

the risk of contamination by pathogenic microorganisms. In accordance with the NACMCF focus on safety (NACMCF, 1992), the current plan specifically addresses microbiological safety. However, it is worth noting that the increased process/product control achieved through the adoption of HACCP is also likely to enhance the microbiological quality of raw beef products. Full implementation is critical for HACCP plans to be successful. Management's commitment to the HACCP concept is imperative for successful implementation. The Committee recommends that HACCP plans include consideration of specific mechanisms for facilitating communication among all levels of plant operations and management.

#### References

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## II. Epidemiology of Foodborne Illness Associated With Raw Beef

### A. Introduction

Foodborne disease is an important cause of morbidity in the United States and throughout the world (Archer and Kvenberg, 1985; Cliver, 1987). Surveillance of foodborne diseases and prospective studies have identified foods of animal origin as important vehicles for microorganisms causing human illness (Todd, 1983, 1989; Bean and Griffin, 1990). The live animal is exposed to a variety of potential sources of microorganisms (e.g., soil, water, feeds, air, other animals, etc.), and often acquires pathogenic microorganisms initially as a result of exposure "on the farm" or during transport (Galton, et al., 1954; Ayers, 1955; Linton, et al., 1974; Martin and Smith, 1984; Clegg, et al., 1986; Grau, 1987; Linton and Hinton, 1987). In healthy animals, microorganisms are confined primarily to the gastrointestinal tract and exterior surfaces (hooves, hide, hair). During slaughtering and dressing, the surface of the carcass and subsequent cuts of meat may become contaminated with these microorganisms (Ayers, 1955; Mackey

and Derrick, 1979; Smeltzer, 1984; Chandran, et al., 1986; Grau, 1987; Dixon, et al. 1991). Foods of animal origin may also be contaminated by microorganisms persisting in the processing environment, or as a result of contact with food handling personnel or equipment during processing, distribution, retailing, and use (Empey and Scott, 1939; Ingram, 1949; DeWit and Kampelmacher, 1981, 1982; Smeltzer, 1984; Smulders and Woolthuis, 1983; Druce, 1988; Ligugnana and Fung, 1990; Restaino and Wind, 1990). The extent of this contamination will depend, to a large degree, on the sanitary control exerted during slaughtering and dressing (Ayers, 1955; Empey and Scott, 1949; Ingram, 1949; Smulders and Woolthuis, 1983; Chandran, et al., 1986; Dixon, et al., 1991). This section focuses on the microorganisms that are the primary cause of morbidity and mortality associated with raw beef products.

### B. Sources and Limitations of Data

In the United States, foodborne disease data are derived from outbreak investigations, prospective studies, and outbreak and sporadic disease surveillance conducted and reported by public health organizations such as the U.S. Centers for Disease Control and Prevention (CDC). The majority of the data is acquired through passive outbreak surveillance programs. It is assumed that the incidence data represent only a fraction of the total number of cases due to significant under reporting (Bean and Griffin, 1990; Buchanan and DeRoever, 1993). Such programs do not effectively record the incidence of sporadic disease. Assessing the impact of raw beef products on foodborne disease is complicated by the potential for such foods to serve as an indirect source of pathogens. Further, most available outbreak data are for cooked beef products. Identification of any relationship between an outbreak and the presence of pathogenic microorganisms in raw beef must be determined through adequate investigations that pinpoint food handling, processing, and preparation errors. Typically, microbial foodborne disease outbreaks involve errors associated with mishandling or inadequate processing of the raw beef, failure to control time and temperature after cooking, or post-processing contamination.

### C. Outbreak Data

In the United States between 1973 and 1987, beef products accounted for 9% of reported outbreaks and 10% of the cases in which a food vehicle was

implicated (Bean and Griffin, 1990). Similar results were reported for Canada (Todd, 1989). Raw beef has been reported to serve as a vehicle for a variety of disease causing organisms (i.e., viruses, protozoa, parasites, etc.); however, bacterial pathogens accounted for 92% (159 of 172) of beef-associated outbreaks in which an etiologic agent was identified (Bean and Griffin, 1990). The primary bacterial etiologic agents for beef-related outbreaks were *Salmonella* spp. (48%), *Clostridium perfringens* (32%), and *Staphylococcus aureus* (14%). Recently, *Escherichia coli* 0157:H7 has played an increasingly important role as a cause of raw beef associated foodborne illness. Contamination of the raw beef combined with improper food handling practices is an important factor in a substantial portion of the *Salmonella* cases (Silliker, 1982; Bryan, 1979). *Clostridium perfringens* outbreaks are generally associated with cooked products that are held at inadequate holding temperatures in institutional and food service settings (Bryan, 1980). Spices and other dry ingredients can also be a source of *C. perfringens*, enterotoxigenic *Bacillus cereus*, *S. aureus*, and *Salmonella* (NRC, 1985). Food handling personnel are the primary source of *S. aureus*, and outbreaks are generally associated with temperature abuse after contamination of the cooked products (Bryan, 1980).

### D. Sporadic Cases

Foodborne diseases that are predominately associated with sporadic cases are under-represented by outbreak data. A pertinent recent example associated with beef is *E. coli* 0157:H7, a major agent of hemorrhagic colitis (Belongia, et al., 1991; Doyle, 1991; Griffin, et al., 1988; Riley, 1987; Wells, et al., 1991). A prospective study of diarrheal disease in the State of Washington identified this organism as the third most frequently isolated cause of bacterial diarrheal disease (MacDonald, et al., 1988). Of particular concern is this organism's association with hemolytic uremic syndrome (HUS), a sequela of hemorrhagic colitis. This life-threatening, chronic kidney disease occurs in 2-7% of patients with shiga-like toxin *E. coli*-associated disease (Griffin and Tauxe, 1991). HUS has a 6% rate of mortality, with children being the most susceptible.

*Listeria monocytogenes* is another pathogen where a substantial portion of the cases caused by this microorganism are sporadic. While foodborne transmission appears to account for most human listeriosis cases, no epidemiological link to beef products