THE EFFECT OF COOKING AND FREEZING ON THE CARAPACE LENGTH OF THE AMERICAN LOBSTER, *HOMARUS AMERICANUS* H. MILNE EDWARDS, 1837

BY

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ABSTRACT

In the southern Gulf of St. Lawrence, American lobsters (*Homarus americanus*) seized as evidence in cases of suspected infraction to the minimum legal size regulation are stored frozen. This study tested whether freezing or cooking and freezing measurably affected the carapace length of live lobsters. Tests were performed on 30 soft- and 30 hard-shell animals to reflect the carapace condition of lobsters caught during Spring (hard shell) and Summer/Fall (soft- and hard-shell) fisheries. Cooking and/or freezing had a measurable impact on the carapace length and the changes observed were related to the carapace condition. Except for freezing of soft-shell lobsters, all treatments produced a statistically detectable reduction in carapace length. However, the average carapace length reduction ranged from 0.1 to 0.5 mm, the highest decrease being for hard-shell lobsters after cooking, freezing then thawing (repeated ANOVA, $P < 0.0001$). Of the 60 animals studied, none had carapace length reductions over 0.7 mm, while four had carapace length increases. Although a carapace length reduction could be detected statistically, the impact on regulation enforcement should be minimal.

RÉSUMÉ

Dans le sud du golfe du Saint-Laurent il est pratique courante, en attendant la tenue des procédures judiciaires, de congeler les homards (*Homarus americanus*) saisis dans des cas présumés d'infraction au règlement sur la taille minimale légale. L'objectif de cette étude était de vérifier la possibilité qu'une telle pratique entraîne une diminution de la longueur de carapace. Des tests ont été effectués sur 30 homards de carapace dure et 30 de carapace molle afin de tenir compte des conditions de carapaces observées durant les saisons de pêche du printemps (carapace dure) et d'été/automne (carapace molle et dure). La cuisson et/ou la congélation produit dans la plupart des cas une diminution mesurable de la taille de carapace et les changements observés sont reliés à la condition de la carapace du homard. Tous les traitements ont entraîné une légère diminution de la longueur de carapace à l'exception de la congélation de homards de carapace molle. La diminution moyenne de la longueur de carapace était entre 0,1 et 0,5 mm, et la plus grande diminution s'est

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produite chez les homards cuits puis congelés (ANOVA données répétées, $P < 0{,}0001$). Parmi les 60 animaux étudiés, la plus forte diminution observée de la longueur de carapace fut de 0,7 mm alors que quatre homards ont subi une augmentation de leur longueur de carapace. Malgré la diminution statistiquement significative de la longueur de carapace du homard, une diminution de l'ordre observé ne devrait pas influencer l'application d'une taille minimale légale.

INTRODUCTION

The American lobster, *Homarus americanus* H. Milne Edwards, 1837 supports the most valuable fishery in the southern Gulf of St. Lawrence (sGSL) (Lanteigne et al., 1998). Although the sGSL lobster fishery is managed through five Lobster Fishing Areas (LFAs) and two fishing seasons (spring and summer-fall), minimum carapace length regulations, called minimum legal size (MLS), exist in all LFAs. Carapace length (CL in mm) is defined as the length from the posterior part of the eye socket to the back of the carapace, parallel to the medio-dorsal line. If post-catch handling of lobsters modifies their CL, there is a potential for problems with the MLS enforcement. In Australia, there was a concern that rock lobsters *Jasus edwardsii* (Hutton, 1875) could shrink during cooking but Ibbot et al. (2001) concluded that there was no statistically detectable effect on the CL. Recently, questions were raised concerning the possible effect of freezing on the CL of the American lobster, since it is a common procedure to freeze seized lobsters (either live or cooked animals) in order to preserve evidence for the court. Melville-Smith & Thomson (2003) have found that cooking and/or freezing produced a statistically significant reduction of CL in western rock lobsters *Panulirus cygnus* (George, 1962). They concluded that a 76 mm western rock lobster could decrease from an expected 0.05 to 0.11 mm in CL after freezing, cooking, or cooking and freezing. The largest CL reduction observed in their study was less then 0.3 mm for a cooked then frozen lobster.

