

# The Quality of Squid Held in Chilled Seawater Versus Conventional Shipboard Handling

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## Introduction

The principle of using refrigerated seawater for the bulk holding of fish aboard vessels is not a new concept. One of the earliest records of this application is found in a U.S. patent issued in 1919 to J. M. Larsen for a method of holding freshly caught fish in clear filtered seawater at about 0°C (32°F) or lower (Peters et al., 1965).

Some reasons for using seawater cooled either by mechanical means (refrigerated = RSW) or by ice (chilled seawater = CSW) are to cool the fresh fish down to a temperature of 0°C (32°F) or lower as quickly as possible since spoilage rates are directly related to storage temperature, to disperse spoilage inducing products by the washing effect of the seawater, to eliminate crushing and ice damage, and also for ease of loading and unloading (Roach, 1965).

Chilled seawater, using ice as the coolant, has recently been used in the bulk holding of herring (Hewitt and McDonald, 1972; Hulme and Baker, 1977), squid (Learson and Ampola, 1977), and mixed species of fish (Baker and Hulme, 1977).

The two objectives of this work were to compare the fresh shelf life of squid held in CSW after being caught versus squid held in the traditional manner—iced down in boxes or iced down in pens aboard ship, and to compare the organoleptic quality of squid frozen at

sea immediately after capture against squid held in CSW, in boxes, and in pens aboard the boat and then frozen 1 to 2 days after capture.

## Procedure at Sea

The fishing vessel used for catching the squid, *Loligo pealei*, used in this experiment had an insulated fish hold capable of holding 15 tons of seawater, ice, and squid. The hold was divided into six pens, five to hold squid, and one pen reserved as working space for loading and unloading squid. A schematic of the hold layout is shown in Figure 1.

Before each trip, Pen C was charged with about 3 tons of crushed ice. Pen boards dividing the insulated hold had openings covered with perforated stainless steel mesh which allowed for the free circulation of chilled seawater which was pumped from the bottom of Pen F into the top of each of the other pens.

## Squid Held in CSW

In all, three separate trips were made to catch squid. Squid caught on the ear-

liest tow of each trip were always placed in Pen A, and the squid/ice/seawater ratio was adjusted as close to 3:1:1 as possible according to the procedure of Baker and Hulme (1977). This mixture provided a workable slush into which the freshly caught squid were submerged. During each trip, the top and bottom temperatures of all the pens were monitored by a Cole Palmer<sup>1</sup> electronic thermometer.

## Boxed Squid

A shovelful of ice was placed on the bottom of a 45-kg (100-pound) capacity wooden fish box, about 35 kg (80 pounds) of squid were added, together with some additional ice, another shovelful of ice was placed on top of the mass, and the cover was nailed on. The boxes were stored in an aft compartment of the boat.

## Penned Squid

Squid were mixed with ice in approximately a 3:1 squid/ice ratio, and then shoveled into pens with pen boards holding the mass. The height of the mixture was about 1.2 m (4 feet). These pens were located in another area of the boat.

## Squid Frozen at Sea

On the first trip, 12 cartons, each containing 2.3 kg (5 pounds) of freshly caught squid were frozen in dry ice.

<sup>1</sup>Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

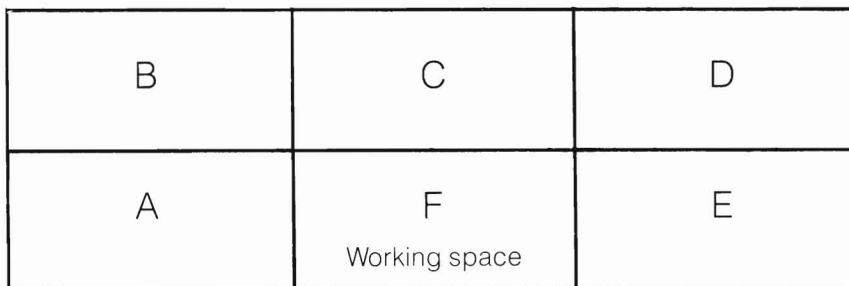


Figure 1.—Chilled seawater hold aboard the vessel.

