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Implication of *Corynebacterium* species in food's contamination

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ABSTRACT

Corynebacterium spp. are part of the human microbiota. Recently, species of this genus are increasingly implicated in different types of infections especially in immunocompromized and hospitalized patients. The significance of the presence of the genus *Corynebacterium* in foods is not clearly established. These bacteria may be involved in spoilage or ripening of cheese and meats. This review focused on different researches concerning the implication of *Corynebacterium* species in food's contamination.

1. Introduction

The genus *Corynebacterium* represents one of the earliest described bacterial genera. Recently, we can observe an increasing number of publications describing different incidents of infections, where species of *Corynebacterium* are isolated as the etiological factor[1-6]. This genus was originally proposed for the causative organism of *Corynebacterium diphtheriae* (Lehmann and Neumann, 1896) for diphtheria with the most important human-pathogenic significance[7-9]. Strains of this species produce a strong exotoxin and are responsible for causing diphtheria. Actually, the genus *Corynebacterium* comprises a broad range of additional important different species with pathogenic significance including species pathogenic for animals, *e.g. Corynebacterium pseudotuberculosis* (*C. pseudotuberculosis*)[10,11], *Corynebacterium kutscheri*[12,13], *Corynebacterium canis*[14] and a very large group of saprophytic species colonizing the skin and mucous membranes of man, which may become the cause of serious infections in immunocomprmosed and hospitalized patients.

The genus *Corynebacterium* includes also species unrelated to the human organism, *e.g. Corynebacterium glutamicum* (*C. glutamicum*), producing L-glutamic acid and lysine, used in biotechnological processes on the industrial scale and in genetic studies[15-17]. However, the significance of the presence of the genus *Corynebacterium* in foods is not clearly established. These bacteria may be involved in spoilage or ripening of cheese and meats. They may also act as indicators of sanitation or hygienic quality. In this work, we summarized the implication of *Corynebacterium* species in food's contamination.

2. *Corynebacterium* in milk

Together with the genera *Staphylococcus, Escherichia* and *Enterococcus*, members of the genus *Corynebacterium* represent one of the most relevant mastitis-associated pathogens in dairy farming[18,19]. *Corynebacterium bovis* (*C. bovis*) and *Corynebacterium amycolatum* are frequently isolated from bovine mammary glands[20].

The lipophilic species *C. bovis* is frequently isolated from milk samples in many dairy farms. It is associated with very mild forms of mammary inflammation. Slightly increased somatic cell counts in the milk are usually the only manifestations of these infections.

In a preliminary study, yield and composition of milk from 53 *C. bovis*-infected quarters of 44 cows at four consecutive milkings were compared with those of the contralateral uninfected quarters. Differences between infected and uninfected quarters in milk, fat and protein content were small and statistically non significant. However, numbers of somatic cells were significantly higher in

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infected than in uninfected quarters[21]. In agreement with previous work, this preliminary trial with uninfected quarters revealed that front quarters produced less milk than rear quarters. Composition of milk from front and rear quarters was similar. Also, as expected, milk produced after a longer milking interval was greater in volume but lower in fat and protein content than that produced after a shorter interval. In the same work, milk yields from *C. bovis* infected and uninfected quarters were compared. There was a small but non-significant reduction in yield from infected quarters[22]. This is in agreement with Brooks who found no significant effect of experimental infection with *C. bovis* on milk production[23].

In addition to *C. bovis*, a new lipophilic oxidative species, *Corynebacterium mastitidis*, has been recognized and described from the milk of sheep[24]. In another work, the same team isolated a new species, *Corynebacterium camporealensis*, from sheep milk associated with subclinical mastitis[25,26]. Fermentative nonlipophilic corynebacteria are much less often found in mastitic milk. *Corynebacterium ulcerans* has been described as a cause of bovine mastitis with a potential risk for humans, but its pathogenic significance has remained unclear[27-29]. In addition to caseous lymphadenitis, *C. pseudotuberculosis* was isolated as a causative agent of cows and mastitis of sheep. Aroch *et al*.[30] noted a decrease in milk production and considerable increase in the somatic cell count in the mastitic cows. Several studies suggested that the housefly plays an important role in harbouring and disseminating *C. pseudotuberculosis* in dairy herds in Israel[31,32].

Two other species, *Corynebacterium amycolatum* and *Corynebacterium minutissimum*, are known to be associated with mastitis of dairy cows[28]. In a published work, Wiertz *et al*.[33] described 2 new species: *Corynebacterium frankenforstense* belonging to Frankenforst, the name of the experimental farm, isolated from a bulk milk tank of a dairy farm in Germany and *Corynebacterium lactis* isolated from raw cow milk produced in Germany.

3. *Corynebacterium* in cheese

Smear-ripened cheeses, such as Munster, Livarot, Maroilles, Limburger, and Tilsit, are characterized by the presence of a complex flora on the surface, comprising many species of yeasts and bacteria. The surface flora has a strong effect on the flavor, texture, and appearance of these cheeses. Yeasts dominate during the early stages of ripening because they are acid tolerant and salt tolerant[34]. They increase the pH of the cheese curd by assimilating lactate and producing alkaline compounds, and they also liberate growth factors, thereby favoring the growth of bacterial species. At the end of ripening, the bacteria are dominant, especially the bacteria belonging to the genera *Corynebacterium*, *Brevibacterium*, *Arthrobacter*, and *Micrococcus*[35-39]. The main sources of surface microorganisms are milk, ripening environment, and inoculation of cheese by the use of defined surface cultures or of the so-called "old-young" smearing procedure, in which young cheeses are inoculated with microorganisms from mature cheeses[37].

