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COMPARATIVE STUDIES ON THE KEEPING QUALITY OF COOKED, BEHEADED AND WHOLE SHRIMPS STORED IN ICE[1]

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Cooking shrimp prior to ice storage showed a great advantage over storing raw shrimp (whole or beheaded) that were stored under similar conditions. Cooked shrimps were rejected by the taste panel after 16 days, while the raw beheaded ones were rejected after 14 days and 11 days for the raw whole shrimps.

INTRODUCTION

Shrimp is one of the most esteemed shellfish not only for its good and peculiar taste, but also for its fine qualities, both nutritionally and gastronomically.

The edible portion of fresh shrimp compares favorably in protein content with fish. It has a very low percentage of fat and consequently, a low fuel value per pound. Shrimp contains high amino acid which is believed to be responsible for its characteristic flavor, but in a way also facilitates bacterial spoilage. Shrimp also contains enzymes which break the protein and provide food for bacteria. Some may also, through a series of reactions, oxidize certain compounds and produce a black pigment called melanin which cause melanosis or black spots. The deteriorative factors that cause shrimp spoilage can be roughly divided into two categories: the microbial activity and the chemical process. Several studies and investigations have been

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undertaken to prevent such deteriorative processes in shrimp storage, but such investigations were made separately and independently, that is, no investigation has been made to compare the shelf-life of cooked, beheaded, and whole shrimp stored in ice.

This storage experiment has been conducted to compare the keeping quality of shrimp prepared and treated in the three most common ways by which fishermen and/or processors handle and store them. These three preparations are *cooked, beheaded* and *whole shrimp,* stored in ice and handled under equal conditions. Generally, shrimps die not long after they are landed, and soon after death spoilage sets in, either through marine bacteria or through micro-organisms that happen to contaminate them on deck. For these reasons fishermen and/or processors usually pack their shrimps in ice either whole, beheaded, or cooked. The three situations have been observed and compared by undertaking organoleptic assessment, chemical analysis and bacteriological observations.

MATERIALS AND METHODS

The experimental samples are North Sea shrimps caught by trawl and were 1½ days old upon landing. The iced samples were transported by air from the landing place (Hanstholm), and from the airport they were brought to the laboratory by car. The shrimps were two days old when the experiment began. During transport, the shrimps were placed in plastic boxes and were properly iced, thus, they were still very fresh when received.

The shrimps were divided into three working lots:

First lot: COOKED — The shrimps were cooked for 3 minutes in boiling water with 3% salt; the proportion of shrimp and water is one part shrimp to five parts water. This is to ensure that all the shrimps received almost equal heat treatment. After cooking, the shrimps were allowed to cool and drain at room temperature for about one hour. The shrimps were packed in a polystyrene box with sufficient ice on the bottom of the box, then a plastic netting was placed over the ice before putting the shrimps on top. The shrimps were covered with a plastic sheet to prevent direct contact with the ice above it and to avoid the drip from melted ice. This lot was labelled *C* throughout the experimental period.

The weight loss during the cooking process is about 9% which is surprisingly low in comparison with previous studies in deep sea shrimp wherein 26% weight loss was incurred during the three minutes cooking (Torry Advisory Note No. 54).

Second lot: BEHEADED — The shrimps were beheaded then packed in a polysterene box with sufficient ice below and above the shrimps. This lot was labelled *B* throughout the experimental period. A yield of 60% (tail) was obtained after beheading and this coincided with previous findings that shrimp heads constitute 40% of the weight of whole raw shrimps (Torry Advisory Note No. 54).

Third lot: WHOLE — The whole raw shrimps, were similarly packed in a polystyrene box with sufficient ice below and above the shrimps. This lot was labelled *W* throughout the experimental period. All three lots *C, B* and *W* were stored at 0°C and were handled or treated in a similar manner during the experimental process.

Observations on organoleptic quality assessments, percentage yield, weight loss, chemical analysis (pH and TVB) and total plate count were made every two days until the samples have reached a state of quality rejection based on the following guidelines:

I. The changes in texture, odor, color and general appearance of the three lots which were noted each time samples were prepared for quality assessment.

II. Organoleptic quality assessment. A panel of eight members consisting of four laboratory staff and four training course participants was organized, and, whenever possible, the same members were made to judge the samples throughout the experimental process.

III. Percentage yield. Yield of meat from whole raw shrimps was determined for each lot each time samples were prepared for quality assessment.

IV. Chemical analysis: pH and TVB determinations of each of the samples were carried out in accordance with the experimental procedures set out in the Laboratory Manual for Analytical Methods (Issued by the Technical Laboratory, Danish Ministry of Fisheries).

