



**Investigations on the quality and shelf life of *Harpodon nehereus*,
Pampus chinensis and *Penaeus monodon* during smoke curing,
traditional sun drying and drying in the tunnel drier**

A Thesis Submitted in Partial Fulfillment for the Degree of
Requirements M. Phil in Fisheries

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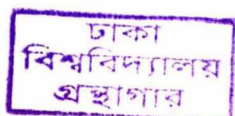


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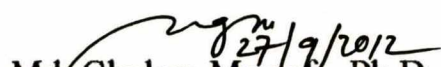
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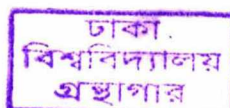
Certificate

This is to certify that this thesis entitled "Investigations on the quality and shelf life of *Harpodon nehereus*, *Pampus chinensis* and *Penaeus monodon* during smoking, traditional sun drying and drying in the tunnel drier" submitted by Kismat Ara has been carried out under my supervision. This is further to certify that it is an original work and suitable in partial fulfillment for the degree of M. Phil. in Fisheries, University of Dhaka.


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Dedicated

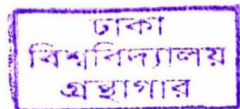
to my

beloved uncle

Late. Md. Abul Kalam Shumsuddin

Ex-Principal of Ekramunnesa degree

College, Rampura, Dhaka, Bangladesh.



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The Author

A great quantity of fish have been found to spoil during post harvest period of fresh water fish, marine water fish as well as fishes harvested from waterbody where fish is cultured in our country as well as in many other countries of the world. Fish processing and preservation have been introduced by the working Scientists Fish Technology as well as by the educated professional with a view to minimize the spoilage loss of the fishes during post harvest period. We have take the present thesis work involving quantitative and qualitative changes of three species of fishes such as Chinese Pomfret, Bombay duck and black tiger Shrimp respectively during the processing and preservation method of sun drying, solar tunnel drying and smoke curing method as well as during storage to study the shelf life of the fishery products .

We have collected three well known species of fish Chinese Pomfret, Bombay duck and black tiger Shrimp and analyzed their biochemical composition in highly fresh and acceptable raw condition. We have also processed the above mentioned three species of fish through sun drying, solar tunnel drying and smoke curing method of fish processing and preservation method. The processed fish products during processing period and during preservation and storage period were evaluated by both physical and chemical parameters with a view to assess their standard of quality and shelf life.

The experimental results were statistically analyzed by using SPSS-12 version and SPSS-20 version. The average biochemical composition of the smoke cured, the Solar Tunnel dried and sun dried unsalted Chinese Pomfret samples contained $24.23 \pm 0.237\%$ moisture, $55.01 \pm 0.256\%$ protein, $10.97 \pm 0.218\%$ fat, $9.32 \pm 0.218\%$ ash; $17.17 \pm 0.209\%$ moisture, $62.09 \pm 0.198\%$ protein, $12.08 \pm 0.188\%$ fat, $10.23 \pm 0.223\%$ ash and $22.13 \pm 0.266\%$ moisture, $59.98 \pm 0.243\%$ protein, $8.91 \pm 0.261\%$ fat, $8.60 \pm 0.142\%$ ash respectively whereas salted Chinese Pomfret samples contained $26.08 \pm 0.237\%$ moisture, $54.20 \pm 0.356\%$ protein, 8.88% fat, $7.78 \pm 0.161\%$ ash; $20.20 \pm 0.221\%$ moisture, $58.10 \pm 0.183\%$ protein, $11.06 \pm 0.187\%$ fat, $8.12 \pm 0.224\%$ ash and $23.09 \pm 0.262\%$ moisture, $57.19 \pm 0.258\%$ protein, $10.14 \pm 0.242\%$ fat, $6.93 \pm 0.217\%$ ash respectively. The average biochemical composition of the smoke cured, the Solar Tunnel dried and sun dried unsalted Bombay duck samples contained $25.06 \pm 0.268\%$ moisture, $54.01 \pm 0.345\%$ protein, $11.75 \pm 0.246\%$ fat, $10.51 \pm 0.164\%$ ash; $15.99 \pm 0.227\%$ moisture, $63.18 \pm 0.229\%$ protein, $13.11 \pm 0.196\%$ fat, $9.93 \pm 0.225\%$ ash and $21.80 \pm 0.358\%$ moisture, $58.24 \pm 0.376\%$ protein, $11.17 \pm 0.233\%$ fat, $9.40 \pm 0.233\%$ ash

respectively whereas salted Bombay duck samples contained 27.12 ± 0.241 %moisture, 51.84 ± 0.484 % protein, 9.93 ± 0.207 % fat, 8.58 ± 0.104 % ash; 17.96 ± 0.228 % moisture, $60.100.231$ % protein, 12.09 ± 0.223 % fat, 8.43 ± 0.208 % ash and 25.16 ± 0.259 % moisture, 55.26 ± 0.219 % protein, 9.33 ± 0.186 % fat, 8.01 ± 0.182 % ash respectively. The average biochemical composition of the smoke cured, the Solar Tunnel dried and sun dried unsalted black tiger Shrimp samples contained 25.88 ± 0.242 %moisture, 59.80 ± 0.368 % protein, 7.59 ± 0.218 % fat, 8.78 ± 0.133 % ash; 17.89 ± 0.233 % moisture, 60.15 ± 0.239 % protein, 11.62 ± 0.108 % fat, 9.77 ± 0.295 % ash and 21.70 ± 0.366 %moisture, 57.25 ± 0.374 % protein, 11.15 ± 0.216 % fat, 10.09 ± 0.155 % ash respectively whereas salted Shrimp samples contained 28.02 ± 0.250 %moisture, 52.36 ± 0.187 % protein, 7.30 ± 0.277 % fat, 8.30 ± 0.208 % ash; 20.96 ± 0.219 % moisture, 57.76 ± 0.331 % protein, 10.23 ± 0.205 % fat, 9.59 ± 0.153 % ash and 24.23 ± 0.212 %moisture, 55.38 ± 0.185 % protein, 9.24 ± 0.202 % fat, 8.15 ± 0.197 % ash respectively.

The co-relation coefficient of the sun dried, the Solar Tunnel dried and smoke cure cured unsalted and salted Chinese Pomfret samples expressed as “r” between moisture and protein, moisture and fat, protein and fat had been computed which were (-)0.959, (-) 0.954, (+) 0.912 and (-) 0.075, (-) 0.055, (+) 0.522; (-)0.248, (-) 0.830, (+) 0.896 and (-)0.835, (-) 0.963, (+)0.858; (-)0.955, (-)0.243, (+) 0.086 and (-) 0.744, (-) 0.513, (+)0.376 respectively. The co-relation coefficient of the sun dried, the Solar Tunnel dried and smoke cure cured unsalted and salted Bombay duck samples expressed as “r” between moisture and protein, moisture and fat, protein and fat had been computed which were (-)0.991, (-) 0.786, (+) 0.818 and (-) 0.647, (-) 0.232, (+) 0.561; (-) 0.943, (-) 0.976, (+) 0.966 and (-) 0.985, (-) 0.987, (+) 0.986; (-) 0.817, (-) 0.844, (+) 0.844 and (-) 0.821, (-) 0.680, (+) 0.611 respectively. The co-relation coefficient of the sun dried, the Solar Tunnel dried and smoke cure cured unsalted and salted black tiger Shrimp samples expressed as “r” between moisture and protein, moisture and fat, protein and fat had been computed which were (-) 0.951, (-) 0.386, (+) 0.415 and (-) 0.614, (-) 0.854, (+) 0.703; (-) 0.982, (-) 0.926, (+) 0.982 and (-) 0.875, (-) 0.881, (+) 0.878; (-) 0.110, (-) 0.651, (+) 0.633 and (-) 0.692, (-) 0.892, (+) 0.750 respectively.

Analytical work along with physical parameters study indicated that Solar Tunnel Dried fish products are better in quality than dried and dehydrated fish products produced by the two other methods of fish processing and preservation methods. Solar Tunnel Dryer > Sun Drying

> Smoke Curing . Salt and Turmeric treated dried and dehydrated fish products were found to have better quality than salt treated and unsalted fish products. That is salt +turmeric treated fish products > salt treated fish products > unsalted fish products. Shelf life and quality control study of the three species of experimental fish products (Chinese Pomfret, Bombay duck and black tiger Shrimp) while stored at ambient temperature and at refrigerated temperature were found to have 150 days of shelf life (five months) and 180 days of shelf life (Six months) at refrigerated temp. Irrespective of fish processing and preservation methods (solar tunnel dryer ,sun drying & smoke curing), the processed fish products were found to have longer shelf life at refrigerated temperature than the fish product stored at ambient temperature .

TVN value /100 gm fish product were found to increase from 61mg/100g to 330mg/100g fish products in case of dried and dehydrated Bombay duck and the corresponding sensory score value decrease from 9.0 to 5.0. During the same period of storage life dried fish products kept at thick polythene paper were found to have longer shelf life than the fish product kept at thin polythene at ambient temp.

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CHAPTER -I

CHAPTER- I INTRODUCTION

Fish is one of the most familiar and popular consumable food item in dishes of Bangladeshi people irrespective of professional of rural or urban area and among the rich or poor section people. Fish alone is supplementing about 60% of the animal protein of our daily diet. Recent trends toward more functional and healthier food products have strengthened the consumption of processed fish products in the European Community (Dirk and Markus, 2004). Also, the consumers are becoming more health conscious and interested in convenience fish food. The changing pattern of the lifestyle and increasing number of households in the rural area have an impact on the market demand since consumers nowadays prefer the products that should be acceptable in terms of both quality and safety. In order to solve this problem, some new drying methods and techniques have been introduced by many working scientists. Drying such as solar drying, vacuum freeze drying and microwave drying (Bala and Mondol, 2001) were done with shrimp and many other species of fishes. On the other hand it has got economical value having direct and indirect contribution on economical development by creating job facilities during fish culture, harvesting, handling, processing and marketing both inside and outside the country. Processed fish product of Bangladesh especially frozen fish product, dried and dehydrated fish product, and semi fermented fish product (Chapa shutki) etc while exported abroad earned foreign currency there by having direct effect on the economical development of our motherland – Bangladesh. At present 2.73 % of the country's export earning comes from this sector alone-DoF Annual report 2011.

In other words fishery and fishery products have got direct relationship to contribute a vast formation Bangladeshi culture and as well as nutritional and economical development within our country. Fish processing and preservation method have been developed to minimize the spoilage loss of the fish during post harvest handling, marketing etc. And there by getting importance of the role of the fish processor through establishing and running fish processing industries and thus putting more nutrition to the Bangladeshi nationals. Direct contribution for increasing the economical and nutritional value of fish in Bangladesh and fishery Exports of Bangladesh have increased by about 15% a year over the past 10 years. Fish fishery products now hold fourth position in export earnings in comparison with garment, jute, and leather (FAO, 1992). The fish processing industry has been able to expand and diversify the markets which now include over 20 countries of the world (EPB, 1995). We the academic personals have taken the present problem entitled (Investigation on the quality and shelf life

bacteria. A saturated salt solution has a water activity of 0.75 (Horner, 1992). Maximum salt concentration attainable in fish tissue under saturated salt solution is around 26% under normal temperature. Salting is done in combination with sun drying and smoking for variety of species. But sometimes excess salting may denature protein and impact upon the sensory and biochemical properties of the final product. Low quality of pure salt is used that inhibits the development of good texture, attractive color and nice flavor of the product.

Salt has long been used both as the primary preserving ingredient, and in combination with other methods such as drying and smoking. Salting is usually done by one of the four methods, dry salting, pickle salting, mixed salting and brine salting. These processes require constant handling of the fish and the process could take up to 3 months to complete. Product quality is usually quite low. In addition, most of the salted products require refrigeration and have a very limited shelf life, a distinct disadvantage for underdeveloped countries or subtropics (Tressler and Lemmon, 1951; Stansby and Lemmon, 1963; Burgess et al., 1965). Common salt (NaCl) preserve the fish when sufficient water extract from fish tissue and salt penetrating into fish (Cutting and Waterman, 1965). It is used in pre-historic time (Tressler and Lemmon, 1951) with extensive advance in other countries.

Sun drying is one of the most important low cost methods and the product plays an important role particularly in providing nutrition to the poor and economically disadvantaged people in many Asian countries. In developing countries, including Bangladesh, traditional fish-drying practice on the sand of the sea beach, on raised bamboo racks and on the bamboo made covering are very common. The drying process in the sun takes about 1 week depending on the climatic conditions. The longer duration of drying causes considerable spoilage, blowfly infestation, broken pieces and contamination with filth and soil particles. Some reports indicate that losses from insects, animals and weather may be up to 30 to 40% (Hollick, 1999; Wall et al., 2001). There is also widespread use of different types of insecticides to avoid insect infestation during the traditional drying process that make the product unattractive to the consumers (Reza et al., 2005). Besides, considerable postharvest losses are reported to occur during processing, storage and during different stages of marketing channel. The physical and organoleptic qualities of most of the traditional sun-dried products available in the market are not satisfactory for human consumption (Kamruzzaman, 1992; Saha, 1999).

Solar drying in a fishing community is an alternative to the traditional sun drying for producing products of required quality and minimizes the post-harvest losses. In a previous

study, a Hohenheim-type solar tunnel dryer, constructed with locally available material, was found very suitable for drying of salt treated silver jew fish at temperature of 35 to 52°C for 5 days without showing any infestation, oxidative rancidity, spoilage and contamination (Bala and Mondol, 2001). The design of this dryer realizes the demand for higher drying capacity and better moisture removal. However, optimization of the drying process for producing high quality dried fish products was not performed, which is very important for commercial use of the solar tunnel dryer.

Polythene tent solar driers were introduced in coastal areas of Bangladesh in 1977. This drier was effective in controlling insect larvae. But it did not provide any improvement in the performance of drying although the temperature inside drier was 7-20°C higher than the ambient temperature. The polythene tent solar drier thus suffers from the limitation due to extremely low buoyancy induced low airflow inside the drier. Though the polythene tent drier for producing improved quality dried fish products were successful but it was successful only experimentally and not on commercial scale. There was little merit of the tent drier in the early stages of drying fish when the drying process governed by the transmission of moisture from the surface and exposed to wind. In tropical climates, under humid conditions, heavy infestation of unsalted dried fish by blow flies may cause up to 30% loss of the product (Wood, 1981).

It is very important to know the chemical composition of the flesh of fish in order to ascertain its nutritional quality and to determine the proper condition for its processing and preservation. The biochemical composition of fish is affected by numerous factors either of intrinsic or extrinsic in nature. The spoilage nature of fish also varies from one species to another and within the same species. The physical properties and chemical composition of the fish may also vary within the same species depending on the state of maturity, size, seasons sex and from where the fish is harvested. The nutritive values of the processed and preserved fish are influenced by chemical nature of their fat and lipid component also. In order to evaluate the nutritional status of the raw fish and dried fish, it is necessary to collect relevant information particularly on the biochemical composition of the fish sample concerned.

In Bangladesh most of the dried fish products are marketed without adequate packaging. The products losses the quality and quantity through spoilage and insect attack as well as uptake of moisture from the environment especially during storage

and marketing. Dried fish wrapped in polythene bags during storage is found to have better shelf life than the fish kept in gunny bags without wrapping in polythene bags. Not much precaution is taken by the processors to prevent bacterial growth resulting in spoilage of dried fish, which causes health hazards. Bacteria grow on the dried fish, which are harmful to man (Shewan and Liston, 1955; Sen et al., 1966).

The biochemical composition is an important aspect of fish quality and it influences both the keeping quality and technological characteristics of fish product. Large group of consumers have become more conscious and interested in processed fish products free from health hazard materials.

Again, a comparative study of tent drier, cabinet drier to be the most and a drier with a separate collector unit and drying unit shows the tent dryer to be the most suitable design (Curran and Trim, 1982; Sachithanathan et al., (1985) conducted four experimental trials in Yemen comparing the performance of solar drying and sun drying of fish.

In the middle of the nineteenth century made it possible for the first time to satisfy the demand for fresh fish in preference to the dried and salted fish available up till then, in the same period, changes in the taste for smoked fish, again brought about chiefly by quick railway transport. In most tropical developing fisheries, Smoking is used not only to impart desirable flavours but also and more importantly, to accelerate the drying process. Smoked products in tropical countries have storage properties which enable them to be marketed without the use of sophisticated refrigeration system. Smoking is often combined with a period of the sun drying. The temperature of smoking varies from place to place depending on consumer preference and the type of smoking Kiln or oven available for use. The fish are salted by twenty to thirty minutes immersion in 80 per cent saturated brine, the time depending on the size and fattiness of the fish.

Shephard, 2000. points out, archaeologists have uncovered the remains of what was evidently a substantial fish-smoking "factory" in Poland, dating back to the seventh century. And it is clear that European use of the technique was greatly expanded, perhaps mainly in order to deal with gluts of herring, in the medieval period. Dedicated smoke houses used for this purpose were in common use in England, and no doubt elsewhere in the fourteenth century. If the fire was smoky, fish would acquire a different flavor and keep better. Indeed Cutting, 1955. suggests that people might have begun to smoke fish deliberately in the

Neolithic. However, it seems to be uncertain whether such smoking of fish was carried out later on, in ancient Egypt or classical Greece and Rome.

Hot smoking was developed in northern Europe in medieval times. In this process the smoke temperature is very high and the fish is wholly or partly cooked by being smoked. Herring which were hot smoked on the northern coast of Germany were known as Bucklinge, which became “buckling” in English, but the process was also used for many other species of fish. The hot smoking of fish is also common in Africa. For example, a kind of shad is hot smoked in Ghana in primitive kilns made from oil drums. Hot smoked fish is succulent and tasty but in general does not travel or keep as well as cold smoked. Cold smoking, on the other hand, is not a cooking process; it consists simply in hanging fish in smoke (which may of course be slightly warm, but that is irrelevant), and the result keeps well.

Smoking is a method of fish preservation affected by a combination of drying and deposition of naturally produced chemicals resulting from the thermal break down of wood. It is a popular technology of fish preservation in many parts of the world. Modern fish smoking is, however, used to impart colour and flavor to the product rather than a simple preservation. Smoked fish is a delicacy in modern world and getting importance in many countries of Central Africa and Middle-eastern Asia is, on the other hand, largely a technical necessity rather than delicacy due to dry and less humid climatic conditions and other reasons (Watanabe and Dzekedzeke, 1969). The smoke fish product attracted the consumer in the Southeast Asia, smoking is practiced not necessarily to impart desirable colour and flavor, but mainly to accelerate the drying of the fish (Clucas and ward, 1996).

Sodium chloride (NaCl) content is one of the most important parameters in smoked and marinated products since it has a strong influence on flavor, as well as on aw, and consequently on shelf life. In this sense, Truelstrup et al., (1995) reported that in samples processed in the same way and stored under the same conditions but with different salt concentration in water phase (4.6 and 2.2% w/w), the high salt samples were acceptable for at least 2–3 weeks longer than low salt samples. However, the salt presence enhances lipid oxidation of fish, which is directly related to the production of off-flavors and odors, and also to protein denaturation and texture changes. The aim of marinating, as in the case of smoking, is not only to delay the product spoilage, but also to tenderize or to change the taste, textural and structural properties of raw material, resulting in a product with a characteristic sensory profile (Sallam et al., 2007).

For consumers, one of the most important purchase criteria, only after the remaining shelf life, is the appearance of the package (Rora et al., 2004). In this regard, Torrissen et al., (2000) also reported that the color of the fish is the main quality aspect of interest to consumers on both the German and the French market. In the food industry, much attention has been given to the packaging of the products, both as wrapping and for eye-catching appeal. For smoked fish products, it is important for the package to be designed so that the fish is clearly visible to the consumer.

Several studies have reported the effect of the smoking process on the quality parameters of many fish species (Truelstrup et al., 1995 ; Espe et al., 2001 ; Røra and Einen 2003; Martinez et al., 2007). However, there is little information about the values of physicochemical parameters in commercial smoked and marinated fish products; information about physicochemical characterization can only be found for commercial samples of cold-smoked salmon (Truelstrup et al., 1998; Cardinal et al., 2004; Espe et al., 2004; Røra et al. 2004). The characterization of smoked and marinated fish products could be useful in order to know the chemical composition and the typical values of the main quality parameters of these commercial products, as well as to establish the common characteristics of this type of products. This information would be a useful reference for producers and for researchers in the field of new product development.

The physical and organoleptic qualities of most of the traditional sun dried fish available in the market do not meet the expected standard for human consumption (Kamruzzaman, 1992; Khan, 1992; Saha, 1999) .There are frequent complaints from the consumers about the quality of the sun dried fish in Bangladesh. The major problems associated with sun drying of fish are infestation of the products by the fly and other insect larvae during drying and storage, contaminants associated with spoilage. But during sun drying of fish it has been observed that about 50% of the dried fish were wasted, 30% during drying and 20% during subsequent storage in high humid and high temperature condition, especially in subtropical countries like Bangladesh as estimated in study for improved sun drying of fish (Doe et al., 1977). To overcome this problem of wastage of fish during sun drying of fish, polythene tent dryer was developed for drying of fish.

Under the hot and generally humid conditions of the tropical countries including Bangladesh fish deteriorate rapidly after landing and methods of drying, salting or par-boiling have been developed as a means of prolonging shelf life and getting the fish to distant markets in good

condition. Notwithstanding such efforts, processed fish are prone to infestation by certain insect and mites which can cause considerable losses. Estimates of quantities of fish, damaged by insect pests to be marketed, are sometimes put as high as 50% financial losses (Rolling and Hayward, 1962; Aref et al., 1964).

Drying involves removal of water from a fish body. Traditionally, sun drying is carried out in the open air using the solar energy to evaporate the water in the food. The evaporated water is then carried away by the natural air currents. The processing method of open sun drying fish to produce dried fish has got disadvantages, some of which are the inferior product, in quality due to contamination with dirt, sand, fly larvae infestations and overall the whole process is dependable on weather condition. Drying parameters are not also controlled. Overall the sundried fish products do not meet the expected quality standard. If not properly stored, then the sun dried fish products possess a shorter period of shelf life in comparison with other types of mechanical drying.

Fresh and dried fish is very popular food item. Fish contributes about 9% of total protein consumption and 63% of the per capita animal protein intake in the daily diet of the people. Fish protein is said to be healthier and cholesterol free. Fish is only protein that contain all the Essential Amino Acids (EAA) in about right proportion and such called complete protein needed for the proper growth and development of human body (Hossain, 1996)

In order to improve the dried and dehydrated fish quality and extend the shelf life of the dried fish product many attempts were made. One of the such attempt made it possible to design and construct Solar Tunnel Dryer at the experimental label. We have also designed and constructed solar tunnel dryer by using locally available raw materials and also tried to study the product quality and to find out the shelf life of the product at the experimental label. We have also attempted and compare the product quality of the experimental fishes as well as the shelf life comparison during storage at different storage conditions.

Objective of this thesis work:

The overall of the present thesis work have been written by pinpointing the objectives are under :

1. To take a comparative study on the quality assessment and shelf life study of the traditional sun dried, Solar Tunnel Dried and smoke cured product of *Pampus chinensis* (Chines Pomfret), *Harpodon nehereus* (Bombay duck) and *Penaeus monodon* (Black tiger Shrimp).
2. To develop and construct Solar Tunnel Drier using locally available raw materials.
3. To study the performance of developed self-life smoker while smoke curing of fishes and shrimp.
4. To assess the quality standard of the dried fish in the Solar Tunnel Dryer and traditional sundrying.
5. To assess the actual shelf life of the processing fishes and shrimp products in the laboratory during storage condition.
6. To study about some known parameters of quality of the dried, salted smoked fishes and shrimp.
7. To assess the quality of processed fishes and shrimp.

CHAPTER - II

CHAPTER II. LITERATURE REVIEW

Dry and dehydrated fish is one of the most important, popular and well known food item in the dishes of Bangladeshi people both in the urban and rural area and even also to the Bangladeshi community living outside Bangladesh throughout the world. The demand for dried fish and shrimp has also been driven by the characteristic flavor of each product. For example, dried and seasoned squid products dried salted cod (Doe et al., 1998), dried shrimp (Lin et al., 1999) and dried shark fin are one of most popular items which has gained wide acceptance in the U.S. and European markets and China, especially in the south, smoke pomfret is an important delicacy. Dried and dehydrated fish have been found to be a highly protein enriched food and is less costly in comparison with the other type processing fish products. Fish drying in the open sun and fish salting are nothing but very old method of fish processing and preservation and have been used since time immemorial throughout the world including Bangladesh. Fish drying in the sun by simple spreading the fish on the ground and the rocks make the fish product contaminated by the dirt, sand, mud etc and ranks below the expected quality standard. Some of the published works related with processing and preservation of the fish including drying, salting, smoking, freezing, canning, icing have been carried out throughout the world and also in Bangladesh, out of which are citing source of the published workes of fish processing and preservation the following portion:

BFRI (2012) made a comparative study on Solar Tunnel Dryer and observed that solar tunnel dried (*Lepturacanthus savala*) fish product contained 63.5% protein, 14.7% moisture, 10.7% fat and 06.9% salt. They observed that the solar tunnel dryer consume less time for drying of fish in comparison with traditional method of sun drying according to BFRI Solar Tunnel dried fish product displayed at the “Fisheries Fair-2012” at Ramna park area were dust free, free from fly larvae infestation and were better in quality.

Azad et al., (2011) studied at initial time of experimental TVN value of 4°C preserved fish of control chemical treated and radiated samples were 16.04±0.39, 13±0.18, 10.34±0.12 respectively and after 14 days TVN value of 4°C preserved fish control treated and radiated sample were 45.80±0.80, 33.88±0.03, 29.67±0.9 and TVN value of -3°C preserved control, treated and radiated were 15.73± 0.22, 12.73± 0.239, 34±0.12 and after 35 days TVN value were 60.59± 0.22, 55.59±0.10 and 38.81± 0.222.

Boran and Caracam (2011) studied seasonal change in proximate composition of some fish species from the Black sea over the period from to March in 2010. The average moisture

content in Horse mackerel, Shad, Garfish and Golden Mullet were in the range of 65.56-75.25%, 57.81-68.13%, 73.08-81.24% and 74.38%-80.11% respectively. The average protein content for six month was found to be 14.78% in horse mackerel.

Nurnadia et al. (2011) reported 77.72% moisture, 2.23% lipid, 19.55% protein, and 1.37% ash in black Pomfret (*Parastromaveus miger*); 79.32% moisture, 2.09% lipid, 18.63% protein and 1.01% ash in silver Pomfret (*Pampus argenteus*); 76.58 % moisture, 1.80% lipid, 20.51% protein and 1.26% ash in Indian mackerel (*Rastrelliger Kanagunta*); 80.13% moisture, 0.85% lipid, 19.59% protein and 1.09% ash in Indian thread Fin (*Polynemus indicas*).

Ahmed et al. (2010) analyzed quality change of salted kass (*Hydrocynus forskalii*) during storage at ambient temperature ($37\pm 10^{\circ}\text{C}$) and recorded 70.21% moisture, 20.20% protein, 1.9% ash and 1.84% lipid of fresh *Hydrocynus forskalii*.

Ahmed et al., (2009) studied effect of gamma radiation on the chemical, microbiological and organoleptic change in *Pampus chinensis*. The initial bacterial load of control was 1.3×10^4 and at the end of 90 days observation TBC values were 2.3×10^4 , 6.7×10^3 , 3.5×10^3 cfu/g in 3, 5 and 8 kGy treated respectively.

Fuentes et al., (2009) determined the proximate composition and physicochemical parameters of different smoked and marinated fish to provide a database with the typical values of the parameters which best define these products. Three batches corresponding to different purchase dates of 15 commercial products were analyzed. Great variability in all parameters was observed between products and between batches of a same product, e.g., in smoked anchovy, NaCl contents varied from 7.1 to 11.8% (w/w), which led to a wide variation in the a_w (from 0.877 to 0.931). These important differences found in moisture, NaCl contents, pH, a_w , water holding capacity, and color, between batches would affect product shelf life and its sensory features. This variability implies that the consumer expectations would not be met. For this reason, producers should adjust the processing parameters in order to obtain smoked and marinated fish with homogeneous characteristics.

Reza et al., (2009) conducted to optimize fish-drying process in a Hohenheim-type Solar Tunnel Dryer to produce safe and high quality dried fish products. Five commercially important tropical marine fish species in the Bay of Bengal such as silver jew fish, Bombay duck, big-eye tuna, Chinese pomfret and ribbon fish were used and drying was performed at

45 to 50 and 50 to 55°C temperature ranges. Moisture content of the fish samples reached 16% after 36 and 32 h of drying at temperature ranges of 45 to 50 and 50 to 55°C, respectively. Products produced at 45 to 50°C were found to be excellent on the basis of flavor, color and texture. Their rehydration ability ranged from 65 to 80% with minimum in big-eye tuna and maximum in silver jew fish. Values of total volatile base, peroxide and aerobic plate count of all the final dried products were within the acceptable limit.

According to Hossain (2008), the bio-chemical composition such as moisture, protein, lipid, ash were 78.45%, 18.45%, 1.73% and 1.12% respectively. Some mineral contents such as calcium and phosphorus were 210.78 mg/100g and 102.80 mg/100g of muscle respectively. Fish were preserved by the treatment of different doses of gamma radiation (3.6 and 9 KGy) at freezing temperature (-20 °C) during 90 days of storage period. Quality assessment for fish were carried out at an interval of 15 days during the storage period. Quality assessment were done by organoleptic, chemical (TVN, TMA) and microbiological (Total bacterial count, TBC, Total mould counts, TMC, Total yeast count, TYC, Total coliform count, TCC and salmonella count).

According to Mazumder (2008), the percentage of new profit of traditional block frozen product (product A), value added ready to cook (product B and product C) and value added ready to eat (product D product E) were observed 13.52%, 23.69%, 38.42%, 50.89% and 41.86% respectively and highest profit was found from the value-added cooked products. the microbiological analyses of different varieties of products were also carried out. After processing, the percentage reduction of total bacterial counts (TBC) and total coliform were 66.56%, 47.55%, 89.26%, 91.41% and 44.87%, 42.87%, 63.26%, 71.40% in different value added products (B-E) respectively. It is observed that if the findings of this research will be implemented in the shrimp processing plant, it could be helpful to sustain our export trade and fetch better price for our value-added products.

According to Rabbane et al., (2008). The protein and fat content (%) of the frozen stored fish dropped from 16.96 ± 1.9 to 15.50 ± 1.64 and 2.96 ± 0.89 to 1.50 ± 0.99 respectively in ice block condition whereas in freezer pack the values dropped from 18.00 ± 1.22 to 16.65 ± 1.56 and 3.13 ± 1.05 to 1.80 ± 0.96 respectively. But the moisture and ash content (%) did not show any significant ($P > 0.05$) changes during frozen storage in all packaging conditions. The fish was highly acceptable in ice block condition followed by aluminum foil, polythene pack and freezer pack condition.

Kabir et al., (2008) observed that the performance of smoke curing process was better which takes 6 hours than sun drying process which takes more than 13 hours. Smoke cured and sun dried fish products stored in sealed polythene bag at refrigerator temperature (4 °C) had found longer shelf life (8-9 months) than the fish stored at ambient Temperature (3-4 months). Salted fish products also have a longer shelf life than unsalted fish products.

Mansur et al., (2007) observed that tunnel dried fish quality was better. In both cases fishes were processed with or without salt. Though the protein level decreases with increase in salt concentration. It was clear that the salted dried fish produced better quality product. In salt curing process commonly used four methods were examined and it was found that dry salted fish quality were best than another three methods. Then pickle salting produced better quality than mixed salting. The quality of fish in brine salting was not desirable. Smoking, an improved technique in fish processing was conducted by newly designed and developed shelf-life fish smoker (easily constructed), produced an excellent quality of fish in terms of nutritional as well as storage facilities. Processed fish stored in sealed polythene bag at freezing temperature for six months have been found to have longer shelf life than the fish stored in sealed polythene bag at room temperature.

Begum et al., (2007) observed that salt, sugar and preservative treated hilsa fish product are better in quality than all other experimentally salt cured fish product. Experimentally salt cured fish products have been found not to contain sands, dirty materials etc. and develop any off taste, colour and odor whereas commercial salt cured hilsa fish product have been found to contain higher level of acid insoluble ash indicating the presence of sand and dirty material in it. It is also inferior in its appearance, taste, odor etc. and is not so storage stable in comparison with the experimental one. All the experimentally salt cured fish products are better in quality and storage stable.

According to organoleptic evaluation pabda fish was acceptable for 180, 210, 240 and 270 days in polythene pack, freeze pack, aluminum foil and ice block, respectively. No weight loss occurred in ice blocks condition up to 45 days of freezing preservation. The drip loss was 28.48, 27.9, 15.25 and 10.5 ml/100g of fish in polythene pack, freeze pack, aluminium foil and ice block respectively after 270 days of freezing preservation. Water holding capacity (WHC) of pabda fish in every keeping condition slowly decreased but total volatile nitrogen (TVN) value slowly increased with the progression of freezing period. The mean weight loss, drip loss, WHC and TVN value under the above mentioned keeping conditions and storage period differed significantly ($p < 0.0001$) (Rabbane et al., 2007).

Osibana et al. (2006) determined proximate composition of the African cat fish (*clarias gariepinus*). Mean values for the proximate composition (wet basis) were: protein 19.64%, lipid 1.15%, moisture 76.71% and ash 1.23%.

According to Bille and Shemkai, (2006). Sun drying of dagaa is often affected by heavy and prolonged rains in Tanzania, so he introduced spice-smoke curing as preservation method for all year round dagaa supply and marketing.

According to Anon (2005). In cold smoking the temperature of the smoke is maintained at 30-40c; it never rises to high level where fish flesh is cooked and the cold smoked product must be preserved in cooled condition (4-5c).

According to Islam (2005), in his project report on sun dried *Pampus argenteus* have been found to have 16.6-18.9% moisture, 65.73-67.7% protein, 6.2-6.6% fat, 5.8-6.3% ash. He also observed TVN value ranged from 100 to 330 mg/100g of fish during storage condition.

According to Islam (2005) in his project report on experimental sun dried *Amblypharyngodon mola* samples in fresh dried conditions contained moisture content ranged from 15% to 20%, protein from 59% to 70% fat from 6.1% to 8.8%, ash from 6% to 11%. He also reported that the experimental open sun dried *Gudusia chapra* contained moisture content ranged from 15.5% to 20%, protein from 55.1% to 60%, fat from 15% to 19%, ash from 5.6% to 9.6%. Considerable information regarding the proximate composition is available by investigations in many tropical countries. In most of the studies the chemical composition of sun dried and salted dehydrated sun dried fishery products were found to have a wide of variation.

According to Wahed et al., (2005), The fish kept at 0% salt concentration at 30 °C has been found to have self life of 6.25 hours while at 15% salt concentration the fish have been found to have self life of 28 hours at the same storage temperature. Lowering the temperature to 12 °C with the addition of ice the fish kept at 0% salt concentration have been found to have self life of 28 hours and at 15% salt concentration have been found to have self life of 28 hours and at 15% salt concentration, the self life of the fish extended to 60 hours. Acceptable limit of the tvn value at 30 °C was found to be 38 mg/ 100g fish. No correlation between sensory score and TVN value was observed during the preservation of the fish at 12 °C storage temperature. The present Findings revealed that the increase of salt

concentration and decrease of storage temperature during short-term preservation favors extension of self life of the fish.

According to Islam (2005), The solar radiation, air velocity, relative humidity and temperature inside the dryer varied between 350-850 w/m², 0.24-0.60 m/sec, 38-54 % and 40-50% respectively. He observed that the higher range of temperature and lower range of the RH of the drying air inside the dryer. Facilitated the dehydration process of fish compared to the open sun drying of the same fish. The dried and dehydrated fish were free from inside infestation due to low RH. The drying temperature inside the tunnel dryer was regulated by the variation of solar radiation. During long sun shine hours more energy was received by the solar drier that resulted increase in the inner air temperature.

Morshed et al., (2004) observed raw Bomboy duck fishes contained 81% moisture, 15.3% protein, 1.30% fat and 1.90% ash and experimentally sun dried Bomboy duck contained 21.8% moisture, 60.5% protein, 10.6% ash and 8% fat. They also observed the dried fishes when kept in polythene bags at low temperature of 4°C with low a RH of 18% kept the fish in good condition for a period 8 months.

According to Khaleque et al., (2002), The atmospheric relative humidity (RH) was recorded as 43.88-88.125% and temperature varying from 21-35 °C. The observed value of acceptability score, TVN and moisture content of dried fish ranged from 3.5-8.5, 230.74-325.55 mg/100g, 16.5-26.05% respectively. In case of chemical changes, the highest TVN value was recorded 325.55 mg/100g in the month of June, followed by second highest 312 mg/100 g of fish in september, and the lowest TVN value was found 230.74 mg/100 g in March. The highest atmospheric relative humidity (RH) was recorded 88.25% in the month of June, followed by second highest 25.86% in september and lowest value 16.2% in March.

Adeparusi et al., 2001. A survey of fish smoking processes was conducted in Ilaje Local Government Area (ILGA) of Ondo State between March and June 2001. Data were collected from fish processors at different fishing communities with the aid of structured questionnaires. Data collected were analyzed using descriptive and inferential statistics. The predominant processing and preservation techniques employed is smoke-drying (93.75%) with sundrying accounting for 6.25%. Two types of traditional smoking kiln used were oil drum and raffia palm racks. Firewood and kerosine are the main combustion fuels used during smoke-drying. Commonly use wood that produced good quality smoked fish were *Rhizophora racemosa*, *Nauclea diderrichii*, *Lophira alata*, *Nauclea latifolia*, and *Entadrophragma*

cylindricum. various fish species and sizes were processed Based on frequency of occurrence the family Clupidae had the highest number of fish processed while shrimp/prawn had the least. Fish smoking procedure starts from collection from the capture site to smoking of fish in the smoking room. Scales of fish are not removed before smoking. Small size fish are smoked singly or in multiples on sticks. Large sized fish are smoked singly or in twos and threes. The same species are always stucked together. Small, medium and large-sized fish were not gutted before smoking while extra large are cut in o chunks before smoking.

Eyabi et al., (2001) worked with brine treatment, smoking and storage techniques and their effects on the microbial quality of smoked mackerel and observed that brining and smoking time retarded mould growth, controlled discolouration, off-odour development, softening of the fish and positively affected personal preference.

Saha et al., (1999) studied on production, marketing and nutritional aspects of traditional dried products of Bangladesh and focused on the three aspects of the dried fish namely production, marketing and nutrition and reported a linkage among them.

Bala and Hossain (1998) made an experimental investigation of solar drying of fish using tunnel dryer and reported about better performance of tunnel dryer for drying of fish using solar energy through the tunnel dryer.

Several studies were also conducted on the design of solar drier such as solar tent drier and a solar cabimet drier and a SCD drier, which has a separate solar collector and drying chamber and all the solar- dried fish were of good quality and were marketable products but polythene tent drier was found suitable for small- scale processor (Ramachandan et al., 1998).

According to Lilabati et al., (1993), the nutritive value of smoke fish is considered high and not affected much by the traditional smoking technique.

Demir and Evcin (1993) worked with a green house type solar dryer to observe drying characteristics of salted fish (*Merlangius merlangus*) were investigated by the drying experiments carried out in a green house constructed for dehydration and augmented by parabolic reflectors. Drying time of samples was 26h in the greenhouse and 38h for samples dried outside to 25% moisture content.

Mansur et al. (1993) made a comparative study on solar tent drier and with the traditional sun dried fish. They observed in their comparative study that the solar tent drier consume less time for drying of fish in comparison with the traditional method of sun drying fish and the sun dried fish in the polythene tent dryer is dust free, free from fly larvae infestation, so on and so forth.

FAO (1992) reports suggest that when water content falls below 25% of the wet weight, bacterial action stops and if the water content is further reduced to below 15%, molds ceases to grow. When salt is added to the fish before drying, less water needs to be removed to achieve the same effect and the produce with a water content of 35% to 54% depending on amount of salt present is often dry enough to inhibit the growth of molds and bacteria under most climate condition.

Ali et al., (1992) also worked with the polythene tent drier for improved sun drying of fish and they reported about improved quality sun dried fish in the polythene tent dryer during their test carried out in Bangladesh.

