Research Note

Aspects of the Microbiological Quality and Safety of Ready-to-Eat Foods in Sharjah Supermarkets in the United Arab Emirates

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ABSTRACT

Over the last few years, ready-to-eat (RTE) foods have become popular in grocery stores all over the world. This study was conducted to evaluate the microbiological safety and shelf life of some RTE salads sold in supermarkets in Sharjah Emirate, United Arab Emirates. Samples of four RTE salads, tabbouleh, hummus, Greek salad, and coleslaw, were obtained from supermarkets and examined for aerobic bacteria, Escherichia coli, Staphylococcus aureus, Salmonella, and Listeria monocytogenes. The results indicated significant differences (P ≤ 0.05) for the aerobic bacteria count among the RTE salad types. In tabbouleh, hummus, Greek salad, and coleslaw, E. coli counts of 0.9, 0.50, 0.27, and 0.25 log most probable number (MPN)/g and total aerobic bacterial plate counts of 3.57, 2.71, 2.76, and 2.52 log CFU/g, respectively, were found after preparation (day 0). At day 0, all RTE salads tested except tabbouleh contained an acceptable count of total bacteria, but the aerobic bacteria count for all the RTE salads increased rapidly during storage from day 2 to day 6, regardless of the storage temperature (5, 25, and 40 °C). Twenty percent of all samples contained E. coli, although the numbers were as low as 1 log MPN/g. No S. aureus, L. monocytogenes, or Salmonella serotypes were detected in any of the RTE salads tested in this study.

Ready-to-eat (RTE) foods include various types of food products that can be categorized in many different ways. According to the definition given by the Codex Alimentarius Commission (4), RTE foods include any food (including beverages) that is normally consumed in its raw state or any food handled, processed, mixed, cooked, or otherwise prepared into a form in which it is normally consumed without further processing. RTE foods differ in different countries, according to local eating habits, availability, and the integrity of the chill chain and regulations.

Demand for RTE foods has led to an increase in the amount and selection of products available for the consumers. Some examples of RTE foods are meals for lunch, such as fresh cut vegetables, fruit salad, spinach salad, and other meals of meat and poultry products. RTE appetizers prepared from vegetables may consist of trimmed, peeled, sliced, shredded, washed, and disinfected vegetables. Raw vegetables may be combined with cooked vegetables, meats, pastas, or salad dressing. The products are generally packaged and stored at refrigeration temperatures (15).

RTE foods contain the indigenous microflora of the raw materials from which they are prepared. Pathogens may form part of the microflora, posing a public health problem. The microbiological quality and safety of RTE foods also are influenced by processing steps and storage conditions that may introduce other microorganisms. RTE foods prepared from vegetables harbor large and various populations of microorganisms frequently present at a rate of 10^5 to 10^7 CFU/g (6). In general, 80 to 90% of the bacteria associated with vegetables are gram-negative rods, predominantly Pseudomonas, Enterobacter, and Erwinia species (5, 11, 13). Lactic acid bacteria also have been detected in mixed salads that are held at above 30°C (12). RTE foods have an acceptable track record in terms of food safety (14); however, foodborne pathogens may be present, and outbreaks of foodborne diseases have been traced to RTE foods (3, 8, 18, 19, 22). Pathogens frequently associated with RTE foods are Listeria monocytogenes, Salmonella, Staphylococcus aureus, Clostridium botulinum, Aeromonas hydrophila, Yersinia enterocolitica, and Campylobacter jejuni (18), and some of these pathogens were investigated in this study.

In England and Wales, 4.4% of foodborne diseases were associated with consumption of RTE salads, fruits, and vegetables (16). However, a foodborne outbreak of listeriosis was the first to occur in the Maritime Provinces of Canada in 1981 and involved 34 prenatal cases and 7 adult cases. The source of the outbreak was coleslaw, and L. monocytogenes was found in the stored cabbage used to produce the coleslaw (22). At the end of September 2005, 157 cases of Escherichia coli O157:H7 infection in the United States were associated with consumption of raw
Salmonella is one of the most frequently reported causes of foodborne outbreaks of gastroenteritis. A number of outbreaks of salmonellosis have been linked to vegetables. An outbreak of salmonellosis in the United Kingdom in 1988 was associated with consumption of bean sprouts and was attributed to Salmonella Saint Paul and Salmonella Virchow PT34 (19). Few data have been published with regard to interactions between E. coli and other microorganisms in food. E. coli O157:H7 is more competitive with spoilage microorganisms than is Salmonella (29) and, through its acid tolerance properties, is hypothetically more resistant to the acidic fermentation end products produced by lactic acid bacteria.

