Penaeus monodon*) at different points of
distribution channel in Bagerhat District**



**Fisheries and Marine Resource Technology Discipline
Khulna University, Khulna**

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**Quality of Shrimp (*Penaeus monodon*) at different points of
distribution channel in Bagerhat District**

Sham Sun Naher

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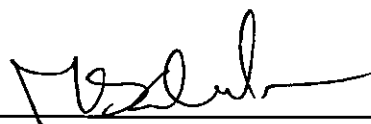
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Approved as to style and content by



Professor Dr. Md. Saifuddin Shah

Head

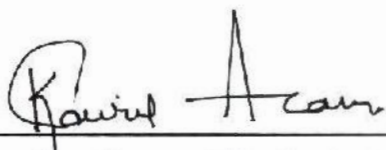
**Fisheries and Marine Resource Technology Discipline
Khulna University, Khulna
Bangladesh**

October, 2004

DECLARATION

The results submitted in this thesis are entirely of the candidate's own investigations and no part of the results have been accepted for any degree, nor it is being concurrently submitted for any degree.

Supervisor



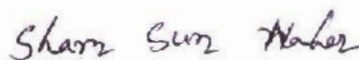
Professor Khairul Azam, Ph.D

Fisheries and Marine Resource Technology Discipline

Khulna University, Khulna

Bangladesh.

Candidate



Sham Sun Naher



**Dedicated to
My
BELOVED PARENTS**

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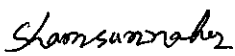
I want to accord my heartfelt reverence to **Md. Ashraf Ali Sheikh** Deputy Director, Fish Inspection and Quality Control (FIQC), Matshya Bhaban, Boyra, Khulna and the concerned **Scientific Officers** of FIQC laboratory.

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ABSTRACT

The present study was conducted to assess the quality of *Penaeus monodon* at each point of distribution channel as practiced normally (NP). The study area included Bagerhat district and the points of distribution channel were Gher (pond), Depot, Agent and Processing Plant. Another set of experiment was carried out using ice at the ratio of 1:1(Ice: Shrimp) at all points of distribution channel and referred as controlled study (CS). This was then compared with that of normal practice (NP). Quality assessment included Organoleptic, Biochemical (Trimethylamine Nitrogen and Total volatile base Nitrogen) and Microbiological (Standard Plate Count, Total Coliform, Faecal Coliform, *Salmonella* spp. and *Vibrio cholerae*.) parameters. Overall, organoleptic acceptability score ranged between 'highly acceptable' to 'moderately acceptable' (Gher = 8.8, Depot = 5.47, Agent = 6.67 and Processing Plant = 6.33 in a scale of 10) for shrimp harvested from Gher to Processing Plant as practiced normally (NP). Controlled study (CS) indicated relatively better score and quality of shrimp as judged by organoleptic evaluation. TVB-N value of shrimp in Gher and Agents were found to be very low for normal practice (2.40 and 5.32 mgN/100g). However, these values increased sharply to 15.35 and 8.13 mgN/100g in Depot and Processing Plant. For controlled study, the value of TVB-N did not vary much at each point but were particularly lower at Depot (7.85 mgN/100g) in comparison to value observed in Depot for normal practice. In both the cases, TVB-N values remained within the acceptable limit (30-40 mgN/100g). The highest value of TMA-N was found in Depot (10.75mgN/100g) for controlled study. But all values of TMA-N were low in both the experiments and remained within acceptable range (12-15 mgN/100g). The maximum value of Standard Plate Count (SPC) were (0.5×10^5 , 1.2×10^5 , 1.3×10^5 and 0.36×10^5 cfu/gm) in Gher, Depot, Agent and Processing Plant respectively for shrimp collected from normal practice. But these values differed from that observed in controlled study. However, the differences were within one log cycle and were within the acceptable limit (10^6 cfu/gm). Total Coliform (TC) counts varied between 3-28 MPN/gm for shrimp collected under controlled study. While, relatively higher Total Coliform counts were observed for shrimp collected in normal practice (Gher = 53 MPN/gm, Depot = 20 MPN/gm, Agent = 43 MPN/gm and Processing Plant = 28 MPN/gm). All these values were lower than the recommended limit (100 MPN/gm). In most cases, Faecal Coliform (FC) was not detected in both the experiment. The highest FC count was found in Gher (15 MPN/gm) for normal practice which was slightly higher than the acceptable limit (10 MPN/gm). *Salmonella* spp. and *Vibrio cholerae* were not detected in any samples in controlled study and normal practice.

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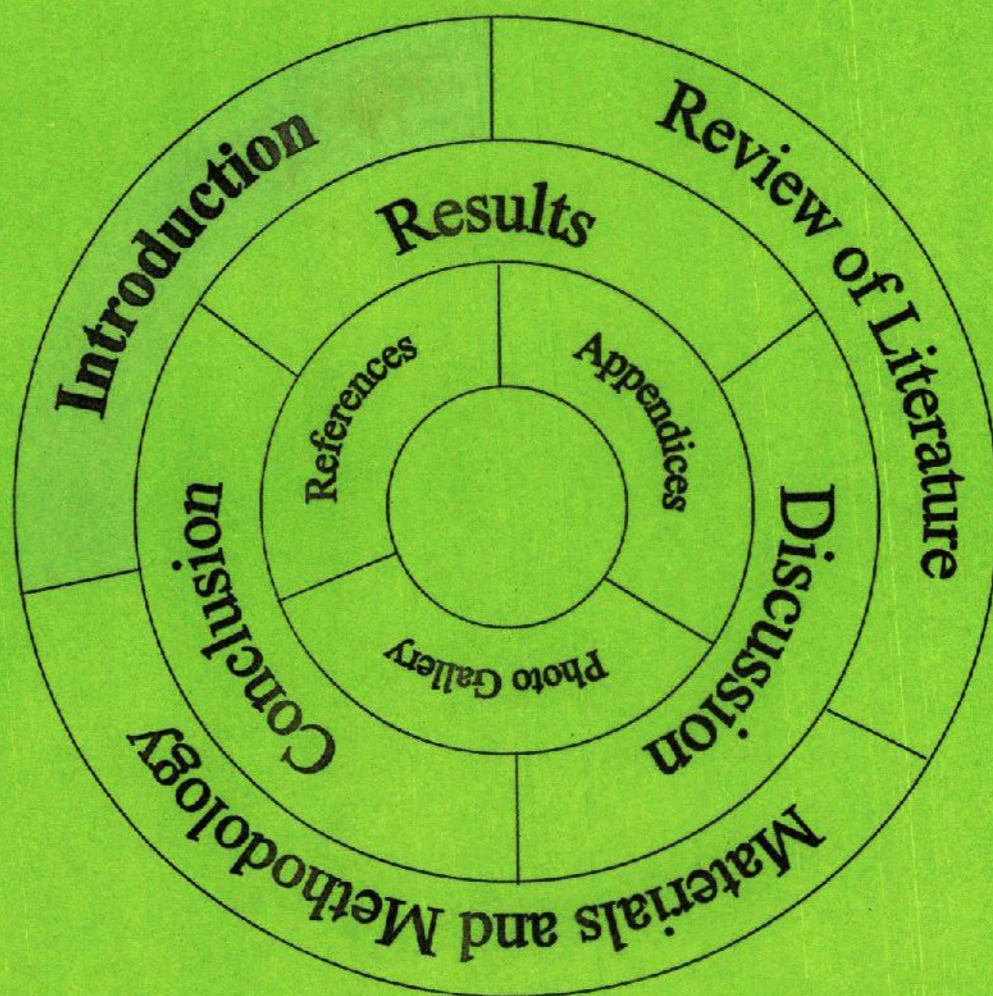
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ABBREVIATIONS

APW	=	Alkaly Pepton Water
ATDP	=	Agro-based Industries and Technology Development Project
BGLB	=	Brilliant Green Lactose Bile Broth
CS	=	Controlled Study
EMB	=	Eosin Methylene Blue Agar
EU	=	European Union
FC	=	Faecal Coliform
HACCP	=	Hazard Analysis Critical Controlled Point
LSTB	=	Lauryl Sulfate Tryptose Broth
MR	=	Methyl Red
NGO	=	Non Governmental Organization
NP	=	Normal Practice
P.Plant	=	Processing Plant
SPC	=	Standard Plate Count
TC	=	Total Coliform
TCA	=	Trichloro Acetic Acid
TCBSA	=	Thiosulphate Citrate Bile Salts Sucrose Agar
TMA	=	Trimethylamine
TMA-N	=	Trimethylamine Nitrogen
TMAO	=	Trimethylamine Oxygen
TVB	=	Total Volatile Base
TVB-N	=	Total Volatile Base Nitrogen
TW	=	Tryptone Water
XLD	=	Xylose Lysine Deoxycholate



Current Position Indicator

Introduction

1.0 INTRODUCTION

Bangladesh has limited wealth but have a lot of possibilities to increase wealth. One of the most important potential resources of is its vast area of water bodies with a diversified species of commercially important fish and shellfish. The total production reached 1.78 million metric ton (MT) and per capita consumption was 26 gm/day. Fish is the main source of animal protein in the diet of the people of Bangladesh. More than 63% of the animal protein in Bangladesh comes from fish and 1.2 core people are engaged in this sector (DOF, 2001).

Shrimp sector plays a vital role in the national economy of Bangladesh and its contribution to export earning is rapidly increasing. In Bangladesh, shrimp industry engages in various stages i.e., Fry, Wild, Hatchery, Agent, Shrimp farms, Transportation, Processing Plants, Export.

Bangladesh produces 2.5 percent of the global production of shrimp. In Bangladesh, the shrimp sector is the second largest export industry, giving employment to 840,000 people. (Frankenberger, 2002) The total contribution of the shrimp sector to the country's Gross Domestic Product (GDP) is estimated at 0.6% but that frozen seafood accounts for a round 6% of the total export value, of which shrimp export constitutes almost 90%. (BCAS, 2001b)

The main cultivated species is *Penaeus monodon* (tiger shrimp), more commonly referred to as bagda and *Macrobrachium rosenbergii* (gaint freshwater prawn) commonly known as golda. In 2001, 25,000 tons of bagda (representing 58% of the total national shrimp production of 42,000 tons) and 12,000 tons of golda (28% of the total production) were produced (Banks, 2001). Whilst production is orchestrated to produce bagda and golda, small amounts of other shrimp species (all salt/ brackish water type) are also grown. There are: *Fenneropenacus indicus* (Chaka or Indian white shrimp); *Metapenacus monoceros* (horina or brown shrimp); *Penacus semisulcatus* (green tiger shrimp); and *Fenneropenacus merguensis* (banana shrimp). Together they account for about 6,000 tons, equivalent to 14% of the total production (Banks, 2002).

Total sales from both bagda and golda farms in 2001 was Tk. 17,169 M (US\$301 M). (Banks, 2002). Bagda gher outputs account for 80% (Tk. 13,864 M or US\$243M), and golda gher outputs for 20% (Tk 3,305M or US\$58M).

In 2001, the total sector gross value added was established at Tk 15,942M (US\$279M)(Banks, 2002). Bagda gher were the highest contributors (50%; Tk 7,674M or US\$135 M)(FFP,2002), followed by golda gher (16%; Tk 2,389 M or US\$42 M), processing (18%), fry collection (9%) and hatcheries (7%).

Once harvested, the flow of shrimps from Gher to factory takes place within 12-24 hours. The post-harvest trade flow goes from farmer to Depot to Agent to factory. All trade ultimately feeds through the Agents who buy the entire product to supply to the factory.

Each Depot purchase directly from the farm (Gher) while some larger scale farmers are able to supply direct to the depot or even to the agents (estimated to be around 10% of the total). There are no direct links between farmers and the processing factories (less than 1%). Processors provide a commission to agents who complete for supplies at the Depots. One Agent may deal with several factories. They exert influence at both ends of the scale. The commission Agents largely fix the prices.

Processing includes de-heading (Bagda) and cleaning of the shrimps, freezing and packing. There are 124 processing factories in Bangladesh with a capacity for processing of 825t per day. Of these, 35 are presently operational in Khulna (mostly located along Rupsha River), 38 are operational in the Chittagong district and 51 plants have either closed down or are awaiting approval for the quality inspection license. Khulna accounts for around 60-75% of the total production capacity. Only around 20% of the total factory capacity is utilized.

Quality control of fish and fish products are like the two sides of a coin. One cannot do without the other. Quality, in general, means the wholesomeness or the state of excellence of a particular product in terms of its appearance, shape, color, taste, and competitiveness in price to the buyer. In a nutshell, quality means the fulfillment of the

customer's requirements. Quality control is a critical element in the shrimp distribution channel. DOF has recently amended the Fish Inspection and Quality Control Act to incorporate Hazard Analysis Critical Control Point (HACCP) standards and principles and EU requirements. Moreover, the Upazila Fisheries Officers in Bangladesh have been instructed officially to enforce the Fish Inspection and Quality Control Act under which they can visit shrimp depots and take action on defaulters.

Fresh fish and shrimp losses are mainly a result of spoilage, caused principally by lack of chilling, coupled with poor storage, distribution and marketing facilities. The spoilage process in shrimp result in changes related to flavor, texture, appearance, and many biochemical components of shrimp muscle. Spoilage is irreversible, and process does not improve the quality of bad raw material. Proper processing techniques can only preserve the state of the raw material. Thus, loss of freshness of shrimp during storage can be evaluated by using many different methods i.e. sensory, biochemical and microbiological parameters. Increasing fresh fish and shrimp stability will not only permit the retail marketing of an acceptable product over a longer period of time, but will also permit market expansion by allowing high quality shrimp to be sent to distant inland markets.

Almost all of bagda and golda shrimp products in Bangladesh are exported (BCAS, 2000a). As these shrimps are produced by the extensive culture method without any use of chemicals such as antibiotics, they are of high quality in terms of size, color, and muscle texture and highly in demand on the international market. However, due to lack of proper post-harvest care and quality control, major buyers from the EU stopped importing shrimp from Bangladesh in 1997. Drastic measures to maintain quality in compliance with HACCP standard helped to regain the international market by 2000 (ICZMP, 2003).

USA, Japan and the EU are the main buyers of Bangladeshi shrimp. Over the past 6 years (1995-2000), the value of their total shrimp imports was quite stable at US\$ 10 billion. Worldwide, however, the consumption of shrimp is steadily increasing. The Republic of Korea, Singapore, and Hong Kong emerged as new shrimp markets. The average annual price increase of shrimp from 1991 to 1998 was about 13% while the total price increase in 10 years was about 140 percent. In 2001-2002, Bangladesh

achieved its ever-highest export earnings from the fisheries sector (Tk.18,851M or US\$325M) by exporting almost 30,000 tons of shrimp, which contributed 90% of the frozen fish export.

Shrimp is one of the most perishable food items, highly susceptible to bacterial and enzymatic spoilage unless handled, processed packed and stored scientifically. Shrimp fishery product is the second largest single foreign exchange earning export item for Bangladesh (Mazid, 2002).

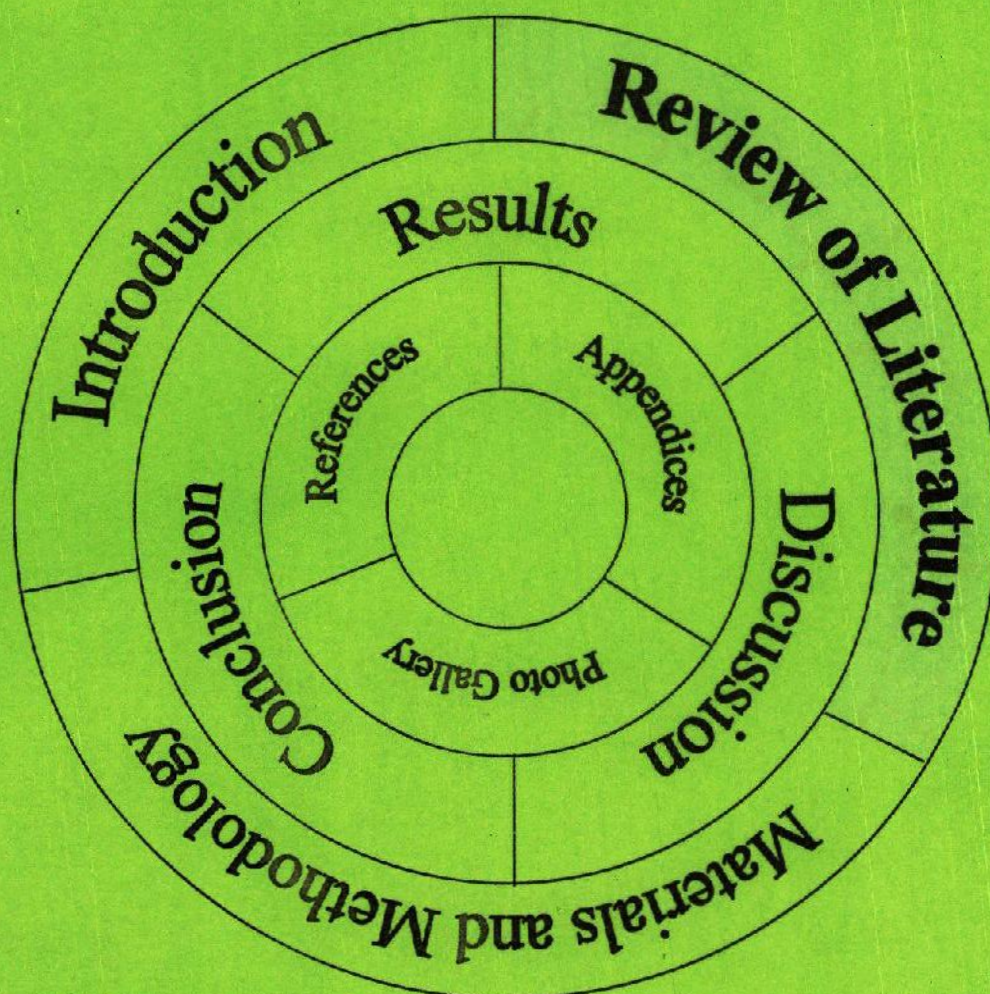
At present, importing countries are becoming more and more quality conscious and are imposing stringent quality standards for the products imported by them. Quality concepts have undergone tremendous changes over years. Earlier, the quality “control” was done at the end product stage. However, quality is the most vital problem in beginning of the process until the end product.

Quality of shrimp is usually dependent mainly on species, storage temperature (0°C , 10°C , 20°C , and 30°C). But researchers have confined the degree of quality to be mainly dependent on temperature. Higher storage temperature results in quicker spoilage of shrimp (Nguyen, 1997). In Bangladesh shrimp are distributed from harvest to the factory/ industry with or without ice. There are great variations in the usage of ice (ratio of ice to shrimp) even when it is being used (Azam, 2004). Even when, ice is used for shrimp, usually the ratio varied i.e., 1:0.5, 1:1, 1:2.

There have been inadequate researches on the quality of shrimp from the point of harvest until it is brought to the processing plant. The broad objectives focused on quality of shrimp at each point of distribution channel in Khulna region. The investigation intended to enhance the quality of shrimp through better management practice i.e., use of ice (1:1; ice: shrimp) referred as ‘**controlled study**’ at each point of distribution channel. This was then compared with the ‘**normal practice**’.

The specific objectives were to:

- Find out organoleptic quality of shrimp collected from different points of distribution channel as normally practiced.
- Find out organoleptic quality of shrimp preserved in ice (1:1; ice: shrimp) throughout the distribution channel.
- Find out biochemical (TVB-N and TMA-N) quality of shrimp collected from different points of distribution channel as normally practiced.
- Find out Biochemical (TVB-N and TMA-N) quality of shrimp preserved in ice (1:1; ice: shrimp) throughout the distribution channel.
- Find out Microbiological (SPC, TC, FC, *Salmonella* spp and *Vibrio cholerae*) quality of shrimp collected from different points of distribution channel as normally practiced.
- Find out Microbiological (SPC, TC, FC, *Salmonella* spp. and *Vibrio cholerae*) quality of shrimp preserved in ice (1:1; fish: ice) throughout the distribution channel.



Current Position Indicator

Review of Literature

2.0 REVIEW OF LITERATURE

Shrimps are considered to be among the most perishable of foodstuffs. Fresh shrimp are very susceptible to spoilage and as a consequence may be expected to undergo some degree of deterioration between catching and delivery to the receiving room of the processing plant. Temperature affects the rate at which bacteria multiply (Ronsivalli and Charm, 1975). The most important means of preserving fresh shrimp is by chilling to about 0-40°C. The most common chilling media are wet ice, mixture of ice and seawater or refrigerated seawater (Sikorski *et. al.*, 1994).

At a temperature of 0°C merely slows down microbiological activity. An increase in temperature of 1 or 2°C will markedly increase the rate of bacterial growth and reduce the shelf life (Matches, 1982).

There are several reports on the storage stability of shrimp in ice (Cheuk *et. al.*, 1979; Fatima *et. al.*, 1981; Shamsad *et. al.*, 1990; Yamagata, 1995).

Microbiology of fresh and spoiled fish has been reviewed extensively (Tarr, 1954; Wood, 1967; Shewan, 1961; Shewan and Hobbs, 1967). Microbial proliferation begins with death of fish, at which time each natural defense mechanisms are destroyed. The rate of growth will depend on the number of types present on the fish and the temperature at which the fish are held (Graikoshki, 1973).

The chemical changes take place is mainly due to bacterial enzymes (Ronsivalli and Charm, 1975; Liston, 1982).

The freshness of quality of a particular food refers to the degree of excellence (Botta, 1995). The degree of excellence referred all sensory/ organoleptic variables (appearance, texture, odor and flavor). Freshness, quality is considered to be an extremely important factor in determining overall quality (Howgate, 1982). The location of harvest (Huss, 1988), time of the year (Love, 1988), method of catching (Botta *et. al.*, 1987; Huss, 1988) and the manner in which seafood handled (Botta *et. al.*, 1989) seriously affect the

degree of excellence. Freshness of seafood has a considerable influence on its quality and is the most important criteria for judging the quality (Botta, 1994).

Many methods have been tested for freshness quality i.e., organoleptic (Shewan and Ehrenberg, 1977) TVB-N (Botta *et. al.*, 1984), TMA (Fatima *et. al.*, 1981).

Sensory/ Organoleptic evaluation is the most satisfactory and acceptable method to access the quality of fish and shellfish (Connell, 1976; Larmond, 1986; Howgate, 1982).

TMA is the compound produced from TMAO by bacterial enzymatic process. TMA has been considered as useful index for some species. TVB is used as an alternative to measuring TMA content. Seafood, when closed to spoilage, contains several bases that are volatile. Volatile bases in TVB mainly contain TMA and ammonia. Changes in TVB content during spoilage are very similar to those of TMA in the same species except that the initial value of TVB is much higher (Botta, 1994).

Detailed bacteriological evaluation of shrimp from cold waters have been attempted by Harrison and Lee (1969); Cann *et. al.* (1971); Novak (1973) and Lee and Pfeifer (1977). Such data regarding tropical shrimp is rather scanty (Cann, 1977; Zuberi *et. al.*, 1983). The shelf life of shrimp in ice has been studied by many workers (Surendran *et. al.*, 1985; Reilly *et. al.*, 1986).

Samples collected from a commercial processing plant had higher initial counts than those processing in the laboratory (Lobrerria *et. al.*, 1990). With proper washing (use of clean, potable, Chilled water), the bacterial load of shrimp can be reduced by as much as 65% (De silvia, 1985; Lisac, 1983; Rajaduraic, 1985).

Studies on farmed brackish water shrimp aimed to reveal whether the microbiological load of tropical shrimps was significantly higher than those from temperate waters and whether salmonella is a natural or commensally contaminant of farmed shrimp. (Putro *et. al.*, 1990)

The tropical shrimp have higher bacterial load compared to temperate species (Peranginangin 1982). Cold water shrimp frequently have bacterial loads of $10^{-10^3}/g$, although the range sometimes vary greatly and on certain occasions has been reported up to $10^7/g$ (Liston, 1980). In most cases, warm water shrimp and prawns have counts of $10^6/g$ on capture. (Cann, 1974; Vanderzant *et. al.*, 1970)

Coliform, *Escherichia coli* and Total bacterial count, *Vibrio parahaemolyticus*, salmonella and qualitative microflora are also reported for prawns. (Fonseka, 1990)

Five treated and untreated samples were subjected to chemical and microbiological analysis together with organoleptic evaluation using hedonic score sheet (appearance, color, texture, taste, flavor). (Rattagool, 1990)

The incidence of human pathogenic vibrios in seafood harvested along the coast of Karnataka State (India) was studied by enrichment and direct plating methods. (Karunasagar *et. al.*, 1990)

Microbiological evaluation of prawn processing was made once a month, from samples obtained at four processing stages in a factory, over a period of six months. (Jayaweera *et. al.*, 1990)

Prawns iced approximately eight hours after capture remained acceptable organoleptically (cooked) for 12 days. (Jayaweera, *et. al.*, 1990)

Microbiological quality indices, namely standard plate count (SPC), presence/ count of *V. cholera*, *Salmonella sps.* and faecal coliforms, were determined at specific points in the preparation of frozen prawns (*Penaeus monodon*). (Rose *et. al.*, 1990)

The physical, chemical and sensory change were determined in shrimp *Penaeus semisulcatus* stored at $0^{\circ}C$, $10^{\circ}C$, $20^{\circ}C$ and $30^{\circ}C$ in order to estimate the effect of temperature and time on quality indices and determine their inter-relationships. (Nguyen, 1997)



The importance of cool chain food products in the international market had stimulated many studies of the effects of freezing and low temperature storage in the bacteria associated with food (Borgstorm, 1995). From the public health point of view, particular interest has been shown in reports indicating the survival of bacteria that have been frequently implicated, directly or indirectly with potential food poisoning hazard (Gunderson and Rose, 1984; Kereluk and Gunderson, 1959; Kereluk *et. al.*, 1961).

In general, the effect of reducing temperature on bacteria depends on various factors such as rate and type of freezing (Luyet and Gehinio, 1940), initial numbers types and stages of growth phase of microorganisms involved (Record and Taylor, 1953) thawing processes, number of cyclical defrosting (Hess, 1934) and the physical protection offered by the food itself its components (Keith, 1913).