According to Horner et al., (1992), smoking is a method of preservation that combines six important effects in fish muscles including- a) drying: the fire that produces smoke generates heat and dried the fish and thus reduced water activity where microorganisms can not survive; b) cooking: hot smoking cooks the flesh and thus destroy the enzymes and kills bacteria; c) preservation: wood-smoke contains compound like phenol that can kill bacteria; d) anti-oxidation: wood-smoke contains compound that acts as anti-oxidants; e) colour: smoking imparts on the products highly acceptable bright brown or reddish colour; f) flavor: wood smoking imparts effects of highly relished characteristic smoke flavor.

Reddy et al., (1991) worked on drying of anchovies (*Stolephorus indicus*) in a solar polythene tent. They conclude that the solar tent drier offered advantage apart from the protection given by tent against dust, insects, bird or sudden showers.

Obanu et al., (1990) made a comparative study of sun and solar drying of freshwater fish (catfish and tilapia). He reported that the quality of dried products was determined by chemical, microbiological and sensory evaluation during a 4 week storage period. Significant difference did not exist between sun and solar-dried products in the parameter studied.

The water holding capacity (WHC) of molafish (*Amblypharyngodon mola*) had been studied during frozen storage at 3 different temperature (-10 °C) and -10 °C, and a temperature fluctuating between -18 °C and -10 °C) under 4 different pretreatment and packaging conditions, such as individual ly quick frozen (IQF), vacuum packed, glazed and block frozen for about 6 months. The rate of change of WHC decreased with the lowering of storage temperature. Fluctuation of storage temperature had severe effect on change of WHC. The rate of degradation was the highest in IQF condition and the lowest in the block frozen condition. (Ahmed et al., 1990)

Ahmed et al., (1990) observation that in IQF condition the PS- value dropped from the initial value of 89% to 62, 62 and 63% in fish groups stored at temperature of -18 °C, -10 °C and -18 °C to -10 °C, respectively, at the termination of the experiment. The rate of loss of PS was highest in IQF fish followed by vacuum sealed, glazed and block frozen fish.

Mukherjee et al., (1990) worked with an improved solar dryer for drying in the coastal belt and reported that it was suitable for adaptation by fisherman-processor families in the coastal belt.

Osei-Opare and Kukan, (1989) worked in Ghana for improving the quality of dried fish through solar drying and reported that the quality of solar-dried fish was judged as clearly superior. The storage life fish dried in the sun was up to 2 weeks and the fish completely disintegrated by 6 weeks of storage.

Roe et al., (1987) studied on solar tent dryer for drying of fish. They have reported about their findings in a seminar on diversification of post harvest technology in low cost fish organized by society of fisheries technology, India. They also reported about the better quality of the dried fish in solar tent dryer.

Many studies on the storage life also reveal that solar dried products have longer shelf life having better quality over sun dried products (Rubbi et al.,1982; Oreganaet al., 1982; Doe and Heruwait, 1987).

Sachithamanthan et al., (1985) reported that the composition of some salted dried marine fish products were 41.4% to 50.6% for protein, 1.0 to 6.5% for fat and 16.1% to 30.6% for

ash and for unsalted dried fish these values were 43.7% to 52.8%, 5.4% to 5.8% and 18.4% to 52.2% respectively.

Faturoti et al., (1985) made a study on biological utilization of sun dried and smoked African catfish (*C. nigrodigitus*) and he reported about the better nutritional quality of the sun dried and smoked African catfish.

The principal involve in smoking is to expose the fish, dressed and salted, to smoke generated by smouldering, sawdust, coconut husk, etc., for varying duration depending upon the degree of flavor desired, followed by drying in the or artificially. Smoke imparts a pleasant and agreeable flavor to the fish, besides exercising preservative action through its several chemical constituents (Govindan, 1985).

Smoke is an aerosol containing oxygen, hydrogen, carbon mono-oxide, carbon dioxide and various hydrocarbons in the dispersing medium and formic acid, acetic acid propionic acid butyric acid, valeric acid, isocaproic acid and their methyl esters, linolenic acid, guaicol, phenol, cresol, catechol, eugenol and humic substances, methyl, ethyl, propyl, allyl, isoamyl and isobutyl alcohols, formaldehyde, acetaldehyde, furfural, acetone, methyl ethyl ketone, methyl propyl ketone, pyridine, methyl pyridine, ect. In varying amounts in the dispersed phase (Govindan, 1985).

It has been reported by Sachithamathan et al., (1985) that the composition of some salted dried marine fish products were 41.4%-50.6% for protein, 1.0-6.5% for fat and 16.1%-30.0% ash and for unsalted dried fish, these values were 43.7%-52.8%, 5.4%-5.8% and 18.4%-25.2% respectively.

Keshvani (1964) observed that well dried fish could be stored for up to one year in sealed polythene bags without serious loss of quality. However, Cole (1963) found that the sharp projections of dried marine fish punctured polythene bags, Nevertheless, both Watanabe (1971) and Toots (1972) recommended sealing dried fish in the bags, the later emphasizing the need to cool the fish after thorough drying and to store the product in a cool shady place to avoid sweating.

Khuda et al., (1962) estimated that the amount of moisture and ash content in *Puntius sophore* and they observed that the fresh fish contained 77.14% moisture and 1.48% ash. They also estimated the amount of protein content on the two stages of growth of *Labeo rohita*, *Cirrhina mrigala* and *Labeo calbasu* and they found that in the cases of groups of

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fishes ranging from 55.5-78.5 gm, body weight and the crude protein level varied from 17.18% to 19.56% but, for higher body. They again reported that the decrease in moisture content and increase in fat content were related with the increase of age, in case of carps.

Cutting et al., (1962) worked on the influence of drying, salting and smoking on the nutritive value of fish. Findings of his worked revealed that processing of drying, salting and smoking of fish influenced to increase the nutritive value in comparison with the raw fish in fresh condition. He reported that the chief alteration caused by drying is the reduction of moisture which resulted in an increase in protein and therefore, changes in food value in terms of unit amount of fish. But the changes in food value during curing varied greatly depending on the type of fish and the method of processing method employed.

Ahmed et al.,(1979) worked with solar drying of silver Jew fish in polythene tent dryer and observed the effectiveness of the polythene tent dryer for improved sun dried fish.

Doe et al., (1977) worked with the problem of sun drying of fish and developed a polythene tent dryer for improved sun drying of fish. The dryer was effective in controlling fly larva in dried fish. But, there was a little merit of tent dryer in the early stages of drying when the drying process is governed by convection from the surface and exposure to wind.

Islam (1982) investigated on the combined solar and cabinet drying of fish and some observation regarding the use of solar energy for drying of fish

Sachithanathan and Trim (1985) worked with a solar dome dryer for drying of fish and Reported about the better performance of solar drier for drying of fish in comparison with the sun drying of fish.

Begum et al., (1979) made comparative study of dried fish, cured in sun and in solar tent dryer and reported about the better performance of the solar tent dryer.

Milory, (1908) estimated the amount of fat and protein contents in the reproductive period of herrings and he derived the value as 3.52% Fat and 18.25% protein.

Johnstone, (1918) worked out the amount of fat in Halibut and the value ranges from 0.5% to 9.6%, while the protein content remained constant at close to 18.0%.

Lovem and Wood, (1947) traced out the amount of moisture, fat and protein contents from the flesh of herrings and the values were 73.5%, 2.9% and 19.2% respectively.

Nilson et al., (1946) estimated that about 85% to 95% of fish proteins are digestible and all dietary essential amino acids are present in fish.

Saha and Choudhury, (1951) made nutritional investigations on the sun dried fish of West Bengal and reported that the sun-dried fish are nutritionally enriched and major source of concentrated form of nutrient for all the people. Their moisture content ranged from 12.6% to 17.5%, body fat to 14% and ash 8.7% to 27.5%.

Venkataraman and Chari, (1951) made a thorough study on seasonal variation of the biochemical composition of Mackerel and found that ash and protein remained constant; moisture and fat were subjected to seasonal variation and observed reciprocal relationship between them.

Stansby (1954) worked on the macronutrient content from the edible flesh of certain fresh water fish and he observed that these fishes contained 78.8% moisture, 1.2% ash, 5% fat and 19% protein.

Brogstrom (1961) pointed out that the variations of protein contents in fish depend on some factors, such as size, age, species sex, seasonal changes and seasons of capture.

Hoque (1975) investigated the moisture, ash, fat and protein contents in the shrimp, *Peaneaus monodon* and he obtained the value from his investigation as 78.65-79.10%, 1.05-1.10%, 0.85-1.30% and 18.87-18.9%.

CHAPTER- III

CHAPTER III: MATERIAL AND METHODS**1. Collection of fish**

Chinese Pomfret (*Pampus chinensis*), Bombay duck (*Harpodon nehereus*) and black tiger Shrimp (*Penaeus monodon*) were collected from Kawran bazaar, Rampura bazaar and New market, Dhaka. The fishes were collected very early in the morning in raw and condition for the present study entitled “Investigation on the quality and shelf life of *Harpodon nehereus*, *Pampus chinensis* and *Penaeus monodon* during smoke curing, traditional sun drying and drying in the tunnel dryer”. After collection, the fishes were brought to the Institute of Food Science and Technology (IFST) BCSIR, Dhaka for laboratory analysis subsequently processing and preservation, storing and studying the shelf of the fish product.



Plate 1: Showing Chinese Pomfret samples collected from local fish market at kawran bazaar, Dhaka, in fresh raw condition and carry out the thesis work at Fish Tech. Laboratory.



Plate 2: Showing Bombay duck fish samples collected from local fish market at kawran

bazaar, Dhaka, in fresh raw condition and carry out the thesis work at Fish Tech. Laboratory.



Plate 3: Showing black tiger Shrimp sample collected from local fish market at kawran

bazaar, Dhaka, in fresh raw condition and carry out the thesis work at Fish Tech. Laboratory.

2. Preparation of the samples

After collection of raw material, the fishes were washed properly with clean water. Then the fishes were degutted and split for drying, solar tunnel drying and smoke curing processes. The split fishes and shrimp were then washed with tap water for making the sample free from any sort of contamination. Lastly fishes were dissected into mid-ventral position and were opened. Each type of the raw fishes and shrimp were divided into three groups. One portion of the fishes and shrimp were left any treatment and another two portions of the fishes and shrimp were treated with salt water for half an hour. The fishes and shrimp were kept in 10% salt solution for two hours for making the salted sample. After salting process the fishes and shrimp samples were treated with turmeric (5%) powder to make the samples salted and turmeric to make as turmeric treated samples. The fishes and shrimp were weighted before and after salting. Then each portion of the fishes and shrimp were placed inside and outside the solar tunnel drier and smoker for drying. The dried samples were then kept in white polythene packet and stored in deep freeze.

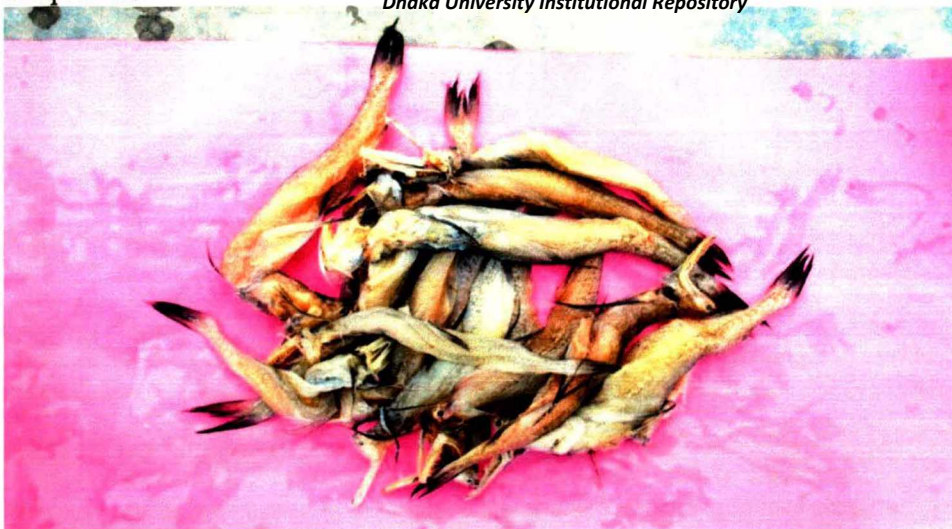


Plate 4. Showing Bombay duck (*Harpodon nehereus*) in dressing from for at the Fish Tech. Laboratory for carrying out the thesis work.



Plate 5. Showing Chinese Pomfret (*Pampus chinensis*) in dressing from for at the Fish Tech. Laboratory for carrying out the thesis work.



Plate 6. Showing black tiger Shrimp (*Penaeus monodon*) in dressing from for at the Fish Tech. Laboratory for carrying out the thesis work.

1) Fish drying and dehydration Technology

The prepared samples of the experimental fishes (Chinese Pomfret, Bombay duck and Black tiger Shrimp) were then dried –a) Traditional sundrying technology, b) Fish solar tunnel dryer technology and c) Fish smoker technology.

The above mentioned three types fish processing technology were categorically divided into the following batches:

- Batch-a. Unsalted Chinese Pomfret dried in the open sun.
- Batch-b. Unsalted Chinese Pomfret dried in the solar tunnel dryer.
- Batch-c. Unsalted Chinese Pomfret dried in the smoke curing.
- Batch-d. Salted Chinese Pomfret dried in the open sun.
- Batch-e. Salted Chinese Pomfret dried in the solar tunnel dryer.
- Batch-f. Salted Chinese Pomfret dried in the smoke curing.
- Batch-g. Salt and turmeric Chinese Pomfret dried in the open sun.
- Batch-h. Salt and turmeric Chinese Pomfret dried in the solar tunnel dryer.
- Batch-i. Salt and turmeric Chinese Pomfret dried in the smoke curing.
- Batch-j. Unsalted Bombay duck dried in the open sun.
- Batch-k. Unsalted Bombay duck dried in the solar tunnel dryer.
- Batch-l. Unsalted Bombay duck dried in the smoke curing.
- Batch-m. Salted Bombay duck dried in the open sun.
- Batch-n. Salted Bombay duck dried in the solar tunnel dryer.

Batch-o. Salted Bombay duck dried in the smoke curing.

Batch-p. Salt and turmeric Bombay duck dried in the open sun.

Batch-q. Salt and turmeric Bombay duck dried in the solar tunnel dryer.

Batch-r. Salt and turmeric Bombay duck dried in the smoke curing.

Batch-s. Unsalted black tiger Shrimp dried in the open sun.

Batch-t. Unsalted Shrimp dried in the solar tunnel dryer.

Batch-u. Unsalted black tiger Shrimp dried in the smoke curing.

Batch-v. Salted black tiger Shrimp dried in the open sun.

Batch-w. Salted black tiger Shrimp dried in the solar tunnel dryer.

Batch-x. Salted black tiger Shrimp dried in the smoke curing.

Batch-y. Salt and turmeric black tiger Shrimp dried in the open sun.

Batch-z. Salt and turmeric black tiger Shrimp dried in the solar tunnel dryer.

Batch-0. Salt and turmeric black tiger Shrimp dried in the smoke curing.

(a) Traditional Sundrying Technology

The experimental fishes (Chinese Pomfret, Bombay duct and black tiger Shrimp) were dried on a bamboo mat –kept at the sunny floor and some of fishes were hunged at the rope and were put in the sun for drying and dehydration. It is to be noted here that the fish samples to be dried and dehydrated were first cleaned, descaled and degutted were treated unsalted, salted salt with turmeric and then were allowed to dry in the sun at the IFST Lab –BCSIR, Dhaka. Proper weight, time, temperature, percent relative humidity, air velocity were recorded .





Plate 7: Showing the freshly sun dried product of of Chinese Pomfret (*Pampus chinensis*)
Bombay duck (*Harpodon nehereus*) and black tiger Shrimp (*Peaneus monodon*)
fish samples produced at the Laboratory premises of IFST, BCSIR, Dhaka.

(b) Solar tunnel drying

Design and construction of the Solar Tunnel Dryer

A Solar Tunnel Dryer having 10 ft. length and 3 m width were designed and developed with locally available raw materials. The dryer consisted of a flat plate air heating collector chamber, the tunnel drying unit and a solar panels of - volt capacity for supplying additional heat energy other then the solar energy to excelarate the drying rate of the solar tunnel dryer during processing and preservation of the experimental fishes at the laboratory scale. The solar panels were used to provide solar energy running to DC fans (6 inches and 12 volt each) to supply the additional air flow over the fishes to be dried both of the air heating collector and the drying unit were covered with white transparent plastic foil. The collector were printed with black colour to increase rate of absorpion of heat collecting from the solar rays. The fishes to be dried were placed in a thin layer of bamboo splitted net within the dryer.

Glass wool was used as insulation to reduce the loss of heat from the bottom of the dryer. The whole system were placed horizontally on raised ona plat from. To DC fans were operated by solar module, solar radiation passing through the transparent cover of the collector got absorb by black coated MS seet that coverted the incoming solar anergy into heat as shown in plate 8a and 8b. The solar tunnel dryer were placed at premises of IFST lab. BCSIR, Dhaka, to produced quality dried and dehydruted fish product of the experimental fishes (Chinese Pomfret, black tiger Shrimp, Bombay duck).

Experimental procedure

Three experimental runs were carried out for drying and dehydration of the experimental fishes (Chinese Pomfret, black tiger Shrimp, Bombay duck) during the experimental period (September, 2009). During the experimental runs variables related with the performance of the solar tunnel dryer were recorded at different time intervals. The air velocity at outlet of the Tunnel dryer (TD) were recorded by anemometer. Relative humidity and drying air temp. Both inside and outside Solar Tunnel Dryer were recorded by hygrometer and thermocouple respectively. The solar radiation during the experiment period were measured by pyranometer weight of the experiment fishes at the initial time and at different time interval were measured by top load electronic balance.



Plate 8A. Showing external and partial of the low cost solar tunnel dryer constructed at the Fish Tec. Laboratory for drying and dehydration of the experimental fishes using locally available raw materials.



Plate 8B. Showing full construction view of the low cost solar tunnel dryer constructed by low cost raw materials with addition of solar panel as a source of solar energy to dry and dehydration of the fishes at the Laboratory label.

The Performance study

with a to view assess the label of performance of the newly design and develop solar tunnel dryer for producing improved quality dried and dehydrated Fish products of the experimental fishes (Chinese Pomfret, black tiger Shrimp, Bombay duck). The Solar Tunnel Dryer were installed at the premises of the institute of food science and technology, BCSIR, Dhaka. Three experimental runs for drying and dehydration of fishes (Chinese Pomfret, Bombay duck) and black tiger Shrimp were carried out in the month of September, 2008.

The influencing variables (air velocity m/s, air temperature, % RH,) both inside and outside the solar tunnel dryer were measured and recorded at different time intervals during the whole experimental run so that we may be able to understand as to what extent the performance of the solar tunnel dryer have extended. This recorded variables have been represented in Table and Figure -1 in case of Chinese Pomfret fish during the first experimental runs. Results shown in Table and Figure -1 revealed clear variation in temperature and % RH between the drying air and drying air inside the solar tunnel dryer. The drying air temp. and % RH inside the Solar Tunnel Dryer were found to vary from 38 to 45 and from % RH 25% to 45% during the first experimental run with Chinese Pomfret fishes. Whereas during the same period the drying air temperature and % RH in the sun that is outside the tunnel dryer vary 32 to 34 % and 25 to 40 % respectively. It is understood from the result represented in Table and Figure -1 that the % RH value is lower inside the tunnel dryer then that of drying air in the sun. Drying air temperature inside the Solar Tunnel is higher than that of the drying air temperature in the sun.

The lower rang of the % RH value and higher rang of temperature of the drying air inside the Solar Tunnel Dryer have been found to influence speedy rate of dehydration of the experiment fish in comparison with the sun dried fish during the same experimental period. Air flow rate inside the solar tunnel dryer during period of the first experimental run have been found to be dependent on the intensity of the solar radiation that is with the increase or decrease of the solar radiation the air flow rate inside the solar tunnel dryer have been found to increase or decrease proportionately.

Moreover the air flow rate have been found to influence the increase or decrease of inside drying air temperature of the Solar Tunnel Dryer. Solar radiation was found to vary from 28 to 866 w/m² during the experimental runs. This relationship between air flow rate and collector outlet temperature have been shown in Figure 1-6. Results represented in Table and Figure 1-6 showed the drying rate period between the dehydration of the Chinese Pomfret fish in the Solar Tunnel Dryer and the drying of the same species of the fish in the sun. It is evident from the result between in Table and Figure . That the drying rate period is different due to two clear reasons one is the different in the use of the Solar Tunnel Dryer and drying of the fish in the sun and the other reason is the size of the fish species.



Plate 9. Showing the solar tunnel dryer during drying and dehydration of the experimental fishes (*Pampus chinensis*, *Harpodon nehereus*) and *P. monodon* at the experimental at label.

(c) Smoke curing of fishes

Design and construction of the smoker

A Lab – type fish smoker were designed and developed at the Fish Technology Laboratory, IFST, BCSIR, Dhaka while at the carrying out the thesis work. Locally available raw materials were used and the raw materials includes stainless steel made and sticks which were sharp at one end and the other end were covered with wood made handles of inches length each. The steel made frame of the fish smoker were more or less rectangular in shape having inches long and inches wide and a depth of inches. It's bottom portion were parporated with thirty two no of perforations through which smoke and heat were allowed to pass with a view to smoke care of the experimental fishes –attached with the steel made hooks (handle) kept at

the upper portion of the fish smoker. Stainless steel made two handle were also a part of the fish smoker for its easy transfer from one place to another and even for placing it at the right portion for fish smoking.

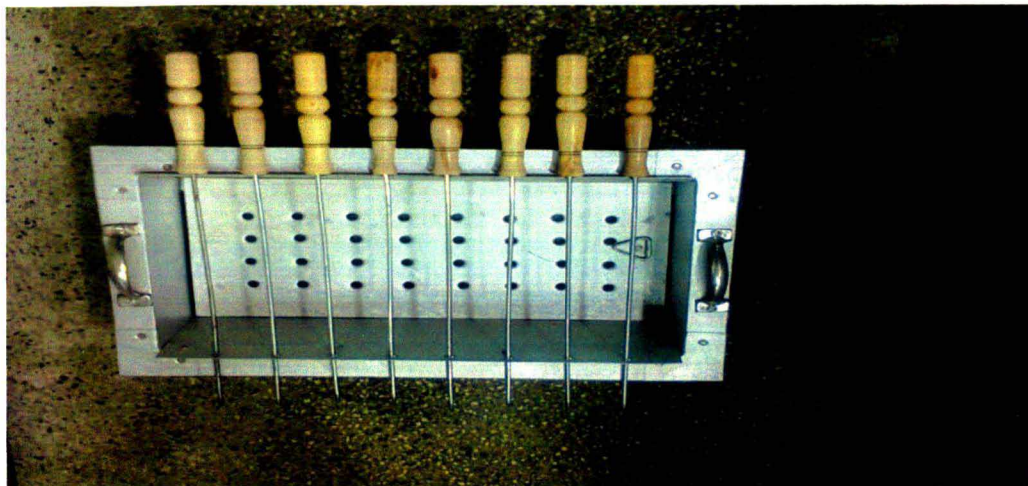


Plate10. Photographs showing the fish smoker designed and developed at the Fish Technology Laboratory, IFST, BCSIR, Dhaka.

Smoke curing of fishes

Smoke curing is the final hurdle before tasting that anxiously awaited fish treat. Here are the simple steps to follow:

Arranged fish on rods or rack so they do not touch. Fish may be hung on “S”- shaped hooks, strung through gills by rods, split and nailed to rods, or simply laid on rack. Regular nails, 8 or 10 gauge steel wires, S-shaped iron hooks, or round wooden sticks were used.

Build fire on level ground with non resinous (hickory, oak, maple, apple) wood chips or sawdust to produce light, constant volume of smoke. Soft (resinous) wood gives an acrid flavor and odor to fish. Never use wood containing pitch, such as a pine. Liquid smoke is also less satisfactory.

Center smokehouse over smoldering fire and close flaps. Danger of fire is minimized if ventilation is controlled to promote smoke rather than flames. Alternate method: fire may be built in covered pit or trench outside chamber. Smoke was conducted into bottom of smoking chamber via tile or stove pipe.

The Performance study

Performance of the fish smoker (design and constructed at the Lab.) was studied during our study period. Both physical and chemical parameter were used to assess the performance of the fish smoker during production of smoke cured fish and there after during storage at different storage temperature. Parameters like Temperature, % RH, weigh of the fish at different time interval, biochemical composition of the experiment fishes before and after smoke curing and also during storage time, sensory evaluation and determination of TVN by Conwat- method. Physical parameters which (temp. and % RH) were recorded during smoke curing of the unsalted, salted and salted and turmeric treated experimental fishes (Chinese Pomfret, Bombay duck) and black tiger Shrimp were recorded and and represented in Table 7-9. It is clear from the result represented in the Table and Figure 7-9. The inside fish smoker ranged from 75 to 90 whereas the outside air temperature rang from 30- 34°C. That is the inside air and the outside air temperature bears inverse relationship with each other.

It is also clear from result represented the Figure 10-12 that the rate of the drying of the smoke cured experimental fishes were represented in table no 7-9. From result represented in various Tables and various figure that a clear variation in drying rate exists between the species of fishes to be treated with salt, unsalt and salt turmeric treated. It took 6 hours for drying unsalted, salted and salt turmeric with samples. Whereas smoke curing of unsalted, salted and turmeric, Bombay duck required 7 hours for drying unsalted, salted, turmeric, black tiger Shrimp required 4.5 hours for drying during smoke curing.

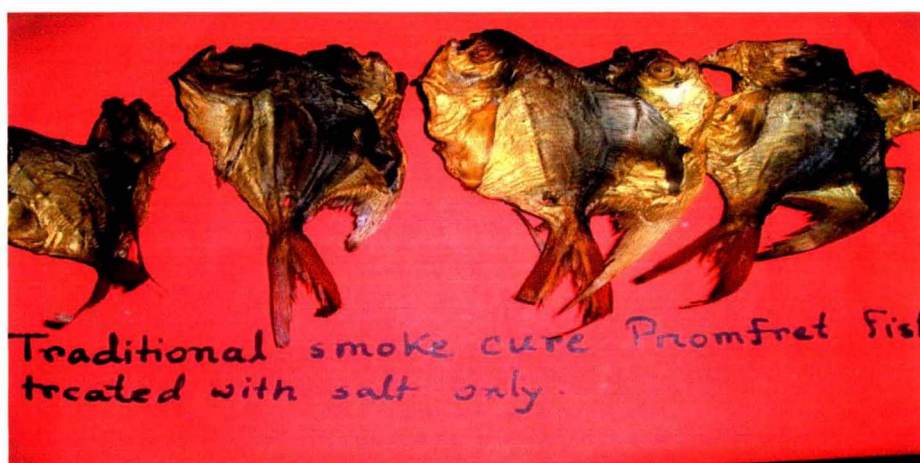


Plate 11. Showing the freshly smoke cured of Pomfret (*Pampus chinensis*). at the Fish smoker Technology Laboratory, IFST, BCSIR, Dhaka.

3) Measurement of important parameters

The effectiveness of the low cost solar tunnel dryer, the shelf type smoker and sun drying for experimental fishes and shrimp has been demonstrated in the laboratory.

Important parameters such as temperature, relative humidity and air velocity affecting the performance of the tunnel drier and smoker were measured and recorded in each two hours time interval. An analog thermometer and relative humidity meter (Hygrometer) were used to measure temperature and relative humidity, respectively both inside and outside the tunnel dryer, sun drying and smoker. The velocity of drying air was measured with an anemometer.

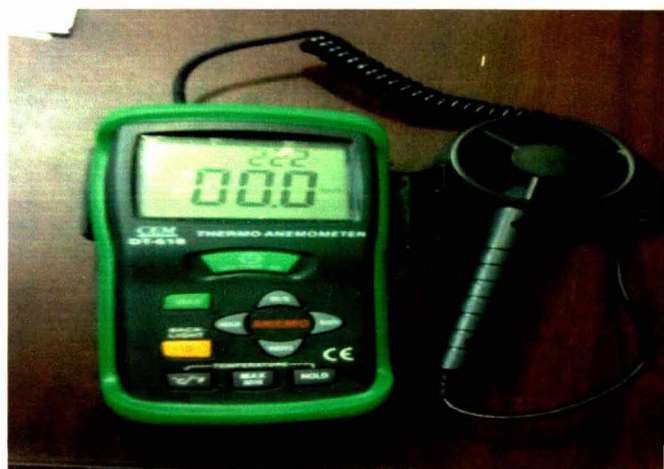


Plate 12. Showing Hygrometer and anemometer during measured and recorded temperature, relative humidity and air velocity affecting the performance of the tunnel drier, in the sun drying and smoker.

4) Recording weight loss

Weight loss of each sample was measured with an electronic balance after two hours interval during drying period. The drying was started at 10 am and then continued up to 4 pm. Then the samples were collected and again put into the drier in the next day until the experimental run was over. To compare the performance among the tunnel drier, the smoke curing and sun drying was carried out at less time between the tunnel drier and sun drying.

5) Packaging and storing

The experimental smoke cured, tunnel dried and sun dried products were then finally graded according to size. After grading, the processed products were weighted and salted, unsalted

and turmeric treated dried fishes and shrimp were packed in polythene bags and finally stored at ambient temperature and in the refrigerator with a view to investigating the shelf life.



Plate 13. Polythene packed Solar Tunnel Dried salted Fishes (Chinese Pomfret, Bombay duck) and black tiger Shrimp for storage.

3. Analysis of Biochemical composition

Biochemical composition of fresh raw fishes and shrimp as well as fresh sun dried, solar tunnel dried and smoke curing fishes and shrimp was analyzed according to the AOAC (1975) method.

In view of the above facts, attempts were made for:

1. Estimation of the Biochemical composition of raw fishes and shrimp as well as dried Samples of the experimental fishes and shrimp.
2. To find out relationship among the nutrient content of the raw fishes and shrimp as well as dried Products.

1) Estimation of moisture content

Some washed and dried tarred porcelain basins of known weight were taken. About five grams of previously prepared fishes and shrimp products were taken in each basin and was dried in an oven at about 105 °C. Drying, cooling and weighing were continued until constant weight was established.

It usually requires 8 to 10 hours for complete drying. Finally the percentage of moisture content was calculated by following equation:

$$\% \text{ of moisture} = \frac{\text{weight loss}}{\text{Original weight of the sample taken}} \times 100$$



Plate 14. Showing an electronic balance while taking weight of fish samples.

2) Estimation of fat content

The estimation of fat content of the dried sample left after moisture determination was finely grinded and about 2 grams was taken in a Soxhlet thimble and the fat was extracted with petroleum ether (60-80 fraction) for about 8-10 hours in "Soxhlet extractor". The petroleum ether was taken in a round bottom flask on a water bath. The evaporation solvent being cooled trickles down onto the thimble and ultimately returns to the flask by siphon with fat in solution and the process continued. When all the fat had gone in solution, the petroleum ether was then recovered by distillation. The trace of solvent was removed first on a water bath, then cooled in a desiccator and weight continued until the constant weight was obtained. Finally the percentage of the fat was calculated in the following way-

$$\% \text{ of fat} = \frac{\text{Weight of the residue}}{\text{Weight of the sample taken}} \times 100$$



Plate 15. Showing different steps determination of fat content of the fish samples.

3) Estimation of crude protein content

The crude protein content of the fishes and shrimp was determined by Micro-Kjeldhal method. The basic principle of this method involves the conversion of nitrogen of protein into NH_4SO_4 when boiled with H_2SO_4 , which on distillation with excess of sodium hydroxide gives ammonia, which is absorbed in boric acid solution containing methyl red. The amount of nitrogen absorbed in boric acid is determined by titration with N/10 H_2SO_4 two washed, dried 50 ml Kjeldhal flasks were taken and about 2 grams of finely minced sample (in case of dried fish 0.6 g) was taken in each flask with a piece of ash less filter paper. About 20 ml concentrated H_2SO_4 was added with traditional digested mixture in Buchi digestion unit until the contents became clear. The digestion product was then made into 100 ml in a 100 ml volumetric flask with distilled water. 5 ml of 40% NaOH and distillate was collected in excess of 2% boric acid solution with indicator and was titrated by N/10 H_2SO_4 . The percentage of nitrogen in the sample was calculated by:



Plate 16. Showing different steps determination of protein content content of the fish samples by micro-kjeldhal method in the laboratory.

4) Estimation of ash content

About 5-10 g of the sample is weighted accurately into a tared platinum (or porcelain) crucible (which) has previously been heated to about 600 °C and cooled. The crucible is placed on a clay pipe triangle and heated first over a low flame till all the material is completely charred, followed by heating in a muffle furnace for about 5-5 hours at about 600 °C. it is then cooled in a desiccators and weighted. To ensure completion of ashing, the crucible is again heated in the muffle furnace for 1 hours, cooled and weighted. This is repeated till two consecutive weights are the same and the ash is almost white or grayish white in colour.

Ash content (g/100 g sample)= Wt. of the ash/ Wt. of the sample taken X 100

5) Estimation of salt content

For the determination of salt content fishes and shrimp were removed from the brine and pickle and drained for five minutes. Samples were taken from fillets of the fish and were ground in a mortar with a pestle. About 5 grams of minced fish were accurately weighed and salt was extracted with distilled water in a conical flask (250ml) and kept them over night at 10 C. contents were then made into (100ml) with filtered water and then salt content in the filtrate was determined titrimetrically against standard silver nitrate solution (with Micro-burette) using potassium chromate as an indicator.

Calculation:

$$\% \text{ of salt content} = \frac{V \times S \times N \times 100 \times 100}{W \times V_1}$$

Where,

V= Volume of standard silver nitrate required

S=Strength of N/10 silver nitrate

N=Conversion factor

V₁=Volume of solution taken

W=weight of the sample.

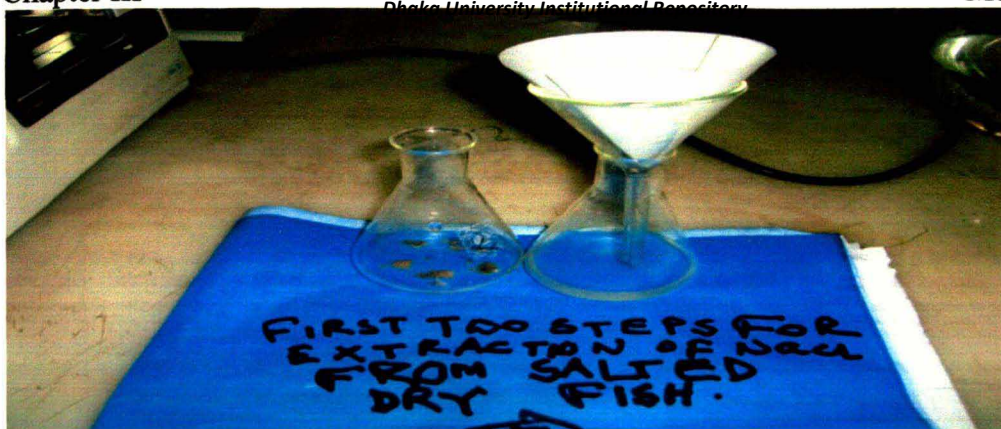


Plate 17. Showing different steps determination of salt content of the salted dried fish samples.

4. Quality assessment of stored fish

During the present qualitative assessment and shelf life study of dried Chinese Pomfret (*Pampus chinensis*), Bombat duck (*Harpodon nehereus*) and black tiger Shrimp (*Peaneus monodon*) the following measures were taken to improved the quality and extend the shelf life.

1. The fishes and shrimp samples were purchased from the local fish market in fresh and highly acceptable condition assessed by visual observation of gill, eye, smell of slime, vent etc.
2. The fishes and shrimp were gutted and cleaned with clean water.
3. All fishes and shrimp were divided into two groups and one group was treated with brine solution.
4. The fishes and shrimp were taken for drying in the sun and tunnel drier.
5. Twenty seven experiment were carried out in November and December, 2008 for the drying of Chinese Pomfret (*Pampus chinensis*), Bombay duck (*Harpodon nehereus*) and black tiger Shrimp (*Penaeus monodon*) in the smoke curing, tuuel dryer and in the sun drying.
6. Dried fish and shrimp samples were stored at ambient temperature and in the refrigerator with a view to invest tigating the shelf life and quality assessment of the dried Cnihese Pomfret, Bombay duck and black tiger Shrimp in their ftesh condition and during storage condition had been carried out and the shelf life of the experimental products were determined by examination of the following physical and chemical parameters.

1) Sensory evaluation score

The dried fishes and shrimp product was evaluated by 9-point hedonic scales described by Paryam and Pilgram (1957). Based on the appearance, color, odor and texture of the dried fishes product applied the sensory evaluation score. The hedonic scale was as follows:

9. like extremely
8. Like very much
7. Like moderately
6. Like slightly
5. Neither like nor dislike
4. Dislike slightly
3. Dislike moderately
2. Dislike very much
1. Dislike extremely

The average score of 5 (Neither like nor dislike) Was considered to be the borderline of acceptability.

2) Chemical changes

For the assessment of chemical changes, total volatile nitrogen (TVN) value was determined for stored fishes and shrimp by micro diffusion technique.

Determination of TVN

Two ml of 2% boric acid solution with indicator (Pearson, 1962) was taken into the inner chamber of a Conway dish. Two ml of the titrate was transferred to the outer part of the same dish. A greased lid was then placed in such a way so that a portion of the outer chamber remained uncovered. Two ml of saturated potassium carbonate was then pipette rapidly through the gap into the outer chamber and the lid was then placed in such a way that the whole dish became air tight. The dish was allowed to stand at room temperature over night. During this time volatile nitrogen diffused into inner chamber and was absorbed by the boric acid solution. In the morning the lead was removed and the volatile bases, which diffused over the inner chamber, were titrated with N/10 H_2SO_4 using a Conway burette. A similar experiment was carried out in the same manner except that the extract was not transferred into the outer chamber. The calculation was done by the following formula:

TVN muscle= (Titration reading-blank reading) X Strength of acid X .2

X Volume of extract/ Volume of extract taken X 100 / Weight of sample taken



Plate 18. Showing different steps determination of TVN content of the fish samples.

CHAPTER- IV

RESULTS AND DISSCUSSION

RESULTS AND DISCUSSION**1. Experimental result for Smoke curing , Solar Tunnel drying and Sun drying****1) Physical Parameter:**

During the Solar Tunnel drying, Sun drying and Smoke curing process fishes are showed in Figure 1-12 while dried either in the Solar Tunnel Dryer, in the traditional sun drying or fish smoker and recorded air velocity, relative humidity (RH) and temperature. The during temperature of the first, second and third experiment of Chinese Pomfret, Bombay duck and black tiger Shrimp varied from 42-45 inside the tunnel drier and 32-36 outside the tunnel drier(Figure 1-6 and Table 1-3). Relative humidity the first, second and third experiment of Pomfret, Bombay duck and shrimp varied from 25-35 inside the Solar Tunnel Dryer and 44-65 outside the Solar Tunnel Dryer. Air velocity of the first, second and third experiment of Pomfret, Bombay duck and shrimp varied from 0.35 to 0.55 m/sec.

The during temperature of the first, second and third experiment of Chinese Pomfret, Bombay duck and black tiger shrimp varied from 32 to 34 in the traditional sun drying and 30 to 32 in the room temperature (Figure 7-9 and Table 4-6). Relative humidity the first, second and third experiment of Chinese Pomfret, Bombay duck and black tiger shrimp varied from 30 to 40 inside the sun dryer and 65 to 75 outside dryer . Air velocity of the first, second and third experiment of Chinese Pomfret, Bombay duck and black tiger shrimp varied from 0.35 to 0.55 m/sec.

The during temperature of the first, second and third experiment of Chinese Pomfret, Bombay duck and black tiger shrimp varied from 75-90 inside the smoker and 32-34 outside the smoker (Figure 10-12 and Table 7-9). Relative humidity the first, second and third experiment of Pomfret, Bombay duck and shrimp varied from 30-40 outside the smoker. Air velocity of the first, second and third experiment of Chinese Pomfret, Bombay duck and black tiger shrimp varied from 0.35 to 0.55 m/sec.

