for *C. perfringens*. Raw beef can be a source of *S. aureus*. This is a concern in the manufacture of fermented and dried meats. Raw beef is a source for sporadic cases and, occasionally, outbreaks of illness due to *E. coli* 0157:H7.

The hazard analysis leads to the conclusion that raw beef can be an important vehicle in the transmission of two important foodborne pathogens: salmonellae and *E. coli* 0157:H7. These pathogens are similar in a number of respects, such as:

- a. Sensitivity to heat and cold,
- b. Sensitivity to chemicals,
- c. The ability to multiply asymptomatically in the bovine intestinal tract, and
  - d. Potential for low infectious doses.
- E. coli 0157:H7 and certain Salmonella serovars may cause secondary infections and chronic sequelae. Also, both pathogens may cause death, particularly with E. coli 0157:H7.

The primary microbiological hazards encountered during the beef slaughtering process are salmonellae and *E. coli* 0157:H7. The following generic HACCP plan will be directed primarily at control of these pathogens. Efforts to improve slaughter hygiene will reduce the presence of other pathogens (*C. perfringens, S. aureus, L. monocytogenes*) on carcass meat.

## V. Generic HACCP

The factors that impact the microbiological safety of raw beef products during its "farm to consumer" lifetime can be subdivided into four segments: (1) live animal practices, (2) slaughter and processing operations, (3) distribution and retailing operations, and (4) consumer food handling practices. Key factors associated with live animal practices are introduced and discussed in Section V.A. The individual steps involved in slaughter and processing operations are detailed as a generic HACCP plan in Section V.B. The primary thrust of the first two sections is the control of enteric bacteria, the class of pathogenic microorganisms associated with and amenable to control during these phases of raw beef production and processing. The factors associated with distribution, retailing, and consumer practices that impact the safety of raw beef products are introduced in Section V.C.

# A. Farm Management Practices

Raw beef originates from several sources of cattle. These can be classified into two major categories, fed beef and mature beef. Fed beef typically comes from animals that have been raised to desired market weight, usually less than two years of age. Mature beef comes from dairy or beef animals that have been marketed after being used for milk or calf production. Fed beef serves as the major source of whole beef products and some ground beef products. Mature dairy and beef animals are a primary source of ground meat and patties to consumers, including food service establishments.

The husbandry practices under which fed beef cattle and mature dairy and beef cattle are managed are quite different. However, potential for microbial contamination of the final product exists in both and they share many of the same risks. There are major aspects in the production phase that can influence incidence, control, and prevention of potential human pathogens in cattle.

# 1. Transportation

The production cycle, especially of fed beef, typically involves time spent on two or more premises prior to movement to processing facilities. Transportation is often necessary but contributes to an increased incidence of contamination due to both the stress placed upon animals and the increased risk of exposure of cattle to potential human pathogens (Cole, et al., 1988; Hutcheson and Cole, 1986). Dairy animals handled in a similar manner would experience similar risk.

Transport time should be such that the animals reach other production facilities and processing establishments in an expedient manner, with stress kept to a minimum. Transport vehicles should be free of injurious structural defects. Vehicles should be clean at the time animals are loaded, and cleaned and sanitized following unloading at the slaughter facility.

#### 2. Marketing

Marketing is accomplished through a number of outlets that introduce varying degrees of risk. Cattle frequently are sold or moved through either auction markets, direct selling from producer to backgrounder or feedlot, video auctions, or collection points. Animals from multiple sources are commonly commingled at one or more points during production, resulting in transfer of potential pathogens between animals.

Inspectors at slaughter plants must maintain high standards regarding diseased and otherwise inferior animals, including continued close communication with cattle producers to provide information to improve quality and safety standards in slaughter animals.

# 3. Animal Husbandry

Numerous management practices are influenced by environmental conditions. For example, excessive moisture conditions generally result in higher levels of hide contamination with mud, feces, and other extraneous matter. Management systems that minimize the impact of adverse environmental conditions would be expected to decrease microbial contamination. This may involve basic changes in animal husbandry (Smith and House, 1992). Controlling exposure and contamination is especially important immediately prior to shipment to slaughter.

# 4. Role of Stress

Stressed animals have lowered disease resistance, making them more susceptible to pathogens and at increased risk of shedding potential human pathogens (Breazile, 1988). For example, animals which are exposed to salmonellae can become intermittent shedders of this organism. Various forms of stress can result in increased shedding and clinical disease, causing increased exposure to pennates, increasing the risk also to humans through contaminated meat.

Management systems addressing increased animal welfare and better husbandry decrease levels of stress, and would be expected to decrease the incidence of pathogens. For example, improvements in cattle handling systems reduce stress-related immune suppression associated with animal processing procedures (Grandin, 1984, 1987). A number of other factors, such as animal density, frequency of feedlot pen use, and commingling of sick animals, can affect stress levels and thus risk of human pathogen exposure. Salmonella is capable of surviving variable, prolonged periods of time in animal facilities (Rings, 1985).

#### 5. Feed and Water Contamination

Feed and water are potential sources of microbial contamination to cattle (Robinson, et al., 1991). Feedstuffs should be documented free of *Salmonella* and other enteric pathogens (Mitchel and McChesney, 1991). This is especially critical for feeds containing rendered byproducts. Water must be from clean, non-fecally contaminated sources.

# 6. Antimicrobial Use

Therapeutic and subtherapeutic use of antimicrobials has long been a practice in the cattle industry. Recent emphasis on regulations and resulting industry response, such as quality assurance programs, has resulted in more