Fish taken from open waters are usually free from salmonella, (Bryan, 1973) but fish caught in sewage-polluted waters have indicated these organisms. (Buttinaux, 1962; Martin 1967)

Large numbers of *V. Cholerae* must usually be ingested to cause cholera, thus problems often occur when poor handling and inadequate refrigeration have allowed the organism to multiply (Young, 1992). In order to compete in the international market, prawn/ shrimp exporters must meet microbiological standards set by importing countries (Dangla, 1984). Problems faced by Asian prawn/ Shrimp producers have been reviewed (Sumner *et. al.*, 1982).

Microbiological studies are useful in determining the build-up and movement of pathogens and other organisms throughout the facility during processing. Microbiological testing has an indispensable role in the HACCP system (Silker, 1995). The danger from microorganisms is greater in tropical countries where the surrounding conditions are favorable for their rapid growth (Cann, 1977).

It has long been established that rapid fish spoilage even at cold temperature is preliminarily due to bacterial action (Shewan, 1962).

It is generally agreed that at 0°C fish and shrimp become unacceptable organoleptically, biochemically and microbiologically within two weeks (Cobb *et. al.*, 1976).

During processing the raw material may be contaminated by bacterial in various ways. If adequate precautions are not adopted soon after catching to prevent such entry, the fish may be become contaminated by heavy bacterial load within a very short period (Valankar, *et. al.*, 1961).

Quality problem are also caused by the particular nature and variability of raw materials +due to the influenced of environment, feed and season. Quality control or the war against spoilage can be defined as "all methods, processing, techniques, and process employed to inhibit, delay or prevent deteriorative changes in freshly killed fish and in fish products and to prevent contamination or adulteration". More simply quality control is the application of technology to the handling, processing, manufacture, storage and distribution of fish and fish products in order to meet established or acceptable forms. (Dempsey, 1971) and (Sunarya, 1996) studied on improvements in fish handling, processing and quality control.

Smole *et. al.*, (1997) carried out rapid detection of food borne pathogens and food spoilage microorganisms is becoming increasingly important in modern food production.

Howgate, (1985) worked on the handling and processing of fish in Pakistan with special reference to the quality and quality control of fish and fish products.

Pokern (1990) worked on microbiology in food processing and provides an analysis of the following: microbiological control of the food quality, role of microbiologists in conducting the production, microbiologic criteria and food legislature, source of microorganisms in food, development in microbial association, in processed article, ecology of microorganisms growth, physiology of food spoilage, inhibition of microorganisms by technologic procedures, thermal processing, freezing, dehydration, preservation with preservatives, strategy of microbiologic control in food industry.

Fresh fish and shellfish are highly perishable food commodities due to their biological composition. The muscle tissue of fish and shellfish spoils fast. This can be explained by the higher water content of shrimp, the high free amino acid content, and the lower content of connective tissue as compared to other flesh foods. This is a good condition for activities of microorganisms (Ranke, 1959).

Backley and Kroll, (1996) reported fresh is certainly related to taste, smell, sight, and mouth-feel, four of the five senses.

Cannon-Bonventure (1992) reported “freshness” defined in term of specific characteristics (appearance, order, flavor and texture) is usually much more consistent and less confusing. However, texture measurement is most widely used since texture has become a new important and desirability for today’s consumer (Szczesniak, 1990). Gill *et. al.* (1979) pointed out that texture deterioration of red hake and haddock muscle in frozen storage and chemical parameters can give significant correlation if carefully controlled conditions are maintained.

Several authors (Poulter, 1981) have reported on the extended shelf life of iced tropical fish species compared with iced fish from cold or temperate waters.

The data available on the organoleptical and biochemical changes in temperate and warm water fish and shrimp are rather scanty and often inconclusive (Lima Dos Santos, 1981).

Temperature, humidity and time of storage are the most important factors influencing the quality of fish (Stansby, 1963).

The keeping quality of fish depends on the species of fish, fishing methods and temperature of storage, storage time, as well as various other conditions, which influence the action of macro-organism (Shewan, 1951).

The organoleptic method may be influenced by the physiological and psychological state of the judges. Considerable variations are often observed in the sensitivity and the test of

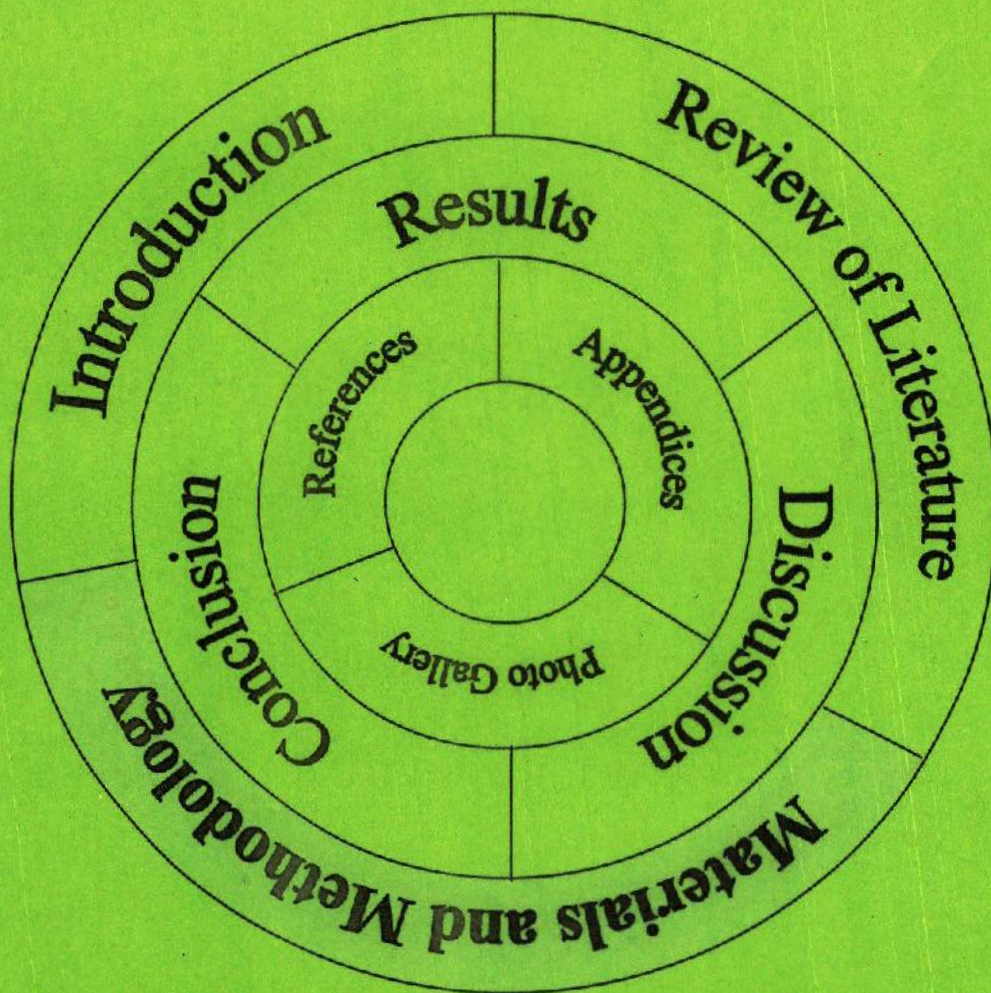
the judges of the panel at different times and the different circumstances under which the examinations are performed (Reay and Shewan, 1949; Farber, 1965).

Certain chemical changes in spoiling fish and shrimp appear to run parallel with changes in odor, texture, appearance, etc. Various attempts have been made to measure freshness by estimating the quantities of some of these end products as a result of enzymatic and bacterial activity (Tanikawa, 1935). Paryam & Pilgrim (1957) has developed a useful method for assessing overall acceptability of food products.

Biochemical (TVB-N, TMA-N) test is quite generally applicable; it usually gives reasonable good correlation with organoleptic freshness and can be carried out rapidly without the use of special equipment (Stansby *et. al.*, 1957; Hilling *et. al.*, 1958).

Jenson *et. al.* (1979) studied the pattern of increase in TVB-N during the storage of cod muscle at 2°C and compared there results with sensory method. A good correlation obtained. Using the total volatile base a quality index does not distinguish the origin or component of these volatile compounds. Hence its use is more general

Kamal *et. al.* (1994) reported that the fish immediately after catch transported in the insulated box in ice remained in acceptable condition for 18 days of storage, while the fish obtained from Mymensingh wholesale fish market and stored in wooden box were organoleptically acceptable for about 8 days in ice storage.



Current Position Indicator

Materials and Methodology

3.0 MATERIALS AND METHODOLOGY

3.1 Study Area

The primary study area was situated in Bagerhat district in Khulna Region from where shrimps were collected from the point of distribution channel i.e. Gher and Depot (Bismilla Fish Traders) of Foila bazar. While the rest of the distribution points included Agent (Palash Fish) in Natun Bazar, Khulna and Processing Plant (Sobi Fish Processing Industries) situated adjacent to Rupsha River.

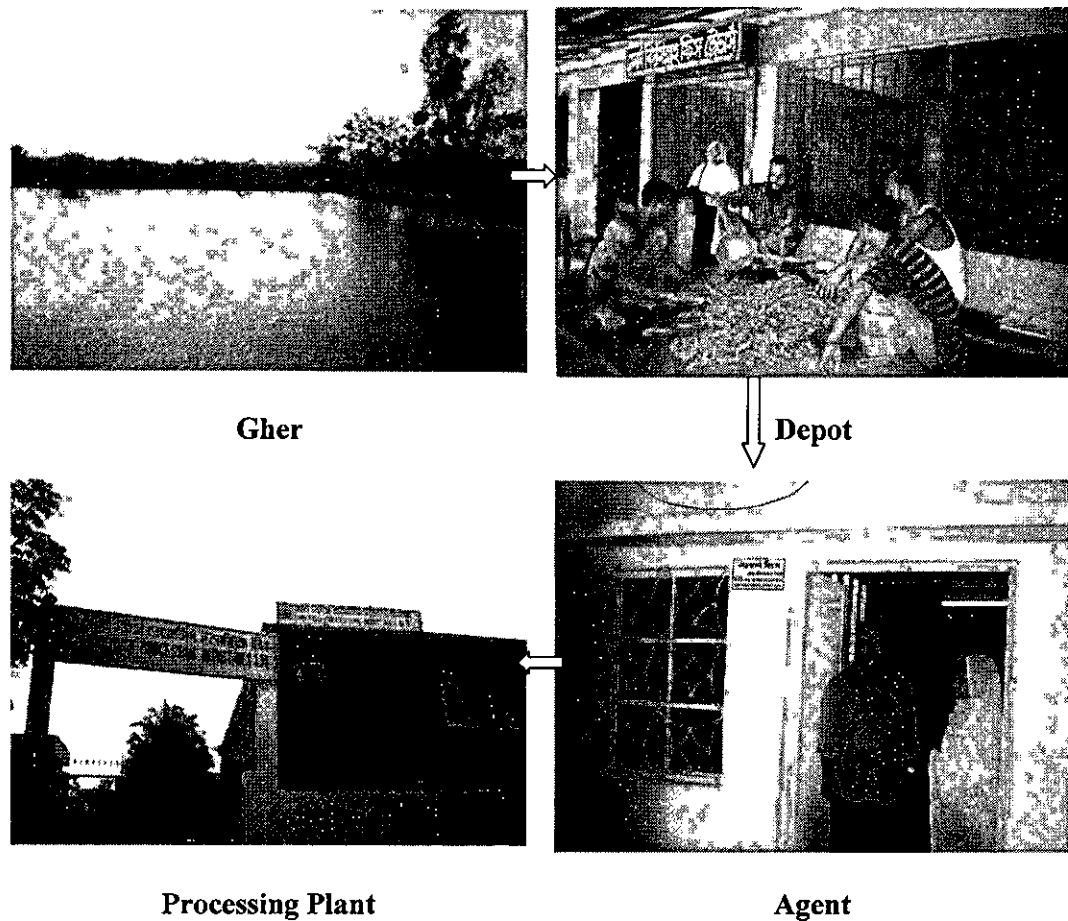


Figure 1: Flow diagram of each point of distribution channel

3.2 Sampling Method

Shrimp (*Penaeus monodon*), weighing between 75 -150gm were collected from the point of harvest (Gher). Total weight of shrimp collected were 2kg that included 20 shrimps

for only normal practice. These were placed in bamboo basket. At this point 5 shrimp were separated, packed in polythene sheet (purchased from local market) and placed back in the bamboo basket along with other 15 shrimps. The bamboo basket was then carried to depot. Here, 15 shrimp (except the shrimp placed in polythene sheet) were taken out and processed (de-headed) these were then washed. Ice was applied in approximate ratio in (1:1; Shrimp: Ice). The processed shrimp were packed in separate polythene sheets (3 having 5 shrimp in each case) and placed in insulated box. The two boxed (insulated box and bamboo basket) were then transported to Agent (Naton bazar, Khulna). Shrimp from the insulated box were taken out, weighed, washed and then placed back in the polythene sheet. The sheets were stored in insulated box. This moment, 15 shrimp in insulated box and 5 shrimp in the bamboo basket were transported to the receiving point of processing plant. Here, all shrimps were weighed and washed. Shrimp were placed back again in the similar manner as mentioned earlier. The bamboo basket and the insulated box having shrimp were ultimately brought to the quality control laboratory of Fisheries and Marine Resource Technology Discipline, Khulna University. This method of collection of shrimp was referred as 'normal practice' (NP).

The average time taken for shrimp transported from harvest (gher) to processing plant was 10 hours, further 2 hours was required to bring the raw materials to the Quality Control Laboratory of Fisheries and Marine Resource Technology Discipline, Khulna University.

A Controlled Study (CS) was done in a separate experiment when ice was used at a ration of 1:1 (Ice: Shrimp) maintained throughout the distribution channel right from the point of harvest. However, total weight of shrimp collected were 2kg that included 20 shrimps for control study.

3.3 Analysis of the sample

Quality of shrimp in the laboratory was analyzed in relation to organoleptic, biochemical (TVB-N, TMA-N) and microbiological (SPC, TC, FC, *Salmonella sps.* and *Vibrio cholerae*) parameters. Shrimp were transported from the studied area in insulated box without ices as normally practiced by different stakeholders. In addition, study was also conducted in controlled condition where Ice: Shrimp (1:1) were used throughout the

distribution channel in insulated box. Shrimps were brought to the laboratory of Fisheries and Marine Resource Technology Discipline, Khulna University for analysis. Quality assessment for each species was carried out in triplicate.

3.3.1 Organoleptic

Organoleptic score sheet was developed for shrimp from the score sheet reported by Shewan and Ehenberg (1977) (Table 1) for fin fish. From the developed organoleptic score sheet, an overall acceptability ranking was done (Table 2). Shrimp were taken out from each point of the distribution channel and were evaluated with the developed score sheet.

Table 1: Organoleptic score sheet for shrimp

Odour Characteristics	Score	Carapace Color Characteristics	Score
Fresh odour	10	Yellowish (Fresh)	10
Sweetly odour	8	Moderately yellowish	8
Slightly spoilage odour	7	Slightly yellowish	6
Moderately spoilage odour	6	Slightly darken	4
Spoilage odour	5	Moderately darken	2
Slightly off odour	4	Darken	0
Moderately off odour	3		
Off odour	2		
Extremely off odour	0		
Carapace Texture Characteristics	Score	Eye Characteristics	Score
Hard	10	Bright and transparent	10
Slightly soft	7	Slightly dull	7
Moderately soft	5	Moderately dull	4
Soft	3	Dull and Opaque	2
Very Soft	0	Fully dull and opaque	0
Shell Color Characteristics	Score		
Bluish white (no spot)	10		
Slight loss of brightness	7		
Loss of brightness & opaque	5		
Slightly reddish	3		
Radish (spotted)	0		

Table 2: Organoleptic score sheet of overall acceptability for shrimp

Overall acceptability characteristics	Score Range
Highly Acceptable	8.5 – 10.0
Acceptable	6.5 – 8.0
Moderately Acceptable	4.5 – 6.4
Just Acceptable	3.6 – 4.5
Just Unacceptable	2.6 – 3.5
Unacceptable	1.5 – 2.5
More Unacceptable	0.5 – 1.4

3.3.2 Biochemical

TVB-N and TMA-N was determined according to the procedure of Conway (1977).

3.3.2.1 Total Volatile Base Nitrogen (TVB-N)

Three Conway's units were taken which had been thoroughly cleaned with a neutral detergent to remove any containment. To the edge of the outer rim of each unit was applied the sealing agent (Vaseline). Using a micropipette, 1 ml of inner ring solution was pipetted into the inner ring of each unit. In to the outer ring of each unit, 1 ml of the sample extract was pipetted. 1 ml of saturated K_2CO_3 solution was carefully pipetted into the outer ring of each unit, carefully to prevent any entering the inner ring, and immediately the units were covered and closed with clip. The solutions in the units were then mixed gently, to prevent any solution mixing from one ring to the other. Next, the units were placed in an incubator at $37^{\circ}C$ for 60 minutes. After that, the units covers were removed and the inner ring solution, now a green color, was titrated with 0.02N HCl using a burette (50ml) until green colored solution turned to pink. An average titrate volume of HCl was found from the results of three titrations for each fish species muscle sample. For each value the TVB-N values were calculated. A blank test was also carried out using 1ml of 1% TCA, instead of sample extract.

3.3.2.2 Trimethylamine Nitrogen (TMA-N)

Trimethylamine in fish muscle was determined by the Conway technique, which is same as TVB-N determination but prior to addition of potassium carbonate, 1 ml of 10% neutralized formalin was pipetted to the extract to react with ammonia and thus allow

only the TMA-N to diffuse over the unit. The calculation was done by the same formula as used in the Conway micro-diffusion technique for TVB-N.

3.3.2.3 Calculation of TVB-N and TMA-N

$$\begin{aligned} \text{TMA-N or TVB-N (mg/100g)} &= \frac{\text{Amt. of HCL used in titration} \times \text{Amt. of ammonium nitrogen equivalent to 1 ml of 0.02N HCL}}{\text{Ratio of the amt. of sample used to 100g muscle}} \\ &= (V_S - V_B) \times (N_{\text{HCl}} \times A_N) \times \frac{\left[\left(W_S \times \frac{M}{100} \right) + V_E \right] \times 100}{W_S} \end{aligned}$$

Where,

V_S	=	Titration volume of 0.02N HCl for sample extract (ml.)
V_B	=	Titration volume of 0.02N HCl for blank (ml.)
N_{HCl}	=	Normality of HCl (= 0.02N $\times$ f, factor of HCl)
A_N	=	Atomic weigh of Nitrogen (14.00)
W_S	=	Weigh of muscle sample (gm)
M	=	Percentage moisture of muscle sample
V_E	=	Volume of 4% TCA used in extraction

N.B. 1 ml of 0.02N Hcl = 0.28 Ammonia nitrogen.

$$= (N_{\text{HCl}} \times f \times 14.00)$$

Detection limit: 0.2 mg/100g.

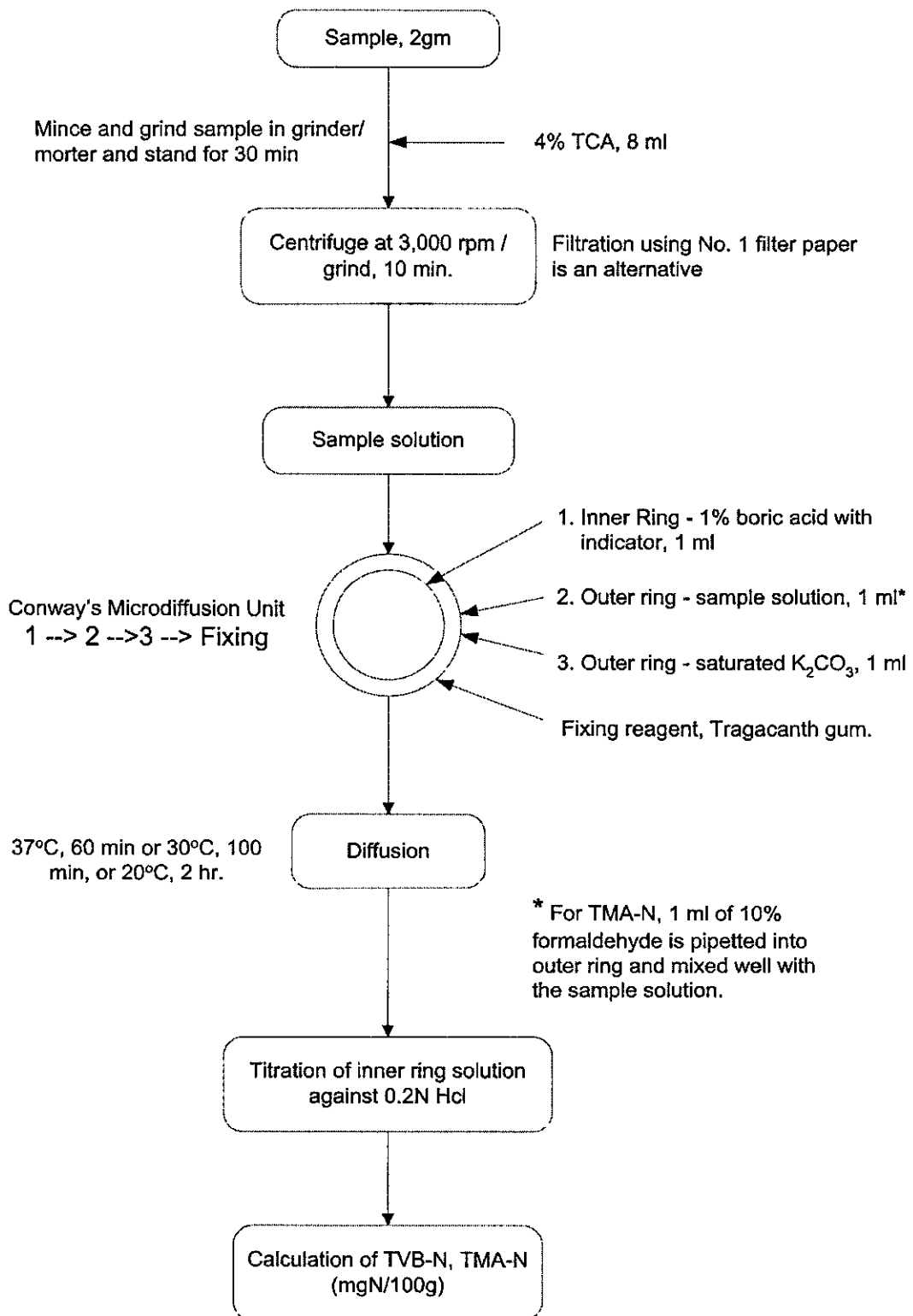


Figure 2: Flow chart for TVB-N and TMA-N determination

3.3.3 Microbiological

Microbial analyses followed the procedures of ICMSF (1988).

3.3.3.1 Standard Plate Count (SPC)

Culture Media

Plate count Agar (PCA)

2.35 grams of plate count agar was first added in 100ml of distilled water and boiled to dissolve the medium completely. The sulphite medium was then sterilized by autoclaving at 15 lbs/inch² pressure (121°C) for 15 minutes.

Procedure

20.0 gm of pooled sample was weighed and taken into a sterile warring blender jar for blending. The sample was added into a flask containing 180 ml 0.1% sterile peptone water. The mixture was homogenised for two minutes. This provided a dilution of 10^{-1} . 1.0 ml. of this suspension was transferred into McCarty's bottles containing 9 ml of 0.1% peptone water to give a dilution of 10^{-2} . The process was repeated for the preparation of 10^{-3} dilutions respectively.

The appropriate dilutions were selected and for every dilution 1.0 ml aliquot were transferred into sterile Petri dishes. 20.0 ml portion of molten Plate Count Agar (PCA) was poured into each of these sterile Petri dishes. The plates were then rotated 5 times clockwise, 5 times anticlockwise, 5 times back and forward. Care was taken not to splash agar on the lid of the dish. Plates were left to solidify the plates were inverted and incubated at $35^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 48 hours. Plates with 30-300 colonies on the surface were only counted.

Flow chart for the enumeration of Standard Plate Count (SPC) is provided in Figure 3.

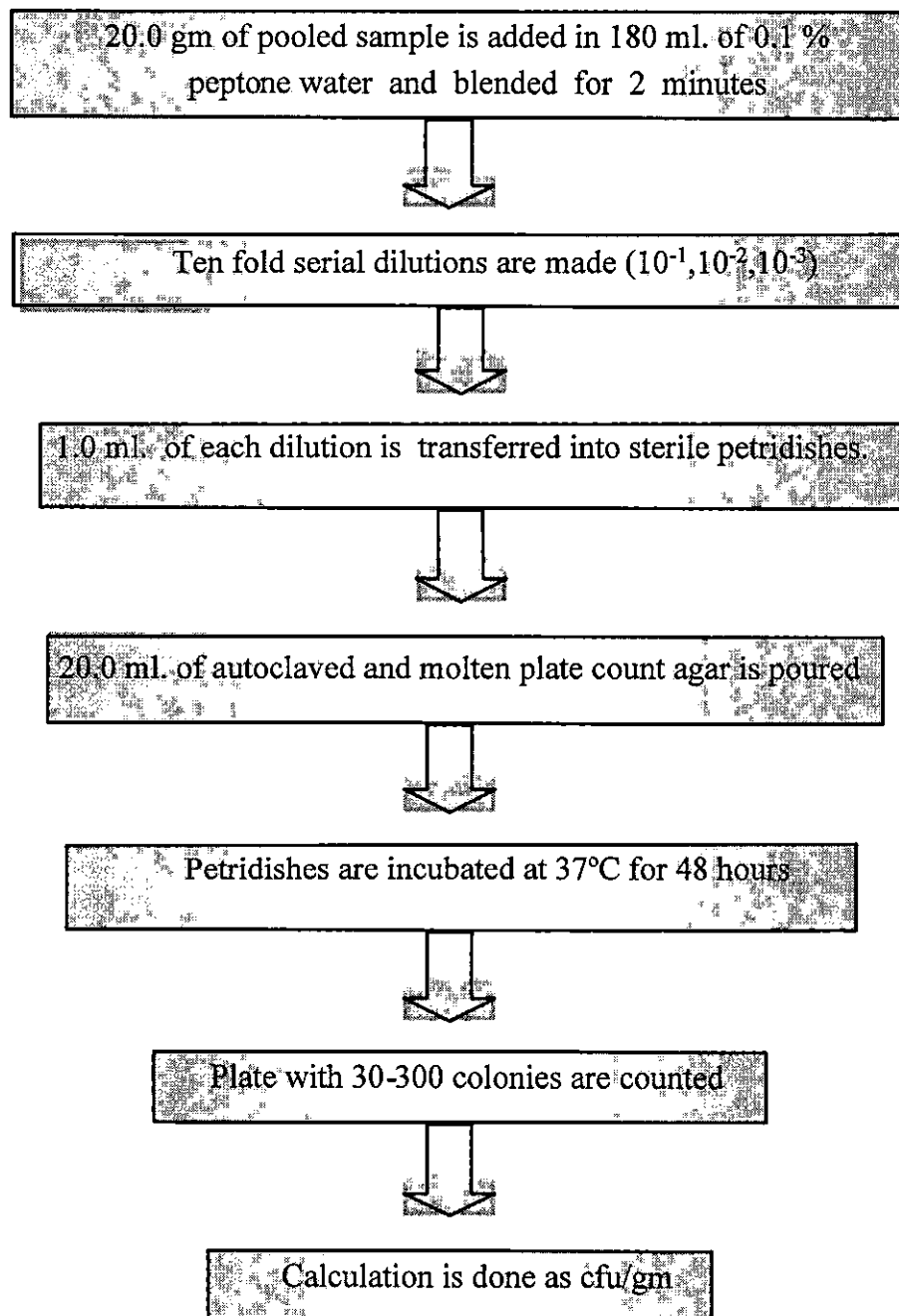


Figure 3: Enumeration of Standard Plate Count (SPC)

3.3.3.2 Total Coliform (TC)

Culture media

Lauryl Sulphate Tryptose Broth (LSTB)

3.56 grams of LSTB was dissolved in 100ml of distilled water and then was distributed into test tubes with inserting Durham tubes and sterilized by autoclaving at 15 lbs/inch² pressure (121°C) for 15 minute.

