INFLUENCE OF VESSEL-HANDLING PRACTICES ON FORMATION OF BLACK SPOT IN SHRIMP[1/]

ABSTRACT

Handling practices were observed aboard commercial shrimp boats fishing in the Dry Tortugas and the Campeche areas. Experiments were designed to test the effect of a number of factors on the incidence and amount of black spot on shrimp during storage. The factors considered were: (1) length of drag, (2) washing shrimp on deck, (3) bruising shrimp, (4) removal of heads, (5) delay in icing, (6) method of icing, (7) type of ice, and (8) position in storage pen. All shrimp were stored in ice except for a small portion of each sample which was held in frozen storage for 8 to 12 months to test the effect of this factor on incidence of black spot.

Delay in icing the shrimp below deck markedly increased incidence of black spot. Natural variation in the pattern of black-spot development and difficulty in separating the individual effects of the numerous handling factors necessarily present in every test series, tended to obscure the influences of the other factors studied. There were indications that the following factors, alone or in various combinations, tended to increase black spot during storage: (1) long drags, (2) bruising of shrimp on deck, (3) storage of shrimp without washing, (4) storage of shrimp with heads on, and (5) poor icing practices. The type of ice used, the method of icing, position of shrimp in the pen, or frozen storage of shrimp up to a year were not associated with differences in the incidence of black spot.

Black-spot development on shrimp stored in ice cannot be eliminated by improvement in handling practices, but rapid icing and careful handling can reduce the incidence of black spot, and will at the same time maintain quality and prolong storage life of the product.

INTRODUCTION

Black spot on shrimp is a condition characterized by the appearance of black zones or spots usually at the edges of the shell segments. The dark color is produced by melanin pigments which form on the internal shell surfaces or, in advanced stages, on the underlying shrimp meat. These pigments are produced by an oxidative reaction of tyrosinase on tyrosine. The reaction is accelerated by copper and other metallic ions (Bailey and Fieger 1954).

Formation of black spot has been observed on all species of shrimp landed from waters contingent to North America, and probably is a world-wide problem. Observations would lead to the belief that the problem is more severe with some species than with others. The amount of black spot on the shrimp, as landed, largely determines the grade of the shrimp and the price the fishermen receive for their catch. The price for shrimp with considerable black spot may be cut from 2 to 10 cents a pound.

It has been thought that black spot on shrimp develops as a result of poor handling or prolonged storage in ice, but there actually has been little or no investigation of the specific factors that result in the formation of black spot. The purpose of this investigation was to determine whether changes in the way the shrimp are handled on the boats could eliminate or at least reduce the incidence of black spot. Specifically, the objectives of the research were (1) to observe commercial practices of handling shrimp on the boats, and during ice and frozen storage to determine the factors that may affect black-spot formation; and (2) to suggest modification in the commercial methods of handling and storing shrimp in ice to reduce the rate of black spot formation if, in fact, handling practices are associated with formation of black spot.

1/ This research was conducted by the Marine Laboratory of the University of Miami under a contract let by the U. S. Bureau of Commercial Fisheries. Funds were provided by the Saltonstall-Kennedy Act of 1954.

Note: This manuscript was prepared by Charles F. Lee, Fishery Technological Laboratory, U. S. Bureau of Commercial Fisheries, from the final contract report by the research investigators, Clare P. Idyll and James Alexander of the Marine Laboratory, University of Miami, Coral Gables, Fla.

OBSERVATIONS ON COMMERCIAL FISHING PRACTICES

Fishing was observed in two localities: the Dry Tortugas and the Campeche Grounds.

DRY TORTUGAS: Most of the shrimp taken in the Dry Tortugas are landed at Key West, Fla., although smaller numbers of boats may land catches at Marathon, Everglades, Fort Myers, Tampa, and other ports on the west coast of Florida. Most of the trawlers used in this fishery are relatively small, averaging about 50 feet in length, and have noninsulated holds. The gear used is a modified otter trawl. Until recently, most of the boats used a single net. Now many boats use a "double rig" in which two nets are fished simultaneously, one on each side of the vessel.

The average duration of a trip to the Tortugas is about five days. The boats seldom are more than a 10-hour run from their home port. From some ports, the boats may start fishing within 2 hours from the dock. The amount of ice carried is dependent upon the intended duration of the trip. For a 5-day trip, 3 to 5 tons of ice may be carried.

