ENGINEERING INTERVENTIONS IN PRESERVATION OF FISH AND FISHERY PRODUCTS

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Fish and fisheries are an integral part of most societies and make important contributions to economic and social health and well-being in many countries and areas. The two major problems with respect to marketing and distribution of seafood's are their high perishability and poor hygienic quality (Olafsdottir *et al*., 1997). To overcome these problems various preservation methods are being practiced. The principle aim of fish preservation is to delay, reduce or inhibit the enzymatic, chemical and microbial spoilage. The engineering interventions in fisheries sector are evolving as an important domain in view of depleting stocks on both pre and post-harvest scenarios. It is important to explore novel ways to obtain, quantify, and integrate industry responses to declining fishing stocks and increasing management regulations into fishery- and ecosystem-based management advice. The engineering interventions help to reduce the wastage of fishes, which is otherwise a highly perishable commodity by preservation technologies and converting it into value added products with higher shelf life. Use of appropriate technologies along the fish value chain will help in producing better quality products and fetch more markets and higher price.

Major areas of engineering interventions in fisheries sector include design and development of fish processing equipment and machineries, energy efficient and eco-friendly solar fish dryers, indigenous electronic instruments for application in harvest and post-harvest technology of fish, *etc*. The major engineering interventions for fish post-harvest operations are given below:

1. Solar dryers: Out of total catch 30-40 % of fish is dried or processed for export and local consumption. Sun drying (open air drying) is the traditional method employed in most parts of the state to dry fishery products. It denotes the exposure of a commodity to direct solar radiation and the convective power of the natural wind. This form of energy is free, renewable and abundant in any part of the world especially in tropical countries. Also it offers a cheap method of drying but often results in inferior quality of product due to its dependence of weather conditions and vulnerability to the attack of dust, dirts, rains, insects, pests, and

microorganisms. Solar drying is an alternative which offers numerous advantages over the traditional method and environmentally friendly and economically viable in the developing countries. In solar drying, a structure, often of very simple construction, is used to enhance the effect of the solar radiation. Compared to the sun drying, solar dryers can generate higher air temperatures and consequential lower relative humidity, which are conducive to improved drying rates and lower final moisture content of the final products. However, there exist some problems associated with solar drying i.e. reliability of solar radiation during rainy period or cloudy days and its unavailability during night time. To overcome this limitation, an auxiliary heat source and forced convection system are recommended for assuring reliability and better control, respectively.

In a hybrid solar drying system, drying can be continued during off-sunshine hours by utilizing back up heat source and stored heat energy of daytime sunshine. In this way, drying becomes continuous process and the product is saved from possible deterioration by microbial infestation. These types of Hybrid solar dryers find useful applications in developing countries where the conventional energy sources are either scarce or expensive and the heat generating capacity of the solar system alone is not sufficient. Further, to assist the drying process (forced convection) in a hybrid dryer, a small blower is attached in between solar collector and drying chamber or inside the drying chamber which is powered by solar PV panels installed on drying chamber.

Design of solar dryer varies from simple direct dryers to more complex hybrid designs. Hybrid model solar dryers are having LPG, biogas, biomass or electricity as alternate back up heating source for continuous hygienic drying of fish even under unfavourable weather conditions. ICAR-CIFT design includes small capacity dryers like solar tent dryers, natural convection dryers *etc*. which will be useful to dry fish hygienically during sunny days. Solar tunnel dryers, solar fish dryers with alternate electrical back up and solar fish dryers with fire wood or biomass alternate back up heating system *etc*. can be efficiently used to dry fish using renewable solar energy which is abundantly and freely available.

2. Fish Descaling Machines

2.1 Fish descaling machine with variable drum speed

Fish de-scaling machine is designed and fabricated for removing the scales of fishes easily. This equipment can remove scales from almost all types/sizes/ species of fishes ranging from marine to freshwater species like Sardine, Tilapia to Rohu. The machine is made of SS

304 and has 10 kg capacity. It contains a 1.5 HP induction motor and a Variable Frequency Drive (VFD) to vary the speed of the drum depending on the variety of the fish loaded. The drum is made of perforated SS 304 sheet fitted in a strong SS Frame. Water inlet facility is provided in the drum for easy removal of the scales from the drum so that area of contact to the surface will be more for removal of scales. The water outlet is also provided to remove scales and water from the machine. An Electronic RPM meter was attached with the de-scaling machine which directly displays the RPM of the drum. Speed of the drum is a factor influencing the efficiency. The machine takes only 3-5 minutes to clean 10 kg fish depending on the size.