Storage of RTE foods at adequate refrigeration temperatures limits the growth of psychrotrophic pathogens. Previous work has revealed that L. monocytogenes survives or grows on a range of RTE foods such as iceberg lettuce (2, 27) and shredded cabbage (10) and on a range of fresh vegetables at refrigeration temperatures (1). Reduced storage temperatures result in extended bacterial lag phases and reduced rates of growth (2, 3). However, temperature abuses during storage markedly reduce the lag and generation times and permit rapid growth of L. monocytogenes.

The aims of this study were to evaluate and assess the prevalence of the most common pathogenic microorganisms (S. aureus, E. coli, Salmonella, and L. monocytogenes) in RTE foods (tabbouleh, hummus, Greek salad, and coleslaw) and to evaluate the effect of storage temperature and time (shelf life) on the growth of the aerobic microorganisms.

**MATERIALS AND METHODS**

The RTE foods analyzed for this study were tabbouleh salad, Greek salad, coleslaw salad, and hummus. A total of 120 RTE food samples were collected from three supermarkets in Sharjah Emirate, United Arab Emirates (UAE), and the total bacterial counts and the prevalence of the most common pathogenic microorganisms (S. aureus, E. coli, Salmonella, and L. monocytogenes) were determined.

**Sampling locations.** The RTE foods were collected from three branches of supermarkets in Sharjah. These supermarkets are the major distributors of the majority of RTE foods available in Sharjah.

**Sample collection.** The RTE foods were freshly prepared in the supermarket kitchens and displayed for sale at refrigerated counters. Appropriate amounts of each RTE food packed in the original container (plastic container with cover) were collected and transferred to the Sharjah Municipality Food Control Laboratory under controlled temperature conditions. The Food Laboratory is accredited by the United Kingdom Accreditation Service (Feltham, UK). At the laboratory, the samples were aseptically and proportionally divided into sterile stomacher bags and stored at three temperatures (5, 25, and 40 °C). The samples stored at 5 °C were analyzed at 0, 1, 2, 4, and 6 days, and the samples stored at 25 and 40 °C were analyzed at 1, 2, 4, and 6 days.

**Microbiological methods.** International Organization for Standardization (ISO; Geneva, Switzerland) techniques were used for microbiological analysis. The enumeration method for aerobic bacteria was the aerobic plate count technique at 30 °C, ISO 4833:2003(E). The method used for the detection and enumeration of presumptive E. coli was the most-probable-number (MPN) technique, ISO 7251:2005(E), and additional biochemical tests were performed to confirm E. coli presence with the API Rapid ID 32 E system (bioMérieux, Marcy l’Étoile, France). The method used for enumeration of coagulase-positive staphylococci (S. aureus) was ISO 6888-1:1999(E), and additional biochemical tests were performed using API ID 32 STAPH (bioMérieux). The method used for the detection and enumeration of Salmonella serotypes was ISO 6579:2002(E), and additional biochemical tests were performed using the API Rapid ID 32 E system. Results for Salmonella were reported as detected or not detected in 25 g of food after confirmation by biochemical and serological tests. The ISO 11290-1:2001 method was used for the enumeration and the detection of L. monocytogenes followed by biochemical testing with the API Listeria 10 300 system (bioMérieux).

**Statistical analysis and software.** All experiments were performed three times with three replicates each. All data are reported as means with standard deviations. An analysis of variance was applied to assess differences among the RTE salads using SPSS version 15.0 software (SPSS, Chicago, IL).

**RESULTS AND DISCUSSION**

The effect of storage time on the aerobic plate count is shown in Figure 1. The mean aerobic bacterial load at day 0 for all RTE salads was 3.7 log CFU/g, and after 6 days of storage the load significantly increased (P ≤ 0.05) to 5.4 log CFU/g, an almost 2-log increase. The effect of storage at 5, 25, and 40 °C on the aerobic plate count is presented in Figure 2. The mean aerobic plate count was 4.2 log CFU/g at 5 °C, 5.1 log CFU/g at 25 °C, and 5.7 log CFU/g at 40 °C, indicating a linear increase. Thus, the effect of storage temperature on the growth of aerobic microorganisms was significant (P ≤ 0.05).
Overall, the *E. coli* counts for all RTE salads were low. Only tabbouleh salad had a higher count than the other salads, 0.9 log MPN/g compared with 0.50 log MPN/g for hummus, 0.27 log MPN/g for Greek salad, and 0.25 log MPN/g for coleslaw. All counts for *E. coli* were lower at after storage at 40 °C (Fig. 3). A temperature of 25 °C was more suitable for *E. coli* growth. One of the most important observations made during this study was that although the UAE standards allow a 1-day shelf life and the products are to be kept under 5 °C, during this study the products were displayed as having a 4-day shelf life (as shown by the manufacturing date) supposedly refrigerated at 5 °C at an open counter, which is in violation of the UAE Food Law Regulations. However, there was no indication of the temperature required in the refrigerator counter. Consequently, this practice may lead to high bacterial counts after 1 day, regardless of the storage temperature. High microbial loads were found in the RTE food samples evaluated during this study.

