International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

The Advantage of Slurry Ice as Cooling Media for Fish in Tropical Area

Nasirin[a*], Budhi H. Iskandar[b], Mulyono S Baskoro[c], Mohammad Imron[d], Zulkarnain[e], Maimun[f]

[a]*Doctoral student of Bogor Agricultural University, Programme of Capture Fisheries Technology, Campus IPB Dramaga Bogor, West Java, Indonesia;16680*

[b,c,d,e]*Department of Fisheries Resources Utilization, Bogor Agricultural University, Bogor, Indonesia;16680*

[f]*Department of Fishing Technology, Jakarta Fisheries University, Jakarta , Indonesia*

[a]*Email: nasirin_stp@yahoo.com*

Abstract

Slurry ice is a brine solution, which has a diameter of ice less than or equal to 1 mm, that can be pumped to refrigerate fresh fish products. This media is still not familiar in Indonesia because the technology has not been widely used by fishermen in the tropics. Local fishermen still use conventional cooling media in the form of ice blocks that are carried out by fishermen or fish farmers to cool the product. Tropical regions have different characteristics to subtropical, namely; the region have different seasons, thus affecting temperature and salinity of waters.

This study aimed to prove the advantages of slurry ice cooling medium to drop the temperature of fish in the tropics. The method used was comparative analysis between slurry ice cooling media and ice blocks in the treatment of freshwater fish and seawater fish.

---

* Corresponding author.

The result showed that slurry ice can decrease the temperature of carp (Cyprinus carpio linnaeus) to 0^0C in 14 minutes while conventional ice block only managed to drop the temperature to $2,5^0$C with a P value of 0.029 > 0.05 (α = 5%).While on Mackerel (Rastrelliger neglectus), slurry ice could drop its temperature to 0^0C in 12 minutes whilst conventional ice blocks only managed to drop the temperature by $2,8^0$C, P value of 0.0003< 0.05 (α=5%). This paper illustrates that the use of slurry icecooling medium is very advantageous for cooling fresh fish that the fish will have higher price and quality.

Keywords: slurry ice; cooling; refrigerate; fish; tropic.

1. Introduction

Fish is a commodity that can easily damaged even faster than other kind of meats. Its quality, especially the level of freshness, will decrease significantly if not treated quickly and properly [1]. The rate of decay, after the fish is caught or harvested, is influenced by the technique of fishing and harvesting, the biological condition of the fish, and storage and handling techniques on board. Fish handling after caught or harvested should be immediately preserved, refrigerated or frozen [1]. Drop the temperature of the fish as quickly as possible to a temperature as low as possible is the principle of cooling but not until its frozen. Cooling process generally cannot prevent decay completely, but the colder the temperature the greater the reduction of bacteria and enzyme activity.

Cooling can affects bacteriological and biochemical processes in the fish, but it is only delayed, not stopped. A good cooling methods is that a fish being covered by cooler medium which can be in the form of solid, liquid, or gas. Fish handling on board is generally done by providing cold treatments such as refrigeration, ice blocks, ice tube, and slurry ice. According to [2] fresh fish storage using ice or another cooling systems have limited ability to keep freshness of the fish, usually last for 10-14 days.

Slurry ice is a liquid solution with ice particles, with a diameter less than or equal to 1 mm, which can flow through the pump [3]. Slurry ice is a round ice crystal with temperature below zero [4]. Slurry ice is formed through ice crystalization process. According to [5], slurry ice has a temperature properties of solution and solid which can reached -1.5^0C. Brine solution as raw materials cause the freezing pointof slurry ice to be below 0^0C.

Slurry ice can be applied for fresh fish [6].The use of slurry ice on fish can preserve its quality. This is evidenced in the research of *Sardina pilchardus* [7], *Trachurus trachurus* [8], *Psetta maxima* [9], *Merluccius merluccius* [10], *Nephrops norvegicus* [11], *Dicentrarchus labrax* [12], and *Oncorhynchus kisutch* [13].

