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Review

Acinetobacter: an underrated foodborne pathogen?

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Abstract

The increasing prevalence of foodborne diseases observed in developing countries has been linked to a rise in the consumption of raw foods. However, unlike the classical pathogens that are commonly implicated in foodborne illnesses, members of the genus *Acinetobacter* are rarely associated with diarrheal disease, probably because of the difficulty in isolating these Gram-negative bacteria from food sources. Nevertheless, several species of *Acinetobacter*, especially *A. baumannii*, possess many of the characteristics associated with successful pathogens and exhibit a prodigious ability to acquire the multiple-drug resistance (MDR) phenotype. In this mini-review, we summarize the epidemiological data relating to MDR *Acinetobacter* and consider evidence suggesting that contaminated dairy products, along with raw fruit and vegetables, constitute extra-hospital reservoirs of this underrated pathogen, and may represent an increased risk to immunocompromised individuals and young children in healthcare settings.

Key words: *Acinetobacter baumannii*; food; multiple drug resistance.

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The controversy

The rise in consumption of uncooked fresh food is one of the principal causes of the increased prevalence of foodborne diseases observed in developing countries [1,2]. Insufficient attention to hygiene during the production and/or processing of food products can give rise to contamination by pathogenic or spoilage bacteria, including members of the genus *Acinetobacter* [3-5]. While some *Acinetobacter* species are present in the microbiota of healthy human skin, many isolates recovered from clinical specimens exhibit significant pathogenicity [6,7]. From an epidemiological viewpoint, *A. baumannii* is the most important species, since it has been associated with a range of serious infections, especially those acquired in intensive care units. Furthermore, since infection with *A. baumannii* has been correlated with increased morbidity, mortality, and multiple-drug resistance (MDR), the presence of this pathogen is now considered to be an important threat in disease treatment [8,9].

A number of authors have suggested that the action of proteolytic and lipolytic enzymes produced by *Acinetobacter* andother bacteria found in dairy foods may contribute to the flavor, odor, or texture of the product [10,11]. In contrast, some reports have described *Acinetobacter* species merely as potential pathogens with no mention of their role in modifying the characteristics of foodstuffs. For example, Gurung *et al*. [12] and Dijkshoorn [13] reported the isolation of *Acinetobacter* strains from samples of milk and milk derivatives and claimed that these microorganisms could be opportunistic pathogens.

The facts

Unlike classical pathogens such as *Shigella dysenteriae*, *Staphylococcus aureus*, *Salmonella enterica* subspecies I, or *Escherichia coli* that are typically implicated in foodborne illnesses, *Acinetobacter* is rarely associated with diarrheal disease. The principal reason for this disparity may be that *Acinetobacter* usually causes much more serious infections and, even when the bacteria is detected in the gastrointestinal tract, its presence is generally overshadowed by the co-occurrence of more common infectious agents, which are then treated collectively as opportunistic pathogens. Although such pathogens do not normally cause disease in healthy immunocompetent adults, the number of immunocompromised individuals continues to rise worldwide. Impairment of the immune system results mainly from human immunodeficiency virus, cancer, recurrent infections, and genetic predisposition, but can

also be caused by protracted antibiotic treatment and immunosuppressive therapy administered to patients who have, for example, received organ transplants [14].

Literature regarding the association of *Acinetobacter* with foodborne illnesses, especially diarrheal events, is somewhat limited, and the few reports that are available generally relate to studies involving immunocompromised individuals or high-risk groups such as young children. For example, Polanco and Manzi [15] isolated strains of *A. baumannii* and *A. calcoaceticus* from the feces of children under five years of age presenting acute diarrhea, and demonstrated that the isolates were toxic to cell cultures, although no specific mechanisms of pathogenicity were proposed. In addition, two case reports have described the isolation of *A. haemolyticus* strains from the feces of infants younger than one year of age affected by bloody diarrhea. One of the papers reported the production of Shiga toxin 2 by the isolate and suggested that the strain may have been the cause of illness [16], while the other disclosed the association between *A. haemolyticus*, bloody diarrhea, and hemolytic uremic syndrome [17]. The authors emphasized that, while such diseases are normally associated with Shiga-toxigenic *E. coli* or *Shigella dysenteriae*, these pathogenic enterobacteria could not be detected in the clinical samples investigated. In this context, there is evidence to suggest that *Acinetobacter* species may colonize the digestive tracts of debilitated patients in a healthcare setting through the consumption of contaminated food. In a recent study conducted by our group [18], MDR strains of *Acinetobacter* were found in reconstituted infant milk formula and on supposedly disinfected utensils employed in preparations served to debilitated or premature infants in a public hospital in Rio de Janeiro, Brazil.