Fig.1 Fish de-scaling machine with variable drum speed

2.2 Fish de-scaling machine with fixed drum speed- table top

Fish de-scaling machine is designed and fabricated for removing the scales of fishes easily. This equipment can remove scales from almost all types/sizes/ species of fishes ranging from marine to freshwater species like Sardine, Tilapia to Rohu. This machine is made of SS 304 and has 5 kg capacity. It contains a 0.5 HP AC motor with proper belt reduction mechanism to achieve required drum speed of 20-30 rpm. Body is fabricated in dismantling type one-inch square SS tube with a suitable covering in the electrical parts. The drum is made of perforated SS sheet fitted in a strong SS Frame having suitable projections to remove the scale and provided with a leak proof door with suitable lock.

2.3 Fish de-scaling machine hand operated

Fish de-scaling machine is designed and fabricated for removing the scales of fishes easily. This equipment can remove scales from almost all types/sizes/ species of fishes ranging from

marine to freshwater species like Sardine, Tilapia to Rohu (Fig.2). This machine is made of SS 304 and has 5 kg capacity. Body is fabricated in dismantling type 1 inch square SS tube. The drum of 255.5 mm diameter and 270 mm length is made of perforated SS sheet fitted in a strong SS Frame having suitable projections to remove the scale and provided with a leak proof door with suitable lock. A pedal is fitted in the side to rotate the drum manually.

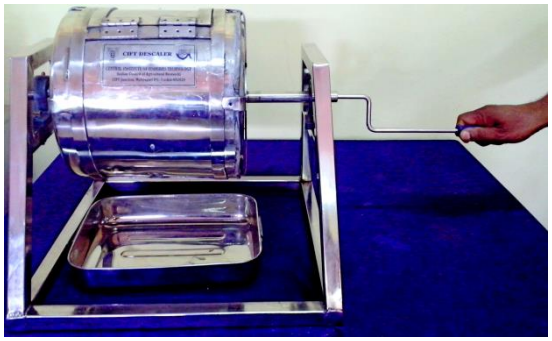

Fig.2 Fish de-scaling machine hand operated

4. Refrigeration enabled fish vending kiosk

Most of the fisher folk across India sell fish in an open basket without any hygienic practices. The fish is kept in an open bag or container, it loses its freshness. They use ice purchased at high cost for temporary preservation and at the end of the day, if the fish is not sold, they give it at a low rate to customers with little or no profit. More over fish gets contaminated under unhygienic handling practices. In this context, the ICAR-CIFT have designed and developed a refrigerated fish vending kiosk for selling fish in the closed chilled chamber under hygienic conditions.

The major advantages of the new Kiosk are as follows:

- The kiosk can carry 100kg fish with 20 kg under chilled storage display in glass chamber and remaining in insulated ice box (developed by CIFT).
- The main components of the kiosk are chilled glass chamber for fish storage and display, hand operated descaling machine and fish dressing deck with wash basin, water tank, cutting tool, waste collection chamber and working space.
- The vending unit has been fabricated mainly using stainless steel (SS 304 Food Grade) and frame and supports are made with MS and GI sheets.
- The kiosk main part *i.e* chilling unit and display for fish storage which is presently powered by AC current and envisaged to power by solar energy through solar PV cells.
- The stored fish is covered with transparent glass cover through which consumer can see the fishes and select according to their choice of purchase.

- Kiosk is attached with hand operated descaling machine for removal of scales. The fishes coming out of descaler is free of scales, dirt or slime.
- It also reduces human drudgery and avoids cross contamination, consumes lesser time. Fish dressing deck with wash basin also designed conveniently to prepare fresh clean fish under hygienic conditions.