Cooling media can maintain the temperature of fresh fish. Refrigeration for 12 days were able to maintain the sensory and microbiological quality still in a good condition [13]. Refrigeration for 13 days on the fish *Sparusaurata* and *Dicentrarchuslabrax* are able to maintain the quality of the fish [14]. The use of slurry ice combined with ozone can maintain the freshness of the fish up to 14 days [15]. The use of slurry ice in the vessel can maintain the quality and extend the shelf life of fish species [16]. In addition, slurry ice can prevent dehydration of fish products [17].Slurry ice can be used as initial cooling before freezing process [18]. It can be used before the canning process [19]. In addition, slurry ice is used to cool other foods [20].

Slurry ice as cooling medium is commonly used to cool the fish by the reason of its fluidity on surface area which is efficient between the ice and the refrigerated media resulting in better cooling effect that makes the process fast, safe (non-toxic properties), cooling temperature can drop to 0^0C. Slurry ice, in its production, can use all kinds of refrigerant [7].

Previous research shows that slurry ice has the potential to maintain the temperature of fresh fish and the result is better than compared to ice flake [6], in other studies [3] examines the decrease in temperature of cod by comparing slurry ice cooling to ice flake in subtropical regions. This study compares the drop in temperature between the slurry ice cooling medium to conventional ice blocks in freshwater fish and seawater fish in the tropics.

Limitation of issues raised in this study is the absence of fish rapid cooling technology (super chiller), hence the need for substantiation in tropical countries. The necessity to prove whether there is a difference between the average temperature of the carp (*Cyprinus carpio* Linnaeus) and mackerel (*Restrelliger neglectus*) in Box 1 (slurry ice) and Box 2 (ice blocks) in tropical countries. This study aimed to prove the advantages of slurry ice cooling medium compared to conventional ice blocks to drop the temperature of freshwater and seawater fish in the tropics which has a high temperature and salinity.

2. Materials And Methods

2.1. Time and Research Location

Research activity, on freshwater fish using slurry ice media and conventional ice blocks, was done at laboratory of Fisheries Resource Utilization, Faculty of Fisheries and Marine Science, Bogor Agricultural University, while treatment on sea water fish was conducted on fishing boats. Research at the sea took place at Latitude S 05^0 41.753 and E 106^0 42.385' Longitude of Thousand Islands region, Jakarta. The study was conducted on October 2014.

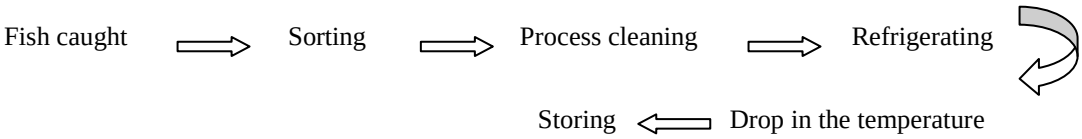
2.2. Tools and materials

The tools used in this research was slurry ice production machine, fishing boats, recording devices and thermometer.The materials used were sea water, Carp (for freshwater fish) and mackerel (for sea water fish).These fishes were selected because of their abundant population in tropics and also frequently consumed by Indonesian. Temperature of tropical waters at the time of sampling was 29 ^{0}C, sea water temperature was 28^0C, and sea water salinity was 35 ppt. The fish used in this research were Mackerel and Carp weighing of 100 g, with 18 cm of Fork Length (FL) with a temperature of 27 ^{0}C.

Slurry ice machine used in this study was slurrytek machine with specifications of 55 cm length, 45 cm width, and 92 cm high with a total weight of 68 kg. Compressors used in the engine was 0.5 HP, with 8 liter of maximum capacity of slurry ice generator tank. This machine could produce 380 liters of slurry ice per day.

