

Incidence of Microorganisms Affecting Shelf-life, Quality and Safety of Locally-Produced Frozen Broiler Chickens in Kuwait

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ABSTRACT. Temperatures in 38 display freezer cabinets and 31 large freezers (bulk storage) of food outlets were monitored to determine market storage temperatures of frozen poultry meat in Kuwait. Data showed that the storage temperatures were too high. Frozen poultry meat stored under simulated market storage conditions showed a rapid increase in spoilage microorganism counts when stored at -5°C , whereas counts in carcasses stored at -18°C and -12°C did not substantially change over 12 months of storage. The counts of psychrotrophic bacteria increased from log 3.4 to 7.2 CFU/ml after three months storage at -5°C and was accompanied by changes in the meat's sensory and organoleptic properties, increased values of total volatile nitrogen, free fatty acids and peroxides. No substantial changes were observed in extract release volume. Data also showed relatively high initial counts of *E. coli* and *coliforms*, (average log 3.2 and 3.4 CFU/ml rinse, respectively), indicating poor sanitation during slaughtering, and processing. These counts decreased with increasing frozen storage, but the decrease rate was higher at lower temperatures (-18°C) than at higher temperatures (-12°C and -5°C). *Salmonella* was present in 60-80% of examined frozen carcasses, and this incidence rate did not substantially change during prolonged frozen storage. *Campylobacter* and *Staphylococcus aureus* were detected in all examined frozen carcasses at relatively high levels (average log 2.9 and 4.4 CFU/ml rinse, respectively). These levels decreased (by about 1 and 1.5 log cycles, respectively) with increasing frozen storage,

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especially in carcasses stored at lower temperatures (-18°C). Freezing and/or prolonged frozen storage generally reduced, but did not render the poultry completely free of bacterial flora.

Poultry is a major source of animal protein in the human diet in Kuwait. Of the 25 million poultry broilers that are annually slaughtered, about 30% are sold frozen; however, the quality of frozen broiler carcasses deteriorates substantially during prolonged storage in retail outlets, which is a major problem for the poultry industry.

Numerous studies have been reported on the effect of freezing on the microbiological quality of poultry meat (Wilkerson *et al.* 1961, Kraft *et al.* 1963, Mulder 1974, Notermans *et al.* 1975, Kraft and Rey 1979). There is general agreement that the greatest destruction of viable organisms occurs soon after freezing takes place; however, a wide variety of microorganisms on poultry carcasses or parts can survive well under prolonged frozen storage. According to Kraft and Rey (1979), surviving microorganisms have the greatest resistance to freezing temperature and are capable of resuming active growth or biochemical activity leading to deterioration of the poultry product or even causing a potential hazard from resistant pathogens. The extent to which spoilage or deterioration occurs or the frozen product becomes health hazardous depends, among other things on: the types and levels of microorganisms on dressed poultry carcasses prior to and/or after freezing; the microbial activity before freezing; release of proteolytic and lipolytic enzymes capable of activity at temperatures as low as -18°C ; and handling conditions during transport and storage (Straka and Stocks 1956, Kraft and Rey 1979, ICMSF 1980a). Experiences have shown that foods with high levels of microorganisms spoil faster and this can adversely affect the quality even at temperatures below freezing. Temperature abuse or improper handling during transportation, at retail stores or in display cabinets, or at the consumer's home may also alter the microbiological characteristics and safety of the product.

In previous studies (Sawya and Abu-Ruwaida 1989 a,b; Abu Ruwaida *et al.* 1989), we found that freshly produced poultry meat was heavily contaminated with a wide variety of microorganisms including spoilage organisms and others affecting sanitary and public health. Because of these observations, and due to lack of information on the microbiological status of locally produced frozen poultry meat, the objectives of the present study were two fold: first, to assess the microbiological shelf-life and quality of locally produced frozen poultry meat in the laboratory, under conditions simulating those prevailing in the local market (retail/commercial conditions); and second, to provide the local industry with information that would lead to improvement of the products' quality, hygiene and safety.

Materials and Methods

Storage Temperature

The storage temperatures of frozen poultry meat were measured by digital thermometers (± 1 °C) both in display cabinets (freezers) of food outlets handling these commodities and in the large freezers used for bulk storage in these outlets. Thirty-eight food outlets, representing most of the food outlets in Kuwait City that handle frozen poultry meat, were visited and the temperatures in display cabinets and large (bulk storage) freezers were determined.

Poultry Samples and Storage

One hundred and sixty-five frozen chicken carcasses (Grade A), weighing about 1 kg each, were obtained directly after processing from a major modern commercial slaughterhouse. They were divided into three groups and stored at -5 , -12 , and -18 °C. These temperatures represented the actual storage temperatures recorded during the market survey. Five carcasses from each storage temperature group were removed from the freezers after 0, 1, 2, 3, 4, 6, 7, 9, 11 and 12 months of storage in the laboratory, thawed overnight (about 18 h) in a refrigerator at 7 °C, and subjected to microbiological, chemical and organoleptic analyses.

