



Research Paper

Development and Construction of Ice Box for the Preservation of Fish

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Abstract

This study developed a plywood ice box using locally available materials to help preserve fish and reduce post-harvest losses. The box was designed and constructed from plywood and insulated with expanded polystyrene foam, with a nylon lining to prevent contamination from the plywood and ensure proper hygiene. Tests were carried out at Usmanu Danfodiyo University, Department of Fisheries and Aquaculture, Teaching and Research Fish Farm using *Clarias gariepinus* (three fish species of 1kg) and a certain amount of ice (2kg). Results showed that the ice lasted about 30 hours, with a progressive decrease of the mass of ice from 2000g to 100g, showing a total melt of 95%, keeping the internal temperature between 4°C and 19°C and external temperatures ranged from 20°C to 31°C minimum and maximum respectively. The design proved effective for short-term preservation, maintaining fish freshness and quality. However, it is recommended that future designs include a drain and improved sealing to enhance performance. Overall, the wooden ice box offers a simple, affordable and sustainable solution for small-scale fishers.

1. Introduction

An ice box is a simple cold-storage system that holds ice and fish together. On fishing vessels and landing sites, insulated boxes significantly reduce spoilage. Fish is a vital source of animal protein worldwide, accounting for roughly 18% of global animal protein intake, and demand for fish is expected to rise by about 30% by 2030 due to population growth (world Bank, 2020). However, fish is a highly perishable but valued food source that requires proper handling and preservation after harvest to increase its shelf life, retain its fresh quality, flavour and nutritional attributes (Ishola et al., 2015). Without adequate cold-chain infrastructures, large quantities of fresh fish rot before reaching consumers. For example, it is estimated that about 30–50% of freshly harvested fish in Nigeria are wasted due to poor handling and preservation (Olowoniyi et al., 1998). Reports from international trade statistics indicated that the importation of frozen fish, excluding fish pellets, gulped about \$876 million in 2020, \$703 million in 2021, \$680 million in 2022, and \$606 million in 2023 (Guardian, 2025). Studies estimate global post-harvest fish losses at about 10–12 million tonnes annually (Maulu et al., 2020), reducing both food supply and Fisher's income.

Chilling with ice or refrigerated cooling is among the most effective means of preserving freshness. In 2018, live fresh or chilled fish still represented the largest share of fish utilized for direct human consumption (44 percent), and was often the most preferred and highly priced form of fish. Refrigeration and freezing have the least impact on the nutritional attributes of fish (FAO, 2020). Worldwide, traditional methods such as smoking, sun-drying, salting and fermentation have long been used to preserve fish. For example, in many small-scale fisheries smoking and drying remain dominant practices (Maulu et al., 2020). However, these methods are weather-dependent, limiting consistency. Modern method such as chilling and freezing, preserve fresh fish characteristics. FAO (2020), emphasises that Proper handling, hygiene and respect of the cold chain are crucial to preventing loss and waste and preserving quality. It is estimated that 35 percent of the global harvest is either lost or wasted every year. In short, preservation methods range from traditional (smoking, drying, salting) to modern (icing, refrigeration, freezing) with ice-based cooling offering an effective balance of cost and quality retention for fresh fish. In tropical regions especially, cooling is critical to maintain fish quality and reduce spoilage losses (Ikape and Cheikyula, 2017).

Globally, iceboxes are made from various materials (wood, plastic, aluminum) often with vacuum or foam insulation. Modern iceboxes may incorporate mechanical cooling or phase-change packs, but in many rural areas simple insulated boxes prevail. In practice, coolers or boxes used for fish may be lined with plastic or plywood and fitted with tight lids to slow ice melt. Insulated boxes are made of an insulating material packed between two layers of durable, waterproof, non-absorbent plastics. A good insulator will maintain the inner temperature of the insulated box for a long time (Atanda et al., 2022). In short, they serve as a basic cold chain unit, bridging the catch at sea or lake to market or processing point, promoted and adopted to reduce spoilage and post-harvest losses.

