ASSESSMENT OF A CHARCOAL-POWERED CABINET DRYER FOR DRYING CATFISH (*Clarias gariepinus*)

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ABSTRACT

The goal of this study was to assess performance of a charcoal-powered cabinet tray dryer in order to determine its suitability in drying catfish by enhancing the quality of the fish and increase economic returns to the fish farmer. The study evaluated desirability of the cabinet tray dryer for improving fish drying processes to prevent post-harvest losses and enhance the status of the fish famers. The dryer consists of 8 trays, heating chamber, tray chamber, a charcoal pot, a gas burner and a chimney at the top from where the hot air exits. Sixty (60) pieces of catfish were obtained from the Landmark University fish farm and were folded by clipping the tail to the tip of the head. The fish was dried for 12 hours in the charcoal powered dryer. Moisture content reduction was monitored by observing temperature falls. Thermometer readings were taken at 30 minutes intervals until the fishes were properly dried. Results showed that the fish attained equilibrium moisture content (27 – 8%) at 18 h of drying and a plenum temperature within the range of 130 – 142^{o}C attaining the sensory properties (colour, taste, aroma and firmness) desired by consumers.

Keywords: Assessment, dryer, drying characteristics, fish processing
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INTRODUCTION

Drying is a bio processing method in which water content of a biological material is reduced to a safe moisture content for storage in order to prevent growth of microorganisms thereby prolong the shelf life of the product and make it suitable for human use. Many researchers have worked on different types of dryers: Ikejiofor and Okonkwo [1], Ilechie *et al.* [2] designed an active solar dryer and a multipurpose dryer for drying various types of agricultural products. Olaniayan and Alabi [3] fabricated aprototype column dryer for paddy rice. Michael [4] developed a motorized fish smoking kiln. Nagori *et al.* [5] developed a solar dryer with electrical energy backup while Fasludeen *et al.* [6] reported evaluation results of drying characteristics of selected fishes in dryers developed by ICAR-CIFT. Post-harvest processing and storage of fish has always posed a challenge. Sun drying is an age-long traditional method of fish drying employed by the local fishermen, processors and marketers. However, sun drying method is a slow process, Okoroigwe *et al.* [7]. Fish dried in the open sun is exposed to many contaminants. It is unhygienic and the process may not be thorough as the fish may be under-dried or over-dried.

Fish plays a very important role in human nutrition in developing nations. It is a ready and cheaper source of protein accounting for about 30% of animal protein intake in West Africa [8]. Production output of catfish (*Clarias gariepinus*) in Nigeria is about 270,000 metric tons/year [9]. Catfish is the major fish cultured in Nigeria because of its resistant to harsh environmental conditions [9]. Demand for fish globally and particularly in Nigeria has been on the increase with supplies not meeting up the demand [10]. Globally, about 130 million tons of fish is produced, but a larger percentage of the production is lost during post harvesting and handling [11]. However, fish has high tendency for deterioration due to the activities of bacteria, bruises and chemical reactions. Handling and preservation methods determine the rate of deterioration of the fish [12]. Refrigeration is the best method of preserving fish. However, the erratic supply of electricity in Nigeria pose a major challenge for refrigeration; thus necessitating use of other forms of preservation such as smoking and sun-drying. Charcoal, being a low rank fuel, besides being available and cheap, has several advantages of high heat rate, longer burning rate, low density, low mechanical strength and high moisture absorption rate The objective of this study was to assess and evaluate a charcoal-powered cabinet tray dryer in drying and processing catfish in order to enhance the quality of the fish and increase economic returns to the fish farmer.

MATERIALS AND METHODS

A cabinet tray dryer (Figure 1) powered by charcoal was used for this experiment. It consists of eight trays, heating chamber, tray chamber, a charcoal pot, a gas burner anda chimney at the top from where the hot air exits. The dryer is rectangular in shape and the dimensions are: breath –270 mm, width – 1950 mm, height – 1770 mm and a clearance of 250 mm from the ground. Its internal and external walls were made of galvanized steel of 1mm and mild-steel of 2mm thickness respectively. It was lagged with polyurethane of 40 mm thickness.