Chicken Sampling

The carcass rinse method was used to obtain samples for microbiological analysis (Sawaya and Abu-Ruwaida 1989a). Accordingly, thawed chicken carcasses were halved and one half was placed in a sterile polyethylene bag (Seward Stomacher 400, England) containing 0.2% sterile lactose broth (1:1 w/v). The bags were shaken vigorously for 1 min and the aliquots transferred into sterile screw cap dilution bottles. A decimal dilution series was set up for each aliquot and used for microbiological analysis. The other half was used for chemical analysis.

Microbiological Analysis

Aerobic (mesophilic) bacteria were determined by pour-plating 1 ml of each dilution using aerobic plate counts (APC)-agar (Oxoid, UK), and colony-counting after 1-2 d of incubation at 35-37 °C, as outlined by ICMSF (1978). Psychrotrophic bacteria were recovered by spreading 0.1 ml of each dilution into APC-agar and incubating for 7 d at 4 °C. All plates with 20-300 colonies were counted and the logarithmic average (mean) of tested samples was calculated. The results were calculated as log₁₀ colony-forming units (log CFU) per ml lactose broth rinse.

E. coli and coliform bacteria were determined by spreading 0.1 ml of each dilution on Levin's eosin-methylene-blue (L-EMB) agar (Difco), and colony counting after 1-2 d or incubation at 37 °C. Typical *E. coli* colonies were confirmed as outlined by ICMSF (1978).

Salmonella was detected by a series of pre-enrichment techniques, as described by ICMSF (1978). Selective enrichment was carried out using selenite cystine (SC) or tetrathionate (TT) broth (Oxoid). *Salmonella* colonies were cultured by spreading 0.1 ml of SC- or TT-cultures onto *Salmonella-Shigella* agar (Oxoid) and modified lysine-iron agar (MLIA), prepared as described by Bailey *et al.* (1988). After 24 h of incubation at 37 °C, suspected *Salmonella* colonies were identified biochemically as outlined by ICMSF (1978) and typed serologically at the Public Health Laboratory (PHL), Kuwait.

Campylobacter was isolated by spreading 0.1 ml of each dilution onto a *Campylobacter* base-agar (Difco) supplemented with 7% horse blood and Skirrow's selective supplement (Oxoid). Plates were incubated at 43 °C for 1-2 d in a microaerophilic atmosphere (85% N₂, 10% CO₂ and 5% O₂), using gas-generating kits (Oxoid; BR 56).

Staphylococcus aureus were recovered by spreading 0.1 ml of each dilution on Baird-Parker egg yolk-tellurite emulsion medium (Difco/Oxoid). After 1-2 d of incubation at 37 °C, typical coagulase and DNase-positive *Staph. aureus* were confirmed using coagulase (rabbit plasma, Difco) and DNASE tests (Oxoid), as outlined by ICMSF (1978) and Collins (1984).

Chemical Analysis

The total volatile nitrogen (TVN) compounds, the extract release volume (ERV), the content of free fatty acids (FFA) and peroxide values (PVs) in frozen poultry meat were determined according to the methods as described previously by Sawaya and Abu-Ruwaida (1989).

Sensory Evaluation

Sensory evaluation of the frozen poultry carcasses was conducted by the research team (five to six judges). Several parameters, including color, odor, texture and overall appearance, were evaluated using a hedonic scale from 0 to 10, with 10 being 'extremely good' and 0 being 'unacceptable' (Larmond 1977).

Results and Discussion

Market Storage Temperature

Data obtained (Fig. 1) showed that frozen poultry meat was stored in display cabinets at -18°C or below, which is the normal freeze-storage temperature, in only 5/38 (13%) food outlets. In the rest of the food outlets, the display freezer storage temperatures were between -12 and -18°C in 13/38 (34%), and more than -12°C in 20/38 (53%). Of the 31 large freezers (bulk storage) examined in the food outlets, 12 (39%) had temperatures of less than -18°C , 8 (26%) between -12 and -18°C , 10 (32%) between -6 and -12°C and 1 (3%) between 0 and -5°C (Fig. 1). In general, these findings indicate that market storage temperatures were inadequate, and that this was more apparent in the market display cabinets than in the large freezers. This inadequacy in storage temperatures, especially in display cabinets, was accompanied by improper handling by the consumer (*e.g.*, shifting and moving the products around), and temperature fluctuations at different locations of the cabinets, which was indicated by other investigators to affect the microbiological characteristics and quality of the products (Jul 1984, Middlehurst *et al.* 1972).