Salmonella, *L. monocytogenes*, and *S. aureus* were not detected in any RTE samples tested in this study. Other researchers (14, 26) have reported the absence of *Salmonella* and very low prevalence of the major pathogenic microorganisms in lettuce samples (14). However, high aerobic plate count and *E. coli* and *S. aureus* counts have been reported and could be due to poor sanitation practices (14). Although chemical inhibitors of pathogens can be found in foods, it is more likely that the low prevalence rates reported are a reflection of the absence of these pathogens in the majority of RTE foods, including the RTE salads analyzed in the present study.

Other researchers have found that vinegar and lemon juice, which contain acetic and citric acids and are used as flavoring and acidifying liquids for vegetables salads, could be considered natural preservatives that remove or at least reduce pathogens while causing no health risk to consumers (23). The antimicrobial activity of these two additives were not measured during the present study; however, other researchers have reported that vinegar and lemon juice can inhibit the most common pathogenic microorganisms found in RTE salads comparable to those sampled in the present study (23).

In the present study, counts of *E. coli* were acceptable at levels as low as 1 log MPN/g, but 20% of all samples contained some *E. coli*. Tabbouleh salads are made of leafy vegetables and herbs, particularly parsley, and those vegetables can have high levels of aerobic bacteria and *E. coli* (9).

In this study, during storage at different temperatures and during the shelf life, the *E. coli* counts decreased, unlike the growth trend for the aerobic microorganisms. This finding is similar to those reported by other researchers (17), who found that storing large quantities of parsley at room temperature increased the risk of sporadic low levels of *E. coli* contamination. In the present study, at low temperatures the *E. coli* counts decreased over time.

In all the salad products, the total bacterial counts at 5, 25, and 40 °C increased significantly (*P* ≤ 0.05). The counts at 5 °C were remained steady during storage in agreement with previous reports that aerobic plate counts for vegetables such as tomatoes, peppers, and aubergines were low whereas those for leafy vegetables and salads could be high due to cross-contamination (20). In general, the bacterial counts were stable at 5 °C, as observed by other investigators (21). The growth of *E. coli* decreased regardless of the storage temperature (data not shown) in agreement with findings of other researchers (25). The numbers of coliforms and *E. coli* in the present study were low, similar to the results reported by Seo and Frank (24), who reported specifically on *E. coli* O157:H7.

In the coleslaw, the total bacterial count increased during the storage time and with increased storage temperature. Coleslaw is made of shredded cabbage and mayonnaise. The complexity and rate of growth of the associated microflora found in mayonnaise-based salads has...
been associated with the concentration of various organic acids in the dressings and their pH (12).

The bacterial counts were lowest in the hummus salad compared with the other RTE foods, but the difference was not significant ($P > 0.05$). The olive oil and citric acid in hummus could exercise a bactericidal effect (7). The hummus samples in this study became drier as the temperature and storage time increased, causing a decline in $E. coli$ numbers. Other researchers noted that $E. coli$ growth was inhibited by fairly low water activity ($<0.95$) in RTE foods (15).

In conclusion, when the temperature increased the aerobic plate counts increased for all the products studied. Prolonging the storage time also increased the total plate counts for all the products studied. $Salmonella$, $L. monocytogenes$, and $S. aureus$ were not detected in any of the products. However, $E. coli$ counts decreased in all products during storage at all three temperatures (5, 25, and 40°C). The microbiological results of all products studied and the high count for aerobic bacteria after only 1 day of storage (more than 5 log CFU/g) exceeded the maximum acceptable standards in the UAE. Consequently, the shelf life of RTE foods should not exceed 1 day, as is stipulated and recommended by the UAE General Secretariat of Municipalities.

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REFERENCES


