Thermal Investigation of an Economical Cold Storage with Superlon Insulation for Fishing Boat

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Abstract: The purpose of this study is to create alternative economic storage which advantages on extending the durability and the ability for cold storage. The alternative storage had used the Styrofoam box by 3 insulations models: superlon, without superlon, and sawdust. The investigation carried out on the measurement of inside temperature of the box and the wall for 3 days per one hour. The measurement tool used type K thermocouple with error limit: +/- 1.1 degrees Celsius or 0.4%, with statistical data processing. Styrofoam box with superlon insulation has the ability of ice to survive until melted for 96 hours, without superlon only lasts for 12-13 hours while with sawdust insulation could last for 60 hours.

1 INTRODUCTION

The boat without equipped proper fish storage that will be suffered damage 20-30% before getting to the dock. It is essential to know that keeping the storage at temperatures below 10°C which the decomposition activity both of chemical and enzymatic dropped, accordingly inhibit the growth of microbes (Buckle, 1978). This study provided the alternative cold storage by using Styrofoam box and superlon sheet with insulated container system for small fishing boat 6-23 GT with economical prices and affordable for small fishing communities. Styrofoam box had selected due to its properties: the non-heat conductive, lightweight, easy to obtain and a product that can be used repeatedly. While superlon had advantages: flexible and lightweight, Nitrile elastomer foam for thermal insulation, also had a low thermal conductivity with highly efficient and effective in insulating cooling systems.

The research on an alternative to fresh fish storage could be found in Bonan (2016) by Styrofoam with 'ela sago' lamination. It founded that the decreasing rate of temperature of fish in the cold box with Styrofoam isolation without 'ela sago' of 0.13°C/min and could maintain the fish temperature at 3.6°C until 180 minutes. While the decreasing rate of the cold box with 'ela sago' isolation of 0.045°C/min. Another researcher on cold storage for fish in a dried system was by Suryaningrum et al (2001) using materials: sawdust, newsprint, wood shavings, burlap, and sand. The temperatures of storage could be last up to 14-15°C on 9 hours for shrimp and 25-40 hours for lobster.

The purpose of this study is to create an alternative cold storage which good on long-lasting storage capabilities and economic. By using the Styrofoam box as a container with insulation that it substitutes for cold storage on the small fishing boats. It had affordable both of materials and prices, so it enabled for small fisherman communities to make their own. Therefore, with this cold storage, the fish freshness estimation could be extended until to the consumer and of course the price will be more expensive.

2 TEST METHOD

The experiment was using a Styrofoam box with three different treatments. The first was a Styrofoam box without insulation that commonly used by fishermen. Secondly, a Styrofoam box laminated by a superlon sheet with adhesive a duct tip. And lastly, a Styrofoam box with isolation sawdust. The experiments were conducted to find out the temperature of the three Styrofoam box on inside and its wall for every 15 minutes for 10 hours.

Table 1: Characteristics physical of superlon (source: Asiatic Refrigeration Pte Ltd).

Average Physical Properties	Rating	Test Method
Density (kg/m³)	70-90	ASTM D 1667
Thermal Conductivity Mean Temp. @ 1 0°C	0.28 Btu.in/hr.ft².F 0.04 W/m°C (0.0346 Kcal/mh°C)	ASTMC 518
Temperature Limits °C	-40°C to + 1 05°C	-
Thermal Stability (% shrinkage) 7 days - 200°F 7 days - 220°F	4.5 5.5	ASTM C 534 ASTM C 534
Fire Resistance	Class 0 Class 1 Self Extinguishing V-O, 5VA	BS 476 Part 6 BS 476 Part 7 ASTM D-635 UL94 / JIS K6911
Toxicity	4.9	NES 713
Water Absorption	4.37	ASTM C 272 / ASTM 1056
Water Vapour Permeability Perm - In. Max g/Pa.s.m.²	0.29 ug.m/N.h 8.17×10^{14}	ASTM E 96
Ozone Resistance	Excellent	ASTM D 1171 / JIS K6301

The equipment and materials of the experiments used, i.e., type K thermocouple with error limits: +/- 1.1C or 0.4%, Styrofoam box, superlon sheet, duct tip, and ice block. The first step of the experiment was checking on the accuracy of the tool of calibration as a verification process of measuring instruments. Secondly, checking in the box was entirely tightly closed was no air coming out and vice versa. The value had taken from its average result of 5 times measurements.

The Styrofoam box had a dimension of 52 cm in length, 37 cm in width, 32 cm in height, and the superlon sheet with a thickness of 2 cm which the characteristics described in Table 1.

The amount of ice or the ratio between the amount of both ice and fish is the factor that determines the temperature in the box and concerns the temperature of the fish to be achieved. Based on the Indonesian regulations from the Directorate General of Quality of the Ministry of Marine Affairs and Fisheries regarding the standard of handling of fresh sea fish on board that the ratio of the amount of fish and ice for hatch with wood coating and without insulation layer is 1: 1.5 (1 kg of ice used to 1.5 kg of fish). And the placement of ice in the box by arranging fish and ice alternately, where ice on the bottom layer and the top.

3 RESULTS AND DISCUSSION

The economical heat insulation material is the optimum density variation of material at minimum thermal conductivity (Stephenson, 2012). The Ministry of Agriculture of Indonesia (1981) had

indicated the cooling temperature significantly effects on durability and shelf life of fish as listed in Table 2. An alternative cold storage in this study expected as a solution for the durability and shelf life of fish with accessible materials, practical, affordable price and long-lasting storage.