Experiment parameters and procedure

Assessment of the charcoal-powered dryer for drying of catfish was carried out at Landmark University Commercial Farms. Sixty (60) pieces of catfish were obtained from the University fish farm. Each fish of the selected sample was folded by clipping the tail to the tip of the head. It was then properly washed and weighed. The fish was then loaded inside the dryer. Eighteen holes were bored on the dryer frame where wet bulb and dry bulb thermometers were inserted to obtain wet bulb and dry bulb temperatures. The fish were dried for 12 h from the heat generated by the burning charcoal. Thermometer readings were taken at 30 minutes intervals until the fishes were properly dried.

RESULTS AND DISCUSSION

Temperature distribution across the dryer

Figure 2 shows the temperature profile in the dryer compartments/trays. The highest dry bulb temperature was recorded at the plenum and the value decreased subsequently as the heated air made its way from tray 1 to tray 7 at the top. The dry bulb temperatures were 135ºC at the plenum, 132ºC at tray 1, 102ºC at tray 2, 112ºC at tray 3, 105ºC at tray 4 till and 62ºC at tray 7. The reduction in temperature across the drying trays as the heated air moves upwards from the plenum to the tray-7 was also noticed after the fish was dried for 18h at 3 h intervals. This is in agreement with the findings of other Authors [1, 2, 4]

Temperature profile and appropriate fish drying duration

It was confirmed by sensory evaluation that after 18 h, the fish had properly dried and attained the sensory properties (colour, taste, aroma and firmness) desired by consumers. This duration had a relationship with the dry bulb temperature profile (Figure 3). It could be seen from the graphs that at the 16th hour the dry bulb temperature profile from tray-1 through tray-6 fall within the interval same range (87 – 78ºC). The same dry bulb temperature distribution was deduced after 18 hours of drying (95 – 85ºC). It could possiblybe that at 18 hours into drying, the fish had attained equilibrium moisture content (a balance between the moisture in the fish and moisture in the drying air). At this point drying is said to have stopped.

Moisture profile across the dryer

Figure 4 shows the moisture profile across the dryer trays. For each of the drying period (2nd to 18th hour), the lowest relative humidity was recorded at the plenum and the highest at the 7th tray. This was because as the air comes into the drier, it was heated up by the hot charcoal thereby drying up the air and increasing its affinity for water which is shown by a reduction in relative humidity of the drying air. As the air moves across trays laden with fish, it picks up moisture from fish, which in turn reduces the temperature of the fish and thus increases its (air) water content, depicted as relative humidity.Figure 4 also showsthat the highest relative humidity attained throughout the drying process was 56% at tray-7 after 4h of drying. This means that the air would not become saturated during the drying process and as such eliminating the fear of condensation and rewetting of fish below the point where saturation occurred as earlier noted by [1] and [4]

Temperature and fish weight distribution

The study further shows that when the mass of fish on an upper tray was more than the mass of fish on the tray directly below it, there was an increase in the relative humidity of the heated air as shown in Figure 4. From the figure, the initial mass of fish on trays 1 and 2 are 6.90 kg and 7.2 kg respectively, while their relative humidity after 2 h increased from 5% at tray 1 to 14% at tray 2. However, the dry bulb temperatures reduced from 132ºC at tray1 to 102ºC at tray 2. The same reduction in dry bulb temperatures (from 112 to 105ºC) was notice for trays 3 and 4 containing 7.0 kg and 7.25 kg of fish respectively. This reduction could be as a result of increased moisture loss (from the tray with heavier fish), resulting in a cooling effect on the drying air. An increase in dry bulb temperature resulted when the mass of fish on a lower tray was more than that on the tray directly above it.