V. Bacteriological analysis. The procedure for determining total aerobic count set out in the Laboratory Manual is as follows:

It should be noted that the samples for bacteriological analysis for all three lots were beheaded with the shells on.

RESULTS AND DISCUSSIONS

I. The changes in texture, color, odor and general appearance were observed each time samples were prepared for quality assessment. The different changes were noted and correlated to the results of the taste panel assessments.

II. Organoleptic quality assessment. The first raw assessment was made on the day the shrimps were received at the laboratory, that was two days after landing. The shrimps have a glistening reddish pink color, with very firm body and a very fresh odor. On the fourth day after catch, the first organoleptic quality assessment was made. All three samples were rated high with very little difference among the three lots. The samples were rated on descending order: cooked, beheaded and whole. All three samples were still very fresh with sweet taste and fresh odor.

As shown in Table I there was a decrease in the score of all three samples but the rate of decrease was greatest for whole raw shrimps followed by the beheaded. The cooked samples' score decrease was rather slow in comparison with the two raw samples. On the

TABLE I. Table of mean quality score of the different lots of shrimp in relation to storage time.

No. of days after catch	No. of days in ice storage	Cooked (C)		Beheaded (B)		Whole (W)		Scoring scale	
		$\bar{x}$	$t\frac{s}{\sqrt{m}}$	$\bar{x}$	$t\frac{s}{\sqrt{m}}$	$\bar{x}$	$t\frac{s}{\sqrt{m}}$		
4	2	8.33	8.88	8 13	1.30	7.88	0.93	Ideal	10
									9
7	5	7.38	0.88	6.63	0.99	5.75	0.74	Good	8
									7
10	8	6.57	0.87	5.43	1.25	5.00	1.15	Fairly	6
								Good	5
11	9	6.25	0.59	4.88	0.83	3.50	1.18	Accept-	
								able	4
14	12	5.13	0.69	3.25	0.59	—	—	Bad	3
16	14	3.38	1.54	—	—	—	—	Very	1
								bad	0
								Rejection point	4

Note: $\bar{x}$: Mean quality score

$t\frac{s}{\sqrt{m}}$; half interval of confidence

11th day after catch the whole raw shrimps have developed strong ammoniacal odor and there were blackening on the head and legs of the shrimps. About 50% of the head had separated from the tail portion and the eyes had fallen apart. The meat was rather soft. Around 6-8% had black spots. As expected, the panel rejected the *whole* samples. Majority of the panel members noticed a stale or spoiled taste, and some noticed the ammonia odor.

On the 14th day after catch the beheaded shrimp had developed slight discoloration on the body and some black marks on the tip of the tail and legs. There was strong ammoniacal odor. The body was soft and the color became pale. The panel rejected the samples. All of them noticed a stale taste and odor.

The cooked shrimp developed a strong ammoniacal and stale sour odor on the 16th day after catch. The meat was watery, slimy and soft. All these characteristics were noticed by the panel, thus the samples were rejected.

Based on the results of the organoleptic assessment it could be deduced that cooked shrimps could be kept longer than beheaded and whole raw shrimps. The storage life of cooked shrimp is longer by five days than that of whole shrimp and two days more than that of beheaded raw samples.

For ice storage of raw shrimp, beheading prolongs the storage life by two days.

III. Percentage yield. The first samples for percentage yield determination were taken on the 4th day after catch. As shown in Table IV, a yield of 39.8% was obtained from cooked samples, whereas the beheaded and whole samples yielded 29.9 and 29.5% respectively or a difference of about 10% between the cooked and raw states. Table IV shows that cooked shrimps always give the highest yield compared to the two other lots throughout the experimental period. At the beginning of the experiment, the yield for both whole and beheaded were about equal. However, during the storage period, the whole shrimps yielded a higher percentage than the beheaded ones. This may be attributed to the fact that during cooking of beheaded shrimps, there was a greater weight loss due to the absence of the head.

IV. Chemical analysis. It should be pointed out that due to uncontrollable practical problems, the pH value and TVB determinations could not be carried out on the day the experiment commenced.

However, these were determined immediately on the following day, so that the values obtained were used as a basis of comparison for the remaining shrimps measured progressively throughout the experimental period.