Acinetobacter, a successful pathogen

Members of the genus *Acinetobacter* are good competitors in the microbiota of food materials, although their success as pathogens may also be attributed to various other factors, including the ability to survive desiccation, form biofilms and adhere to, colonize, and infect human epithelial cells [19]. With respect to the competitive nature of *Acinetobacter*, we recently isolated, from commercial samples of Minas Frescal cheese, four potentially pathogenic strains of the *A. baumannii-calcoaceticus* complex that produced antimicrobial substances with activities against *E. coli* and *Salmonella* [1]. In addition, the capacity of *Acinetobacter* to survive for long periods on dry surfaces, such as those found in food processing plants, constitutes an additional advantage in terms of environmental contamination since this feature is uncommon in non-sporulating bacteria [20-22]. Indeed, some authors have suggested that the multifactorial and manifold capacity of *Acinetobacter* species to form biofilms and to adhere to and survive on biotic and abiotic surfaces contributes to incidence of disease since such ability facilitates long-term persistence in the environment [23,24]. These aspects are clearly issues of considerable concern and require further detailed investigation.

Nevertheless, one of the main reasons why *A. baumannii* attracts considerable attention in the clinical arena is its prodigious ability to acquire and accumulate genetic determinants that confer resistance to antibiotics, resulting in infections caused by strains displaying the MDR phenotype [25]. Of particular concern are illnesses associated with *Acinetobacter* expressing resistance to broad-spectrum antibiotics of the carbapenem group, since there are few therapeutic options available for the treatment of such infections [25-27]. The prevalence of carbapenem-resistant bacteria has been increasing in countries worldwide, including Brazil. In a recent study by our group, a strain of the *A. baumannii-calcoaceticus* complex that was resistant to imipenem, an antibiotic of the carbapenem group, was isolated from reconstituted infant milk prepared in the nursery of a public hospital in Rio de Janeiro [18]. It is worth noting that the gravity of public health issues associated with MDR *Acinetobacter* has led the Infectious Diseases Society of America to include *A. baumannii* among the so-called ESKAPE pathogens (*Enterococcus faecium*, *S. aureus*, *Klebsiella pneumoniae*, *A. baumannii*, *Pseudomonas aeruginosa*, and *Enterobacter* species), a group of organisms that cause the majority of hospital infections in the United States and successfully escape the effects of known antibiotics [28-30].

Various studies have shown that the excessive use over the last 50 years of antimicrobial drugs to treat human and animal infections has resulted in selective pressure, leading to antibiotic resistance [31-33]. Recent studies have demonstrated that reservoirs of genes coding for antibiotic resistance are present in humans, as well as in animals, plants, and the environment, and that these genes can be transferred to human pathogens by direct contact or indirectly via ingestion of contaminated foods [34]. In this context, MDR *Acinetobacter* has been detected in raw cow's milk and raw beef, suggesting that food of animal origin could serve as vectors for the dissemination of MDR *Acinetobacter* in community and hospital settings

[7,35]. In addition, MDR *Acinetobacter* may contaminate fruits and vegetables originating from crops irrigated with wastewater [36-38]. MDR *A. baumannii* and *A. lwoffii* have been detected in carrots originating from crops irrigated with water from the Jakara River in Nigeria, into which domestic, hospital, commercial, and industrial sewage is discharged [39]. Moreover, Al Atrouni *et al*. [40] isolated a strain of carbapenem-resistant *A. calcoaceticus* from vegetables cultivated in Lebanon. Considering that most vegetables are consumed *in natura*, this route may be considered a possible mode of transmission by which MDR bacteria could be introduced into community and healthcare environments.

Conclusions

The scarcity of reports concerning foodborne infection by *Acinetobacter*, and the consequential scarcity of epidemiological data, may be due to the difficulty of isolating this potential pathogen from food sources because of the lack of official standard methods. Considering that MDR *Acinetobacter* strains represent a global challenge to healthcare professionals and facilities, and that foods, particularly dairy products, may be extra-hospital reservoirs of this underestimated pathogen, it is clear that future research needs to focus on evaluating the pathogenicity of isolates of this bacterium obtained from products of plant and animal origin.

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