Shelf Life (Storage)

The shelf life of frozen chicken carcasses stored at different temperatures, simulating market conditions, was assessed by measuring the total aerobic bacterial counts (mesophilic bacteria), the counts of psychrotrophic bacteria and selected microbial spoilage indicators or metabolites (*i.e.*, TVN, ERV, FFA, and PV). Fig. 2 shows the results obtained on the total aerobic bacterial counts and psychrotrophic bacteria on chicken carcasses during frozen storage at -5 , -12 and -18°C . In general, the initial total aerobic bacterial counts, determined directly after freezing, were relatively high (average log 4.6 CFU/ml carcass rinse). These findings corroborate data reported by other investigators (Kraft and Rey 1979), who found that freezing reduced total aerobic populations, but carcasses still had total counts over 100,000 per gram. Other authors, however, showed that the type of freezing procedure used may have different effects on reducing the bacterial populations in poultry. For example, Kraft *et al.* (1963) demonstrated a decrease in aerobic bacterial counts on the skin of turkeys by 84 to 99% using different freezing procedures. Similar findings were reported by Gunaratne and Spencer (1974), who reported a decrease in viable aerobic microorganisms by 96% on the thighs of broiler chickens. These variations in bacterial survival directly after freezing may be due to: the differences in freezing procedures employed; the degree of initial bacterial concentration (the greater the initial bacterial concentration in poultry products, the more these bacterial are resistant to freezing temperatures); the rate and time of

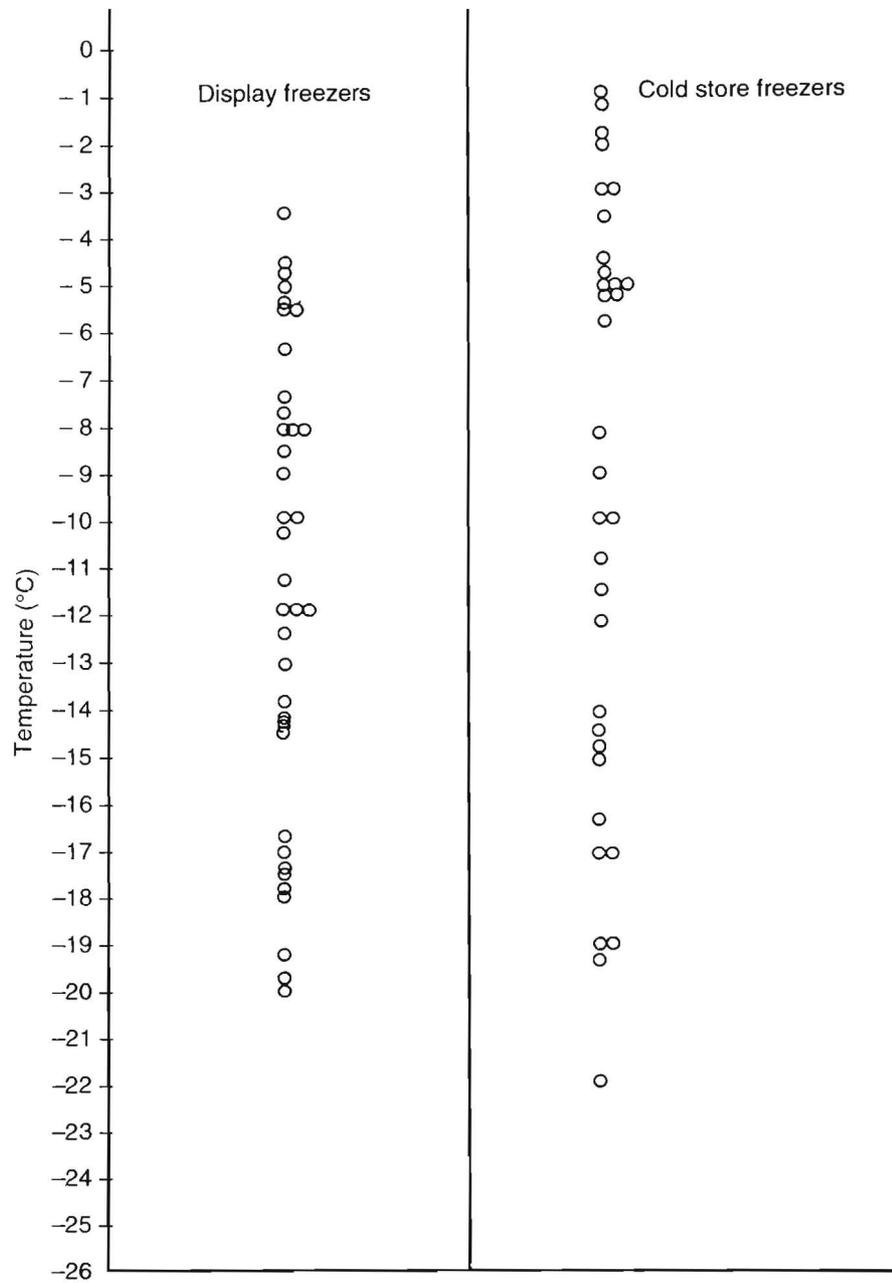


Fig. 1. Number of display and cold store freezers at prevailing market temperatures.

cooling; the temperature at which freezing takes place; and finally, to the susceptibility of the organisms themselves to the freezing process (Kraft *et al.* 1963, Rupp 1968, Foster and Mead 1976, Gunaratne and Spencer 1974, Obafemi and