Traditional wooden ice boxes typically consist of an inner wall surrounded by an insulating layer (sometimes air gap, sawdust or plant fibers), then an outer wooden shell. Globally, designs also use local woods (e.g. teak, mahogany, pine) and simple insulations (gunny sack, rice husk, straw) (Nowsad et al., 2008). However, untreated wood can harbour bacteria and is heavier than plastic. Nigerian government tackle this challenge by promoting technologies to reduce losses and extend the shelf life of fish. For instance, Nigerian Stored Products Research Institute (NSPRI) developed a technology for transportation, storage and distribution of fresh fish in 2014. It was a portable, semi-air-tight lagged-coolant system with an effective cooling capacity due to uniform coldness distribution within the box (Atanda et al., 2022). A wooden fish ice box built from locally available materials could provide an affordable way to preserve fish freshness and reduce spoilage. The overall objective of the study is to develop and construct an ice box for the preservation of fish.

2. Materials and Methods

2.1 Study Area

The study was conducted in the teaching and research fish farm with coordinate 'latitude 13.06740N, longitude 5.32590E', Department of Fisheries and Aquaculture, Usmanu Danfodiyo University Sokoto. Sokoto State is located in the Sudan savanna in the extreme northwest part of Nigeria between longitude 408'E and 605'E and latitude 11030'N and 13052'N.

2.2 Sample collection

The fish sample (*Clarias gariepinus*) was collected from the teaching and research fish farm of the department of Fisheries and Aquaculture, Usmanu Danfodiyo University Sokoto. The ice was sourced from Sokoto metropolis and transported down to the experimental site.

2.3 Procedures of construction of an ice box

The Plywood panels were measured and cut to the required dimensions (approx. 50cm × 30cm × 30cm internal walls and external dimension: 60cm × 40cm × 35cm). The panels were joined together using nails and adhesive to form the inner and the outer frames. A 5

cm thick expanded polystyrene sheet was fitted between the plywood walls. Rope handles were attached securely to the sides of the box for easy handling. Nylon sheet was used to cover the interior surface, ensuring water resistance, easy cleaning and hygiene. Joints were sealed to reduce gaps that could allow heat transfer.

2.4 Procurement of experimental tools

The experimental tools and equipment were sourced from Kara market, kasuwarkatako, Sokoto.

2.5 Materials and tools used in the construction of the ice box

- Wood plank
- Plywood
- Nails
- Rope
- Gum/Glue
- Hammer
- Measuring tape
- Expanded polystyrene foam
- Saw
- Brush
- Polyethylene

2.6 Experimental designed

Prior to testing, the ice box was taken to the experimental area some days before the commencement of the test. 2000g of ice block were weighed and put into the prepared ice box. Temperature was measured with a mercury thermometer. The initial temperature of the ice box and the ambient temperature were immediately taken. Subsequently, readings and observations (temperature readings and weight of ice) were made at an interval of two hours until the ice melted. Certain quantity of fish were obtained (1000g), thoroughly washed with clean water and without the removal of their heads. The fish and the ice were placed in the box at a specific ratio (1:2). Rigor mortis was observed during the storage period.

2.7 Statistical Analysis

The data collected from the experiments were subjected to descriptive statistics and Analysis of Variance (ANOVA) using SPSS 18.0 software. The follow up test was conducted to know the difference between the means using the Duncan Multiple Range Test (DMRT) at 5% Probability levels.

3. Result

3.1 Temperature retention

The maintenance of low internal temperature (4-110C) indicates slow heat penetration, demonstrating strong insulation effect. Such temperature would effectively maintain firmness, reduces Microbial activities, reduce lipid oxidation and rancidity and inhibit autolytic enzymes breakdown. The temperature Falls within a range considered safe for slowing microbial growth and postmortem deterioration. From the result, the ice lasted for approximately 30hours. Which compare

reasonably with similar designs.

