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Kocuria spp. in Foods: Biotechnological Uses and Risks for Food Safety

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Abstract

Background and Objective: Bacteria of the Genus *Kocuria* are found in several environments and their isolation from foods has recently increased due to more precise identification protocols using molecular and instrumental techniques. This review describes biotechnological properties and food-linked aspects of these bacteria, which are closely associated with clinical cases.

Results and Conclusion: *Kocuria* spp. are capable of production of various enzymes, being potentially used in environmental treatment processes and clinics and production of antimicrobial substances. Furthermore, these bacteria show desirable enzymatic activities in foods such as production of catalases and proteases. Beneficial interactions with other microorganisms have been reported on increased production of enzymes and volatile compounds in foods. However, there are concerns about the bacteria, including their biofilm production, which generates technological and safety problems. The bacterial resistance to antimicrobials is another concern since isolates of this genus are often resistant or multi-resistant to antimicrobials, which increases the risk of gene transfer to pathogens of foods.

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1. Introduction

The Genus *Kocuria* includes Gram-positive, catalase-positive coagulase-negative cocci, belonging to Family Micrococcaceae. The genus was first described as *Micrococcus* spp. in 1995 and later transferred to a novel genus due the heterogeneity of the micrococcal species indicated by phylogenetic and chemotaxonomic analyses. Genus *Kocuria* was named after the Slovak microbiologist, Miroslav Kocur, who was one of the first researchers to study Gram-positive cocci [1]. Currently, the genus includes 26 species with *Kocuria* varians and *Kocuria (K.) rosea* as its major representatives. The youngest species, *K. coralli,* has recently been described in 2020 [2,3]. *Kocuria* spp. can be found in diverse environments such as skin of mammals [1,4], birds [5], milks, dairy products [6-8], seafood [9], fermented and unfermented meat products of various origins [10-12], environmental samples [2,13,14] and intestine of bees [15].

Milk and cheese are the foods most associated with the presence of *Kocuria* spp. The bacterial presence is reported in foods and they are sometimes isolated in culture media used for the isolation of other bacteria such as *Staphylococcus* spp. and lactic acid bacteria (LAB) [7,8,16].

Mostly, members of the Genus *Kocuria* present as commensal microorganisms. However, several *Kocuria* spp. have emerged as important pathogens, responsible for several diseases such as endocarditis, meningitis, chole-cystitis, urinary tract infections, catheter linked bacteremia, peritonitis and abscesses [4,17,18]. It is known that the prevalence of these infections is underestimated since phenotypic identification methods frequently used in clinical analysis can mistakenly identify *Kocuria* isolates as coagulase-negative *Staphylococcus* spp. [4,17,19] based on their Gram staining, catalase and coagulase characteristics. Similarly, assessment of these species in foods might be difficult. In general, susceptibility to lysozyme and bacitracin and resistance to lysostaphin and nitrofurantoin/furazolidone is useful in phenotypical differentiation between *Kocuria* and *Staphylococcus* genera [4,17]. However, techniques such as matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDITOF/MS) and 16S rRNA gene sequencing are needed for accurate identifications. *Kocuria* spp. includes a wide variety of species and habitats and are found in most daily foods; therefore, the aim of this study was to discuss the major favorable and unfavorable food-associated aspects with clinical and industrial usability.

2. Potentials for biotechnological uses

Bacteria of the Genus *Kocuria* are extremely versatile from biotechnological and clinical points of view. Scientific literatures report several possibilities for the use of compounds produced by these microorganisms in various industries. In general, species of the Genus *Kocuria* are pigmented, varying between yellowish, orange and reddish tones. These colors are majorly linked to carotenoids pigments [20-22]. Canthaxanthin, astaxanthin and adonirubin are the most isolated carotenoids, which may be useful in diets for salmonids in aquaculture and commercially as nutritional supplements, pharmaceuticals and food colorants [21,22]. These include *Kocuria* (*K.) rhizophila* and *K. rosea*; from which, pigment isolation yields good results. Bertsh and Coello [21] showed that the strain of *K. rosea* LPB-3 was able to produce high concentration of carotenoid pigments (500 $\mu g.g^{-1}$ dry cell) to dye culture broths with orange-pink color. When the culture broths were dehydrated by heat treatment, concentration of carotenoids diminished to 300 $\mu g.g^{-1}$ dry cell; however, the value was still high, compared to other microorganisms. Recently, Rezaeeyan et al. [22] described another biotechnological use for the pigments produced by *Kocuria* spp. Carotenoids produced by *Kocuria* strain QWT-12, were purified and carried out against seven cancer cell lines. These pigments, in concentrations of 2-8 $mg.g^{-1}$, presented inhibitory activities against lung and breast cancer cells. Based on mass spectrophotometry, neurosporene was identified as the major carotenoid pigment.

