A Research Note

Stability of Radurized Indian Mackerel (Rastrelliger kanagurta) as a Function of Temperature

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ABSTRACT

The influence of 1.5 kGy of gamma irradiation on the stability of Indian mackerel (Rastrelliger kanagurta) stored at temperatures of 0, 5, 10 and 15 °C was examined. Using several indices for assessment of quality, it was found that the radiation treatment suppressed the rate of spoilage of fish stored at the above temperatures. However, the relative spoilage rates of both unirradiated and irradiated mackerel were similar as a function of storage temperature. The storage-life of fish calculated on the basis of the Spencer and Baines equation for evaluation of spoilage compared favorably with scores obtained by organoleptic evaluation.

The influence of temperature on microbial as well as autolytic spoilage reactions occurring in flesh foods is well-known. Spoilage rates of several varieties of fish have been shown to be linearly related to storage temperature (2,9). Hence, temperature fluctuations during processing and storage, particularly during handling and distribution of fresh fishery products, could detrimentally affect the shelf-life of the stored material.

Radurization processes developed to extend the shelf-life of fresh fishery products stipulate that such products be stored at ice temperature after being irradiated (6,8). Studies done in our laboratory have shown the feasibility of using gamma radiation to extend the shelf-life of Indian mackerel (Rastrelliger kanagurta). A dose of 1.5 kGy was found to be optimum (1, 10, 11). The present paper pertains to the shelf stability of radurized (1.5 kGy) mackerel as a function of storage temperature.

MATERIALS AND METHODS

Fish

Fresh mackerel were obtained from the local market. The fish were washed, eviscerated and beheaded. The dressed fish were aerobically packed in polycell bags and were irradiated at ice temperature at a dose of 1.5 kGy (150 krad) in a 60 Co Package Irradiator as described in an earlier publication (12). Packages of unirradiated and irradiated fish were then stored in cold cells maintained at 0, 5, 10 and 15 °C. The temperatures of the cold cells were monitored using thermistor thermometers and, at equilibrium, the temperature variation in each cold cell was about ± 1 °C.

Assessment of spoilage

Fish held at the different temperatures were sampled at selected times and evaluated for spoilage by organoleptic, bacteriological and chemical tests. Organoleptic acceptability (OA) of the fish was evaluated by a panel of six judges using the 9-point hedonic scale (11). The score was based on the appearance, texture and, primarily, odor of the fish at the time of evaluation. An OA score of 5 was the borderline of acceptability. Total volatile acids (VA) were determined by the steam distillation technique described by Venugopal et al. (11). Total volatile basic nitrogen (TVBN) was determined by the method of Farber and Ferro (4) and free fatty acids (FFA) by the method of Ducombe (3). Aerobic plate counts (APC) were determined by the pour plate method using Plate Count Agar (Difco). Petri plates were incubated for 48 h at 37 °C.

Determination of spoilage rates

Indices of sensory, bacteriological and chemical quality of fish were plotted against storage time at each temperature. These plots were essentially linear (11, 12), hence, slopes of the plots were used as the spoilage rates of the fish for each quality parameter considered (9). Units of these slopes were defined as follows: APC, log10 CFU/g/day; VA, equivalents of 0.01 N NaOH/100g/day; TVBN, mg of nitrogen/100 g/day; and FFA, μmol of oleic acid/1000 g/day.

The relative spoilage rate was obtained by dividing the spoilage rate for each specific parameter at a particular temperature, by the spoilage rate obtained at 0 °C using the same parameter (7). Thus, the spoilage rate at 0 °C was unity. The statistical average of relative spoilage rates obtained from the different quality parameters along with the standard deviation was used to identify the quality of the fish during storage at each temperature.

Determination of linear temperature response

The linear temperature response (C) for spoilage was calculated from the Spencer and Baines equation (9), namely, \( k = 1 + C\theta \), where, \( k \) = spoilage rate at temperature \( \theta \) (in degrees Centigrade) \( k_0 \) = spoilage rate at 0 °C and \( C \) = linear temperature response.

RESULTS AND DISCUSSION

Effect of storage temperature on spoilage rates

Previous studies have shown that the shelf-stability of mackerel at 0 °C was extended by treating the fish with...
gamma irradiation at a dose of 1.5 kGy (12). When the treated fish was stored at 0 C it had a shelf-life of about 25 days compared with 12 days for unirradiated mackerel.