Table 1: Mean Temperature inside and outside the storage ice Box

No. of days	Time	T ^o Coutside box (Mean ± SE)	T ^o C inside box(Mean ± SE)
Day 1	12:00pm	29.00±0.58 ^a	18.00±0.58 ^b
	2:00pm	30.00±0.58 ^a	11.00±0.58 ^b
	4:00pm	28.00±0.58 ^a	9.00±0.58 ^b
	6:00pm	28.67±0.33 ^a	8.00±0.58 ^b
Day 2	8:00am	21.00±0.58 ^a	4.00±0.00 ^b
	10:00am	22.00±0.58 ^a	4.33±0.33 ^b
	12:00pm	30.00±0.58 ^a	10.33±0.33 ^b
	2:00pm	29.00±0.58 ^a	10.33±0.33 ^b
	4:00pm	30.00±0.58 ^a	11.00±0.58 ^b
	6:00pm	28.00±0.00 ^a	10.42±0.00 ^b

Table 2: Mean mass of ice in the storage ice box

No. of days	Time	Mass of ice (Mean ± SE)
Day 1	12:00pm	2000.00±0.00 ^a
	2:00pm	1890.00±5.77 ^b
	4:00pm	1770.00±5.77 ^c
	6:00pm	1650.00±5.77 ^d
Day 2	8:00am	686.67±8.82 ^e
	10:00am	570.00±5.77 ^f
	12:00pm	450±0.58 ^g
	2:00pm	300±11.55 ^h
	4:00pm	170±11.55 ⁱ
	6:00pm	100±11.55 ^j

Means in columns having same letters were not significantly different ($P > 0.05$)

Figure 1: Mean temperature variations of the ice box (Tb °C) inside and environment (Ta °C) outside.

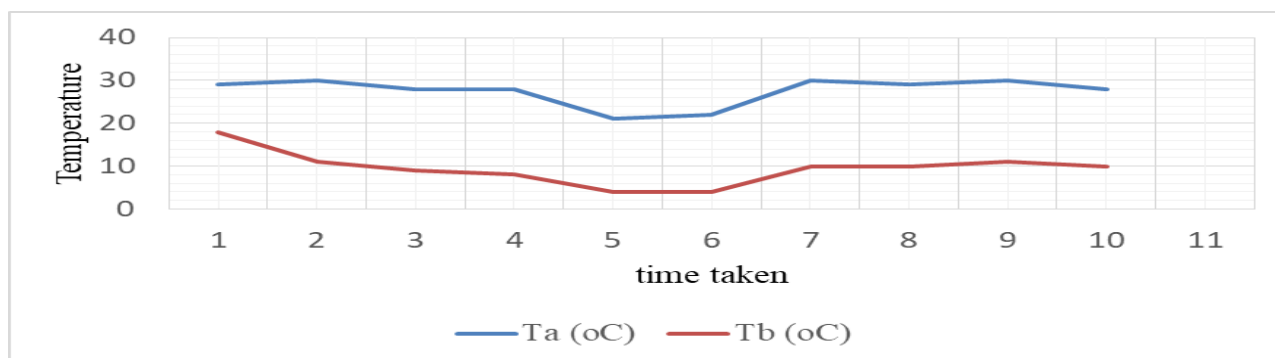
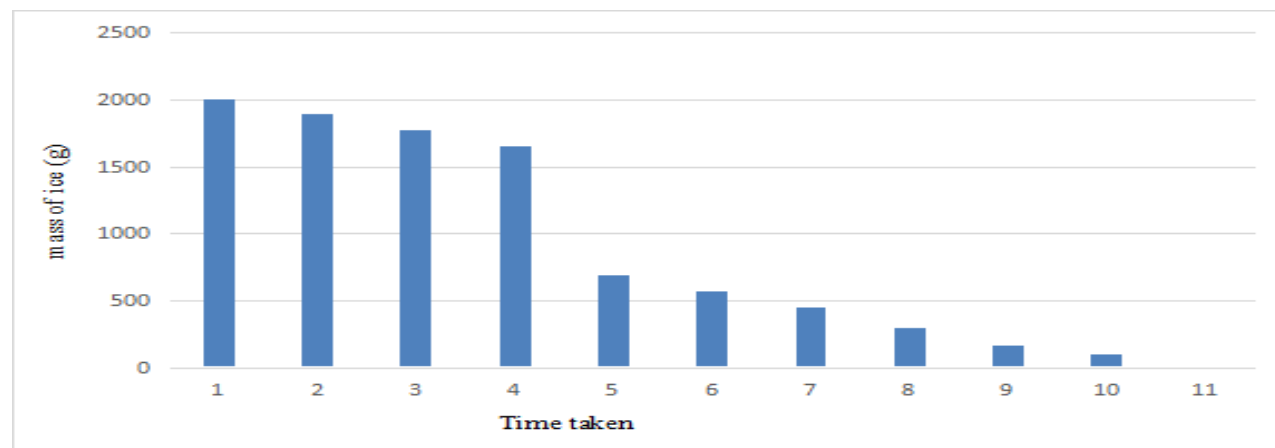