Procedure

20.0 grams pooled sample was weighed and aseptically taken into a sterile warming blender jar and then blended. After blending, the sample was added into conical flask containing 180 ml. of 0.1% peptone water. Ten fold serial dilutions were made with this suspension in McCarty's bottles containing 9.0 ml. of 0.1% peptone water.

1.0 ml. of each dilution was transferred into three screw-capped test tubes containing autoclaved, Lauryl Sulphate Tryptose Broth (LSTB) (10.0 ml) with Durham's tubes. The tubes were inverted to ensure that Durham tubes did not contain gas bubbles. These tubes were incubated at $37^{\circ}\text{C} \pm 1^{\circ}\text{C}$ for 48 hours. The formation of gas within 48 hours was considered as evidence for the positive test for Coliform organisms.

Number of positive tubes out of 3 was recorded for each dilution. Using the MPN tables, the MPN of Total Coliform (TC) was calculated based on the portion of confirmed LSTB tubes (with gas production).

Flow chart for the Quantification Total Coliform (TC) of fish is shown in Figure 4.

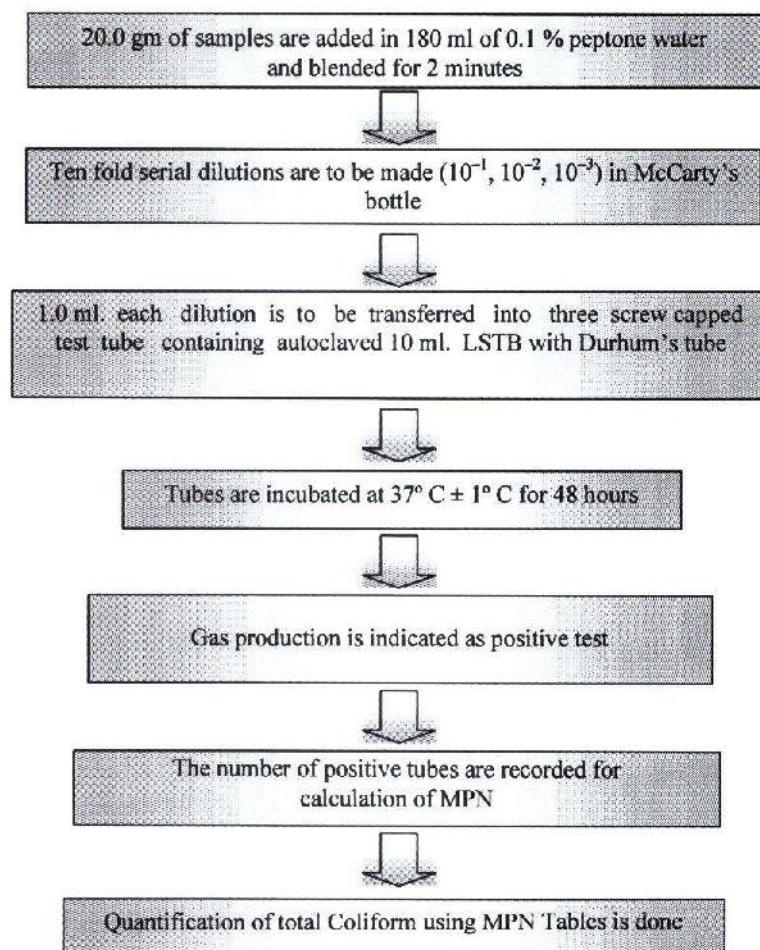


Figure 4: Quantification of Total Coliforms (TC)



3.3.3.3 Faecal Coliform (FC)

Culture media

Brilliant Green Bile broth (BGLB)

4 grams was suspended in 100 ml distilled water. It was mixed well then it was distributed in fermentation tubes and sterilized by autoclaving at 15 lbs/inch² pressure (115°C) for 15 minutes.

Tryptone Water (TW)

1 gram was suspended in 100 ml distilled water. Then it was heated to boiling to dissolve the medium completely. Sterilize by autoclaving for 15 minutes at 15 lbs/inch² pressure (121°C).

Procedure

Those tubes of Lauryl Sulphate Tryptose Broth (LSTB) which were positive for gas production in Total Coliform (TC) estimation tests were considered. Subcultures were made from all positive tubes of Lauryl Sulphate Tryptose Broth (LSTB) into a 10 ml volume of Brilliant Green Lactose Bile broth (BGLB) and 5ml Tryptone Water (TW) incubated at 44.5 ± 0.5 °C up to 48 hours. BGLB tube showing gas production was considered positive for the presence of presumptive Faecal Coliforms (FC).

All positive tubes were sub-cultured by streaking onto plates of EMB agar. Then these plates were incubated at 37° C for 18 - 24 hours. After incubation, the plates were examined for suspicious Faecal Coliform colonies i.e. black or dark centred with the greenish metallic sheen.

Subculture were made from all positive tubes of Lauryl Sulphate Tryptose Broth (LSTB) into a 5ml volume of Tryptone Water (TW) add Kovac's indole reagent for indole test. Any positive tubes showing pink color was considered for the presence of Faecal Coliform (FC). When both BGLB tubes showing gas production and TW tubes showing pink color for the same dilutions then this situation was considered for confirmation test of Faecal Coliform.

Flow chart for the Quantification Faecal Coliform (FC) of fish is shown in Figure 5.

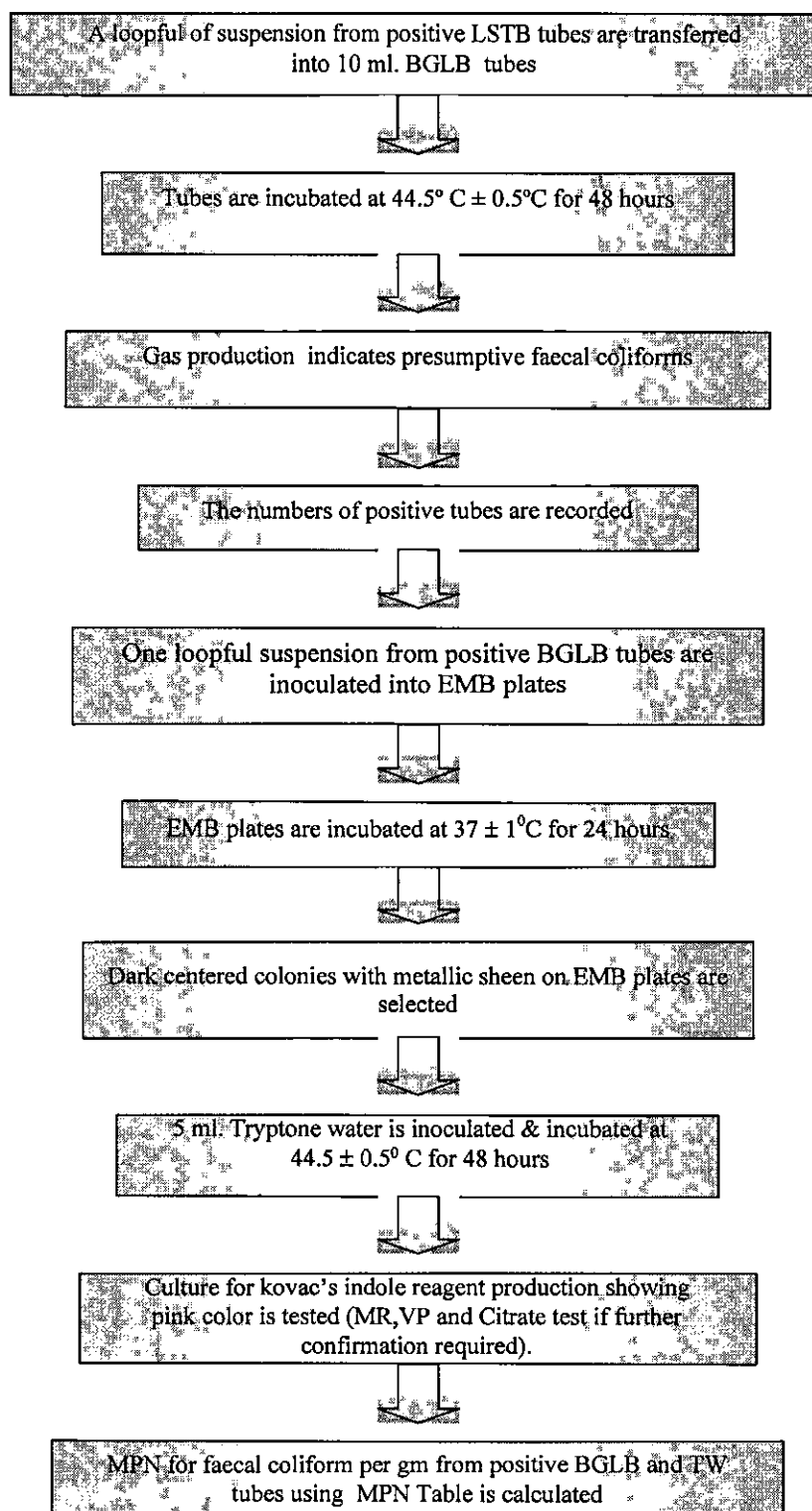


Figure 5: Quantification of Faecal Coliform (FC)

3.3.3.4 *Salmonella Sps.*

Culture media

Selenine Cystine Broth

Part – A

Tryptone – 5gm/litre

Lactose – 4 gm/litre

Sodium – 10gm/litre

Part – B

Sodium Acid selenine – 4 gm litre

0.2 gms of part A and 1.33 gms of part B of selenite broth was suspended in 100ml distilled water. It was warmed to mixed well. It was dispensed and sterilized in a boiling water bath or in free flowing steam for 10 minutes. It was not done in autoclave because excessive heating is detrimental.

Tetrathionate Brilliant Green Broth

9.15 grams of broth was suspended in 100ml distilled water. It was heated to dissolve and kept in free flowing steam for 30 minutes. It was cooled to 45°C and added 4 ml iodine solution containing 0.5 grams iodine and 0.8 grams potassium iodine. It was mixed well and dispensed as desired.

Xylose Lysine Deoxycholate (XLD) Agar

2.5 grams of XLD agar was suspended in 50 ml distilled water and was heated with frequent agitation until the medium boiled and then transferred to a water bath at 60°C for 15 minutes. After cooling, the medium was roused into sterile petridishes.

Procedure

25.0 gm of sample was weighed and taken into a waring blender flask. 225 ml. of buffered peptone water (BPW) was added into the sample and then homogenized for 1 minute. Sample was incubated at 37° ± 1° C for 24 hours.

The resuscitated culture was gently mixed. 1.0 ml. of the mixture was added each to 10 ml of Selenite broth (SB) and 10 ml of Tetrathionate broth (TB). The selective

enrichment broth was then incubated at $37^{\circ} \pm 1^{\circ}\text{C}$ for 24 hours. After incubation, a loopful of each of the two selective enrichment broth were transferred to the surface of the selective agar media, i.e. Xylose Lysine Deoxycholate (XLD) agar. The plates were then incubated at $37^{\circ} \pm 1^{\circ}\text{C}$ for 24 hours and observed for characteristics colonies for *Salmonella sp.* After 24-48 hours, *Salmonella sps.* shows pink colonies with black centre of H_2S on XLD.

Flow chart of the isolation and identification of *Samonella sp* is shown in Figure 6

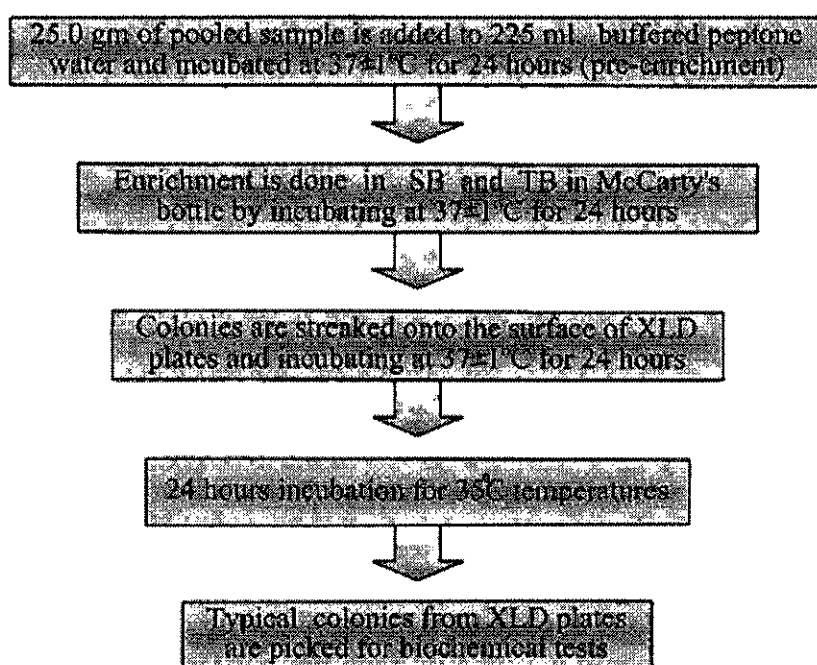


Figure 6: Flow chart for the isolation and identification of *Salmonella sps.*

3.3.3.5 *Vibrio Cholerae*

Culture media

Alkaly Pepton Water (APW)

4.5 grams of Alkaly Pepton Water was suspended in 225 ml distilled water and slightly heated to dissolved completely and sterilized by autoclaving at 15lbs/inch² pressure at 20 minutes.

Thio-sulphate Citrate Bile Salts Sucrose Agar (TCBSA)

4.45 grams of TCBS agar was first boiled 50 ml of distilled water to dissolve and boiled for 1 minute. Then the media was dried to 60°C for 15 minutes and was poured into Petri dishes and allowed to solidify.

Procedure

25 g of the sample was added with approximately 225 ml. of alkaline peptone water in a “ Warring” blender flask . Then the sample containing alkaline peptone water was blended for 1 min. The sample was incubated at $37 \pm 1^{\circ}\text{C}$ for 6-8 hrs.

At the end of the incubation period, a loopful of the alkaline peptone water was streaked onto Thiosulphate Citrate Bile Salt Sucrose (TCBS) agar plates. The plates were then incubated at $37^{\circ}\text{C} \pm 1^{\circ}\text{C}$ for 24 hrs. At the end of incubation, plates were checked for the characteristic colony of *Vibrio cholerae*. On TCBS agar colonies appeared as large (2–3 mm.), smooth and yellow, slightly flattened, with opaque centre and translucent peripheries.

Flow chart for the isolation and identification of *Vibrio cholerae* is shown in Figure 7.

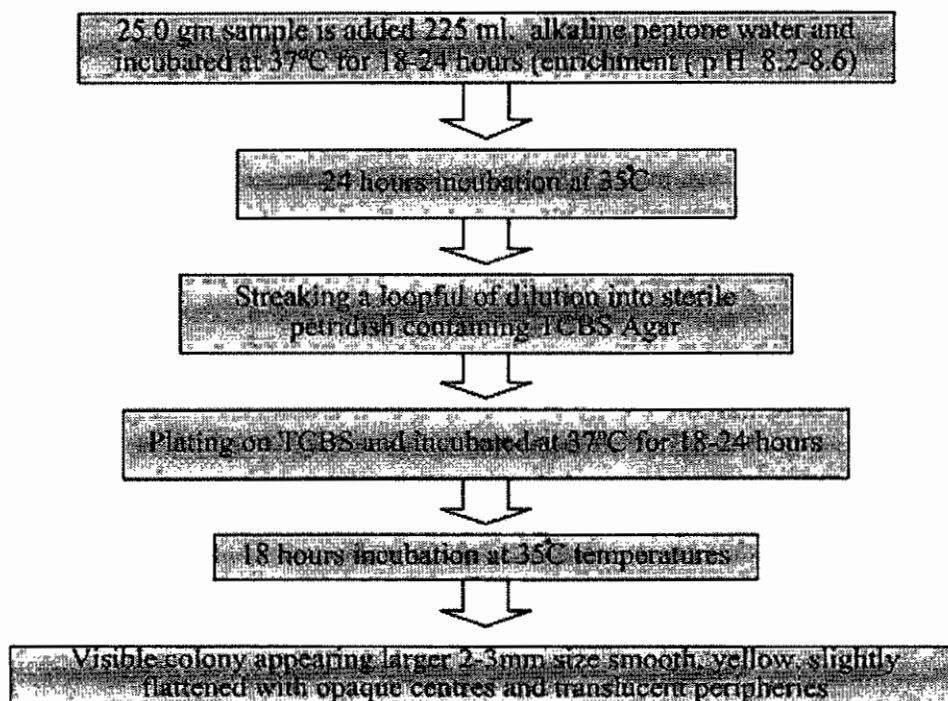


Figure 7: Isolation and identification of *Vibrio cholerae*

3.4 Statistical Analysis

Assays for organoleptic, biochemical and microbiological parameters were performed in triplicate and results averaged. Statistical analyses for correlation co-efficient 'r' and t-test were calculated using the following formula:

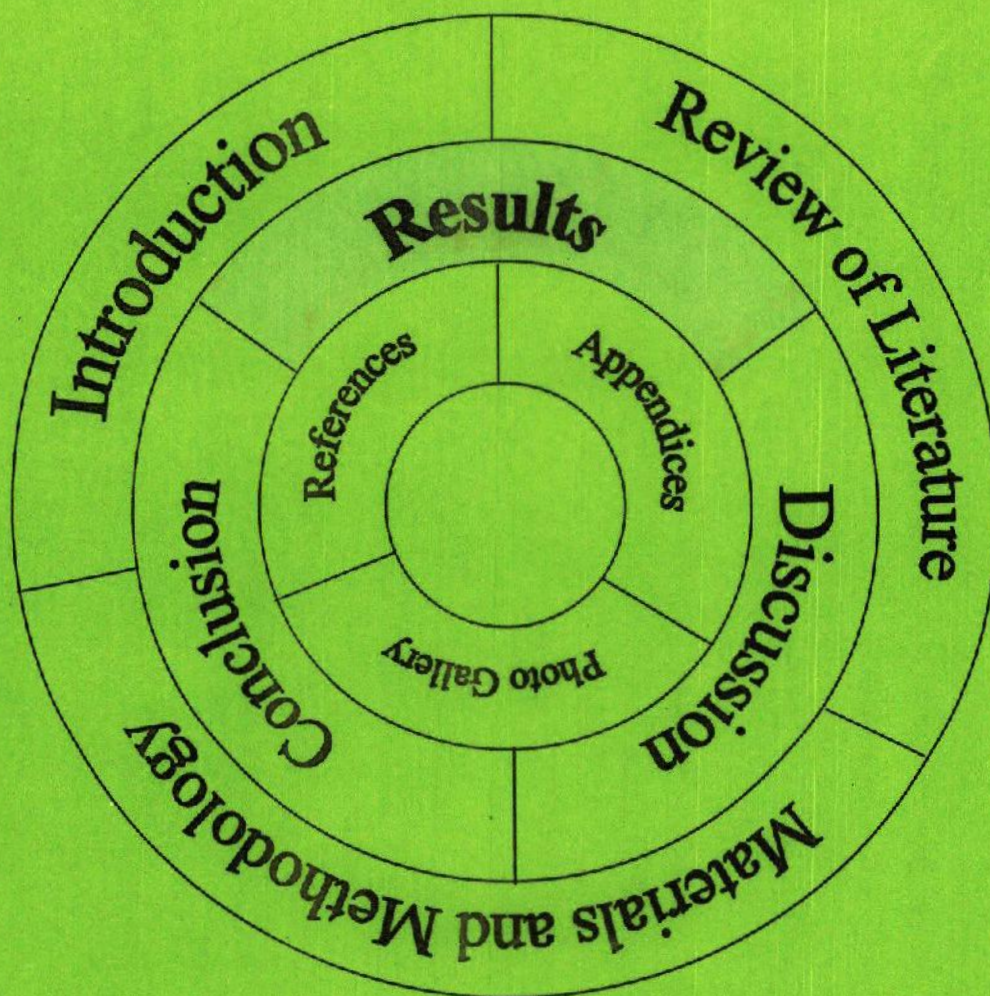
$$r = \frac{\Sigma XY - \frac{\Sigma X \cdot \Sigma Y}{N}}{\left[\left\{ \Sigma X^2 - \frac{(\Sigma X)^2}{N} \right\} \left\{ \Sigma Y^2 - \frac{(\Sigma Y)^2}{N} \right\} \right]^{1/2}}$$

The significance of 'r' is tested by 't' test, 't' was calculated by formula

$$t = \frac{r \sqrt{n-2}}{\sqrt{1-r^2}} \text{ with d. f.}$$

Where n= Sample number and r=correlation co-efficient

Differences between treatments were analyzed by using one way general analysis of variance (ANOVA) procedure (Mian & Miyan, 1984). Graphical and tubular forms were created in Personal Computer using Microsoft Excel Program.



Current Position Indicator

Results

4.0 RESULTS

4.1 Quality of Shrimp at different points of distribution channel

4.1.1 Organoleptic Quality

4.1.1.1 Normal Practice (NP)

Quality of shrimp at different points of distribution channel is illustrated in Table 3(a, b) and Figure 8. Table 3(a) shows the calculation of TSS, TRSS and RSS on the comparative study of organoleptic quality of shrimp as found in the normal practice. The mean value at the point of Gher, Depot, Agent, and processing plant indicated overall good quality shrimp. Table 3(b) provides the ANOVA showing significant differences between the qualities of shrimp collected from different points; however Figure 8 shows the mean value of overall organoleptic score. It was clearly found that shrimp collected at each point were of good quality. However, shrimp collected from Gher were of very good quality (8.8 score). The score then abruptly dropped to 6.47 at Depot, which then increased slightly to 6.67 at Agent and then decreased at the processing plant (6.33 score).

Table (3)a: Calculation of total sum of squares, between treatment sum of squares, residual sum of squares on the comparative study of organoleptic quality (normal practice)

Replication no.	GHER	DEPOT	AGENT	P.PLANT
1	10.00	7.33	8.00	7.67
2	8.33	5.67	7.33	7.00
3	8.33	4.33	5.67	4.67
4	9.67	5.67	6.67	6.33
5	7.67	4.33	5.67	6.00
Total:	44	27.33	33.34	31.67
Mean:	8.80	5.47	6.67	6.33
Grand Total(GT)	136.34			
Sum of Squares	391.12	155.52	226.52	205.71
				978.87=A
Sum of Squares of column total / total no. of observation	387.20	149.39	222.31	200.60
				959.5=B
Difference	3.92	6.13	4.21	5.11
				19.37=C
CF=(GT) ² / total no of observation	929.43 =D			
Total sum of squares	(A-D)= 49.44			
Between treatment sum of squares	(B-D)= 30.07			
Residual sum of squares	(A-B)= 19.37			

Table (3)b: Anova table showing the comparative study of organoleptic quality (normal practice)

Source of variation	Sum of squares	Degree of treatment	Mean Square	Calculated F value	Tabulated F value 5%	Significant Differences
Between treatment (Column)	30.07	4	7.52	6.21	3.01	*
Between Residual	19.37	16	1.21			
Total:	49.44	20	8.73			

*: Significant ($P \leq 0.05$)

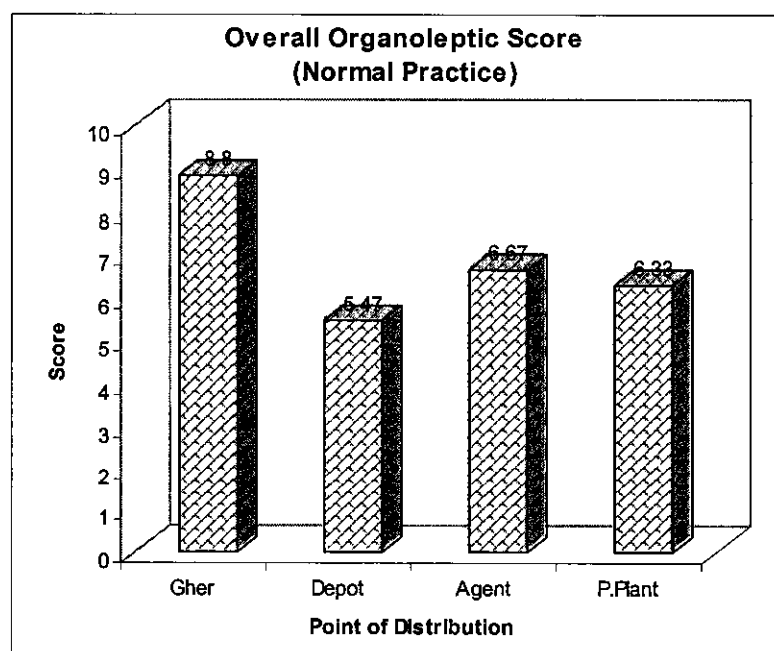


Figure 8: Mean value of overall organoleptic score (Normal Practice)

4.1.1.2 Controlled Study (CS)

Organoleptic quality of shrimp was evaluated at different points of distribution channel in controlled study. This is illustrated in Table 4(a,b) and Figure 9. Table 4(a) shows the calculation of TSS, TRSS and RSS. From the calculation of Table 4(a), ANOVA Table 4(b) has been represented. Table 4(b) shows clearly that there is significant differences ($P \leq 0.05$) in organoleptic quality at different points in the distribution channel. Figure 9 shows the mean value of overall organoleptic score. The results of the organoleptic quality in the controlled study were in concurrence with those observed in normal

practice. Quality of shrimp was highly acceptable when collected at Gher (8.87 score) and moderately acceptable at the point of Agent (7.47 score). But this slightly decreased at the receiving point in the processing plant. Relatively lower acceptable score was observed at Depot (6.6 score). However, better quality score was observed for shrimp collected under controlled study.