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These samples were used as frozen-at-sea controls for subsequent organoleptic tests.

### Procedure Ashore

After each of three trips, squid from the CSW Pen A and some boxed and penned squid were deiced, weighed, and repacked with ice into 22.7-kg (50-pound) cardboard fish boxes. These containers plus the frozen-at-sea squid were transported from Pt. Judith, R.I., to the Gloucester Laboratory where the iced squid were placed in a refrigerated room held at 1.1 °C (34 °F). The frozen sample was stored at -20.6 °C (-5 °F). Some squid taken from the CSW tank and some boxed and penned squid were packed into 2.3-kg (5-pound) cartons, plate frozen at -40 °C (-40 °F) overnight and then stored at -20.6 °C (-5 °F). The rest of the squid were kept in ice (at about a 2:1 squid/ice ratio) in their containers. Ice loss due to melting was replenished as needed.

### Quality Determination

#### Fresh

Squid held in CSW, in boxes and in pens aboard ship, and then held in ice at the laboratory were evaluated daily for appearance and odor by a 12-member panel experienced in the quality evaluation of marine products. The raw squid were presented to the panel whole and cut open. They rated them on a 5-point scale where 5 = Very Good, 4 = Good, 3 = Fair, 2 = Borderline, and 1 = Poor. When the average score of a sample was 2.6 or above for either appearance or odor, the squid were considered acceptable. An average score of 2.5 or less given for either appearance or odor was cause to reject the squid as unacceptable and marked the end of shelf life for that sample.

#### Frozen

For this procedure, frozen squid from each treatment lot were thawed by immersion in cool tap water. Some of the squid were cut open; some were left whole, and they were presented to the evaluation panel. The 5-point scale was used for evaluating their appearance

**Table 1.—Sensory scores<sup>1</sup> and shelf life of raw squid held three different ways before landing and stored in ice at 0.6°-1.1°C (33°-34°F).**

Total age of squid (days)	CSW		Boxed		Penned	
	App.	Odor	App.	Odor	App.	Odor
Trip 1						
2	4.0	5.0	4.0	5.0	4.0	5.0
3	4.5	4.5	4.5	4.5	4.5	4.5
4	4.0	4.0	4.0	4.0	3.0	4.0
5	4.3	4.2	3.9	3.8	4.0	3.9
6	4.3	4.3	3.7	3.3	4.0	3.7
7	4.0	4.1	4.1	3.8	3.8	3.8
8	3.7	4.1	3.7	3.8	3.3	<sup>2</sup> 3.7
10	4.0	3.0	4.0	<sup>2</sup> 3.0	3.0	1.0
11	3.8	<sup>2</sup> 3.2	3.3	2.3		
12	1.8	1.2				
Trip 2						
3	4.8	4.8	4.8	4.8	4.7	4.5
4	4.5	4.6	4.6	4.5	4.5	4.6
5	4.0	3.9	4.3	4.3	4.3	4.3
6	4.2	4.3	4.2	4.1	3.9	3.8
8	3.0	4.0	3.0	<sup>2</sup> 4.0	3.0	4.0
9	3.3	3.1	3.3	2.3	3.3	3.2
10	3.3	<sup>2</sup> 2.8			3.2	2.8
11	3.0	1.5			3.0	<sup>2</sup> 2.8
12					2.6	1.4
Trip 3						
3	4.4	4.3	4.5	4.5	4.5	4.5
4	4.4	4.6	4.3	4.5	4.3	4.5
5	4.3	4.4	4.3	4.2	4.3	4.4
8	4.1	4.0	3.7	3.9	4.1	4.1
9	3.6	3.0	3.6	<sup>2</sup> 3.9	3.5	3.8
10	3.3	<sup>2</sup> 2.9	3.1	1.9	3.0	<sup>2</sup> 2.8
11	2.0	1.3			2.5	1.8