Figure 1: *slurry ice*

Test process diagram is done in stages as follows:



Testing process:

After the fish was caught from the sea, it was then sorted according to type and then cleaned by using clean sea water. Measure the temperature and the length of the fish on the way up from the surface waters. Put the fish into two storage box or cool box. Put slurry ice and ice blocks into different storage boxes. Put thermocouples to record the temperature and time of temperature decrease of the fish in storage boxes.

Testing process for both in the lab and in the field were relatively the same, the difference was the type of the fish used. Fresh water fish used for the test was carp (*Cyprinu scarpio* Linnaeus) while sea water fish used was mackerel (*Restrelliger neglectus*). These measurements of temperature were started after the fish was caught and still alive and directly inserted into the cooling medium, then temperature measurements was done afterwards. Slurry ice in today's era is needed to obtain high-quality fresh fish for small and large-scale fisheries. This is to support government programs in improving the quality of sustainable fisheries in Indonesia.

2.3. Data Analysis

Data analysis in this study was using Microsoft Office Excel 2007 while data test to determine the effect of temperature decrease, using slurry ice, in both fresh water and sea water fish was using Mann-Whitney test. According to [21] Mann-Whitney test formulas are as follows:

$$U = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1$$

or

$$U = n_1 n_2 + \frac{n_2(n_2+1)}{2} - R_2$$

with:

R_1= Number of rank given on the sample with the total number ofn_1

R_2 = Number of rank given on the sample with the total number ofn_2

n_1 = the number of the sample 1

n_2 = the number of the sample 1

U = U test Statistic

Both of these formulas will most likely result in two different values for U. The value chosen for U in hypothesis test is the smallest value from both values.

Hypothetical columns on H0 = μ1 = μ2 means that there are no differences in average temperature of carp from box1 and box 2 and H1 = μ1 ≠ μ2 means that there are differences in average temperature of carp from box1 and box 2. Hypothetical line on H0 = μ1 = μ2 means that there are no differences in the average temperature of carp based on the difference of cooling time and H1 = μ1 ≠ μ2 means that there are differences in average temperature of carp based on the difference of cooling time.

If f count (F)> f table (F crit), then reject H0 and if f count (F) ≤ f table (F crit), then H0 is accepted.The observations in this study is based on cooling place. There are two cooling place, namely box1 and box 2. In box 1 there were 20 observations of carp cooling time as well as box 2.

Decision-making

If probability> 0.05 then $H_0$is accepted

If probability< 0.05 then $H_0$is rejected

3. Results And Discussion

The use of slurry ice for fisheries provide better results in the product. There are two main purpose for the use of slurry ice namely; the product is directly cooled to near freezing and avoid damage to the product from crushed or bruised. The advantage of using slurry ice is because it consists of millions of ice micro crystals that are in liquid brine solution. The crystals which typically have a measurement of 0.25 - 1 mm which can envelop the entire surface of fish products and produce a greater heat transfer from other forms of ice. Slurry ice is also able to cool the fish in large volumes and can keep longer cooling temperature in a given period compared to blocks ice or tube ice. Slurry ice has no sharp edges that it does not damage the surface of fish skin such as bruises on

the fish and also hamper the growth of bacteria.

Production of slurry ice machine has characteristics in the form of small ice crystals in the liquid. It can perfectly cool the product, and since these crystals are round shape so it is easy to distribute via pipelines and perfect for covering product to be cooled and flows into the gap of fish product, thus providing a greater surface contact and faster cooling.

3.1 Cooling Carp (Cyprinus carpio linnaeus)

Temperature drop that can be seen on the fig 2 shows significant difference in temperature drop. The use of ice blocks did not reach a temperature of 0°C while the temperature drop achieved by using slurry ice was below 0°C. This is similar to the result investigated by [3]. These differences are influenced by the ability of slurry ice to cover all parts of fish. The drop in temperatures using slurry ice and ice blocks are shown in figure 2.