Table (4)a: Calculation of total sum of squares, between treatment sum of squares, residual sum of squares on the comparative study of organoleptic quality (controlled study)

Replication no.	GHER	DEPOT	AGENT	P.PLANT
1	10.00	8.00	8.67	8.00
2	9.00	6.67	7.33	7.67
3	7.67	6.67	7.33	8.00
4	9.33	6.67	7.67	6.67
5	8.33	5.33	6.33	5.33
Total:	44.33	33.34	37.33	35.67
Mean:	8.87	6.67	7.47	7.13
Grand Total(GT)	150.67			
Sum of Squares	396.27	225.88	281.52	259.73
				1163.40=A
Sum of Squares of column total / total no. of observation	393.03	222.31	278.71	254.47
				1148.52=B
Difference	3.24	3.57	2.81	5.26
				14.88=C
CF=(GT) ² / total no of observation	1135.07 =D			
Total sum of squares	(A-D)= 28.33			
Between treatment sum of squares	(B-D)= 13.45			
Residual sum of squares	(A-B)= 14.88			

Table (4)b: Anova table showing the comparative study of organoleptic quality (controlled study)

Source of variation	Sum of squares	Degree of treatment	Mean Square	Calculated F value	Tabulated F value 5%	Significant Differences
Between treatment (Column)	13.45	4	3.36	3.61	3.01	*
Between Residual	14.88	16	0.93			
Total:	28.33	20	4.29			

*: Significant (P≤0.05)

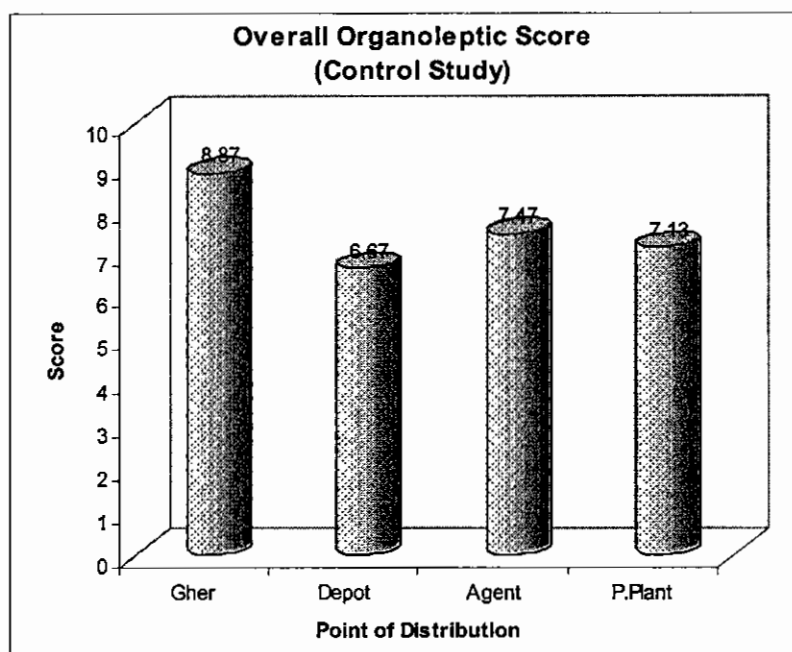


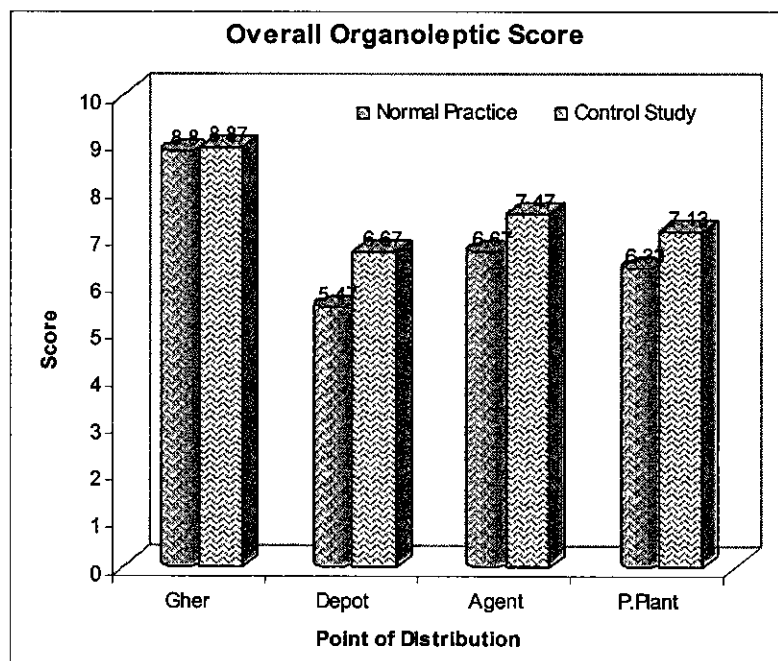
Figure 9: Mean value of overall organoleptic score (controlled study)

4.1.1.3 Comparison between Normal Practice (NP) and Controlled Study (CS)

The comparative data between the organoleptic quality of shrimp observed in normal practice (NP) and controlled study (CS) is shown in Figure 10. The overall organoleptic score of shrimp between the two different experiments did not differ much at the point of Gher. The overall organoleptic score for both the experiments were almost same (8.80-NP; 8.87-CS). But shrimp collected from Depot showed relatively better score in the controlled study (6.67 score). This trend continued at Agent and Processing plant. Statistical analysis (normal practice and controlled study) was done at each point of distribution channel (Gher, Depot, Agent, and Processing Plant). It is clearly observed that the overall organoleptic score between the two experiments did not differ significantly ($P \leq 0.05$) (Table 5). The calculated value “t” at each points of Gher, Depot, Agent, Processing Plant is 0.25, 4.12, 2.96, and 1.19 while the tabulated value “t” is 2.13. (Appendix VII)

Table 5: 't' test for organoleptic quality

Point of Distribution	Calculated Value 't'	Tabulated Value t
Gher	0.25	2.13
Depot	4.12	
Agent	2.96	
Processing Plant	1.19	

**Figure 10:** Comparison of mean value of overall organoleptic score

4.1.2 Biochemical Quality

4.1.2.1 Total Volatile Base Nitrogen (NP)

TVB-N count for shrimp at different points in distribution channel in normal practice (NP) is summarized in Table 6(a,b). Table 6(a) shows the calculation of TSS, TRSS, and RSS. Table 6(b) provides the ANOVA between the different points in distribution channel. There is a significant differences ($P \leq 0.05$), but the counts were within the acceptable limit. Figure 11 shows the mean value of TVB-N counts. The mean value of TVB-N counts at all points was much lower than the acceptable limit recommended. The mean value at Gher (2.40 mgN/100 g) was relatively lower than other points (Figure 11).

The value abruptly increased at Depot (15.35 mgN/100 g) but further abruptly decreased in Agent (5.32 mgN/100 g) and at Processing Plant (8.13 mgN/100 g).

Table (6)a: Calculation of total sum of squares, between treatment sum of squares, residual sum of squares on the comparative study of total volatile base nitrogen (TVB-N) (normal practice)

Replication no.	GHER	DEPOT	AGENT	P.PLANT
1	2.67	18.68	5.34	8.01
2	2.07	12.68	5.31	8.49
3	2.47	14.68	5.30	7.90
Total:	7.21	46.04	15.95	24.4
Mean:	2.40	15.35	5.32	8.13
Grand Total(GT)	93.60			
Sum of Squares	17.51	725.23	84.80	198.65
				1026.19=A
Sum of Squares of column total / total no. of observation	17.33	706.56	84.80	198.45
				1007.14=B
Difference	0.18	18.67	0.00	0.20
				19.05=C
CF=(GT) ² / total no of observation	730.08 =D			
Total sum of squares	(A-D)= 296.11			
Between treatment sum of squares	(B-D)= 277.06			
Residual sum of squares	(A-B)= 19.05			

Table (6)b: Anova table showing the comparative study of total volatile base nitrogen (TVB-N) (normal practice)

Source of variation	Sum of squares	Degree of treatment	Mean Square	Calculated F value	Tabulated F value 5%	Significant Differences
Between treatment (Column)	277.06	2	138.53	65.34	4.26	*
Between Residual	19.05	9	2.12			
Total:	296.11	11	140.65			

*: Significant ($P \leq 0.05$)

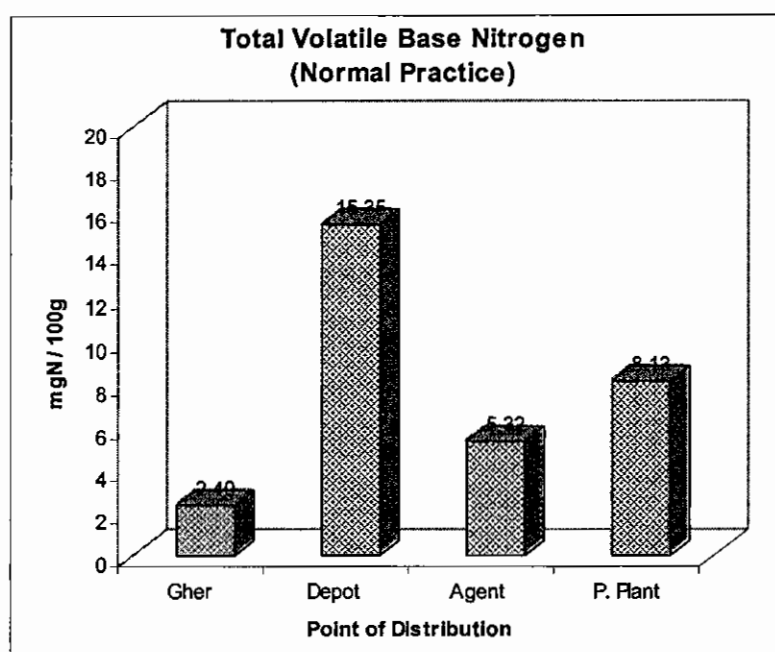


Figure 11: Mean value of TVB-N (normal practice)

4.1.2.2 Trimethylamine Nitrogen (Normal Practice)

TMA-N value of shrimp at different points in the distribution channel in normal practice (NP) is illustrated in Table 7(a,b) and Figure 12. Table 7(a) shows the calculation of TSS, TRSS, and RSS on the comparative study of TMA-N. The mean value in all the points of Gher, Depot, Agent, and processing plant indicated acceptable limit. Table-7(b) provides the ANOVA between the different points. There are no significant differences ($P \leq 0.05$) between the points. Figure 12 shows the mean value of TMA-N. TMA-N values at each point were relatively lower. The mean values of TMA-N were almost similar at Depot and processing plant (2.88 mgN/100 g) and at Gher (2.70 mgN/100 g). The value was slightly lower than that at depot and processing plant. The mean value was 2.78 mgN/100 g at Agent and the value slightly increased at processing plant.

Table (7)a: Calculation of total sum of squares, between treatment sum of squares, residual sum of squares on the comparative study of trimethylamine nitrogen (TMA-N) (normal practice)

Replication no.	GHER	DEPOT	AGENT	P.PLANT
1	2.68	2.66	2.61	2.86
2	2.78	3.04	2.76	3.04
3	2.64	2.94	2.96	2.74
Total:	8.10	8.64	8.33	8.64
Mean:	2.70	2.88	2.78	2.88
Grand Total(GT)	33.71			
Sum of Squares	21.88	24.96	23.19	24.93
				94.96=A
Sum of Squares of column total / total no. of observation	21.87	24.88	23.13	24.88
				94.76=B
Difference	0.01	0.08	0.06	0.05
				0.20=C
CF=(GT) ² / total no of observation	94.70 =D			
Total sum of squares	(A-D)= 0.26			
Between treatment sum of squares	(B-D)= 0.06			
Residual sum of squares	(A-B)= 0.20			

Table (7)b: Anova table showing the comparative study of trimethylamine nitrogen (TMA-N) (normal practice)

Source of variation	Sum of squares	Degree of treatment	Mean Square	Calculated F value	Tabulated F value 5%	Significant Differences
Between treatment (Column)	0.06	2	0.03	1.50	4.26	N. S.
Between Residual	0.20	9	0.02			
Total:	0.26	11	0.05			

N. S. : Non Significant ($P \leq 0.05$)

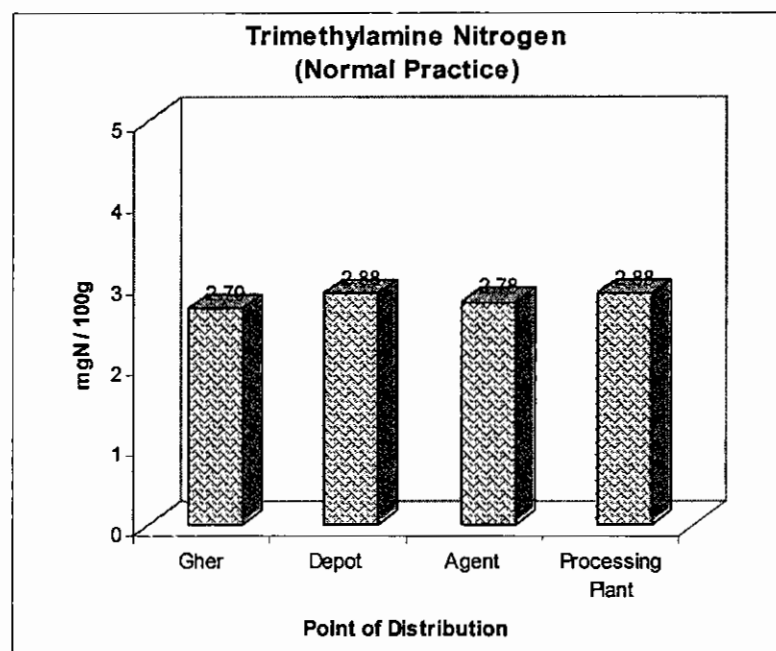


Figure 12: Mean value of TMA-N (normal practice)

4.1.2.3 Total Volatile Base Nitrogen (Controlled Study)

The value of TVB-N under controlled study is presented in Table 8(a,b) and Figure 13. Table 8(a) shows the calculation of TSS, TRSS and RSS. From the calculation of Table-8(a), ANOVA Table-8(b) has been represented. There was a significant differences ($P \leq 0.05$) but the mean value of TVB-N (Figure 13) at different points were relatively lower. The TVB-N values were much lower than the acceptable limit. The mean value was high at Agent (8.68 mgN/100 g). But the mean value abruptly decreased at processing plant 5.06 mgN/100 g). At the point Gher the mean value was 6.17 mgN/100 g and slightly increased at Depot (7.85 mgN/100 g).

Table (8)a: Calculation of total sum of squares, between treatment sum of squares, residual sum of squares on the comparative study of total volatile base nitrogen (TVB-N) (controlled study)

Replication no.	GHER	DEPOT	AGENT	P.PLANT
1	4.11	8.01	8.08	5.37
2	6.91	7.98	8.90	5.49
3	7.49	7.56	8.75	7.01
Total:	18.51	23.55	25.73	17.87
Mean:	6.17	7.85	8.58	5.96
Grand Total(GT)	85.66			
Sum of Squares	120.74	184.99	221.06	108.12
				634.91=A
Sum of Squares of column total / total no. of observation	114.21	184.87	220.68	106.45
				626.21=B
Difference	6.53	0.12	0.38	1.67
				8.70=C
CF=(GT) ² / total no of observation	611.47 =D			
Total sum of squares	(A-D)= 23.44			
Between treatment sum of squares	(B-D)= 14.74			
Residual sum of squares	(A-B)= 8.70			

Table (8)b: Anova table showing the comparative study of total volatile base nitrogen (TVB-N) (controlled study)

Source of variation	Sum of squares	Degree of treatment	Mean Square	Calculated F value	Tabulated F value 5%	Significant Differences
Between treatment (Column)	14.74	2	7.37	7.60	4.26	*
Between Residual	8.70	9	0.97			
Total:	23.44	11	8.34			

*: Significant ($P \leq 0.05$)

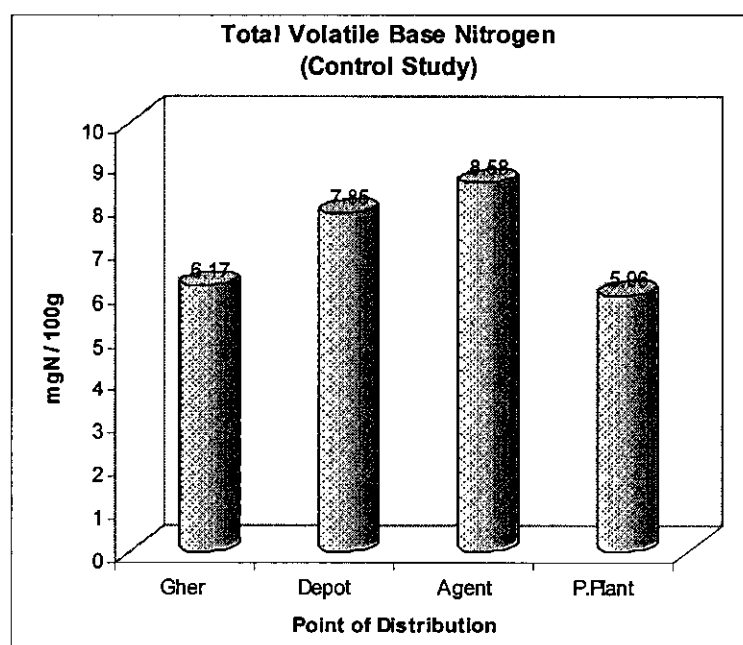


Figure 13: Mean value of TVB-N (controlled study)

4.1.2.4 Trimethylamine Nitrogen (Controlled Study)

TMA-N value of shrimp at different points in the distribution channel is illustrated in Table 9(a,b) and Figure 14 (Controlled Study). Table 9(a) shows the calculation of TSS, TRSS, and RSS on the comparative study of TMA-N at different points. Table 9(b) shows the ANOVA Table indicating significant differences ($P \leq 0.05$) between the quality of shrimp collected from different points. Figure 14 shows the mean value of TMA-N contents. At different points, the mean value was relatively very low then the acceptable limit. The mean value at Gher (2.77 mgN/100 g) was relatively lower than the other points and the value increased sharply at Depot (10.75 mgN/100 g). However, the value decreased at Agent (2.78 mgN/100 g). At the processing plant, the mean value further increased (8.52 mgN/100 g).

Table 9(a): Calculation of total sum of squares, between treatment sum of squares, residual sum of squares on the comparative study of trimethylamine nitrogen (TMA-N) (controlled study)

Replication no.	GHER	DEPOT	AGENT	P.PLANT
1	2.62	10.69	2.69	8.05
2	2.76	10.74	2.74	9.05
3	2.92	10.82	2.90	8.45
Total:	8.30	32.25	8.33	25.55
Mean:	2.77	10.75	2.78	8.52
Grand Total(GT)	74.43			
Sum of Squares	23.01	346.70	23.15	218.11
				610.97=A
Sum of Squares of column total / total no. of observation	22.96	346.69	23.13	217.60
				610.38=B
Difference	0.05	0.01	0.02	0.51
				0.59=C
CF=(GT) ² / total no of observation	461.65 =D			
Total sum of squares	(A-D)= 149.32			
Between treatment sum of squares	(B-D)= 148.73			
Residual sum of squares	(A-B)= 0.59			

Table 9(b): Anova table showing the comparative study of trimethylamine nitrogen (TMA-N) (controlled study)

Source of variation	Sum of squares	Degree of treatment	Mean Squar	Calculated F value	tabulated F valu 5%	Significant Differences
Between treatment (Column)	148.73	2	74.36	1062.29	4.26	*
Between Residual	0.59	9	0.07			
Total:	149.32	11	74.43			

*: Significant ($P \leq 0.05$)

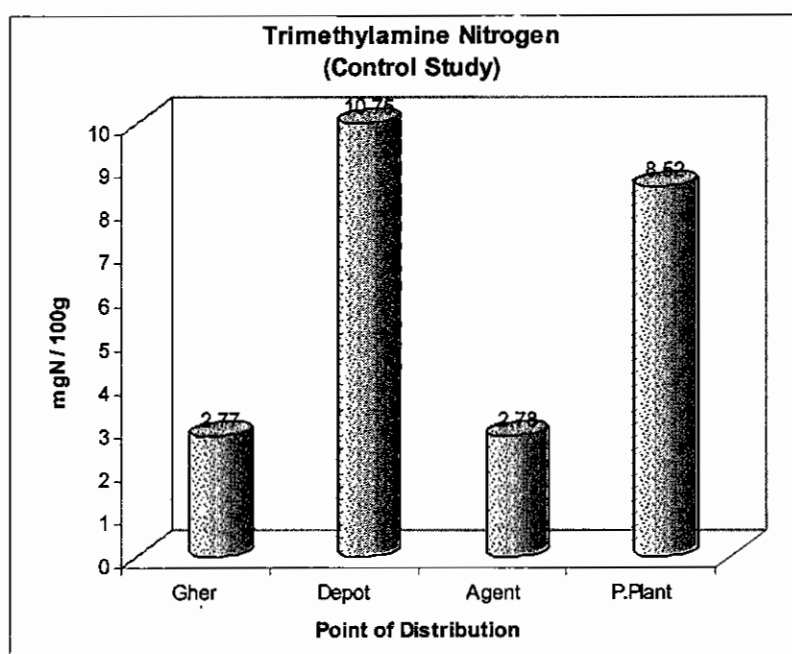


Figure 14: Mean value of TMA-N (controlled study)

4.1.2.5 Comparison of TVB-N value between Normal practice and Controlled study

Comparative data of TVB-N between CS and NP is illustrated in Figure 15. The TVB-N content of shrimp between the two different experiments differed much at the point of Gher. The TVB-N content for normal practice and controlled study was 2.40 and 6.17 mgN/100 g respectively. But TVB-N content at Depot showed higher value for the normal practice experiment compared to controlled study, which shows the inverse relationship with Gher i.e., in the point of Gher where normal practice shows higher content and controlled study shows lower content. However, between the two experiments, the value at Agent and processing plant varied slightly (5.32-NP; 8.58-CS; and 8.13-NP; 5.06-CS). Table 10 shows statistical analysis (CS and NP) at each point (Gher, Depot, Agent, and processing plant) of distribution channel. From the Table-10, it is observed that there were no significant differences ($P \leq 0.05$) between Gher and Agent where the calculated value was -3.23 and -12.39 and the tabulated value was 2.92. However, at Depot and processing plant, the value showed significant differences ($P \leq 0.05$) where the calculated value was 4.32 and 3.34. Though there was a significant difference, the value remained well within the acceptable range.

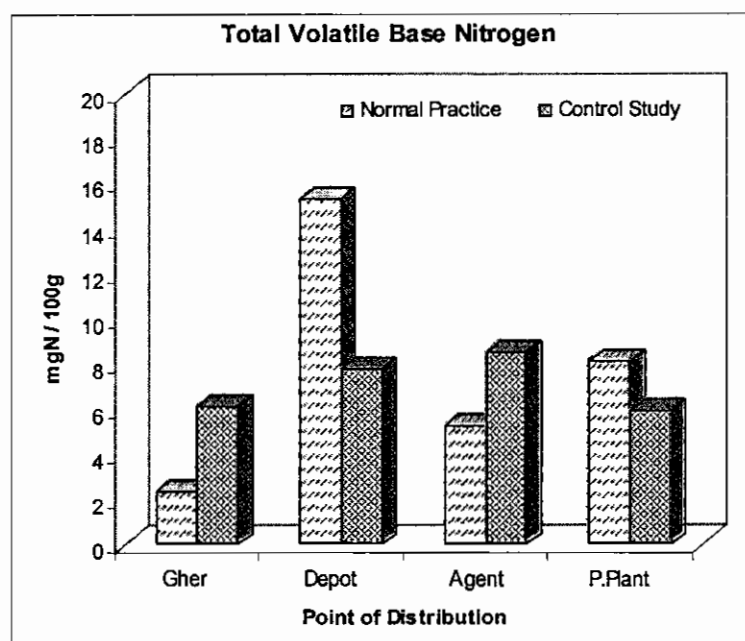


Figure 15: Comparison of mean value of TVB-N

Table 10: 't' test for TVB-N

Point of Distribution	Calculated Value 't'	Tabulated Value 't'
Gher	3.23	2.92
Depot	4.32	
Agent	12.39	
Processing Plant	3.34	

4.1.2.6 Comparison of TMA-N value between Normal practice and Controlled study

The comparative study of TMA-N (NP and CS) at different points in the shrimp distribution channel is shown in Figure 16. The TMA-N content of shrimp between the two different experiments did not differ much at the points of Gher and Agent where the count remained almost same (2.70 -NP; 2.77 -CS; and 2.78 -NP; 2.78mgN/100 g-CS). But a marked difference was observed at Depot where TMA-N content was much lower in normal practice (2.88 mgN/100 g) and higher in controlled study (10.75 mgN/100 g). Similar pattern were observed at the processing plant between the two experiments. . Statistical analysis (Table 11) at each point (Gher, Depot, Agent, and Processing Plant)

indicated tabulated value of 2.35 and calculated value at Gher (-0.62), Depot (-82.50), Agent (-3.56) and Processing Plant (-23.53) at each point. Thus, it was clearly observed that there were no significant differences ($P \leq 0.05$) at each point of distribution channel.

