Radiat. Phys. Chem. 1977, 9, pp. 875-885, Pergamon Press. Printed in Great Britain.

Economic aspects of the introduction of radiation preservation of brown shrimp in the Federal Republic of Germany*

by

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Introduction

The shrimp industry in Northern Europe has shown considerable interest in radiation processing as a means of extending shelf-life without chemical preservatives and as a means of reducing hygienic risks. Research efforts in the countries of the European Community are coordinated and have rendered comparable results (1). Several studies were carried out under the conditions prevailing in German shrimp fisheries (2-4). The results are in general agreement with those obtained in non-European countries (5-8).

European interest in shrimp irradiation is related to the small size of brown shrimp (as compared to deep-sea shrimp) and to the difficulties encountered when attempts are made to peel brown shrimp by machine. Only some prototypes of peeling machines are available and they do not meet practical requirements. Individual brown shrimps are normally smaller than 45 mm. Up to 750 make up one kg and only one third of the weight can be recovered as shrimp meat. At present practically all peeling is done by hand in private homes. A person may peel up to 2 kg of shrimps per hour. One of the prototype machines can peel 70 kg per hour, a throughput replacing about 35 persons. In order to imagine the capacity of the machine and the technical problems involved one should consider that a throughput of 70 kg per hour is equiva-

*Received after final date of submission for manuscripts

lent to peeling 15 shrimps per second. However, to peel the maximum landing per day, which sometimes amounts to 40 t, such a machine would need 24 days; or 24 machines are needed to do the job within 24 hours.

The time required for home peeling and for transportation to and from the homes means reduced shelf-life in trade. Exposure to pathogenic microorganisms in the homes is unavoidable. In order to avoid quick spoilage and hygienic risks, preservative mixtures containing benzoic acid and citric acid are used. Radiation processing is a superior alternative (4):

A minimal dose of 130 krad leads to a reduction of the total microbial count by up to 4 orders of magnitude. In our experience, brown shrimps treated with the usual preservative mixture and stored on ice regained the initial microbial count after about 9 days. Shrimps treated with a dose of 130 krad regained the initial microbial count after 18 to 20 days of storage on ice. Sensory evaluation and determination of the content of total volatile basic nitrogen indicated the same prolongation of shelf-life. Furthermore, the radurization treatment effected a reduction of staphylocci, enterococci and enterobacteriaceae equivalent to a marked reduction of the hygienic hazard. Taking into account data from the literature (1,5-8) it appears that even a dose of 100 krad (minimal) is sufficient.

To evaluate the commercial feasibility of the radurization of brown shrimp in the Federal Republic of Germany a survey carried out for the countries of the European Community has been helpful (9). Earlier studies conducted in the USA are less applicable to the situation in Northern Europe.

Economic situation of the German shrimp fisheries

The per capita annual consumption of 90 g shrimp may appear to be small when compared to a fish consumption of about 10 kg (Table 1). However, the tonnage landed and the economic value demonstrate the importance (Table 2) of this branch of the fishing industry. The proceeds of shrimp fishing amounted to about 20 million DM in 1973, or about 5 % of the proceeds of

all German fishing (10,11).

Shrimp landings are distributed over 28 small harbours along the German North-Sea coast. The regional distribution (Table 3) indicates that Schleswig-Holstein is most important in that it provides over 50 % of the total shrimp landings. Of Schleswig-Holstein's eight harbours five are situated relatively close to each other. The bee-line distance for these harbours is less than 60 km, and about 90 % of the total catch of Schleswig-Holstein are landed there (Figure 1 and 2). For that reason a centrally located irradiator (see arrow in figure 2) could be used to irradiate shrimp from all these harbours.

Size of the irradiator and treatment costs

The amount of shrimp landed in Schleswig-Holstein decreased slightly during the past years (Table 2). We may assume landings of about 4000 t per year, equivalent to about 1300 t of peeled shrimp meat. The amounts landed depend very much on seasons (9): The four months from December to March together yield only 3 %, each of the months of April to June 8.2 %, and the months of July to November 14.5 % each, when related to the average landings of one year. The irradiator should be able to treat 20 t per day during the peak season, i.e. July to November. Sometimes a shrimp landing of up to 40 t per day occurs, and this amount should also be irradiated within 24 hours. Based on only one shift of 8 hours per day, the throughput should be 1.5 t per hour at a dose of 100 krad. The power of the radiation source should then be 1.5 kW, corresponding to about 100 kCi of Cobalt-60 (calculations according to 12).

Estimations of treatment costs are rather uncertain as no irradiator has yet been commercially operated for a long enough time (13). Only some experiences with installations for the sterilisation of medical products are available (14). We follow therefore other published estimates (9,12,15-17): If the irradiator is used for a total of 2000hours a year, and if the source contains 100 kCi in order to radurize about 1.5 t per hour at a dose of 100 krad, then the cost will amount to some-

where between 2.00 and 0.10 DM per kg (0.40 and 0.02 $ per lb.). In relation to retail prices of about 25 DM/kg (or 5 $ lb.) such costs seem reasonable; the process is thus commercially feasible. For a preliminary industrial-scale trial it is proposed to make use of the French mobile irradiator TRMA. This has already been done for the sprout inhibition of potatoes by irradiation (18).