This is a night fishery, and drags may last from 1 to 8 hours, depending on the nature of the bottom, the weather, and the abundance of shrimp. The trawl bag is emptied on deck, and the trawl is reset before the shrimp are sorted from the unwanted material in the catch. This material, usually called "trash," consists of varying amounts of small fish, crustacea, sponges, mollusks, and mud. The ratio of trash to shrimp varies greatly, but in the Dry Tortugas area it is commonly about 2 to 1.

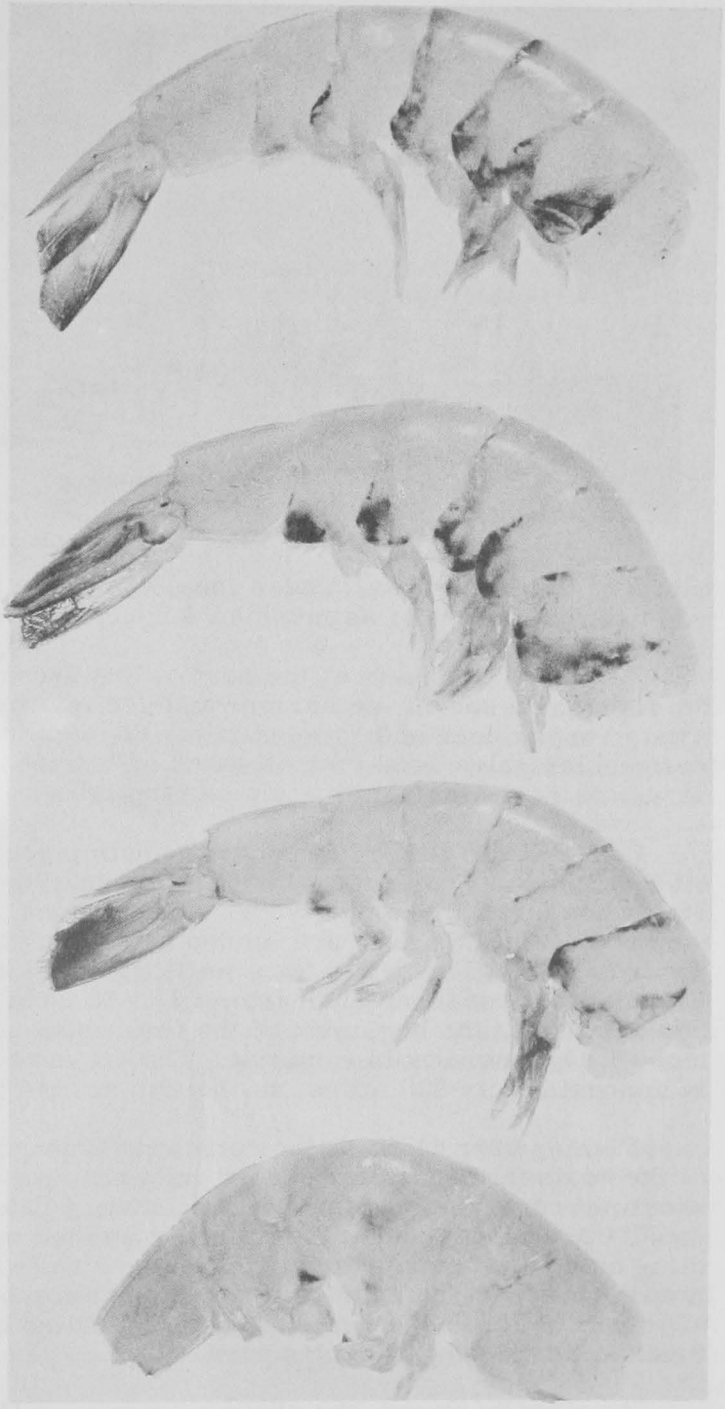

Fig. 1 - Shrimp showing different stages of black spot development. Black spot on the shrimp develops during storage when shrimp are improperly handled on the boats.

Most of the shrimp are "headed" before being iced, but it is not uncommon to ice and bring shrimp to port with heads on, particularly if most of the shrimp are small or if the catch is heavy. It is not the usual practice in this area to wash the shrimp after the heads have been removed. Icing practices are variable. Some fishermen store the shrimp in the hold in baskets covered with a small quantity of ice but most fishermen ice the shrimp in pens. The pen floor is covered with about 6 inches of ice, and more ice is added and mixed with the catch, using a blunt-tined rake.