Corynebacterium casei[40-42], and *Corynebacterium mooreparkense* [subsequently shown to be *Corynebacterium variabile* (*C. variabile*)][43-45], were identified in smeared cheese. Graviera is the most popular traditional Greek hard cooked cheese[46]. Several varieties are produced in different regions of Greece from ewes', ewes' mixed with goats', or cows' milk, and three of them produced in the islands of Crete and Naxos and the mountain area of Agrafa have protected designation of origin status. Recently, Samelis *et al*.[47] evaluated the microbiological quality and the safety of Graviera cheeses traditionally manufactured at semi-industrial plant scale from thermized milk with addition of a product-specific commercial starter culture and isolated five strains of *Corynebacterium* sp. and *C. variabile*.

The importance of the bacterial flora for the ripening process has been emphasized, but few studies on the identification of the species present in red smear cheeses have been published. In 1997, Valdés-Stauber *et al*.[39] focused on the species of coryneform bacteria and yeasts which occur on the surface of ripe brick cheeses and noted that *Arthrobacter nicotianae*, *Brevibacterium linens*, *Corynebacterium ammoniagenes, C. variabile* and *Rhodococcus fascians* were found in significant numbers with a large number of coryneform isolates that could not be identified to the species level. *Corynebacterium* spp. produce extracellular enzymes that are important for the development of the characteristic flavors, colors, aromas and textures of these cheeses[39].

4. *Corynebacterium* in vegetables

Corynebacterium species have been isolated as a causative agent for the spoilage in field and stored vegetables and fruits. *Corynebacterium michiganense* was identified in vascular wilt, canker, leaf and fruit spot on tomatoes. *Corynebacterium nebraskense* may cause leaf spot and blight and wilt corn. *Corynebacterium sepedonicum* was isolated from tuber rot of white potatoes. Also, *Corynebacterium flaccumaciens* was associated with bacterial wilt of beans[48]. Moreover, *Corynebacterium* spp. has been isolated from frozen peas, beans and corns[49] and was responsible for spoilage in frozen vegetables in Botswana[50].

5. *Corynebacterium* in meats

Corynebacterium spp. could grow at 5 ˚C, indicating that species of this genus are psychrophilic. Psychrophilic *Corynebacterium* species have been isolated from refrigerated food. In a survey done in England, large numbers of psychrophilic *Corynebacterium* species were recovered from feathers and feet of poultry during processing. In recent report in Nigeria, *Corynebacterium* spp. were isolated from poultry farms suggesting that the flock of birds and the consumers of the eggs and meat from the chickens are at risk of bacterial infection[51,52]. In previous studies, *Corynebacterium* was isolated from bacon[53]. Also, *Corynebacterium* spp. were isolated from poultry and eggs[54]. In fact, *Brevibacterium* and *Corynebacterium* were the most prevalent isolates from turkey giblets[54]. Recently, *Corynebacterium* spp. was isolated from retail mouton and lamb in South Africa[55].

6. *Corynebacterium* in sea foods

Corynebacterium atrinae was isolated from the gastro intestinal tract of a pen shell. *Corynebacterium maris* sp. nov., a marine bacterium, was isolated from the mucus of the coral *Fungia granulosa*[56]. *Corynebacterium aquaticum*, originally found in both distilled water and natural fresh waters, has been reported to cause disease in some immunocompromised patients[57-59], and it was isolated from brain tissues of fish exhibiting pronounced bilateral

exophthalmia. Personnel involved in culturing fish should be made aware of the pathogenic capability exhibited by *Corynebacterium aquaticum* for mammals.

7. *Corynebacterium* in an alcohol fermentation starter

Shin *et al*.[60] described a novel Gram-positive, strictly aerobic and non-motile bacterial strain *Corynebacterium nuruki* isolated from an alcohol fermentation starter of traditional Korean wine.

8. *Corynebacterium* in food industry

In addition to their implication in food spoilage and contamination, *Corynebacterium* spp. were interestingly implicated in food industry especially *C. glutamicum*. *C. glutamicum* is a very important fermentative bacteria that is most widely known for its role in the production of monosodium glutamate and amino-acids. Discovered in 1957 in Japan as a natural producer of glutamic acid, *C. glutamicum* is a Gram-positive, facultatively anaerobic, heterotrophic bacterium with an irregular rod shape in a V-formation. It is non-pathogenic and is found in soil, animal feces, fruits and vegetables. Though it was originally isolated for its ability to produce massive amounts of glutamic acid, *C. glutamicum* and its closely related organisms have been developed for the production of most of the biogene amino acids, nucleotides, and vitamins[61].

9. Conclusion

In conclusion, the implication of *Corynebacterium* species as food contaminant species is undertaken. However, this bacterium is a serious threat to a safe food supply. It may be present in a variety of consumed food and can be transmitted to human causing diseases. There are several precautions that must be taken to insure that food is not contaminated, that processing procedures are sufficient and that storage conditions don't allow *Corynebacterium* growth. As always, good manufacturing practices and sanitation decrease the risk of a foodborne illness becoming a serious health problem.

Conflict of interest statement

We declare that we have no conflict of interest.

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