Table 1: Variation of temperature and relative humidity inside and outside the Solar Tunnel dryer during the period of the first, second and third experimental run of Pomfret (*Pampus chinensis*) drying and dehydration.

Date	Time (hour)	RH% inside the drier`	RH% outside the drier	Temp(°C) inside the drier	Temp(°C) outside the drier	Air Velocity (m/s)	Solar radiation inside the Dryer w/m2
27/09/09	10 am	28	35	42	30	0.44	556
	12 pm	25	33	44	32	0.58	680
	2 pm	25	34	44.5	33	0.55	740
	4 pm	26	34.5	40	32	0.54	465
28/09/09	10 am	30	35	40	31	0.47	456
	12 pm	28	30	43	34	0.57	590
	2 pm	25	28	43.9	33	0.54	690
	4 pm	29	33	41	32	0.49	485
29/09/09	10 am	31	34	38	30	0.40	425
	12 pm	29	31	40.8	31	0.45	465
	2 pm	22	27	42.5	32	0.52	589
	4 pm	30	32	41	31	0.60	550

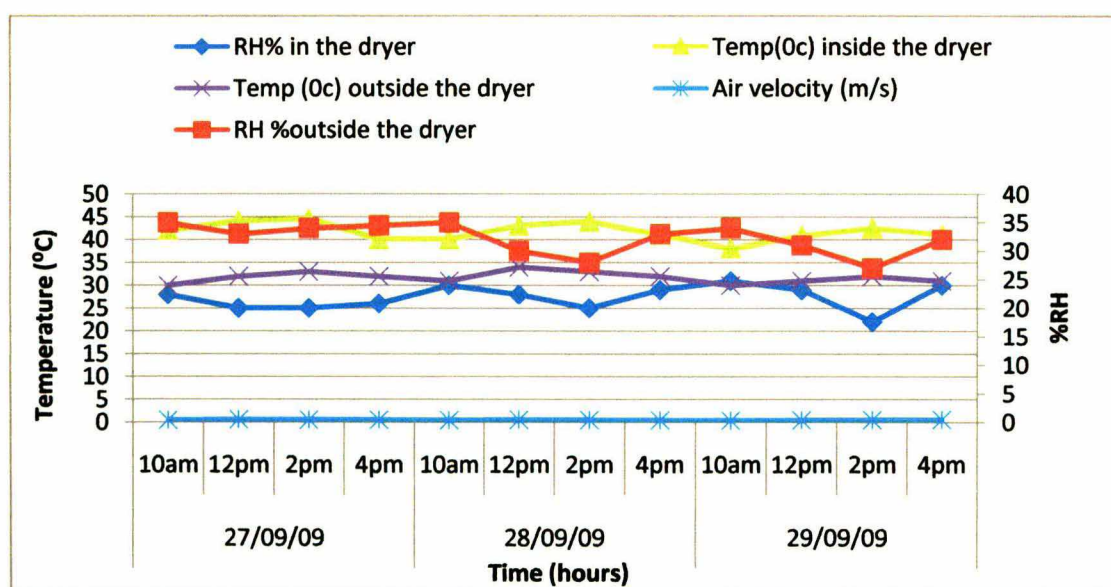


Figure 1: Relationship between temperature and percentage relative humidity (%RH) inside and outside the Solar Tunnel Dryer during the period of the first, second and third experimental run of Pomfret (*Pampus chinensis*) drying and dehydration.

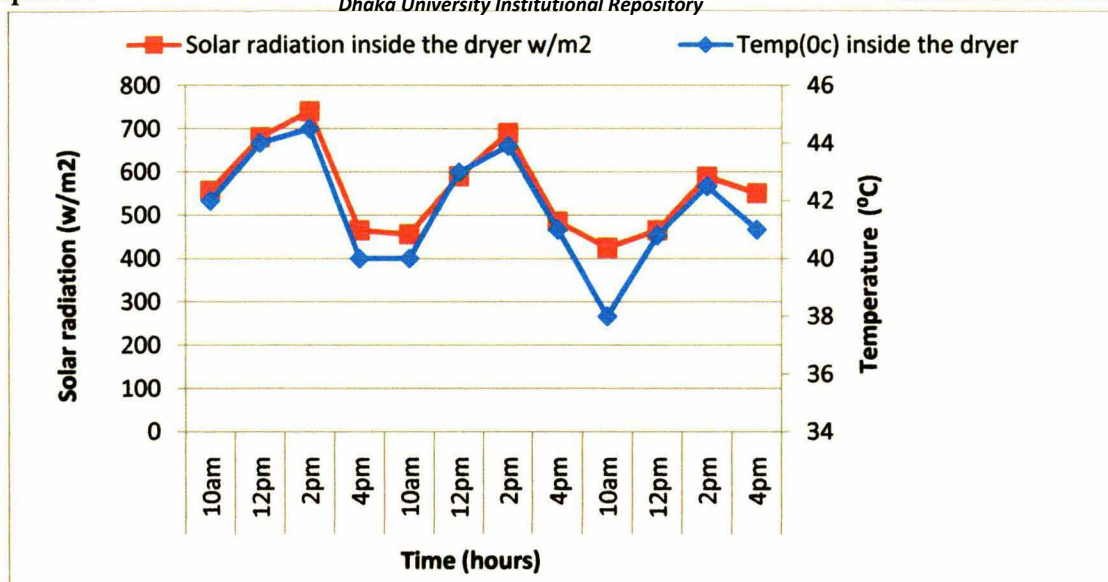


Figure 2: Relationship between temperature and solar radiation inside and outside the Solar Tunnel Dryer during the period of the first, second and third experimental run of Chinese Pomfret (*Pampus chinensis*) drying and dehydration.

Table 2: Variation of temperature and relative humidity inside and outside the Solar Tunnel Dryer during the period of the first, second and third experimental run of Bombay duck (*Harpodon nehereus*) drying and dehydration.

Date	Time (hour)	RH% inside the drier`	RH% outside the drier	Temp(°C) inside the drier	Temp(°C) outside the drier	Air Velocity (m/s)	Solar radiation inside the Dryer w/m2
27/09/09	10am	30	70	40	30	0.44	455
	12pm	28	51	42	32	0.55	500
	2pm	25	52	44	34	0.50	589
	4pm	32	62	41	31	0.51	499
28/09/09	10am	41	65	42	31	0.53	510
	12pm	29	56	44	33	0.53	650
	2pm	29	52	45	34	0.45	720
	4pm	34	58	41	31	0.48	565
29/09/09	10am	44	67	38	30	0.40	450
	12pm	30	56	41	32	0.50	685
	2pm	28	50	43	34	0.55	645
	4pm	29	53	41	31	0.52	525

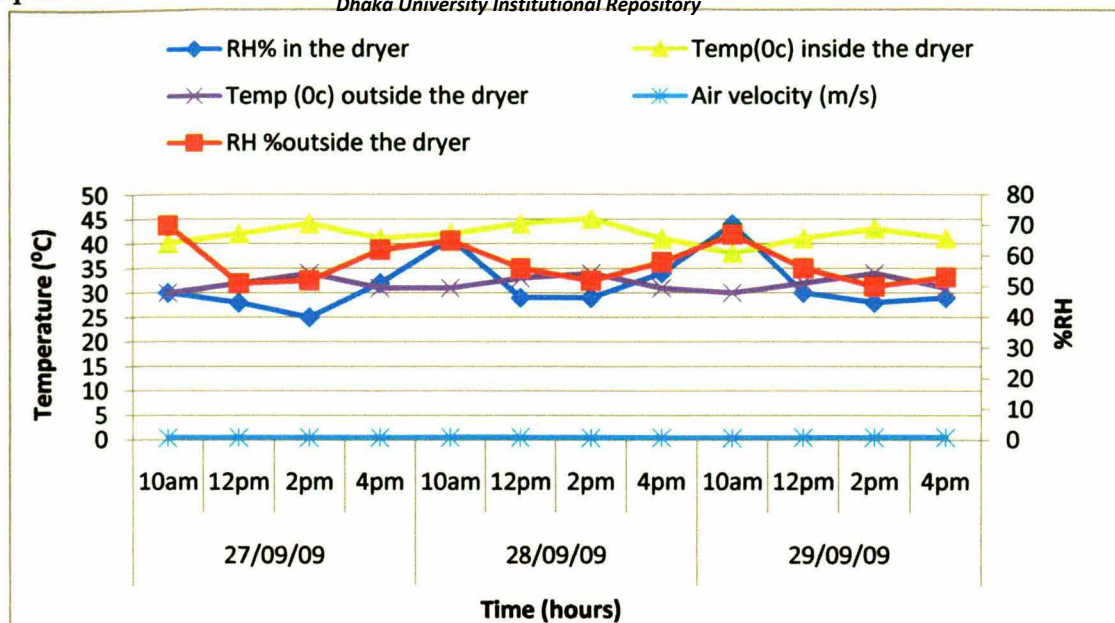


Figure 3: Relationship between temperature and percentage relative humidity (%RH) inside and outside the Solar Tunnel Dryer during the period of the first, second and third experimental run of Bombay duck (*Harpodon nehereus*) drying and dehydration.

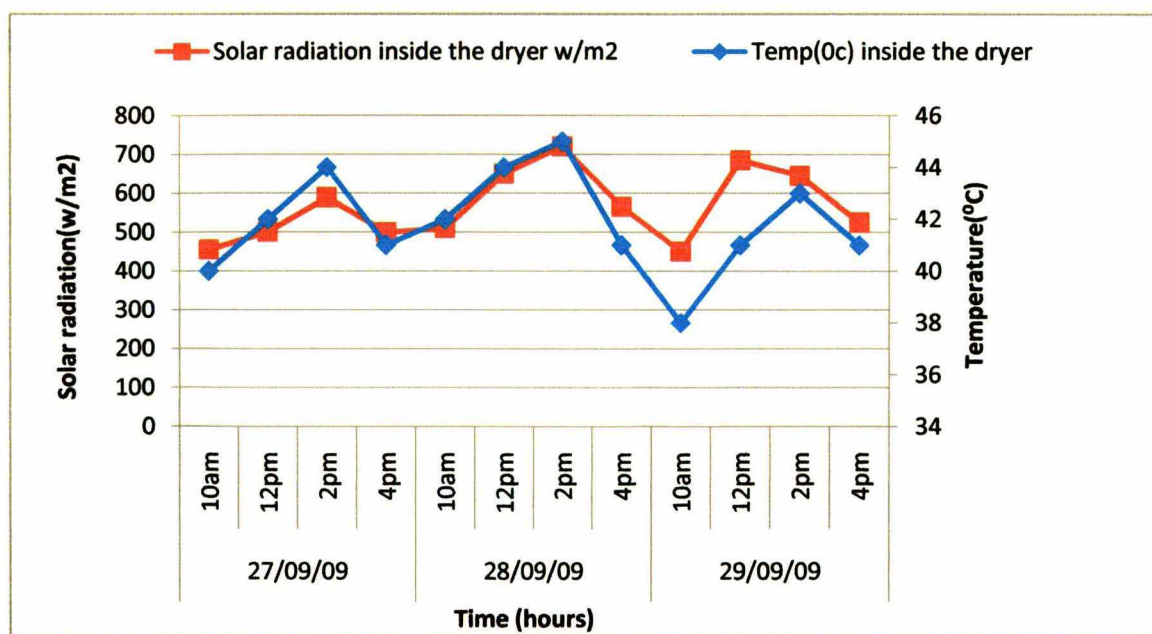


Figure 4: Relationship between temperature and solar radiation inside and outside the Solar Tunnel Dryer during the period of the first, second and third experimental run of Bombay duck (*Harpodon nehereus*) drying and dehydration.

Table 3: Variation of temperature and relative humidity inside and outside the solar tunnel dryer during three days of first, second and third experimental run of black tiger Shrimp (*Penaeus monodon*) drying and dehydration.

Date	Time (hour)	RH% inside the drier	RH% outside the drier	Temp(°C) inside the drier	Temp(°C) outside the drier	Air Velocity (m/s)	Solar radiation inside the Dryer w/m ²
27/09/09	10 am	32	60	38	30	0.66	438
	12 pm	29	55	41	32	0.54	574
	2 pm	25	52	42	34	0.48	720
	4 pm	28	58	40	33	0.50	660
28/09/09	10 am	30	65	41	32	0.53	482
	12 pm	25	55	42	33	0.55	655
	2 pm	22	50	44	34	0.45	788
	4 pm	25	60	43	32	0.40	695

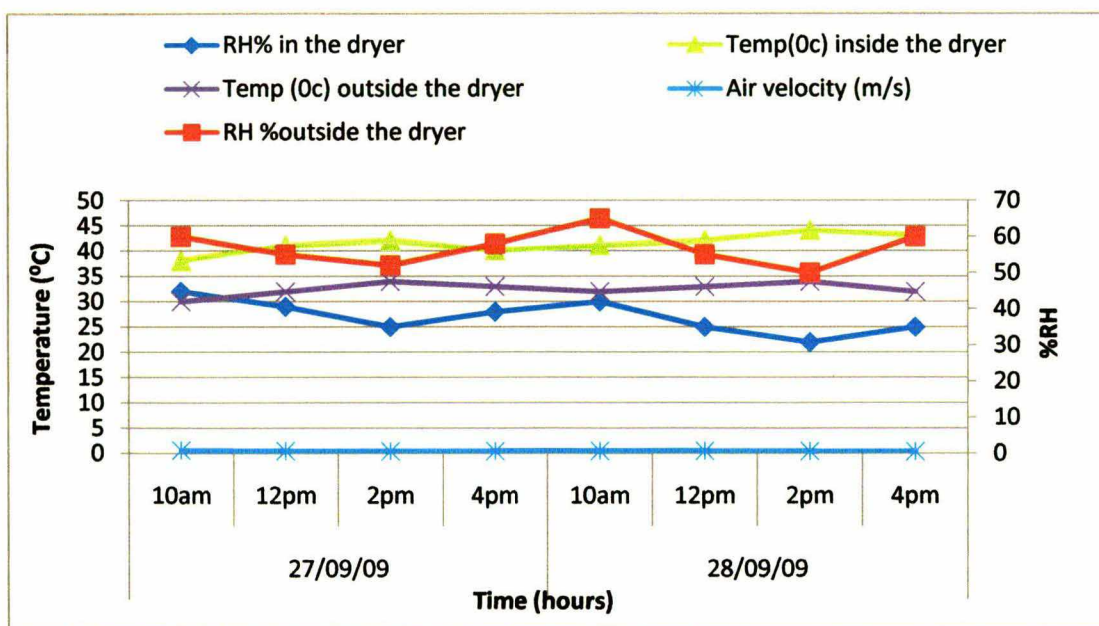


Figure 5: Relationship between temperature and percentage relative humidity (%RH) inside and outside the Solar Tunnel Dryer during the period of the first, second and third experimental run of black tiger Shrimp (*Penaeus monodon*) drying and dehydration.

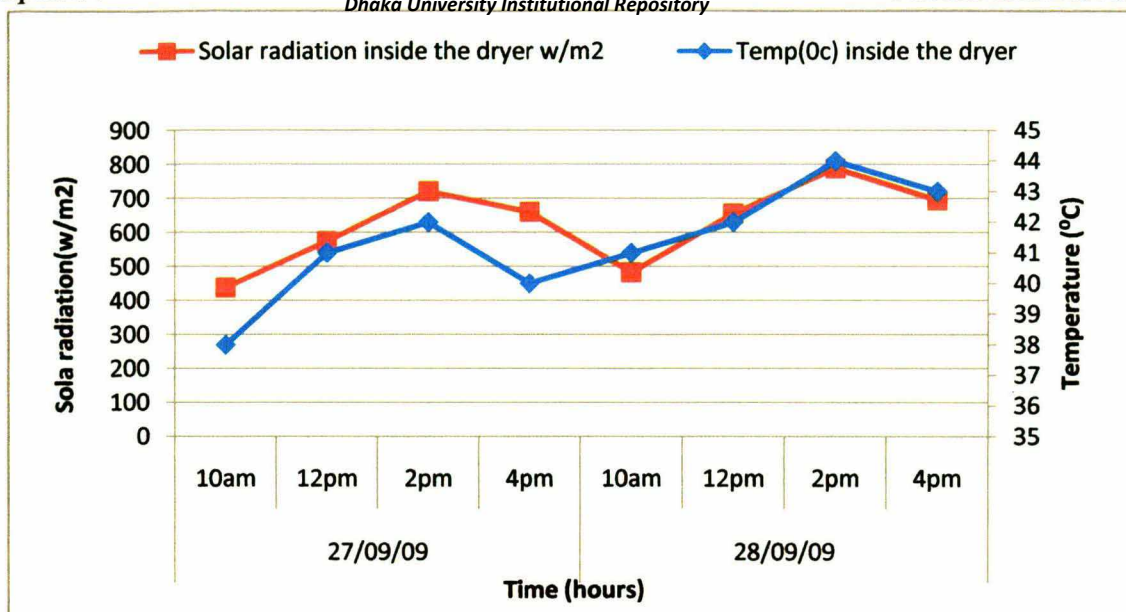


Figure 6: Relationship between temperature and solar radiation inside and outside the Solar Tunnel Dryer during the period of the first, second and third experimental run of Shrimp (*Penaeus monodon*) drying and dehydration.

Table 4: Variation of environmental factors inside the room and outside the room for sun drying during five days of the first, second and third experimental run of chinese Pomfret (*Pampus chinensis*) drying and dehydration.

Date	Time (hour)	RH% inside the room	RH% outside the room	Temp(°C) inside the room	Temp(°C) outside the room	Air Velocity (m/s)
02/11/08	10 am	65	40	29	31	0.38
	12 pm	55	35	30	32	0.44
	2 pm	52	30	31	34	0.45
	4 pm	60	38	30	33	0.44
03/11/08	10 am	66	45	30	31.5	0.55
	12 pm	57	30	31	33	0.50
	2 pm	50	28	31	34	0.51
	4 pm	55	35	30	32	0.53
04/11/08	10 am	65	42	30	31	0.53
	12 pm	55	35	31	32	0.45
	2 pm	50	30.5	32	33.8	0.48
	4 pm	60	40	29	32	0.40
05/11/08	10 am	68	50	29	30	0.55
	12 pm	50	35	30	32	0.56
	2 pm	45	25	31	34	0.69
	4 pm	55	40	30	33	0.45
06/11/08	10 am	59	44	29	31	0.50
	12 pm	52	40	31	33	0.47
	2 pm	50	38	31	34	0.44
	4 pm	54	39	30	31	0.40

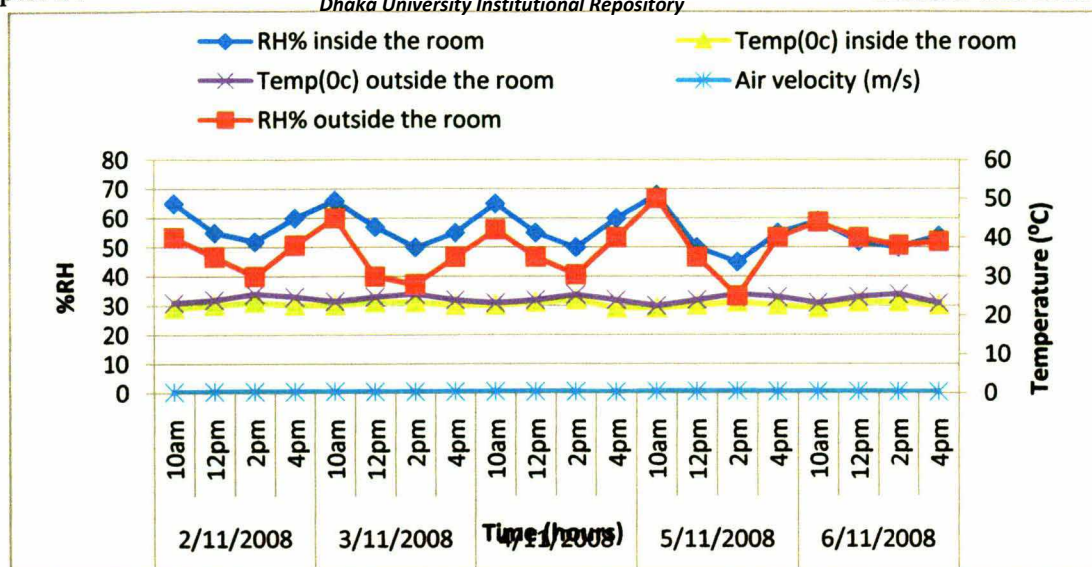


Figure 7: Relationship between temperature and percentage relative humidity (%RH) inside and outside the sun drying during the period of the first, second and third experimental run of Chinese Pomfret (*Pampus chinensis*) drying and dehydration.

Table 5 : Variation of environmental factors inside the room and outside the room for sun drying during four days of the first, second and third experimental run of Bombay duck (*Harpodon nehereus*) drying and dehydration.

Date	Time (hour)	RH% inside the room	RH% outside the room	Temp(°C) inside the room	Temp(°C) outside the room	Air Velocity (m/s)
02/11/08	10am	70	38	29	31	0.45
	12pm	65	35	30	32	0.54
	2pm	52	30	31	34	0.48
	4pm	60	38	30	33	0.50
03/11/08	10am	62	45	30	31.5	0.53
	12pm	57	30	31	33	0.55
	2pm	50	28	31	34	0.45
	4pm	55	35	30	32	0.44
04/11/08	10am	65	42	30	31	0.58
	12pm	55	35	31	32	0.52
	2pm	50	30.5	32	33.8	0.57
	4pm	60	40	29	32	0.42
05/11/08	10am	68	50	29	30	0.53
	12pm	50	35	30	32	0.58
	2pm	45	25	31	34	0.39
	4pm	55	40	30	33	0.44

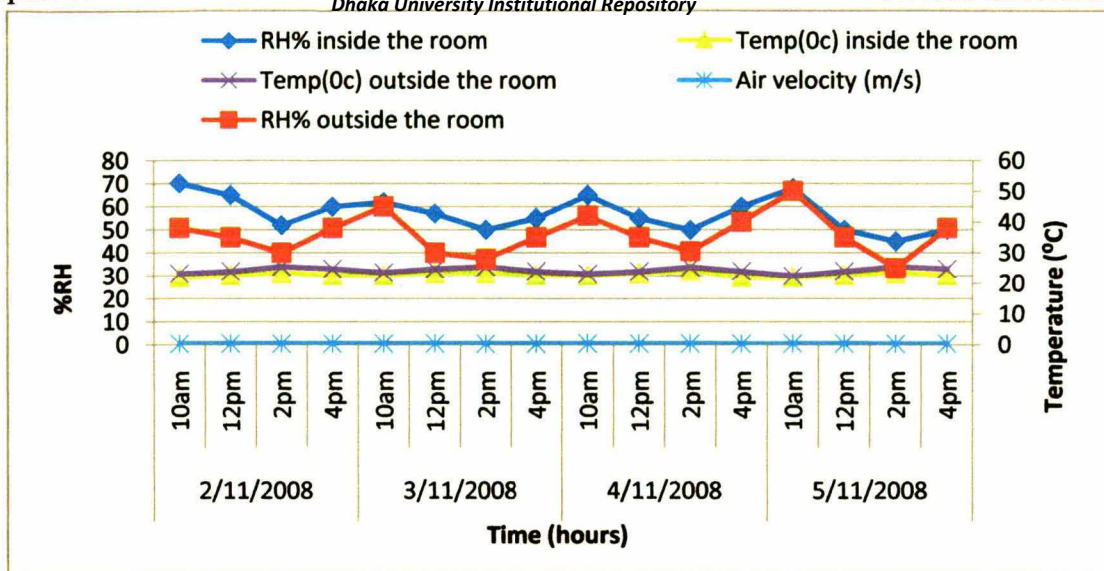


Figure 8: Relationship between temperature and percentage relative humidity (%RH) inside and outside the sun drying during the period of the first, second and third experimental run of Bombay duck (*Harpodon nehereus*) drying and dehydration.

Table 6 : Variation of environmental factors inside the room and outside the room for sun drying during three days of the first, second and third experimental run of black tiger Shrimp (*Penaeus monodon*) drying and dehydration.

Date	Time (hour)	RH% inside the room	RH% outside the room	Temp(°C) inside the room	Temp(°C) outside the room	Air Velocity (m/s)
02/11/08	10 am	66	45	30	31.5	0.55
	12 pm	57	30	31	33	0.50
	2 pm	50	28	31	34	0.51
	4 pm	55	35	30	32	0.53
03/11/08	10 am	65	42	30	31	0.53
	12 pm	55	35	31	32	0.45
	2 pm	50	30.5	32	33.8	0.48
	4 pm	60	40	29	32	0.40
04/11/08	10 am	68	50	29	30	0.55
	12 pm	50	35	30	32	0.56
	2 pm	45	25	31	34	0.69
	4 pm	55	40	30	33	0.45

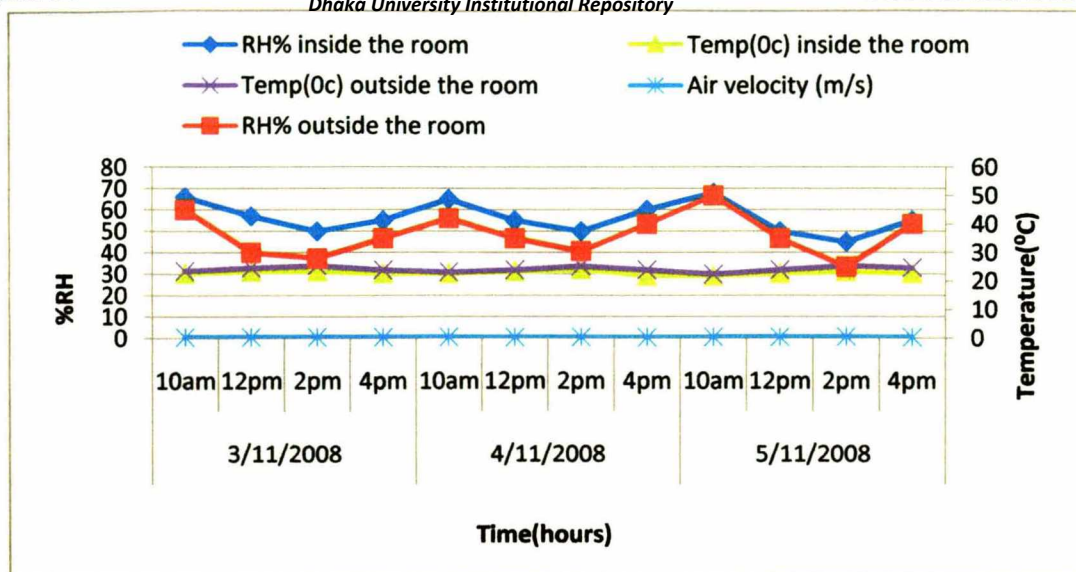


Figure 9: Relationship between temperature and percentage relative humidity (%RH) inside and outside the sun drying during the period of the first, second and third experimental run of black tiger Shrimp (*Penaeus monodon*) drying and dehydration.

Table 7: Variation of temperature and the percent relative humidity inside and outside the fish smoker during Smoke curing of experimental fish (*Pampus chinensis*).

Smoked cured Fish product	Time (hour)	Temp(°C) Inside the smoker	Temp(°C) Outside the smoker	RH% Outside the smoker	Air velocity (m/s)
Unsalted	10.30 am	80	30	35	0.45
	11.30 am	85	32	30	0.44
	12.30 pm	75	34	29	0.58
	1.30 pm	82	33.5	36	0.52
	2.30 pm	85	33	32	0.57
	3.30 pm	80	32	28	0.42
Salted	10.30 am	75	32	40	0.44
	11.30 am	80	32.8	35	0.58
	12.30 pm	85	34	30	0.52
	1.30 pm	90	33	32	0.57
	2.30 pm	88	33.5	35	0.42
Turmeric	10.30 am	79	31	38	0.53
	11.30 am	82	33	35	0.58
	12.30 pm	85	33.5	30	0.39
	1.30 pm	88	32	31	0.44

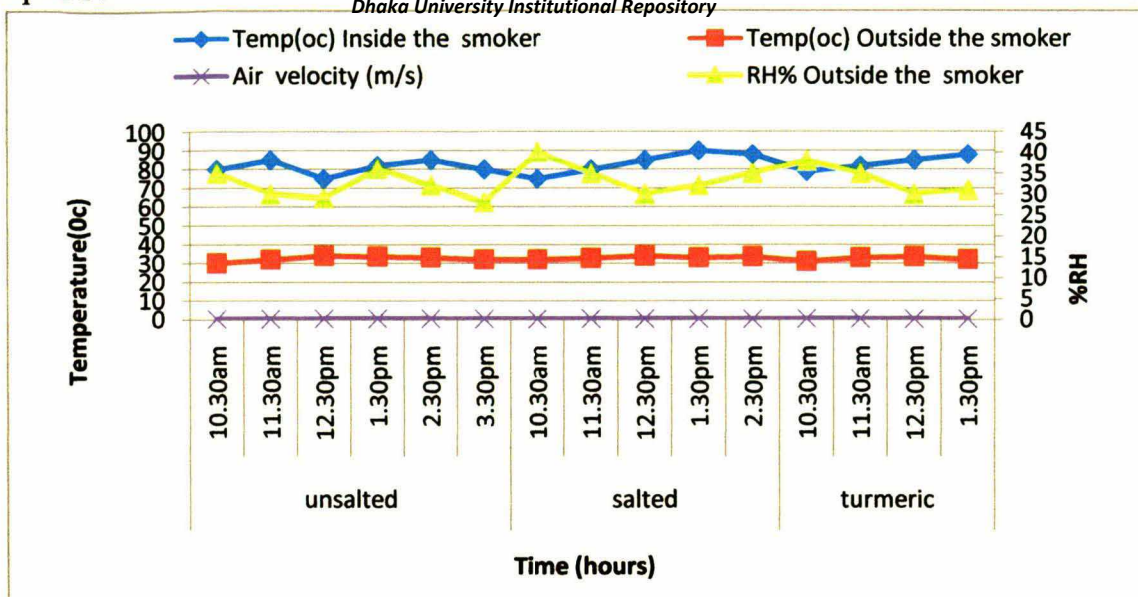


Figure 10: Variation of temperature and relative humidity inside and outside the fish smoker during Smoke curing experimental run of Chinese Pomfret (*Pampus chinensis*).

Table 8: Variation of temperature and the percent relative humidity inside and outside the fish smoker during Smoke curing of experimental fish (*Harpodon nehereus*).

Smoked cured Fish product	Time (hour)	Temp(°C) Inside the dryer	Temp(°C) Outside the dryer	RH% Outside the dryer	Air velocity (m/s)
Unsalted	10.30	75	30	55	0.45
	11.30	82	31	42	0.44
	12.30	85	32	35	0.58
	1.30	80	32	32	0.52
	2.30	90	33.6	34	0.57
	3.30	85	32	40	0.42
Salted	10.30	80	28	50	0.53
	11.30	79	30	40	0.58
	12.30	83	32	38	0.39
	1.30	88	34	35	0.44
	2.30	80	32	30	0.45
Turmeric	10.30	80	31	58	0.44
	11.30	87	32	51	0.58
	12.30	90	32	44	0.52
	1.30	85	33	38	0.57

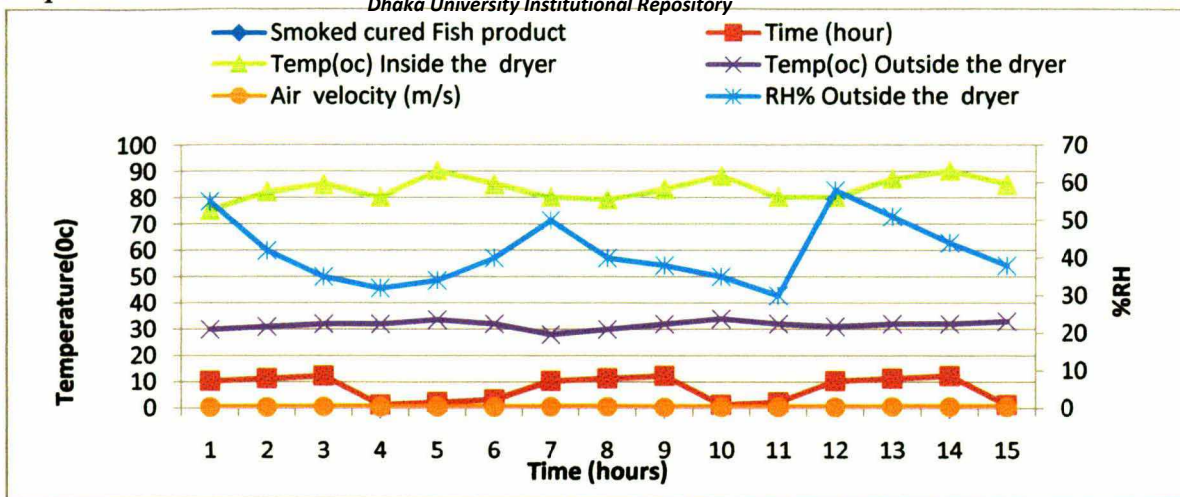


Figure 11: Variation of temperature and relative humidity inside and outside the fish smoker during Smoke curing experimental run of Bombay duck (*Harpodon nehereus*).

Table 9 : Variation of temperature the percent relative humidity inside and outside the fish smoker during Smoke curing of experimental fish (*Penaeus monodon*).

Smoked cured Fish product	Time (hour)	Temp(°C) Inside the dryer	Temp(°C) Outside the dryer	RH% Outside the dryer	Air velocity (m/s)
Unsalted	10.00am	85	31	36	0.58
	11.00am	82	32	32	0.52
	12.00pm	90	32.5	30	0.57
	1.00pm	89	33	30	0.42
Salted	10.00am	85	32	31	0.53
	11.00am	88	33	30	0.58
Turmeric	10.00am	79	31	35	0.39
	11.00am	84	32	32	0.44
	12.00pm	90	32.6	30	0.45

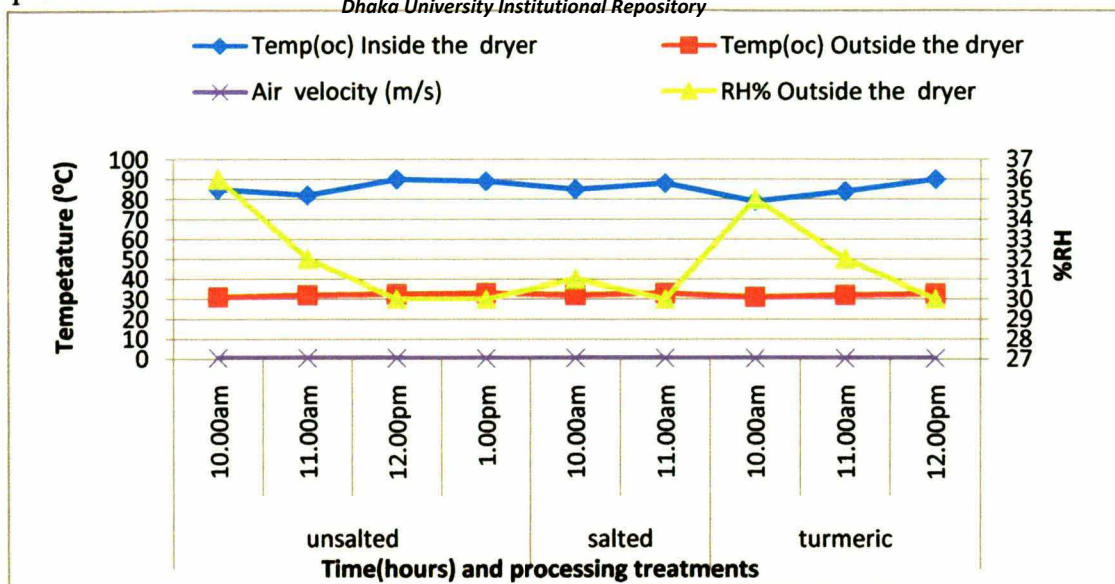


Figure 12: Variation of temperature and relative humidity inside and outside the fish smoker during Smoke curing experimental run of Shrimp (*Penaeus monodon*).

During the tunnel dried, sun dried and smoking curing, the inside the drying temperature varied from 42-45 , 32-34 and 75-90 respectively and outside the drying temperature varied from 32-36, 30-32 and 32-34 respectively while relative humidity 25-35, 30-40 and 0% inside the dryer respectively and 44-65, 60-75 and 30-40 outside the dryer respectively. As a result increased air temperature and decreased relative humidity inside the Solar Tunnel Dryer or traditional sun drying that helped in rapid drying of fishes and shrimp. A change in air temperature is usually accompanied by a change in RH. The smoke temperature is very high (75 to 95°C) and the fish is wholly or partly cooked by being smoked and deposition of naturally produced chemicals resulting from the thermal break down of wood.

By increasing the air temperature, its moisture content capacity can be decreased (cutting et. Al, 1956). In the present study, temperature was high and relative humidity (%RH) was low inside the tunnel dryer. The Solar Tunnel Dried fish showed more water loss than sun dried fish because the Solar Tunnel dryer was shaded with transparent polythene so that solar radiation could easily pass and the polythene sheet prevented the escaping of solar radiation out. A tin sheet coated with black paint was used to absorb the solar radiation inside the tunnel dryer.

Reza et al.,(2009) observed that A Hohenheim-type solar tunnel dryer, constructed with locally available material, was found very suitable for drying of marine fish such as silver jew fish, Ribbon fish, Chinese Pomfret and big-eye tuna and moisture content of the fish samples reached 16% after 36 and 32h of drying at temperature ranges of 45 to 50 and 50 to 55°C respectively. It has been observed by Bala and Hossain, (1998) that the Silver Jew fish could be dried within 3-4 day in the tunnel drier as compared to 5-6 days needed for natural sun drying. The tests on solar tunnel drying of fish were carried out by bala and hossain, in April and may 1997; whereas the present investigation has been carried out in November and December, 2008-2009.

2) Rate of Drying:

(a) Chinese Pomfret (*Pampus chinensis*)

While smoke curing required 6 hours period in drying unsalted, salted and turmeric treated Samples of pomfret, tunnel dryer required 12 hours and open sun drying method required 20 hours. Weight of smoke curing unsalted, salted and turmeric treated samples of Chinese Pomfret reduced from 500 to 170, 185 and 215 respectively whereas weight of tunnel dried samples of the same reduced from 500 to 160, 170 and 190g respectively and weight of sun dried samples of same reduced from 500 to 175, 180 and 200g respectively (Figure-13 and Table -10).