Table III indicates that very fresh raw shrimps have a pH value about neutral, but the freshly cooked shrimps showed a higher value of 7.65. Cooking, therefore, increased the pH but this does not seem to accelerate spoilage any faster than the raw shrimps although the trend towards spoilage in all three different lots of shrimps showed progressive increase in pH. The progressive increase in pH during storage was probably associated with the increased formation of ammonia and other volatile bases through autolysis, but there is a lack of knowledge about what causes the pH increase.

The determination of TVB values are shown in Table II. The first two sets of TVB values given in the Table for the third and fifth days after catch are not to be accepted as true values as experimental breakdown had occurred during the process. However, these values also demonstrate the fact that as the shrimps are stored through a prolonged period, TVB values increased. In other words TVB formation progresses with increase of pH during storage

TABLE II. Total volatile basic nitrogen values of the different lots of shrimp as a measurement of autolysis during ice storage.

No. of days after catch	No. of days in ice storage	TVB Values in mg per 100 g of shrimp		
		Cooked (C)	Beheaded (B)	Whole (W)
3	1	6.72	13.44	18.82
5	3	9.41	21.50	22.85
8	6	2.02	2.83	23.52
10	8	4.70	29.57	51.74
12	10	10.75	44.35	86.02
14	12	22.85	76.61	—
16	14	42.34	—	—

TABLE III. Progressive increase in pH values towards the alkaline side during storage of the shrimp.

No. of days in ice storage	No. of days after catch	Cooked (C)	Beheaded (B)	Whole (W)
3	1	7.65	7.20	7.05
5	3	7.87	7.45	7.45
8	6	8.10	7.86	7.84
10	8	8.30	8.00	7.93
12	10	8.43	8.08	8.24
14	12	8.39	8.30	—
16	14	8.50	—	—

time, resulting in the loss of yield and quality. It is rather obvious that the breakdown progresses most rapidly in the whole shrimp, followed by the beheaded and the least in the cooked shrimps. Whole shrimps still contain a considerable amount of enzymes which are mainly found in the head. By beheading the shrimps, the enzymes are greatly reduced, resulting in much slower autolytic changes. In cooking the shrimps, the enzymes are inactivated and therefore autolysis progresses at the slowest rate.

V. Total aerobic plate count. As shown in Fig. III, cooking had practically rendered the shrimps sterile. At the start of the storage experiment (up to almost one week), the plate count of the cooked sample remained low. After 11 days there was a steep increase in the total number of organisms which approached those of both beheaded and whole raw samples. The raw samples, both beheaded and whole shrimps, had higher counts even at the start of the storage experiment and were relatively high compared to the cooked sample throughout the experimental period. However, the beheaded shrimps have a lower bacterial count compared to the whole shrimps.

SUMMARY AND CONCLUSION

The three preparations or treatments by which the shrimps were divided before ice storage are the three most common ways of pre-

TABLE IV. Comparative yield of the different lots. In all cases, the yield was calculated on the basis of the raw shrimps in their original whole state.

No. of days after catch	No. of days in ice storage	Cooked (C)				Beheaded (B)				Whole (W)			
		Weight in grams			% Yield	Weight in grams			% Yield	Weight in grams			% Yield
		Raw (whole)	Cooked	Peeled		Raw (whole)	Cooked	Peeled		Raw (whole)	Cooked	Peeled	
4	2	866.7	800	344.7	39.8	1,000	451.7	299.0	29.9	1,000	785.7	294.6	29.5
7	5	433.3	400	156.1	36.0	500	213.2	134.9	27.0	500	425.0	143.8	28.8
10	8	433.3	400	152.2	35.1	500	199.8	130.4	26.4	500	403.5	140.0	28.0
11	9	433.3	400	146.3	33.8	500	199.5	128.2	25.7	500	387.0	143.3	26.9
14	12	433.3	400	146.1	33.7	500	198.4	125.8	25.2	—	—	—	—
16	14	433.3	400	154.9	35.8	—	—	—	—	—	—	—	—

paring shrimps on board or in processing plants. The results of the experiment showed a great advantage of cooking shrimps prior to ice storage over the raw shrimp that were iced and stored under similar conditions.

Cooked shrimps were rejected organoleptically after 16 days while the beheaded ones were rejected after 14 days and 11 days for the whole. Evidently by cooking the shrimps prior to storage in ice, keeping time of the shrimp can be prolonged by 2 to 5 days as compared to the raw ones. The number of bacteria is also greatly reduced in cooked shrimps. Thereby, bacterial spoilage is greatly retarded.

A higher yield of 10% is obtained from the cooked shrimp compared to both the raw lots.