The same trend (from 8 to 27 %) was noticed for trays 5 and 6 containing an initial mass of 7kg and 7.6 kg of fish respectively. This increases in relative humidity was as a result of increased moisture gain (from the tray with heavier fish), resulting in a cooling effect on the heated air. A decrease in relative humidity resulted when the mass of fish on a lower tray was more than that on the tray directly above it. This could be seen on Figure 4 for trays 4 and 5 after 4 h of drying. Figures 5 – 13 shows the temperature and moisture profiles from the beginning to the end of the fish drying process.

CONCLUSION

A charcoal-powered cabinet tray dryer was evaluated at the Commercial Farm of Landmark University, Omu Aran. It was observed that the fish attained equilibrium moisture content (27 – 8%) at 18h of drying. The dry bulb temperatures were 135ºC at the plenum, 132ºC at tray 1, 102ºC at tray 2, 112ºC at tray 3, 105ºC at tray 4 till and 62ºC at tray 7. The reduction in temperature across the drying trays as the heated air moves upwards from the plenum to the tray 7 was also noticed. The dryer developed proved to have the capacity of improving fish drying processes, prevent post-harvest losses, and enhance status of the fish famers.Concerns of public health and sanitation associated by traditional fish drying method due to contamination by bacteria and pathogens during scaling, gutting, dressing and cutting due to usage of unclean knives, containers or tools are minimized with this technology.