Table 10: Weight loss during different hours of drying of Chinese Pomfret (*Pampus chinensis*)

Time (hrs)	Smoke curing			Solar Tunnel dried			Sun dried		
	Unsalted (g)	Salted (g)	Turmeric (g)	Unsalted (g)	Salted (g)	Turmeric (g)	Unsalted (g)	Salted (g)	Turmeric (g)
0	500	500	500	500	500	500	500	500	500
2	400	420	435	405	425	440	380	410	435
4	330	360	375	330	325	375	320	360	390
6	275	300	335	270	290	320	280	315	343
8	225	260	290	235	255	270	245	290	310
10	210	235	260	215	235	245	220	260	275
12	190	210	245	200	220	230	200	235	260
14	180	200	240	190	200	220	190	215	240
16	175	192	225	175	190	200	185	210	225
18	172	188	220	165	180	195	175	190	210
20	170	185	215	160	170	190	175	180	200

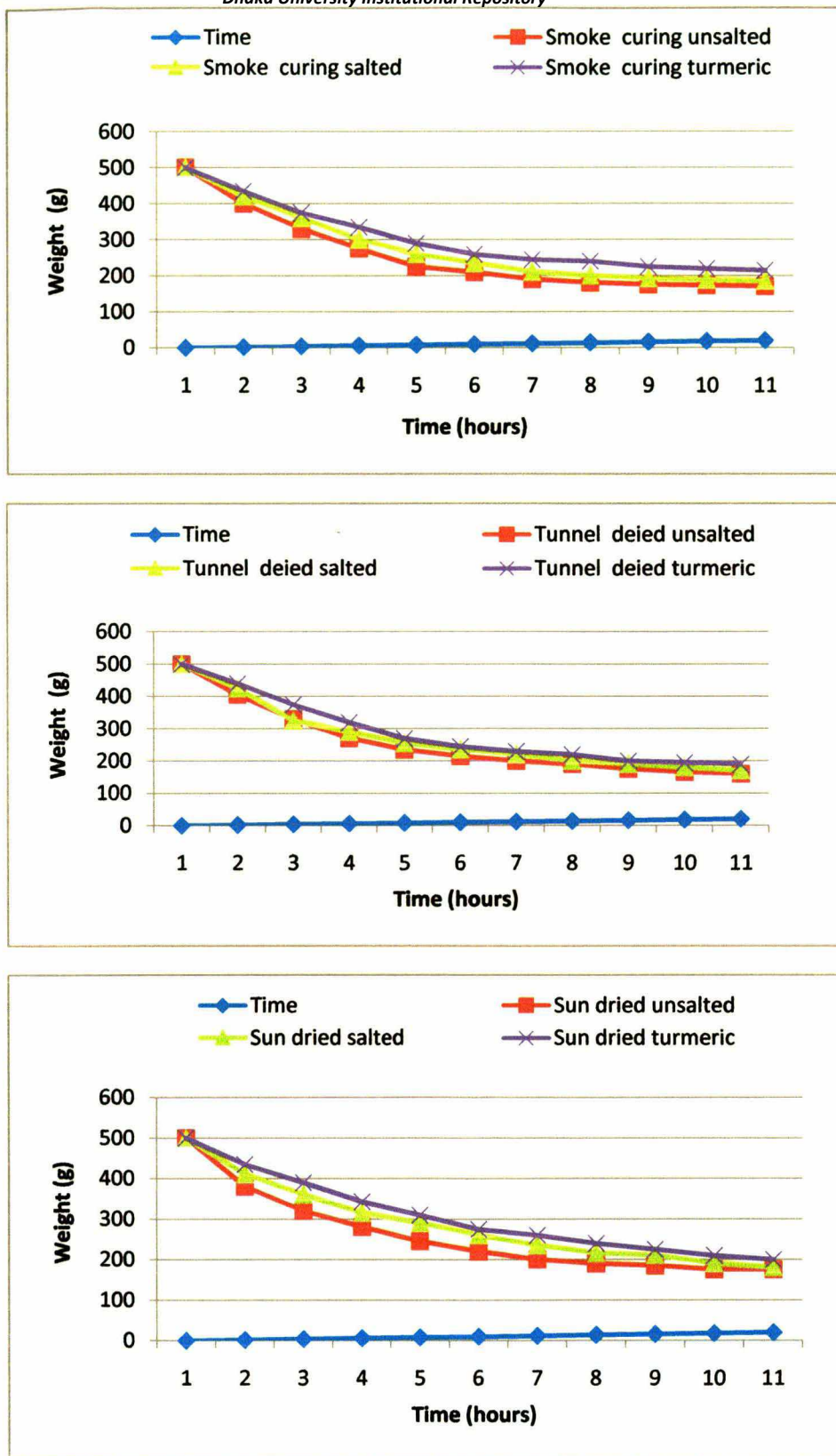


Figure 13: Drying rate of Chinese Pomfret (*Pampus chinensis*) in traditional sun drying method, solar tunnel drying method and smoke curing method.

b) Bombay duct (*Harpodon nehereus*)

While smoke curing required 7 hours period in drying unsalted, salted and turmeric treated Samples of Bombay duck tunnel dryer required 10 hours and open sun drying method required 18 hours. Weight of smoke curing unsalted, salted and turmeric treated samples of Bombay duct reduced from 500 to 110, 115 and 128g respectively whereas weight of tunnel dried samples of the same reduced from 500 to 160, 175 and 190g respectively and weight of sun dried samples of same reduced from 500 to 170, 185 and 200g respectively (Figure-14 and Table- 11).

Table 11: Weight loss during different hours of drying of Bombay duct (*Harpodon nehereus*).

Time (hrs)	Smoke curing			Solar Tunnel dried			Sun dried		
	Unsalted (g)	Salted (g)	Turmeric (g)	Unsalted (g)	Salted (g)	Turmeric (g)	Unsalted (g)	Salted (g)	Turmeric (g)
0	500	500	500	500	500	500	500	500	500
2	395	410	425	395	410	420	385	395	425
4	300	325	340	325	345	355	280	325	362
6	215	245	275	265	275	300	240	270	315
8	165	195	225	225	240	265	215	240	290
10	133	165	185	205	225	240	200	220	270
12	125	140	158	190	210	225	190	210	250
14	120	135	140	180	200	215	180	200	230
16	115	125	135	170	190	205	175	195	220
18	110	120	130	165	180	200	172	190	215
20	110	115	128	160	175	190	170	185	200

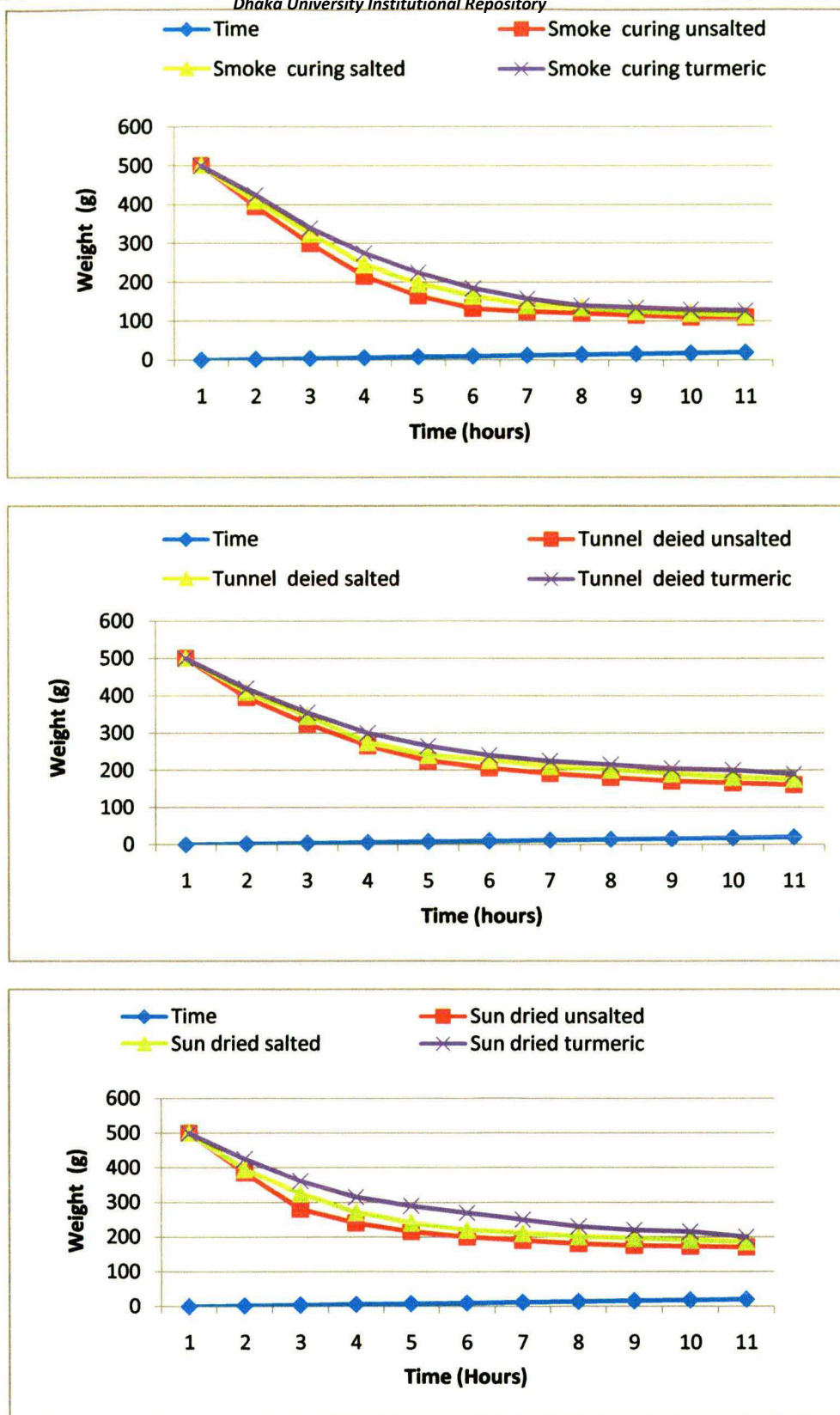


Figure 14: Drying rate of Bombay duck (*Harpodon nehereus*) in traditional sun drying method, Solar Tunnel drying method and smoke curing method.

c) Black tiger Shrimp (*Penaeus monodon*)

While smoke curing required 4.5 hours period in drying unsalted, salted and turmeric treated Samples of Shrimp, tunnel dryer required 8 hours and open sun drying method required 12 hours. Weight of smoke curing unsalted, salted and turmeric treated samples of Shrimp reduced from 500 to 135, 150 and 158 respectively whereas weight of tunnel dried samples of the same reduced from 500 to 125, 140 and 160g respectively and weight of sun dried samples of same reduced from 500 to 130, 150 and 165g respectively (Figure-15 and Table -12).

Table 12: Weight loss during different hours of drying of black tiger Shrimp (*Penaeus monodon*).

Time (hrs.)	Smoke curing			Solar Tunnel dried			Sun dried		
	Unsalted (g)	Salted (g)	Turmeric (g)	Unsalted (g)	Salted (g)	Turmeric (g)	Unsalted (g)	Salted (g)	Turmeric (g)
0	500	500	500	500	500	500	500	500	500
2	405	415	440	405	415	425	390	400	435
4	320	340	380	315	335	350	320	355	370
6	250	280	325	245	260	280	265	300	310
8	205	230	260	210	225	240	220	255	270
10	170	200	215	185	200	215	195	220	240
12	145	170	185	170	185	195	175	195	220
14	140	158	170	155	165	185	160	170	195
16	138	155	165	140	155	175	145	160	175
18	135	152	160	135	145	165	135	155	170
20	135	150	158	125	140	160	130	150	165

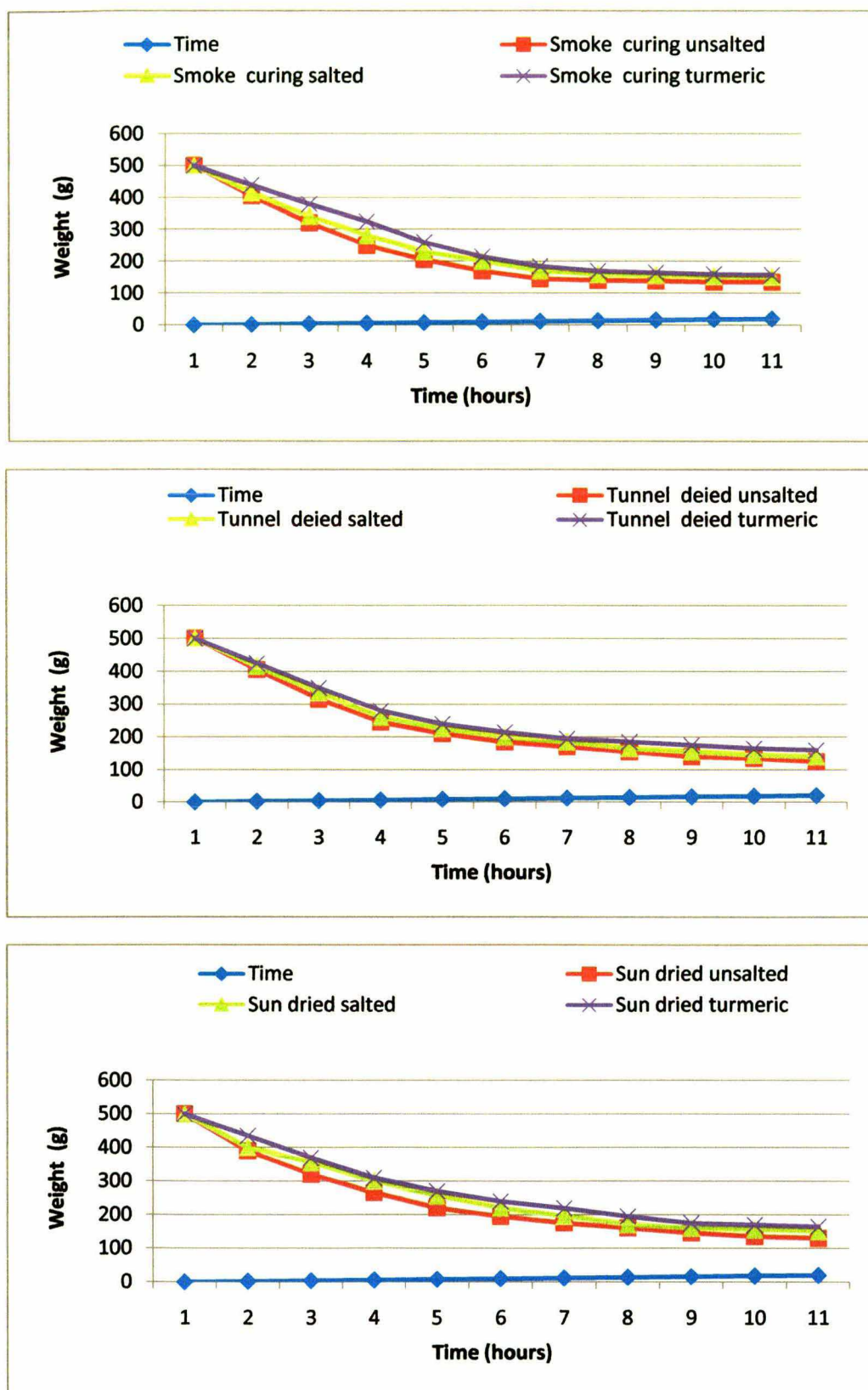


Figure 15: Drying rate of black tiger Shrimp (*Penaeus monodon*) in traditional sun drying method, Solar Tunnel drying method and smoke curing method.

Smoke curing, tunnel drying and sun drying took 6, 12 and 20 hours of drying to dry unsalted, salted and turmeric treated Chinese Pomfret in November; Smoke curing, tunnel drier and sun drying took 7, 12 and 18 hours of drying to dry unsalted, salted and turmeric treated Bombay duck in November and Smoke curing, tunnel drier and sun drier took 4.5, 8 and 12 hours of drying to dry unsalted, salted and turmeric treated black tiger Shrimp in November.

Production of good quality dried products largely depends on the appropriate temperature during the drying process and the moisture content of the final product. Excessive heat in the dryer may cause 'case hardening' of the dried products. It is, therefore, important to assess the required drying temperature, humidity and moisture content for each species of fish to be dried to produce good quality end products. It is well known that the drying process largely depends on the surface area, water and fat content of fish, temperature, relative humidity and air velocity. The present study reports the optimization of the drying process for several commercially important tropical marine fish species in the Bay of Bengal, namely Bombay duck, Pomfret and Shrimp fish in a solar tunnel dryer and maintenance of required moisture level for production of high quality dried fish products. When salt is added to the fish before drying, less water needs to be removed to achieve the same effect, and the product with a water content of 35 to 45% depending on amount of salt present, is often dry enough to inhibit the growth of molds and bacteria under most climatic condition.

The rate of drying is influenced by the following factors such as air temperature, air velocity, relative humidity (RH) of the air, constant rate drying period, falling rate drying period etc. Moreover, the composition and nature of individual fish, its chemical composition and physical structure are important factors influencing the rate of drying.

The rate of weight loss of the samples of all three species was found rapid at the beginning of the experiment, then slowed down and finally stopped when the system attained almost equilibrium (Figure 13-15 and Table 10-12). During the falling-rate period, it was observed that the main factor influencing drying rate is the air temperature (Bellagha et al. 2002). Thus, a higher air temperature produced a higher drying rate. Actually drying rates at 75 to 90°C were faster than that at 45 to 50°C and then at 32 to 34 °C and the drying period was reduced. This is because of the acceleration of water migration inside the fish. It was observed that during air drying, at first, moisture is being removed from the surface of the fish and then water moves from the deeper layers to the surface. Once all the surface moisture has been carried away, falling rate period starts and this depends on the rate at which moisture can be

brought to the surface of the fish. As the concentration of moisture in the fish falls, the rate of movement of moisture to the surface is reduced and the drying rate becomes slower, reaching zero at equilibrium between the product and the surrounding drying conditions (Bellagha et al. 2002). Once all the surface moisture has been carried away, falling rate period starts and this depends on the rate at which moisture can be brought to the surface of the fish. As the concentration of moisture in the fish falls, the rate of movement of moisture to the surface is reduced and the drying rate becomes slower, reaching zero at equilibrium between the product and the surrounding drying conditions (Bellagha et al. 2002).

Some workers (Charm, 1963; Jason 1965; Burgess et. al.,1965) also observed 3 distinct phases in their drying rate curves, stage-1 : setting down period, stage-2: constant period, stage-3: falling rate period. The curved in the present study showed the falling rate period was apparently absent.

For solar drying process the drying rate of fatty fish is less than that of lean fish. However, the presence of high amounts of water and hence, the rate of drying (Burgess, 1965) exposed to the sun. Splitting the fish results in increase of surface area relative to weight and the rate of drying becomes faster. In these experiments, Shrimp (*Penaeus monodon*) took less time to dry due to lower surface in relation to weight, Bombay duck (*Harpodon nehereus*) and Pomfret (*Pampus chinensis*) took more time due to larger surface area in relation to weight.

Shrimp>Bombay duck>Pomfret

Some reports indicate that losses from insects, animals and weather may be up to 30 to 40% (Hollick et al.,1999; Wall et al., 2001). There is also widespread use of different types of insecticides to avoid insect infestation during the traditional drying process that make the product unattractive to the consumers (Reza et al., 2005).

The physical and organoleptic qualities of most of the traditional sun-dried products available in the market are not satisfactory for human consumption (Kamruzzaman, 1992; Saha et al., 1999) . Bala and Mondol, (2001) was found very suitable for drying of salt treated silver jew fish at temperature of 35 to 52°C for 5 days without showing any infestation, oxidative rancidity, spoilage and contamination. The design of this dryer realizes the demand for higher drying capacity and better moisture removal.

The drying method is to produce a high quality product at a relatively low cost. Although 50% of sun dried fish wasted during drying and subsequent storage as estimated by Doe at. al. (1977) in Bangladesh due to fly larvae infestation. Hayward, (1961) reported that in drying on racks, heat penetration was not sufficient to kill the fly larvae inside and results fly larvae infestation.

The temperature inside the tunnel dryer and smoker was higher compared with the control samples, which was effective in killing the larvae and adults flies and protected from the rain and dust. FAO (1992) report suggests that when water content falls below 25% of the wet weight, bacterial action stops and if the water content is further reduced down to 15% , mold ceases to grow.

2. Proximate composition:

1) Proximate composition of fresh fishes and shrimp

The results of biochemical composition of Chinese Pomfret (*Pampus chinensis*), Bombay duck (*Harpodon nehereus*) and black tiger Shrimp (*Penaeus monodon*) in fresh Condition have been represented (Figure-16 and Table 13-15). The average biochemical composition of Chinese Pomfret was 82.23% moisture, 17.84% protein, 1.47% fat, 1.69% ash. The composition of Bombay duck was 78.14% moisture, 15.49% protein, 2.80% fat, 3.49% ash and The composition of black tiger Shrimp was 78.43% moisture, 17.62% protein, 1.73% fat, 1.91% ash respectively.

Table13: Variation in proximate composition(%) of fresh Chinese Pomfret (*Pampus chinensis*)

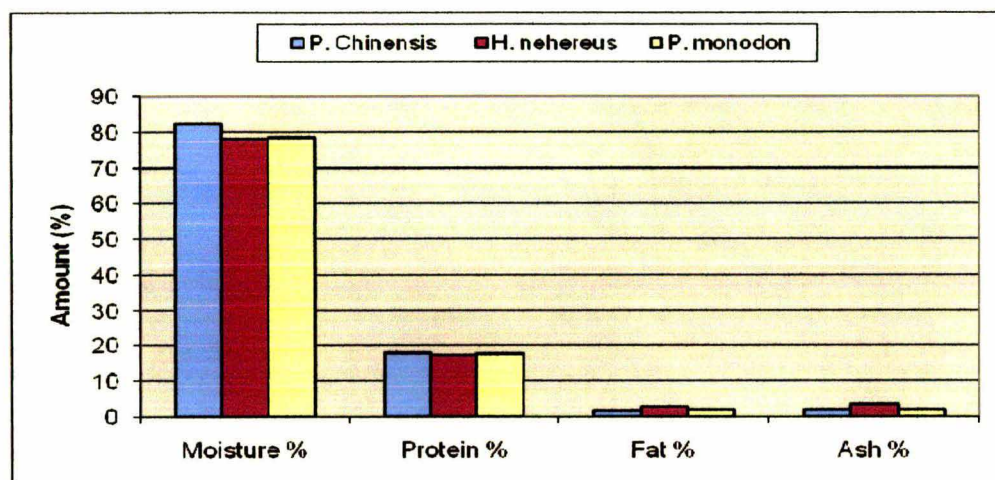
Sample No.	Moisture	Crude protein	Fat	Ash
1	78.0	17.0	2.0	1.7
2	80.0	18.2	1.2	1.5
3	79.0	18.0	1.4	2.0
4	79.5	17.8	1.4	2.0
5	80.0	18.1	1.2	1.5
6	78.5	17.4	1.9	2.5
7	78.9	17.8	1.5	1.6
8	79.8	18.1	1.3	1.9
9	80.0	18.5	1.2	1.6
10	78.6	17.5	1.6	2.2
Avg.	82.23	17.84	1.47	1.85

Table 14: Variation in proximate composition (%) of fresh Bombay duck (*Harpodon nehereus*)

Sample No.	Moisture	Crude protein	Fat	Ash
1	79.0	18.0	2.0	3.0
2	77.0	16.0	3.5	4.0
3	78.5	17.5	2.5	3.5
4	77.5	16.5	3.0	3.2
5	78.0	17.0	3.0	3.5
6	79.0	17.8	2.2	3.0
7	77.8	16.5	3.0	4.0
8	79.0	18.0	2.1	3.2
9	77.6	16.5	3.2	4.0
10	78.0	17.1	3.5	3.5
Avg.	78.14	17.09	2.80	3.39

Table15: Variation in proximate composition (%) of fresh black tiger Shrimp (*Penaeus monodon*)

Sample No.	Moisture	Crude protein	Fat	Ash
1	79.0	18.0	1.6	1.9
2	78.5	17.8	1.7	2.0
3	78.0	17.5	1.8	2.0
4	77.0	16.5	2.0	1.8
5	79.0	17.9	1.6	1.9
6	77.5	17.0	1.8	2.0
7	78.8	17.9	1.7	2.0
8	79.0	17.8	1.7	1.8
9	78.5	17.7	1.8	1.9
10	79.0	18.1	1.6	1.8
Avg.	78.43	17.62	1.73	1.91

Figure 16: Proximate composition of Chinese Pomfret (*Pampus chinensis*), Bombay duck (*Harpodn nehereus*) and black tiger Shrimp (*Penaeus monodon*).

The physical and chemical composition of fish are influenced by the environment, season, size, sex and maturity from where the fish is harvested (Gopalan, 1978). The biochemical composition of fish is affected by numerous factors either of intrinsic or extrinsic in nature. The nutritive values of processed and preserved fish are influenced by chemical nature of their fats and lipid component. Increase in moisture content and decrease in fats and protein content were related with the increase of age. According to Khuda (1962), crude protein level varied from 17.18% to 19.56% but, for higher body and the fresh fish contained 77.14% moisture and 1.48% ash and Nurnadia et. al, (2011) showed that protein level varied from 20.51%, moisture 76.58 % and fat 1.80 %. It was similar to the present study.

2) Proximate composition of dry fishes and shrimp

(a) Pomfret

The result of proximate composition of Chinese Pomfret (*Pampus chinensis*) in smoke curing, solar tunnel dried and sun dried condition have been represented in Figure- 17 and Table - 16. The smoke curing, Solar Tunnel and sun dried unsalted samples contained 24.24% moisture, 55.01 % protein, 10.97 % fat and 9.32 % ash; 17% moisture, 62.09% protein, 12.08 % fat and 10.23 % ash and 22.23 % moisture, 59.68% protein, 8.91% fat and 8.60 % ash respectively. The smoke curing, Solar Tunnel and sun dried salted samples contained 26.08 % moisture, 54.20 % protein, 8.88% fat and 7.78 % ash; 20.20 % moisture, 58.10 % protein, 11.06% fat and 8.12% ash and 23.09 % moisture, 57.19% protein, 10.14 % fat and 6.93 % ash respectively.

Table16: Variation in proximate composition (%) (Mean $\pm$ SD) of smoke curing, Solar Tunnel dried and sun dried Chinese Pomfret (*Pampus chinensis*)

Sample		Moisture	Crude protein	Fat	Ash
Smoke curing	Unsalted	24.23 $\pm$ 0.749	55.01 $\pm$ 0.811	10.97 $\pm$ 0.768	9.32 $\pm$ 0.690
	Salted	26.08 $\pm$ 0.749	54.20 $\pm$ 1.127	8.88 $\pm$ 0.500	7.78 $\pm$ 0.511
Solar tunnel dried	Unsalted	17.17 $\pm$ 0.624	62.09 $\pm$ 0.576	12.08 $\pm$ 0.688	10.23 $\pm$ 0.668
	Salted	20.20 $\pm$ 0.600	58.10 $\pm$ 0.624	11.06 $\pm$ 1.264	8.12 $\pm$ 0.685
Sun dried	Unsalted	22.13 $\pm$ 1.974	59.68 $\pm$ 6.035	8.91 $\pm$ 0.787	8.60 $\pm$ 0.424
	Salted	23.09 $\pm$ 0.830	57.19 $\pm$ 0.818	10.14 $\pm$ 0.767	6.93 $\pm$ 0.688

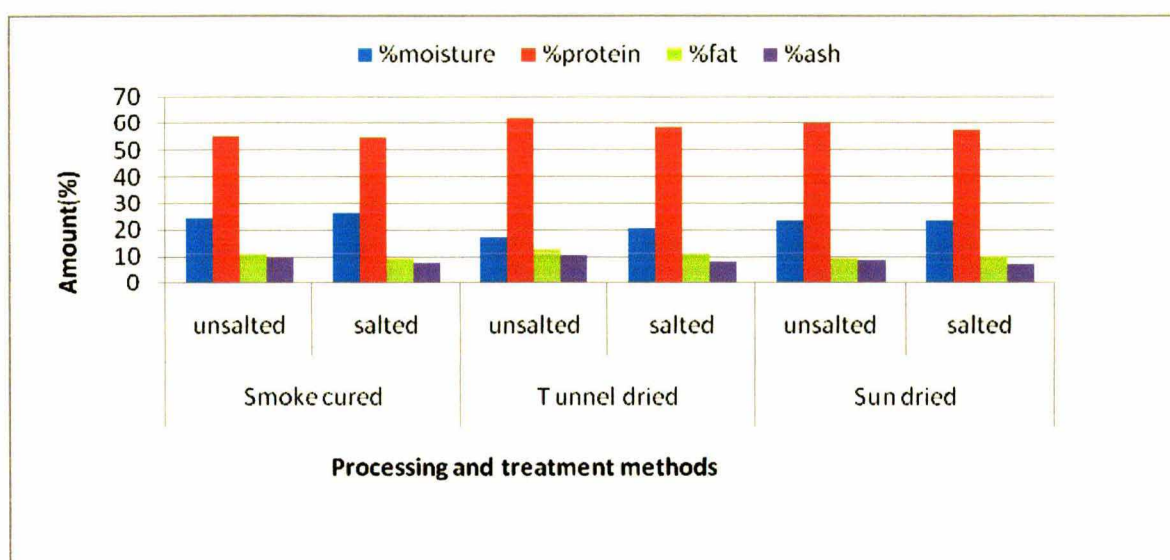


Figure 17: Proximate composition of smoke curing, Solar Tunnel dried and sun dried Chinese Pomfret (*Pampus chinensis*).

The average moisture content was 22.16 . Unsalted, salted and turmeric treated smoke curing Chinese Pomfret had 24.24% and 26.08% moisture content respectively .But Solar Tunnel dried unsalted, salted and turmeric treated samples contained 17.17% and 20.20 % moisture content respectively and sun dried unsalted, salted and turmeric treated samples contained 22.23% and 23.09 % moisture content respectively. Drying rate of unsalted Chinese Pomfret was higher than that of salted and turmeric treated samples. It is due to fact that moisture diffuses to the surface to the slowly in case of salted turmeric treated samples. Cutting et. al,(1956) showed that the higher the amount of salt and turmeric added, the more slowly the moisture diffuses to the surface.

It is observed that all the Solar Tunnel dried Pomfret is more enriched with higher nutrient contents in comparison with that of the dried Pomfret of the open sun and smoke cured.

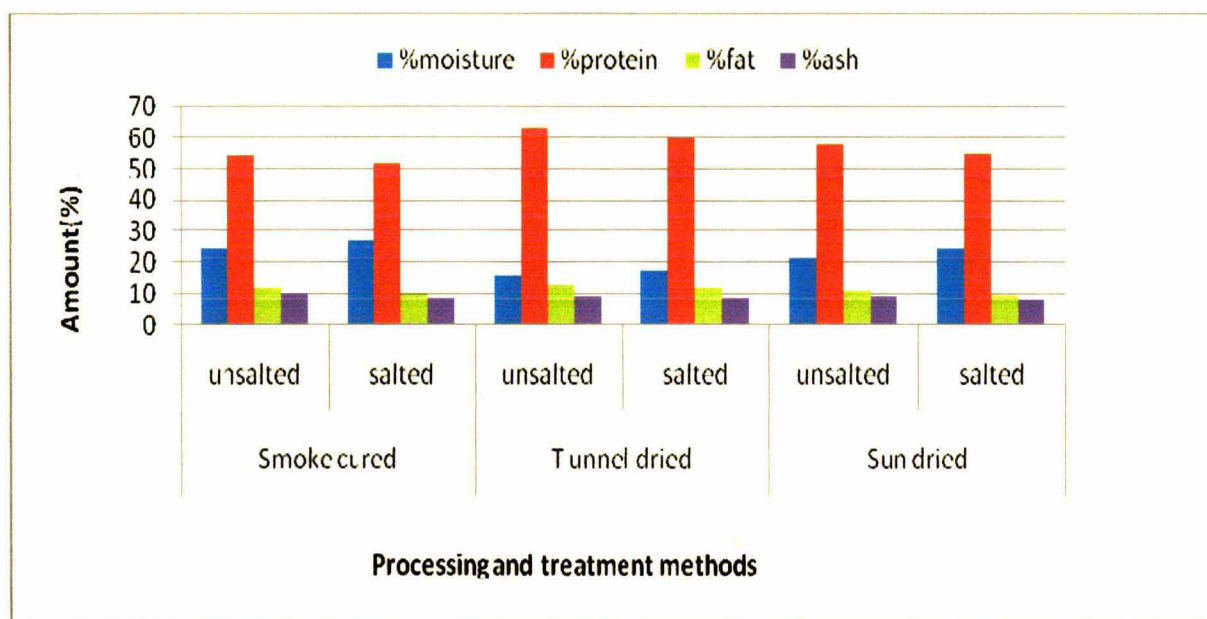
According to Islam (2002), protein level of *Pampus argenteus* varied from 65.73% to 67.7%, Moisture 16.6% to 18.9% and fat 6.2% to 6.6%.and BFRI (2012) showed that protein level of marine fish (*Lepturacanthus savala*) varied 63.5%, moisture 14.7 % and fat 10.7% . It was similar to the present study.

(b) Bombay duck

The result of Biochemical composition of Bombay duck (*Harpodon nehereus*) in smoke curing , solar tunnel dried and sun dried condition have been represented in Figure-18 and Table-17. The smoke curing , solar tunnel and sun dried unsalted samples contained 25.06 % moisture, 54.01% protein, 11.75 % fat and 10.51 % ash; 15.99% moisture, 63.18 % protein, 13.11 % fat and 9.13% ash and 21.80% moisture, 58.24 % protein, 11.17 % fat and 9.40 % ash respectively and The smoke curing , Solar Tunnel and sun dried salted samples contained 27.12% moisture, 51.93% protein, 9.93% fat and 8.58 % ash; 17.96 % moisture, 60.10% protein, 12.09 % fat and 8.43% ash and 25.16 %moisture, 55.35 % protein, 9.23 % fat and 8.01 % ash respectively.

Table 17: Variation in proximate composition (%) (Mean $\pm$ SD) of smoke curing, solar tunnel dried and sun dried Bombay duck (*Harpodon nehereus*).

Sample		Moisture	Protein	Fat	Ash
Smoke curing	Unsalted	25.06 $\pm$ 0.848	54.12 $\pm$ 1.091	11.75 $\pm$ 0.778	10.51 $\pm$ 0.519
	Salted	27.12 $\pm$ 0.762	51.84 $\pm$ 0.1.532	9.93 $\pm$ 0.656	8.58 $\pm$ 0.329
Solar tunnel dried	Unsalted	15.99 $\pm$ 0.718	63.18 $\pm$ 0.726	13.11 $\pm$ 0.620	9.13 $\pm$ 0.713
	Salted	17.96 $\pm$ 0.722	60.11 $\pm$ 0.732	12.09 $\pm$ 0.706	8.43 $\pm$ 0.658
Sun dried	Unsalted	21.80 $\pm$ 1.134	58.24 $\pm$ 1.190	11.17 $\pm$ 0.737	9.40 $\pm$ 0.737
	Salted	25.16 $\pm$ 0.819	55.26 $\pm$.694	9.33 $\pm$ 0.590	8.01 $\pm$ 0.576



Figurein 18: Proximate composition of smoke curing, Solar Tunnel dried and sun dried Bombay duck (*Harpodon nehereus*).

The average moisture content was 18.22 . Unsalted, salted and turmeric treated smoke curing Bombay duct had 25.06 and 27.12 % moisture content respectively. But tunnel dried Unsalted, salted and turmeric treated samples contained 15.99 and 17.96% moisture content respectively and sun dried Unsalted, salted and turmeric treated samples contained 21.80 and 25.16 % moisture content respectively.

Islam et.al. (2005) observed that open sun dried Mola and Gudusia fish contained 15 to 20% and 15.5 to 20% moisture and 59 to 70 % and 51.1 to 60% protein respectively and Morshed et al (2004) observed that dried Bombay duck contained 20.8% moisture, 60.5% protein and 8.0% fat. It was similar to the present study.

It is observed that all the solar tunnel dried Bombay duck is the highest nutrient contents in comparison with that of the dried Bombay duck of the open sun and smoke curing. The sun dried Bombay duck is more enriched nutrient contents than smoke cured Bombay duck. Smoking process for Bombay duck does not better because the smoke temperature is very high and the fish is wholly or partly cooked. It is observed that protein content of unsalted Bombay duck was higher in case of salted and turmeric treated Solar Tunnel dried Bombay duck.

(c) Black tiger Shrimp

The result of Biochemical composition of black tiger Shrimp (*Peaneus monodon*) in smoke curing, solar tunnel dried and sun dried condition have been represented in Figure-19 and Table-18. The smoke curing, Solar Tunnel and sun dried unsalted samples contained 25.88 %moisture, 59.80 % protein, 7.59 % fat and 8.78 % ash; 17.89 % moisture, 60.15 % protein, 11.62 % fat and 9.77 % ash and 21.70 % moisture, 57.33 % protein, 11.15 % fat and 10.09% ash respectively and The smoke curing, Solar Tunnel and sun dried salted samples contained 25.32 % moisture, 47.26 % protein, 6.70% fat and 7.60 % ash; 20.95% moisture, 57.74 % protein, 10.23 % fat and 9.59 % ash and 24.23% moisture, 55.38 % protein, 9.22 % fat and 8.08% ash respectively.

Table 18 . Variation in proxomate composition (%) (Mean $\pm$ SD) of smoke curing, Solar Tunnel dried and sun dried black tiger Shrimp (*Peaneus monodon*)

Sample		Moisture	Crude protein	Fat	Ash
Smoke curing	Unsalted	25.88 $\pm$ 0.767	59.80 $\pm$ 1.165	7.59 $\pm$ 0.690	8.78 $\pm$ 0.421
	Salted	28.02 $\pm$ 0.791	52.36 $\pm$ 0.592	7.30 $\pm$ 0.878	8.30 $\pm$ 0.659
Solar tunnel dried	Unsalted	17.89 $\pm$ 0.700	60.15 $\pm$ 0.712	11.62 $\pm$ 0.325	9.77 $\pm$ 0.883
	Salted	20.96 $\pm$ 0.924	57.76 $\pm$ 1.813	10.23 $\pm$ 0.614	9.59 $\pm$ 0.449
Sun dried	Unsalted	21.70 $\pm$ 1.159	57.25 $\pm$ 1.184	11.15 $\pm$ 0.683	10.09 $\pm$ 0.490
	Salted	24.23 $\pm$ 0.671	55.39 $\pm$ 0.585	9.24 $\pm$ 0.639	8.15 $\pm$ 0.624

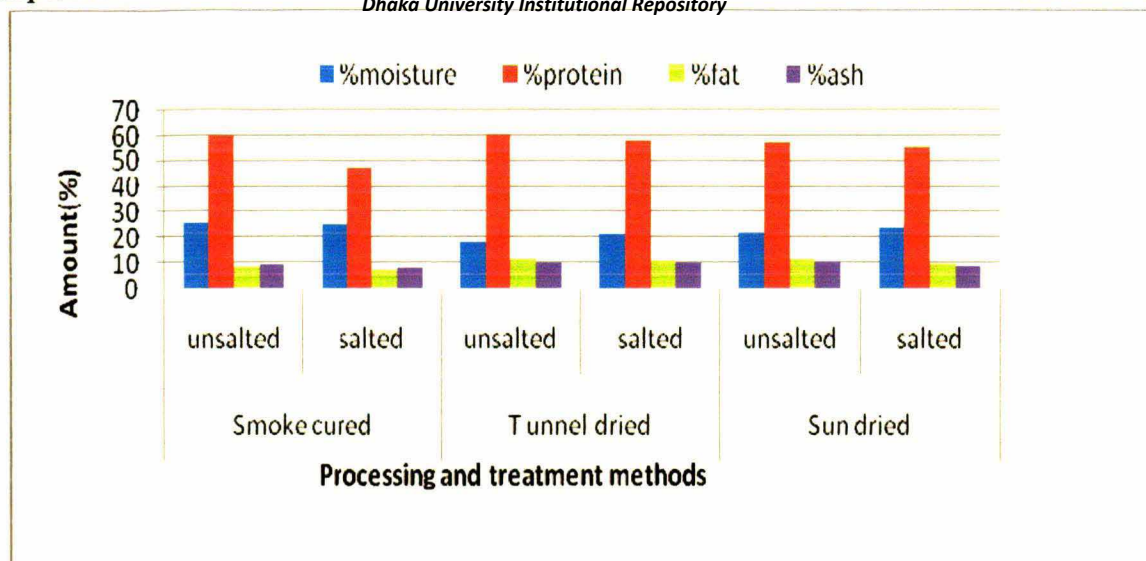


Figure 19: Proximate composition of smoke curing, solar tunnel dried and sun dried black tiger Shrimp (*Penaeus monodon*).

The average moisture content was 22.66 . Unsalted, salted and turmeric treated smoke curing had Shrimp 25.88% and 25.32% moisture content respectively. But tunnel dried Unsalted, salted and turmeric treated samples contained 17.89% and 20.95 % moisture content respectively and sun dried unsalted, salted and turmeric treated samples contained 21.70% and 24.23 % moisture content respectively.

It is observed that all the Solar Tunnel dried Shrimp is the highest nutrient contents in comparison with that of the dried Shrimp of the open sun and smoke curing. It is observed that smoke cured Shrimp is more enriched nutrient contents than sun dried shrimp.

Several studies have reported about the better quality of the dried fish in the solar tunnel dryer. (BFRI-2012,Islam et al., 2005, Roe et al. 1987).But change in food value during curing varied greatly depending on the type of fish and the method of processing method employed (Cutting et al.,1962). Mukherjee et al., (1990) also reported that improved solar dryer was suitable for adaptation by fisherman- processor families in the coastal belt.

