The quality of commercially prepeeled potatoes deteriorates rapidly during nonrefrigerated transportation and storage. A major factor in this deterioration is the development of microorganisms. Ceponis and Friedman (1957) have shown that the shelflife of prepeeled potatoes at room temperature is less than 24 hr. Similar results were reported by Feustel and Harrington (1957).

Gamma irradiation of potatoes has received much attention during the past few years (U. S. Army Quartermaster Corps, 1957). At low levels of irradiation (8,000 to 10,000 rad), no detrimental effects with respect to color, flavor, and texture of the cooked or fried product have been reported. Recent reports on the irradiation pasteurization (up to 300,000 rad) of prepackaged fruits (Gernon, 1959) have opened new possibilities for increasing the shelflife of fresh produce.

The application of antibiotics in prepackaged vegetables has been reported to delay bacterial spoilage (Carroll and co-workers, 1957). Recently, Francis et al. (1959) reported that the addition of oxytetracycline and chlortetracycline to a sodium bisulphite dipping solution increased the shelflife of prepeeled packaged potatoes. The improvement in shelflife was attributed, in part, to the prevention of exudation during the storage period. Supposedly, exudation control was associated with control of bacterial development. However, most of the data are applicable only to storage at refrigerated temperatures.

The present study was undertaken in an attempt to increase the shelflife of prepeeled, sulphite-treated potatoes at room temperature by the separate or combined use of gamma irradiation and antibiotics.

**Materials and Methods**

Sebago and Katahdin potatoes were obtained locally. After peeling and trimming, the potatoes were sliced into French fries of 3/4 in. by 3/4 in. cross section and...
held in cold water until ready for use. The experimental dipping solutions included sodium metabisulphite, oxytetracycline, and nisin. The cut potatoes, after dipping in the selected solutions for specific periods, were drained for 30 sec. Ten samples of approximately 100 g each were packaged in Cryovarc or polyethylene bags. The Cryovac bags were evacuated, sealed, and dipped in hot water of 185 °F for 10 sec. Polyethylene bags were treated similarly, not with the idea of maintaining a vacuum in these bags, but to provide standard initial conditions.

The irradiation treatments were carried out in a GammaCell 220. This irradiation cell contains 4,000 curies of Co\(^{60}\) and the average dose rate is 200,000 rad per hr. Ten sample bags were irradiated at one time. After irradiation, the samples were stored at room temperature and observations on color, flavor, texture, and bacterial counts were made at predetermined intervals.

For the taste panel evaluation, the potatoes were French fried and judged by four panel members.

For the determination of microbial populations, 10 g of the treated potatoes were washed by shaking with 100 ml sterile water in a Precision horizontal mechanical shaker. Serial dilutions of this wash water were plated on Bacto-

tryptone glucose extract agar. Plates were incubated at 30 to 32 °C for 72 hr for mesophilic bacteria counts and in Brewer anaerobic jars for 96 hr for anaerobe counts.

The composition of gas, developed in the samples packaged in Cryovac bags, was determined with the Fisher-Orsat gas analyser.

Peroxidase activity was determined with hydrogen peroxide and guaiacol solutions (Masure and Campbell, 1944).

Results

In the preliminary experiment of this project, peeled, cut potatoes were packaged in Cryovac bags and irradiated immediately at 4,000,000, 1,200,000, 300,000, and 100,000 rad. Upon removal from the GammaCell 220, the potatoes irradiated at 4,000,000 rad showed greyish discoloration and complete breakdown of the tissue. At the 1,200,000 rad level the color of the potatoes had not been affected, but the tissue was softened noticeably. Organoleptic evaluation of these samples was limited to cursory examination because of strong off-odors. These off-odors did not disappear in samples stored for 6 months at room temperature.

Irradiation at 300,000 rad caused no changes in color and texture. The French fries made from these potatoes immediately after irradiation had slight off-flavor. This off-flavor was removed completely by rinsing the potatoes in cold water for 15 min prior to frying.

