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INDUCED DETOXIFICATION OF SHELLFISH - SOME PRELIMINARY RESULTS

by

A. PRAKASH[1]

Fisheries Research Board of Canada,
Marine Ecology Laboratory,
Bedford Institute,
DARTMOUTH (Nova Scotia), CANADA

INTRODUCTION

Frequent outbreaks of paralytic shellfish poisoning on the Atlantic and Pacific coasts of Canada and the United States have not only resulted in numerous human fatalities and illnesses but have also hindered the fullest possible use of molluscan shellfish resources. Several attempts have been made in both countries to find a practicable method which would eliminate or reduce toxicity in commercially important shellfish, but so far a satisfactory method has not emerged. Furthermore, the high volume, low price characteristic of the affected species and stringent public health regulations have generally discour-

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[1]Present address: Norwegian Institute of Seaweed Research, N-7034 TRONDHEIM-NTH, Norway.

aged potential processors to adopt partially successful detoxification methods or to try out new ones.

Efforts to achieve partial or complete detoxification of shellfish can be grouped under two headings, (1) elimination by transplanting toxic shellfish to non-toxic or low toxicity areas, and (2) elimination by modifying commercial processing methods. Detoxification by transplantation is the most frequently tested method (Medcof et al, 1947; Chambers et al, 1955) but the toxicity decreases achieved by this method are too slow to be economic. In certain species it may take a year or more before the shellfish become safe for human consumption. Substantial reductions in toxin load of shellfish have been achieved by modifying home and commercial processing (Prakash et al, 1971). This has involved a variety of treatments ranging from removal of toxic parts of shellfish before packing, increasing the steaming period prior to canning, raising or lowering the pH, to subjecting toxic meats to ionizing radiations. Such procedures although successful in reducing the poison content to a considerable extent, may also produce extreme changes in the quality of the product and reduce its marked acceptability.

In certain areas of the Atlantic coast of Canada where appearance of toxic shellfish is a seasonal phenomenon, considerable new information on the mechanisms of toxin accumulation in shellfish has been gathered (Prakash et al, 1971). In addition much has become known about the structure and character of the toxin. In recent years, it has been found that shellfish toxin originating in marine dinoflagellates apparantly does not undergo any chemical change within the body of shellfish (Schantz, 1970). This fact prompted a search for simple

means of inducing toxic shellfish to 'spit out' their toxin. Experiments on induced detoxification were carried out on toxic soft-shell clams (Mya arenaria) and blue mussels (Mytilus edulis) at the Fisheries Research Board of Canada, Biological Station, in St. Andrews, New Brunswick. This report deals with some of the positive preliminary results of such experiments.

Live toxic mussels and clams were collected from intertidal beds at Lepreau Basin and Beaver Harbour, New Brunswick, during peak toxicity season (July and August). After estimating their initial toxicity, the shellfish were divided into several experimental batches, each consisting of between 300 to 500 animals of roughly equal size. The shellfish were subjected to a variety of physiological stresses involving different temperatures, salinities and oxygen concentrations. These experiments involved 125 extractions of clams and mussels over a period of 5 weeks. Shellfish extracts were prepared at the Fish Inspection Laboratory of the Department of Fisheries, St. Andrews, N.B., and sent to the Department of National Health and Welfare, Ottawa for toxin bioassays.

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NATURAL DETOXIFICATION

Under natural conditions, the decreases in toxicity with time vary with the species of shellfish as well as with the season. Studies carried out in eastern Canada by Medcof

(1958, 1971) have shown that blue mussels (Mytilus edulis), ocean clams (Arctica islandica) and red mussels (Volsella modiolus) eliminate their poison quickly, whereas Atlantic oysters (Crassostrea virginica) and bay quahaugs (Mercenaria mercenaria) are less efficient in getting rid of their poison. Bay of Fundy bar clams (Spisula solidissima) and sea scallops (Placopecten magellanicus) on the other hand, eliminate their poison so slowly that they often remain toxic the year round. Soft-shell clams (Mya arenaria) are somewhere between mussels and bar clams in their efficiency in poison elimination. There is evidence that low water temperatures retard poison elimination and natural detoxification process slows down considerably in winter months (Prakash et al, 1971).