The yield of cooked meat from the raw shrimps, Fig. II, decreased minimally. In fact the decrease is even smaller than that shown on the figure, because the raw shrimps absorbed up to 10% of moisture during ice storage, which is disregarded in the graph. However, it is believed that there was a loss of dry matter during storage, but the loss was concealed by a gradual increase in water content, which again was associated with the increase in pH. Unfortunately, time did not allow us to determine the contents of the dry matter of our samples.

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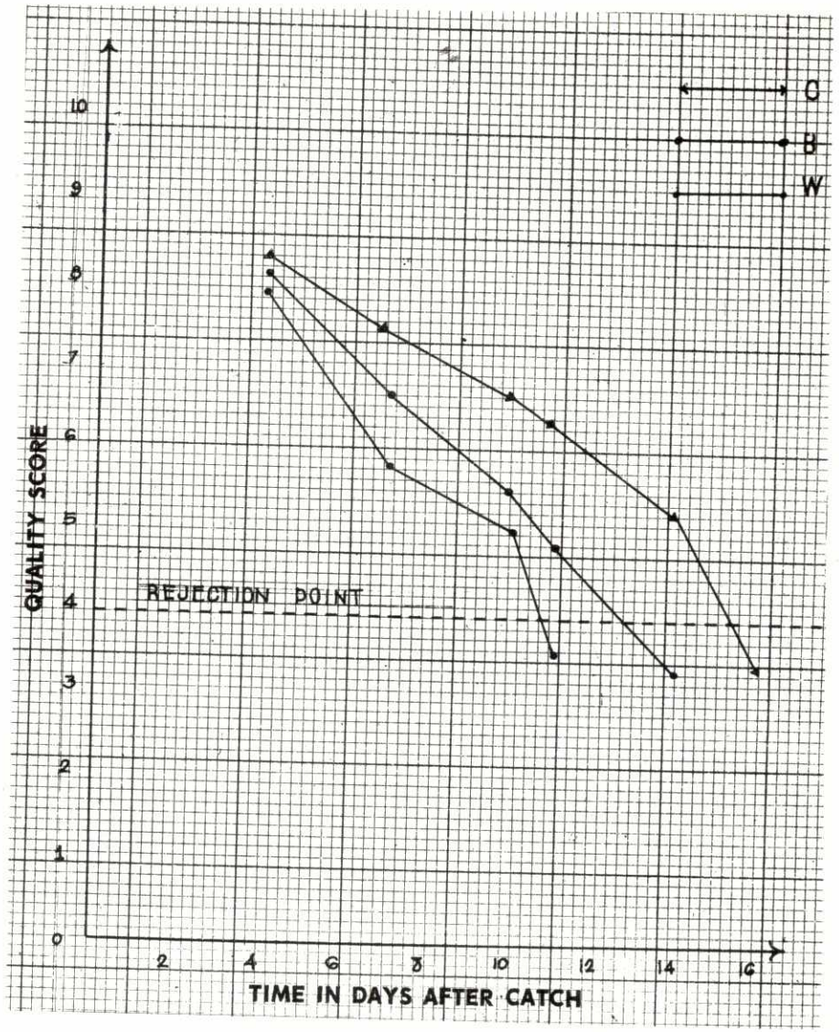

Fig. 1. Quality score of the different lots of shrimped as judged by a taste panel.