Figure 2: Mean mass of ice



3.2 Ice retention

From fig. 2, the result showed a progressive decrease of the mass of ice from 2000g to 100g showing a total melt of 95%. The internal temperature remained significantly lower than the ambient temperature. This means that the design greatly reduced heat transfer into the box.

3.3 The physical condition of the ice Box

All materials were sourced locally. Expanded polystyrene of 5cm thick was used between the walls. The construction does not require highly skilled labor or expensive machinery as simple tools were employed to achieve the desired goal. The plywood provided the structural strength, rigidity and lightweight making it suitable for field and repeated usage. The polyethylene sheets serves as waterproof and enhance the hygienic condition of the box. The ropes attached to either sides of the box, enable easy lifting and transportation.

4. Discussions

Ishola et al. (2015), found that 20 kg of ice in NSPRI's fish box melted in about 33 hours under lab conditions. This suggests that the ice box can preserve fish for a short time. Traditional methods used by many small scale fishers include; exposing fish on open boat, storing fish in an un-insulated containers with poorly applied ice. These leads to rapid temperature rise, leading to spoilage rate that exceeds 20-30%.

The temperature inside the ice box was a function of the surrounding temperature as observed in fig. 1. But because there was no drain hole, melted water remained in contact with the fish keeping the fish at temperature of 00C. Melted water was poured out at regular intervals by tilting the ice box. Scott Thomas (2017) advises that removing melted water extends retention time. Nowsad et al. (2008) observed that melted water retained for a prolonged period might cause the fish to lose color and wholesomeness. Rigor was observed to set in within 2 hours after storage and increased gradually. Although, the fish were still in rigor throughout the experiment without any signs of spoilage, it was observed that dissolution of rigor began with slight flexing of the caudal region. The result support the adoption of low-cost technologies, with potential to reduce post-harvest losses improve livelihood and strengthen food security.

Expanded polystyrene is widely reported to be an effective thermal insulator due to its superior insulation properties (Singh, 2018) and high resistance to moisture.its use in icebox likely reduced heat penetration.

5. Conclusion

This study showed that a simple ice box made from local materials can help small-scale fishers keep their catch fresh for longer. The box maintained low temperatures between 4 °C and 19 °C, with the ice lasting for approximately 30 hours. This proves that with basic materials like plywood and polystyrene foam, it is possible to build an affordable and reliable cooling

system for fish preservation. Although, the box performed well, adding a drain plug and improving the lid seal could make the design even more effective. The project demonstrates that locally made ice boxes can reduce post-harvest fish losses, improve income for fishers and strengthen food security. With small modifications, this can become a sustainable and practical solution for fishing communities and industries.

6. Statement of Declarations

Ethical Approval: Not applicable.

Conflict of Interest: The authors in this article declare that they have no known competing financial interests or personal relationship that could have appeared to influence the work reported in this article.

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