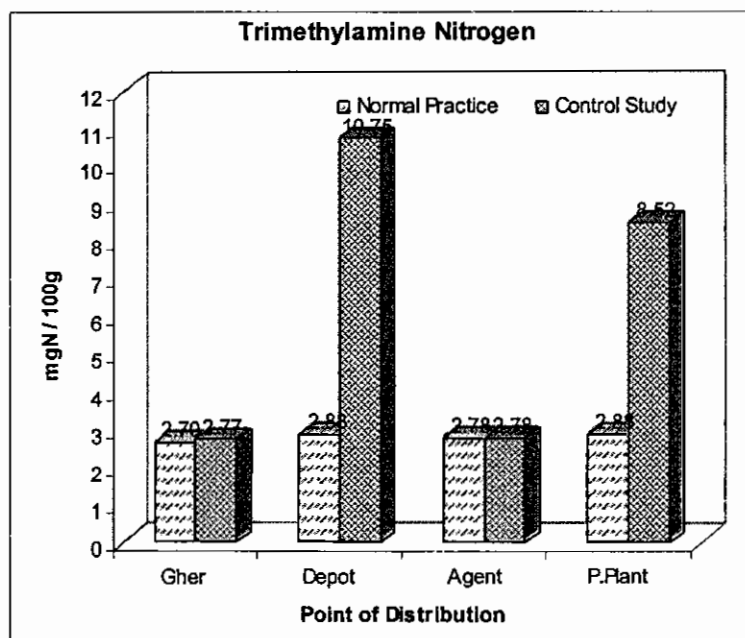


Figure 16: Comparison of mean value of TMA-N

Table 11: 't' test for TMA-N

Point of Distribution	Calculated Value 't'	Tabulated Value 't'
Gher	0.62	2.92
Depot	82.5	
Agent	3.56	
Processing Plant	23.53	

4.1.3 Microbiological Quality

4.1.3.1 Standard Plate Count (Normal Practice)

Standard Plate Count was measured at different points in the shrimp distribution channel. Shrimp samples were collected from four different points (Gher, Depot, Agent and Processing Plant). Statistical analysis was carried out in order to find significant differences ($P \leq 0.05$). Table-12(a) shows the calculation of total sum of square (TSS), TRSS, and RSS. From the calculation of Table-12(a), ANOVA Table-12(b) has been represented. Table-12(b) shows clearly that there was a significant difference ($P \leq 0.05$) in

SPC between different points. The calculated “F” value was 4.26 indicating significant differences. Fig 17 shows the mean value of SPC for shrimp at different points of distribution channel. SPC at different points did not vary much. The values of SPC at Gher were lower compared to Depot. Within the different points at shrimp distribution channel, the value of SPC is same at the points of Depot ($\log_{10}$ value 5.03) and Agent ($\log_{10}$ value 5.09). The lowest value of SPC was observed at the Processing Plant ($\log_{10}$ value 4.22).

Table 12 (a): Calculation of total sum of squares, between treatment sum of squares, residual sum of squares on the comparative study of standard plate count ($\log_{10}$) (normal practice)

Replication no.	GHER	DEPOT	AGENT	P.PLANT
1	4.65	5.03	5.08	3.53
2	4.70	4.99	5.11	4.56
3	3.93	5.08	5.08	4.56
Total:	13.28	15.1	15.27	12.65
Mean:	4.43	5.03	5.09	4.22
Grand Total(GT)	56.3			
Sum of Squares	59.16	76.01	77.72	54.05
				266.94=A
Sum of Squares of column total / total no. of observation	58.79	76.00	77.72	53.34
				265.85=B
Difference	0.37	0.01	0.00	0.71
				1.09=C
CF=(GT) ² / total no of observation	264.14 =D			
Total sum of squares	(A-D)= 2.80			
Between treatment sum of squares	(B-D)= 1.71			
Residual sum of squares	(A-B)= 1.09			

Table 12 (b): Anova table showing the comparative study of standard plate count ($\log_{10}$) (normal practice)

Source of variation	Sum of squares	Degree of treatment	Mean Square	Calculated F value	Tabulated F value 5%	Significant Differences
Between treatment (Column)	1.71	2	0.85	7.08	4.26	*
Between Residual	1.09	9	0.12			
Total:	2.80	11	0.97			

*: Significant ($P \leq 0.05$)

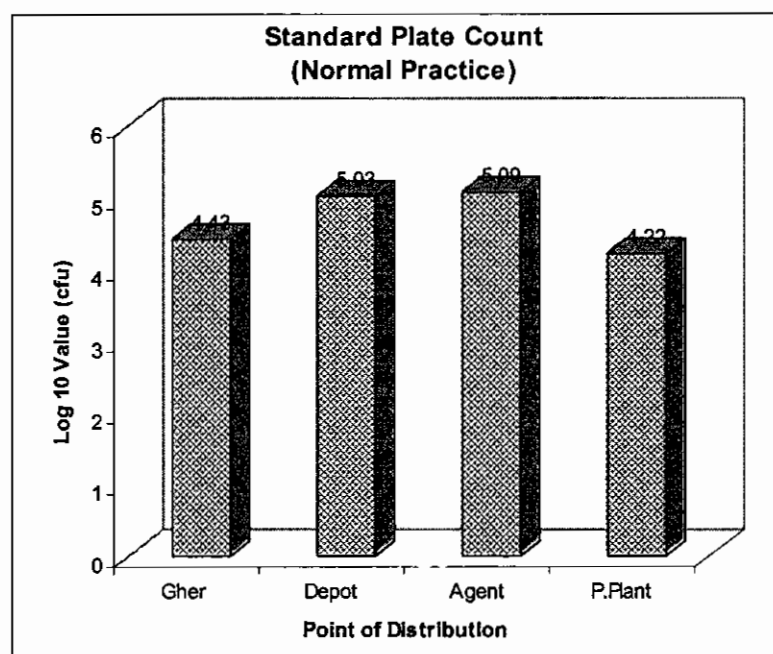


Figure 17: Mean value of SPC (normal practice)

4.1.3.2 Total Coliform (Normal Practice)

The pattern of growth of Total Coliform is provided Table-13(a,b). Table-13(a) shows the calculation of Total sum of squares (TSS), treatment sum of squares (TRSS), and Residual sum of squares (RSS). Table-13(b) provides the ANOVA between the different points in shrimp distribution channel. It is observed that there was no significant differences ($P \leq 0.05$) between the value of TC at different points. Figure 18 shows the mean value of Total Coliform counts at different points. Although no significant differences ($P \leq 0.05$) were observed between the points, abrupt increase of value was observed at Gher (35.33 MPN/gm) in comparison to other points. The results of Total Coliform count was very low at Depot (8.67 MPN/gm), but increased at the point of Agent (26.00 MPN/gm) and decreased in Processing Plant (14.00 MPN/gm). At Depot, TC showed the lowest number (Figure 18). Total Coliform counts were much lower and within the acceptable limit.

Table 13 (a): Calculation of total sum of squares, between treatment sum of squares, residual sum of squares on the comparative study of total coliform (mpn/g) (normal practice)

Replication no.	GHER	DEPOT	AGENT	P.PLANT
1	53.00	3.00	43.00	28.00
2	29.00	20.00	28.00	3.00
3	24.00	3.00	7.00	11.00
Total:	106	26	78	42
Mean:	35.33	8.67	26.00	14.00
Grand Total(GT)	252			
Sum of Squares	4226.00	418.00	2682.00	914.00
				8240.00=A
Sum of Squares of column total / total no. of observation	3745.33	225.33	2028.00	588.00
				6586.66=B
Difference	480.67	192.67	654.00	326.00
				1653.34=C
CF=(GT) ² / total no of observation	5292.00 =D			
Total sum of squares	(A-D)= 2948.00			
Between treatment sum of squares	(B-D)= 1294.66			
Residual sum of squares	(A-B)= 1653.34			

Table 13 (b): Anova table showing the comparative study of total coliform (mpn/g) (normal practice)

Source of variation	Sum of squares	Degree of treatment	Mean Square	Calculated F value	Tabulated F value 5%	Significant Differences
Between treatment (Column)	1294.66	2	647.33	3.52	4.26	N. S.
Between Residual	1653.34	9	183.7			
Total:	2948.00	11	831.03			

N.S. : Non Significant ($P \leq 0.05$)



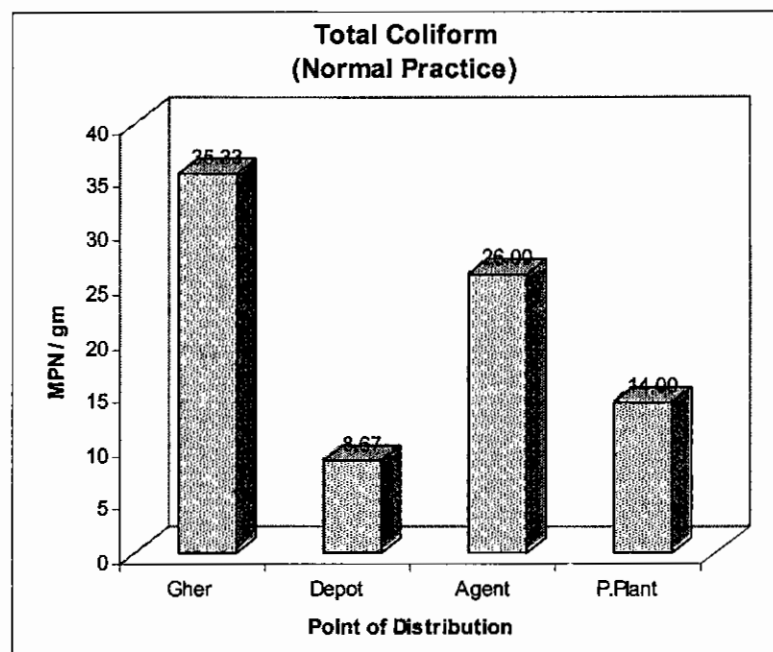


Figure 18: Mean value of TC (normal practice)

4.1.3.3 Faecal Coliform (Normal Practice)

Statistical analysis of Faecal Coliform count for shrimp collected at different points in the distribution channel is shown in Table-14(a, b) and the mean values is illustrated in Figure-(19). There were no significant differences ($P \leq 0.05$) of faecal coliform count at different points (Table-14(b)). The tabulated 'F' value (5%) was '4.26' and the calculated 'F' value was '2'. The mean value of Faecal Coliform counts were much higher at Gher 8.67 MPN/gm) and Depot (3.33 MPN/gm). But the mean value did not differ between the two points of Agent and Processing. Plant (2.33 MPN/ 100g). Although there were variation at different points with regard to Faecal Coliform, there were no significant differences ($P \leq 0.05$) within the points and the mean values of all the points were much lower than the acceptable recommended limit.

Table 14 (a): Calculation of total sum of squares, between treatment sum of squares, residual sum of squares on the comparative study of faecal coliform (mpn/g) (normal practice)

Replication no.	GHER	DEPOT	AGENT	P.PLANT
1	11.00	3.00	0.00	4.00
2	15.00	7.00	7.00	0.00
3	0.00	0.00	0.00	3.00
Total:	26	10	7	7
Mean:	8.67	3.33	2.33	2.33
Grand Total(GT)	50			
Sum of Squares	346.00	58.00	49.00	25.00
				478.00=A
Sum of Squares of column total / total no. of observation	225.33	33.33	16.33	16.33
				291.32=B
Difference	120.67	24.67	32.67	8.67
				186.68=C
CF=(GT) ² / total no of observation	208.33 =D			
Total sum of squares	(A-D)= 269.67			
Between treatment sum of squares	(B-D)= 82.99			
Residual sum of squares	(A-B)= 186.68			

Table 14(b): Anova table showing the comparative study of faecal coliform (mpn/g) (normal practice)

Source of variation	Sum of squares	Degree of treatment	Mean Square	Calculated F value	Tabulated F value 5%	Significant Differences
Between treatment (Column)	82.99	2	41.49	2	4.26	N. S.
Between Residual	186.68	9	20.74			
Total:	269.67	11	62.23			

N. S. : Non Significant ($P \leq 0.05$)

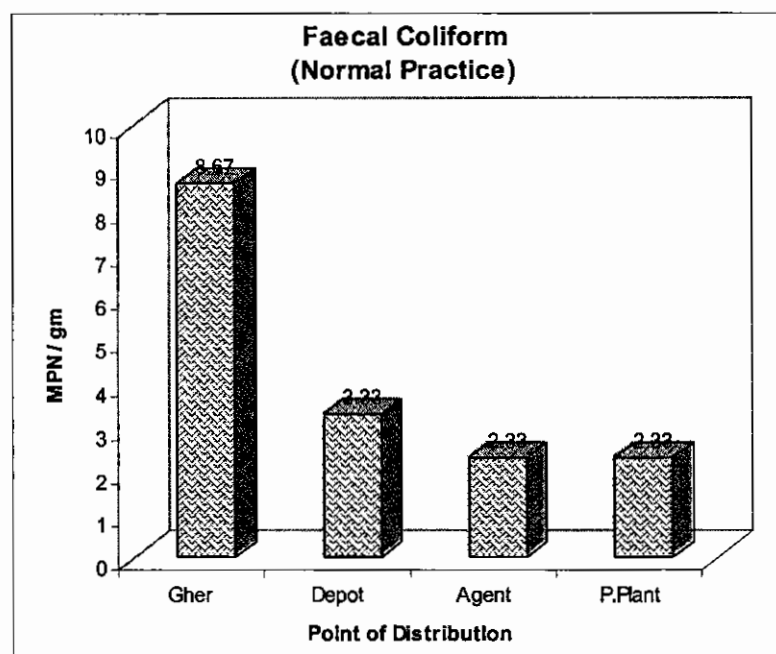


Figure 19: Mean value of FC (normal practice)

4.1.3.4 Standard Plate Count (Controlled Study)

The results of SPC at different points in the shrimp distribution channel is given in Table-15(a,b). Table-15(a) indicates the calculation of TSS, TRSS, RSS. From Table-15(a), ANOVA Table-15(b) has been constructed. ANOVA Table shows a significant differences ($P \leq 0.05$) of SPC between the different points (Gher, Depot, Agent, Procressing. Plant). Figure 20 illustrates the mean value of standard plate count at four different points in shrimp distribution channel. The results in the graph indicate clearly a reduced value of SPC at Processing. Plant ($\log_{10}$ value 3.88). The value of SPC varied between $\log_{10}$ 5.21 to $\log_{10}$ 3.88. Within the different points, the mean value of SPC was much higher at Depot ($\log_{10}$ value 5.21). The mean value decreased at Agent ($\log_{10}$ 3.93); it slightly increased at Processing Plant. At the Gher, spc counts were relatively lower than at Depot.

Table 15(a): Calculation of total sum of squares, between treatment sum of squares, residual sum of squares on the comparative study of standard plate count ($\log_{10}$) (controlled study)

Replication no.	GHER	DEPOT	AGENT	P.PLANT
1	4.15	5.26	3.90	3.85
2	4.94	5.18	3.94	3.90
3	4.90	5.18	3.95	3.90
Total:	13.99	15.62	11.79	11.65
Mean:	4.66	5.21	3.93	3.88
Grand Total(GT)	53.05			
Sum of Squares	65.64	81.33	46.34	45.24
				238.55=A
Sum of Squares of column total / total no. of observation	65.24	81.33	46.33	45.24
				238.14=B
Difference	0.40	0.00	0.01	0.00
				0.41=C
CF=(GT) ² / total no of observation	234.53 =D			
Total sum of squares	(A-D)= 4.02			
Between treatment sum of squares	(B-D)= 3.61			
Residual sum of squares	(A-B)= 0.41			

Table 15(b): Anova table showing the comparative study of standard plate count ($\log_{10}$) (controlled study)

Source of variation	Sum of squares	Degree of treatment	Mean Square	Calculated F value	Tabulated F value 5%	Significant Differences
Between treatment (Column)	3.61	2	1.81	36.2	4.26	*
Between Residual	0.41	9	0.05			
Total:	4.02	11	1.86			

*: Significant ($P \leq 0.05$)

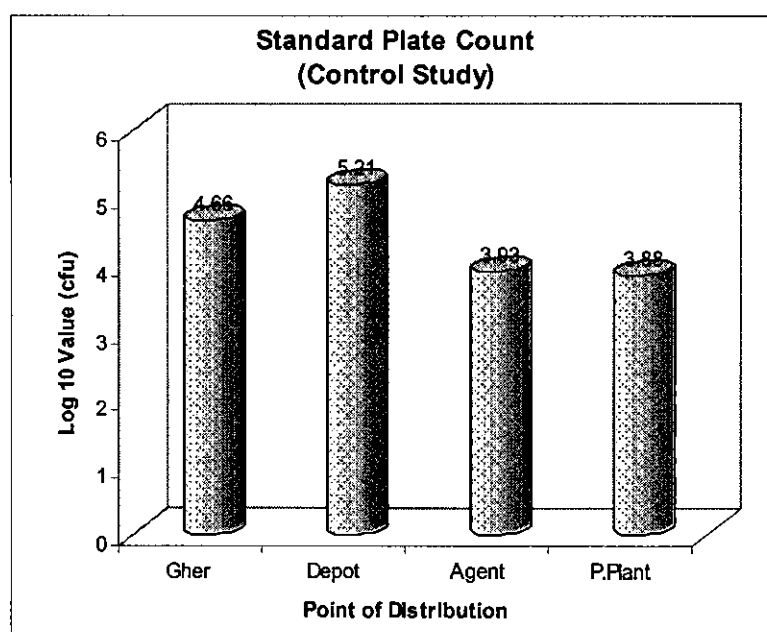


Figure 20: Mean value of FC (controlled study)

4.1.3.5 Total Coliform (Controlled Study)

The statistical analysis of total coliform between the different points of shrimp distribution channel is illustrated in Table-16(a,b). As usual, Table-16(a) indicate the calculation of TSS, TRSS, and RSS. From the ANOVA Table-16(b), it is observed that there is no significant differences ($P \leq 0.05$) of Total Coliform. The calculated 'F' value was 0.55 while the tabulated 'F' (5%) value was 4.26 indicating no significant differences ($P \leq 0.05$). The mean value of total coliform counts for shrimp are spread out and shown in Figure 21. The Figure confirmed the fact that the value of Total coliform was found to be very low (6.70 MPN/g) at Processing. Plant. However, there was a drastic increase in Total Coliform counts at Depot (13.33 MPN/g) which was much higher than observed at Processing Plant. At Depot, the mean value of Total Coliform count decreased both at Gher (11 MPN/g) and Agent (9.67 MPN/g). However the count of Total Coliform at all points in shrimp distribution channel were much lower compared to acceptable limit.

Table 16 (a): Calculation of total sum of squares, between treatment sum of squares, residual sum of squares on the comparative study of total coliform (mpn/g) (controlled study)

Replication no.	GHER	DEPOT	AGENT	P.PLANT
1	9.00	9.00	15.00	7.00
2	4.00	3.00	11.00	4.00
3	20.00	28.00	3.00	9.10
Total:	33.00	40.00	29.00	20.10
Mean:	11.00	13.33	9.67	6.70
Grand Total(GT)	122.10			
Sum of Squares	497.00	874.00	355.00	147.81
				1873.81=A
Sum of Squares of column total / total no. of observation	363.00	533.33	280.33	134.67
				1311.33=B
Difference	134.00	340.67	74.67	13.14
				562.48=C
CF=(GT) ² / total no of observation	1242.37 =D			
Total sum of squares	(A-D)= 631.44			
Between treatment sum of squares	(B-D)= 68.96			
Residual sum of squares	(A-B)= 562.48			

Table 16 (b): Anova table showing the comparative study of total coliform (mpn/g) (controlled study)

Source of variation	Sum of squares	Degree of treatment	Mean Square	Calculated F value	Tabulated F value 5%	Significant Differences
Between treatment (Column)	68.96	2	34.48	0.55	4.26	N. S.
Between Residual	562.48	9	62.5			
Total:	631.44	11	96.98			

N. S. : Non Significant ($P \leq 0.05$)

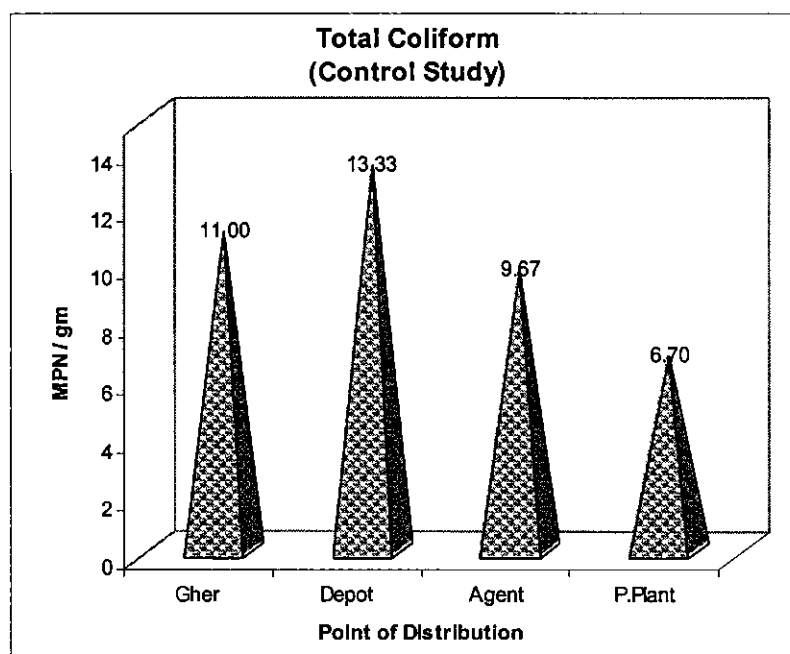


Figure 21: Mean value of TC (controlled study)

4.1.3.6 Faecal Coliform (Controlled Study)

The result of Faecal Coliform count for shrimp at different points in the shrimp distribution channel is shown through statistical analysis and in Table-17(a,b). Table-17(a) provides the total calculation in order to achieve ANOVA. The ANOVA Table-17(b) shows no significant differences ($P \leq 0.05$) of Faecal Coliform between the different point in the shrimp distribution channel. The calculated value of 'F' (5%) was 0.41 while the tabulated 'F' value was 4.26. The ANOVA table indicated no significant differences. Figure 22 shows differences between the mean values of Faecal Coliform at different points. Faecal coliform counts were much higher at Depot (3.67 MPN/g) and lower at Processing Plant (1.33 MPN/g). The mean value of Faecal Coliform decreased between the two points at Gher (3.00 MPN/g) and Agent (2.33 MPN/g).

Table 17(a): Calculation of total sum of squares, between treatment sum of squares, residual sum of squares on the comparative study of faecal coliform (mpn/g) (controlled study)

Replication no.	GHER	DEPOT	AGENT	P.PLANT
1	9.00	4.00	4.00	4.00
2	0.00	0.00	3.00	0.00
3	0.00	7.00	0.00	0.00
Total:	9	11	7	4
Mean:	3.00	3.67	2.33	1.33
Grand Total(GT)	31			
Sum of Squares	81.00	65.00	25.00	16.00
				187.00=A
Sum of Squares of column	27.00	40.33	16.33	5.33
total / total no. of observation				88.99=B
Difference	54.00	24.67	8.67	10.67
				98.01=C
CF=(GT) ² / total no of observation	80.08 =D			
Total sum of squares	(A-D)= 106.92			
Between treatment sum of squares	(B-D)= 8.91			
Residual sum of squares	(A-B)= 98.01			

Table 17(b): Anova table showing the comparative study of faecal coliform (mpn/g) (controlled study)

Source of variation	Sum of squares	Degree of treatment	Mean Square	Calculated F value	Tabulated F value 5%	Significant Differences
Between treatment (Column)	8.91	2	4.45	0.41	4.26	N. S.
Between Residual	98.01	9	10.89			
Total:	106.92	11	15.34			

N. S. : Non Significant ($P \leq 0.05$)

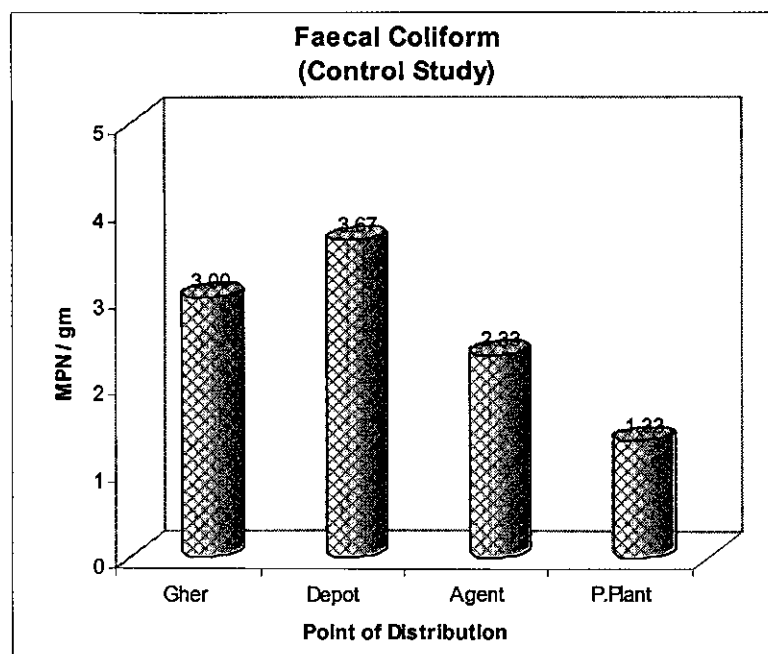


Figure 22: Mean value of FC (controlled study)

4.1.3.7 Comparison between NP and CS for SPC

The comparative study of SPC under normal practice (NP) and controlled study (CS) at different points in shrimp distribution channel are provided in Figure 23. In totality the mean value of SPC at all points were lower than the acceptable limit. From Figure 23, it is clearly indicates that the mean value of SPC for both the experiment did not differ much between the two experiment did not differ much between the two points of Gher (4.43-NP;4.66-CS) and Depot (5.03-NP; 5.21-CS). However, shrimp collected under controlled condition showed better results than normal practice system between the points of Agent and Processing Plant. From the different points (Gher, Depot, Agent, and Processing Plant) of distribution channel, statistical analysis has been made the Table 18. From the Table-(18), it is observed that the point of Gher, Depot and Processing Plant shows no significance differences where calculated 't' value is -0.56, -4.51 and 1.02 from the tabulated value 't' is 2.92. However, the points of Agent shows a significant differences where the calculated value 't' is 75.94. It is clearly observed from the Table 18, through there were a significant differences between the points, but all the values at each point of distribution channel are shows better quality as well as good quality shrimp.