This study examines the effect of freezing on the CL of American lobster as well as the effects of cooking and cooking followed by freezing, in relation to the carapace condition. Experiments were conducted on both soft-shell and hard-shell lobsters to cover the lobster's physiological stages during the two fishing seasons in the sGSL.

MATERIALS AND METHODS

Two treatments were considered in the study: (1) freezing of live animals, and (2) cooking of live animals followed by freezing, with each treatment being applied to soft- and hard-shell lobsters. The experiment was carried out in two different periods to account for the seasonality in shell condition, soft-shell lobsters being newly post-moulted animals (July-September) while hard-shell lobsters are considered as late post-moulted or intermoult lobsters. The experiment on soft-shell lobsters took place from 23 to 26 August 2002, and the one on hard-shell lobsters, from 4 to 7 October 2002. Thirty lobsters were used for each shell condition, 15 males and 15 females, and only lobsters of 66.7 to 70.1 mm CL were considered. Lobsters used for this study were collected during regular fishing activities in the Cap Pelé area, Canada (46.17°N 64.16°W) where the MLS was 67.5 mm for the 2002 fishing season. All lobsters were alive and vigorous at the start of the experiment.

The shell hardness criterion (i.e., thumb/finger pressure test) suggested by Ennis (1977) was used in the field to determine the shell condition. At the lab, the carapace hardness of hard-shell lobsters was confirmed by two durometer readings (Model 307HF, PTC Instruments™) as described in Comeau & Savoie (2001). Furthermore, a pleopod reading was performed on all lobsters from the October sample to confirm that they were not in the pre-moult period (Aiken & Waddy, 1980).

At the beginning of each experiment, lobsters were randomly divided into two groups of 15, and identified on their claws by a unique combination of numbered rubber bands. The CL of lobsters was randomly measured twice at each step in the experiment using an electronic calliper (Model CD-8″, Mitutoyo Corporation™). For both the soft- and hard-shell experiments, all lobsters were first measured alive. One group of 15 lobsters was then frozen at -20 ± 1°C, while the other group of 15 lobsters was cooked in boiling salted water for 17 min and then cooled for 1 hr at room temperature (± 20°C). Lobsters were measured again after cooking, then frozen. After 48 hrs, lobsters were measured frozen then left to thaw at room temperature for 4 hrs, and measured for the last time.

To test for difference in CL before and after treatment (before = alive, after = frozen or cooked then frozen) for both soft- and hard-shell lobsters, data were analysed using a repeated measure ANOVA. Three sources of variation were considered in the models, the treatments effect (before and after), the repeated measurements at each treatment stages (time effect) and the carapace condition effect. When required, further tests were conducted using contrasts.

RESULTS

Although the same person performed all of the measurements, there were variations between any two CL measurements of the same lobster at any given step of the experiment. The maximum observed standard error of the mean of the 2 measurements was 0.1 mm.