When recently fished toxic shellfish are first placed in sea water, there is a tendency for toxicity scores to increase slightly followed by a slow decline with time. Medcof et al (1947) first reported this phenomenon in clams and mussels held in flowing sea water tanks. This initial rise in toxicity is not related to feeding of shellfish on toxic plankton element in sea water because in our experiment scores increased even when clams and mussels were suspended in millipore-filtered sea water (Fig. 1, Tables 1 and 2). At this moment it is difficult to explain this phenomenon, but there is little doubt that it is a physiological response on the part of shellfish and may be linked with maintenance of oxygen equilibrium. Both Mya and Mytilus build up an oxygen debt when exposed to air and this debt is offset by increased rate of pumping when they are resubmerged (Newell, 1964). Since complete neutralization of the

shellfish toxin can be achieved by reducing it in the presence of hydrogen or by using a strong oxidizing agent (Chin, 1970), it is probable that its reverse may be happening when the shellfish are paying off their oxygen debt. Thus, the initial increase in toxicity following submergence of shellfish may be more apparant than real.

DETOXIFICATION UNDER ALTERED SALINITY AND TEMPERATURE CONDITIONS

To examine the effect of varying salinity and temperature on shellfish toxicity, several fiberglass tanks with properly aerated filtered seawater of different salinity and temperature characteristics were set up. The control tanks were supplied with filtered seawater (salinity 30.6 °/oo) collected from where the shellfish were originally removed. In all salinity experiments the water temperature was maintained at 12°C which corresponded with water temperature around shellfish beds. Separate experimental lots of toxic clams and mussels were transferred to these tanks within four hours of their removal from natural beds. All lots were sampled at frequent intervals for toxicity assays.

The effect of exposure to different salinities for varying lengths of time on shellfish toxicity is seen in Table 1. Both clams and mussels responded to changes in salinity by reducing more than half of their toxicity within a week. In both cases the controls showed relatively little reduction in toxicity. At salinities higher than 34 °/oo, the shellfish gaped and died within a few days.

Table 1. Changes in toxicity (µg/100 g meat) of clams and mussels exposed to different salinities for varying lengths of time.

Time (hrs)	S ‰	*Mya arenaria*[1] 28	30.6[2]	32	33	34.6	*Mytilus edulis*[1] 28	30.6	32	33	34.6
17		97	88	88	95	92	286	286	264	242	286
88		55	84	59	62	68	264	264	213	220	117
136		47	77	52	<44[3]	55	156	242	130	169	dead
184		44	62	44	<44[3]	dead	108	209	110	121	dead

[1]The initial toxicity was 101 for *Mya* and 242 for *Mytilus*

[2]Control

[3]Toxicity scores <44 are regarded as negative since 44 µg represents the limit of sensitivity of mouse test.

Table 2 shows the results of exposure to different temperatures. Lower temperatures generally retarded detoxification, whereas considerable reduction in toxicity was noticed when shellfish were exposed to elevated temperatures. Increases in water temperature appeared to be more effective in hastening detoxification of mussels than increases or decreases in salinity. However, the data in Table 2 should be interpreted with some caution because in 17 and 21 degree tanks, the salinity increased from 30.6 °/oo to 32.2 °/oo three days after the start of the experiment possibly due to evaporation. It appears that in these tanks the shellfish responded to a combined effect of temperature and salinity by reducing their toxin load.

Table 2. Changes in toxicity (µg/100 g meat) of Mytilus edulis held at different temperatures.

Exposure time (hrs)	TEMPERATURE (°C) 12	17	21
Initial toxicity (in air) = 75			
24	88	81	88
96	62	54	59
120	70	51	48
144	59	59	53
168	59	47	47
192	59	47	<44

Immediate responses to sudden exposures to 'non-adapted' salinities and temperatures may involve changes in behavioural, osmoregulatory, secretory, excretory and other metabolic activities of the shellfish. Evidence is lacking as to which of these activities is involved in detoxification process. More critical experiments on a variety of toxic shellfish are needed before any definitive opinion about mechanism of toxin elimination can be given. The results of our rather simple and perhaps crude experiments suggest that it is possible to reduce or eliminate toxin in live shellfish and that quickest detoxification can be achieved by sudden exposure of shellfish to combined elevation of temperature and salinity.

