



Article

Essential Oils from Indigenous Iranian Plants: A Natural Weapon vs. Multidrug-Resistant *Escherichia coli*

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Abstract: Aim of this study was to investigate the antimicrobial properties of herbal plant essential oils (EOs) from selected Iranian plant species such as *Ferulago angulata*, *Zataria multiflora*, *Cuminum cyminum*, and *Mentha longifolia* against antibiotic-resistant *Escherichia coli* (*E. coli*) strains. For this purpose, the *Escherichia coli* strains, isolated from raw cow's milk and local dairy products (yogurt, cream, whey, cheese, and confectionery products) collected from different areas of Hamedan province, Iran, were investigated for their resistance to antibiotics (i.e., streptomycin, tetracycline, gentamicin, chloramphenicol, ciprofloxacin, and cefixime). Thus, the *E. coli* strains were tested for their susceptibility to the above-mentioned essential oils. Regarding antibiotics, the *E. coli* strains were highly sensitive to ciprofloxacin. In relation to essential oils, the most effective antibacterial activity was observed with *Zataria multiflora*; also, the bacteria were semi-sensitive to *Cuminum cyminum* and *Mentha longifolia* essential oils. All strains were resistant to *Ferulago angulata* essential oil. According to the results, the essential oil of *Zataria multiflora* can be considered as a practical and alternative antibacterial strategy to inhibit the growth of multidrug-resistant *E. coli* of dairy origin.

Keywords: antibiotic susceptibility; pathogen; *Zataria multiflora*; essential oils; dairy products



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1. Introduction

Escherichia coli (*E. coli*) is one of the most important microorganisms causing infections of the digestive and urinary tracts in humans and animals. The main way of transmission of this pathogen is through the fecal–oral chain; however, the handling of food during processing is considered risky because it can allow the transfer of this pathogen [1]. Furthermore, *E. coli* is one of the most important and leading causes of mastitis in cattle, from which the pathogen can easily be transmitted to consumers through milk and dairy products [2]. In this regard, due to the excessive use of antibiotics used to control these diseases, significant resistance to a wide range of antibiotics has developed in several *E. coli* strains [3,4]. For this reason, the presence of the multi-drug pathogens in foods of animal origin such as milk, meat, and poultry has dramatically increased in recent years [5]. So, the consumption of high-risk foods including raw milk and artisanal (traditional) products such as cheese, yoghurt, whey, cream, creamy desserts, and roulette cakes can play an important role in the transmission of these multi-drug resistant pathogens. In the last decades, many strategies have been undertaken to fight multidrug-resistant bacterial infections, including phage therapy, new vaccines, and new peptides, to name a few [6]. In addition, many studies are focusing on finding new and effective antimicrobial agents such as essential oils (EOs),