Microbiological Deterioration of Frozen Parfried Potatoes upon Holding After Thawing

H. DAVID MICHERNER, FRANK P. BOYLE, GEORGE K. NOTTER, AND D. G. GUADAGNI

Western Regional Research Laboratory, Western Utilization Research and Development Division, U.S. Department of Agriculture, Albany, California 94710

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Frozen parfried potatoes were thawed and stored at 55, 45, and 34 °F (12.8, 7.2, 1.1 °C). Significant changes in flavor and texture did not occur at these temperatures until the total bacterial count exceeded 100 million per gram. These sensory changes were produced after 4, 8, and 20 days of storage at 55, 45, and 34 °F, respectively. Detectable color change appeared sooner and probably was not of microbial origin. It is unlikely that any health hazard exists under the range of conditions studied. Nevertheless, it seems undesirable to market food with such a high bacterial count. At half the storage periods given above, the count did not exceed 100,000 per gram.

Materials and Methods

We used a uniform supply of parfried potatoes which had been packed on the same day from the same potatoes, shipped to this laboratory in frozen condition, and stored at −20 °F (−28.9 °C) until the storage tests began. The potatoes were then divided into lots which were stored experimentally at 55, 45, and 34 °F (12.8, 7.2, 1.1 °C). Each lot consisted of the six 5-lb bags from one carton; each bag served as a separate replicate and was sampled on successive days as described below. All samples were removed from the bags with sterile tongs in such a way as to minimize contamination and mechanical disturbance to the remaining potatoes.

Total aerobic plate counts were made on Plate Count Agar (Difco) with the procedure recommended for frozen vegetables by the American Public Health Association (1), except that the plates were incubated at 30 °C instead of 32 °C. Counts were about the same when plates were incubated at 25 or 18 °C for longer periods. Each sample weighed about 80 g and was blended in an electric blender with nine times its weight of water; the resulting slurry was diluted and plated by the usual methods. Molds were rarely seen on the plates. Counts on Difco Potato Dextrose Agar (not acidified) were lower than those on Plate Count Agar. Large sampling variations were encountered, as previously reported for several frozen vegetables (8). The variation between the lowest and highest count in a set of six replicates was 2- to 10-fold in the 55 and 45 °F (12.8 and 7.2 °C) storage runs and up to 70-fold in the 34 °F (1.1 °C) runs. Nevertheless, the arithmetic means of the replicates, when plotted against time, gave very similar growth curves for separate storage runs on the same material.

Samples of potato for quality determination were removed at the same time as those for bacterial counts. These potatoes were fried by a carefully standardized procedure until fully cooked [375 °F (190.6 °C), 4 min]. They were then compared with controls [stored at −20 °F (−28.9 °C) and similarly fried] by a panel of 19 to 22 trained judges in order to detect changes in flavor, texture, and color. Differences in each of these quality attributes were determined on completely separate sets of samples. All comparisons were made by the duo-trio test and replicated twice, to give a total of 38 to 44 judgments. The time required for significant change (P ≤ 0.01) in each quality attribute was determined by plotting the percentage of correct responses against holding time at the three temperatures. The basis of this procedure is discussed in detail elsewhere (6).
RESULTS AND DISCUSSION

The total aerobic plate count, when plotted against time, gave typical microbial growth curves for all three temperatures (Fig. 1). Both lag phase and growth rate during the logarithmic phase were temperature-dependent. The decrease in count during the lag phase at 34 F (1.1 C) probably resulted from death of some cold-sensitive organisms before the cold-tolerant organisms began to grow. This phenomenon has been described elsewhere (8).

The time-temperature combinations which caused significant changes, at 1% probability ($P < 0.01$), in color, texture, and flavor are shown in Table 1. The bacterial counts corresponding to these storage times are shown in Fig. 1. At each temperature, the count was in the range of $10^8$ to $10^9$ at the time when the judges first found significant flavor and texture changes in the product. They detected color changes at much lower bacterial counts.

Three runs (one a preliminary two-replicate run) were made with these potatoes at each temperature. The counts from all the runs were in agreement. In another set of storage tests with parfried potatoes from a different source, the total count rose slightly faster, but the judges did not detect flavor or texture changes until it had reached $10^8$ to $10^9$ per gram.

Since flavor and texture changes were detected when the bacterial count reached the same order of magnitude regardless of the temperature, and since this represents an increase in count of 100,000-fold from the beginning of each storage experiment, it seems a reasonable assumption that these sensory changes occurred as a result of the microbial growth. Color changes were detected much earlier, in one case when the bacterial growth curve was barely past its lag phase, and in others when the bacterial count had not increased over 500-fold (or exceeded $2 \times 10^6$ per gram). Because the color change appeared early and its appearance was not closely related to bacterial count, it does not appear to be of bacterial origin. In a previous report (8), flavor deterioration in several vegetables was judged to be of nonbacterial origin because the off-flavor appeared before the bacterial counts doubled. Bacterial counts in this case ranged between approximately $10^4$ and $10^6$ per gram.

These data can be readily compared with the rather numerous reports on cold stored meat, poultry, fish, etc. (summarized by Elliott and Michener, 4). The microbial counts after storage periods just sufficient to produce detectable off-odor varied between $10^4$ and $10^6$ per gram or per cm$^2$, but most were in the upper part of this range. One should remember, however, that the potatoes were fried, thus presumably eliminating volatile constituents which might have affected the flavor.

If the storage periods required for flavor change (Table 1) are taken as the shelf life of the product...
at these temperatures, it may be seen that, at relatively high temperature, e.g., 55 F (12.8 C), a small temperature reduction will give only a small increase in shelf life, whereas at a lower temperature, such as 34 F (1.1 C), the same temperature reduction will result in a much larger increase in shelf life. This relationship holds for numerous sets of published data on beef, fish, and poultry meat (5).

It seems very undesirable, however, to store these parfried potatoes until they have bacterial counts in the range of $10^6$ per gram, only because they do not have an off-flavor until then. Maximal counts suggested as standards for frozen vegetables have been in the range of $10^6$ per gram (4), and most rules and recommendations regarding handling of frozen foods state that they should be kept frozen, in fact, kept at or near 0 F (−17.8 C) until they reach the consumer. If the storage times of approximately 4, 8, and 20 days (Table 1) had been cut in half, the count would not have been above $10^6$ per gram. Even this reduced storage time, however, is borderline for color changes. In addition, thawed potatoes absorb more fat on frying than do frozen ones (9).

The safety of these potatoes should also be considered, because food-poisoning staphylococci can produce a heat-resistant toxin (2). However, these organisms are not known to grow below 44 F (6.7 C) even in pure culture; at 50 F (10 C), they failed to grow in mixed cultures, and only limited growth was observed at 68 F (20 C) (reviewed by Michener and Elliott, 7). Furthermore, the frying conditions [375 F (190.6 C), 4 min] were severe enough to inactivate staphylococcal enterotoxin A (3) at the surface of the potato (where the bacterial growth generally occurs), although this toxin would remain active at the center of the potato pieces, where the maximal temperature was about 214 F (101.1 C). Any danger from the other common food-poisoning organisms (Clostridium botulinum and Salmonella species) was ruled out by the high temperature at which the product was cooked. In addition, growth of these organisms is unlikely at the storage temperatures and times under consideration, and potato is not an optimal substrate for them.

Literature Cited