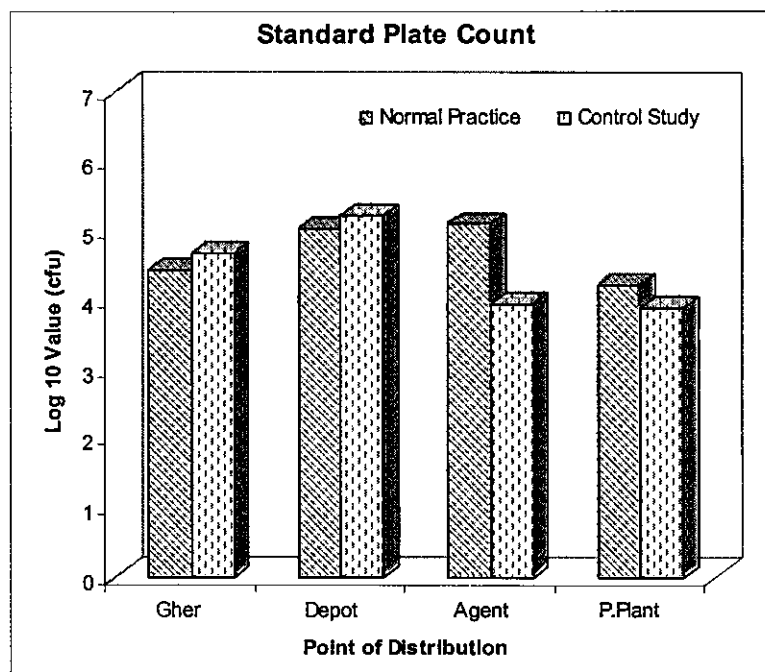


Figure 23: Comparison of mean value of FC

Table 18: 't' test for SPC

Point of Distribution	Calculated Value 't'	Tabulated Value 't'
Gher	0.56	2.92
Depot	4.51	
Agent	75.94	
Processing Plant	1.02	

4.1.3.8 Comparison between NP and CS for TC

The comparative study of Total Coliform (TC) observed in CS and NP system at different points in shrimp distribution channel for shrimp are provided in Figure 24 and Table 19 shows statistical test result sheet. The mean value for both the experiments did differ at each point. From the Figure 24, it is clearly observed, that under controlled study system showed always better results at each point than normal practice. Here, the point in Gher (35.33 MPN/gm) as normal practice shows higher count of Total Coliform and abruptly decreases the count of Gher as controlled study system and in the point of Depot slightly change shows both the experiments and in the point Agent (26.00 MPN/100 g) as normal practice shows higher count of total coliform and in this point abruptly decreases the mean value is count as controlled study system. In the same case

occur at the point in Processing Plant between the two experiments. Although, there were the mean value at each point but there is no significant differences ($P \leq 0.05$) shows Table 19.

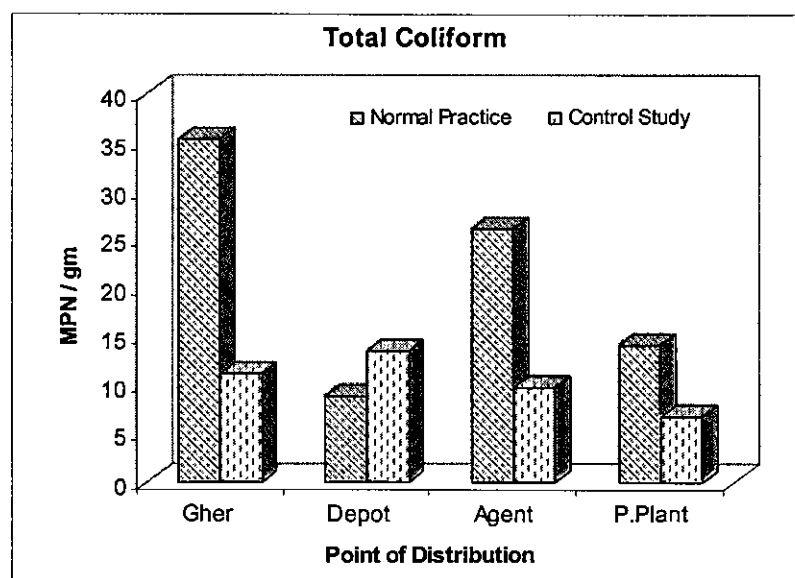


Figure 24: Comparison of mean value of TC

Table 19: 't' test for TC

Point of Distribution	Calculated Value 't'	Tabulated Value 't'
Gher	2.12	2.92
Depot	0.38	
Agent	2.35	
Processing Plant	1.06	

4.1.3.9 Comparison between NP and CS for FC

The comparative study between normal practice (NP) and controlled study (CS) of Faecal Coliform at different points is shown in Figure 25. The mean value of Faecal Coliform between the two experiments did not differ much at the points of Depot, Agent, and Processing Plant. But at the point of Gher (8.67-NP; 3.00-CS) the mean value greatly differ between the two experiments. But shrimp collected from Agent (2.33-NP; 2.33-CS) showed same value in both the experiments. However, slightly variation showed in between the two points such as Depot (3.33-NP; 3.67-CS) and Processing Plant (2.33-NP; 1.33-CS). Table 20 carried out statistical analysis. From the Table 20 it is observed

that there is no significant variance ($P \leq 0.05$) between the two experiments at each point in shrimp distribution channel and all the counts at each point considered as much lower than the acceptable limit.

Figure 25: Comparison of mean value of FC

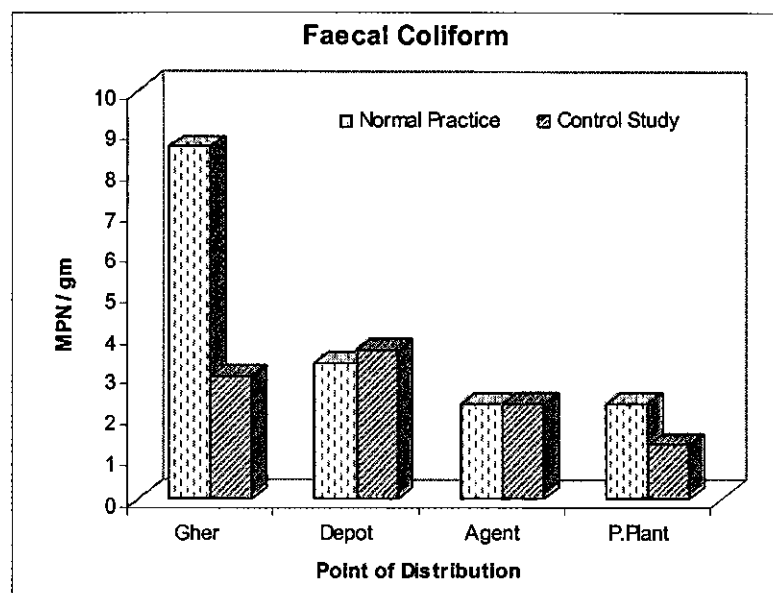


Table 20: 't' test for FC

Point of Distribution	Calculated Value of 't'	Tabulated Value of 't'
Gher	1.21	2.92
Depot	0.08	
Agent	0	
Processing Plant	1	

4.1.3.10 *Salmonella* sp. and *Vibrio cholerae*

Salmonella sp. and *Vibrio cholerae* were not detected in 25g samples of shrimp sample collected from each point (Gher, Depot, Agent, and Processing Plant) of distribution channel in Bagerhat district. (Appendix V-VI).

4.1.4 Co-efficient of Correlation between Organoleptic Score and TVB-N, TMA-N, SPC, TC, FC for NP

Co-efficient of correlation of different organoleptic, biochemical and microbiological parameters at different points in shrimp distribution channel for normal practice is shown in Table-(21). The value of 'r' showed a diversified relationship between the various

parameters (Organoleptic/ TVB-N, Organoleptic/ TMA-N, Organoleptic/ SPC, Organoleptic/ TC, Organoleptic/ FC) in each point. For example in biochemical parameters, the point at Gher the 'r' value of Organoleptic and TVB-N showed highly negative relationship ($r = -0.98$) while the relationship between Organoleptic/ TMA-N indicated highly positive relationship. However, for example, in microbiological parameters, the point at Gher the 'r' value of organoleptic and Total Coliform showed highly negative relationship ($r = -0.77$) while the relationship between Organoleptic/SPC and Organoleptic/ FC indicated highly positive relationship. The diversified relationship is shown at all points in Depot, Agent, and Processing Plant. Thus 'r' value did not give sufficient evidence to reveal the significance of relationship, henceforth; it had become necessary to test the significance of 'r' between a given pair of variables. From the Table-(21) it has been observed that the value of 't' calculated at 5% level significance is much lower than the tabulated value (12.706).

Table 21: Co-efficient of correlation between organoleptic score versus TVB-N, TMA-N, SPC, TC, FC for normal practice

Characters Observed	GHER		DEPOT		AGENT		PROCESSING PLANT		5% values of t
	r	t	r	t	r	t	r	t	
Organoleptic Vs TVB-N	-0.98	-5.20	0.74	1.09	0.97	4.04	-0.38	-0.41	12.706
Organoleptic Vs TMA-N	0.69	0.96	-0.79	-1.27	0.14	0.14	0.60	0.76	
Organoleptic Vs SPC	0.06	0.06	-0.46	-0.51	-0.05	-0.58	0.94	2.89	
Organoleptic Vs TC	-0.77	-1.22	-0.11	-0.12	0.81	1.40	-0.79	-1.31	
Organoleptic Vs FC	0.26	0.27	0.32	0.34	-0.50	-0.58	-0.42	-0.46	

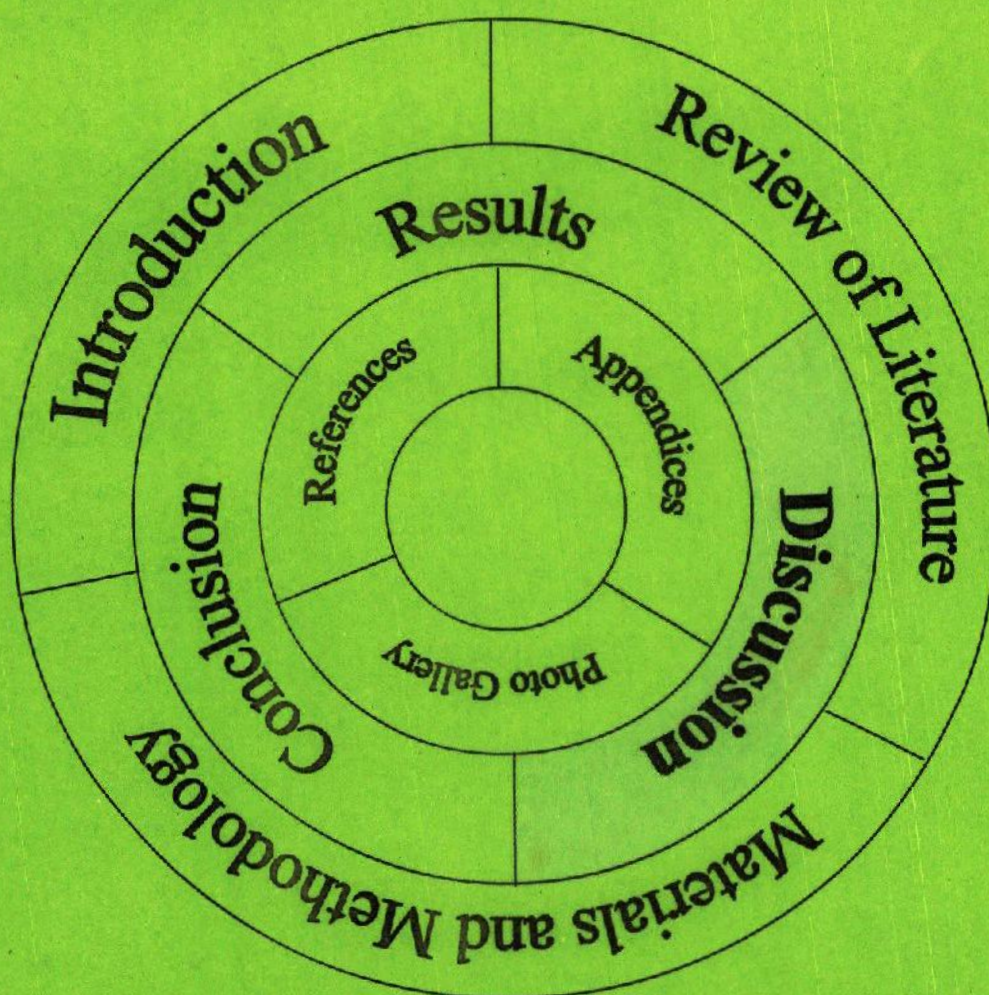
4.1.5 Co-efficient of Correlation between Organoleptic Score and TVB-N, TMA-N, SPC, TC, FC for CS

Table-(22) illustrates the co-efficient of correlation (r value) between organoleptic score versus TVB-N, TMA-N, SPC, TC, and FC of shrimp in iced storage (CS) of different points in distribution channel. In Gher during ice storage, highly positive correlation ($r =$

0.5) was found between organoleptic score versus FC. In case of organoleptic score versus TMA-N, TVB-N, SPC, and TC a highly negative correlation ($r = -0.88$), ($r = -0.63$), ($r = -0.40$), and ($r = -0.95$) was found. In Depot in iced storage, organoleptic score TVB-N, and SPC, a highly negative correlation ($r = -0.92$) and ($r = -0.19$) was found. There is no correlation found between organoleptic score versus TMA-N, TC, and FC in iced storage in the point of depot. In case of Agent shrimp stored at controlled condition, organoleptic score versus TVB-N, TMA-N, and SPC also shows highly negative correlation and it was ($r = -0.97$), ($r = -0.34$) and ($r = -0.83$). In the point of Processing Plant, the co-efficient of correlation between organoleptic score versus TVB-N, TMA-N, SPC and TC also shows highly negative correlation and it was count ($r = -0.96$), ($r = -0.22$), ($r = -0.76$) and ($r = -0.57$). But no correlation found between organoleptic score versus FC in case of Processing Plant and no correlation found between organoleptic score versus TC and FC in the point of Agent. From the Table-(22) it has been observed that the value of 't' calculated at 5% level significance is much lower than the tabulated value (12.706) in case of controlled study (CS).

Table 22: Co-efficient of correlation between organoleptic score versus TVB-N, TMA-N, SPC, TC, FC for controlled study

Characters Observed	GHER		DEPOT		AGENT		PROCESSING PLANT		5% values of t
	r	t	r	t	r	t	r	t	
Organoleptic Vs TVB-N	-0.63	-0.82	-0.92	-2.41	-0.97	-4.16	-0.96	-3.64	12.706
Organoleptic Vs TMA-N	-0.88	-1.90	0.75	1.13	-0.34	-0.36	-0.22	-0.22	
Organoleptic Vs SPC	-0.46	-0.52	-0.19	-0.19	-0.83	-1.47	-0.76	-1.15	
Organoleptic Vs TC	-0.95	-3.12	0.99	9.81	0.43	0.48	-0.57	-0.70	
Organoleptic Vs FC	0.58	0.58	0.96	3.58	0.35	0.37	0.76	1.15	



Current Position Indicator

Discussion

5.0 DISCUSSION

5.1 *Quality Characteristics of Shrimp*

5.1.1 Normal Practice (NP) and Controlled Study (CS)

5.1.1.1 Organoleptic

Organoleptic quality characteristics of shrimp in both the experiment indicated almost similar results at each point (Gher, Depot, Agent, and Processing Plant) of distribution channel. Study of organoleptic quality of shrimp in both practices mainly depended on some factors such as odor, eye, texture, shell color, carapace color. At the point of Gher, shrimp had fresh odor, carapace color were moderately greenish with hard texture, and eyes were bright and transparent in both the practices. These attributes started deteriorating as shrimp were distributed further. The overall acceptability score of shrimp in Gher, Depot, Agent and Processing Plant were 8.8, 5.47, 6.67 and 6.33 respectively in the case of normal practice. However, controlled study showed always better score compared to normal practice i.e. Gher (8.87), Depot (6.67), Agent (7.47) and Processing Plant (7.13). (Appendix I-II).

The storage quality of shrimp at different temperature have been studied by many workers (Valankar *et. al.*, 1961; Farooqui *et. al.*, 1978; Foda *et al.*, 1984, Surendran *et. al.*, 1985; Matches, 1982; Flores and Crawford, 1973). The most prevalent method of preserving shrimp in the fresh form is by using ice. The present experiments always showed better organoleptic score of shrimp in controlled study (using ice) in comparison to normal practice.

Jayaweera *et. al.* (1990) judged the raw appearance of shrimp and classified them as Grade I on the 1st and 3rd days of shrimp stored in ice and Grade II for shrimp stored on the 7th day. Shrimp were just acceptable on the 10th day, after which they were rejected. In the present experiment, sample handling period took 10-12 hours in the distribution

channel. At the point of harvest (Gher), shrimp quality was the best. However, the quality relatively decreased as shrimp were transported further until it reached the processing plant.

Farooqui *et. al.* (1978) reported that shrimp in ice maintained good quality for 0-2 days as judged by organoleptic quality i.e. acceptable up to 7 days and rejected after 9 days. Shrimp in ice started to lose flavor early (2-4 days); black spots were formed by 6-9 days, which affected the organoleptic quality of shrimp (Cann, 1974).

Reilly *et. al.* (1986) observed that shrimp lost their value as prime quality head-on produce after 2 days, during storage at 0°C. Reilly *et. al.* (1985) found that shrimp iced immediately kept for 17 days, while 4h, 8h and 12h delayed iced shrimp kept for 16, 13 and 11 days respectively. Reilly *et. al.* (1985) reported that prawn (*P. monodon*) held at normal temperature were rejected after 16 hours due to discoloration with a pinkish cooked appearance, strong ammonical odor and very soft textures. Prawn lost up to 15% of their body weight after 16 hours.

At normal temperature, *Haplochromis* sp. spoiled after 20 hours, *Protopterus pictus* after 3 days and *Lates calcarifer* fillets after 2 days. However, in the present study of the shrimp at different points in distribution channel, no rejection characteristics were found in relation to eye, odor, shell color, carapace texture, and carapace color.

Nguyen Le Ha (1997) reported that there was a gradual loss in quality of shrimp stored at four different temperatures (0°C, 10°C, 20°C, and 30°C); the highest spoilage rate was observed in shrimp stored at 30°C and the rate decreased with a decreased in temperature from 30°C to 0°C.

Shamshad *et. al.*, (1990) reported that the shelf life of shrimp *Penaeus semisulcatus* caught in Nhatrang, Vietnam was longer than that of *Penaeus merguensis* caught in Pakistan (13 days, 4 days, 25 hours and 13 hours when stored at 0°C, 10°C, 20°C and 30°C respectively). Yamagata and Low (1995) found that the shelf life of *Penaeus merguensis* caught in Singapore and stored in ice was 4 days, compared to 6 days for the shrimp stored at -3°C and 9 weeks stored at -10°C.

5.1.1.2 Biochemical

5.1.1.2.1 Total Volatile Base Nitrogen

Mean value of TVB-N under normal practice and controlled condition is presented in Appendix III. The value of TVB-N in both condition indicated an acceptable limit as suggested by Connell (1976). In case of normal practice, it is observed that at Gher and Agent, TVB-N value decreased to a large extent (2.07mgN/100g to 5.34mgN/100g) (Appendix III). However, in case of Depot and Processing Plant, TVB-N value increased abruptly to 18.68 and 8.49mgN/100g as shown in Appendix III. In the case of controlled study, TVB-N value increased sharply to 7.56mgN/100g to 8.90mgN/100g at Depot and Agent which was still below the acceptable limit. Also very low value (4.11mgN/100g to 7.49mgN/100g) of TVB-N was observed in Gher. (Appendix III).

Putro *et. al.* (1990) suggested that TVB-N of Gher shrimp varied between 7 and 28mgN/100g. The result of the present study in CS was in agreement with the findings of Putro *et. al.* (1990). Connell (1975) stated that TVB-N content in shrimp had highly positive and highly negative correlation with storage time indicating that TVB-N was a good indicator of spoilage. However, with increased storage time, in some species, TVB-N content was found to decrease (Mlay *et. al.*, 1985). The explanation for this can be that volatile bases were leached out due to melting of ice. Boee *et. al.* (1982) demonstrated that if the leaching could be prevented, TVB-N value would show regular increase. As well, leaching could be prevented using plastic foil.

Rattagool *et. al.* (1990) reported that TVB-N content in Gher sample was 11.79 mgN/100g in fresh shrimp and 9.82 mgN/100g in iced shrimp. The present investigation, TVB-N content of shrimp was observed, higher and lower value count in Depot and Gher (18.68 mgN/100g and 2.07mgN/100g in normal practice) and higher and lower value in Agent and Gher (8.90mgN/100g and 4.11mgN/100g in controlled study).

In the present study, samples were collected at different points (Gher, Depot, Agent, and Processing Plant) in distribution channel. The total time had been recorded as 12 hours. In normal practice, higher TVB-N value in Depot (18.68mgN/100g) was found as against controlled study in Agent (8.9mgN/100g). Rattagool *et. al.* (1990) reported that

tiger shrimp after being caught and kept frozen for 7 days and left at room temperature ($20^{\circ}\text{C} \pm 3^{\circ}\text{C}$) for 27 hours showed TVB-N value of 91.85 mgN/100g.

Reilly *et. al.* (1985) stated that TVN are not reliable as indices of quality. Boee *et. al.* (1982) working on the storage of shrimp has observed that TVN increased evenly. Matches (1982) working on shrimp stored at five different temperature found that TVN increased both with increase in time and temperature. Valenkar *et. al.* (1961) and Cann (1974) have found the increase in TVN to be low during the initial period of storage, with a rapid increase noted afterwards. The result of the present study is in absolute agreement with the findings of Cann (1974) because lower TVB-N content was observed immediately at the point of Gher in both the practices.

Montgomery *et. al.* (1970) and Cantoni *et. al.* (1978), have suggested 30mg/100g TVB-N as the limit of acceptability of fresh shrimp. The result from the present study confirms to the level of 30mg/100g TVB-N for fresh shrimp as suggested by Montgomery *et. al.* (1970). Ali (1965) reported that the TVB-N had evidently changed between 16 and 20mgN/100g during its first 7 days of ice storage and the organoleptic score had then reached 5 marks. This showed remarkable increase in TVB-N as compared to the more regular increase of the organoleptic score after the 7th day. This indicates that the value of TVB-N is not a reliable measurement to determine the freshness of iced shrimp. However, other researchers also did not find TVB-N as a good indicator of spoilage (Barile, 1985).

According to Connell (1976), the limit of acceptability of TVB-N is 25-30 mgN/100g. In the present investigation, all the values of TVB-N were within this acceptable limit indicating that shrimps were of good quality throughout the distribution channel.

5.1.1.2.2 Trimethylamine Nitrogen

Trimethylamine is a volatile compound and has a very low order threshold (Botta and Shaw, 1976). Trimethylamine could serve as an index of spoilage for marine fish. Fresh water fish can not be judged by only TMA values because they do not contain the precursor, TMAO-N, in sufficient amount (Bligh, 1971). TMA-N is one of the volatile

basic compounds; which is found in very low quantity in fresh fish but accumulates in spoiling marine fish as a result of mainly bacterial reduction of trimethylamine oxide (TMAO). This means that analysis does not give any information about early autolytic changes or degree of freshness but only about the much later bacterial changes or degree of spoilage.

The accepted limit of TMA-N is 12-15 mgN/100g (Montgomery *et. al.*, 1970; Connell, 1976). The results as found in the present investigation indicated much higher value for controlled study at point in Depot (10.82 mgN/100g) and much lower value for normal practice at point of Agent (2.61 mgN/100g). (Appendix III). There was a little variation shown in shrimp content TMA-N for both the practices at different points. However, much higher count occurred in CS as observed in Depot and Processing Plant (10.82 and 9.05 mgN/100g). Initially, the TMA level was very low, and though it increased steadily with storage time, the level was too low to be of much value as an index of quality. Montgomery *et. al.* (1970) has reported a level of 5mg/100g TMA as the limit to assess spoilage in Australia. During the present experiment, even at the point of Gher, TMA level was only 2.62 to 2.92 mgN/100g in both NP and CS practices

Reilly *et. al.* (1985) observed that the level of 5mg/100g was never reached during ice storage of shrimps. These findings differed from the present investigation for both practices.

The use of TMA-N as an index of fish freshness was first proposed by Beatty and Gibbons (1937). This was based on the observation that the production of TMA-N was dependent on bacterial activity and the role of autolysis was negligible. In recent years, there are opinions that TMA-N itself may not be a very suitable freshness index. This is because the TMA-N content in a fish may vary with season, habit, feeding, and also the distribution of TMA-N within a piece of fillet may not be uniform (Siang and Kim, 1992).

TMA content of brackish water prawn (*Penaeus monodon*) fluctuated during storage at normal temperature and was regarded as poor indices of quality (Reilly *et. al.*, 1985). The value of TMA was found to be questionable use as indices of spoilage for mackerel

(*Rastrelliger faughni*) (Barile *et. al.*, 1985). This findings are in agreement with the result of the present investigation as TMA-N value did fluctuate and showed irregular correlation with storage points and organoleptic score. Probably, the value of TMA-N for all the fish increased gradually due to continuous autolytic and bacterial action (Azam *et. al.*, 1997).

From the different result it may therefore be considered that TMA-N was not a suitable index for assessing the quality of freshwater fish (Castell *et. al.*, 1955). TMA-N is generally not detected in fresh water fish (Harada, 1975). Botta and Shaw (1976) noticed that TMA does not always correlate with flavor, odor, and other sensory test in fresh water fish. Present study is in concurrence with the findings of Rahman (1980).