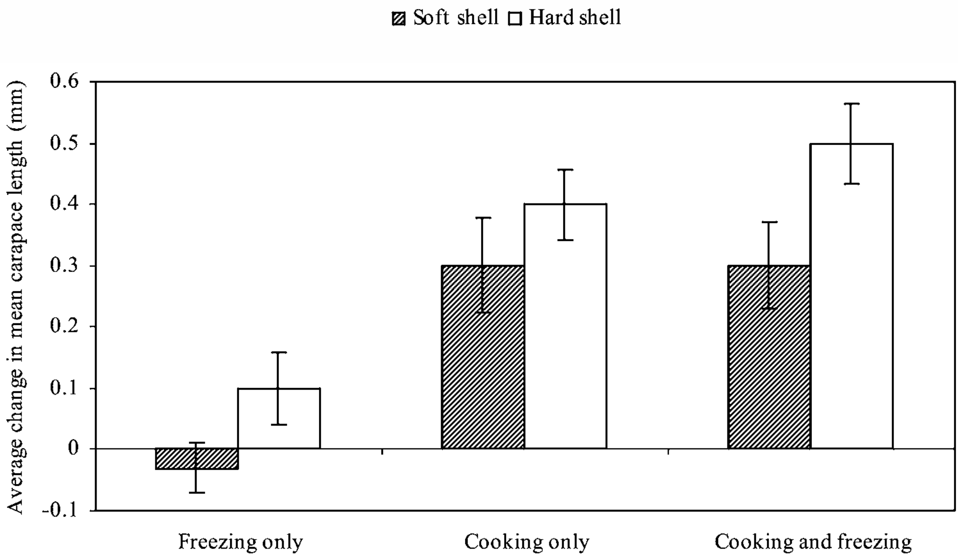

Fig. 1. Average change in mean carapace length measurements after treatment for soft- and hard-shell lobsters *Homarus americanus* H. Milne Edwards, 1837 and the 95% confidence interval band.

The thumb/finger-pressure test on the lobster carapace of the August sample confirmed that all were in soft-shell condition. However, 6 of the 30 lobsters in the October sample were just at the end of their soft-shelled condition, with durometer readings on the posterior portion of the dorsolateral region slightly under 70. They were identified as new hard-shell lobsters. Pleopod samples also confirmed that all October lobsters were not in pre-moult condition and would not moult before the following summer (Comeau & Savoie, 2001).

The CL variation depended on the shell condition and treatment received. All treatments produced a statistically detectable reduction in CL except for soft-shell freezing then thawing (fig. 1). The average CL of frozen only soft-shell lobsters did not change ($P = 0.12$) while the CL for hard-shell lobsters decreased by 0.1 mm ($P = 0.0143$). Cooking produced a significant reduction in the CL of 0.3 mm ($P < 0.0001$) and 0.4 mm ($P < 0.0001$) for soft-shell and hard-shell lobsters, respectively. When cooked lobsters were further frozen then thawed, the CL was reduced an additional 0.1 mm for hard shell lobsters ($P < 0.0001$), while soft shell lobsters did not change. Finally, soft- and hard-shell lobsters had a significantly different change in CL for both freezing only ($P = 0.0031$) and cooking then freezing ($P = 0.0037$) post-catch manipulations.

The proportion of lobsters that had a CL change varied depending on the treatment received (table I). The range of values for changes in mean CL was also larger for soft-shell than hard-shell lobsters (table I). When frozen, three of the soft-shell lobsters increased in CL, 10 stayed the same and two experienced a decrease

TABLE I

Observed frequencies of the changes in mean CL after treatment for soft- and hard-shell lobsters, *Homarus americanus* H. Milne Edwards, 1837. Negative values indicate increases in mean CL

Changes in	Frozen-thawed only		Cooked only		Cooked-frozen-thawed	
mean CL (mm)	Soft-shell	Hard-shell	Soft-shell	Hard-shell	Soft-shell	Hard-shell
−0.1	3	1				
0	10	5	1		1	
0.1	1	2				
0.2	1	4	2			
0.3		3	7	5	10	3
0.4			2	3	2	2
0.5			3	7	1	7
0.6					1	2
0.7						1

in CL. For hard-shell lobsters, only one of the 15 lobsters studied increased in CL, five stayed the same and nine decreased in CL after treatment. There was no CL increase when lobsters were cooked, or when cooked then frozen. All cooked soft-shell lobsters had a CL decrease ranging from 0.0 to 0.5 mm while hard-shell lobsters had a CL decrease varying between 0.3 mm and 0.5 mm. When cooked lobsters were later frozen then thawed, the CL decrease varied from 0.0 to 0.6 mm and 0.3 to 0.7 mm for soft and hard-shell lobsters, respectively. One soft-shell and three hard-shell lobsters had a decrease in mean CL above 0.5 mm after cooking, freezing then thawing.