<sup>1</sup>A 5-point scale was used where 5 = Excellent, 4 = Very Good, 3 = Good, 2 = Borderline, and 1 = Poor

<sup>2</sup>End of acceptable shelf life.

and odor. After this procedure, the squid were cleaned; the mantles were diced and then boiled in unsalted water until tender. Several pieces of squid from each lot plus some of the cook water were presented to the panelists who rated them for appearance, odor, flavor, and texture on a 9-point hedonic scale. Organoleptic scores for each of these sensory attributes were analyzed for significant difference by analyses of variance.

### Organoleptic Results

#### Iced Squid

Sensory scores for appearance and odor of raw squid obtained from the CSW tank, boxes, and the pans of the vessel and stored in ice at the laboratory are shown in Table 1.

There was little difference in the iced shelf life of squid held in CSW, in boxes, and in pens. The total shelf life of squid held in CSW aboard the boat

**Table 2.—Organoleptic results of squid held at -20.6°C (-5°F) for 9 months.**

Age of squid (months)		Raw evaluation thawed		Cooked evaluation <sup>1</sup>
		App.	Odor	
1	Frozen at sea	4.6	<sup>2</sup> 4.3	<sup>3</sup> 7.1
	CSW	4.4	4.3	6.9
	Boxed	4.3	4.3	7.1
	Penned	4.4	4.5	7.3
2	Frozen at sea	4.5	4.3	7.7
	CSW	4.3	4.3	7.5
	Boxed	4.5	4.7	7.3
	Penned	4.3	4.3	7.4
3	Frozen at sea	4.6	4.5	7.5
	CSW	4.1	4.3	7.4
	Boxed	4.3	4.4	7.2
	Penned	4.6	4.6	7.8
4	Frozen at sea	4.8	4.6	7.6
	CSW	4.5	4.5	7.5
	Boxed	4.3	4.4	7.1
	Penned	<sup>4</sup> 3.9	4.5	7.2
5	Frozen at sea	4.8	4.7	7.2
	CSW	4.1	4.2	7.3
	Boxed	4.3	4.5	7.2
	Penned	4.3	4.8	7.2
6	Frozen at sea	4.7	4.6	7.0
	CSW	4.3	4.4	7.3
	Boxed	4.3	4.3	7.0
	Penned	4.1	4.5	7.2
8	Frozen at sea	4.5	4.8	7.8
	CSW	4.0	4.1	7.6
	Boxed	4.2	4.3	7.6
	Penned	3.7	3.9	7.7
9	Frozen at sea	4.6	4.3	7.4
	CSW	4.1	4.0	7.4
	Boxed	4.3	4.3	7.4
	Penned	4.1	4.1	7.4

<sup>1</sup>Overall average of appearance, odor, flavor, and texture.

<sup>2</sup>Evaluated on the 5-point scale used in Table 1

<sup>3</sup>A 9-point scale was used where 9 = Excellent, 8 = Very Good, 7 = Good, 6 = Fair, 5 = Borderline, 4 = Slightly Poor, 3 = Poor, 2 = Very Poor, and 1 = Inedible.

<sup>4</sup>P = 0.05 percent from the frozen-at-sea sample.

for 1-2 days and then in ice in the laboratory was 11, 10, and 10 days. Iced squid held in boxes had a total shelf life of 10, 8, and 9 days. The penned squid held in ice had a total shelf life of 8, 11, and 10 days.

#### Frozen

The sensory data on the raw and cooked evaluation for squid obtained from the CSW tank, the boxes, and pens, and then held at -20.6 °C (-5 °F) were compared with squid frozen at sea immediately after capture. These results are shown in Table 2.

Except for a significant difference in the appearance of the penned squid and the frozen-at-sea control at 4 months,

all samples evaluated in the raw state remained highly acceptable over the 9-month storage period.