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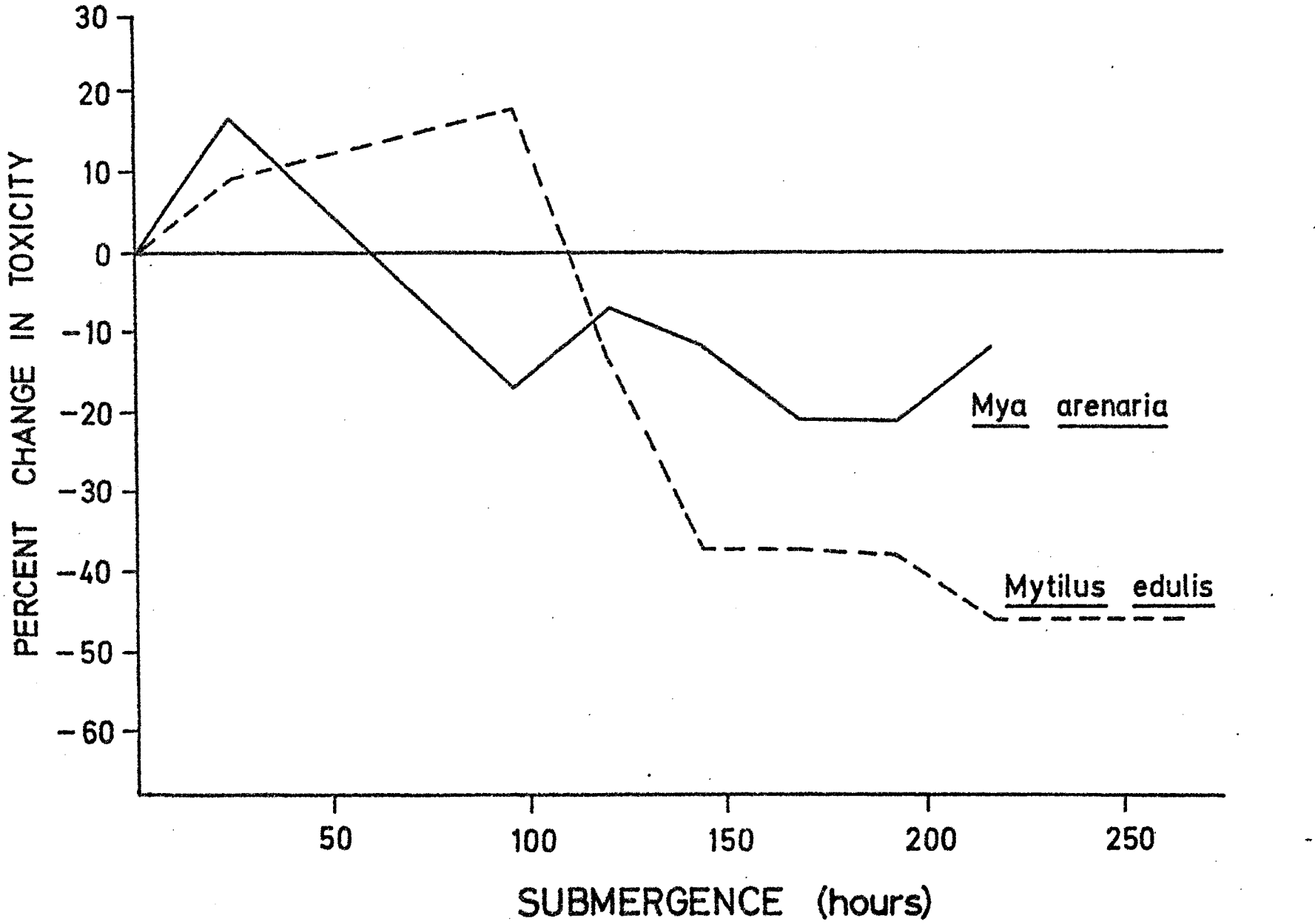

Fig. 1. Percentage change in toxicity of shellfish held in sea water tanks ($T^{\circ}C$ = 12.0; $S^{\circ}/_{\circ\circ}$ = 30.0) for varying lengths of time. The base line at zero indicates the initial toxicity on the first day.