For whiting (*Sillago maculatus*) stored at normal temperature, TMA-N content was 13mg/100g. The limit of acceptability of 5mg/100g (TMA-N) was suggested by Montgomery *et. al.* (1970). The results obtained were in the range of acceptability in both practices.

5.1.1.3 Microbiological

At all points of distribution channel, shrimp (with or without ice) did not show distinct difference in any of the microbiological criteria for which further microbiological assessment for water or ice were not carried out.

5.1.1.3.1 Standard Plate Count (SPC)

The international accepted limit of SPC is 10^6 cfu/g (ICMSF, 1988). All the results showed that the SPC values were lower than accepted limit (Appendix IV) for both practices. SPC of freshly harvested shrimp ranged from 6.8×10^4 to 1.5×10^5 as observed by Lobrerria *et. al.*, 1990. These counts are within the range of reported values (10^3 - 10^5) of shrimp from temperate environments (Lillard *et. al.*, 1984; Matches and Layrisse, 1985) although Lannelongue *et. al.* (1982) mentioned counts as high as 10^6 - 10^7 . Counts reported from tropical countries also ranged from 10^3 to 10^6 (Varma *et. al.*, 1982; Surendran *et. al.*, 1985). A report by De Silva (1985), however, indicated counts as high as 10^8 /gm. Result of this present study showed that freshly harvested shrimps could meet the existing standards for SPC which is 10^6 /g (ICMSF, 1974).

According to Azam, (2004), shrimp collected from all the three districts (Bagerhat, Khulna, and Satkhira) and from all the points (Gher, Depot, Agent, and Processing Plant) indicated value within 10^5 cfu/g, is acceptable limit even when being practiced normally. The mean ($\log_{10}$ value 1.26) was higher than the acceptable limit as recommended, by Paul (1994). Lyer *et. al.* (1969) reported that 1×10^6 /gm to 6×10^6 /gm of bacteria which can not meet the present study.

Bacterial counts on *P. monodon* immediately after harvesting ranged from 2.23 to 4.20 (expressed as $\log_{10}$ cfu/g) at 20°C and 3.36-4.20 at 37°C (Dangla, 1984). The findings of this investigation did not correlate with the findings of Dangla having higher bacterial load. However the results were in convenience with the results reported by Cobb *et. al.* (1976) for *penaeus* sps. (10^4 - 10^6 /g). Cann (1976) also observed as high as 10^6 - 10^7 . The lower counts of the brackish water species were probably due to the method of harvesting and to the avoidance of extensive handling and on board storage of marine prawns (Dangla, 1984).

The total bacterial load of shrimp samples gradually declined during processing. A significant drop in bacterial load was noticed when the shrimp arrived in the processing plant. The initial load of bacteria was $\log$ 6.99 to $\log$ 7.55, whereas the frozen shrimp product was between $\log$ 5.98 to $\log$ 6.73 (Putro *et. al.*, 1990). The results of the present investigation are in concurrence with the result of Putro.

The mean bacterial counts of freshly caught pond-cultured shrimps was 3.2×10^5 and were lower than the counts reported for marine shrimps 3.9×10^6 (Fonseka, 1990). The lower counts in the present study may be attributed mainly to the fact that immediate icing of cultured shrimps after harvesting limits the likelihood of bacterial multiplication (Liston, 1980).

There is evidence to support the fact that surface water carries less bacteria compared to bottom mud about 50ft below the surface (Williams *et. al.*, 1952). As shrimps are bottom dwelling animals, the likelihood of their becoming contaminated with bacteria from the muddy substrate is always a possibility. Deheading of shrimps has lead to reduction of

bacterial counts by 75% (Fiegar, 1950) and the effect of through washing on the reduction of microbial load of prawns has been documented by Green (1949) and Williams *et. al.* (1952). These results demonstrate that a wash with clean water and proper handling techniques will reduce high SPC.

According to Castell *et. al.* (1956), Georgala (1957) and Iyer and Chouduri (1966) icing with inadequate quality water introduced bacteria into fish, causing higher bacterial counts. The present study result did differ from the statement. According to Shewan (1961) most of the bacteria adhering to the slime and skin surface could be washed away with water. Shewan (1961) reported the bacterial count of shrimp to be in the range of 10^4 - 10^5 /g, 10^5 being very common. Similar values were also reported by Harrisan and Lee (1969); and Lee and Pfeier (1977).

Cann (1977) on the other hand, states that based on studies in Thailand and USA, the differences in bacterial counts between whole and deheading shrimps was not significant. The beheading of shrimps in the present study was carried out manually. The effect of washing on the bacterial load of the processed product produced was evident as a majority (58.3%) of counts fell within the 10^5 - 10^6 /g range and this reduction was statistically non significant. The coefficient of correlation between the organoleptic score and the standard plate count was '0.06' for NP and '-0.46' for CS. However, the result of the present investigation was in agreement with Azam, (2004)

5.1.1.3.2 Total Coliform (TC)

TC values were very low in CS compared to normal practice. The acceptability limit of TC is 10 and 100 MPN/g. At all points, their values were lower and were acceptable. This also indicated a better status of shrimp quality. The Coliform contents of farm shrimp varied between 460-1100 (Putro *et. al.*, 1990). In the present study, Coliform contents were not very high in CS. The counts varied between 2 to 28/gm in CS (Appendix IV). However, shrimp collected in normal practice showed relatively higher coliform count. The higher count were observed in Gher (53MPN/gm) and Agent (28 to 43MPN/gm) (Appendix IV).

According to Fonseka (1990), 50% of the shrimp samples had coliform less than 20 (MPN/g) while the rest of the samples carried coliforms below 75 (MPN/g). The present study showed similar result.

Detailed bacteriological evaluation of shrimp from cold waters have been attempted by Harrison and Lee (1969); Cann, (1971); Novak (1973) and Lee and Pfeifer (1977). Such data regarding tropical shrimp is rather scanty (Cann, 1977; Zuberi *et. al.*, 1983). Jayaweera *et. al.* (1990) observed coliform counts of raw material ranging from <3 to 1,100/g, with 50% of the counts in the $3-10^2$ /g range. Shrimp caught in deeper waters generally do not carry coliform, but those caught close to the shore and from inshore waters have been found to be contaminated frequently with coliform (Cann, 1977).

The changes in the bacterial flora of shrimps have been studied previously, but not as extensively as that of fish. Various authors have studied the coliform counts in shrimp (Cambell and Williams, 1952; Cann, 1974; Matches, 1982 and 1985)) during storage in ice. Their results indicated relatively lower coliform counts. In the present investigation, it was also observed that the coliform counts were reduced during ice storage.

5.1.1.3.3 Faecal Coliform (FC)

Shrimp collected from Bagerhat region showed a very lower count of Faecal Coliform. The recommended value of Faecal Coliform is $\log_{10}$ value 1.00 (Paul, 1994). The acceptable limit of FC is 10 MPN/g. The present investigation showed FC count was within acceptable limit. A slightly higher count was observed in normal practice (15 MPN/gm) but in most cases, FC was not detected (Appendix IV). The relatively lower counts were observed in CS, which varied between 0 to 9 MPN/gm (Appendix IV).

Putro *et. al.* (1990) could not detect FC either for shrimp or surrounding waters. According to Fonseka, (1990), FC were not detected in 82.5% samples and counts of FC in pond water were also found to be less than those in shrimps. Cann (1977) reported that freshly caught penaeid shrimps did not carry FC but smaller samples were observed for sea water contaminated with FC.

Coliform organisms are primarily used to indicate some degree of potentially hazardous contamination based on the assumption that the natural habitat of the family (Enterobacteriaceae) to which these bacteria belong is the faeces of man and other mammals, thereby indicating faecal contamination. Jayaweera et.al. (1990) found FC counts in the raw material ranging from <3 to 10^3 /g but were reduced between <3 /g (66.7%) and 3 to 10^2 /g (33.3%). The FC counts did not vary significantly during the processing stage of beheading and grading, but the counts declined slightly during the next stage i.e., just before storage in ice, but significantly reduced after keeping ice for a prolonged period.

Surendran et. al. (1985) found Moraxella and Acinetobacter to be the predominant group at spoilage in *P. indicus*, *M. dobsoni* and *M. affinis*. Surendran and Gopakumar (1981) also reported that Moraxella and Acinetobacter comprised 74% of the spoilage flora in shrimps. Reilly et. al. (1986) working on the spoilage of shrimp at different temperature, found the initial microflora to be mesophilic. The rate of survival of different types of faecal organisms like *E. coli* occurring along with normal flora of iced fish at subsequent storage at -23.3°C had been studied, by Pillai et. al. (1969). However, the present study indicated that cold storage resulted in decreased number of bacterial load.

Rose et. al. (1990) observed counts of the incoming product to be high, i.e., more than 20/g. According to Azam, (2004), no FC was detected in shrimp distribution channel in Khulna region. However, in the present study, value of FC count showed a different trend in Bagerhat region.

Although there were variations at different points with regard to FC count, there were no significant differences ($P \leq 0.05$) within the points and the value lower than the acceptable limit recommended in International market.

5.1.1.3.4 *Salmonella* sps.

According to Azam, (2004) salmonella were not detected in the sample of shrimps. The present investigation is in absolute agreement with the findings of Azam, (2004). Salmonella was not isolated from freshly harvested shrimp (Lobrerria et. al., 1990; Putro

et. al., 1990). However salmonella contamination was observed in freshly harvested shrimp as found by Rattagool *et. al.* (1990). In a study of microbial flora of pond cultured shrimp, salmonella was not detected (Fonseka, 1990). The results of the microbial parameters in this investigation indicated a similar pattern as observed by Fonseka (1990). The author reported that salmonella was not detected from farm shrimp.

The present study indicated no detection of Salmonella Sps in 25g samples of shrimp collected from any points of distribution channel in Bagerhat (Appendix V). Salmonella were detected in prawn samples in the storage stability of brackish water prawn during processing for export (Dangla, 1984) particularly after harvesting but was not found during or after processing.

Rose (1990) found the presence of salmonella on the frozen marine prawn immediately after processing. The absence of salmonella in the frozen farmed prawn might have been caused due to the absence of these bacteria in the raw material rather than the effect of processing measures. Rattagool *et. al.* (1990) found salmonella sp. associated with raw peeled shrimp and factory peeled shrimp. Jayaweera *et. al.* (1990) could not detect salmonella in 25g samples from any stage of processing. The present study is in absolute agreement. Rose *et. al.* (1990) state that salmonella was not found in the marine shrimp naturally and any salmonella in the marine shrimp was probably due to contamination during handling, transportation or processing.

5.1.1.3.5 *Vibrio cholerae*

Vibrio cholerae were detected in prawn samples in the storage stability of brackish water prawn during processing for export (Dangla, 1984) particularly after harvesting but was not found during or after processing. In the present investigation, no *Vibrio Cholerae* were detected in any samples throughout the laboratory experiment for shrimps at any points in distribution channel (Gher, Depot, Agent, and Processing Plant). (Appendix VI)

In a study of microbial flora of pond cultured shrimp, only two samples were positive for vibrio sps. (Fonseka, 1990). The presence of vibrio in pond reared shrimps (Christopher *et. al.*, 1978; Vanderzant *et. al.*, 1971) and fish and shellfish from estuarine and marine

waters is well documented (Durairaj *et al.*, 1983; Reilly, 1984; Simidu *et al.*, 1969; Surrindran and Gopakumar, 1982).

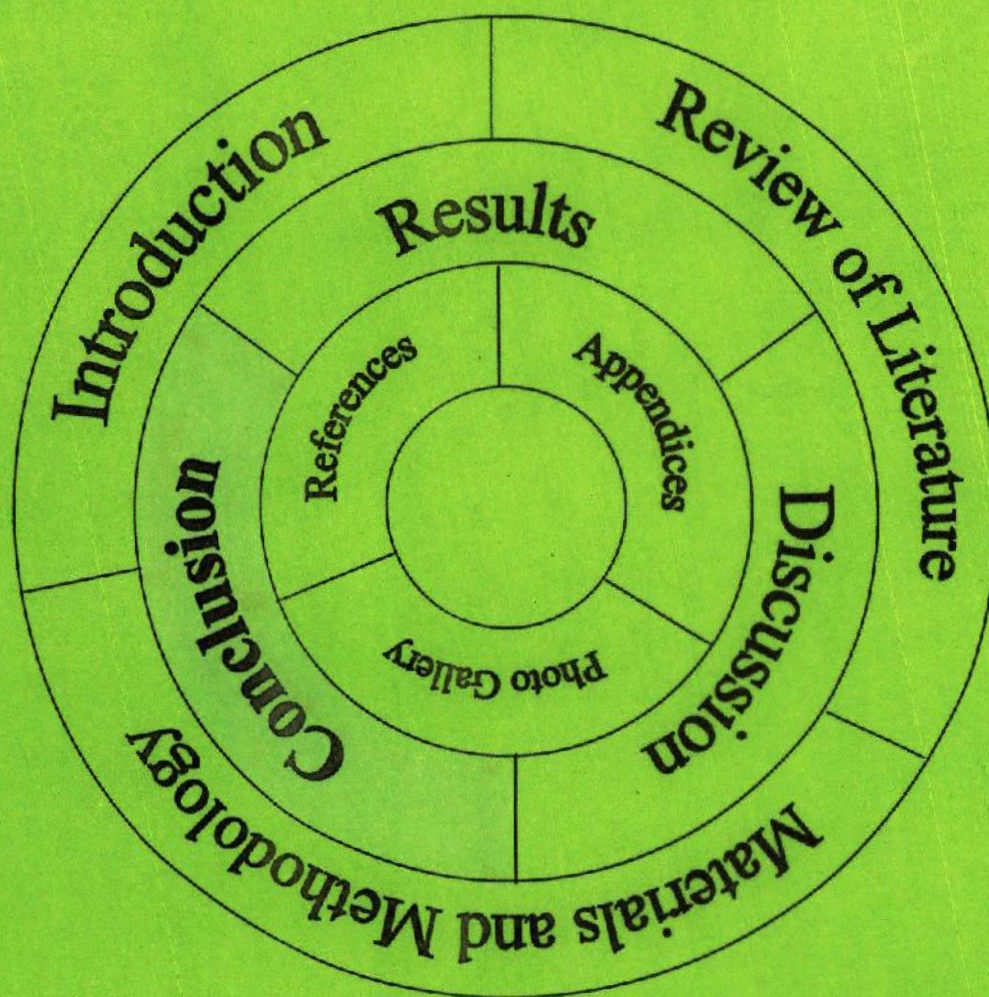
Rosmaewaty *et al.* (1985) found *Vibrio parahaemolyticus* being not detected throughout the processing lines. Reilly *et al.* (1984) working on brackish water prawns reported that *Vibrio parahaemolyticus* was present commonly as part of the natural flora, but not isolated after processing. According to Azam, (2004), *Vibrio* sps. were not detected in 25g samples of shrimp sample collected from any points of distribution channel in Bagerhat, Khulna and Satkhira district. The present investigation did not differ from those observed by Azam, (2004). However, *V. cholerae* strains have been reported to be widely distributed in the environment in Europe, Asia and United States (Karunasagar *et al.*, 1990). Blake *et al.* (1979) summarized that *V. cholerae* is an autochthonous species of the estuarine ecosystem in as much as the occurrence of *V. cholerae* was not correlated with other microbial indicators of faecal pollution.

Karunasagar *et al.* (1990) did not find statistically significant correlation between faecal coliform count and incidence of *V. cholerae*. Karunasagar *et al.* (1990) showed that *V. parahaemolyticus* was the most common (69%) *Vibrio* found in all the samples tested, *V. vulnificus* was present in 25% of samples, *V. cholerae* is 9% and *V. mimicus* in 6.5% of the samples. Jayaweera *et al.* (1990) showed that *V. parahaemolyticus* does not present a problem for the Sri Lanka prawn industry.

Reilly *et al.* (1986) working on the spoilage of *P. monodon* at different temperatures, found the initial microflora to be mesophilic and dominated by several sp. and *Vibrio cholerae* (6.7%). According to Rose *et al.* (1990), *V. cholerae* was detected twice throughout the pond and plant survey. Reilly (1986) reports isolated of *V. cholera* in brackish water prawn and suspected that the bottom mud is the source. Iyer *et al.* (1990) found no presence of *Vibrio Cholerae* as observed in the present study.

5.2 Co-efficient of Correlation between Different Quality Parameters for Normal Practice and Controlled Study

The correlation between the organoleptic score and TVB-N value was found to be $r = 0.71$ for some shrimp species. This is not acceptable as a significant correlation value. The correlation between the organoleptic score and TMA-N value, however, was found to be $r = 0.9$, which may be classed as a significant correlation (Ali, 1965). In this investigation, the correlation between the organoleptic score and TVB-N, TMA-N value in both the practices at each points (Gher, Depot, Agent, Processing Plant) was found to be highly negative which is considered as good indicator of relationship except in normal practice at the point in Gher (organoleptic score versus TMA-N i.e. $r = 0.69$). For controlled study, the correlation between organoleptic score versus SPC value showed highly negative correlation at each point of distribution channel considered to be a good relation except in normal practice at the points of Depot and Agent, which showed highly negative correlation. The correlation between organoleptic score versus TC in Gher, Depot, and Agent for normal practice and the points of Gher and Processing Plant showed highly negative value, which is acceptable expect in Gher for normal practice ($r = -0.77$). However, the correlation between organoleptic score versus FC value, at Agent and Processing Plant in normal practice showed negative correlation. Further, in the present study, it has been observed that the value of 't' calculated at 5% level significance was much lower than the tabulated value (12.706) in both the experiments. In general it has clearly been observed that the quality of shrimp at different points of distribution channel in all parameters remained below the accepted recommended level in both the practices indicating an overall good hygienic condition. It has been already observed by Pillai *et. al.* (1969) that quality consideration of shrimp sample is dependent upon particular factor such as the nature of raw materials and its pre-treatment before processing in the industry.



Current Position Indicator

Conclusion

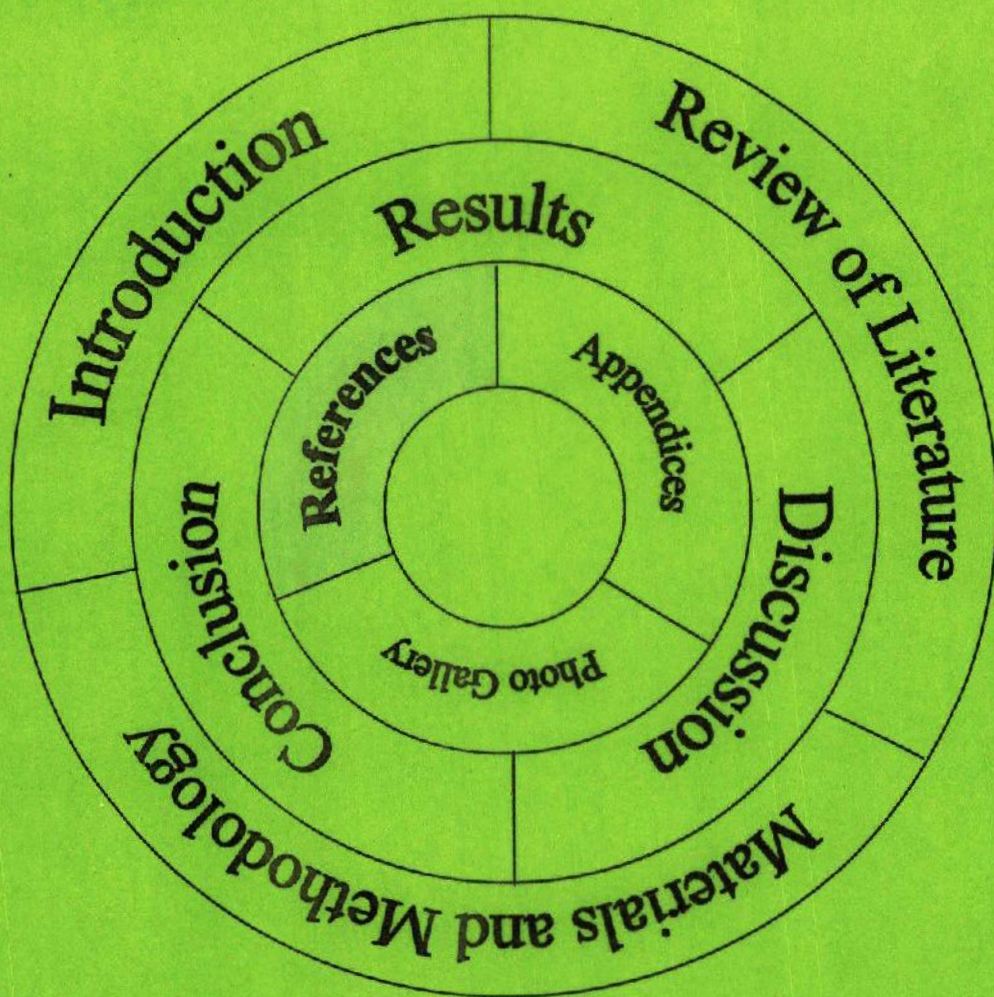
6.0 CONCLUSION

Quality of *Penaeus monodon* collected from normal practice at each point of distribution channel was assessed. This was then compared with a controlled study where ice: shrimp (1:1) were used throughout the distribution channel. Overall organoleptic score did not differ significantly ($P \leq 0.05$) between controlled study (CS) and normal practice (NP). However quality of shrimp indicated higher score for controlled study for certain point.. Biochemical parameters (TMA-N and TVB-N) showed values lower than the acceptable range and the results were in concurrence with that of the organoleptic for both the experiments. Microbiological parameters (SPC, TC and FC) showed variation in numbers at each point in both the experiment but remained well within the recommended range of ICMSF. *Salmonella* sps. and *Vibrio cholerae* were not detected in any samples.

A lack of coordination among the stakeholders was a common feature in the shrimp distribution channel. Institutional indifference due to the ambiguity of jurisdictions had in many cases resulted in counterproductive and conflicting development activities. Collaborative partnerships among the stakeholders mandated by legislation may be an option for addressing the institutional quagmire. Institutionally, neutral national and international NGOs would be in a unique position to facilitate the development of such collaboration. Govt./NGOs could ensure all stakeholders in the shrimp distribution channel be under one apex body. A well organized team with relevant background should be formed to monitor the complete shrimp distribution channel. All stakeholders (Gher, Agent, Depot, and Processing Plant) should be guided with adequate scientific knowledge from time to time (workshops/ seminars/ training by Department of Fisheries, Universities and NGOs etc).

Shrimp is mainly for export as Bangladesh earns substantial amount of foreign exchange. Though the quality of shrimp in both the experiments was acceptable, yet the country has to cater for the need of the buyers in the international market. The importers are not only satisfied with quality now. They would like to see that the product has a 'Seal of Quality' brand certified by a third party which is internationally recognized. The 'Seal of Quality' encompasses traceability, food safety, human rights violation, fair trade practices, and environment friendly product. The stakeholders in the shrimp distribution channel must be made aware of 'Seal of Quality' in order.