Further costs may arise from the additional transportation from the harbours to the location of the irradiator. However, at the time being, shrimps are always transported over considerable distances to distribute them for home-peeling and to collect the recovered meat. In comparison the transport to the irradiator is considered to cause negligible additional costs. On the other hand, packaging the shrimp meat in retail quantities and labeling the packages for shipping before irradiation could rationalize the distribution and yield a saving.

Prospects for practical application

The main obstacle to practical application is the lack of a clearance under the Federal food law. Short-term experiments carried out in the Netherlands on the wholesomeness of brown shrimp showed no adverse effects (19). This finding supports the published observations from long-term feeding studies on other shrimp species carried out in India (20) and in the USA (21,22). A provisional clearance was granted in the Netherlands, to sell test lots of radurized shrimp (23). It is hoped that the Federal health authorities will issue a similar clearance for market testing of irradiated shrimp. A general clearance cannot be expected until the World Health Organization has given a favorable recommendation. Consumer reaction to irradiated shrimps is hard to predict - but it is encouraging that consumers have reacted favorably to irradiated potatoes in Hungary (24), Israel (25) and Uruguay (26) and that a commercial potato irradiator in Japan (13) is operating successfully in its third year.

Summary

Radurization of brown shrimp and shrimp meat to improve the shelflife and the hygienic quality is technically and economically feasible. Prospects of the process for the shrimp fisheries in the Federal Republic of Germany are good. Costs for treatment with a dose of 100 krad are only 0.10 DM per kg under favorable conditions, and about 2.00 DM per kg under the most unfavorable conditions. In view of the benefits to consumer and producer, and in relation to retail prices which sometimes exceed 25.00 DM per kg, such costs appear reasonable.

Economic conditions of shrimp fisheries favour the first installation at a central location in Schleswig-Holstein where about one half of the total German landings could be irradiated. It is suggested to test the market and consumer reactions with experimental lots of shrimp irradiated by use of a mobile irradiator at one of the shrimp harbours. Such a commercial-scale experiment should render enough data to determine whether an investment in a permanent irradiator for brown shrimp will be worthwhile.

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Table 1: Consumption of shrimp, crawfish and mussel products; amounts available for the domestic market (10,11)

	1969	1970	1971	1972	1973
total (t)	2875	3527	4369	5257	5507
per capita and year (kg)	0.05	0.06	0.07	0.09	0.09
for comparison: total fish consumption per capita and year (kg)	9.9	10.6	10.3	8.6	10.4

Table 2: Landings of brown shrimp (10,11)

	1969	1970	1971	1972	1973
total amount (t)	8709	9666	6693	7703	6745
Proceeds (million DM)	17.4	15.4	15.2	19.4	19.6
fraction of proceeds of all fishing (%)	5.2	4.5	4.3	5.8	5.4
amount landed in Schleswig-Holstein (t)	5105	5635	4134	4285	3669

Table 3: Distribution of shrimp landings (in %) for four North-Sea regions of the Federal Republic of Germany (10,11)

	1969	1970	1971	1972	1973
Schleswig-Holstein	58.62	58.30	61.78	55.63	54.40
Oldenburg		6.58	7.39	9.46	9.43
Ostfriesland	27.32	21.69	18.30	19.90	20.89
Elbe-Weser and Bremen	14.06	13.43	12.53	15.01	15.28