And some studies have reported the effect of the smoking process on the quality parameters of many fish species (Cardinal et al. 2001; Espe et al. 2001, 2002;Røra and Einen 2003; Martinez et al. 2007). Smoked fish is tasty and excellent (ex. pla kaphong in Thailand) but in general does not keep as well as cold smoked. The characterization of smoked, tunnel dried and sun dried fish products could be useful in order to know the chemical composition and the typical values of the main quality parameters of these commercial products, as well as to

establish the common characteristics of this type of products. This information would be a useful reference for producers and for researchers in the field of new product development.

The aim of this work was to determine the composition and physicochemical parameters of different smoked, tunnel dried and sun dried fish products in order to provide values of the parameters which best define these products.

3) Statistical analysis of biochemical variables of dry fishes and shrimp.

Statistical analysis of the biochemical parameters has been done by SPSS-20. This analysis compares the parameters within treatment groups and different processing methods. The result with graphical presentation given below.

(a) Biochemical variables of Pomfret (*Pampus chinensis*).

Table 19: Levels (mean+sem) of moisture (%), ash(%), fat(%), and protein (%) detected in fresh, preserved and processed Chinese Pomfret (*Pampus chinensis*)

Fresh					moisture	Protein	fat	Ash
			1		78.0	17.0	2.0	1.7
			2		80.0	18.2	1.2	1.5
			3		79.0	18.0	1.4	2.0
			4		79.5	17.8	1.4	2.0
			5		80.0	18.1	1.2	1.5
			6		78.5	17.4	1.9	2.5
			7		78.9	17.8	1.5	1.6
			8		79.8	18.1	1.3	1.9
			9		80.0	18.5	1.2	1.6
			10		78.6	17.5	1.6	2.2
			Total	Mean	82.23	17.84	1.47	1.69
				SEM	±1.023	±0.256	±0.523	±0.446
	Unsalted dried	Sun dried	1		23.00	59.20	8.20	9.00
			2		21.50	60.50	9.80	8.50
			3		21.00	61.00	10.00	8.90
			4		22.50	59.60	8.00	9.00
			5		23.00	59.50	8.20	8.50
			6		22.90	59.20	8.50	7.90
			7		21.90	60.60	9.00	7.80
			8		21.50	60.20	9.50	9.00
			9		23.00	59.00	8.00	8.50
			10		21.00	61.00	9.90	8.90
			Total	Mean	22.13	59.98	8.91	8.60
				SEM	±0.266	±0.243	±0.261	±0.142
		Tunnel dried	1		17.5	61.7	11.9	10.2
			2		18.0	61.0	11.0	9.8
			3		16.0	63.0	12.8	10.9
			4		16.5	62.6	12.4	11.0
			5		17.8	62.0	11.5	9.0
			6		16.9	62.2	12.0	10.8
			7		16.8	62.4	12.6	10.4
			8		17.0	62.3	12.2	11.0

			9		18.0	61.2	11.6	9.5
			10		17.2	62.5	12.8	9.7
			Total	Mean	17.17	62.09	12.08	10.23
				SEM	±0.209	±0.198	±0.188	±0.223
		Smoke cured	1		23.09	56.00	12.0	9.0
			2		24.51	54.50	10.8	9.5
			3		25.00	54.20	10.1	10.0
			4		24.20	55.50	11.2	8.9
			5		23.60	55.90	10.0	9.8
			6		25.00	54.00	11.7	8.0
			7		24.80	54.50	10.1	9.9
			8		24.90	54.20	11.8	10.0
			9		23.08	56.00	11.5	9.6
			10		24.20	55.30	10.5	8.5
			Total	Mean	24.23	55.01	10.97	9.32
				SEM	±0.237	±0.256	±0.243	±0.218
	Salted dried	Sun dried	1		22.00	7.50	9.50	58.00
			2		23.50	7.00	10.00	56.50
			3		22.50	6.50	10.60	57.50
			4		24.00	8.00	9.00	57.20
			5		23.90	6.90	11.00	58.00
			6		22.70	7.80	10.80	57.90
			7		22.50	6.60	10.50	56.80
			8		23.80	6.00	9.00	56.00
			9		24.00	6.00	11.00	58.00
			10		22.00	7.00	10.00	56.00
			Total	Mean	23.09	57.19	10.14	6.93
				SEM	±0.262	±0.258	±0.242	±0.217
		Tunnel dried	1		19.60	58.40	11.80	8.40
			2		19.90	58.00	11.20	7.90
			3		20.20	58.10	10.90	7.50
			4		21.00	57.00	10.20	8.70
			5		20.80	57.70	10.50	7.00
			6		19.40	58.80	11.60	8.00
			7		19.00	59.00	12.00	9.00
			8		20.50	58.60	11.00	7.20
			9		21.00	57.20	10.50	8.80
			10		20.60	58.20	10.90	8.70
			Total	Mean	20.20	58.10	11.06	8.12
				SEM	±0.221	±0.183	±0.187	±0.224
		Smoke cured	1		26.00	55.00	8.80	7.20
			2		26.90	52.60	9.30	7.80
			3		25.00	55.00	9.40	7.90
			4		26.60	54.60	8.20	8.00
			5		25.20	55.00	9.60	7.50
			6		26.50	53.00	8.00	7.00
			7		27.00	52.20	8.50	7.80
			8		26.00	54.80	9.20	7.40
			9		26.50	54.80	9.00	7.90
			10		25.10	55.00	8.80	9.00
			Total	Mean	26.08	54.20	8.88	7.78
				SEM	±0.237	± 0.356	±0.166	±0.161

(1) Moisture%

Levels of moisture (%) measured in the samples of sun dried Chinese Pomfret of salted (23.09 ± 0.262), unsalted (22.23 ± 0.658) preserved treatment groups were not significantly different (Figure-20 and Table-19). Moisture % found in the sample of Solar Tunnel dried Chinese Pomfret of salted (20.20 ± 0.20), unsalted (17.17 ± 0.208) preserved treatment groups were significantly different. Similarly moisture % found in the sample of smoking dried Chinese Pomfret of salted (26.08 ± 1.67), unsalted (24.24 ± 0.134) preserved treatment groups were significantly different. However, moisture (%) level detected in the samples of tunnel dried Chinese Pomfret was lower than those observe in others two methods (sun dried and smoke cured). But smoke cured sample varied higher moisture content than sun dried and tunnel dried samples.

Table 19A: Moisture content of Chinese Pomfret (*Pampus chinensis*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt

Methods of drying	Methods of processing	
	Salted	Unsalted
Sun dried	23.09 ± 0.262	22.13 ± 0.266
Tunnel dried	20.20 ± 0.221	17.17 ± 0.209
Smoke cured	26.08 ± 0.237	24.23 ± 0.237

Mean $\pm$ SEM (n=10).

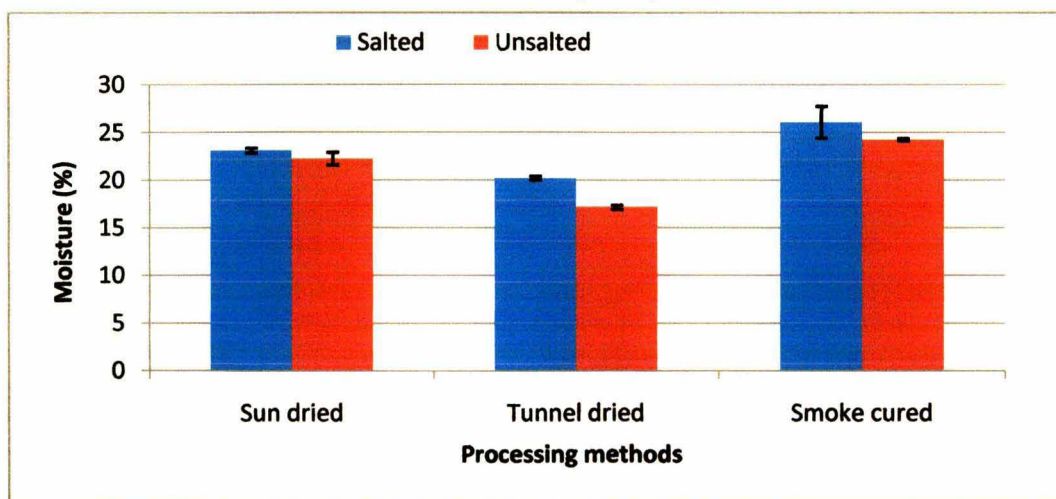


Figure 20 : Moisture content of Pomfret (*Pampus chinensis*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt .

(2) Protein%

Levels of protein (%) measured in the samples of sun dried Chinese Pomfret of salted (57.19 ± 0.258), and unsalted (59.68 ± 2.011) preserved treatment groups were significantly different (figure 21 and Table 20). Protein% levels found in the sample of tunnel dried Pomfret of salted (58.10 ± 0.208) and salted (62.09 ± 0.192) preserved treatment groups were significantly different. Similarly Protein% levels found in the sample of smoking dried Pomfret of salted (54.20 ± 0.355) and unsalted (55.01 ± 0.256) preserved treatment groups were not significantly different. However, protein (%) level detected in the samples of tunnel dried chinese pomfret were higher than in others two methods (sun dried and smoke cured) and unsalted samples were significantly higher than salted treated sample.

Table 19B : Protein content of Chinese Pomfret (*Pampus chinensis*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt

Methods of drying	Methods of processing	
	Salted	Unsalted
Sun dried	57.19 ± 0.258	59.98 ± 0.243
Tunnel dried	58.10 ± 0.183	62.09 ± 0.198
Smoke cured	54.20 ± 0.356	55.01 ± 0.256

Mean $\pm$ SEM (n=10).

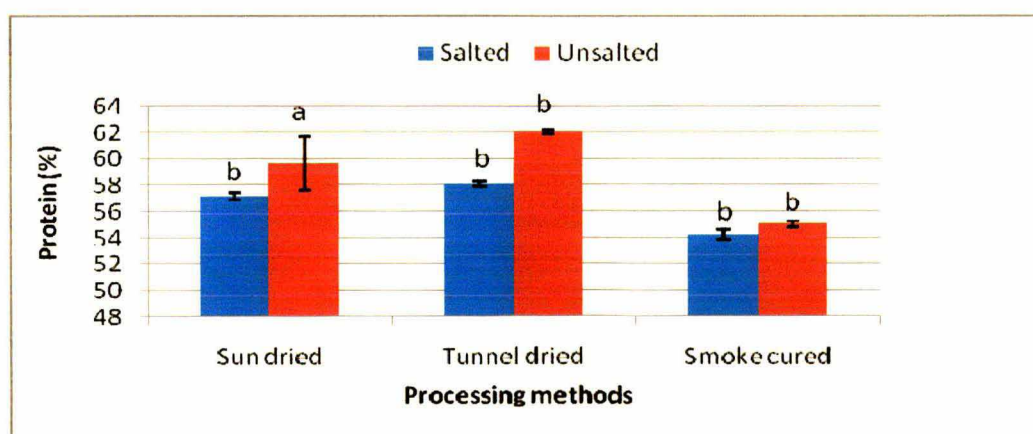


Figure 21 : Protein content of Pomfret (*Pampus chinensis*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt .

(3) Fat%

Levels of fFat% measured in the samples of sun dried Chinese Pomfret of salted (10.14 ± 0.238) and unsalted (8.91 ± 0.262) preserved treatment groups were not significantly different (figure 22 and Table 21). Fat% levels found in the sample of tunnel dried Chinese Pomfret of salted (11.06 ± 0.242) and unsalted (12.08 ± 0.229) preserved treatment groups were significantly different. Similarly Fat% levels found in the sample of smoking dried Pomfret of salted (8.88 ± 0.166) and unsalted (10.97 ± 0.242) preserved treatment groups were not significantly different. However, fat (%) level detected in the samples of sun dried, tunnel dried and smoke cured chinese pomfret in salted and unsalted treated groups were not significant different within treatment group. But fat (%) level detected in the samples of tunnel dried and chinese pomfret was higher than other two methods.

Table 19C : Fat content of Pomfret (*Pampus chinensis*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt

Methods of drying	Methods of processing	
	Salted	Unsalted
Sun dried	10.14 0.242	8.91 0.261
Tunnel dried	11.06 0.187	12.08 0.188
Smoke cured	8.88 0.166	10.97 0.243

Mean $\pm$ SEM (n=10).

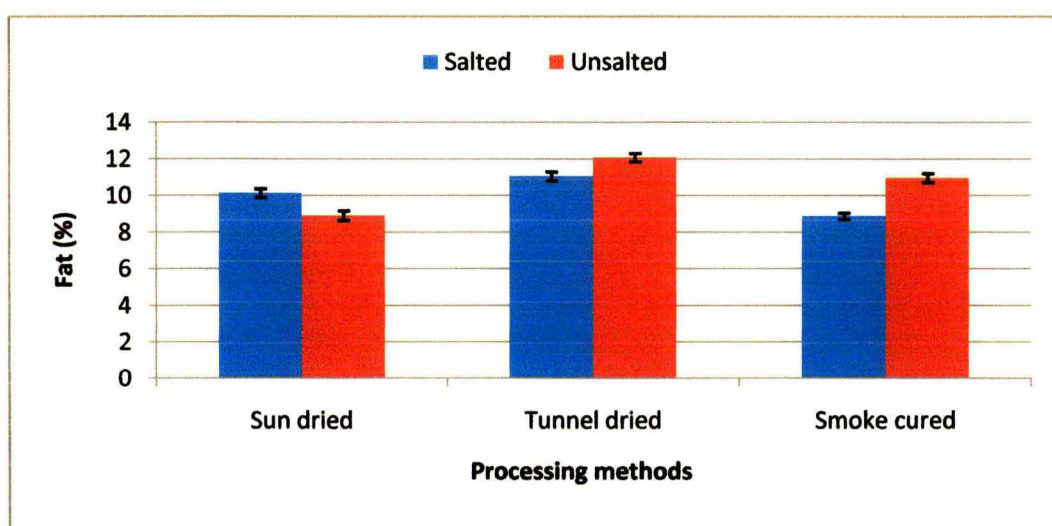


Figure 22: Fat content of Pomfret (*Pampus chinensis*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt.

(4) Ash %

Levels of ash (%) measured in the samples of sun dried Chinese Pomfret of salted (6.93 ± 0.218) and unsalted (8.60 ± 0.141) served treatment groups were significantly different (figure 24 and Table 22). Ash(%) levels found in the sample of tunnel dried Chinese Pomfret of salted (8.12 ± 0.228) and unsalted (10.23 ± 0.222) preserved treatment groups were significantly different. Similarly Ash (%) levels found in the sample of smoking dried Pomfret of salted (7.78 ± 0.163) and unsalted (9.32 ± 0.218) preserved treatment groups were significantly different. However, ash(%) level detected in the samples of sun dried, solar tunnel dried and smoke cured chinese pomfret in salted and unsalted treated groups were not significant different difference within treatment group.

Table 19D: Ash content of Chinese Pomfret (*Pampus chinensis*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt

Methods of drying	Methods of processing	
	Salted	Unsalted
Sun dried	6.93 ± 0.217	8.60 ± 0.142
Tunnel dried	8.12 ± 0.224	10.23 ± 0.223
Smoke cured	7.78 ± 0.161	9.32 ± 0.218

Mean $\pm$ SEM (n=10).

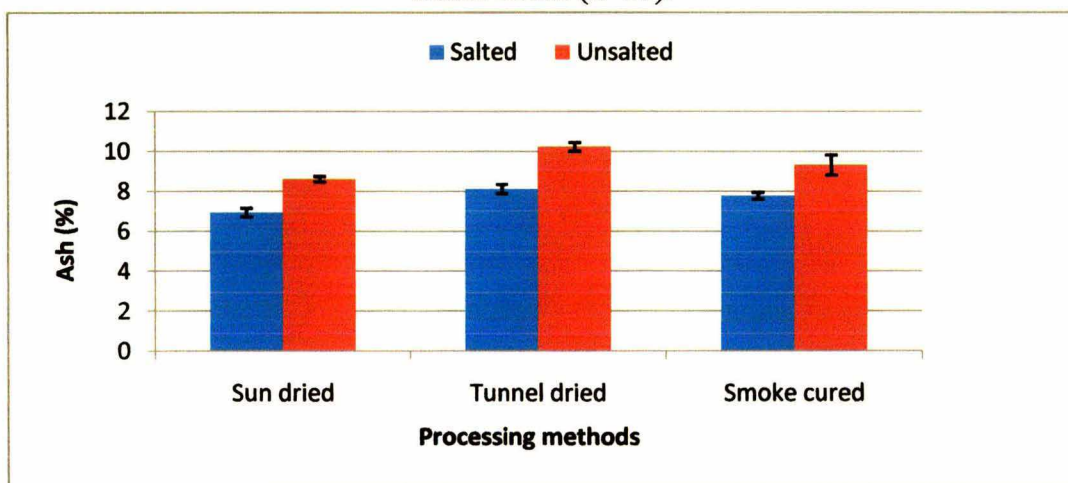


Figure 23: Ash content of Pomfret (*Pampus chinensis*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt .

b) Biochemical variables of Bombay duck (*Harpodon nehereus*)Table 21: Levels (mean+sem) of moisture (%), ash(%), fat(%), and protein (%) detected in fresh, preserved and processed Bombay duck (*Harpodon nehereus*).

Fresh					moisture	Protein	fat	Ash
			1		79.0	18.0	2.0	3.0
			2		77.0	16.0	3.5	4.0
			3		78.5	17.5	2.5	3.5
			4		77.5	16.5	3.0	3.2
			5		78.0	17.0	3.0	3.5
			6		79.0	17.8	2.2	3.0
			7		77.8	16.5	3.0	4.0
			8		79.0	18.0	2.1	3.2
			9		77.6	16.5	3.2	4.0
			10		78.0	17.1	3.5	3.5
			Total	Mean	78.14	15.49	2.80	3.49
				SEM	0.432	0.150	0.893	1.203
	Unsalted dried	Sun dried	1		20.00	60.00	12.00	8.50
			2		22.00	58.00	11.00	9.00
			3		23.00	57.00	10.00	9.50
			4		21.00	59.00	11.50	9.50
			5		23.00	57.20	11.50	8.50
			6		22.80	56.90	10.60	9.00
			7		21.70	58.50	11.80	10.00
			8		20.50	59.80	11.80	11.00
			9		21.00	59.00	11.50	9.50
			10		23.00	57.00	10.00	9.50
			Total	Mean	21.80	58.24	11.17	9.40
				SEM	0.358	0.376	0.233	0.233
		Tunnel dried	1		16.00	63.20	13.10	9.50
			2		15.50	63.70	13.40	8.90
			3		16.70	62.40	12.60	9.80
			4		15.00	64.00	14.00	9.00
			5		15.90	63.00	13.20	9.90
			6		16.30	63.50	13.10	8.00
			7		17.00	62.00	12.00	10.00
			8		15.40	63.80	13.60	8.00
			9		16.90	62.30	12.40	9.20
			10		15.20	63.90	13.70	9.00
			Total	Mean	15.99	63.18	13.11	9.13
				SEM	0.227	0.229	0.196	0.225
		Smoke cured	1		24.00	55.00	12.80	10.50
			2		26.00	53.02	11.30	10.50
			3		24.60	55.80	12.60	9.80
			4		25.00	53.20	11.09	11.00
			5		25.90	53.80	11.20	9.50
			6		25.50	53.03	11.01	10.90
			7		24.01	55.50	12.02	11.02
			8		25.60	54.00	11.30	10.50
			9		26.00	53.00	11.20	10.40
			10		24.02	54.90	13.00	11.00
			Total	Mean	25.06	54.01	11.75	10.51
				SEM	0.268	0.345	0.246	0.164
	Salted dried	Sun dried	1		24.20	56.00	9.50	7.90

			2		26.00	54.50	9.00	7.50
			3		25.40	55.20	10.00	8.20
			4		24.90	55.80	9.50	9.00
			5		26.00	54.70	9.70	7.60
			6		24.00	55.80	10.00	7.90
			7		25.80	55.00	9.30	8.40
			8		24.10	56.00	9.20	8.60
			9		25.20	54.00	8.00	7.00
			10		26.00	55.60	9.00	8.00
			Total	Mean	25.16	55.26	9.33	8.01
				SEM	0.259	0.219	0.186	0.182
		Tunnel dried	1		17.50	60.70	12.60	7.00
			2		17.90	59.90	11.90	8.80
			3		19.00	59.00	11.20	9.00
			4		18.20	59.90	12.00	8.50
			5		17.00	61.00	13.00	8.20
			6		19.00	59.20	11.00	9.00
			7		18.00	60.00	12.10	7.90
			8		17.40	60.80	12.70	8.00
			9		17.10	61.00	12.90	8.90
			10		18.50	59.60	11.50	9.00
			Total	Mean	17.96	60.10	12.09	8.43
				SEM	0.228	0.231	0.223	0.2081
		Smoke cured	1		26.2	53.0	11.0	8.2
			2		27.9	50.3	10.5	8.8
			3		28.0	50.1	9.3	8.5
			4		26.0	54.9	10.8	8.9
			5		27.0	52.8	9.9	8.7
			6		27.8	51.5	9.5	8.9
			7		28.0	50.2	9.0	8.2
			8		27.0	52.6	9.8	9.0
			9		26.5	51.0	10.0	8.1
			10		26.8	52.0	9.5	8.5
			Total	Mean	27.12	51.84	9.93	8.58
				SEM	0.241	0.484	0.207	0.104

1) Moisture (%)

Levels of moisture (%) measured in the samples of sun dried Bombay duck of salted (25.16 ± 0.238) and unsalted (21.80 ± 0.357) preserved treatment groups were significantly different (figure -24 and Table - 23). Moisture (%) levels found in the sample of tunnel dried Bombay duck of salted (17.96 ± 0.194) and unsalted (15.99 ± 0.240) preserved treatment groups were significantly different. Similarly Moisture (%) levels found in the sample of smoking dried Bombay duck of salted (27.12 ± 0.240) and unsalted (25.06 ± 0.298) preserved treatment groups were significantly different. However, moisture (%) level detected in the samples of solar tunnel dried Bombay duck was lower than those observed in the sun dried groups. But smoke cure was higher than those observed two groups.

Table 20A: Moisture content of Bombay duck (*Harpodon nehereus*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt

Methods of drying	Methods of processing	
	Salted	Unsalted
Sun dried	25.16 ± 0.259	21.80 ± 0.358
Tunnel dried	17.96 ± 0.228	15.99 ± 0.227
Smoke cured	27.12 ± 0.241	25.06 ± 0.268

Mean $\pm$ SEM (n=10).

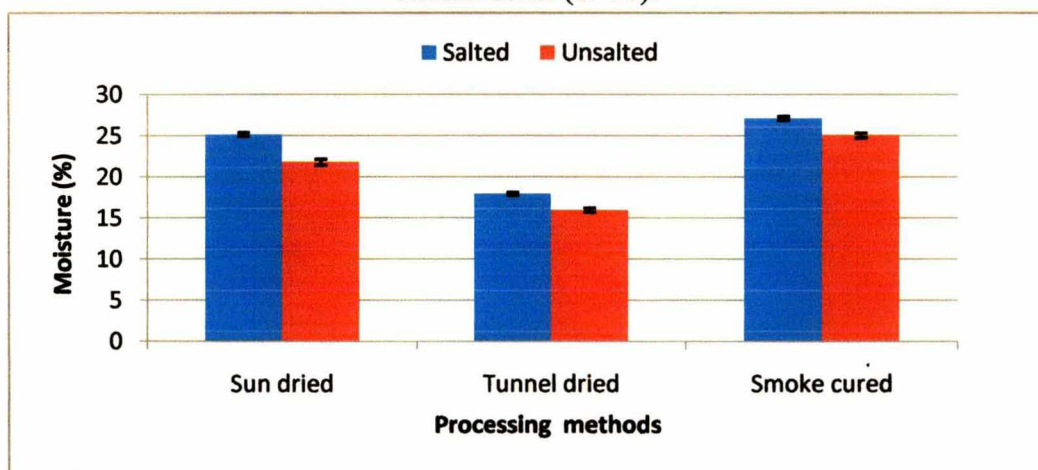


Figure 24: Moisture content of Bombay duck (*Harpodon nehereus*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt.

2) Protein (%)

Levels of protein (%) measured in the samples of sun dried Bombay duck of salted (55.35 ± 1.02) and unsalted (58.24 ± 0.377) preserved treatment groups were significantly different (Figure -25 and Table -24). Protein (%) levels found in the sample of tunnel dried Bombay duck of salted (60.10 ± 0.433) and unsalted (63.18 ± 0.208) preserved treatment groups were significantly different. Similarly protein (%) levels found in the sample of smoking dried Bombay duck of salted (51.93 ± 0.895) and unsalted (54.01 ± 1.224) preserved treatment groups were significantly different. However, protein (%) level detected in the samples of solar tunnel dried Bombay duck was higher than those observe in the sun dried groups. But smoke cure was lower than those observed two groups.

Table 20B : Protein content of Bombay duck (*Harpodon nehereus*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt

Methods of drying	Methods of processing	
	Salted	Unsalted
Sun dried	55.26 ± 0.219	58.24 ± 0.376
Tunnel dried	60.10 ± 0.231	63.18 ± 0.229
Smoke cured	51.84 ± 0.484	54.01 ± 0.345

Mean $\pm$ SEM (n=10).

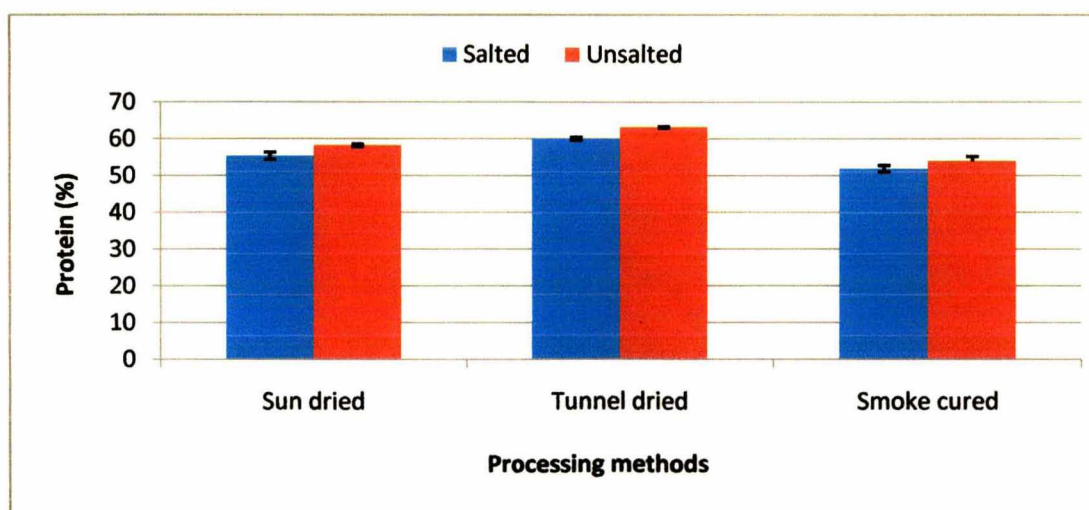


Figure 25: Protein content of Bombay duck (*Harpodon nehereus*) measured in smoke cured, sun dried and solar Tunnel dried samples preserved with and without salt .

3) Fat (%)

Levels of Fat (%) measured in the samples of smoking dried Bombay duck of salted (9.93 ± 0.208) and unsalted (11.75 ± 0.256) (figure -26 and Table -25). Fat (%) levels found in the sample of tunnel dried Bombay duck of salted (12.09 ± 0.194) and unsalted (13.11). Similarly Fat (%) levels found in the sample of sun dried Bombay duck of salted (9.23 ± 0.491) and unsalted (11.17 ± 0.233). However, fat (%) level detected in the samples of solar tunnel dried Bombay duck was higher than those observe in the other two methods but smoke cured and sun dried samples were similar.

Table 20C: Fat content of Bombay duck (*Harpodon nehereus*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt .

Methods of drying	Methods of processing	
	Salted	Unsalted
Sun dried	9.93 ± 0.207	11.75 ± 0.246
Tunnel dried	12.09 ± 0.223	13.11 ± 0.196
Smoke cured	9.33 ± 0.186	11.17 ± 0.233

Mean $\pm$ SEM (n=10).

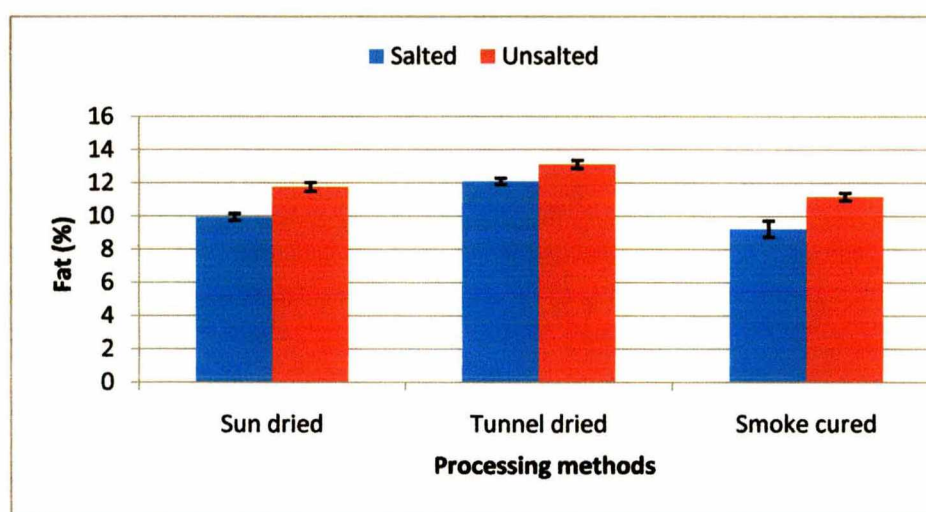


Figure 26: Fat content of Bombay duck (*Harpodon nehereus*) measured in smoke cured, sun dried and Solar tunnel dried samples preserved with and without salt .

4) Ash (%)

Levels of ash (%) measured in the samples of smoking dried Bombay duck of salted (8.58 ± 0.105) and unsalted (10.51 ± 0.176) preserved treatment groups were significantly different (Figure -27 and Table -26. Ash (%) levels found in the sample of tunnel dried Bombay duck of salted (8.43 ± 0.161) and unsalted (9.13 ± 0.223) preserved treatment groups were significantly different. Similarly ash (%) levels found in the sample of sun dried Bombay duck of salted (8.01 ± 0.179) and unsalted (9.40 ± 0.233) preserved treatment groups were significantly different. However, ash (%) level detected in the samples of sun dried, solar tunnel dried smoke cured Bombay duck were similar.

Table 20D: Ash content of Bombay duck (*Harpodon nehereus*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt

Methods of drying	Methods of processing	
	Salted	Unsalted
Sun dried	8.58 ± 0.104	10.51 ± 0.164
Tunnel dried	8.43 ± 0.208	9.13 ± 0.225
Smoke cured	8.01 ± 0.182	9.40 ± 0.233

Mean $\pm$ SEM (n=10).

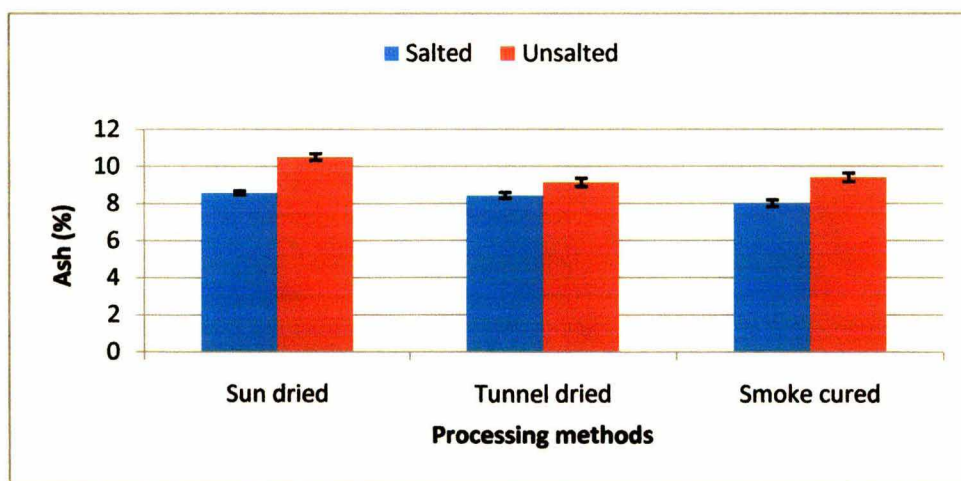


Figure 27: Ash content of Bombay duck (*Harpodon nehereus*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt .

(c) Biochemical variables of black tiger Shrimp (*Penaeus monodon*).Table 21: Levels (mean+sem) of moisture (%), ash(%), fat(%), and protein (%) detected in fresh, preserved and processed black tiger Shrimp (*Penaeus monodon*)

Fresh					Moisture	Protein	fat	Ash
			1		79.0	1.9	1.6	18.0
			2		78.5	2.0	1.7	17.8
			3		78.0	2.0	1.8	17.5
			4		77.0	1.8	2.0	16.5
			5		79.0	1.9	1.6	17.9
			6		77.5	2.0	1.8	17.0
			7		78.8	2.0	1.7	17.9
			8		79.0	1.8	1.7	17.8
			9		78.5	1.9	1.8	17.7
			10		79.0	1.8	1.6	18.1
			Total	Mean	78.43	17.6	1.73	1.91
				SEM	0.305	0.225	0.451	0.132
	Unsalted dried	Sun dried	1		23	56	10.5	9.5
			2		22	56	11.2	11.0
			3		20	59	12.0	9.6
			4		21	58	11.0	10.0
			5		20	59	12.0	10.2
			6		22	57	10.0	9.5
			7		23	56	11.0	10.5
			8		21	58	10.5	9.9
			9		22	57	11.5	10.2
			10		23	56.5	11.8	10.5
			Total	Mean	21.70	57.25	11.15	10.09
				SEM	0.366	0.374	0.216	0.155
		Tunnel dried	1		17.6	60.5	11.8	8.9
			2		18.0	60.0	11.5	10.5
			3		18.5	59.6	11.4	9.8
			4		17.9	59.8	11.9	10.6
			5		17.0	61.0	12.0	9.0
			6		19.0	59.1	11.2	8.0
			7		17.4	60.8	11.8	9.5
			8		17.5	60.7	11.6	9.9
			9		19.0	59.0	11.0	10.5
			10		17.0	61.0	12.0	11.0
			Total	Mean	17.89	60.15	11.62	9.77
				SEM	0.233	0.239	0.108	0.295
		Smoke cured	1		25.02	61.00	8.00	8.60
			2		25.80	60.60	7.90	9.00
			3		26.00	60.20	7.50	8.50
			4		27.00	58.02	6.01	9.00
			5		26.50	58.50	7.02	7.90
			6		25.00	60.90	8.00	8.80
			7		26.02	60.30	7.60	8.90
			8		25.50	60.00	7.40	9.00
			9		27.00	58.03	8.00	8.60
			10		25.04	60.50	8.50	9.50
			Total	Mean	25.88	59.80	7.59	8.78
				SEM	0.242	0.368	0.218	0.133
	Salted dried	Sun dried	1		23.9	55.5	9.5	8.5

			2		25.0	55.0	8.6	8.2
			3		24.0	55.5	10.0	9.0
			4		24.8	55.2	8.9	8.0
			5		23.0	55.9	10.0	8.9
			6		25.0	54.0	8.0	7.5
			7		24.5	55.3	9.2	7.0
			8		23.6	55.6	9.4	8.2
			9		24.7	56.0	9.0	7.7
			10		23.8	55.9	9.8	8.5
			Total	Mean	24.23	55.38	9.24	8.15
				SEM	0.212	0.185	0.202	0.197
		Tunnel dried	1		21.0	57.5	10.1	10.0
			2		20.5	59.0	10.5	9.5
			3		20.0	57.8	11.0	9.8
			4		20.8	58.4	10.3	10.0
			5		21.5	56.0	10.6	9.9
			6		22.0	57.6	9.0	8.9
			7		20.9	59.0	10.3	8.6
			8		20.0	56.2	11.0	9.6
			9		21.9	57.5	9.3	9.6
			10		21.0	58.6	10.2	10.0
			Total	Mean	20.96	57.76	10.23	9.59
				SEM	0.219	0.331	0.205	0.153
		Smoke cured	1		28.0	52.6	7.8	8.9
			2		29.0	52.0	6.5	7.8
			3		27.2	53.0	8.5	8.0
			4		28.5	52.8	7.0	9.0
			5		27.0	52.9	8.0	8.5
			6		27.5	52.5	8.5	8.2
			7		28.5	52.2	6.8	9.0
			8		29.0	52.0	6.5	7.8
			9		28.5	52.6	7.4	8.8
			10		28.0	52.0	7.0	8.0
			Total	Mean	28.02	57.36	7.30	8.30
				SEM	0.250	0.187	0.277	0.208

1) Moisture (%)

Levels of moisture (%) measured in the samples of smoking dried black tiger Shrimp of salted (25.32 ± 2.822) and unsalted (25.88 ± 0.305) preserved treatment groups were significantly different (Figure -28 and Table -27). Moisture (%) levels found in the sample of tunnel dried Shrimp of salted (57.74 ± 0.604) and unsalted (60.15 ± 0.237) preserved treatment groups were significantly different. Similarly, moisture (%) levels found in the sample of sun dried Shrimp of salted (24.23 ± 0.210) and unsalted (21.70 ± 0.366) preserved treatment groups were significantly different.

Table 21A: Moisture content of black tiger Shrimp (*Penaeus monodon*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt.

Methods of drying	Methods of processing	
	Salted	Unsalted
Sun dried	28.02 ± 0.250	25.88 ± 0.242
Tunnel dried	20.96 ± 0.219	17.89 ± 0.233
Smoke cured	24.02 ± 0.250	21.70 ± 0.366

Mean $\pm$ SEM (n=10).

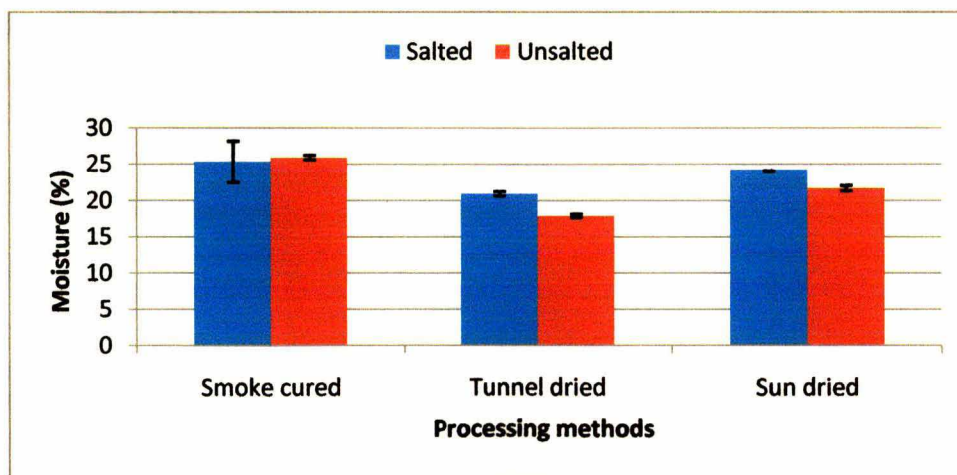


Figure 28. Moisture content of black tiger Shrimp (*Penaeus monodon*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt.

2) Protein (%)

Levels of protein (%) measured in the samples of smoking dried black tiger Shrimp of salted (47.26 ± 5.252) and unsalted (59.8 ± 0.449) preserved treatment groups were significantly different (Figure -29 and Table -28). Protein (%) levels found in the sample of tunnel dried Shrimp of salted (57.74 ± 0.604) and unsalted (60.15 ± 0.237) preserved treatment groups were significantly different. Similarly, protein (%) levels found in the sample of sun dried Shrimp of salted ($55.38 \pm$) and unsalted (57.33 ± 0.936) preserved treatment groups were significantly different .

Table 21B: Protein content of black tiger Shrimp (*Penaeus monodon*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt .

Methods of drying	Methods of processing	
	Salted	Unsalted
Sun dried	52.36 ± 0.187	59.8 ± 0.368
Tunnel dried	57.76 ± 0.331	60.15 ± 0.239
Smoke cured	55.39 ± 0.185	57.25 ± 0.374

Mean $\pm$ SEM (n=10).