The Styrofoam box without superlon at the initial 30 minutes showed inside temperature of the box 9.2°C and wall of 22.2°C. After 2 hours, inside temperature tends to rise slowly with changes only occur in the number behind the comma. By day-2, inside temperature of the box reached about 10.7°C for the initial, while the wall 21.8°C. Up to 12 hours passed inside temperature tends to rise slowly. By day-3, inside temperature of the box reached about 11.8°C for the initial, while the wall 21.8oC. At the end of measurement after 12 hours, inside temperature reached about 12.7°C with some ice had melted, and the wall reached 23.5°C. The measurement results every one hour in 3 days expressed in the graph shown in Figure 1.

Table 2: Endurance of fish in storage.

Degree	Feasibility of consumption
16 ºC	1 -2 days
11 ºC	3 days
5 ºC	5 days
0 ºC	14 - 15 days

The Styrofoam box with superlon on day-1 at the initial 30 minutes showed inside temperature of the box of 5.0°C, and the wall of 23.0°C. Until 12 hours passed, inside temperature still in 5.0°C, but the wall reached 23.3°C. By day-2, inside still in 5.0°C for the

initial, while the wall 22.6°C. Up to 12 hours passed, inside showed up to 6.0°C and the wall in 23,2°C. By day-3, inside reached till on 6.0°C for the initial, while the wall 22.8°C. At the end of measurement after 12 hours, inside reached about 7.2°C with some ice had melted, and the wall still in 22.8°C. The measurement results every one hour in 3 days expressed in the graph shown in Figure 2.
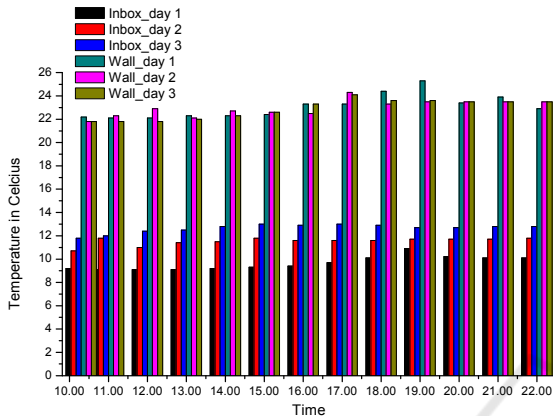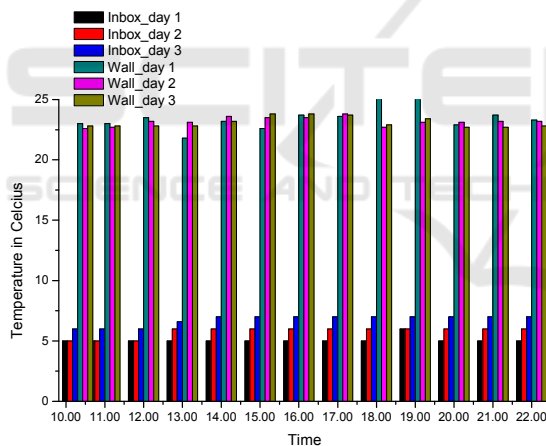

Figure 1: Styrofoam box without superlon.

Figure 2: Styrofoam box with superlon.

For the box with sawdust insulation in day-1 after 30 minutes showed inside temperature of the box 7.4°C, and the wall of 22.6°C. Until 12 hours passed inside reduce to 7.1°C and the wall 22.3°C. In day-2, inside still reached to 7.2°C for the initial, while the wall 21.8°C. Up to 12 hours passed inside up to 7.7°C and the wall in 22,6°C. By day-3, inside reached about 7.9°C for the initial, while the wall 21.8°C. At the end of measurement after 12 hours, inside reached about 9.1°C with some ice had melted, and the wall still in 23.5°C. The measurement results every one hour in 3 days expressed in the graph shown in Fig 3.

The tests had shown that Styrofoam with superlon lasts longer in maintaining ice conditions, also better than Styrofoam boxes without superlon and box with sawdust insulation.
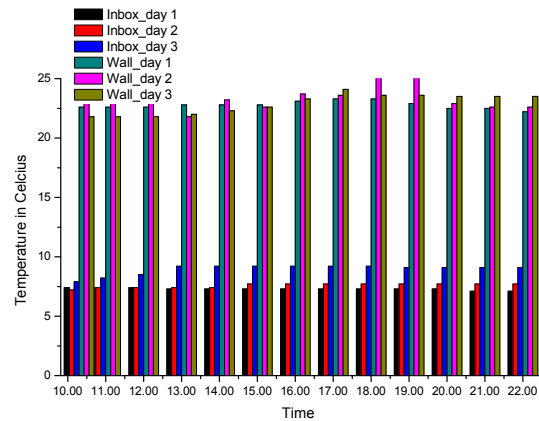

Figure 3: Box with sawdust isolation.

4 CONCLUSIONS

The experiment had analysed on Styrofoam box with 3 insulation materials as alternative cold storage. The results had shown the Styrofoam box with superlon insulation able to keep ice more prolonged than the others, which the lowest inside temperature of 5oC and the highest of 7°C, after 3 days. While the box without insulation, the temperature inside reached about 12.7°C and the wall 23.5°C, after 12 hours. The insulation between sawdust and superlon showed superlon insulation more extended 3-5 hours in storing ice than sawdust insulation.

This study still had a lot of weaknesses especially on variations of insulation materials and methods. The results were not a statement that Styrofoam with superlon the best as alternative cold storage. It expects that more research alternative cold storage on other raw materials for insulation. And also analyse the factors of the influence temperature fluctuations as well as find other alternative materials as well.

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