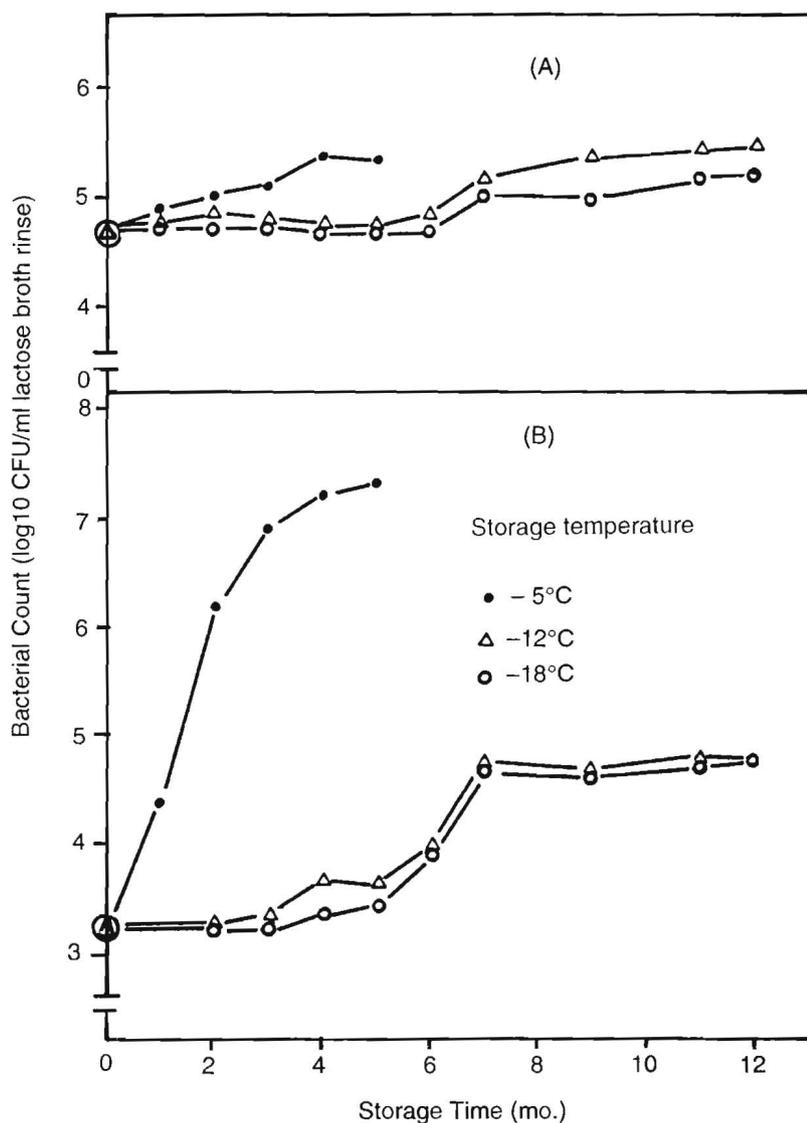


Fig. 2. Total counts of mesophilic (A) and psychrotrophic (B) bacteria in frozen poultry meat stored at different temperatures.

Davies 1986, Sauter 1987). With respect to the effect of frozen storage on total aerobic bacterial counts, results show that these counts did not change substantially during five months storage at -5°C or 12 months at -12 and -18°C (Fig. 2A); the counts ranged between log 5.0 and 5.3 CFU/ml rinse throughout the storage periods. Similar trends were reported earlier (Notermans *et al.* 1975, Lillard 1977). Nevertheless, the results obtained in the present work indicate that frozen storage apparently was not effective in reducing aerobic bacterial counts, possibly because these bacteria were greatly resistant to freezing temperatures, or that sublethally injured bacteria were recovered during frozen storage, or both (Kraft and Rey 1979, ICMF 1980a,b).

Concerning the effect of frozen storage on the counts of psychrotrophic bacteria, results show that these counts were initially low (log 3.1 CFU/ml rinse), but increased during continuous frozen storage (Fig. 2B). These findings corroborate data reported by other investigators, who showed that psychrotrophic bacteria were susceptible to the cold shock of the freezing process, but were more stable to prolonged frozen storage than non-psychrotrophic organisms originally present on the poultry (Kraft and Rey 1979). The increase in the counts of psychrotrophic bacteria was more apparent at higher storage temperature (-5°C) than at lower temperatures (-12 and -18°C). At this temperature (-5°C), the bacterial counts increased rapidly, reaching their highest level (log 7.2 CFU/ml rinse) after three months of frozen storage. This increase was accompanied by substantial changes in the meat's sensory and organoleptic properties (Table 1), such as poor appearance (slight freezer burn), off-odor and discoloration. These findings are generally consistent with reports by other investigators, who found that microbial deterioration and spoilage of frozen poultry increase as the storage temperature rises above -12°C (Jay 1978, Ristic 1982). This could also explain the results obtained with the frozen poultry carcasses stored in the laboratory at -12 and -18°C (Fig. 2B), which indicated no substantial increase in the bacterial counts of spoilage organisms during 12 months storage at these temperatures. Consequently, no substantial changes were observed in the sensory and overall organoleptic characteristics of the meat (Table 1) except for slight freezer burn on individual carcasses towards the end of the experiment, *i.e.*, after nine months of storage. The samples showing freezer burn ranged from 20 to 30% of the tested carcasses.