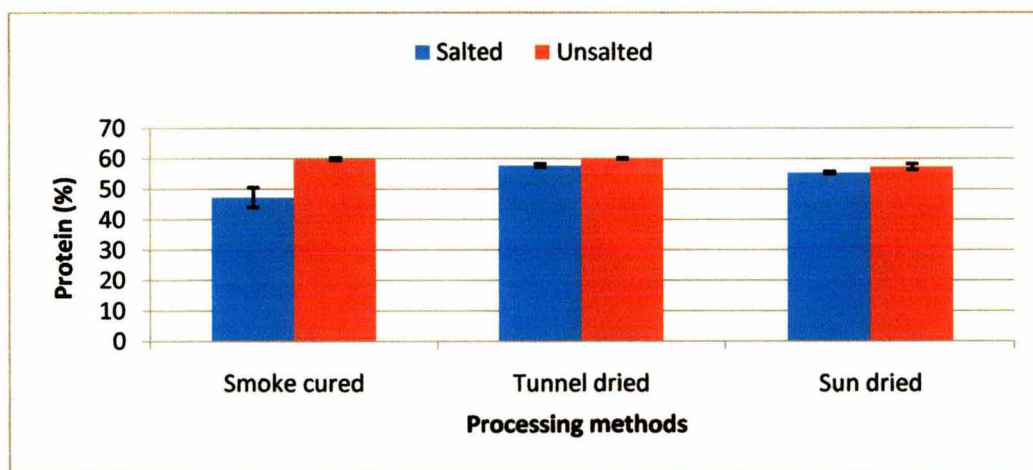


Figure 29. Protein content of black tiger Shrimp (*Penaeus monodon*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt.

3) Fat (%)

Levels of fat (%) measured in the samples of smoking dried black tiger Shrimp of salted (6.70 ± 0.781) and unsalted (7.59 ± 0.230) preserved treatment groups were significantly different (figure -30 and Table -29). Fat (%) levels found in the sample of tunnel dried Shrimp of salted (10.23 ± 0.204) and unsalted (11.62 ± 0.108) preserved treatment groups were significantly different. Similarly, fat (%) levels found in the sample of sun dried Shrimp salted (9.22 ± 0.286) and unsalted (11.15 ± 0.216) preserved treatment groups were significantly different.

Table 21C: Fat content of black tiger Shrimp (*Penaeus monodon*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt.

Methods of drying	Methods of processing	
	Salted	Unsalted
Sun dried	7.30 ± 0.277	7.59 ± 0.218
Tunnel dried	10.23 ± 0.205	11.62 ± 0.108
Smoke cured	9.24 ± 0.202	11.15 ± 0.216

Mean $\pm$ SEM (n=10).

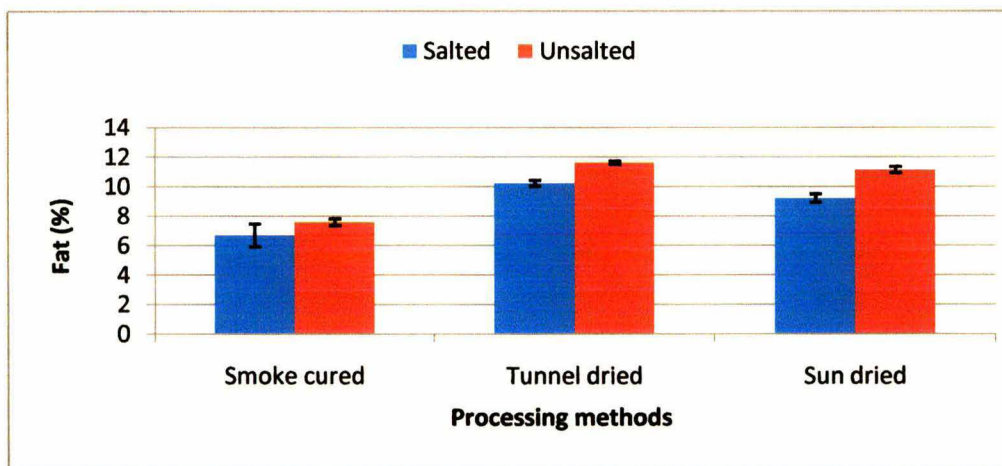


Figure 30. Fat content of black tiger Shrimp (*Penaeus monodon*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt.

4) Ash (%)

Levels of Ash (%) measured in the samples of smoking dried black tiger Shrimp of salted (7.60 ± 0.857) and unsalted (8.78 ± 0.149) preserved treatment groups were significantly different (Figure -31 and Table -30). Ash (%) levels found in the sample of tunnel dried Shrimp of salted (9.59 ± 0.149) and unsalted (9.77 ± 0.294) preserved treatment groups were significantly different. Similarly, ash (%) levels found in the sample of sun dried Shrimp salted (8.08 ± 0.696) and unsalted (10.09 ± 0.156) preserved treatment groups were significantly different.

Table 21D: Ash content of black tiger Shrimp (*Penaeus monodon*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt.

Methods of drying	Methods of processing	
	Salted	Unsalted
Sun dried	8.30 ± 0.208	8.78 ± 0.133
Tunnel dried	9.59 ± 0.153	9.77 ± 0.295
Smoke cured	8.15 ± 0.197	10.09 ± 0.155

Mean $\pm$ SEM (n=10).

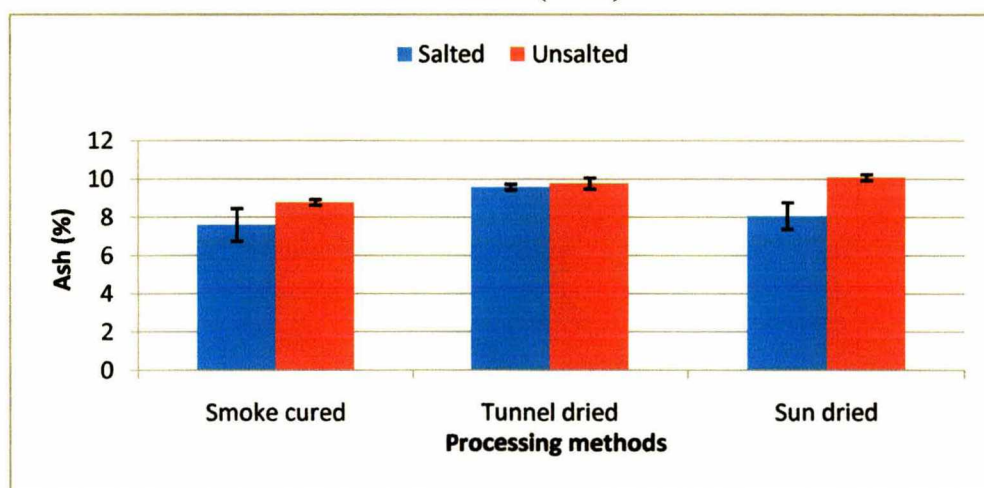


Figure 31. Ash content of black tiger Shrimp (*Penaeus monodon*) measured in smoke cured, sun dried and Solar Tunnel dried samples preserved with and without salt.

4. Statistical analysis of co-relation between protein, fat and moisture of dry fishes and shrimp.

(1). Determination of co-relation between protein, fat and moisture of Chinese Pomfret in the sun dried unsalted and salted condition.

The co-relation co-efficient value expressed as “r” between moisture and protein, moisture and fat and Protein and fat of sun dried unsalted and salted Chinese Pomfret fish had been computed which were (-) 0.959, (-) 0.954, (+) 0.912 and (-) 0.075, (-) 0.055, (+) 0.522 respectively has been presented in Table 31. The “r” values are determined by the application of the statistical program software titled as “SPSS for windows-11.5.”

The negative “r” value between protein and moisture, fat and moisture content refers to an inverse co-relationship between protein and moisture, fat and moisture which indicates that the value of protein and fat content increase with the decrease of the value of moisture content. On the other hand, the positive value of “r” between protein and fat refers to a direct co-relation that is with increase or decrease of one of the two values the corresponding value of the other nutrient will be decrease or increase respectively.

Table 22: Showing co-relation co-efficient among moisture, protein and fat of Chinese Pomfret fish in the sun dried and highly acceptable unsalted condition

Variables		Pearson's correlation	N	T	Sig.
Unsalted	Moisture (%) and Protein (%)	-0.959	10	-9.557	.000
	Moisture (%) and Fat (%)	-0.954	10	-8.965	.000
	Protein (%) and Fat (%)	+0.912	10	+6.274	.000
Salted	Moisture (%) and Protein (%)	-0.075	10	-0.837	.877
	Moisture (%) and Fat (%)	-0.055	10	-0.880	.880
	Protein (%) and Fat (%)	+0.522	10	+0.121	.121

Correlation is significant at the 0.01 level.

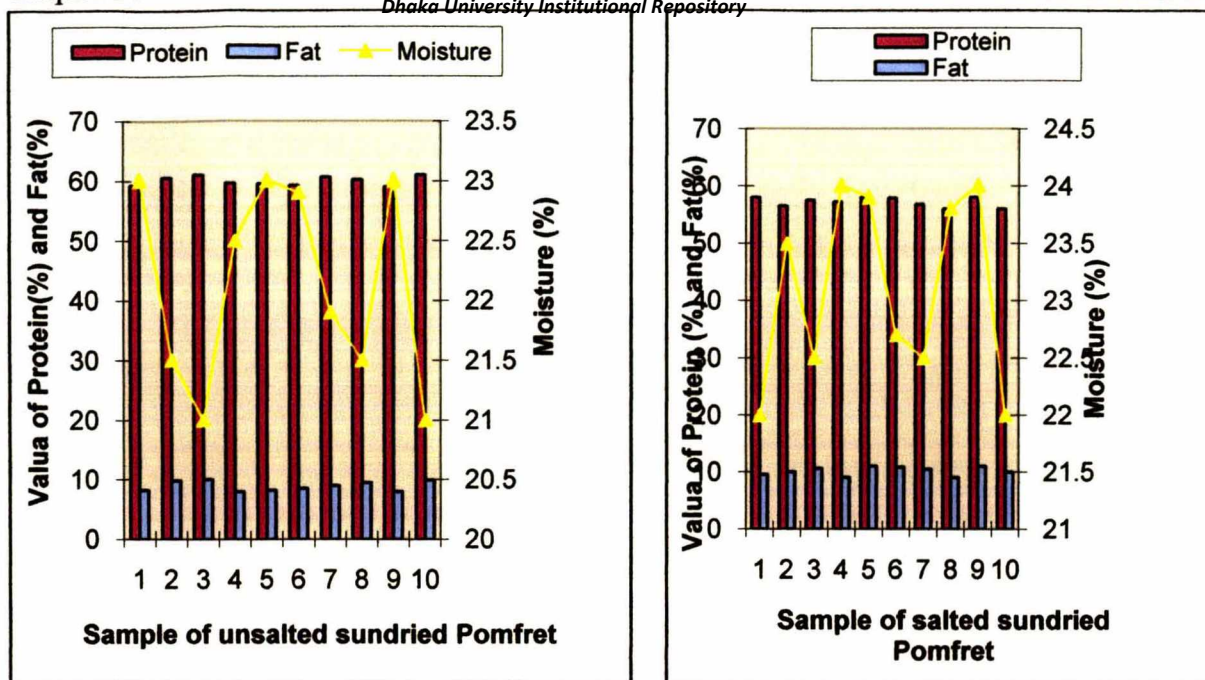


Figure 32: Showing direct relationship “Protein and Fat” content and inverse relationship between “Moisture and Protein” content and “Moisture and Fat” content of sun dried Chinese Pomfret fish.

The graphical representation of the direct and inverse relationships among the nutrients contents of fish samples by sun drying method had been shown in Figure 32. The line and bar diagram in this Figure had shown the direct co-relation between “Protein and Fat” content and inverse co-relation between “Moisture and Protein” content and “Moisture and Fat” content.

The “t” value between percent of “Moisture and Protein” content and “Moisture and Fat” content of fish sample by sun drying unsalted and salted condition had been computed and found to be (-) 9.557, (-) 8.965 and (-) 0.213, (-) 0.156 respectively which was highly significant at 1% significance level ($P < 0.01$) and indicated a strong inverse or negative relationship between them.

The “t” value between percent of “Protein and Fat” content of fish sample by sun drying unsalted and salted condition had been computed and found to be (+) 6.274 and (+) 1.733 which were highly significant at 1% significance level ($P < 0.01$) and indicated a strong direct or positive relationship.

(2). Determination of co-relation between protein, fat and moisture of Chinese Pomfret in tunnel dried unsalted and salted condition.

The co-relation co-efficient value expressed as “r” between moisture and protein, moisture and fat and Protein and fat of tunnel dried unsalted and salted Chinese Pomfret fish had been computed which were (-) 0.248, (-) 0.830, (+) 0.896 and (-) 0.835, (-) 0.963, (+) 0.858 respectively has been presented in Table 32. The “r” values are determined by the application of the statistical program software titled as “SPSS for windows-11.5.”

The negative “r” value between protein and moisture, fat and moisture content refers to a inverse co-relationship between protein and moisture, fat and moisture which indicates that the value of protein and fat content increase with the decrease of the value of moisture content. On the other hand, the positive value of “r” between protein and fat refers to an direct co-relation that is with increase or decrease of one of the two values the corresponding value of the other nutrient will be decrease or increase respectively.

Table 23: Showing co-relation co-efficient among moisture, protein and fat of Chinese Pomfret fish in the tunnel dried and highly acceptable unsalted condition

Variables		Pearson's correlation	N	T	Sig.
Unsalted	Moisture (%) and Protein (%)	-0.248	10	-0.723	0.490
	Moisture (%) and Fat (%)	-0.830	10	-4.210	0.003
	Protein (%) and Fat (%)	+0.896	10	+5.711	0.000
Salted	Moisture (%) and Protein (%)	-0.835	10	-4.292	0.003
	Moisture (%) and Fat (%)	-0.963	10	-10.058	0.000
	Protein (%) and Fat (%)	+0.858	10	+4.715	0.000

Correlation is significant at the 0.01 level.

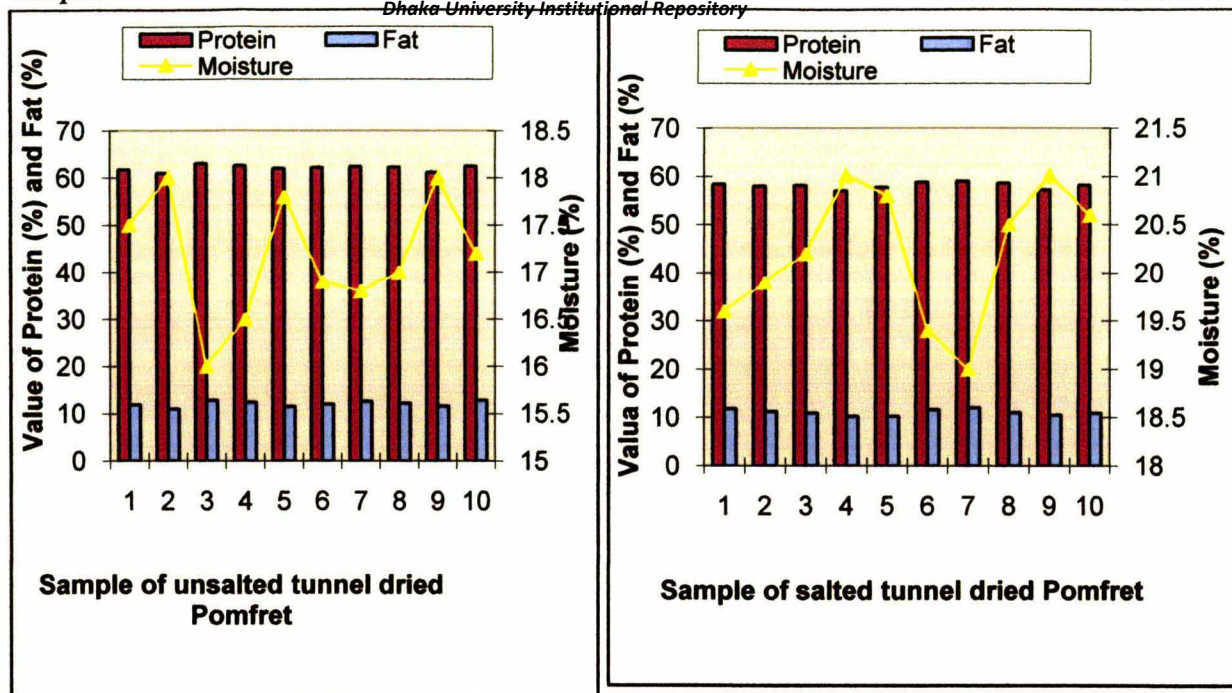


Figure 33: Showing direct relationship “Protein and Fat” content and inverse relationship between “Moisture and Protein” content and “Moisture and Fat” content of Solar Tunnel dried Chinese Pomfret fish.

The graphical representation of the direct and inverse relationships among the nutrients contents of fish samples by tunnel drying method had been shown in Figure 33. The line and bar diagram in this Figure had shown the direct co-relation between “Protein and Fat” content and inverse co-relation between “Moisture and Protein” content and “Moisture and Fat” content.

The “t” value between percent of “Moisture and Protein” content and “Moisture and Fat” content of fish sample by tunnel drying unsalted and salted condition had been computed and found to be (-) 0.723, (-)4.210 and (-) 4.292, (-) 10.058 respectively which was highly significant at 1% significance level ($P < 0.01$) and indicated a strong inverse or negative relationship between them.

The “t” value between percent of “Protein and Fat” content of fish sample by sun drying unsalted and salted condition had been computed and found to be (+) 5.711 and (+)4.715 which were highly significant at 1% significance level ($P < 0.01$) and indicated a strong direct or positive relationship.

(3). Determination of co-relation between protein, fat and moisture of Chinese Pomfret in smoke cured unsalted condition.

The co-relation co-efficient value expressed as “r” between moisture and protein, moisture and fat and Protein and fat of smoke cured unsalted and salted Chinese Pomfret fish had been computed which were (-) 0.955, (-) 0.243, (+) 0.086 and (-) 0.744, (-) 0.513, (+) 0.376 respectively has been presented in Table 33. The “r” values are determined by the application of the statistical program software titled as “SPSS for windows-11.5.”

The negative “r” value between protein and moisture, fat and moisture content refers to an inverse co-relationship between protein and moisture, fat and moisture which indicates that the value of protein and fat content increase with the decrease of the value of moisture content. On the other hand, the positive value of “r” between protein and fat refers to a direct co-relation that is with increase or decrease of one of the two values the corresponding value of the other nutrient will be decrease or increase respectively.

Table 24: Showing co-relation co-efficient among moisture, protein and fat of Chinese Pomfret fish in smoke cured and highly acceptable unsalted condition

Variables		Pearson's correlation	N	T	Sig.
Unsalted	Moisture (%) and Protein (%)	-0.955	10	-9.086	0.000
	Moisture (%) and Fat (%)	-0.243	10	-0.709	0.499
	Protein (%) and Fat (%)	+0.086	10	+0.244	0.813
Salted	Moisture (%) and Protein (%)	-0.744	10	-3.151	0.014
	Moisture (%) and Fat (%)	-0.513	10	-1.689	0.130
	Protein (%) and Fat (%)	+0.376	10	+1.147	0.285

Correlation is significant at the 0.01 level.

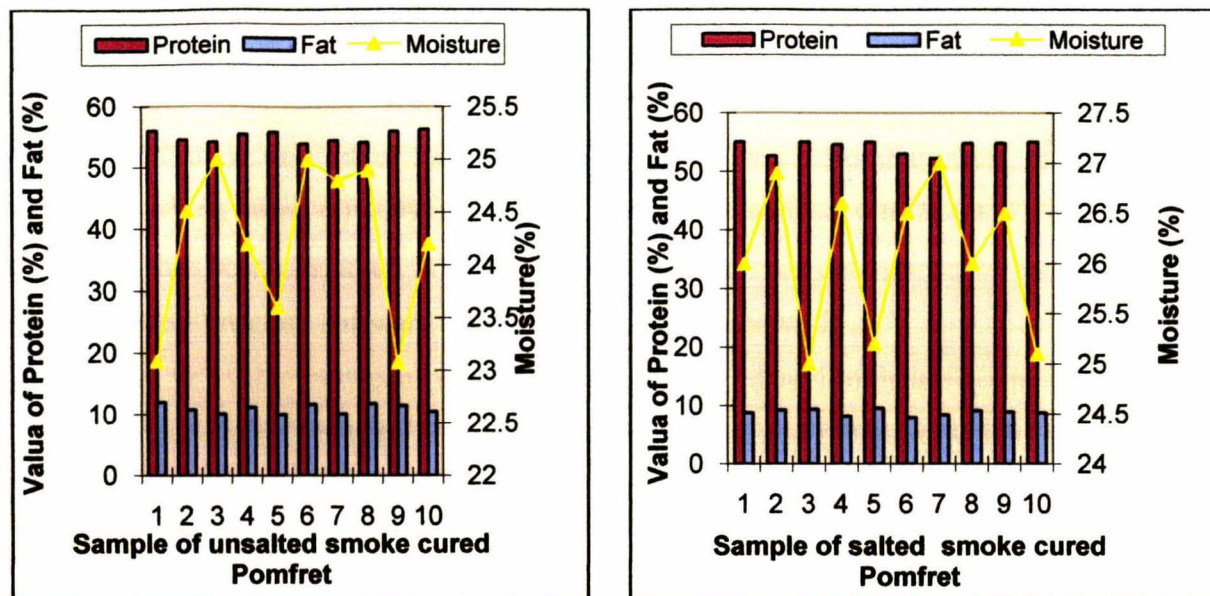


Figure 34: Showing direct relationship “Protein and Fat” content and inverse relationship between “Moisture and Protein” content and “Moisture and Fat” content of smoke cured pomfret fish.

The graphical representation of the direct and inverse relationships among the nutrients contents of fish samples by smoke curing method had been shown in Figure 34. The line and bar diagram in this Figure had shown the direct co-relation between “Protein and Fat” content and inverse co-relation between “Moisture and Protein” content and “Moisture and Fat” content.

The “t” value between percent of “Moisture and Protein” content and “Moisture and Fat” content of fish sample by smoke curing unsalted and salted condition had been computed and found to be (-) 9.086, (-) 0.709 and (-) 3.151, (-) 1.689 respectively which was highly significant at 1% significance level ($P < 0.01$) and indicated a strong inverse or negative relationship between them.

The “t” value between percent of “Protein and Fat” content of fish sample by sun drying unsalted and salted condition had been computed and found to be (+) 0.244 and (+) 1.147 which were highly significant at 1% significance level ($P < 0.01$) and indicated a strong direct or positive relationship.

(4). Determination of co-relation between protein, fat and moisture of Bombay duck in the sun dried unsalted and salted condition.

The co-relation co-efficient value expressed as “r” between moisture and protein, moisture and fat and Protein and fat of sun dried unsalted and salted Bombay duck fish had been computed which were (-) 0.991, (-) 0.786, (+) 0.818 and (-) 0.647, (-) 0.232, (+) 0.561 respectively has been presented in Table 34. The “r” values are determined by the application of the statistical program software titled as “SPSS for windows-11.5.”

The negative “r” value between protein and moisture, fat and moisture content refers to an inverse co-relationship between protein and moisture, fat and moisture which indicates that the value of protein and fat content increase with the decrease of the value of moisture content. On the other hand, the positive value of “r” between protein and fat refers to a direct co-relation that is with increase or decrease of one of the two values the corresponding value of the other nutrient will be decrease or increase respectively.

Table 25: Showing co-relation co-efficient among moisture, protein and fat of Bombay duck fish in sun dried and highly acceptable unsalted condition

Variables		Pearson's correlation	N	T	Sig.
Unsalted	Moisture (%) and Protein (%)	-0.991	10	-21.118	.000
	Moisture (%) and Fat (%)	-0.786	10	-3.594	.007
	Protein (%) and Fat (%)	+0.818	10	+4.026	.004
Salted	Moisture (%) and Protein (%)	-0.647	10	-2.401	.043
	Moisture (%) and Fat (%)	-0.232	10	-0.673	.520
	Protein (%) and Fat (%)	+0.561	10	+1.918	.019

Correlation is significant at the 0.01 level.

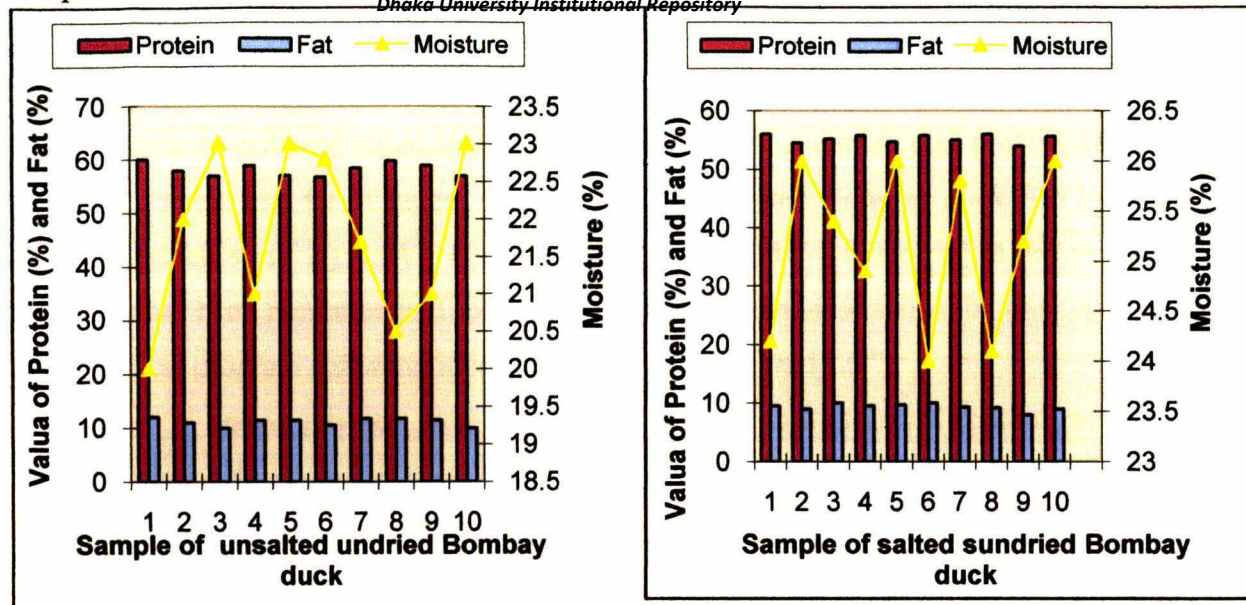


Figure 35: Showing direct relationship “Protein and Fat” content and inverse relationship between “Moisture and Protein” content and “Moisture and Fat” content of sun dried Bombay duck fish.

The graphical representation of the direct and inverse relationships among the nutrients contents of fish samples by sun drying method had been shown in Figure 35. The line and bar diagram in this Figure had shown the direct co-relation between “Protein and Fat” content and inverse co-relation between “Moisture and Protein” content and “Moisture and Fat” content.

The “t” value between percent of “Moisture and Protein” content and “Moisture and Fat” content of fish sample by sun drying unsalted and salted condition had been computed and found to be (-) 21.118, (-) 3.594 and (-)2.401, (-) 0.673 respectively which was highly significant at 1% significance level ($P < 0.01$) and indicated a strong inverse or negative relationship between them.

The “t” value between percent of “Protein and Fat” content of fish sample by sun drying unsalted and salted condition had been computed and found to be (+) 4.026 and (+)1.918 which were highly significant at 1% significance level ($P < 0.01$) and indicated a strong direct or positive relationship.

(5) Determination of co-relation between protein, fat and moisture of Bombay duck in the tunnel dried unsalted and salted condition.

The co-relation co-efficient value expressed as “r” between moisture and protein, moisture and fat and Protein and fat of tunnel dried unsalted and salted Bombay duck fish had been computed which were (-) 0.943, (-) 0.976, (+) 0.966 and (-) 0.985, (-) 0.987, (+) 0.986 respectively has been presented in Table 35. The “r” values are determined by the application of the statistical program software titled as “SPSS for windows-11.5.”

The negative “r” value between protein and moisture, fat and moisture content refers to a inverse co-relationship between protein and moisture, fat and moisture which indicates that the value of protein and fat content increase with the decrease of the value of moisture content. On the other hand, the positive value of “r” between protein and fat refers to an direct co-relation that is with increase or decrease of one of the two values the corresponding value of the other nutrient will be decrease or increase respectively.

Table 26: Showing co-relation co-efficient among moisture, protein and fat of Bombay duck fish in Solar Tunnel dried and highly acceptable unsalted condition

Variables		Pearson's correlation	N	T	Sig.
Unsalted	Moisture (%) and Protein (%)	-0.943	10	-7.979	.000
	Moisture (%) and Fat (%)	-0.976	10	-12.642	.000
	Protein (%) and Fat (%)	+0.966	10	+10.498	.000
Salted	Moisture (%) and Protein (%)	-0.985	10	-16.310	.000
	Moisture (%) and Fat (%)	-0.987	10	-17.151	.000
	Protein (%) and Fat (%)	+0.986	10	+16.763	.000

Correlation is significant at the 0.01 level.

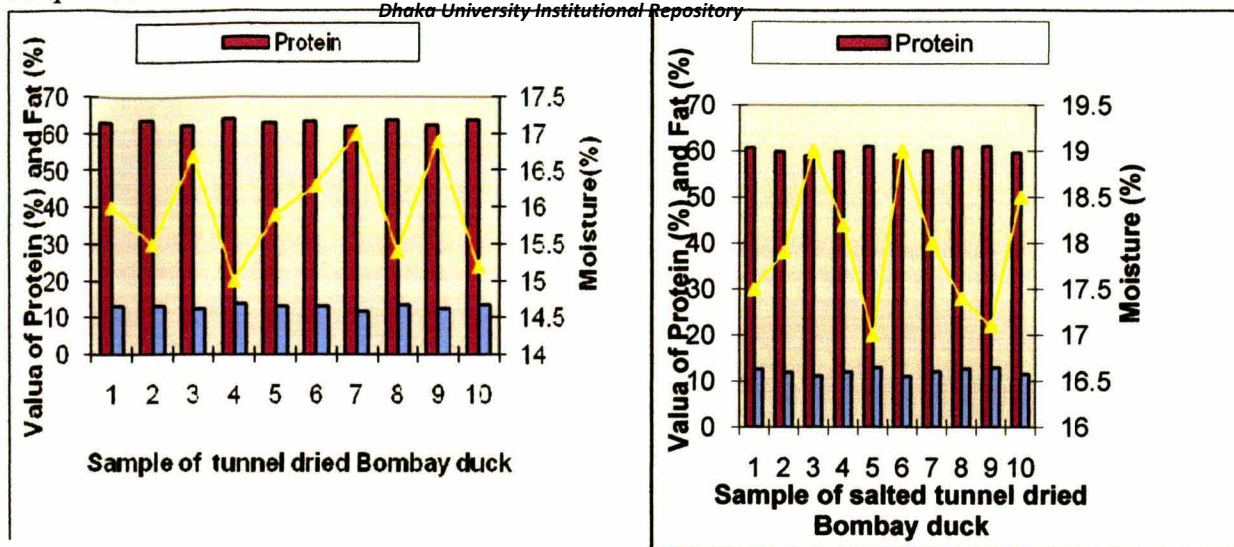


Figure 36: Showing direct relationship “Protein and Fat” content and inverse relationship between “Moisture and Protein” content and “Moisture and Fat” content of Solar Tunnel dried Bombay duck fish.

The graphical representation of the direct and inverse relationships among the nutrients contents of fish samples by solar tunnel drying method had been shown in Figure 36. The line and bar diagram in this Figure had shown the direct co-relation between “Protein and Fat” content and inverse co-relation between “Moisture and Protein” content and “Moisture and Fat” content.

The “t” value between percent of “Moisture and Protein” content and “Moisture and Fat” content of fish sample by tunnel drying unsalted and salted condition had been computed and found to be (-) 7.979, (-) 12.642 and (-)16.310, (-) 17.151 respectively which was highly significant at 1% significance level ($P < 0.01$) and indicated a strong inverse or negative relationship between them.

The “t” value between percent of “Protein and Fat” content of fish sample by sun drying unsalted and salted condition had been computed and found to be (+) 10.498 and (+)16.763 which were highly significant at 1% significance level ($P < 0.01$) and indicated a strong direct or positive relationship.

6). Determination of co-relation between protein, fat and moisture of Bombay duck in the smoke cured unsalted and salted condition.

The co-relation co-efficient value expressed as “r” between moisture and protein, moisture and fat and Protein and fat of smoke cured unsalted and salted Bombay duck fish had been computed which were (-) 0.817, (-) 0.844, (+) 0.844 and (-) 0.821, (-) 0.680, (+) 0.611 respectively has been presented in Table 36. The “r” values are determined by the application of the statistical program software titled as “SPSS for windows-11.5.”

The negative “r” value between protein and moisture, fat and moisture content refers to an inverse co-relationship between protein and moisture, fat and moisture which indicates that the value of protein and fat content increase with the decrease of the value of moisture content. On the other hand, the positive value of “r” between protein and fat refers to a direct co-relation that is with increase or decrease of one of the two values the corresponding value of the other nutrient will be decrease or increase respectively.

Table 27: Showing co-relation co-efficient among moisture, protein and fat of Bombay duck fish in smoke cured and highly acceptable unsalted condition

Variables		Pearson's correlation	N	T	Sig.
Unsalted	Moisture (%) and Protein (%)	-0.817	10	-4.006	0.004
	Moisture (%) and Fat (%)	-0.844	10	-4.454	0.002
	Protein (%) and Fat (%)	+0.844	10	+4.450	0.002
Salted	Moisture (%) and Protein (%)	-0.821	10	-4.067	0.004
	Moisture (%) and Fat (%)	-0.680	10	-2.624	0.030
	Protein (%) and Fat (%)	+0.611	10	+2.185	0.060

Correlation is significant at the 0.01 level.

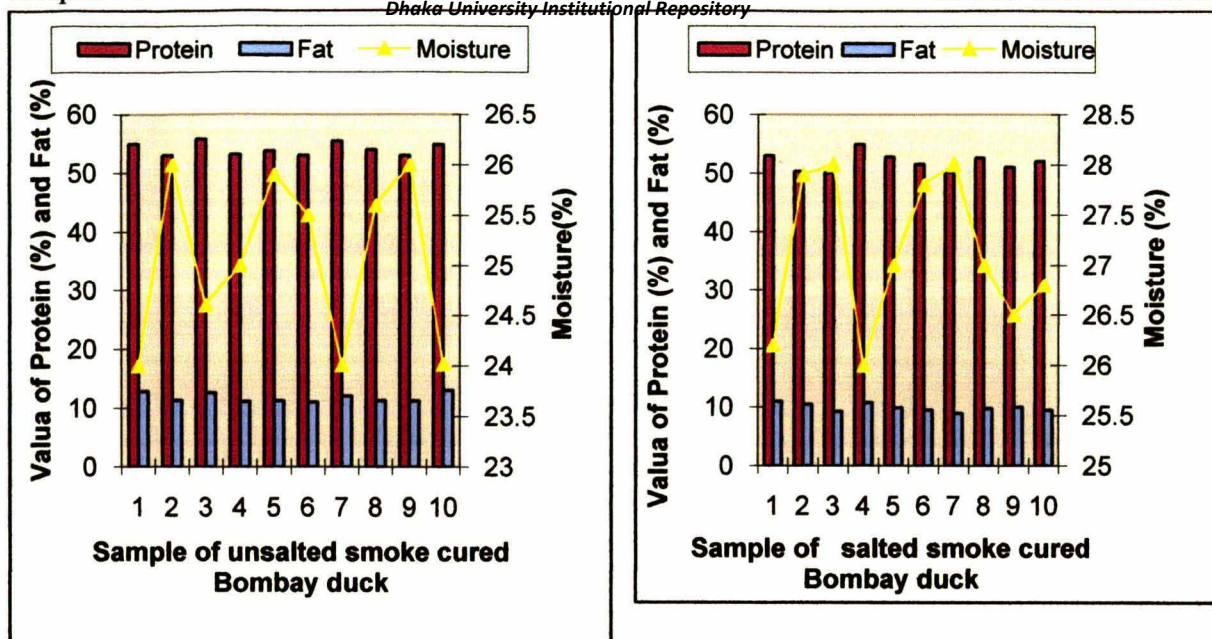


Figure 37: Showing direct relationship “Protein and Fat” content and inverse relationship between “Moisture and Protein” content and “Moisture and Fat” content of smoke cured Bombay duck fish.

The graphical representation of the direct and inverse relationships among the nutrients contents of fish samples by smoke curing method had been shown in Figure 37. The line and bar diagram in this Figure had shown the direct co-relation between “Protein and Fat” content and inverse co-relation between “Moisture and Protein” content and “Moisture and Fat” content.

The “t” value between percent of “Moisture and Protein” content and “Moisture and Fat” content of fish sample by smoke curing unsalted and salted condition had been computed and found to be (-) 4.006, (-) 4.454 and (-) 4.067, (-) 2.624 respectively which was highly significant at 1% significance level ($P < 0.01$) and indicated a strong inverse or negative relationship between them.

The “t” value between percent of “Protein and Fat” content of fish sample by sun drying unsalted and salted condition had been computed and found to be (+) 4.450 and (+) 2.185 which were highly significant at 1% significance level ($P < 0.01$) and indicated a strong direct or positive relationship.

(7). Determination of co-relation between protein, fat and moisture of black tiger Shrimp in the sun dried unsalted and salted condition.

The co-relation co-efficient value expressed as “r” between moisture and protein, moisture and fat and Protein and fat of sun dried unsalted and salted black tiger Shrimp fish had been computed which were (-) 0.951, (-) 0.386, (+) 0.415 and (-) 0.614, (-) 0.854, (+) 0.703 respectively has been presented in Table 37. The “r” values are determined by the application of the statistical program software titled as “SPSS for windows-11.5.”

The negative “r” value between protein and moisture, fat and moisture content refers to an inverse co-relationship between protein and moisture, fat and moisture which indicates that the value of protein and fat content increase with the decrease of the value of moisture content. On the other hand, the positive value of “r” between protein and fat refers to a direct co-relation that is with increase or decrease of one of the two values the corresponding value of the other nutrient will be decrease or increase respectively.

Table 28: Showing co-relation co-efficient among moisture, protein and fat of black tiger Shrimp fish in sun dried and highly acceptable unsalted condition

Variables		Pearson's correlation	N	T	Sig.
Unsalted	Moisture (%) and Protein (%)	-0.951	10	-8.668	0.000
	Moisture (%) and Fat (%)	-0.386	10	-1.182	0.271
	Protein (%) and Fat (%)	0.415	10	1.291	0.233
Salted	Moisture (%) and Protein (%)	-0.614	10	-2.201	0.059
	Moisture (%) and Fat (%)	-0.854	10	-4.637	0.002
	Protein (%) and Fat (%)	+0.703	10	+2.794	0.023

Correlation is significant at the 0.01 level.

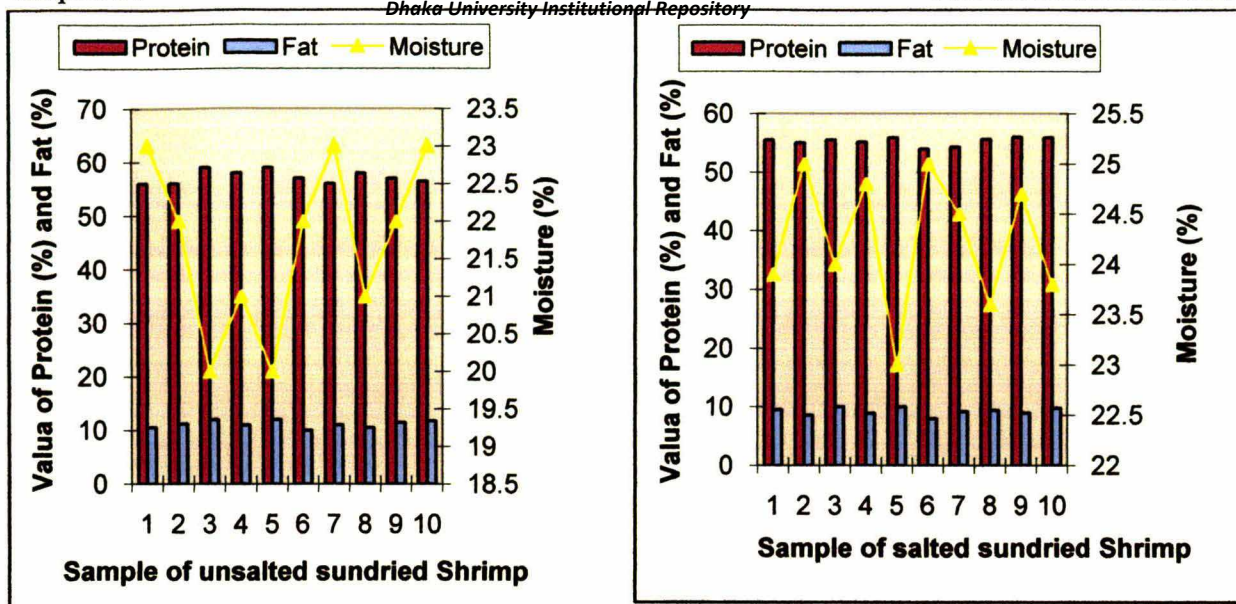


Figure 38 : Showing direct relationship “Protein and Fat” content and inverse relationship between “Moisture and Protein” content and “Moisture and Fat” content of sun dried black tiger Shrimp fish.