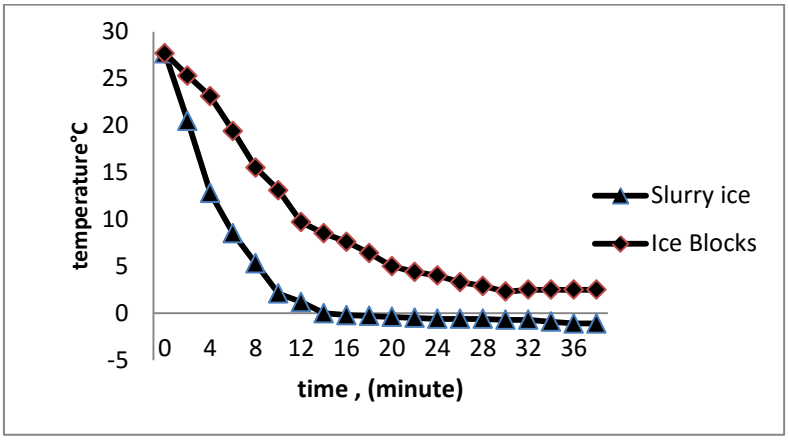


Figure 2: Carp (*Cyprinus carpio Linnaeus*) temperature decrease

The result showed that the valueof sig.(2-tailed) was0.029< 0.05 (α=5%), which means reject H0 or there is a difference in the average temperature of sea water fish on the box 1 and 2. Differences in median values of average temperature of sea water fish on box 1 and 2 were -5.89^{o}C. In the interval, it was found that the average difference in temperature of sea water fish on the box 1 and 2 ranged from -11.13^{o}C to -0.64^{o}C at 95% confidence level.

3.2 Cooling Mackerel (Restrelliger neglectus)

Temperature decrease reached in the mackerel on this study is described in fig 3 below:

The result showed that the value of sig. (2-tailed) was 0.0003 <0:05 (α = 5%), which means reject H0 or there is a difference in the average temperature of sea water fish on the box 1 and 2. , this is similar to the result investigated by [3].Differences in median values of average temperature of sea water fish on box 1 and 2 were -6.79^{o}C. In the interval, it was found that the average difference in temperature of sea water fish on the box 1 and 2 ranged from -10.28°C to -3.29°C at 95% confidence level.

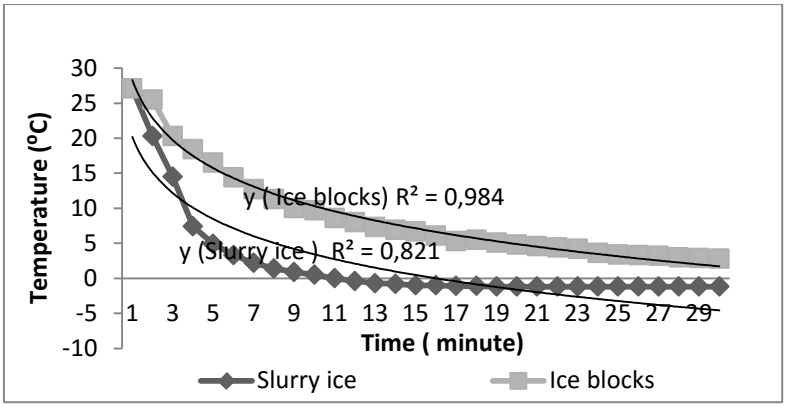


Figure 3: Mackerel (*Restrelliger neglectus*) temperature decrease

Both treatment on two different fish had the same level of confidence (95%), but the temperature decrease was difference between those treatments. This is probably due to carp contains of more fat than mackerel.Fresh fish handling can be done by lowering the temperature as quickly as possible to a temperature of 0°C. By doing that, fish shelf life can be extended. This is due to bacteria can multiply rapidly with increasing temperature above 0°C.According to data that have been published, at a temperature of 2°C bacterial growth twice higher than at a temperature of -1°C. This can be achieved when using ice slurry technology. [10]

The results of cooling ice performance in fishing sector shows some benefits namely;

- Increaseof productivity.