Figure 1 shows the spoilage rates of fish in terms of APC, TVBN, VA, OA and FFA values. Spoilage rates of irradiated mackerel were less than the corresponding values for unirradiated mackerel at 0 to 15 C and concur with earlier observations that irradiation at 1.5 kGy eliminated many psychrotrophic spoilage microorganisms (1).

Relative spoilage rates of unirradiated and irradiated mackerel at different temperatures with respect to spoilage rates of the same fish at 0 C are shown in Table 1. The relative spoilage rate of both irradiated and unirradiated fish increased at similar rates with increased storage temperature. Also shown in Table 1 are the values for linear temperature response (C') which measures the relative increase in spoilage rate per degree above 0 C. The values of C' for both unirradiated and irradiated mackerel were comparable to those obtained for several other flesh foods (7). The value of C' was used to determine the storage-life of mackerel at various temperatures, using the modified Spencer and Baines expression, \[ \frac{1}{D} = \frac{1}{D_0} + C \theta \] where D and D_0 are the storage-life at temperatures \( \theta \) and 0 C, respectively (9). From earlier studies, D_0 values, i.e., storage-life of unirradiated and irradiated mackerel at 0 C, were determined to be 12 and 25 days, respectively (12). Using the values of D_0 and C', the storage-life of the fish was calculated. Table 2 shows the storage-life of unirradiated and irradiated mackerel calculated from the Spencer and Baines equation and also the actual values obtained from organoleptic data. It can be seen that these values were comparable. These results suggest that if one knows the temperature at which Indian mackerel is stored, it is possible to predict the shelf-life of the fish at any storage temperature ranging from 0 to 15 C.

Radurization processes for extension of shelf-life of fresh seafoods require that the treated food be stored at a temperature of 3 C or less to ensure against any possible *Clostridium botulinum* type E hazard. In this study we have examined the influence of any inadvertent increase in storage temperature on spoilage rates of mackerel. At higher temperatures it is known that spores of *C. botulinum*, if initially present, will have an opportunity to outgrow and produce toxin. However, as indicated by Hobbs (5), unless high levels of contamination occurred or storage temperatures were higher than 10 C, the botulism hazard would be marginal. This aspect is being investigated with respect to radurized Indian mackerel and will be discussed elsewhere.

### Table 1. Relative spoilage rates and linear temperature response (C') values for Indian mackerel.

<table>
<thead>
<tr>
<th>Temperature (C)</th>
<th>Relative spoilage rate</th>
<th>Linear temperature response (C')</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unirradiated mackerel</td>
<td>Irradiated mackerel</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>2.28 ± 0.98</td>
<td>2.06 ± 0.28</td>
</tr>
<tr>
<td>10</td>
<td>3.30 ± 1.60</td>
<td>4.10 ± 0.75</td>
</tr>
<tr>
<td>15</td>
<td>5.46 ± 0.75</td>
<td>5.84 ± 1.20</td>
</tr>
<tr>
<td></td>
<td>0.26</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>0.23</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td>0.29</td>
<td>0.32</td>
</tr>
</tbody>
</table>

### Table 2. Storage-life of Indian mackerel at different temperatures.

<table>
<thead>
<tr>
<th>Storage Temperature (C)</th>
<th>Storage-life (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unirradiated mackerel</td>
</tr>
<tr>
<td></td>
<td>Calculated from spoilage data</td>
</tr>
<tr>
<td></td>
<td>Calculated from spoilage data</td>
</tr>
<tr>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>5.2</td>
</tr>
<tr>
<td>10</td>
<td>3.6</td>
</tr>
<tr>
<td>15</td>
<td>2.2</td>
</tr>
</tbody>
</table>

*Actual storage-life was obtained from organoleptic data.*
REFERENCES


Ibrahim, con't. from p. 359

greater in batches of processed cheese made from SC as compared with those made from USC. This indicates that lactose was still present in SC immediately before processing at concentrations higher than those of USC. Depletion of lactose in USC was due to the comparatively higher fermentation rate occurring in this cheese because salt was omitted (Tables 1, 2).

It has been reported previously (3,4) that omitting salt from cheese curd made with sub-normal starter activity inhibited growth and enterotoxin production of S. aureus. Results of the current investigation are compatible with these reports.

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REFERENCES