When tested cooked, there were no significant differences in appearance, odor, flavor, or texture between the frozen-at-sea samples and squid held in CSW, in boxes, or pens aboard ship and then frozen for 9 months.

### Discussion

There was a slight difference between the shelf life of squid held in CSW and those iced down in boxes and in pens after capture. Squid held in CSW for 1-2 days and then in ice had an average shelf life for the three determinations of 10.3 days, while the average shelf life of boxed squid was 9 days, and the penned squid, 9.7 days. In all cases, the squid were rejected primarily on the basis of odor rather than appearance. The odor of all samples during iced storage deteriorated rather slowly. As time progressed, the panelists commented on lack of fresh odor, no odor, and finally, flat sour or slightly ammoniacal odors upon rejection.

There was, however, a great difference in appearance between the CSW squid and the boxed and penned squid when seen at dockside. Squid held in CSW were of unusually good appearance with very few bruises, skin tears, and no crush marks. Some of them were still in rigor; the eyes were bright, and the tentacles of most of them were tightly curled. This may have been due to the lower temperature in the CSW tank—the average temperature of the ice/seawater slush averaged  $-1.4^{\circ}\text{C}$  ( $29.4^{\circ}\text{F}$ ) for the three trips. The temperature of the squid held in boxes and pens averaged about  $0.6^{\circ}\text{C}$  ( $33^{\circ}\text{F}$ ). Boxed squid exhibited bruise marks and showed the effects of compression, while those held in pens showed both of these characteristics and also some inky discoloration.

The organoleptic data obtained on frozen squid tested raw and cooked

(Table 2) show that the products were of excellent quality over the 9-month storage period. Squid frozen immediately after capture differed in color from squid frozen at the laboratory. During frozen storage and even after thawing, the pigmentation of the frozen-at-sea squid was a vivid reddish purple rather than the purplish gray of the other samples. The skin chromatophores were sharply defined and slightly larger than normal. This coloration manifested itself in higher appearance scores received when they were examined in the raw, thawed state; however, when boiled, this difference was not evident. The frozen-at-sea squid were also firmer and slightly more rigid than the other samples after thawing. The other samples may have been lightened by the bleaching effect of the salt water or ice.

### Conclusion

Holding freshly caught squid in CSW for 1 or 2 days after capture was not long enough to appreciably extend its iced shelf life over the other two methods. There are, however, advantages for holding squid in CSW. One is that the initial appearance of these squid was considerably better than the boxed or penned samples. Another advantage is the elimination of the labor intensive practice of icing them down in boxes or pens. Squid placed in CSW are rapidly chilled to about  $-1.7^{\circ}$  to  $-1.1^{\circ}\text{C}$  ( $29^{\circ}$  to  $30^{\circ}\text{F}$ ). They are separated from intimate contact with one another and to ice by floating in a fluid medium. They could be pumped from the hold, thus making off-loading less labor intensive and less damaging to the squid. Squid frozen at sea were better in appearance and in firmness than those held in CSW, boxes, or in pens prior to freezing.

There may be disadvantages in storing squid in CSW. According to Roach (1965) and Merritt (1969), prolonged immersion (over 7 days) of ungutted fish in CSW has led to undesirable

changes in appearance, changes in the salt composition of the flesh, and leaching out of soluble components, including protein.

In a previous experiment, Learson and Ampola (1977) held freshly caught *Illex illecebrosus* in CSW, in boxes, and in pens, and found that the shelf life of the squid held continuously in CSW was 7.3 days as compared with 6.0 and 5.0 days, respectively, for the boxed and penned squid.

Although these results indicate that there is an advantage to holding freshly caught squid in CSW, the appearance of the frozen-at-sea samples would seem to indicate that packaging and freezing of freshly caught squid at sea, although not practical for small boats, would be of definite advantage, especially if they were consigned for sale in foreign markets.

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