Slurry ice can be pumped that makes it easy in the handling, distribution and can be used directly to products. The transportation of slurry ice does not require extra effort which will save costs associated with equipment, maintenance and labor.

- More hygiene.

Slurry ice is produced and distributed in isolated environment until it is used to cool fishery products. This can eliminate the risk of contamination of slurry ice from outside that can cause contamination of the product.

- The effectiveness of cost. Slurry ice system has the advantage on energy efficient and effective cost which can be interpreted as a low cost on operational, low energy required to deal with products, but high cooling efficiency on product.
- Easy to use. Slurry Ice crystal has a size of 0.25 mm to 0.5 mm, ice fraction of 0% to 100%, temperature of 0 to -30°C, and salinity levels of 0% and above which is adaptable, that can makes slurry ice suitable for any application.
- Efficient cooling. The unique properties of the slurry ice allow to perform rapid cooling, even cooling at any desired temperature with no cause of freezing.
- Good protection. The form of its crystalline is rounded and smooth that is not going to damage the

product and prevent skin discoloration, unlike other forms of sharp, ice jagged (ice blocks, ice shall, ice shards,etc.).

- Easy distribution. Slurry ice can be pumped so that it can easily be sent to various points of use on the product. It can affects the reduction on labor, reduction on ice waste and gives better conservation control.
- Good sanitation. The system is isolated that no external contamination can penetrate into the product that will be cooled.
- Low cost of maintenance. Slurry ice machine has a simple design, made with anti-corrosion materials, so the maintenance cost is cheap.
- Flexibility. The design of slurry ice machine is made with efficient installation that does not require too large capacity and does not need to renovate existing place.
- Energy saving during production. Refrigeration does not require defrost cycle and does not have freezing ice on cooling system, slurry ice produced by the machine is a super chiller, it can save up to 30% - 40% in energy consumption compared with the use of conventional refrigerator (ice flake, ice blocks, etc).

4. Conclusion

The conclusion from the discussion of this study proved that the reduction in the temperature for both of the test specimen is very significant in cooling by using slurry ice, so that the profits generated are the fish which use slurry ice has better quality and freshness. Several advantages on refrigerated fish are that the fish does not have bruises on its body, fresh and it can slow the decay in fish. While the lack of the use in this technoligy are that slurry ice machines has not been popular and very little information about the slurry of ice and its benefits are known by fishermen in Indonesia.

Recommendations

The development and socialization of ice slurry cooling medium for the preservation of the fish in the tropics is needed.

Acknowledgements

Head of Fishing boats and Fisheries Transportation, Faculty of Fisheries and Marine Science, Bogor Agricultural University and International Journal of Sciences : Basic and Applied Research.

References

[1] Medina I, Gallardo J, Santiago P. 2009 Quality preservation in chilled and frozen fish products by employment of slurry ice and natural antioxidants. International Journal of Food Science & Technology 44(8): 1467-1479.

[2] Wibowo S, Yunizal (1998). Fresh fish handling, Installation of Marine Fisheries. Jakarta

[3] Davies T. 2005. Slurry ice as a heat transfer fluid with a large number of application domains. International Journal of Refrigeration Ice Slurries 28(1): 108-114.

[4] Losada V, Piñeiroa C, Velázquezb J, Aubourga S. 2005. Inhibition of chemical changes related to freshness loss during storage of horse mackerel (Trachurus trachurus) in slurry ice. Food Chemistry 93(4): 619–625.

[5] Múgica B, Velázquez J, Miranda J, Aubourg S. 2008 Evaluation of a slurry ice system for the commercialization of ray (Raja clavata): Effects on spoilage mechanisms directly affecting quality loss and shelf-life. Food Science and Technology. 41(6): 974-981.

[6] Bellas I, Tassou S. 2005. Present and future applications of ice slurries. International Journal of Refrigeration Ice Slurries 28(1): 115-121.