Since this technology has well insulated storage space for fish with provisions for refrigeration, it reduces the ice melting rate and its cost, thereby reducing the selling price. The unit also extends the keeping quality of fish for 4- 5 days and increases marginal benefit to fish vendors. It also helps change the practice of unhygienic handling and marketing of fish.

4. Hot air-assisted continuous infrared dryer

Infrared drying is an advanced drying method which offers faster drying of agricultural products with minimum energy consumption and nutrient losses than the conventional dryers. IR has been applied in combination with other drying methods. IR and hot-air drying combination is an innovative method and offers many benefits over other traditional drying methods and also saves 20% of drying time as compared to IR drying alone. During combined IR and hot air drying, infrared radiation increases the rate of moisture movement towards the surface by rapid heating of food materials and convective hot air flow removes the moisture from the surface effectively thereby increasing mass transfer. Combined drying offers many advantages over conventional drying in terms of reduced drying time, reduced energy usage and improved product quality. Thus, a hot air-assisted continuous infrared dryer was fabricated which finds multitude of applications in processing of fish and fishery products.

The major components of the IR dryer comprised of belt conveyor, infrared radiation heating system, hot air generation and circulation, power transmission, feed hopper, discharge chute, and control panel.

Fig. 3 Hot air-assisted continuous infrared dryer

Shrimp and anchovy fish were dried using the hot air-assisted continuous IR dryer. The drying process was carried out with the IR intensity of 3,000 W/m^2, IR source to sample distance of 10 cm, drying temperature of 65^{0}C, and air velocity of 1.5 m/s. The total drying time of 3 and 2.5 h were recorded for shrimp and anchovy, respectively.

5. Fish freshness sensor

Fish tends to spoil after harvest due to microbial deterioration, and enzymatic and other autolytic chemical reactions. Therefore, safety and quality are the real concerns for consumers. The quality and freshness of fish are generally determined by a sensory assessment which mainly relies on the assessors. It is a highly subjective method, thereby arises a need for an objective instrumental system. Hence, it is necessary to find an alternative, instrumental method to provide an objective system to assess the freshness of fish. Moreover, any such objective instrumental technique should be reliable, rapid, non-destructive, and easy to use. The developed portable sensor can be used to evaluate and inspect the fish quality and freshness which is critical in the preparation of quality fish products. The color changes in fish eye (Indian Mackerel) due to deterioration during iced storage were measured in pixel counts and simultaneously correlated with the results of fish quality and freshness tests to find the threshold quality limits. Further, the pixel count ranges were provided as input to the sensor to categorize the fish samples into extremely fresh, fresh, and spoiled. The results of the validation study report that the sensor accurately predicts the freshness of fish.

6. Mobile alert system for dryer users

The mobile alert system works based on the principle of recording of weight loss of samples on a real-time basis using load sensors and sending the information of weight loss, moisture content, and extent of drying as a short message service (SMS) using the GSM

module. A microcontroller “ATmega328P” is coupled with an Arduino UNO board which offers a 16MHz clock cycle speed. The weight-loss and moisture percentage calculation algorithms were written and uploaded to the microcontroller using Arduino software integrated development environment. A GSM module “SIM800” with a valid SIM card is interfaced to the microcontroller through an analog-to-digital converter (HX711 IC) which can amplify the low voltage signals coming from the 1kg load cell. Weight loss and moisture percentage are frequently calculated by the algorithm and based on the moisture percentage set on the algorithm, the GSM module will receive signals from the microprocessor through the transmission and receiver pins. A unit consisting of a 1kg load cell is placed inside the dryer, upon which 100grams of the material is provided for continuous data acquisition, monitoring, calculating, and transferring information.

Conclusion

By effective use of efficient and appropriate engineering technologies which are cost-effective, adaptable and environment friendly, the fishermen community as well as seafood industry can reduce the harvest and post-harvest expenses and losses, add more value to the products, ensure better fish value chain dynamics and thereby obtain more income. The use of green and clean technologies also ensures less carbon and water foot prints.

Reference

Olafsdottir G, Martinsdottir E, Oehlenschlager J, et al. Methods to evaluate fish freshness in research and industry. Trends in Food Science & Technology. 1997;8:258–265.