The graphical representation of the direct and inverse relationships among the nutrients contents of fish samples by sun drying method had been shown in Figure 38. The line and bar diagram in this Figure had shown the direct co-relation between “Protein and Fat” content and inverse co-relation between “Moisture and Protein” content and “Moisture and Fat” content.

The “t” value between percent of “Moisture and Protein” content and “Moisture and Fat” content of fish sample by sun drying unsalted and salted condition had been computed and found to be (-) 8.668, (-) 1.182 and (-) 2.201, (-) 4.637 respectively which was highly significant at 1% significance level ($P < 0.01$) and indicated a strong inverse or negative relationship between them.

The “t” value between percent of “Protein and Fat” content of fish sample by sun drying unsalted and salted condition had been computed and found to be (+) 1.291 and (+) 2.794 which were highly significant at 1% significance level ($P < 0.01$) and indicated a strong direct or positive relationship.

(8). Determination of co-relation between protein, fat and moisture of black tiger Shrimp in the tunnel dried unsalted and salted condition.

The co-relation co-efficient value expressed as “r” between moisture and protein, moisture and fat and Protein and fat of tunnel dried unsalted and salted black tiger Shrimp fish had been computed which were (-) 0.982, (-) 0.920, (+) 0.982 and (-) 0.875, (-) 0.881, (+) 0.878 respectively has been presented in Table 38. The “r” values are determined by the application of the statistical program software titled as “SPSS for windows-11.5.”

The negative “r” value between protein and moisture, fat and moisture content refers to an inverse co-relationship between protein and moisture, fat and moisture which indicates that the value of protein and fat content increase with the decrease of the value of moisture content. On the other hand, the positive value of “r” between protein and fat refers to a direct co-relation that is with increase or decrease of one of the two values the corresponding value of the other nutrient will be decrease or increase respectively.

Table 29: Showing co-relation co-efficient among moisture, protein and fat of black tiger Shrimp in Solar Tunnel dried fish in sun dried and highly acceptable unsalted condition

Variables		Pearson's correlation	N	T	Sig.
Unsalted	Moisture (%) and Protein (%)	-0.982	10	-14.727	0.000
	Moisture (%) and Fat (%)	-0.926	10	-6.930	0.000
	Protein (%) and Fat (%)	0.982	10	14.912	0.001
Salted	Moisture (%) and Protein (%)	-0.875	10	-5.22	0.001
	Moisture (%) and Fat (%)	-0.881	10	-5.254	0.001
	Protein (%) and Fat (%)	+0.878	10	+14.912	0.001

Correlation is significant at the 0.01 level.

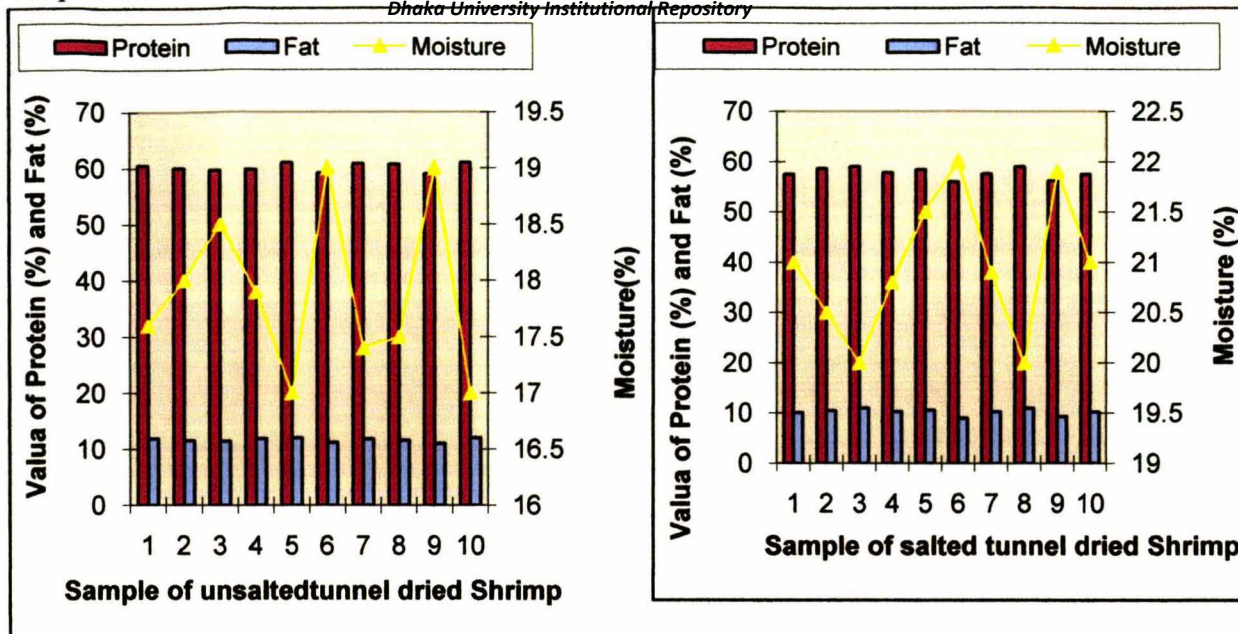


Figure 39: Showing direct relationship “Protein and Fat” content and inverse relationship between “Moisture and Protein” content and “Moisture and Fat” content of Solar Tunnel dried black tiger Shrimp fish.

The graphical representation of the direct and inverse relationships among the nutrients contents of fish samples by tunnel drying method had been shown in Figure 39. The line and bar diagram in this Figure had shown the direct co-relation between “Protein and Fat” content and inverse co-relation between “Moisture and Protein” content and “Moisture and Fat” content.

The “t” value between percent of “Moisture and Protein” content and “Moisture and Fat” content of fish sample by solar tunnel drying unsalted and salted condition had been computed and found to be (-) 14.727, (-) 6.930 and (-) 5.22, (-) 5.254 respectively which was highly significant at 1% significance level ($P < 0.01$) and indicated a strong inverse or negative relationship between them.

The “t” value between percent of “Protein and Fat” content of fish sample by sun drying unsalted and salted condition had been computed and found to be (+) 14.912 and (+) 14.912 which were highly significant at 1% significance level ($P < 0.01$) and indicated a strong direct or positive relationship.

(9). Determination of co-relation between protein, fat and moisture of black tiger Shrimp in the smoke cured unsalted condition.

The co-relation co-efficient value expressed as “r” between moisture and protein, moisture and fat and Protein and fat of smoke cured unsalted and salted black tiger Shrimp fish had been computed which were (-) 0.110, (-) 0.651, (+) 0.633 and (-) 0.692, (-) 0.892, (+) 0.750 respectively has been presented in table 39. The “r” values are determined by the application of the statistical program software titled as “SPSS for windows-11.5.”

The negative “r” value between protein and moisture, fat and moisture content refers to an inverse co-relationship between protein and moisture, fat and moisture which indicates that the value of protein and fat content increase with the decrease of the value of moisture content. On the other hand, the positive value of “r” between protein and fat refers to a direct co-relation that is with increase or decrease of one of the two values the corresponding value of the other nutrient will be decrease or increase respectively.

Table 30: Showing co-relation co-efficient among moisture, protein and fat of black tiger Shrimp in smoke cured fish in sun dried and highly acceptable unsalted condition

Variables		Pearson's correlation	N	T	Sig.
Unsalted	Moisture (%) and Protein (%)	0.110	10	0.312	0.763
	Moisture (%) and Fat (%)	-0.651	10	-2.424	0.042
	Protein (%) and Fat (%)	0.633	10	2.314	0.049
Salted	Moisture (%) and Protein (%)	0.692		-2.714	0.026
	Moisture (%) and Fat (%)	-0.892		-5.584	0.001
	Protein (%) and Fat (%)	+0.750		+3.206	0.013

Correlation is significant at the 0.01 level.

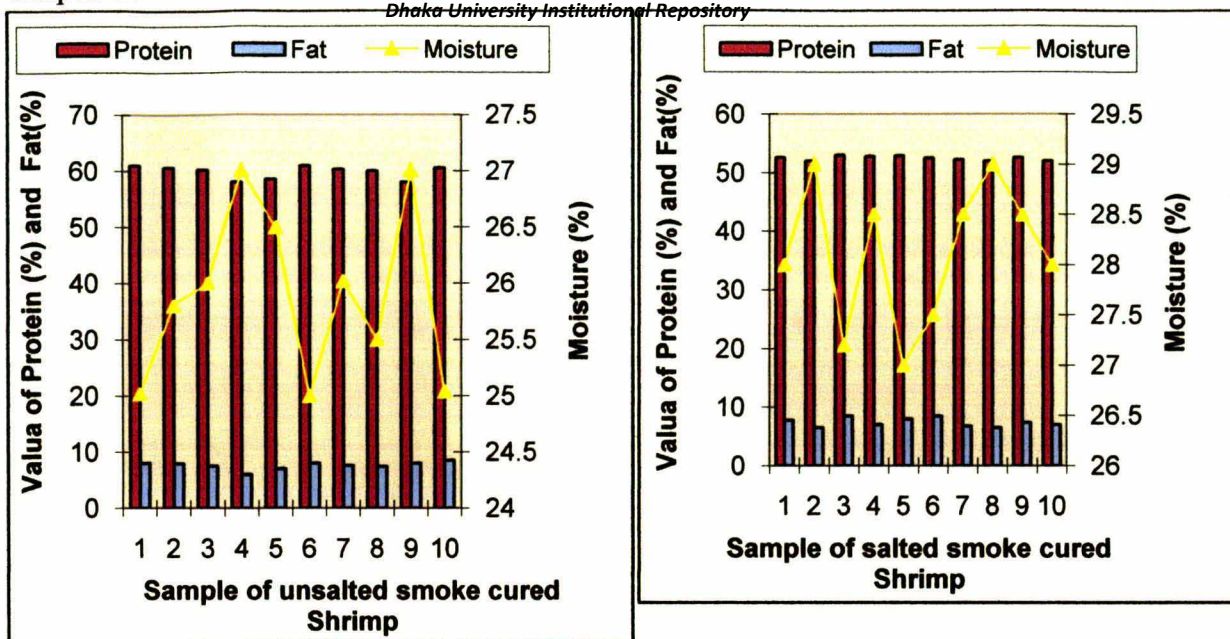


Figure 40: Showing direct relationship “Protein and Fat” content and inverse relationship between “Moisture and Protein” content and “Moisture and Fat” content of smoke cured Shrimp fish.

The graphical representation of the direct and inverse relationships among the nutrients contents of fish samples by smoke curing method had been shown in Figure 40. The line and bar diagram in this Figure had shown the direct co-relation between “Protein and Fat” content and inverse co-relation between “Moisture and Protein” content and “Moisture and Fat” content.

The “t” value between percent of “Moisture and Protein” content and “Moisture and Fat” content of fish sample by smoke curing unsalted and salted condition had been computed and found to be (-) 0.312, (-) 2.424 and (-) 2.714, (-) 5.584 respectively which was highly significant at 1% significance level ($P < 0.01$) and indicated a strong inverse or negative relationship between them.

The “t” value between percent of “Protein and Fat” content of fish sample by sun drying unsalted and salted condition had been computed and found to be (+)2.313 and (+)3.206 which were highly significant at 1% significance level ($P < 0.01$) and indicated a strong direct or positive relationship.

5. Quality and shelf life.

(a) Biochemical variables and TVN values in Chinese Pomfret (*Pampus chinensis*).

The smoking dried unsalted Chinese Pomfret had 24.24% moisture, 55.01% protein, 70 mg/100g TVN in which the corresponding sensory score was 9; smoking dried salted Chinese Pomfret contained 26.08% moisture, 54.20% protein, 56 mg/100g TVN and the corresponding sensory score was 9; The Solar Tunnel dried unsalted samples contained 17.17% moisture, 62.09% protein, 60 mg/100g TVN in which the corresponding sensory score was 9; tunnel dried salted samples contained 20.20% moisture, 58.10% protein, 62 mg/100g TVN and the corresponding sensory score was 9; Whereas sun dried unsalted samples contained 22.23% moisture, 59.68% protein, 68 mg/100g TVN in which the corresponding sensory score was 9; sun dried salted samples contained 23.09% moisture, 57.19% protein, 60 mg/100g TVN and the corresponding sensory score was 9;

Acceptance condition.

1. Chinese Pomfret (*Pampus chinensis*):

The experimentally Sun dried, Solar tunnel dried and Smoke cured samples of *Pampus chinensis* was stored in different storage conditions at room temperature and in refrigerator in the laboratory and their quality were assessed in fresh dried conditions as well as at different time intervals during the storage experiment. The different samples of dried fish were stored as to find out the effect of different storage conditions on the extent of shelf life of those samples.

The results of quality assessment of experimentally sun dried, solar tunnel dried and smoke cured samples of *Pampus chinensis* while stored at room temperature in the laboratory have been represented in Table 40. The quality of sundried, solar tunnel dried and smoke cured samples of *Pampus chinensis* while at room temperature in the laboratory was found to be highly unacceptable in October (Table-40). The percentage of moisture, protein, TVN values and sensory score of these samples observed in October were 24.29%, 55.52%, 310mg/100g and 4.0 (unsalted sun dried); 25.50%, 54.00%, 315mg/100g and 4.5 (salted sun dried); 22.89%, 56.00%, 302mg/100g and 4.0 (unsalted solar tunnel dried); 24.04%, 55.00%, 300mg/100g and 3.5 (salted solar tunnel dried); 28.44%, 55.00%, 320mg/100g and 4.0

(unsalted smoke cured); 28.60%, 52.05%, 316mg/100g and 3.5 (salted smoke cured) respectably.

Table 40 also indicates the variation in shelf life of dried *Pampus chinensis* by sensory score, visual observation of fungus and moulds growth and insect infestation. Salted Sun dried Chinese Pomfret remained in acceptable for a period of four month (May- August 2009), salted solar tunnel dried Chinese Pomfret remained in acceptable condition for five month(May- September 2009) Whereas salted smoke cured Pomfret remained in acceptable condition three month (May-July 2009).Unsalted Sun dried Pomfret remained in acceptable for a period of Three month (May-July 2009), unsalted solar tunnel dried Pomfret remained in acceptable condition for four month(May- September 2009) Whereas unsalted smoke cured Pomfret remained in acceptable condition two month(May-July 2009).The above mentioned quality parameters indicate better quality of Solar Tunnel dried Chinese Pomfret (Salted, unsalted) in comparison with sun dried and smoke cured Chinese Pomfret (Salted, unsalted).

The quality of sun dried, solar tunnel dried and smoke cured samples of *Pampus chinensis* while stored in refrigerator is also shown in (Table 40). After six months storage in the freeze, the percentage of moisture, protein, TVN values and sensory score of these samples observed in October were 18.00%, 64.00%, 66mg/100g and 8.5 (sun dried unsalted); 14.69%, 64.00%, 66mg/100g and 8.0 (solar tunnel dried unsalted); 20.42%, 61.20%, 69mg/100g and 8.5 respectively.

The quality of Sun dried, Solar Tunnel dried and Smoke cured samples of *Pampus chinensis* while stored in refrigerator was found to be highly acceptable in October. Sun dried, solar tunnel dried and smoke cured samples of *Pampus chinensis* while stored in refrigerator remained in acceptable condition over a period of six months (May- October 2009). The above mentioned quality parameters indicated better quality of Solar Tunnel dried *Pampus chinensis* compared with sun dried and smoke cured.

Change of moisture content of Sun dried, Solar Tunnel dried and Smoke cured samples of Pomfret while stored in refrigerator had been represented in Table 40. It was found that each sample lost moisture during storage period. As a result, percentage of protein content increased and the values of TVN remained fairly constant. No fungal growth was observed during storage. It was clear that the dried fish stored in refrigerator had longer shelf life than the dried fish stored in polythene bag at room temperature.

Change of moisture content of Sun dried, Solar Tunnel dried and Smoke cured samples of Pomfret while stored at room temperature in the laboratory have been represented in figure 41. From the figure it is clear that a gradual increase of moisture occurred and the relationship between moisture and TVN maintained direct relationship. The relationship between TVN and sensory score has been represented in figure 42 and observed TVN and sensory score maintained an inverse relationship.

Wahed et al., (2005) observed that acceptable limit of the TVN value at 30°C was found to be 38 mg/100g fish and Islam et al., (2004) observed that salted tunnel dried *pampus argenteus* 67% protein, 16% moisture, 75mg/100g TVN and unsalted tunnel dried *pampus argenteus* 69.05% protein, 14.9% moisture, 80mg/100g TVN. He also observed TVN value ranged from 100 to 330 mg/100g of fish during storage contiontion. In the initial time TVN value, moisture content and protein content were similar.

Khaleque et al., (2004) observed that the value of acceptability score and TVN range from 3.5-8.5 and 230.74-325.55 mg/100g. Ahmed et al., (2009) studied Organoleptic Changes in *Pampus chinensis* and observed that average score of initial sensory investigation was 8.48 and it decreased slowly with the progress of storage period and after 90 days of observation at-20°C, the sensory score for control was 3.2 . It was clear that with the increase of storage period the organoleptic score were rapidly decreasing in the control fish.

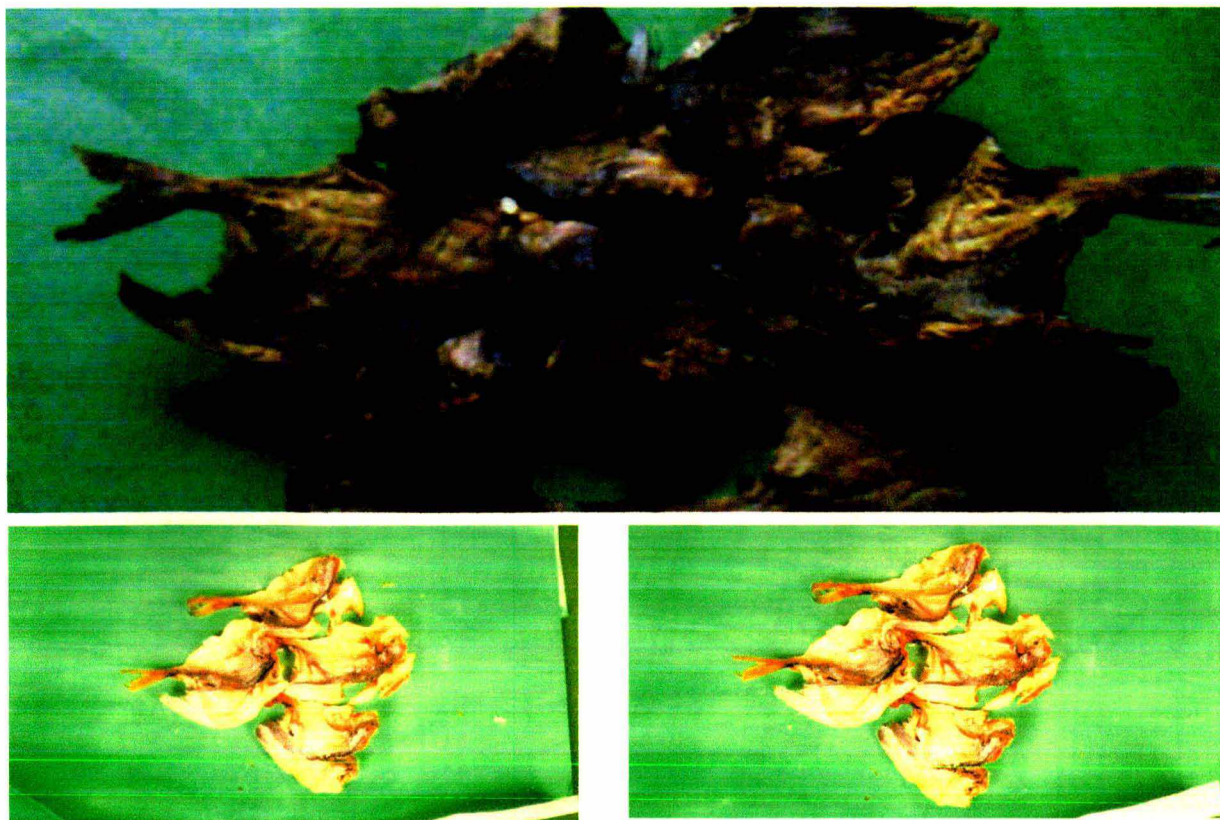


Plate 19: Spoiled sun dried and smoke cured Chinese Pomfret fish after storage at room temperature.

Table 31: Variation in the quality parameters (%) of different samples of Chinese Pomfret (*Pampus chinensis*) while stored at room temperature and refrigerator.

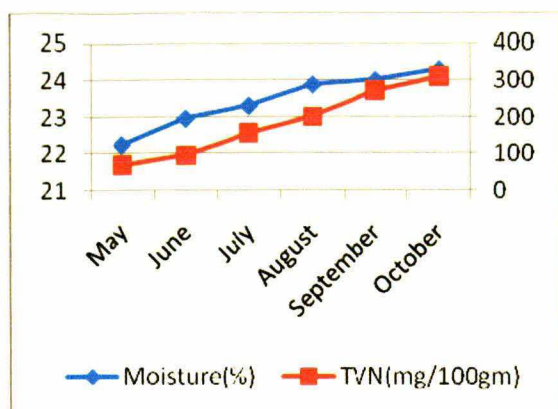
Method-1. Sun drying method							
Factors			Parameters				
			Moisture	Protein	TVN (mg/100g)	Sensory score	Visual Observation
Preservation	Storage condition	Months					
Unsalted	Refrigerator	May	22.23	59.68	60	9.0	Nil
		June	21.60	60.59	61	8.5	Nil
		July	21.10	61.40	61	8.5	Nil
		August	19.80	62.20	62	8.5	Nil
		September	19.20	63.50	64	8.5	Nil
		October	18.00	64.00	66	8.0	Nil
	Room temperature	May	22.23	59.68	68	9	Nil
		June	22.95	58.84	95	8.6	Nil
		July	23.30	57.90	156	7.5	Nil
		August	23.88	56.79	200	6.5	Slightly visible
		September	24.00	56.22	270	5.0	More visible
		October	24.29	55.52	310	4.0	More visible
Salted	Refrigerator	May	23.09	57.19	58	9	Nil
		June	22.82	58.99	60	9	Nil
		July	21.50	60.00	61	9	Nil
		August	20.60	61.75	62	9	Nil
		September	19.30	62.30	64	9	Nil
		October	18.55	63.95	67	8.8	Nil
	Room Temperature	May	23.09	57.19	60	9	Nil
		June	23.85	56.13	90	8.6	Nil
		July	24.60	56.90	155	7.5	Nil
		August	24.98	55.88	208	6.5	Nil
		September	25.00	55.22	290	5.0	Slightly visible
		October	25.50	54.00	315	4.5	More visible
Method-2. Solar tunnel drying method							
Factors							
			Moisture	Protein	TVN (mg/100g)	Sensory score	
Preservation	Storage condition	Months					
Unsalted	Refrigerator	May	17.17	62.09	61	9	Nil
		June	17.00	62.85	62	9	Nil
		July	16.92	63.45	63	9	Nil
		August	15.65	64.60	66	9	Nil
		September	15.21	65.35	68	9	Nil
		October	14.69	66.23	72	8.5	Nil
	Room temperature	May	17.17	62.09	60	9	Nil
		June	18.47	61.50	100	8.5	Nil
		July	20.55	60.65	155	7.0	Nil
		August	21.52	59.31	205	6.5	Nil
		September	22.06	57.00	285	4.5	Slightly visible
		October	22.89	56.00	302	4.0	More visible
	Refrigerator	May	20.20	58.10	60	9	Nil
		June	19.65	59.69	62	9	Nil
		July	18.54	60.30	64	9	Nil
		August	17.98	61.40	66	9	Nil

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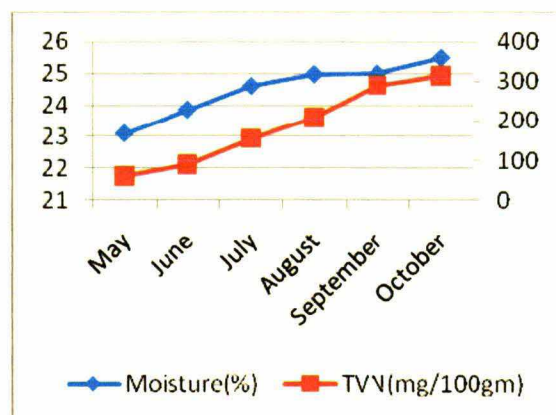
Salted		September	17.20	62.78	69	9	Nil
		October	16.22	63.72	75	9	Nil
	Room Temperature	May	20.20	58.10	62	7.5	Nil
		June	21.65	57.74	99	6.0	Nil
		July	22.10	56.85	178	5.6	Nil
		August	23.39	56.10	230	4.4	Nil
		September	23.99	55.63	280	4.0	Nil
		October	24.05	55.00	300	3.5	Slightly visible
Method-3 Smoke curing method							
			Parameters				
			Moisture	Protein	TVN (mg/100g)	Sensory score	Visual Observation
Preservation	Storage condition	Months					
Unsalted	Refrigerator	May	24.24	55.01	56	9	Nil
		June	23.85	56.30	59	9	Nil
		July	22.95	57.23	61	9	Nil
		August	22.10	58.60	63	9	Nil
		September	21.60	60.22	66	9	Nil
		October	20.42	61.20	69	8.5	Nil
	Room temperature	May	24.24	55.01	70	9	Nil
		June	25.90	54.78	115	8.6	Nil
		July	26.60	54.22	195	7.5	Slightly visible
		August	27.00	53.88	255	6.5	More visible
		September	27.55	52.62	300	5.5	More visible
		October	28.44	48.00	320	3.0	Abandantly vi.
Salted	Refrigerator	May	26.08	54.20	55	9	Nil
		June	25.44	55.61	58	9	Nil
		July	24.66	56.32	60	9	Nil
		August	23.44	57.56	62	9	Nil
		September	22.10	58.20	66	9	Nil
		October	21.30	58.76	75	8.8	Nil
	Room Temperature	May	26.08	54.20	56	9	Nil
		June	27.55	54.00	89	8.6	Nil
		July	27.69	53.75	130	7.0	Nil
		August	27.99	53.09	199	5.5	Slightly visible
		September	28.16	52.84	255	4.0	More visible
		October	28.60	45.00	316	3.5	More visible

Figure 41: Relationship Between Moisture and TVN of Chinese Pomfret while stored at room temperature.

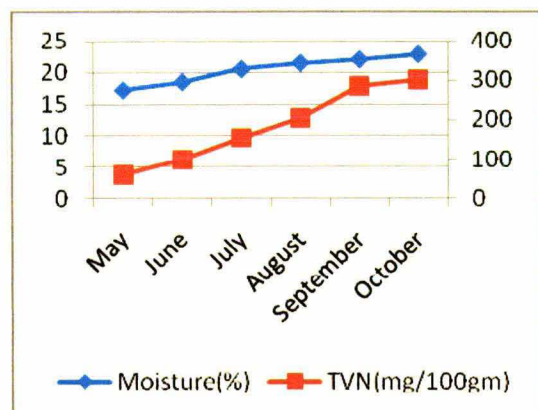
A. Sun dried Unsalted



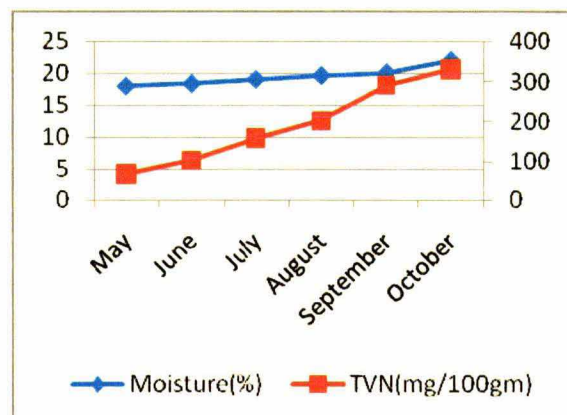
B. Sun dried Salted



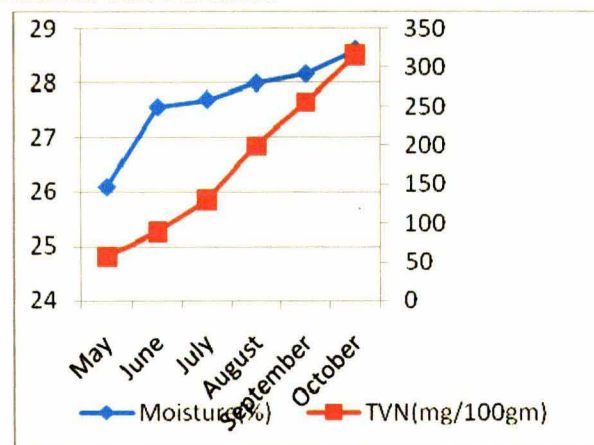
C. Solar tunnel dried unsalted



D. Solar tunnel dried salted



E. Smoke cured unsalted



F. Smoke cured salted

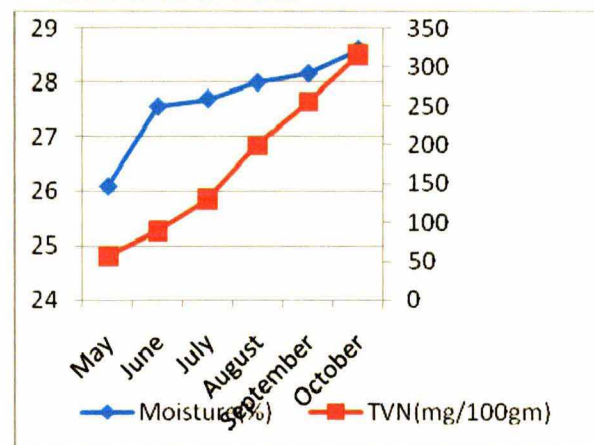
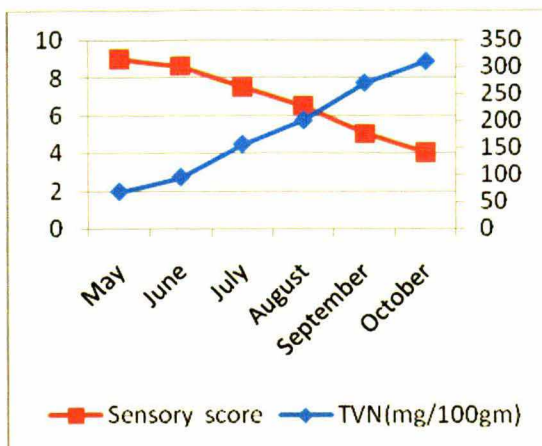
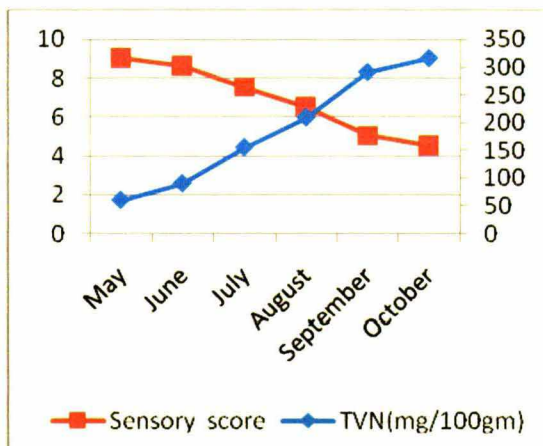


Figure 42: Relationship Between TVN and Sensory Score of Chinese Pomfret while stored at room temperature.

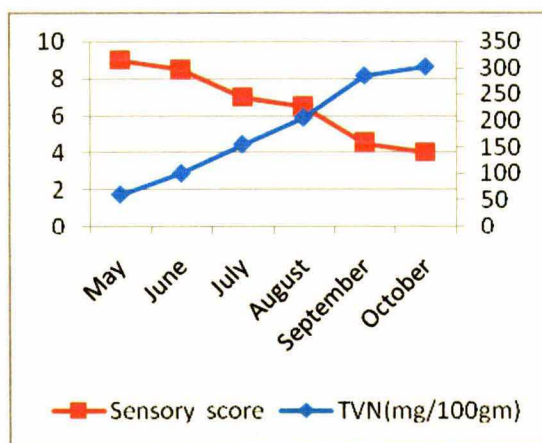
A. Sun dried unsalted



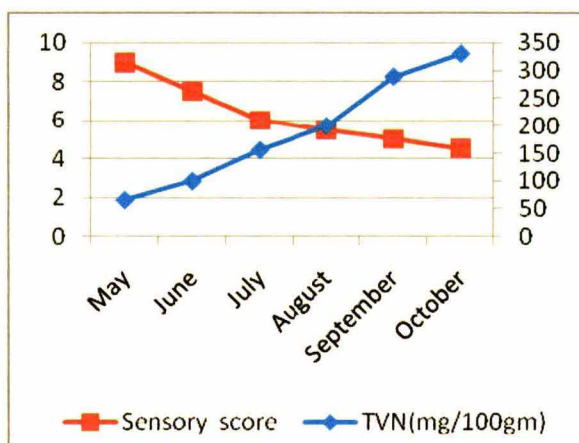
B. Sun dried salted



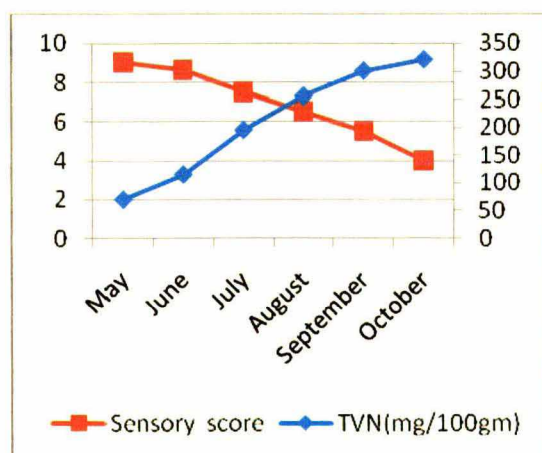
C. Solar tunnel dried Unsalted



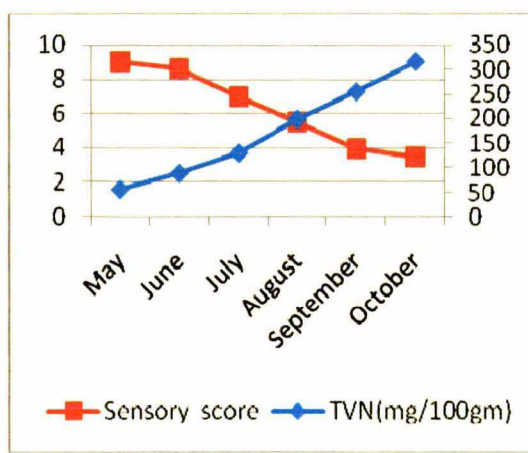
D. Solar tunnel dried salted



E. Smoke cured Unsalted



F. Smoke cured salted



(b) Biochemical variables and TVN values in Bombay duck (*Harpodon****nehereus*).**

The smoking dried unsalted Bombay duck had 25.06% moisture, 54.01% protein, 58 mg/100g TVN in which the corresponding sensory score was 9; smoking dried salted Bombay duck contained 27.12% moisture, 51.93% protein, 55mg/100g TVN and the corresponding sensory score was 9; The solar tunnel dried unsalted samples contained 15.99% moisture, 63.18% protein, 65mg/100g TVN in which the corresponding sensory score was 9; tunnel dried salted samples contained 17.96% moisture, 60.10% protein, 66 mg/100g TVN and the corresponding sensory score was 9; Whereas sun dried unsalted samples contained 21.80% moisture, 58.24% protein, 60mg/100g TVN in which the corresponding sensory score was 9; sun dried salted samples contained 25.16% moisture, 55.35% protein, 65 mg/100g TVN and the corresponding sensory score was 9;

Acceptance condition**1. Bombay Duck (*Harpodon nehereus*)**

The results of quality assessment of experimentally sun dried, solar tunnel dried and smoke cured samples of *Harpodon nehereus* while stored at room temperature in the laboratory have been represented in Table 1. The quality of sundried, solar tunnel dried and smoke cured samples of *Harpodon nehereus* while at room temperature in the laboratory was found to be highly unacceptable in October (Table-41). The percentage of moisture, protein, TVN values and sensory score of these samples observed in October were 24.97%, 55.20 %, 310mg/100g and 3.0 (unsalted sun dried); 27.44 %, 52.40 %, 355 mg/100g and 4.0 (salted sun dried); 18.50%, 60.84%, 299 mg/100g and 4.0 (unsalted solar tunnel dried); 21.98%, 56.16%, 330mg/100g and 4.5 (salted solar tunnel dried); 27.86%, 51.46%, 305mg/100g and 4.0 (unsalted smoke cured); 29.87%, 49.09%, 325mg/100g and 4.5 (salted smoke cured) respectably.

Table 41 also indicates the variation in shelf life of dried *Harpodon nehereus* by sensory score, visual observation of fungus and moulds growth and insect infestation. Salted Sun dried Bombay duck remained in acceptable for a period of four month (May- August 2009), salted solar tunnel dried Bombay duck remained in acceptable condition for five month (May- September 2009) Whereas salted smoke cured Bombay duck remained in acceptable condition three month (May-July 2009). Unsalted Sun dried Bombay duck remained in acceptable for a period of Three month (May-July 2009), unsalted solar tunnel dried Bombay

duck remained in acceptable condition for four month(May-August 2009) Whereas unsalted smoke cured Bombay duck remained in acceptable condition two month(May-June 2009).The above mentioned quality parameters indicate better quality of Solar tunnel dried Bombay duck (Salted, unsalted) in comparison with sun dried and smoke cured Bombay duck (Salted, unsalted). Similar findings have been

The quality of sun dried, solar tunnel dried and smoke cured samples of *Harpodon nehereus* while stored in refrigerator is also shown in (Table-1 and plate 21). After six months storage in the freeze, the percentage of moisture, protein, TVN values and sensory score of these samples observed in October were 18.95%, 61.53%, 72mg/100g and 8.0 (sun dried unsalted);21.78%,59.00%, 74mg/100g and 8.0 (sun dried salted); 13.30%, 67.54%, 77mg/100g and 8.5 (solar tunnel dried unsalted); 15.00%, 65.58%, 72mg/100g and 8.5 (solar tunnel dried unsalted); 20.58%, 59.00%, 74mg/100g and 8.0(smoke cured unsalted); 22.20%, 56.81%, 68mg/100g and 8.0 (smoke cured unsalted) respectively.

The quality of sun dried, solar tunnel dried and smoke cured samples of *Harpodon nehereus* while stored in refrigerator was found to be highly acceptable in October. Sun dried, solar tunnel dried and smoke cured samples of *Harpodon nehereus* while stored in refrigerator remained in acceptable condition over a period of six months (May- October 2009). The above mentioned quality parameters indicated better quality of solar tunnel dried *Harpodon nehereus* compared with sun dried and smoke cured.

Change of moisture content of sun dried, solar tunnel dried and smoke cured samples of Bombay duck while stored in refrigerator had been represented in table 41. It was found that each sample lost moisture during storage period. As a result, percentage of protein content increased and the values of TVN remained fairly constant. No fungal growth was observed during storage. It was clear that the dried fish stored in refrigerator had longer shelf life than the dried fish stored in polythene bag at room temperature.