Table 2 shows the levels of the microbial spoilage indicators or metabolites, such as TVN compounds, ERV, FFA and peroxide values (PVs) produced in frozen chicken carcasses stored at -5 , -12 and -18°C . In general, the levels of TVN compounds were relatively high initially, possibly due to the microbial activity of spoilage microorganisms associated with carcasses during processing at the slaughterhouse. These levels increased steadily during frozen storage, but were more apparent in carcasses stored at -5°C than in those stored at -12 and 18°C . The

levels detected in carcasses during frozen storage ranged between 20.6 and 38.4 mg N₂/100g meat, and were generally higher than the acceptable levels (16.5-19.7 mg N₂/100 g) recommended by Egan *et al.* (1981). This may be due to the degradation of nitrogenous compounds by microbial activity prior to and/or after freezing, or by extracellular proteolytic enzymes resistant to freezing temperatures, or both (Swanson and Sloan 1953, Kraft and Rey 1979, ICMSF 1980a, Abed-El-Rahman *et al.* 1989). As for the effect of frozen storage on the waterholding capacity (expressed as ERV), no substantial changes were observed in the ERV values, independent of the storage temperatures. This may be due to the fact that the ERV test is not directly applicable to meat that has not undergone the normal spoilage that occurs under chilled conditions (Jay 1986, 1965, Sawaya and Abu-Ruwaida 1989a). Concerning the FFA levels, data presented in Table 2 show that these levels increased rapidly in the carcasses stored at -5 °C, reaching 1.3% and 1.5% after two and three months, respectively. In those stored at lower temperatures, *i.e.*, at -12 and -18 °C, the FFA levels increased slowly and reached the maximum acceptable value of 1.2-1.5% (Egan *et al.* 1981) after seven and nine months of storage, respectively. This increase, particularly at lower temperatures, was not associated with incipient spoilage or increased bacterial counts, as is evident in Table 2. A similar effect was observed on the peroxide values, which increased rapidly in the carcasses stored at

Table 1. Sensory and organoleptic properties of frozen poultry meat during storage at different temperatures

| Storage Time (d) | Evaluation* | | | | | | | | | | | |
|------------------|-------------|----|----|----|--------|----|----|----|--------|----|----|----|
| | -5 °C | | | | -12 °C | | | | -18 °C | | | |
| | O | C | T | OL | O | C | T | OL | O | C | T | OL |
| 0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 1 | 7 | 7 | 7 | 7 | | | | | | | | |
| 2 | 5 | 5 | 5 | 5 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 3 | 2 | 2 | 2 | 2 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 4 | 1 | 1 | 1 | 1 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 5 | 0 | 0 | 0 | 0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 6 | | | | | 10 | 7 | 7 | 7 | 10 | 10 | 10 | 10 |
| 7 | | | | | 7 | 2 | 5 | 5 | 10 | 7 | 7 | 7 |
| 9 | | | | | 7 | 5 | 5 | 5 | 7 | 7 | 5 | 7 |
| 12 | | | | | 7 | 5 | 5 | 5 | 7 | 7 | 5 | 7 |

* Evaluation scores: 10, very good; 7, good; 5, fair; 2, poor; 1, very poor; 0, unacceptable.

Symbols: O, odor; C, color; T, texture; OL, overall appearance

Values represent the means of 5 samples.

-5 °C, but slowly in those stored at -12 and -18 °C. As with the FFA content, however, the increase in peroxide value was not accompanied by an increase in bacterial counts or incipient spoilage; the increase in both FFA and peroxide values during storage at lower temperatures (-12 and -18 °C) is not correlated with spoilage organisms, but it could be due to lipid hydrolysis and/or oxidation in the meat (Jul 1984, Viehweg *et al.* 1989).

Table 2. Production of microbial spoilage indicators or metabolites in locally-produced frozen poultry meat during storage at different temperatures

| Storage | | TVN (mg N ₂ /100g) | ERV (ml) | FFA (%) | PV (meq/kg) | |
|---------------|-------------|----------------------------------|-------------|------------|----------------|------|
| Temp. (°C) | Time (M) | | | | | |
| -5°C | 0 | 17.2 | 16.0 | 0.54 | 0.95 | |
| | 1 | 21.3 | 14.0 | 0.63 | 1.40 | |
| | 2 | 29.1 | 16.8 | 1.30 | 1.70 | |
| | 3 | 38.4 | 14.5 | 1.50 | 2.10 | |
| | 5 | 32.3 | 13.0 | 1.60 | 2.70 | |
| -12°C | 0 | 17.2 | 16.0 | 0.54 | 0.95 | |
| | 2 | 20.6 | 17.0 | ND | ND | |
| | 3 | ND | 16.5 | 0.61 | 1.00 | |
| | 4 | 24.2 | 21.5 | 0.66 | 1.10 | |
| | 5 | 23.7 | 17.5 | 0.80 | 1.10 | |
| | 6 | ND | ND | 0.84 | 1.20 | |
| | 7 | 35.7 | 23.5 | 1.20 | ND | |
| | 9 | 21.8 | 17.25 | 1.40 | 1.56 | |
| | 11 | 17.7 | 22.0 | 1.46 | 1.80 | |
| | 12 | ND | ND | 1.67 | ND | |
| | -18°C | 0 | 17.2 | 16.0 | 0.54 | 0.95 |
| | | 2 | 21.1 | ND | 0.63 | 0.95 |
| 3 | | ND | 16.0 | 0.65 | 0.99 | |
| 4 | | 29.3 | 14.0 | 0.66 | 1.03 | |
| 5 | | 26.9 | ND | 0.79 | 1.10 | |
| 6 | | 22.8 | 15.5 | 0.81 | 1.13 | |
| 7 | | 32.2 | 14.4 | 0.90 | 1.20 | |
| 9 | | 25.4 | 17.9 | 1.00 | 1.27 | |
| 11 | | 27.5 | 19.0 | 1.28 | 1.45 | |
| 12 | | ND | ND | 1.28 | ND | |