French fries prepared from the potatoes irradiated at the 100,000 rad level had good color and flavor initially. The shelflife of the 100,000 rad and 300,000 rad samples did not exceed 1 day at room temperature because of black discoloration, presumably caused by enzymes not inactivated at the low dosages.

In the next experiment an attempt was made to prevent the discoloration by one of the following pretreatments prior to packaging: (1) steam blanching for 2 min at 212 °F., (2) 30 sec dip in 2,000 ppm sodium metabisulphite, and (3) 30 sec dip in 2 per cent ascorbic acid.

The steam-blanced potatoes after irradiation at 100,000 and 300,000 rad were not acceptable because of black discoloration after 1 day at room temperature. Since the potatoes after blanching had no peroxidase activity, which is accepted in the food industry as being indicative of an adequate blanching treatment, it was thought that the blackening might be a direct result of irradiation. In further studies, however, samples receiving 1 megarad treatment retained their white color for a minimum of 6 days. It is not known whether the good color retention in this latter instance was due to destruction of enzymes which may have escaped destruction in blanching or to chemical changes in substrate(s) due to the higher irradiation dosage.

The samples dipped in the sodium metabisulphite or the ascorbic acid solution and irradiated at 100,000 and 300,000 rad retained their color for 4 to 5 days. However, because Cryovac bags have a very low permeability to gases, the gas formation caused the bags to swell and eventually break. Analysis of this gas revealed a composition of 78 per cent carbon dioxide and 21 per cent nitrogen. Since neither aerobic nor anaerobic culture tests showed any bacterial development up to this time, the gas formation may be assumed to be associated with the respiration of the potato tissue.

To determine if a more permeable packaging film would prevent gas build-up, and thereby improve the shelflife, the use of polyethylene bags was investigated. Peeled, cut potatoes were dipped in 2,000 ppm sodium metabisulphite solution for 2 min, packaged in polyethylene, and irradiated at 100,000 and 300,000 rad. The results showed no gas build-up in these polyethylene bags for 4 days. However, during this period the bacterial counts of the samples increased from less than 100 per g product immediately after irradiation, to approximately 60,000,000 and 5,000,000 bacteria per g for the 100,000 and the 300,000 rad samples, respectively. Bacteriological analyses of the above samples before irradiation indicated a heterogeneous.

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3 Water-soluble nisin, supplied through the courtesy of Aplin and Barrett Ltd., Yeovil, England.
4 Cryovac Division of the W. R. Grace & Co., Cambridge Massachusetts.
5 Fisher Scientific Co. Ltd., Toronto, Ont. Canada.
microflora. After irradiation, macroscopical and microscopical examination of bacterial colonies showed a gram positive sporeforming rod (Bacillus subtilis) and a lesser number of yeasts and gram negative bacteria.

The effect of various concentrations of nisin and oxytetracycline on pure and mixed cultures of bacteria isolated from the above irradiated and spoiled samples was investigated. It was found that nisin at 10, 20, or 100 ppm was effective only against B. subtilis, but was ineffective against gram negative bacteria or the mixed flora. Oxytetracycline in similar concentrations inhibited the growth of both B. subtilis and the gram negative bacteria in pure culture form, but did not control growth of yeasts in the mixed flora.

Based on the results of the above experiments, the combined use of antibiotics and irradiation was investigated. Peeled, cut potatoes were dipped for 2 min in one of the following solutions: (1) 2,000 ppm sodium metabisulphite, (2) 2,000 ppm sodium metabisulphite plus 100 ppm oxytetracycline, (3) 2,000 ppm sodium metabisulphite plus 100 ppm nisin, and (4) 2,000 ppm sodium metabisulphite, plus 100 ppm oxytetracycline, plus 100 ppm nisin.

Samples from each of these treatments were then packaged into Cryovac or polyethylene bags and irradiated at 100,000 or 300,000 rad. To increase the bacterial concentration on the cut potatoes prior to irradiation, aliquots of rinse water collected during the peeling of the potatoes were added to some of the above pretreatment solutions. The results of these studies are summarized in Table 1.