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Figure 1: Cabinet dryer

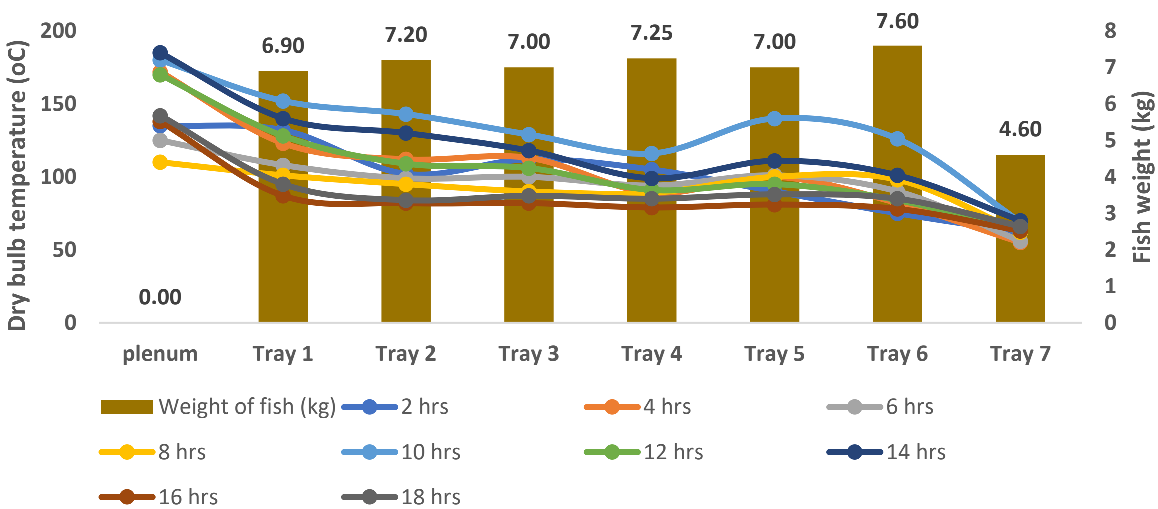

Figure 2: Temperature profile across the drying trays

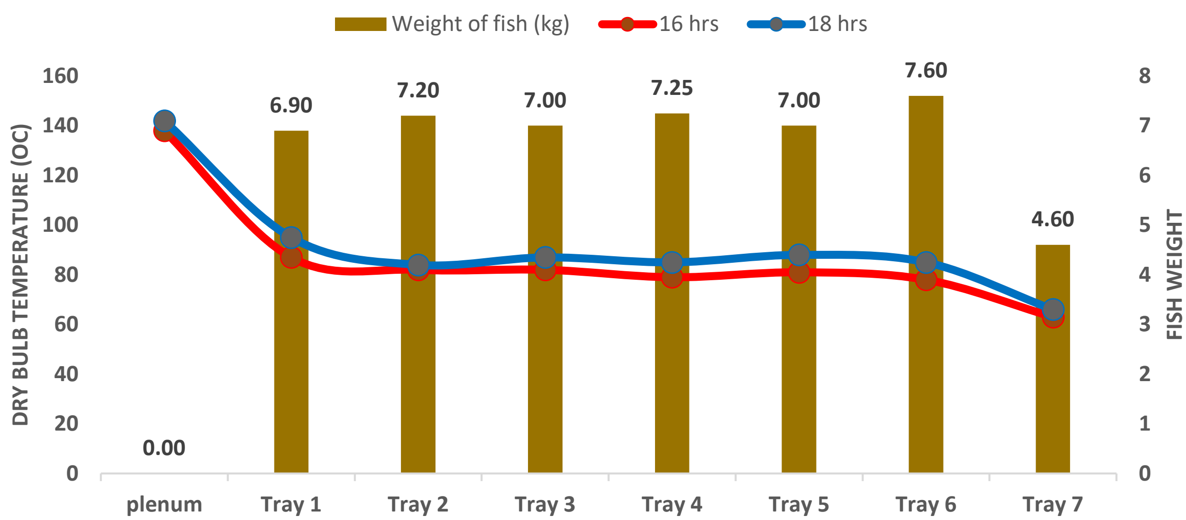

Figure 3: Temperature profile after 16 and 18 h of drying