The promptness with which the shrimp are sorted from the trash, the heads removed, and shrimp iced below decks also varies widely, depending largely on the

Fig. 2 - Shrimp boats at dock in port of Tampa, Fla.

habits of the fishermen. Under ideal conditions, the shrimp may be iced within 30 minutes, but delays of as much as 4 hours on deck have been observed.

To unload the boats at the port of Key West and at most of the smaller ports, the fishermen shovel the shrimp-and-ice mixture into a large basket, which then is hoisted to the dock and dumped into a de-icer wash tank. The de-icer is simply a rectangular galvanized tank of water with a mesh conveyor belt on one end, which serves to carry the shrimp to a sorting table.

CAMPECHE GROUNDS: Large shrimp grounds are located near Campeche, off the Yucatan Peninsula, Mexico. International waters here are fished by United States boats and those of several other nations. Most of the shrimp taken by United States boats in this area are landed at the port of Tampa, Fla. The boats average about 70 feet in length and have well-insulated holds. The average trip from the Florida west coast may last from 50 to 60 days, and a supply of ice and fuel is taken by the boats at the beginning of the trip, sufficient to last this time. More than 30 tons of ice generally is required. The distance from Tampa to the fishing grounds is approximately 800 miles, so the trip across the Gulf of Mexico takes 3 to 4 days.

Fishing operations differ somewhat from those at the Dry Tortugas area. Most of the boats fishing Campeche grounds now use the double-rig gear. Drags are shorter--rarely more than 4 hours; shrimp heads always are removed; the shrimp usually are muddy and are thoroughly washed with a deck hose to remove mud; handling on deck is more rapid; and a larger ratio of ice to shrimp is used. One factor facilitating more rapid handling of the shrimp on deck is a generally lower amount of trash, which may amount to about one-third of the average catch or about half as much as in the Dry Tortugas area.

As already stated, the shrimp boats near Campeche stay on the fishing grounds for long periods, but most are not equipped to freeze the catch. Consequently, the iced shrimp must be returned to port frequently, usually every five days. This is done by other vessels of the usually large fleet in the area that have completed their trips. These returning vessels fill up their holds with the catch of several other shrimp boats.

The transferring operations usually take place on "The Flats," a shallow area west of the port of Campeche. The vessels whose captains want to send their catch

home transfer the mixture of shrimp and ice from one hold to another in large mesh bags holding about 300 pounds. In the hold of the returning vessel the catches of the different boats are separated by pieces of webbing, and the entire pen loan is capped with a heavy layer of ice. The hold of the returning boat usually is not opened until arrival in port in order to make the ice last longer.

Most of the plants in Tampa use a bucket elevator-conveyor that can be lowered into the boat hold to unload the shrimp. This method of unloading results in less damage to the shrimp than does the use of the shovel-basket hoist.

METHODS AND MATERIALS

The following experimental variations were introduced into the methods of handling and storage of shrimp aboard the boat and in the laboratory to observe their effect on incidence of black spot:

1. Length of drag--observations were made of shrimp taken in drags lasting for 2, 3, 4, 5, and 6 hours.

2. Washing shrimp on deck--a comparison was made with shrimp stored in ice without previous washing.

3. Bruising--some of the shrimp were deliberately bruised on deck, and compared with others of the same lot that were handled carefully.

4. Removal of heads--some shrimp were stored in ice with heads on and compared to others of the same lot from which heads were removed before storage.

5. Delay in icing--observations were made of black spot incidence during storage of lots of shrimp that had been exposed on deck before being iced. A portion of the lot was iced promptly, then other portions were iced after periods of exposure varying from 1 to 6 hours.

6. Method of icing--the usual method of mixing shrimp and ice was compared with icing the shrimp in layers.

7. Type of ice--finely crushed "snow" ice was used on board the boats. However, in one test the shrimp were stored in the laboratory in coarse, medium, and finely crushed ice to determine if particle size affected the rate of black spot formation. In another test, a special aerated ice was compared with the regular non-aerated ice.