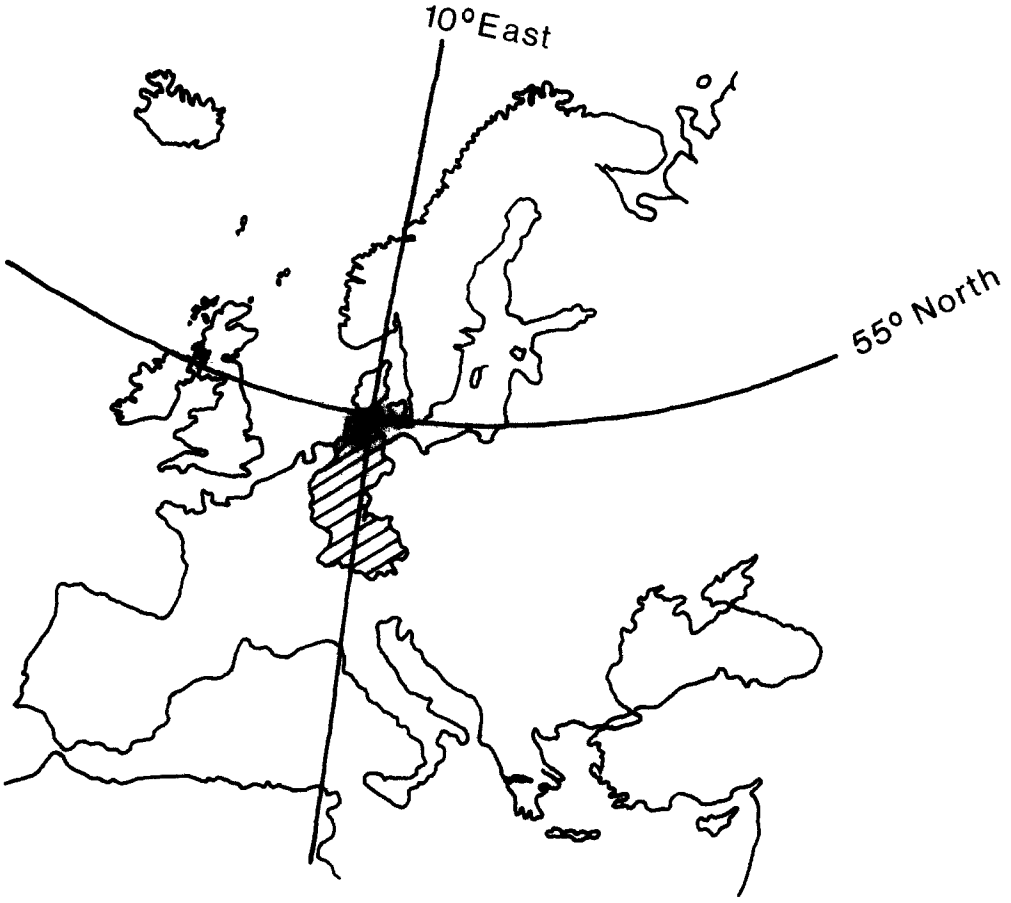

Figure 1: Survey-map of Europe, territory of the Federal Republic of Germany shaded, dark rectangle section shown enlarged in Figure 2

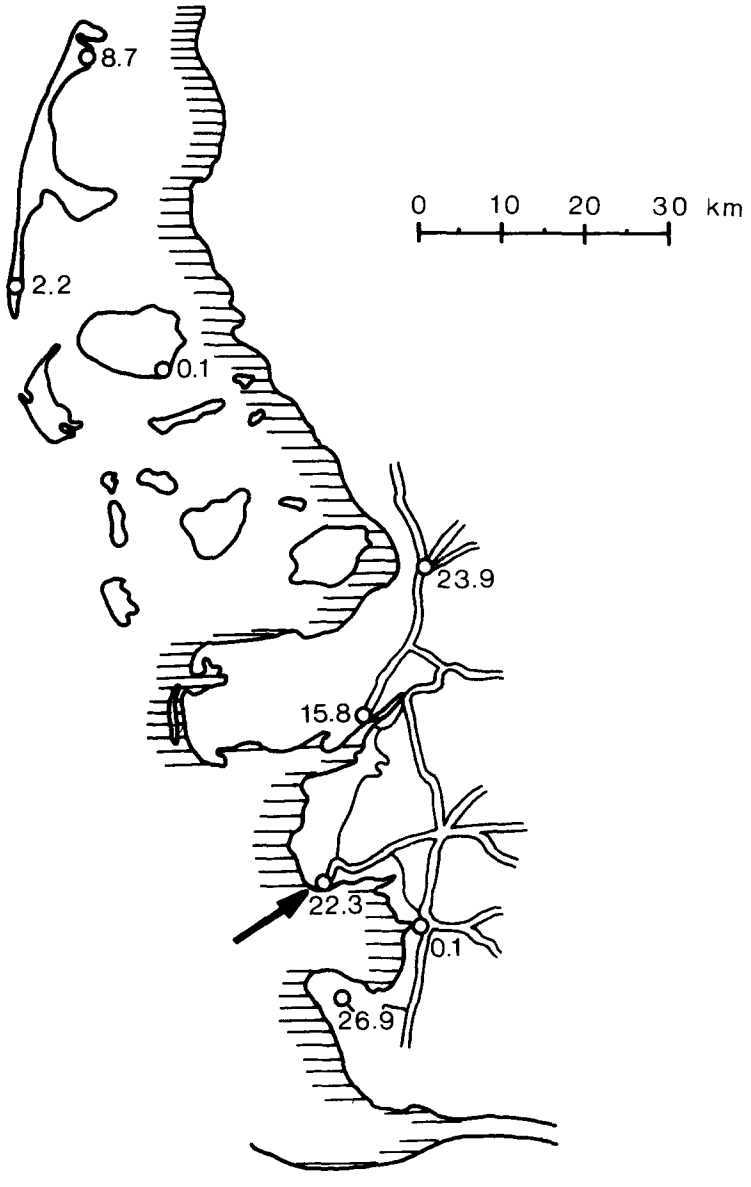

Figure 2: North-Sea coasts of Schleswig-Holstein. Locations of shrimp landings indicated by small circles; figures give portion in percent of total landings in Schleswig-Holstein at the particular harbour. Federal highways shown by double lines, local roads by single lines. The arrow indicates the proposed location of the irradiator