Current Position Indicator

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7.0 REFERENCES

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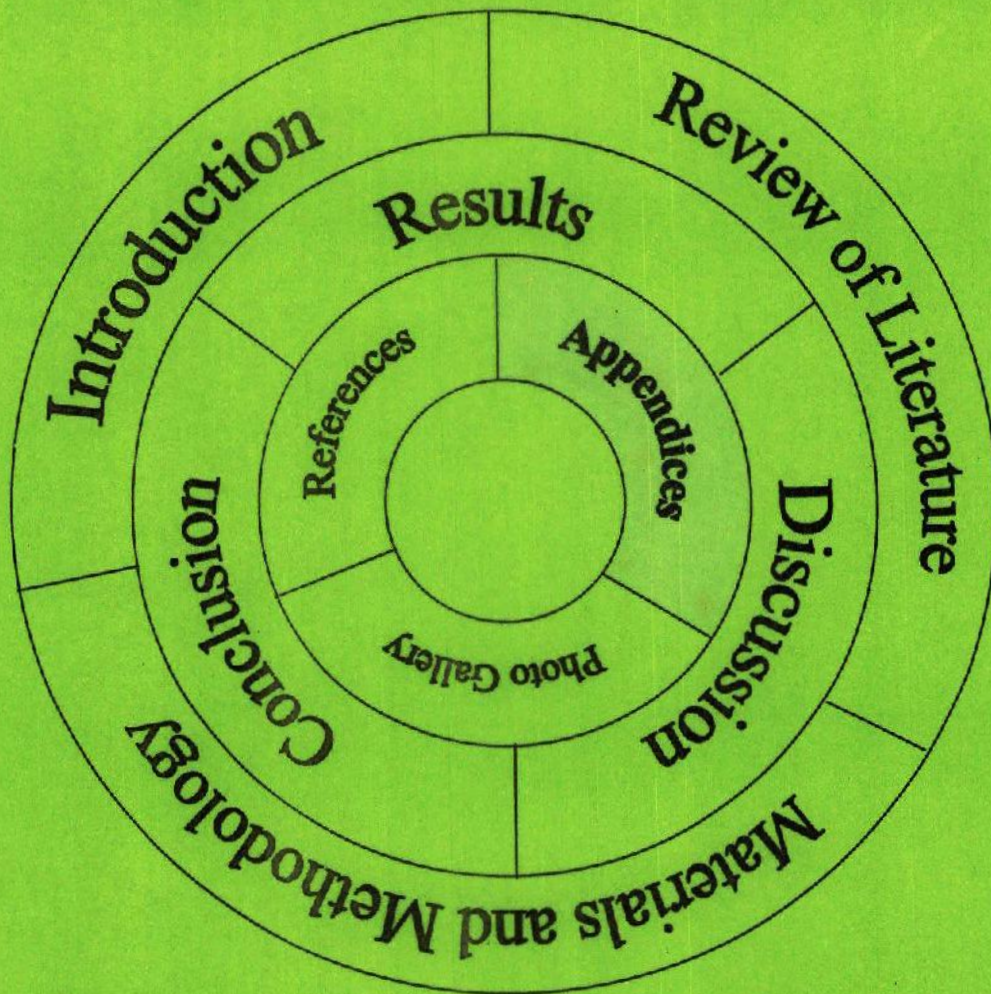
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Current Position Indicator

Appendices

8.0 APPENDICES**Appendix I: Organoleptic Score Sheet (Normal Practice)**

Gher				
Characteristics	Sample 1	Sample 2	Sample 3	Overall
Odour	10	10	10	10.00
Carapace Color	8	9	8	8.33
Carapace Texture	7	9	9	8.33
Eye	10	9	10	9.67
Shell Color	8	8	7	7.67
Average	8.6	9.0	8.8	8.8

Depot				
Characteristics	Sample 1	Sample 2	Sample 3	Overall
Odour	8	7	7	7.33
Carapace Color	6	5	6	5.67
Carapace Texture	5	5	3	4.33
Eye	6	6	5	5.67
Shell Color	5	4	4	4.33
Average	6.0	5.4	5.0	5.47

Agent				
Characteristics	Sample 1	Sample 2	Sample 3	Overall
Odour	9	7	8	8.00
Carapace Color	7	8	7	7.33
Carapace Texture	6	6	5	5.67
Eye	7	6	7	6.67
Shell Color	5	6	6	5.67
Average	6.8	6.6	6.6	6.67

Processing Plant				
Characteristics	Sample 1	Sample 2	Sample 3	Overall
Odour	7	8	8	7.67
Carapace Color	6	7	8	7.00
Carapace Texture	5	4	5	4.67
Eye	6	7	6	6.33
Shell Color	6	6	6	6.00
Average	6.0	6.4	6.6	6.33

Appendix II: Organoleptic Score Sheet (Controlled Study)

Gher				
Characteristics	Sample 1	Sample 2	Sample 3	Overall
Odour	10	10	10	10.00
Carapace Color	9	10	8	9.00
Carapace Texture	8	7	8	7.67
Eye	10	9	9	9.33
Shell Color	8	9	8	8.33
Average	9.0	9.0	8.6	8.87

Depot				
Characteristics	Sample 1	Sample 2	Sample 3	Overall
Odour	9	7	8	8.00
Carapace Color	6	6	8	6.67
Carapace Texture	7	6	7	6.67
Eye	6	7	7	6.67
Shell Color	5	6	5	5.33
Average	6.6	6.4	7.0	6.67

Agent				
Characteristics	Sample 1	Sample 2	Sample 3	Overall
Odour	9	8	9	8.67
Carapace Color	8	7	7	7.33
Carapace Texture	8	7	7	7.33
Eye	8	7	8	7.67
Shell Color	7	6	6	6.33
Average	8.0	7.0	7.4	7.47

Processing Plant				
Characteristics	Sample 1	Sample 2	Sample 3	Overall
Odour	8	7	9	8.00
Carapace Color	8	8	7	7.67
Carapace Texture	9	8	7	8.00
Eye	7	7	6	6.67
Shell Color	5	6	5	5.33
Average	7.4	7.2	6.8	7.13

Appendix III: Biochemical Test**Normal Condition**

Gher				
	Sample 1	Sample 2	Sample 3	Average
TVB-N (mg N/100g)	2.67	2.07	2.47	2.40
TMA-N (mg N/100g)	2.68	2.78	2.64	2.70
Depot				
	Sample 1	Sample 2	Sample 3	Average
TVB-N (mg N/100g)	18.68	12.68	14.68	15.35
TMA-N (mg N/100g)	2.66	3.04	2.94	2.88
Agent				
	Sample 1	Sample 2	Sample 3	Average
TVB-N (mg N/100g)	5.34	5.31	5.30	5.32
TMA-N (mg N/100g)	2.61	2.76	2.96	2.78
Processing Plant				
	Sample 1	Sample 2	Sample 3	Average
TVB-N (mg N/100g)	8.01	8.49	7.90	8.13
TMA-N (mg N/100g)	2.86	3.04	2.94	2.88

Controlled Study

Gher				
	Sample 1	Sample 2	Sample 3	Average
TVB-N (mg N/100g)	4.11	6.91	7.49	6.17
TMA-N (mg N/100g)	2.62	2.76	2.92	2.77
Depot				
	Sample 1	Sample 2	Sample 3	Average
TVB-N (mg N/100g)	8.01	7.98	7.56	7.85
TMA-N (mg N/100g)	10.69	10.74	10.82	10.75
Agent				
	Sample 1	Sample 2	Sample 3	Average
TVB-N (mg N/100g)	8.08	8.90	8.75	8.58
TMA-N (mg N/100g)	2.69	2.74	2.90	2.78
Processing Plant				
	Sample 1	Sample 2	Sample 3	Average
TVB-N (mg N/100g)	5.37	5.49	7.01	5.96
TMA-N (mg N/100g)	8.05	9.05	8.45	8.52

Appendix IV: Microbial Test

Standard Plate Count

Normal Condition				
Gher	Conc.	Cfu(Coloni forming units)		
	10^{-1}	300	320	294
	10^{-2}	109	100	110
	10^{-2}	84	64	63
	10^{-3}	45	65	25
	10^{-3}	40	35	30
Result =		$0.42 \times 10^5/\text{gm}$	$0.5 \times 10^5/\text{gm}$	$0.086 \times 10^5/\text{gm}$
Log ₁₀ Value =		4.65	4.70	3.93

Normal Condition				
Depot	Conc.	Cfu		
	10^{-1}	380	320	385
	10^{-2}	175	140	170
	10^{-2}	150	130	145
	10^{-3}	118	108	140
	10^{-3}	98	89	100
Result =		$1.08 \times 10^5/\text{gm}$	$0.98 \times 10^5/\text{gm}$	$1.2 \times 10^5/\text{gm}$
Log ₁₀ Value =		5.03	4.99	5.08

Normal Condition				
Agent	Conc.	Cfu		
	10^{-1}	220	232	218
	10^{-2}	180	220	165
	10^{-2}	160	142	142
	10^{-3}	150	185	165
	10^{-3}	90	85	89
Result =		$1.2 \times 10^5/\text{gm}$	$1.3 \times 10^5/\text{gm}$	$1.2 \times 10^5/\text{gm}$
Log ₁₀ Value =		5.08	5.11	5.08

Normal Condition				
Processing Plant	Conc.	Cfu		
	10^{-1}	33	40	25
	10^{-2}	38	35	30
	10^{-2}	30	30	32
	10^{-3}	11	34	35
	10^{-3}	16	38	38
Result =		$0.034 \times 10^5/\text{gm}$	$0.36 \times 10^5/\text{gm}$	$0.36 \times 10^5/\text{gm}$
Log ₁₀ Value =		3.53	4.56	4.56

Coliform

Normal Condition										
Gher	Broth Base	Concentration								
		10 ⁻¹			10 ⁻²			10 ⁻³		
	LSTB	2	1	1	3	3	2	3	3	3
	BGLB	1	1	1	2	2	1	2	2	2
	TW	1	1	0	1	1	0	1	2	0
Result:		TC:	53/gm		TC:	29/gm		TC:	24/gm	
		FC:	11/gm		FC:	15/gm		FC:	Absent	

Normal Condition										
Depot	Broth Base	Concentration								
		10 ⁻¹			10 ⁻²			10 ⁻³		
	LSTB	0	1	0	0	2	0	1	2	1
	BGLB	0	1	0	0	2	0	1	2	0
	TW	0	1	0	0	1	0	1	0	0
Result:		TC:	3/gm		TC:	20/gm		TC:	3/gm	
		FC:	3/gm		FC:	7/gm		FC:	Absent	

Normal Condition										
Agent	Broth Base	Concentration								
		10 ⁻¹			10 ⁻²			10 ⁻³		
	LSTB	3	2	1	1	2	1	0	1	0
	BGLB	1	1	0	0	1	0	0	1	0
	TW	0	1	0	0	1	0	0	0	0
Result:		TC:	43/gm		TC:	28/gm		TC:	7/gm	
		FC:	Absent		FC:	7/gm		FC:	Absent	

Normal Condition										
P. Plant	Broth Base	Concentration								
		10 ⁻¹			10 ⁻²			10 ⁻³		
	LSTB	2	0	1	2	1	1	1	0	1
	BGLB	2	0	1	2	0	1	1	0	0
	TW	1	0	0	0	0	1	0	0	0
	Result:		TC:	28/gm		TC:	3/gm		TC:	11/gm
		FC:	4/gm		FC:	Absent		FC:	3/gm	

Standard Plate Count

Controlled Study				
Gher	Conc.	Cfu		
	10^{-1}	375	370	342
	10^{-2}	147	165	130
	10^{-2}	135	140	135
	10^{-3}	53	94	79
	10^{-3}	44	81	81
Result =		$0.14 \times 10^5/\text{gm}$	$0.87 \times 10^5/\text{gm}$	$0.80 \times 10^5/\text{gm}$
Log ₁₀ Value =		4.15	4.94	4.90

Controlled Study				
Depot	Conc.	Cfu		
	10^{-1}	400	410	399
	10^{-2}	325	302	344
	10^{-2}	355	313	300
	10^{-3}	200	175	201
	10^{-3}	170	140	114
Result =		$1.08 \times 10^5/\text{gm}$	$1.5 \times 10^5/\text{gm}$	$1.5 \times 10^5/\text{gm}$
Log ₁₀ Value =		5.26	5.18	5.18

Controlled Study				
Agent	Conc.	Cfu		
	10^{-1}	350	342	350
	10^{-2}	91	100	100
	10^{-2}	85	92	84
	10^{-3}	21	35	35
	10^{-3}	44	34	32
Result =		$0.08 \times 10^5/\text{gm}$	$0.09 \times 10^5/\text{gm}$	$0.09 \times 10^5/\text{gm}$
Log ₁₀ Value =		3.90	3.94	3.94

Controlled Study				
Processing Plant	Conc.	Cfu		
	10^{-1}	89	100	102
	10^{-2}	80	85	83
	10^{-2}	69	84	84
	10^{-3}	60	72	70
	10^{-3}	43	50	69
Result =		$0.07 \times 10^5/\text{gm}$	$0.08 \times 10^5/\text{gm}$	$0.08 \times 10^5/\text{gm}$
Log ₁₀ Value =		3.85	3.90	3.90

Coliform

Controlled Study										
Gher	Broth Base	Concentration								
		10 ⁻¹			10 ⁻²			10 ⁻³		
	LSTB	2	1	2	0	0	1	0	0	1
	BGLB	2	0	0	0	0	1	0	0	0
TW		1	0	0	0	0	0	0	0	0
Result:		TC:	9/gm		TC:	4/gm		TC:	20/gm	
		FC:	9/gm		FC:	Absent		FC:	Absent	

Controlled Study										
Depot	Broth Base	Concentration								
		10 ⁻¹			10 ⁻²			10 ⁻³		
	LSTB	2	0	2	0	1	2	0	0	1
	BGLB	1	0	2	0	0	2	0	0	0
TW		1	0	1	0	0	1	0	0	0
Result:		TC:	9/gm		TC:	3/gm		TC:	28/gm	
		FC:	4/gm		FC:	Absent		FC:	7/gm	

Controlled Study										
Agent	Broth Base	Concentration								
		10 ⁻¹			10 ⁻²			10 ⁻³		
	LSTB	2	1	0	1	0	1	0	2	0
	BGLB	2	1	0	1	0	0	0	2	0
TW		1	0	0	0	0	0	0	1	0
Result:		TC:	15/gm		TC:	11/gm		TC:	3/gm	
		FC:	4/gm		FC:	3/gm		FC:	Absent	

Controlled Study										
P. Plant	Broth Base	Concentration								
		10 ⁻¹			10 ⁻²			10 ⁻³		
	LSTB	1	1	0	0	0	1	1	0	1
	BGLB	1	0	0	0	0	1	1	0	0
TW		1	0	0	0	0	0	0	0	0
Result:		TC:	7/gm		TC:	4/gm		TC:	9.1/gm	
		FC:	4/gm		FC:	Absent		FC:	Absent	

APPENDIX V: *Salmonella* sps. detection

Agar Base			Broth Base		
Tetrathionate			Selenite		
XLDA	YES / NO ✓		YES / NO ✓		
Result:	<i>Salmonella</i>	(Absent ✓ / Suspected) /			
		25gm			
Agar Base			Broth Base		
Tetrathionate			Selenite		
XLDA	YES / NO ✓		YES / NO ✓		
Result:	<i>Salmonella</i>	(Absent ✓ / Suspected) /			
		25gm			
Agar Base			Broth Base		
Tetrathionate			Selenite		
XLDA	YES / NO ✓		YES / NO ✓		
Result:	<i>Salmonella</i>	(Absent ✓ / Suspected) /			
		25gm			
Agar Base			Broth Base		
Tetrathionate			Selenite		
XLDA	YES / NO ✓		YES / NO ✓		
Result:	<i>Salmonella</i>	(Absent ✓ / Suspected) /			
		25gm			
Agar Base			Broth Base		
Tetrathionate			Selenite		
XLDA	YES / NO ✓		YES / NO ✓		
Result:	<i>Salmonella</i>	(Absent ✓ / Suspected) /			
		25gm			

APPENDIX VI: *Vibrio* sps. detection

Normal Practice			Controlled Study		
Gher			Gher		
Agar Base	Colony		Agar Base	Colony	
TCBSA	YES / NO ✓		TCBSA	YES / NO ✓	
Result:	<i>Vibrio</i> sps.	(Absent ✓ / Suspected) / 25gm	Result:	<i>Vibrio</i> sps.	(Absent ✓ / Suspected) / 25gm

Normal Practice			Controlled Study		
Depot			Depot		
Agar Base	Colony		Agar Base	Colony	
TCBSA	YES / NO ✓		TCBSA	YES / NO ✓	
Result:	<i>Vibrio</i> sps.	(Absent ✓ / Suspected) / 25gm	Result:	<i>Vibrio</i> sps.	(Absent ✓ / Suspected) / 25gm

Normal Practice			Controlled Study		
Agent			Agent		
Agar Base	Colony		Agar Base	Colony	
TCBSA	YES / NO ✓		TCBSA	YES / NO ✓	
Result:	<i>Vibrio</i> sps.	(Absent ✓ / Suspected) / 25gm	Result:	<i>Vibrio</i> sps.	(Absent ✓ / Suspected) / 25gm

Normal Practice			Controlled Study		
Processing Plant			Processing Plant		
Agar Base	Colony		Agar Base	Colony	
TCBSA	YES / NO ✓		TCBSA	YES / NO ✓	
Result:	<i>Vibrio</i> sps.	(Absent ✓ / Suspected) / 25gm	Result:	<i>Vibrio</i> sps.	(Absent ✓ / Suspected) / 25gm



Appendix VII: T-test result for Organoleptic Quality

GHER:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	8.8	8.866
Variance	0.9789	0.80923
Observations	5	5
Pearson Correlation	0.8059550	
Hypothesized Mean Difference	0	
Df	4	
t Stat	-0.2482256	
P(T≤t) one-tail	0.4080912	
t Critical one-tail	2.1318464	

AGENT:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	6.668	7.466
Variance	1.05112	0.70468
Observations	5	5
Pearson Correlation	0.8085715	
Hypothesized Mean Difference	0	
Df	4	
t Stat	-2.9575035	
P(T≤t) one-tail	0.0208287	
t Critical one-tail	2.1318464	

DEPOT:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	5.466	6.668
Variance	1.53468	0.89112
Observations	5	5
Pearson Correlation	0.85540271	
Hypothesized Mean Difference	0	
Df	4	
t Stat	-4.1222440	
P(T≤t) one-tail	0.00729287	
t Critical one-tail	2.13184649	

P. PLANT:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	6.334	7.134
Variance	1.27723	1.31423
Observations	5	5
Pearson Correlation	0.13069641	
Hypothesized Mean Difference	0	
Df	4	
t Stat	-1.1918282	
P(T≤t) one-tail	0.1496028	
t Critical one-tail	2.13184649	

Appendix VIII: T-test result for TVB-N**GHER:****t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	2.40333333	6.17
Variance	0.09333333	3.2668
Observations	3	3
Pearson Correlation	-0.64109679	
Hypothesized Mean Difference	0	
Df	2	
t Stat	-3.23459735	
P(T≤t) one-tail	0.041873352	
t Critical one-tail	2.91998731	

DEPOT:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	15.3466667	7.85
Variance	9.33333333	0.0633
Observations	3	3
Pearson Correlation	0.2471914	
Hypothesized Mean Difference	0	
Df	2	
t Stat	4.32420847	
P(T≤t) one-tail	0.02476954	
t Critical one-tail	2.91998731	

AGENT:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	5.31666667	8.5766667
Variance	0.00043333	0.1906333
Observations	3	3
Pearson Correlation	-0.9150374	
Hypothesized Mean Difference	0	
Df	2	
t Stat	-12.389677	
P(T≤t) one-tail	0.00322575	
t Critical one-tail	2.91998731	

P. PLANT:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	8.13333333	5.9566667
Variance	0.09843333	0.8357333
Observations	3	3
Pearson Correlation	-0.5924799	
Hypothesized Mean Difference	0	
Df	2	
t Stat	3.34012068	
P(T≤t) one-tail	0.03957009	
t Critical one-tail	2.91998731	

Appendix IX: T-test result for TMA-N**GHER:****t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	2.7	2.7666667
Variance	0.0052	0.0225333
Observations	3	3
Pearson Correlation	-0.31409753	
Hypothesized Mean Difference	0	
Df	2	
t Stat	-0.62136976	
P(T≤t) one-tail	0.29887050	
t Critical one-tail	2.91998731	

AGENT:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	2.77666667	2.7766667
Variance	0.03083333	0.0120333
Observations	3	3
Pearson Correlation	0.97774135	
Hypothesized Mean Difference	0	
Df	2	
t Stat	-3.5556E-15	
P(T≤t) one-tail	0.5	
t Critical one-tail	2.91998731	

DEPOT:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	2.88	10.75
Variance	0.0388	0.0043
Observations	3	3
Pearson Correlation	0.61161341	
Hypothesized Mean Difference	0	
Df	2	
t Stat	-82.5000166	
P(T≤t) one-tail	0.00007344	
t Critical one-tail	2.91998731	

P. PLANT:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	2.88	8.5166667
Variance	0.0228	0.2533333
Observations	3	3
Pearson Correlation	0.68421053	
Hypothesized Mean Difference	0	
Df	2	
t Stat	-23.5315476	
P(T≤t) one-tail	0.00090052	
t Critical one-tail	2.91998731	

Appendix X: T-test result for SPC**GHER:****t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	4.42666667	4.6633333
Variance	0.18563333	0.1980333
Observations	3	3
Pearson Correlation	-0.40829323	
Hypothesized Mean Difference	0	
Df	2	
t Stat	-0.5577082	
P(T≤t) one-tail	0.3165687	
t Critical one-tail	2.91998731	

AGENT:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	5.09	3.93
Variance	0.0003	0.0007
Observations	3	3
Pearson Correlation	0.32732684	
Hypothesized Mean Difference	0	
Df	2	
t Stat	75.9398258	
P(T≤t) one-tail	8.668E-05	
t Critical one-tail	2.91998731	

DEPOT:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	5.03333333	5.2066667
Variance	0.00203333	0.0021333
Observations	3	3
Pearson Correlation	-0.0640184	
Hypothesized Mean Difference	0	
Df	2	
t Stat	-4.5089718	
P(T≤t) one-tail	0.0229157	
t Critical one-tail	2.91998731	

P. PLANT:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	4.21666667	3.8833333
Variance	0.35363333	0.0008333
Observations	3	3
Pearson Correlation	1	
Hypothesized Mean Difference	0	
Df	2	
t Stat	1.02040816	
P(T≤t) one-tail	0.20743721	
t Critical one-tail	2.91998731	

Appendix XI: T-test result for TC**GHER:****t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	35.3333333	11
Variance	240.333333	67
Observations	3	3
Pearson Correlation	-0.36644479	
Hypothesized Mean Difference	0	
Df	2	
t Stat	2.10645098	
P(T≤t) one-tail	0.08487869	
t Critical one-tail	2.91998731	

AGENT:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	26.96666667	
Variance	327.3733333	
Observations	3	3
Pearson Correlation	0.99556684	
Hypothesized Mean Difference	0	
Df	2	
t Stat	2.35478972	
P(T≤t) one-tail	0.07136116	
t Critical one-tail	2.91998731	

DEPOT:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	8.66666667	13.333333
Variance	96.3333333	170.33333
Observations	3	3
Pearson Correlation	-0.68567963	
Hypothesized Mean Difference	0	
Df	2	
t Stat	-0.38431963	
P(T≤t) one-tail	0.36887798	
t Critical one-tail	2.91998731	

P. PLANT:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	14	6.7
Variance	163	6.57
Observations	3	3
Pearson Correlation	0.40794797	
Hypothesized Mean Difference	0	
Df	2	
t Stat	1.0578229	
P(T≤t) one-tail	0.20051434	
t Critical one-tail	2.91998731	

Appendix XII: T-test result for FC**GHER:****t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	8.66666667	3
Variance	60.3333333	27
Observations	3	3
Pearson Correlation	0.26015295	
Hypothesized Mean Difference	0	
Df	2	
t Stat	1.20509805	
P(T≤t) one-tail	0.17570477	
t Critical one-tail	2.91998731	

AGENT:**t-Test: Paired Two Sample for Means**

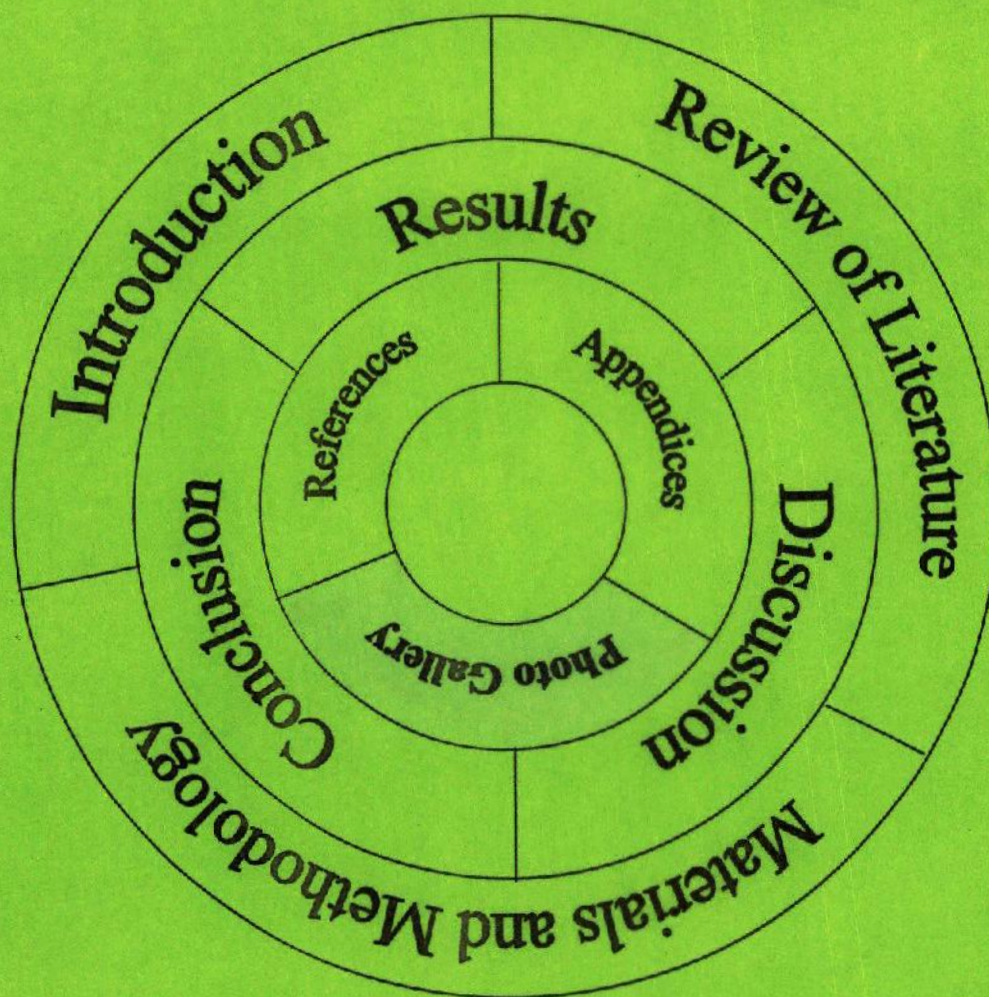
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	2.33333333	2.33333333
Variance	16.3333333	4.33333333
Observations	3	3
Pearson Correlation	0.2773501	
Hypothesized Mean Difference	0	
Df	2	
t Stat	0	
P(T≤t) one-tail	0.5	
t Critical one-tail	2.9199873	

DEPOT:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	3.33333333	3.66666667
Variance	12.3333333	12.3333333
Observations	3	3
Pearson Correlation	-1	
Hypothesized Mean Difference	0	
Df	2	
t Stat	-0.0821995	
P(T≤t) one-tail	0.4709871	
t Critical one-tail	2.9199873	

P. PLANT:**t-Test: Paired Two Sample for Means**

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	2.33333333	1.33333333
Variance	4.33333333	5.33333333
Observations	3	3
Pearson Correlation	0.69337525	
Hypothesized Mean Difference	0	
df	2	
t Stat	1	
P(T≤t) one-tail	0.21132486	
t Critical one-tail	2.91998731	



Current Position Indicator

Photo Gallery

9.0 PHOTO GALLERY



Netting in Gher



Sorting of Shrimp in Depot



De-heading of Shrimp in Depot



Sorting of Shrimp in Agent

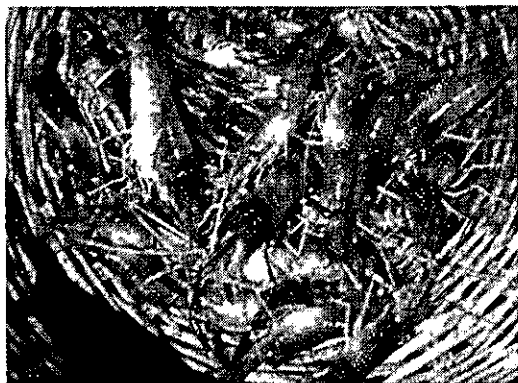


Weighting of Shrimp in P.Plant



Grading of Shrimp in P. Plant

Laboratory Works



**Shrimp for Organoleptic
Evaluation**



**Titration in Conway Micro
Diffusion Plate**



**Sample collection by micro
pipette**



Incubation