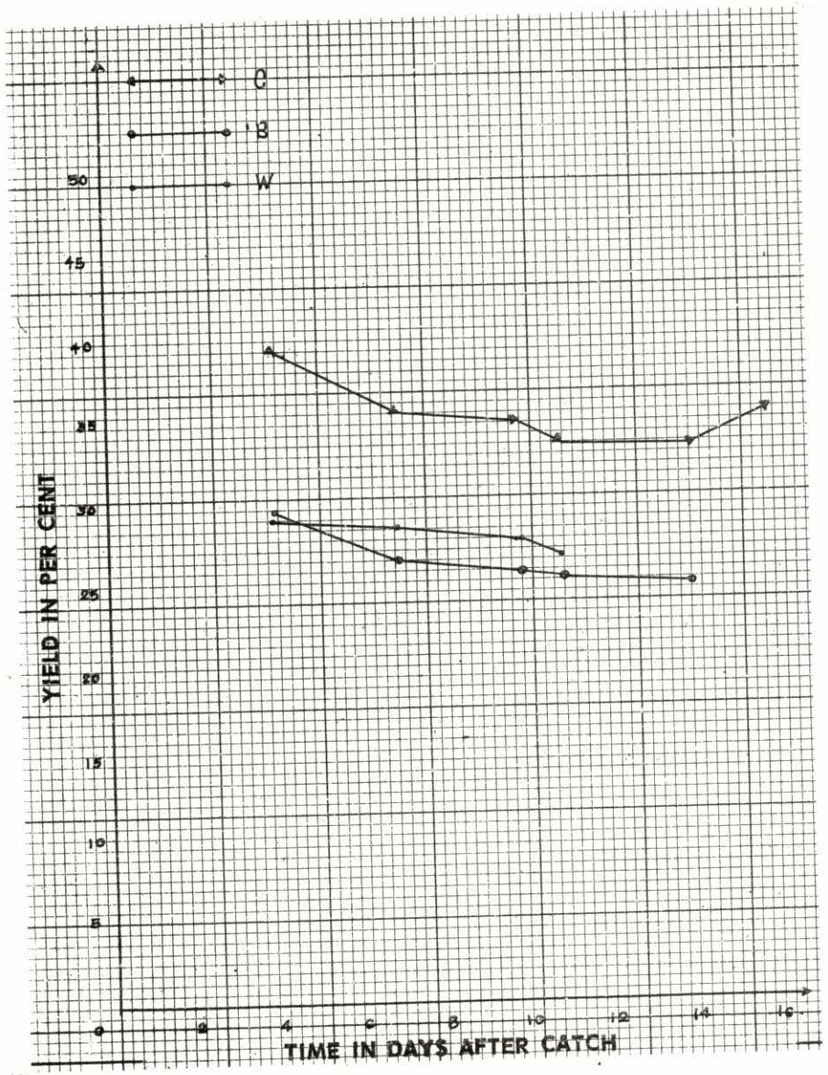

Fig. 2. Yield in per cent of raw whole shrimp in relation to storage time.

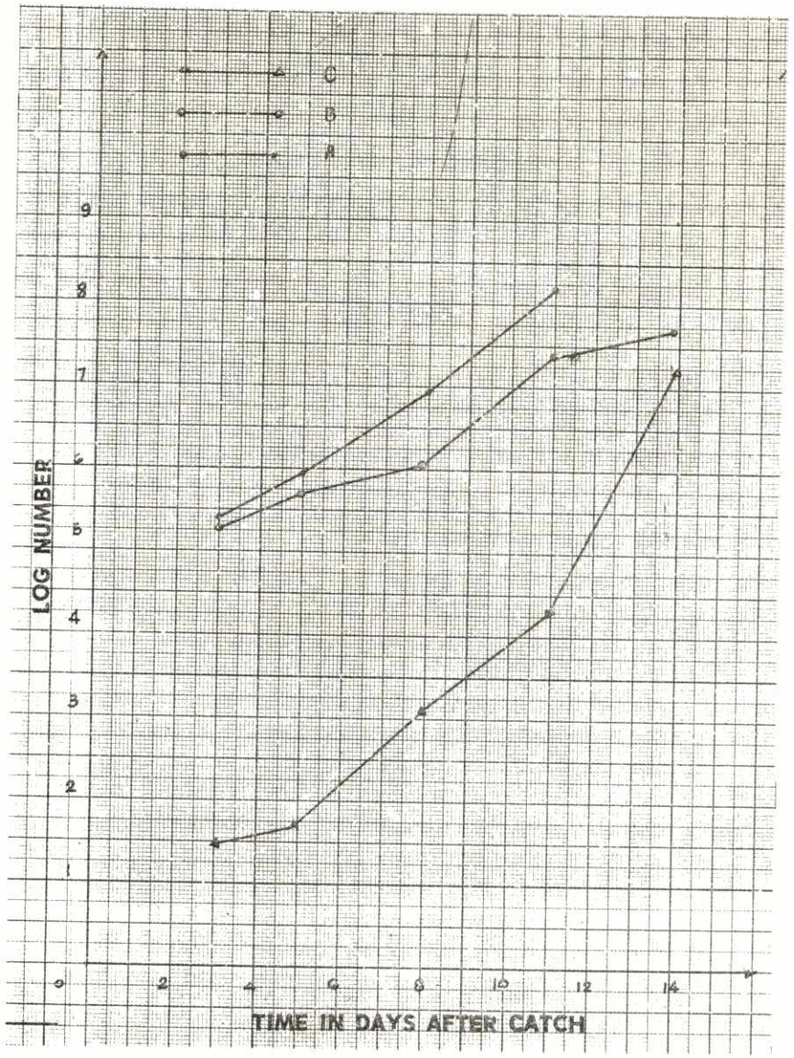

Fig. 3. Relationship between log mean number of total bacterial count and time in days after catch.