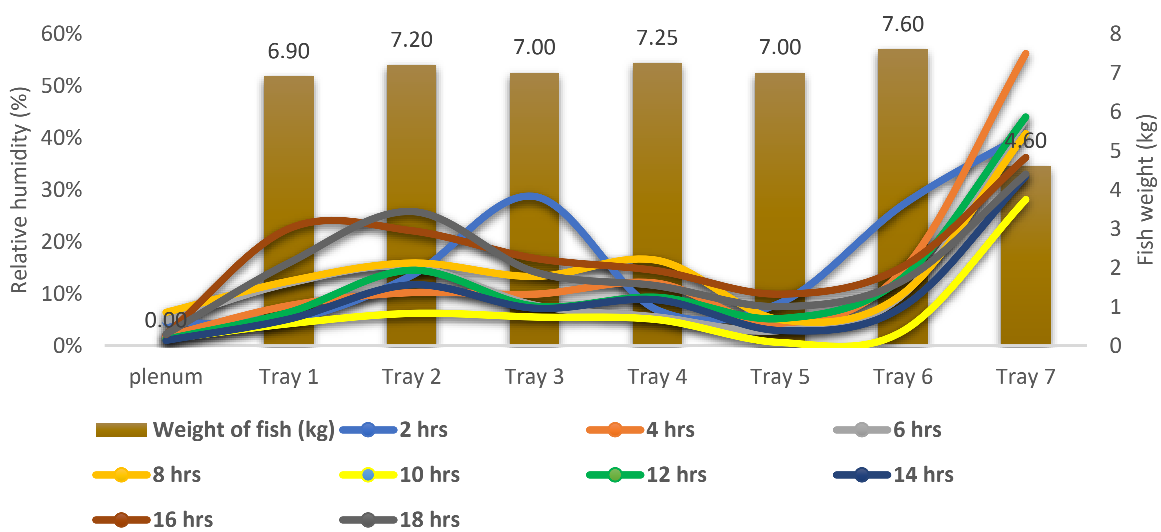

Figure 4: Moisture Profile across the drying trays

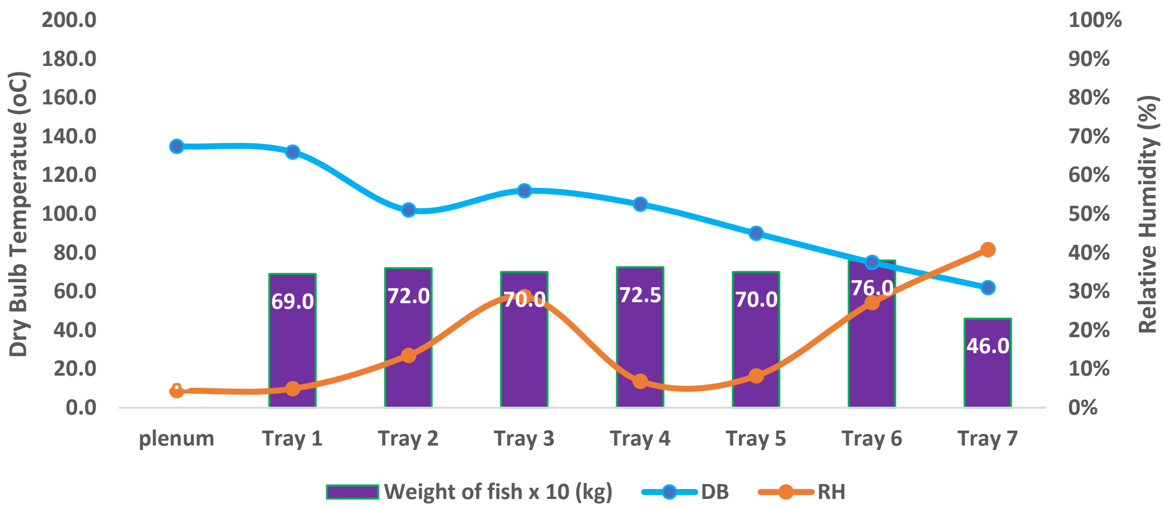

Figure 5: Temperature and moisture profile after 2 hours

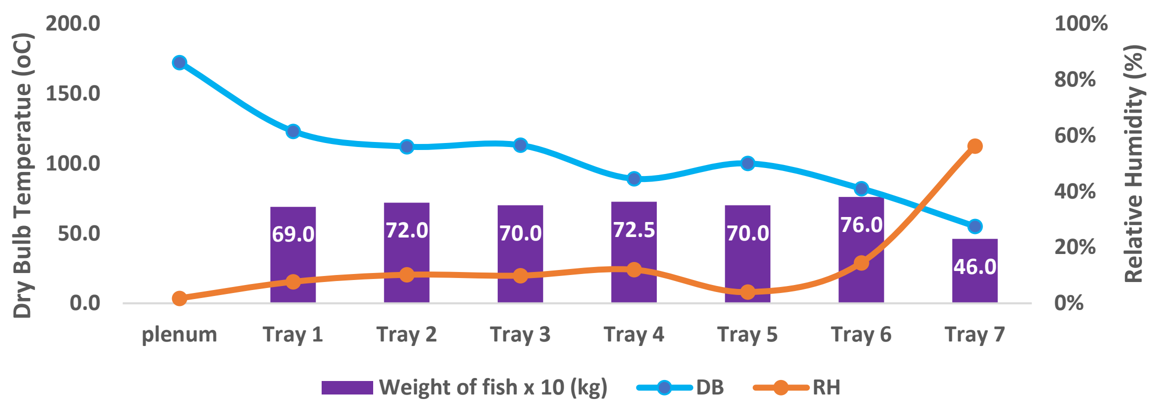