It is shown that the sulphite dip and the sulphite dip plus irradiation did not control bacterial development. The sulphite plus nisin dip, followed by irradiation gave some control when the initial bacterial count was very low; however, when the initial count was slightly higher, bacterial spoilage became apparent within 4 days. A sulphite and oxytetracycline dip without irradiation treatment resulted in bacterial spoilage of the samples within 2 days. However, the same treatment with irradiation at 300,000 rad resulted in control of bacterial development for at least 6 days. Similar results

<table>
<thead>
<tr>
<th>Pretreatments</th>
<th>Packaging Film</th>
<th>Irradiation Dosage</th>
<th>Bacterial Count per G before Irradiation</th>
<th>Bacterial Count per G ( \times 10^{-3} ) after Irradiation at Following No. of Days’ Storage:</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000 ppm sodium metabisulphite dip for 30 sec</td>
<td>Cryovac</td>
<td>100,000</td>
<td>15.0</td>
<td>100,000</td>
</tr>
<tr>
<td>2000 ppm sodium metabisulphite dip for 30 sec</td>
<td>Polyethylene</td>
<td>100,000</td>
<td>0.9</td>
<td>300,000</td>
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<tr>
<td>2000 ppm sodium metabisulphite dip for 30 sec</td>
<td>Polyethylene</td>
<td>300,000</td>
<td>15.0</td>
<td>100,000</td>
</tr>
<tr>
<td>2000 ppm sodium metabisulphite dip for 30 sec</td>
<td>Polyethylene</td>
<td>300,000</td>
<td>100.0</td>
<td>300,000</td>
</tr>
<tr>
<td>2000 ppm sodium metabisulphite + 100 ppm nisin dip for 30 sec</td>
<td>Cryovac</td>
<td>100,000</td>
<td>1.8</td>
<td>0.3</td>
</tr>
<tr>
<td>2000 ppm sodium metabisulphite + 100 ppm nisin dip for 30 sec</td>
<td>Cryovac</td>
<td>100,000</td>
<td>13.5</td>
<td>1.2</td>
</tr>
<tr>
<td>2000 ppm sodium metabisulphite + 100 ppm oxytetracycline for 30 sec</td>
<td>Cryovac</td>
<td>100,000</td>
<td>36.0</td>
<td>1.5</td>
</tr>
<tr>
<td>2000 ppm sodium metabisulphite + 100 ppm oxytetracycline for 30 sec</td>
<td>Polyethylene</td>
<td>100,000</td>
<td>1.1</td>
<td>0.3</td>
</tr>
<tr>
<td>2000 ppm sodium metabisulphite + 100 ppm oxytetracycline for 30 sec</td>
<td>Polyethylene</td>
<td>300,000</td>
<td>1.5</td>
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<td>2000 ppm sodium metabisulphite + 100 ppm oxytetracycline for 30 sec</td>
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<tr>
<td>2000 ppm sodium metabisulphite + 100 ppm oxytetracycline for 30 sec</td>
<td>Polyethylene</td>
<td>300,000</td>
<td>50.0</td>
<td>0.3</td>
</tr>
</tbody>
</table>

* — = No data.
† x = Further analyses were considered unnecessary.
‡ TNTC = Too numerous to count.
were obtained with the samples pretreated with the sulphite, oxytetracycline, and nisin solution. The incidence of molds, especially when bacterial development had been controlled, caused rejection of several samples. Also, the color of the cut potatoes gradually changed from white to grey during the 8-day storage period. This color change occurred faster when the pretreatment included nisin. Organoleptically, the samples were considered unacceptable because, in addition to the change in color, the potatoes developed a “storage” off-flavor after 2 to 4 days in the package. It was therefore decided to discontinue further experimentations.

SUMMARY

The combined use of low dosage gamma irradiation (300,000 or 100,000 rad) and oxytetracycline controlled bacterial development in prepeeled, packaged potatoes stored at room temperature for at least 6 days. However, color changes and the development of a “storage” off-flavor would preclude the use of this technique for commercial use.

REFERENCES