TVN = Total volatile nitrogen
PV = Peroxide value

ERV = Extract release volume
ND = Not determined

FFA = Free fatty acids

Organisms Affecting Sanitation and Public Health

Table 3 presents data on selected organisms of sanitary and public health significance. In general, the counts of coliform bacteria and *E. coli* (average log 3.5 and 3.2 CFU/ml lactose broth rinse, respectively) were initially high, indicating contamination or improper sanitation during slaughtering (Abu-Ruwaida *et al.* 1993b). These counts, and particularly those of *E. coli*, decreased with increasing frozen storage time, independent of storage temperatures; however, the decrease rate in the counts of these bacteria at lower temperature (-18°C) was higher than that at the higher temperatures (-12 and -5°C). These findings are in accord with those reported by other investigators, who showed that freezing and prolonged frozen storage generally reduced, but did not kill or eliminate all coliforms and *E. coli* in frozen poultry meat (Wilkerson *et al.* 1961, Kraft *et al.* 1963, Schmidt-Lorenz and Gutschmidt 1969). Generally, the reduction in *E. coli* and other coliform bacteria is

Table 3. Counts (Mean \pm SD) of organisms of sanitary and public health concern in local frozen poultry meat during storage at different temperatures

| Storage | | Mean Bacterial Count* (log CFU/ml rinse) | | | | |
|--------------------------|----------|--|----------------|----------------|----------------------|----------------------|
| Temp. $^{\circ}\text{C}$ | Time (d) | <i>S. aureus</i> | <i>E. coli</i> | Coliforms | <i>Campylobacter</i> | <i>Salmonella</i> ** |
| -5°C | 0 | 4.4 \pm 0.35 | 3.5 \pm 0.03 | 3.7 \pm 0.06 | 2.9 \pm 0.25 | 5 (3) |
| | 2 | 3.6 \pm 0.34 | 2.7 \pm 0.15 | 3.6 \pm 0.23 | 2.5 \pm 0.41 | 5 (4) |
| | 5 | 3.9 \pm 0.03 | 3.2 \pm 0.35 | 3.7 \pm 0.72 | 1.9 \pm 0.16 | 5 (3) |
| -12°C | 0 | 4.4 \pm 0.13 | 2.5 \pm 0.29 | 3.7 \pm 0.64 | 2.9 \pm 0.32 | 5 (3) |
| | 3 | 3.9 \pm 0.21 | 2.9 \pm 0.23 | 3.5 \pm 0.42 | 2.5 \pm 0.39 | 5 (3) |
| | 7 | 3.8 \pm 0.14 | 2.8 \pm 0.61 | 3.3 \pm 0.12 | ND | 5 (3) |
| | 9 | 3.7 \pm 0.08 | 2.4 \pm 0.12 | 2.9 \pm 0.18 | ND | 5 (4) |
| | 11 | 3.6 \pm 0.34 | 2.5 \pm 0.19 | 3.0 \pm 0.01 | 2.3 \pm 0.13 | 5 (3) |
| | 12 | 3.1 \pm 0.09 | 1.9 \pm 0.02 | 2.4 \pm 0.03 | ND | 5 (4) |
| -18°C | 0 | 4.4 \pm 0.12 | 3.5 \pm 0.31 | 3.7 \pm 0.41 | 2.9 \pm 0.46 | 5 (3) |
| | 3 | 3.8 \pm 0.19 | 2.8 \pm 0.01 | 3.4 \pm 0.32 | 2.2 \pm 0.06 | 5 (3) |
| | 7 | 3.7 \pm 0.08 | 2.9 \pm 0.25 | 3.2 \pm 0.53 | ND | 5 (3) |
| | 9 | 3.8 \pm 0.28 | 2.4 \pm 0.17 | 3.3 \pm 0.27 | ND | 5 (4) |
| | 11 | 3.8 \pm 0.10 | 2.3 \pm 0.27 | 2.7 \pm 0.14 | 1.9 \pm 0.13 | 5 (4) |
| | 12 | 3.1 \pm 0.06 | 2.2 \pm 0.49 | 2.8 \pm 0.09 | ND | 5 (5) |

* Mean counts of 5 samples.