Figure 6: Temperature and moisture profile after 4 hours

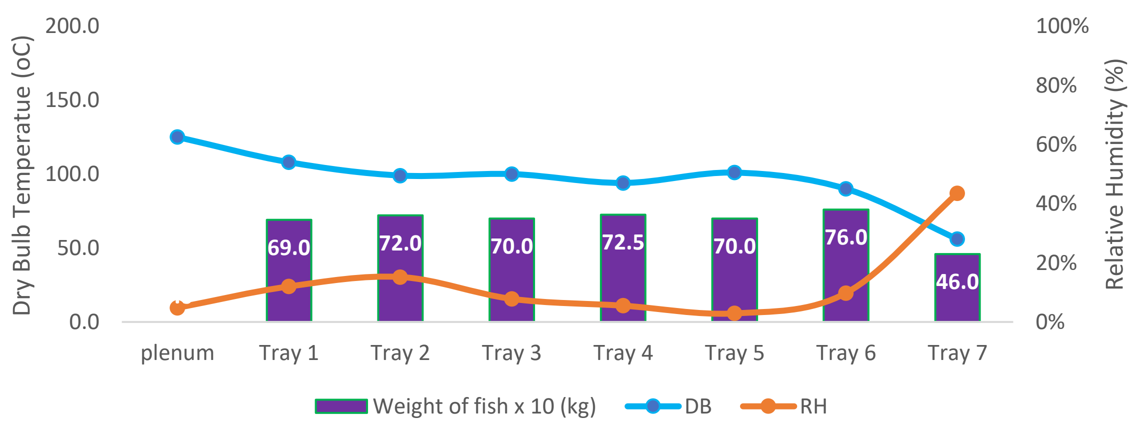

Figure 7: Temperature and moisture profile after 6 hours

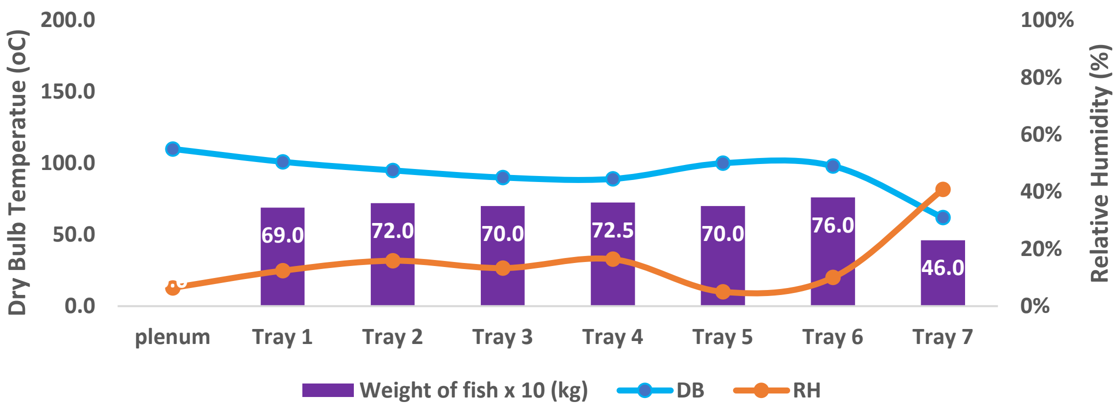

Figure 8: Temperature and moisture profile after 8 hours