[7] Campos C, Rodríguez O, Losada V, Aubourg S, Velázquez J. 2005. Effects of storage in ozonised slurry ice on the sensory and microbial quality of sardine (Sardina pilchardus) International Journal of Food Microbiology. 103(2): 121-130.

[8] Rodríguez O, Velázqueza J, Piñeirob C, Gallardob J, Aubourg S. 2006. Effects of storage in slurry ice on the microbial, chemical and sensory quality and on the shelf life of farmed turbot (Psetta maxima). Food Chemistry. 95(2): 270-278.

[9] Losada V, Piñeiro C, Velázquez J, Aubourg S. 2004. Effect of slurry ice on chemical changes related to quality loss during European Hake (Merluccius merluccius) chilled storage. European Food Research and Technology 219(1): 27-31.

[10] Aubourg S, Losada V, Prado M, Miranda J, Velázquez J. 2007. Improvement of the commercial quality of chilled Norway lobster (Nephrops norvegicus) stored in slurry ice: Effects of a preliminary treatment with an antimelanosic agent on enzymatic browning. Food Chemistry. 103(3): 741-748.

[11] Cakli S, Kilinc B, Cadun A, Tolasa S. 2006. Effects of using slurry ice on the microbiological, chemical and sensory assessments of aquacultured sea bass (Dicentrarchus labrax) stored at 4 °C. European Food Research and Technology. 222(1): 130-138.

[12] Rodríguez A, Carriles N, Cruz J, Aubourg S. 2008. Changes in the flesh of cooked farmed salmon (Oncorhynchus kisutch) with previous storage in slurry ice (−1.5 °C) LWT. Food Science and Technology. 41(9): 1726-1732.

[13] Rodríguez O, Losada V, Aubourg S, Velázquez J, . 2004. Sensory, microbial and chemical effects of a slurry ice system on horse mackerel Trachurus trachurus. Journal of the Science of Food and Agriculture. 85(2): 235-242.

[14] Kılınc B, Cakl S, Cadun A, Dıncer T, Tolasa S. 2007. Comparison of effects of slurry ice and flake ice pretreatments on the quality of aquacultured sea bream (Sparus aurata) and sea bass (Dicentrarchus labrax) stored at 4 °C. Food Chemistry. 104,(4): 1611-1617.

[15] Campos C, Losada V, Rodríguez O, Aubourg S, Velázquez J. 2006. Evaluation of an ozone-slurry ice combined refrigeration system for the storage of farmed turbot (Psetta maxima). Food Chemistry. 97(2): 223-230.

[16] Aubourg S, Losada V, Gallardo J, Miranda J, Velázquez J. 2006 On-board quality preservation of megrim (Lepidorhombus whiffiagonis) by a novel ozonised-slurry ice system. European Food Research and Technology 223(2): 232-237.

[17] Piñeiro C, Bautista R, Rodríguez O, Losada V, Velázquez J, P. aS. 2005. Quality retention during the chilled distribution of farmed turbot (Psetta maxima): effect of a primary slurry ice treatment. International Journal of Food Science & Technology. 40(8): 817-824

[18] Losada V, Rodríguez O, Miranda J, Velázquez J, Aubourg S. 2006. Development of different damage pathways in Norway lobster (Nephrops norvegicus) stored under different chilling systems. Journal of the Science of Food and Agriculture. 86(10): 1552-1558.

[19] Losada V, Rodríguez A, Ortiz J, Aubourg S. 2006. Quality enhancement of canned sardine (Sardina pilchardus) by a preliminary slurry ice chilling treatment. European Journal of Lipid Science and Technology 108(7): 541-623.

[20] Kauffeld M, Wang MJ, Goldstein V, Kasza KE. 2010. Ice slurry applications. International Journal of Refrigeration 33(8): 1491-1505.

[21] Supranto J. 2009. StatisticalTheory and Applications Jakarta: Erlangga.