** The first number represents the number of samples examined, the number between parenthesis represents *Salmonella* positive samples.

ND = Not determined.

influenced by many factors, such as the freezing substrate, the storage temperature and the physiological status of the cells prior to freezing (Mackey *et al.* 1980). Consequently, the value of *E. coli* and/or coliform bacteria as an indicator of the quality of frozen poultry meat becomes limited after a lengthy period of frozen storage (Wilkerson *et al.* 1961, White and Hall 1985).

The initial counts of *Staphylococcus aureus* averaged log 4.4 CFU/ml lactose broth rinse, of which about 60% were coagulase- and DNase-positive. Similar levels of *Staph. aureus* were recovered previously from freshly dressed carcasses obtained from the same slaughterhouse (Sawaya and Abu-Ruwaida 1989b). These relatively high counts indicate improper (unsanitary) conditions during processing and packaging, and also that the freezing process was not effective in killing or reducing the number of *Staph. aureus* contaminating the carcasses. During continuous frozen storage, *Staph. aureus* were reduced in number, but the organism survived well in frozen carcasses for 5 months at -5°C or 12 months at -12 and -18°C (Table 3). A similar effect was observed in *Staph. aureus* of imported frozen broiler chickens (unpublished work). These findings corroborate data reported by other researchers, who noted that *Staph. aureus*, like many other species of gram-positive bacteria, is particularly resistant to freezing (Georgala and Hurst 1963, Kraft and Rey 1979, White and Hall 1984) and moderately resistant to frozen storage (Fanelli and Ayres 1959, Raj and Liston 1961, Hooshyar *et al.* 1982). Therefore, freezing cannot be relied upon to reduce significantly the levels of contamination of *Staph. aureus*, and prolonged frozen storage will not reduce the potential of growth during subsequent thawing (White and Hall 1984, El-Leithy and Rashad 1989), however, data obtained in this study showed that the number of *Staph. aureus* was substantially reduced during continuous frozen storage. These findings agree with those previously reported by Sawaya and Abu-Ruwaida (1989a), and by other investigators, who found that storage at low temperature (below $6-7^{\circ}\text{C}$) negatively affects the growth of *Staph. aureus* (Angelotti *et al.* 1961, Kraft *et al.* 1963, Michener and Elliot 1964, Koburger *et al.* 1981). However, it must be remembered that *Staph. aureus* is capable of resuming active growth in pre-cooked foods after thawing (El-Leithy and Rashad 1989). Hence, careless or improper handling during frozen storage or after thawing could present potential hazards of food poisoning, because many strains of this organism are capable of producing heat-resistant enterotoxin (Gilbert and Wienicke 1973, Bennett 1986). Staphylococcal toxin is even resistant to freezing at temperatures as low as -50°C (ICMSF 1980a, Jacob 1989).

Poultry represents the single most important food source of *Salmonella* and *Campylobacter* to man, and there is epidemiological incidence linking salmonellosis and campylobacteriosis with poultry consumption in many countries (Todd 1980, Cunningham 1982, Green *et al.* 1982, Kvenberg and Archer 1987, Franco 1988).

According to ICMSF (1980b), raw frozen poultry products harbor the same pathogens as chilled products and present the same problems of cross-contamination after they thaw. Evidence is presented in this report that locally produced frozen broiler chickens contained food-poisoning pathogens such as *Salmonella* and *Campylobacter*, but at much lower levels than those detected in freshly slaughtered chickens (Sawaya and Abu-Ruwaida 1989b). Accordingly, *Salmonella* was present in 60-80% of examined frozen chicken carcasses, independent of the storage temperatures (Table 3), compared with 100% incidence rate in freshly processed non-frozen carcasses. These findings suggest that the freezing process reduced the incidence of salmonellae in poultry meat, but that the organism survived well the frozen storage for considerable periods of time. This result is in accord with data reported by other researchers, who showed that freezing and/or prolonged frozen storage may reduce the number, but did not render the poultry completely free of *Salmonella* (Kraft *et al.* 1963 Bryan *et al.* 1968, Davey *et al.* 1983, Hooshyar *et al.* 1982). The major serotypes found associated with frozen chicken carcasses investigated in this work were *S. Ohio*, *S. enteritidis*, *S. paratyphi* and *S. krefeld*, independent of the storage temperature. These serotypes were previously isolated from chilled carcasses obtained from the same slaughterhouse (Sawaya and Abu-Ruwaida 1989a). No *S. typhimurium*, *S. heidelberg*, or *S. infantis* were recovered; these are the most serotypes of *Salmonella* commonly associated with poultry, and all of which have been incriminated in food poisoning attributed to poultry meat in many countries (Todd 1980, Cunningham 1987, Kvenberg and Archer 1987, Lammerding *et al.* 1988).