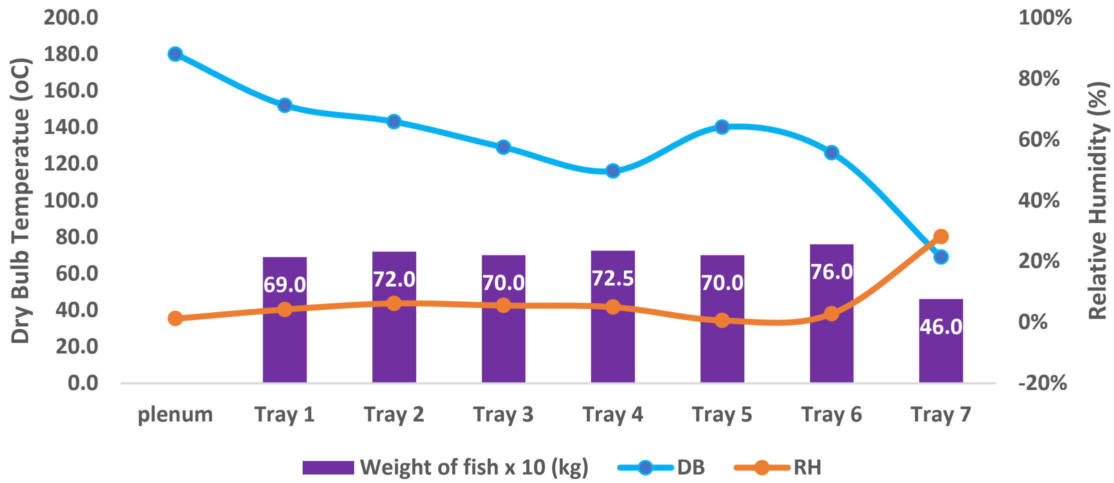

Figure 9: Temperature and moisture profile after 10 hours

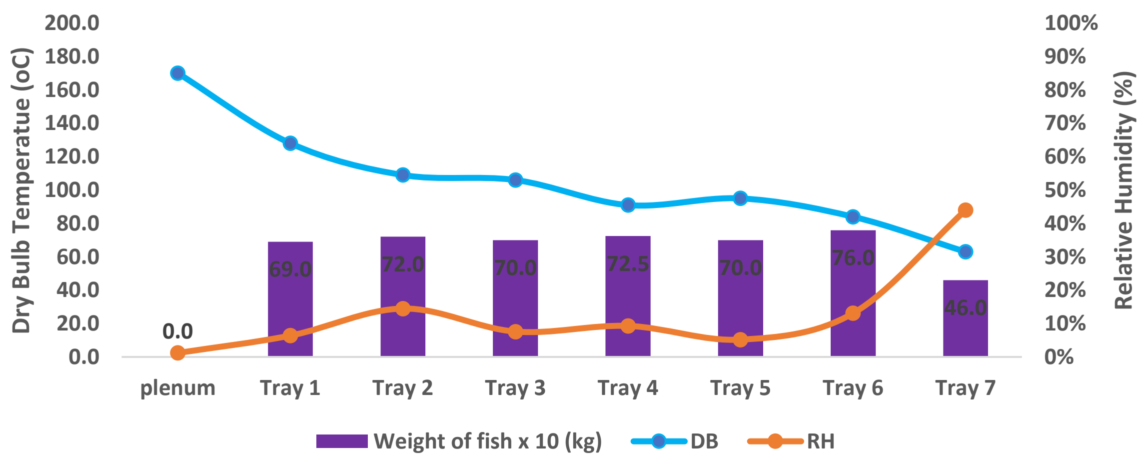

Figure 10: Temperature and moisture profile after 12 hours

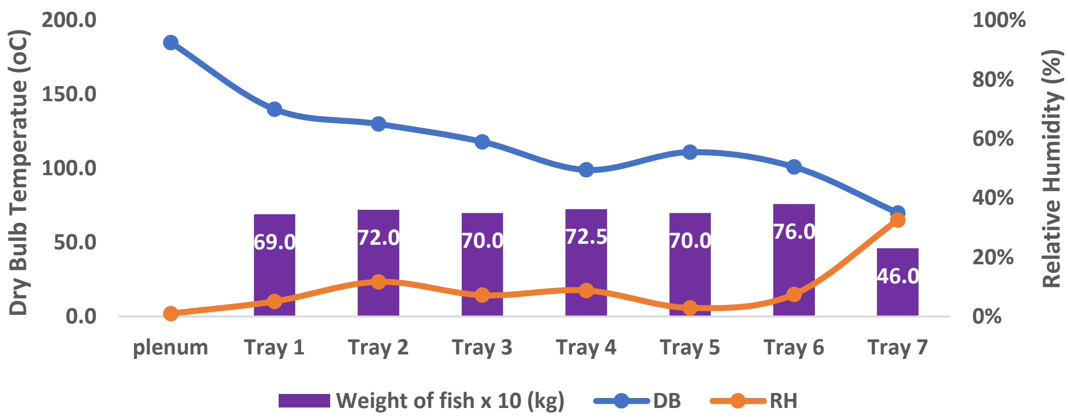