Change of moisture content of sun dried, solar tunnel dried and smoke cured samples of Bombay duck while stored at room temperature in the laboratory have been represented in figure 43. From the figure it is clear that a gradual increase of moisture occurred and the relationship between moisture and TVN maintained direct relationship. The relationship between TVN and sensory score has been represented in figure 44 and observed TVN and sensory score maintained an inverse relationship. Similar inverse relationship between

moisture and protein content commercially sun Bombay duck has been observed by Khaleque et al.,(2004)



Plate 20: Good quality sun dried Bombay duck fish after storage at refrigerator.

Table 41: Variation in the quality parameters (%) of different samples of Bombay duck

(Harpodon nehereus) while stored at room temperature and refrigerator.

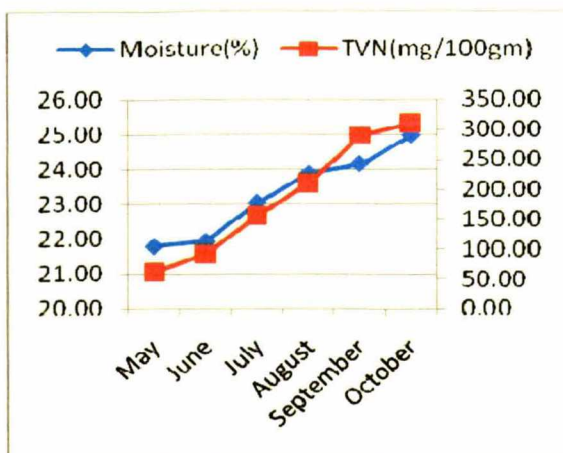
Method-1. Sun drying method							
Factors			Parameters				
			Moisture	Protein	TVN (mg/100g)	Sensory Score	Visual observation
Preservation	Storage condition	Months					
Unsalted	Refrigerator	May	21.80	58.24	59	8.5	Nil
		June	21.12	58.92	61	8.5	Nil
		July	20.85	59.66	63	8.5	Nil
		August	20.25	60.10	64	8.5	Nil
		September	19.55	50.89	66	8.5	Nil
		October	18.95	61.53	72	8.0	Nil
	Room temperature	May	21.80	58.24	60	8.5	Nil
		June	21.93	58.00	91	7.0	Nil
		July	23.05	57.65	155	6.5	Nil
		August	23.86	56.98	209	5.0	Slightly visible
		September	24.16	56.24	290	4.5	More visible
		October	24.97	55.20	310	3.0	More visible
Salted	Refrigerator	May	25.16	55.35	58	8.5	Nil
		June	24.45	55.95	60	8.5	Nil
		July	23.88	56.29	61	8.5	Nil
		August	23.00	57.00	65	8.5	Nil
		September	22.56	58.21	70	8.5	Nil
		October	21.78	59.00	74	8.0	Nil
	Room Temperature	May	25.16	55.35	65	8.5	Nil
		June	25.79	55.00	85	6.5	Nil
		July	26.06	54.82	125	5.5	Nil
		August	26.87	54.06	266	4.6	Nil
		September	27.00	53.66	320	4.5	Slightly visible
		October	27.44	52.40	355	4.0	More visible
Method-2. Solar tunnel drying method							
Factors			Parameters				
			Moisture	Protein	TVN (mg/100g)	Sensory Score	Visual observation
Preservation	Storage condition	Months					
Unsalted	Refrigerator	May	15.99	63.18	65	9	Nil
		June	15.20	63.90	66	9	Nil
		July	14.90	64.02	69	9	Nil
		August	14.00	65.30	72	9	Nil
		September	13.96	66.95	75	9	Nil
		October	13.30	67.54	77	8.5	Nil
	Room temperature	May	15.99	63.18	65	9.0	Nil
		June	16.25	63.00	99	8.5	Nil
		July	16.92	62.80	122	7.0	Nil
		August	17.22	62.05	200	6.5	Nil
		September	17.96	61.26	256	5.0	Slightly visible
		October	18.50	60.84	299	4.0	More visible
	Refrigerator	May	17.96	60.10	61	9	Nil
		June	17.00	61.20	63	9	Nil
		July	16.54	62.87	66	9	Nil
		August	15.91	63.56	67	9	Nil

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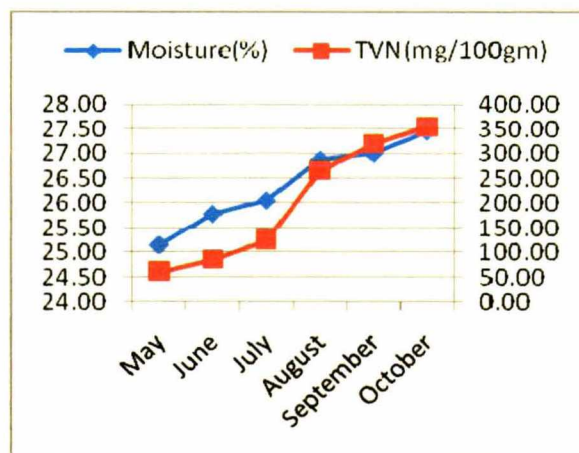
Salted		September	15.23	64.63	70	9	Nil
		October	15.00	65.58	72	8.5	Nil
	Room Temperature	May	17.96	60.10	66	9	Nil
		June	18.33	59.51	100	7.5	Nil
		July	18.99	58.88	156	6.0	Nil
		August	19.60	58.00	200	5.5	Nil
		September	20.06	57.25	289	5.0	Nil
		October	21.98	56.16	330	4.5	Slightly visible
Method-3 Smoke curing method							
			Parameters				
			Moisture	Protein	TVN (mg/100g)	Sensory Score	Visual observation
Preservation	Storage condition	Months					
Unsalted	Refrigerator	May	25.06	54.10	56	8.5	Nil
		June	24.66	55.40	59	8.5	Nil
		July	23.94	56.20	60	8.5	Nil
		August	22.21	57.09	64	8.5	Nil
		September	21.63	58.06	69	8.5	Nil
		October	20.58	59.00	74	8.0	Nil
	Room temperature	May	25.06	54.10	58	9	Nil
		June	25.85	53.94	89	8.6	Nil
		July	26.09	53.02	109	7.5	Slightly visible
		August	26.92	52.78	255	6.5	More visible
		September	27.05	52.00	299	5.0	More visible
		October	27.86	51.46	305	4.0	Abandantly vi.
Salted	Refrigerator	May	27.12	51.93	53	9	Nil
		June	26.26	52.68	55	9	Nil
		July	25.49	53.42	58	9	Nil
		August	24..03	54.60	59	9	Nil
		September	23.58	55.72	63	9	Nil
		October	22.20	56.81	68	8.0	Nil
	Room Temperature	May	27.12	51.93	55	9	Nil
		June	27.89	51.03	99	8.6	Nil
		July	28.02	50.82	156	7.5	Nil
		August	28.94	50.00	240	6.5	Slightly visible
		September	29.05	49.89	300	5.0	More visible
		October	29.87	49.09	325	4.5	More visible

Figure 43: Relationship Between Moisture and TVN of Bombay duck while stored at room temperature.

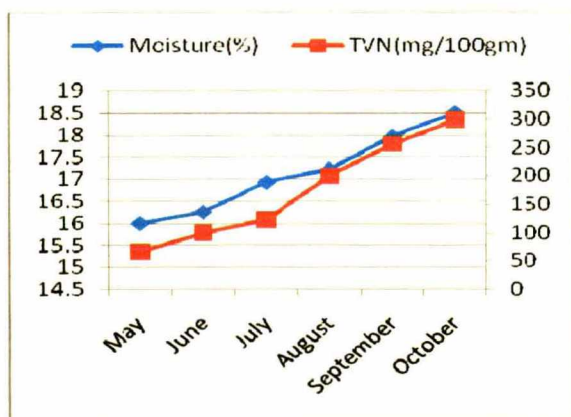
A. Sun dried unsalted



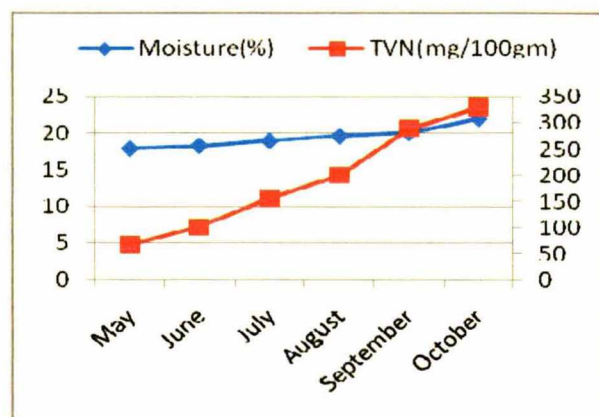
B. Sun dried salted



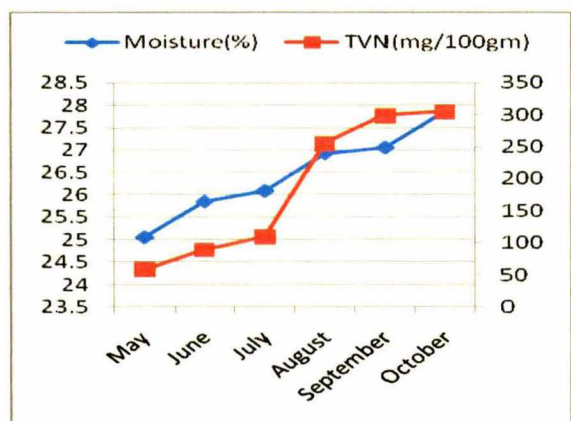
C. Solar tunnel unsalted



D. Solar Tunnel Salted



E. Smoke cured unsalted



F. Smoke cured salted

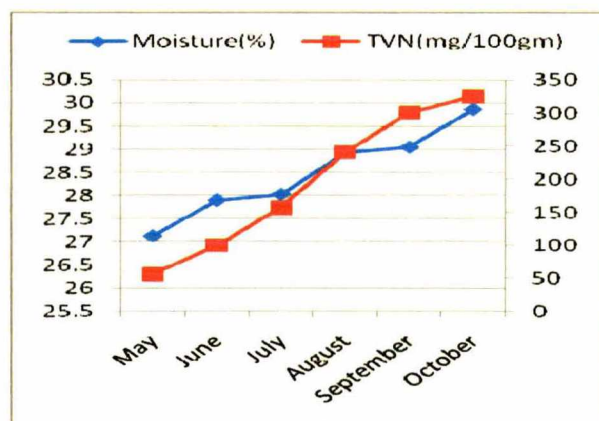
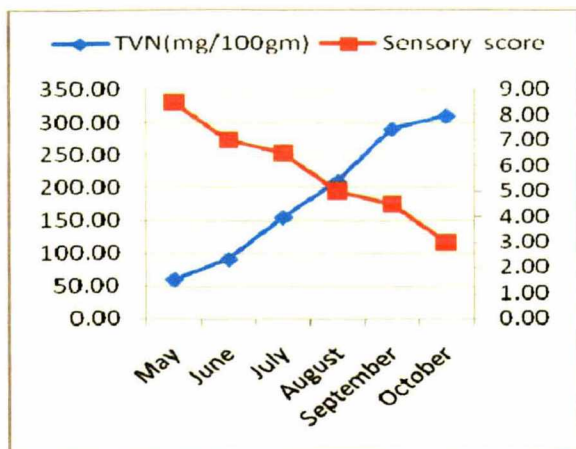
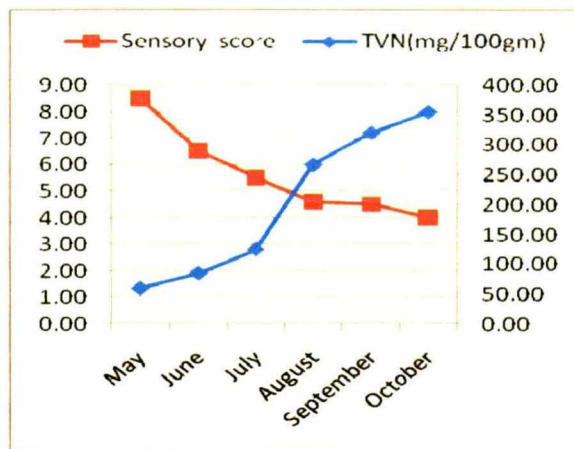


Figure 44: Relationship Between TVN and Sensory Score of Bombay duck while stored at room temperature.

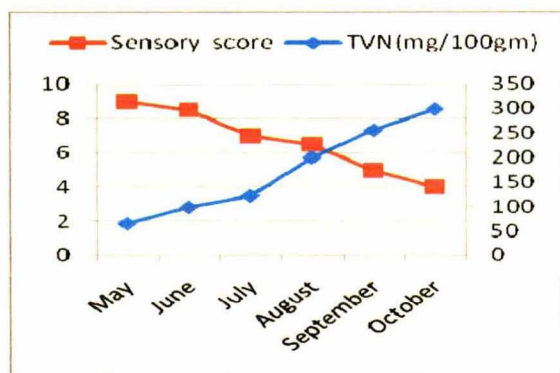
A. Sun dried unsalted



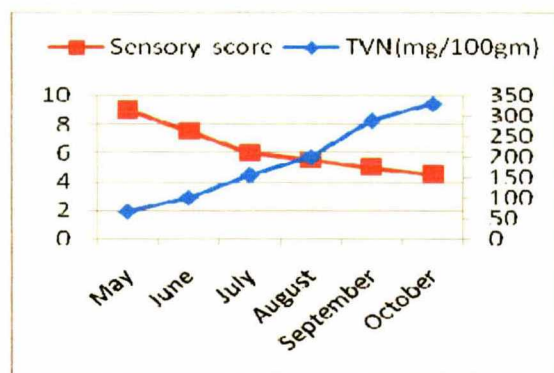
B. Sun dried salted



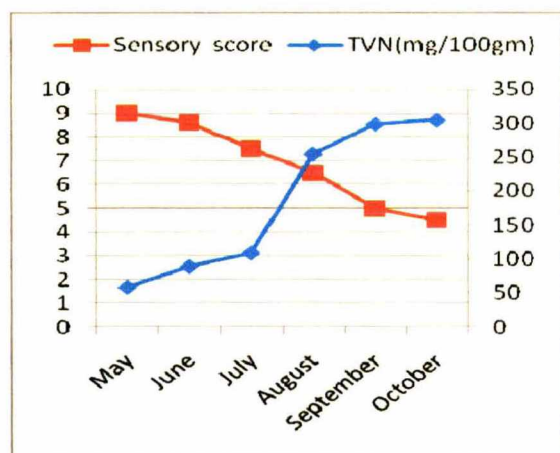
C. Solar Tunnel Unsalted



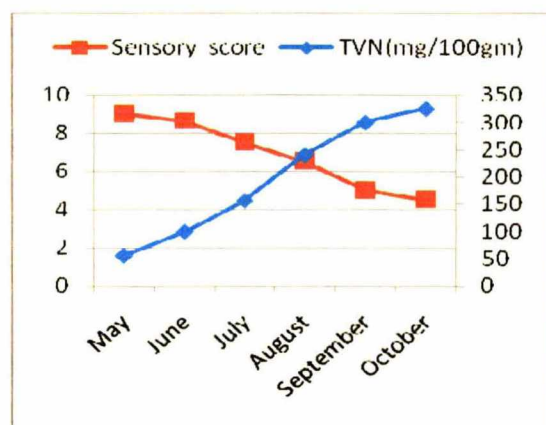
D. Solar Tunnel Salted



E. Smoke cured unsalted



F. Smoke cured salted



(c) Biochemical variables and TVN values in black tiger Shrimp (*Penaeus monodon*)

The smoking dried unsalted Shrimp had 25.88% moisture, 59.80% protein, 66 mg/100g TVN in which the corresponding sensory score was 9; smoking dried salted black tiger Shrimp contained 25.32% moisture, 47.26% protein, 50 mg/100g TVN and the corresponding sensory score was 9; The solar tunnel dried unsalted samples contained 17.89% moisture, 60.15% protein, 65 mg/100g TVN in which the corresponding sensory score was 9; tunnel dried salted samples contained 20.95% moisture, 57.74% protein, 65 mg/100g TVN and the corresponding sensory score was 9; Whereas sun dried unsalted samples contained 21.70% moisture, 57.33% protein, 59 mg/100g TVN in which the corresponding sensory score was 9; sun dried salted samples contained 24.23% moisture, 55.38% protein, 59 mg/100g TVN and the corresponding sensory score was 9;

Acceptance condition.

1. Black tiger Shrimp (*Penaeus monodon*)

The results of quality assessment of experimentally sun dried, solar tunnel dried and smoke cured samples of *Penaeus monodon* while stored at room temperature in the laboratory have been represented in Table 42. The quality of sundried, solar tunnel dried and smoke cured samples of *Penaeus monodon* while at room temperature in the laboratory was found to be highly unacceptable in October (Table-42) The percentage of moisture, protein, TVN values and sensory score of these samples observed in October were 25.16 %, 53.75%, 315mg/100g and 3.5 (unsalted sun dried); 27.23 %, 52.20 %, 325 mg/100g and 4.0 (salted sun dried); 21.25 %, 56.52%, 315 mg/100g and 4.0 (unsalted solar tunnel dried); 23.87%, 54.50%, 309 mg/100g and 4.0 (salted solar tunnel dried); 28.85%, 55.29%, 305mg/100g and 2.5 (unsalted smoke cured); 27.87%, 45.21%, 335mg/100g and 3.5 (salted smoke cured) respectively.

Table 42 also indicates the variation in shelf life of dried *Penaeus monodon* by sensory score, visual observation of fungus and moulds growth and insect infestation. Salted Sun dried Shrimp remained in acceptable for a period of four month (May- August 2009), salted solar tunnel dried Shrimp remained in acceptable condition for five month (May- September 2009) Whereas salted smoke cured Shrimp remained in acceptable condition three month (May-July 2009). Unsalted Sun dried Shrimp remained in acceptable for a period of Three month (May-July 2009), unsalted solar tunnel dried Shrimp remained in acceptable condition for four month (May- August 2009) Whereas unsalted smoke cured Shrimp remained in acceptable condition two month (May-July 2009). The above mentioned quality

parameters indicate better quality of Solar tunnel dried Shrimp (Salted, unsalted) in comparison with sun dried and smoke cured Shrimp (Salted, unsalted).

The quality of sun dried, solar tunnel dried and smoke cured samples of *Penaeus monodon* while stored in refrigerator is also shown in (Table-42). After six months storage in the freeze, the percentage of moisture, protein, TVN values and sensory score of these samples observed in October were 17.68%, 62.58%, 66mg/100g and 7.5 (sun dried unsalted); 20.62%, 60.93%, 69mg/100g and 8.5(sun dried unsalted); 15.15%, 63.54%, 73mg/100g and 9 (solar tunnel dried unsalted); 16.23%, 61.87%, 75mg/100g and 9(solar tunnel dried salted); 21.38%, 63.63%, 78mg/100g and 7.5(smoke cured unsalted); 22.06%, 52.42%, 66mg/100g and 8.0(smoke cured unsalted) respectively.

The quality of sun dried, solar tunnel dried and smoke cured samples of *Penaeus monodon* while stored in refrigerator was found to be highly acceptable in October. Sun dried, solar tunnel dried and smoke cured samples of *Penaeus monodon* while stored in refrigerator remained in acceptable condition over a period of six months (May- October 2009). The above mentioned quality parameters indicated better quality of solar tunnel dried *Penaeus monodon* compared with sun dried and smoke cured.

Change of moisture content of sun dried, solar tunnel dried and smoke cured samples of Shrimp while stored in refrigerator had been represented in table 42. It was found that each sample lost moisture during storage period. As a result, percentage of protein content increased and the values of TVN remained fairly constant. No fungal growth was observed during storage. It was clear that the dried fish stored in refrigerator had longer shelf life than the dried fish stored in polythene bag at room temperature.

Change of moisture content of sun dried, solar tunnel dried and smoke cured samples of Shrimp while stored at room temperature in the laboratory have been represented in figure 45. From the figure it is clear that a gradual increase of moisture occurred and the relationship between moisture and TVN maintained direct relationship. The relationship between TVN and sensory score has been represented in figure 46 and observed TVN and sensory score maintained an inverse relationship.

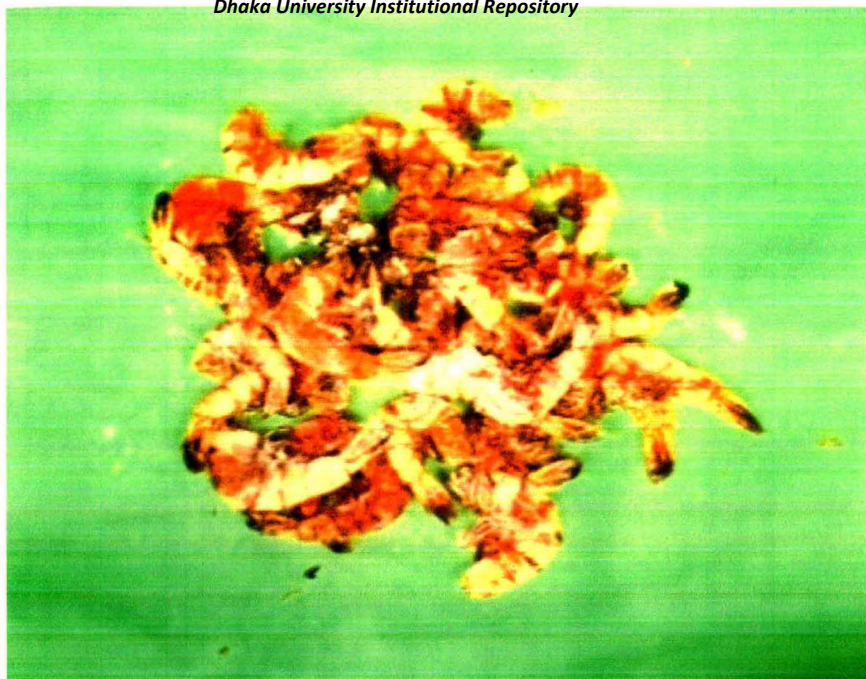


Plate 21: Spoiled sun dried fish after storage at room temperature.

Many studies on the storage life also reveal that Solar dried products have longer shelf life having better quality over sun dried products (Rubbi et al., 1982; Oregana, 1982; Camu et al; Doe and heruwait, 1987). It has been reported by Bala (2003) that different tunnel dried fish showed shelf life of 3 months in polythene bag without any treatment and Islam et al., (2004) studied that Solar dried products stored for upto 5 months in simple low cost storage media (earthen pot). Kesvani Well dried fish could be stored for upto 1 year in sealed polythene bag without serious loss of quality (Kesvani, 1962). It was clear that with the increase of storage period the organoleptic score were rapidly decreasing in the control fish.

Table 33: Variation in the quality parameters of different samples of black tiger Shrimp (*Penaeus monodon*) while stored at room temperature and refrigerator.

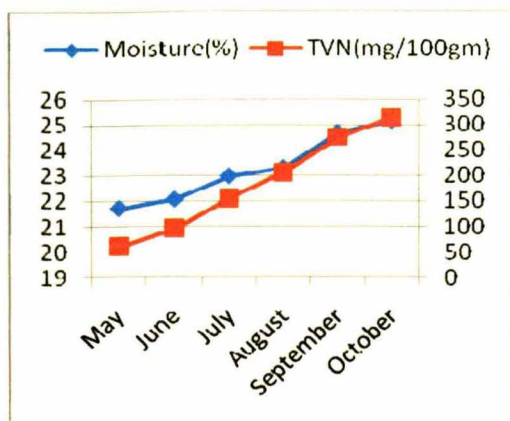
Method-1. Sun drying method							
Factors			Parameters				
			Moisture	Protein	TVN (mg/100g)	Sensory score	Visual Observation
Preservation	Storage condition	Months					
Unsalted	Refrigerator	May	21.70	57.33	60	8.5	Nil
		June	20.85	58.85	60	8.5	Nil
		July	19.99	59.68	62	8.5	Nil
		August	19.16	60.18	63	8.5	Nil
		September	18.77	61.65	65	8.5	Nil
		October	17.68	62.58	66	7.5	Nil
	Room temperature	May	21.70	57.33	59	8.5	Nil
		June	22.06	56.98	95	7.0	Nil
		July	22.98	56.03	155	6.5	Nil
		August	23.30	55.82	205	5.0	Slightly visible
		September	24.69	54.61	275	4.6	More visible
		October	25.16	53.75	315	3.5	More visible
Salted	Refrigerator	May	24.23	55.38	58	8.5	Nil
		June	23.38	56.35	60	8.5	Nil
		July	22.85	57.63	62	8.5	Nil
		August	22.00	58.25	65	8.5	Nil
		September	21.49	59.70	66	8.5	Nil
		October	20.62	60.93	69	8.5	Nil
	Room Temperature	May	24.23	55.38	59	9	Nil
		June	25.00	54.97	110	7.5	Nil
		July	25.87	54.21	199	6.5	Nil
		August	26.15	53.75	259	5.5	Nil
		September	26.99	52.97	300	4.5	Slightly visible
		October	27.23	52.20	325	4.0	More visible

Method-2. Solar tunnel drying method							
Factors			Parameters				
			Moisture	Protein	TVN (mg/100g)	Sensory score	Visual observation
Preservation	Storage condition	Months					
Unsalted	Refrigerator	May	17.89	60.15	62	9	Nil
		June	17.02	60.96	63	9	Nil
		July	16.71	61.20	65	9	Nil
		August	16.10	62.06	68	9	Nil
		September	15.98	62.89	70	9	Nil
		October	15.15	63.54	73	9	Nil
	Room temperature	May	17.89	60.15	65	9.0	Nil
		June	18.50	60.00	120	7.5	Nil
		July	19.50	59.55	200	6.0	Nil
		August	19.36	58.89	266	5.6	Nil
		September	20.25	57.65	299	4.4	Slightly visible
		October	21.25	56.52	315	3.5	More visible
		May	20.95	57.74	60	9	Nil

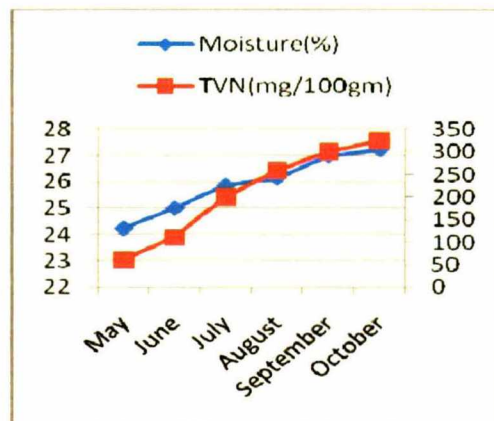
Salted	Refrigerator	June	19.64	58.45	62	9	Nil
		July	18.23	59.60	65	9	Nil
		August	18.00	60.54	69	9	Nil
		September	17.70	61.12	71	8.5	
		October	16.23	61.87	75	9	Nil
	Room Temperature	May	20.95	57.74	62	7.5	Nil
		June	21.32	56.59	95	6.5	Nil
		July	21.99	56.00	150	5.5	Nil
		August	22.49	55.85	210	4.5	Nil
		September	23.08	55.09	289	4.0	Nil
	October	23.87	54.50	309	4.0	Slightly visible	
Method-3 Smoke curing method							
			Parameters				
			Moisture	Protein	TVN (mg/100gm)	Sensory score	Visual observation
Preservation	Storage condition	Months					
Unsalted		May	25.88	59.80	65	8.0	Nil
		June	24.54	60.81	68	8.0	Nil
		July	23.69	61.58	69	8.0	Nil
		August	22.78	62.03	72	8.0	Nil
		September	22.00	62.89	75	8.0	Nil
		October	21.38	63.63	78	7.5	Nil
	Room temperature	May	25.88	59.80	66	8.0	Nil
		June	26.24	58.87	90	7.5	Nil
		July	26.97	58.00	135	6.5	Slightly visible
		August	27.25	57.96	205	4.0	More visible
		September	27.89	56.90	262	3.5	More visible
		October	28.85	55.29	305	2.5	Abandantly vi.
Salted	Refrigerator	May	25.32	47.26	55	8.0	Nil
		June	24.89	48.60	59	8.0	Nil
		July	24.00	49.64	60	8.0	Nil
		August	23.87	50.55	61	8.0	Nil
		September	22.99	51.23	65	8.0	Nil
		October	22.06	52.42	66	8.0	Nil
	Room Temperature	May	25.32	47.26	50	8.0	Nil
		June	25.98	47.00	85	7.0	Nil
		July	26.23	46.84	155	6.0	Nil
		August	26.99	46.02	225	5.5	Slightly visible
		September	27.12	45.86	300	4.5	More visible
		October	27.87	45.21	335	3.5	More visible

Figure 45: Relationship Between Moisture and TVN of black tiger Shrimp while stored at room temperature.

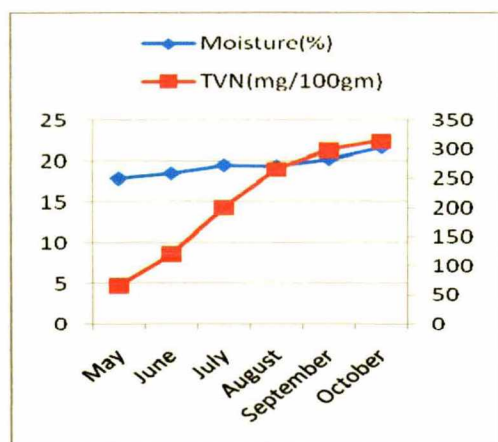
A. Sun dried unsalted



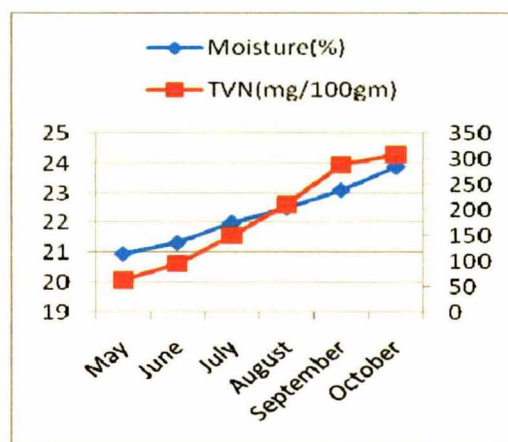
B. Sun dried salted



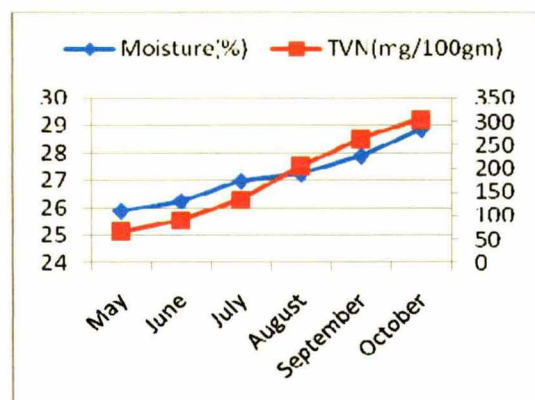
C. Solar Tunnel Unsalted



D. Solar Tunnel salted



E. Smoke cured unsalted



F. Smoke cured salted

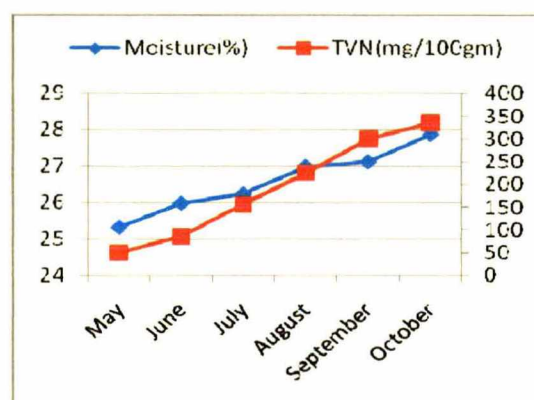
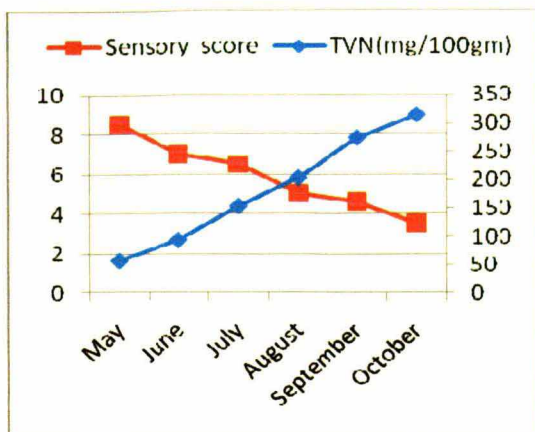
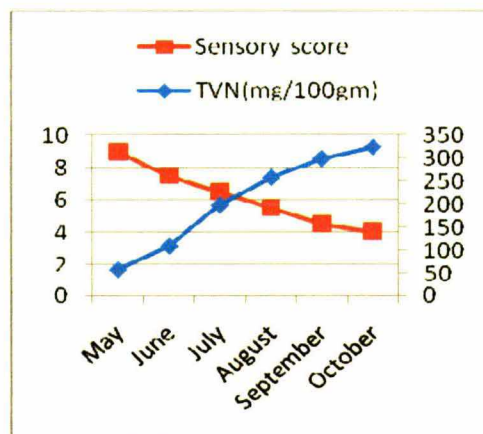


Figure 46: Relationship Between TVN and Sensory Score of black tiger Shrimp while stored at room temperature.

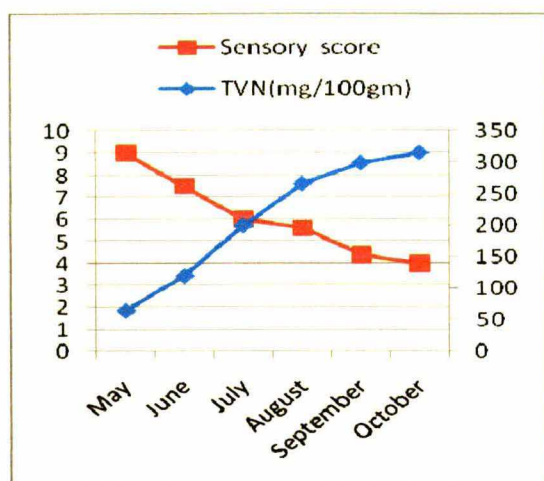
A. Sun dried unsalted



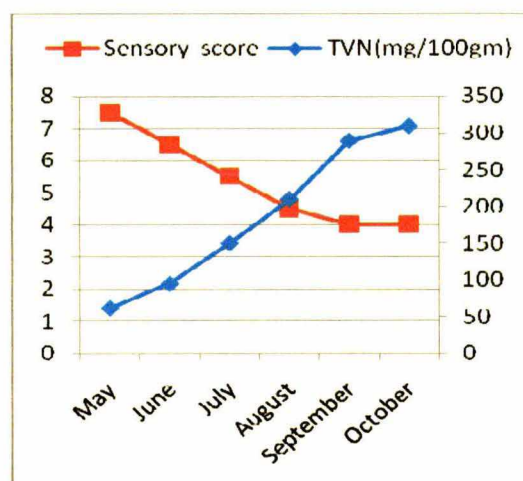
B. Sun dried salted



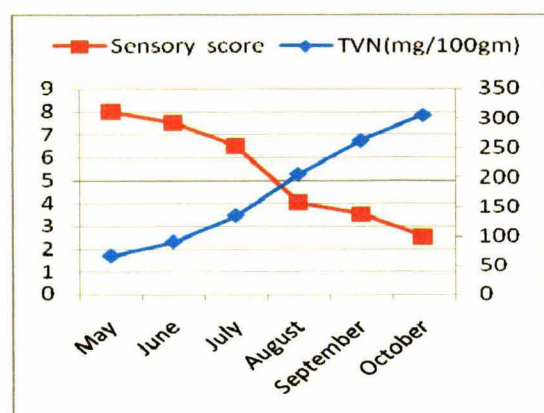
C. Solar Tunnel Unsalted



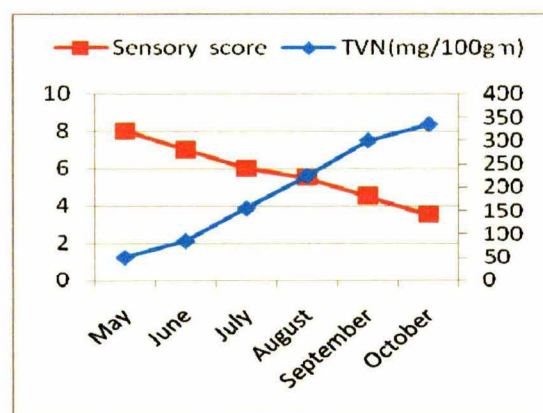
D. Solar Tunnel salted



E. Smoke cured unsalted



F. Smoke cured salted



CHAPTER- V

CONCLUSION

CHAPTER-V CONCLUSION

Fish and fishery resource plays a very vital role in the field of human nutrition, employment among qualified as well as non-qualified personnels and earns foreign currency as well as local currency while marketing both at outside the country and within the local market. During post-harvest period a huge quantity of fishes have been found to undergo spoilage deterioration which intern causes both financial as well or nutritional loss. To minimize the spoilage loss of the fishes during post harvest period different kinds of processing and preservation methods have been introduced in our country along with many other countries the world. Now, with a view to see the effectiveness of three methods of processing and preservation (Solar Tunnel drying, Sun drying and Smoke curing) methods --along with three species of experiment fishes (Pomfret, Bombay duck and Shrimp) thesis work entitled (Investigation on the quality and shelf life of *Harpodon nehereus*, *Pampus chinensis* and *Penaeus monodon* during smoke curing, traditional sun drying and drying in the solar tunnel dryer”) . The thesis work were done within schedule time and we are summerizing the findings as outlined below.

Making the thesis work plan first.

Selection and collection of the two species of marine fishes (Bombay duck and Chinese Pomfret) and black tiger Shrimp. Then bringing the fish and shrimp samples at the fish Tech. Laboratory, IFST, BCSIR, Dhaka in highly acceptable and fresh raw condition.

1. Grading, cleaning and descaling of the fish samples were done.
2. Biochemical analysis in fresh and raw condition were carried out by AOAC methods and were compared with many other working scientists of the world including Bangladesh. The results were also analyzed statistically by SPSS 12 version and SPSS 20 version.
3. The process of sundrying, Solar Tunnel Drying and Smoke curing- with salt+turmeric, with salt and without any treatment were done simultaneously recording physical parameter with a view to know the drying rate and dried fish product quality.
4. Dried and dehydrated fish products produced at the laboratory level were analyzed in fresh dried

condition and were stored at ambient temperature (in thick and thin polythene bag) and at refrigerated temperature.

5. The quality and shelf life of the dried and dehydrated fish products were studied and compared with each other with a view to ascertain which product quality is better and which storage condition will favour better and longer shelf life. Sensory score and Total Volatile Nitrogen were used to study the dried fish quality and shelf life.

Conclusion

We have studied three processing and preservation methods such as Sun drying, Smoke curing and Solar Tunnel Drying of Chinese Pomfret, Bombay duck and black tiger Shrimp with salt+turmeric, with salt and without any treatment.

In view of the overall finding of our thesis work we may draw a few conclusions as follows:

- * Processing and preservation methods are measures to minimize spoilage loss during post harvest period.
- * Sun drying and smoke curing are considered to be the oldest methods of processing and preservation of fish.
- * Solar Tunnel Drying of fish is an improved Technology for producing improved quality of dried and dehydrated fish products at the Laboratory level as well as at the commercial scale.
- * Treatment of the raw fishes with salt+turmeric, with salt and without any treatment produces dried and dehydrated fish products with better quality and longer shelf life.
- * Overall finding of the present thesis work may be helpful to people engaged at the industrial level to the students as well as the educated professionals in this sector.

CHAPTER- VI

SUMMARY & CONCLUSION

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- * Solar Tunnel Drying of fish is an improved Technology for producing improved quality of dried and dehydrated fish products at the Laboratory level as well as at the commercial scale.
- * Treatment of the raw fishes with salt+turmeric, with salt and without any treatment produces dried and dehydrated fish products with better quality and longer shelf life.
- * Overall finding of the present thesis work may be helpful to people engaged at the industrial level to the students as well as the educated professionals in this sector.

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