DISCUSSION

When comparing the size of lobsters before and after treatment, one has to take into consideration measurement errors. In this study, lobsters were measured twice at each step of the study and the largest observed standard error of the mean was 0.1 mm. This value represents the random error. Thus, in this case a difference in CL of less than 0.1 mm can be attributed simply to random error. Increasing the number of measurements taken on an animal would not have further reduced the experimental random error since the precision of the measuring tool was 0.1 mm.

Freezing of live soft-shell lobsters had no statistically detectable impact on their CL. All CL differences before and after freezing were equal to or below the 0.1 mm random error level. For hard-shell lobsters, freezing of live animals produced a statistically detectable reduction of 0.1 mm in the CL, but this reduction is within the random error and could be considered insignificant. However, cooking had both a statistical and physical effect on the CL and average CL reductions observed were above the 0.1 mm random error level. Furthermore, none of the lobsters experienced an increase in CL and length reduction ranged from 0 to 0.7 mm. The average CL reductions were 0.3 mm for the cooked soft-shell and 0.3 mm for cooked frozen then thawed soft-shell, 0.4 mm for the cooked hard-shell and 0.5 mm for the cooked frozen then thawed hard-shell lobsters. For a given treatment, the range of value for the mean CL change was larger for soft-shell lobster.

For the freezing-only treatment, four lobsters had an increase in CL of 0.1 mm. Although the increase is within the measurement error, three of the observed increases in CL were for soft-shell lobsters and could be explained by the water content of those lobsters. After moulting, the integument (carapace) of the lobster is not fully developed with all the membranous layers, and it is still soft and flexible in order to allow body distension through water absorption (Cockcroft & Goosen, 1995; Waddy et al., 1995). Lowndes & Panikkar (1941) found that lobsters absorb about 47% of their fresh weight in water 34 $\pm$ 6 hrs after moulting. Since water expands when frozen, water filled lobsters would have a tendency to increase in length with the expanding freezing water rather than to decrease. In this study, water lost after freezing was noticed for all lobsters, but to a higher degree for the uncooked ones.

The morphology of the lobster carapace is uneven and although not tested, the CL could be slightly different depending on the side of the animal that is measured. In this study, only the right side of the animal was measured. From our observations and by using 0.5 mm as a threshold value for detecting a CL reduction, the probability that freezing or cooking alone produces a reduction in CL above 0.5 mm is zero for soft- and hard-shell lobsters. For lobsters that have been cooked, frozen then thawed, the probability of observing a lobster with a CL reduction above 0.5 mm is 0.033 and 0.100 for soft- and hard-shell lobsters, respectively. Although there is a 0.100 or 10% probability that one hard-shell lobster experiences a CL decrease after cooking, freezing and thawing, this probability quickly decreases with the increasing number of lobsters. The treated lobsters can be seen as independent Bernoulli trials so that the probabilities of observing n cooked, frozen then thawed lobsters with CL reduction above 0.5 mm become 0.033^n and 0.100^n. For instance, the probability that 3 hard-shell lobsters have a CL reduction higher then 0.5 mm after cooking, freezing and thawing is 0.001 or 0.1%.

In this study, we focused our research on near MLS lobsters to investigate the possibility that a legal size lobster could become an undersize lobster by post-catch manipulations. We found that the effect of cooking and/or freezing on the lobster CL seemed to be influenced by the lobster's shell condition. Freezing of lived animals produced the smallest decrease in CL, followed by cooking and cooking then freezing. However, we found that the average CL reduction varied between 0.0 and 0.5 mm and that none of the lobsters in our study experienced a reduction in CL larger then 0.7 mm. Melville-Smith & Thomson (2003) also found a gradual decrease in CL in western rock lobster *Panulirus cygnus* as they increased the number of post-catch manipulations and the largest CL reduction observed in their study was less then 0.3 mm for a cooked then frozen lobster. Ibot et al. (2001) observed fluctuations in CL after cooking for the southern rock lobster *Jasus edwardsii* but concluded that the CL change was not proportional to the initial length. From these results, we conclude that cooking and/or freezing can have a small impact on the lobster CL but should not be considered significant for enforcement purposes.

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