Regarding the incidence of *Campylobacter* in frozen poultry meat, results show that this group of organisms was present in all carcasses examined (Table 3). The initial contamination level of frozen carcasses by *Campylobacter* was relatively low (average log 2.9 CFU/ml lactose broth rinse) when compared with log 4.7-5.2 in freshly slaughtered, non-frozen birds (Sawaya and Abu Ruwaida 1989b). Unlike data reported previously by other investigators (Norberg 1981, Stern *et al.* 1984), the high incidence rates as well as the large number of *Campylobacter* recovered from carcasses immediately after the freezing process indicated that this process was not very effective in reducing the *Campylobacter* associated with chicken carcasses. The data also indicated poor sanitation and contamination during slaughtering and processing; however, this level of contamination declined during prolonged frozen storage by about 1 log cycle, independent of storage temperatures. These findings corroborate data reported by other researchers, who showed that freezing and prolonged frozen storage generally reduced the number, but did not destroy *Campylobacter* completely when these organisms were present in poultry meat (Simmons and Gibbs 1979, Norberg 1981, Rosef *et al.* 1984).

In conclusion, these findings clearly showed that freezing and/or prolonged frozen storage generally reduced, but did not destroy the bacterial flora completely when these organisms were present in poultry meat. The data also indicated that improper storage temperatures (above -12°C) could negatively affect the microbiological characteristics and quality of the products. Furthermore, the higher recovery rates of all microorganisms investigated indicated contamination, cross-contamination, and improper sanitation during processing and handling at the processing plant. This trend was also seen in fresh chilled poultry meat that originated from the same slaughterhouse (Sawaya and Abu-Ruwaida 1989a, 1989b). In light of these data, the poultry industry has a great responsibility to improve control, sanitation and safety measures to reduce contamination of carcasses by microorganisms affecting their shelf-life, safety and quality. Improvement should start on the farm and continue during transport, slaughtering, processing, freezing, distribution and storage. The consumer should also be aware of foodborne infections and the proper procedures for handling frozen poultry meat, such as in defrosting, and should follow closely the handling and cooking instructions provided by the producer.

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حالات تأثر صلاحية وجودة سلامة الدجاج المجمد المنتج محلياً بالكائنات الحية الدقيقة

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ص. ب. (٢٤٨٨٥) - الصفاة ١٣١٠٩ - الكويت

تم قياس درجات الحرارة في ٣٨ فريزر عرض و ٣١ غرفة من غرف التجميد الواسعة في عدد من المراكز التسويقية المحلية بهدف تحديد درجات حرارة تخزين الدجاج المجمد المنتج في الكويت . وقد أظهرت النتائج أن لحوم الدواجن المجمدة والمخزنة تحت ظروف مماثلة لظروف التخزين في مراكز التسويق أبدت زيادة سريعة في نمو الكائنات الدقيقة المسببة لتلف الأغذية وذلك عند درجة حرارة تخزين تعادل -٥ درجات مئوية ، بينما لم تحصل هناك زيادة تذكر في تعداد هذه الكائنات في الدجاج المخزن تحت درجة حرارة -١٨ و -١٢ لمدة ١٢ شهراً من التخزين . كما زادت البكتيريا المحبة للبرودة من ٤, ٣ إلى ٢, ٧ مستعمرة/ ملل ، وذلك بعد مضي ثلاثة أشهر من التخزين تحت درجة حرارة -٥ ، وصاحب ذلك تغيرات في الخواص الحسية والذوقية ، وزيادة في قيمة اجمالي مركبات النيتروجين المتطاير ، والأحماض الدهنية الحرة ، والبيروكسيدات . إلا أنه لم تلاحظ أية تغيرات في حجم المستخلص المتحرر .

كما أظهرت البيانات أيضاً ارتفاعاً نسبياً في التعدادات الأولية لـ *E. coli* و *Coliform* مما يشير إلى رداءة الظروف الصحية عند ذبح الدجاج وتصنيعه .

وقد تضاعف تعداد هذه البكتيريا بازدياد مدة التخزين تحت التبريد ، إلا أن معدل هذا التضاعف كان أعلى عند درجات الحرارة المتدنية (-١٨) منه عند درجات الحرارة الأعلى (-١٢ و -٥) . كما ظهرت بكتيريا السالمونيلا في ٦٠-٨٠٪ من عينات الدجاج التي شملتها الدراسة . والجدير بالذكر أن هذا المعدل لم يطرأ عليه تغيير يذكر طوال مدة التخزين تحت التبريد .

كذلك ظهرت البكتيريا المسببة للتسمم الغذائي الـ *Campylobacter* و الـ *Staphylococcus aureus* في جميع العينات التي تم تحليلها ، وبمعدلات عالية نسبياً (متوسط تعداد لوغاريتمي يعادل ٩, ٢, ٤ و ٤, ٤ مستعمرة/ ملل على التوالي) . وقد تضاعفت هذه النسب (بنسبة حوالي ١-٥, ١ كل على حدة) بزيادة مدة التخزين ، وذلك في الدجاج المخزن تحت درجات حرارة أقل من (-١٨) . واتضح بأن التبريد أو التخزين المطول تحت التبريد أدى إلى انحسار نسبة البكتيريا في الدجاج دون أن يقضي عليها .

أهم المصطلحات : لحوم الدواجن - تلف اللحوم - العوامل المسببة للمرض - البكتريات المحبة للبرودة .

* إلى من توجه له المراسلات .