8. Position of shrimp in the pen--portions of the catch that had been iced near the front, in the middle, and at the rear of the pen were separated as they were removed from the hold, to observe differences due to pen position on the incidence of black spot during subsequent storage.

9. Frozen storage--a portion of each lot of shrimp was packaged and placed in storage at +5° F. immediately after arrival at the laboratory. Some lots were observed after 4, 8, and 12 months to determine if storage resulted in increased incidence of black spot.

The shrimp used were pink shrimp, Penaeus duorarum, obtained from commercial vessels fishing in the Tortugas and Campeche areas. The experimental samples of shrimp were well-iced in the vessel hold in separate boxes and were iced on the truck en route from Key West or Tampa to the Marine Laboratory in Miami. Only three 10-oz. packages from each sample were frozen for the storage studies. Five to seven pounds of each sample were held for 14 to 17 days in ice in a cool room. A portion of each of the iced samples was removed for evaluation of

black spot every 2 or 3 days. The black spot evaluations were made by experienced laboratory personnel. Ten shrimp were examined and graded for amount of black spot on the basis of five for no black spot and a reduced score as black spot increased. Black spot was evaluated with both shell-on and peeled shrimp, and a permanent photographic record was made of each test lot.

RESULTS AND DISCUSSION

The condition known as black spot, sometimes called melanosis, of shrimp develops during iced storage even under optimum storage conditions. However, it is evident from examination of even a single lot of iced shrimp that black spot does not affect the lot uniformly. Perhaps the most remarkable fact about black spot is that in any given lot of shrimp stored in ice some shrimp will show no more than greyish markings under the segment edges while a few others will be badly discolored with black spot and most will show intermediate stages of discoloration. The reasons for this difference in individual susceptibility to black spot are not known.

Even when the black spot scores for 10 shrimp are averaged, this variability makes it difficult to detect the effect on rate of black spot development of experimental variations in handling practices.

For example, the average initial scores for black spot, rated on arrival at the laboratory 2 to 4 days after the shrimp were caught, ranged from a perfect 5.0 (these are called "pearls" by the industry) to 3.5. On the other hand, after 14 to 17 days of storage in ice the range of black spot scores was only 4.0 to 2.5. Thus some lots of shrimp started out the tests with more black spot than other lots had at the end of the test period. Further evidence of this unaccountable difference from shrimp to shrimp and lot to lot was the observation that frequently the minimum black spot scores were not recorded at the end of the storage test period. Several of these low average scores were recorded on the ninth day, and one on the seventh day after the shrimp were caught.

Factors not subject to experimental control, such as ratio of shrimp to trash, and the amount of shrimp in the trawl may contribute to these irregularities. However, when the normal handling of any trawl load of shrimp involves six or seven of the test variables, it is impracticable to design an experimental series and obtain a sufficient volume of data to permit statistical separation of all these interacting effects. As a result only very strong influences on black spot development, such as delay in icing the shrimp, have an effect which is definitely noticeable, in spite of natural variability and the maze of compensating handling factors.

This should be considered in the following discussion of the effect of each of the handling factors studied on development of black spot.

LENGTH OF DRAG: There was no consistent relationship of length of drag to amount of black spot. Although samples from the 2-hour drags showed less black spot development during subsequent ice storage, the shrimp from the 3- and 4-hour drags showed more black spot than did those dragged 6 hours. However, the 3- and 4-hour drags had a much higher percentage of trash (86 and 93 percent) than the 2- and 6-hour drags (25 and 44 percent). Possibly a heavy load of shellfish, fish, sponge, and other trash in the net may bruise the shrimp and accelerate black spot formation more than the factor of drag time alone.

WASHING: Washing the shrimp on deck did not reduce the amount of black spot significantly as compared to the unwashed samples in these trials. It should be noted, however, that the Tortugas shrimp used in this test had relatively little mud on them.

BRUISING: Deliberate bruising of the shrimp did not definitely increase the amount of black spot. This variable was investigated in combination with the washing studies and variation in length of drag which made it difficult to interpret the results, that is, the individual effects of the various factors could not be separated with the limited amount of data available.

REMOVAL OF HEADS: Shrimp heads are usually removed before the shrimp are iced, except when the shrimp are very small, or catch rate is very heavy. However, when heads were left on the incidence of black spot during storage in ice was not consistently or significantly increased so as to be apparent as a separate effect among the effects of other handling practices.