Figure 11: Temperature and moisture profile after 14 hours

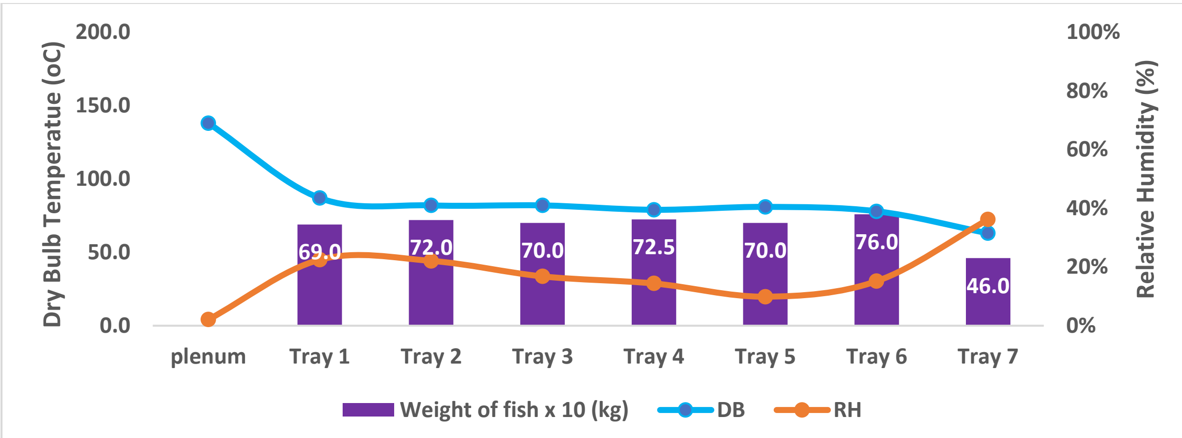

Figure 12: Temperature and moisture profile after 16hrs

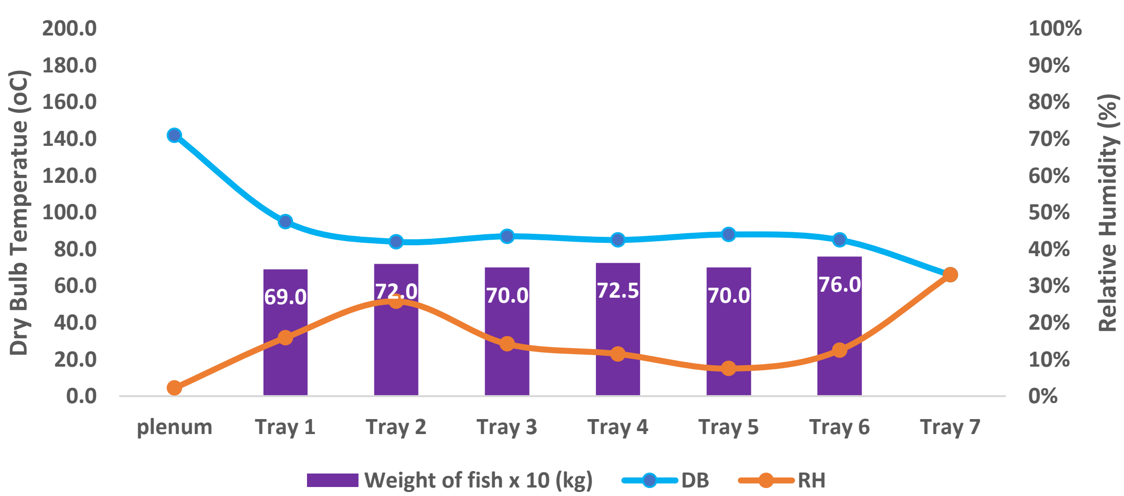

Figure 13: Temperature and moisture profile after 18 hours