INFLUENCE OF SPAGHETTI EXTRUDING CONDITIONS, DRYING AND STORAGE ON THE SURVIVAL OF Salmonella typhimurium

INTRODUCTION

THE PROBLEM of microbial contamination of food greatly concerns food processors and regulatory agencies, as well as consumers. Foods of many types, including macaroni and spaghetti (pasta) products, have been seized or recalled from the market because of contamination with microorganisms. According to the Food and Drug Administration (FDA), the number of legal actions and voluntary food recalls for all types of contamination has increased steadily in the last few years. Of specific interest are the number of seizures and recalls which involved microbiologically contaminated pasta products. In 1969 and 1970, the number of such recalls was three and eight per year, respectively (Walsh, 1973).

Because of the nature of flour and semolina and the fact that pasta products are not heated high enough to destroy many bacteria during commercial processing, some microorganisms will be found in even the most carefully processed pasta products. In nearly all cases, these organisms are harmless saprophytes which are of little concern. However, under certain circumstances, potentially pathogenic organisms, particularly salmonellae, can contaminate commercially processed pasta products. Of 909 samples of macaroni, spaghetti, and other similar products analyzed by the FDA in selected periods from 1969-1974, salmonellae were isolated from 37 of the samples (Schwab, 1974).

Commercial food drying operations are often lethal to salmonellae. McBee and Cotterill (1971) reported that spray drying destroyed approximately 99% of S. oranienburg cells which were added to egg whites. High inlet air temperature (121°C) and air velocity (300 cm/sec) were used. Bayne et al. (1965) reported that salmonellae were relatively sensitive to heat. However, in foods such as milk solids, heat resistance of S. typhimurium increased (Dega et al., 1972). Consequently, it is difficult to predict survival rates for Salmonella in food drying operations. Survival of S. typhimurium of up to 53% was reported for freeze drying in model systems (Sinsky et al., 1967). High platen temperature reduced survival. Addition of 5% dextrose to a model system increased survival of the organism during storage.

In the present research, the influence of spaghetti extrusion, drying and shelf storage on the survival of Salmonella typhimurium was studied.

MATERIALS & METHODS

Preparation of inoculated spaghetti

Spaghetti ingredients consisted of commercial enriched semolina, spray-dried whole egg solids and distilled water. To make spaghetti dough, 1.580g semolina, 80g egg solids and 350 ml water were premixed in a Hobart C-100 mixer by blending for 3 min with a pastry knife. S. typhimurium inoculum was added with the water so that the product contained 10-15 million bacteria per gram (dry basis). Spaghetti was extruded (Walsh et al., 1971) on a continuous DeMacO pasta extruder which had an extrusion capacity of 11 kg/hr. The extruder produced spaghetti under conditions comparable to commercial practice. Each lot of spaghetti was extruded through a 1.5 mm Teflon spaghetti die. Auger speeds of 12, 20 and 30 rpm and temperatures of 35, 45 and 55°C were used to study the influence of processing variables on survival of S. typhimurium. Each batch of spaghetti was dried at 37°C for 18 hr in an experimental pasta dryer (Gilles et al., 1966). The relative humidity (RH) in the drying chamber was lowered in a straight line gradient from 95% RH at the beginning to 61% RH at the end of the spaghetti drying cycle. The dough and wet spaghetti contained 31.5% moisture and the dry spaghetti had a moisture content of approximately 12.5%. Dry spaghetti was packaged in commercial half-pound spaghetti boxes and stored at room conditions.

Bacteriological materials and methods

S. typhimurium was provided by the Microbiology Facility, Food & Drug Administration, Minneapolis, Minn. The culture was isolated from a commercial pasta product and no strain number was provided.

Cultures were grown overnight in 100 ml Nutrient Broth (Difco) at 37°C with shaking. The culture was centrifuged and the pellet was suspended in phosphate buffer, pH 7.2 (Sharf, 1966). The concentration of the cell suspension was adjusted to 20% transmittance (0.70 OD) at 420 nm. 20 ml of the suspension were diluted to 250 ml with phosphate buffer. This diluted suspension and 100 ml distilled water were premixed with the semolina and egg solids, as previously described.

Bacterial counts were determined for each portion from the dough for an initial count, on wet spaghetti emerging from the extruder, the dry spaghetti at the end of the drying cycle and for packaged spaghetti.

A representative 25-g sample of dough or spaghetti was blended in 225 ml 0.1% Peptone Broth (Difco) in a Waring Blender at high speed for 2 min. Mixture were allowed to settle for 3 min and samples of approximately 2 cm from the bottom of the blender container. When subsequent sampling was required, samples were resuspended by 5 sec of blending. Serial dilutions were made in 0.1% Peptone Broth. The inoculum (0.1 ml) was evenly spread with a bent glass spreader on duplicate plates. All plates were incubated for 48 hr at 37°C prior to counting.

Spread-plate techniques were limited to populations of 5,000 cells/ml or higher (FDA, 1972). For estimation of lower numbers of cells a most probable number (MPN) method was used (Sharf, 1966). 20-g samples were blended for 2 min with 180 ml 0.1% Peptone Broth and serially diluted, 10-ml aliquots of each dilution were added to five screw-cap tubes, each of which contained 10 ml of double-strength Selenite-Cystine broth (Difco). After these tubes were incubated for 24 hr at 37°C, the presence of S. typhimurium was tested by streaking onto plates of brilliant green-MacConkey agar (Difco). Appearance of typical colonies on this medium constituted evidence of a tube positive for S. typhimurium (Thatcher and Clark, 1968). Confirmation was made by inoculation of colonies from each plate onto TSA (Difco) and Lysine Iron (Difco) agar slants and subsequent appearance of biochemical reactions typical of S. typhimurium (FDA, 1972).

All counts were expressed on a dry weight basis to correct for variation in moisture content.

RESULTS & DISCUSSION

FIGURE 1 shows the effects of extrusion, drying and storage on the population of S. typhimurium in a representative sample. Of the original inoculum of 1.5 x 10⁴ cells/g only 6% survived extrusion. Of these survivors, 95% were destroyed by the drying process.

At the beginning of the drying cycle the moisture content of the spaghetti was approximately 31% and probably adequate for bacterial growth. The 35°C temperature and initial humidity (95% RH) of the drying cabinet suggests the possibility of growth of microorganisms during the early stages of drying. However, the net result of the drying process was a reduction in numbers of viable S. typhimurium.
CONCLUSIONS

FROM THE RESULTS, it was concluded that spaghetti, after extruding and storage resulted in a decrease in viability of S. typhimurium. Conditions of high extrusion rates at low temperatures resulted in the highest death rates of the test organism. Spaghetti drying further diminished the S. typhimurium detectable population. Shelf storage resulted in the death of most of the S. typhimurium which remained viable after drying. However, the population appeared to stabilize after 2 months of storage and even after 4 months a residual number of viable S. typhimurium remained.

REFERENCES


M. revised 3/21/74; accepted 6/13/74; accepted 6/18/74.

Presented at the 57th Annual Meeting of the American Association of Cereal Chemists, Miami Beach, October 29, 1972. The work was sponsored in part by grants from the National Macaroni Manufacturers Association and the Cargill Inc.

The authors gratefully acknowledge the technical assistance of M.B. Boeder and S. Vasiljevic.