DELAY IN ICING: The interval from the time the shrimp are removed from the water until they are iced below deck was found to have the most positive relationship of any of the factors studied to the amount of black spot developing during storage. Shrimp that were iced immediately developed the least black spot, and the incidence of black spot increased for other portions of the same net load of shrimp in a direct relation to the time the shrimp were permitted to lie exposed on deck.

Measurement of temperatures at various positions in the piles of shrimp on deck showed some increases at the top of the pile, especially when exposed to the sun. On the other hand, a strong wind caused a drop in temperature initially at the top of the pile due to evaporation. Thus it was not practical to correlate the amount of black spot to position in the pile or temperature of the shrimp.

MANNER OF ICING: No difference in the amount of black spot that developed during subsequent storage could be demonstrated between two methods for icing shrimp in the hold. Most fishermen ice their catch by mixing ice and shrimp. Use of layers of ice and shrimp was equally effective in preserving quality if the layers of shrimp were not more than 3-4 inches thick and ample ice was used to maintain temperatures near 32° F. In either case a heavy layer of ice was first placed over the hold surface.

TYPE OF ICE: Crushed ice of medium size was used to store the shrimp in the laboratory except for two lots. Aerated ice, that is, ice that had been constantly aerated during freezing was used for one lot and in another test three different particle sizes of ice were used during the storage period. No significant difference in the rate of development of black spot was observed.

POSITION OF SHRIMP IN THE PEN: Observations were made of the temperature of shrimp at six positions in the pens in which the shrimp were iced. The temperature of the shrimp was reduced rapidly, from about 70° F. originally to 35°-36° F. within an hour, and reached 32° F. within $4\frac{1}{2}$ hours. Layered icing was slightly more effective in maintaining the shrimp at or near 32° F. regardless of position in the pens. Actual position in the pen showed little effect on shrimp temperature as long as sufficient ice was maintained between shrimp and the rear hold surface and on the top. The pen position had no definite influence on the amount of black spot.

FROZEN STORAGE: Four of the lots of shrimp frozen immediately after arrival at the laboratory were examined after 4, 8, and 12 months' storage. Five of 29 samples showed a slight increase in black spot during this period. Three lots of samples stored for only 8 months showed no increase in black spot during this time.

PEELED SHRIMP: Since shrimp are never peeled on the boats, this was not an experimental variable. However, the shrimp were peeled in the procedure for evaluating black spot, and it was noted that most of the black discoloration was on the inner surface of the shell. Only when black spot was severe, and especially

when the shell had been injured or perforated, was the muscle tissue of the shrimp noticeably discolored.

CONCLUSIONS AND RECOMMENDATIONS

Natural variability in the incidence of black spot, and the fact that it was not practical to test the effect of the various handling practices individually, tended to obscure the effect of all but the very strong influences on black spot. Thus delay in icing of the shrimp was the only factor that showed a consistent and definite correlation to increased incidence of black spot. However, there was evidence in some of the test series that in various combinations long drags, excessive trash in the catch, bruising the shrimp, storage with heads on, failure to wash free of mud, and poor icing practices may increase the incidence of black spot during subsequent storage of the shrimp in ice.

To maintain optimum quality of shrimp on board the fishing vessel and to keep black spot at a minimum during ice storage the following recommendations are made:

1. Keep time of drag short, particularly when fishing in areas where ratio of trash to shrimp is high.

2. Separate shrimp from trash as soon as possible.

3. Remove heads and wash the shrimp free of mud and other extraneous material.

4. Avoid bruising or crushing the shrimp as they lay on deck.

5. Get the shrimp below deck and iced as rapidly as possible after the net has been reset. The shrimp may be iced either in layers or mixed with the ice, but the amount of ice should be adequate to maintain a cover over the hold surfaces and over the top of the pile of shrimp until the catch is unloaded at port.

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HEAVY CROPS OF PONDFISH CHANNEL CATFISH

Pondfish production records are being broken right and left since many U. S. Bureau of Sport Fisheries and Wildlife pondfish hatcheries are now engaging in the production of channel catfish. To be sure, artificial feeding sometimes supplements the natural and induced fertility of the pond water, but production records are still somewhat phenomenal, averaging between 400 and 800 pounds of catfish per surface acre at various stations during the season ended early in 1959.