Production and secretion of keratinases by *Kocuria* strains have already been described. A similar *K. rosea* strain, described by Bertsch and Coello [21] as a highly carotenoid-producing strain, presented a high keratinolytic capacity when cultured aerobically on submerged feathers to achieve fermented meals [23] as cheap protein sources in animal foods. The authors highlighted that enzymes from the biodegradation of feathers could be biotechnological tools for cosmetics and leather industries [23]. Moreover, use of *Kocuria* spp. in pulp and paper industries is possible. Recently, Boruah et al. [13] described the lignolytic potential of *Kocuria* PBS-1 isolated from soils. The strain produced highly-thermostable laccase and was tolerant to various pH values with a potential use in bleaching of bamboo pulps in papermaking processes [13]. Nowadays, this bleaching is carried out with chlorine, which includes undesirable effects on the environment. Bioremediation is another environmentally potential use of *Kocuria* spp. Lalevic et al. [24] demonstrated crude oil degradation by *Kocuria* strain 27/1 isolated from contaminated wastewaters by oil hydrocarbons from a oil refinery in Serbia. The bacterial strain was incubated at 30 ºC for seven days at various concentrations of crude oil of 500-4,000 ml l^{-1}. Results showed that pure cultures of *Kocuria* 27/1 were capable of crude oil biodegradation with a maximum degradation rate of 72% at a crude oil concentration of 2,000 ml l^{-1}. Authors suggested that the bacterial strain included potential to be used in the bioremediation of crude oil-contaminated environments [24].

Similarly, crude oil biodegradation was demonstrated in *Kocuria* SAR1, a strain isolated from oil water pits in eastern coast of Libya. This strain was able to produce biosurfactants with high emulsifying potentials of crude oils in presence of corn steep liquors and solid waste dates used as agro-industrial products. After 28 days of incubation, bacterial strain effciently removed 68 and 70% of the crude oils of corn steep liquors and solid waste dates, respectively [25]. Heavy metal removal from water by *K. Rhizophila* strain 14ADP was described by Haq et al. [26]. This endophytic strain was isolated from leaves of *Oxalis corniculata*, a metal accumulating plant and was able to act as a biosorbent to remove cadmium and chromium from aqueous solutions with a maximum sorption by *K. rhizophila* at 35 °C ±2 within 60 min at pH 8 and 4 for Cd and Cr, respectively [26]. Other studies reported the potential use of *Kocuria* spp. in bioremediation [27,28].

In recent years, potential biotechnological uses of *Kocuria* spp. have been further popular (Table 1). Several other patent uses involving *Kocuria* spp. in consortia with other microorganisms are majorly associated with the fermentation of foods or other biotechnological processes. In food industries, further examples of potential uses of these microorganisms are available. The first one includes fermenting processes of foods (e.g., sausages and cheeses). The maturation process generally occurs under controlled conditions of temperature and humidity. This needs participation of homofermentative microorganisms such as LAB and Gram-positive cocci, including coagulase negative staphylococci and *Kocuria* spp. and *Micrococcus* spp.) [29-32]. They act as starter cultures and contribute to the production of enzymes, affecting maturation of the foods. *Staphylococcus* spp. and *Kocuria* spp. include major roles in production of fermented sausages because they contribute to development of sensory and visual characteristics of the sausages [29,30]. These cocci are responsable for the development of red color in fermented sausages by reducing nitrate into nitrite through nitrate reductase activity and formation of nitrosomyoglobin [30].

Table 1. Patented uses of the Genus *Kocuria*

Strain/Species involved	Application area(s)	Description	Record number	Country	Deposit year
K. rhizophila PQ86	Clinical	Biological conversion of asymmetry of adrenaline, with high specificity, high performance, simple operation, low cost and easy separation of the target product	CN101067121A	China	2007
Kocuria sp. ZMAB-1 /MTCC5269	Clinical	Production process of the antibacterial compound PM181104 obtained by fermentation, with potential for use in medicines for the treatment and prevention of diseases caused by bacterial infections	NZ571636A	New Zealand	2007
K. rosea 307	Biotechnology	The strain produces a site-specific endonuclease, Kro1, which recognizes and cleaves both strands of the 5'-GCCGGC-3 'and 3'-CGGCCG-5' nucleotide sequence	RU2394099C1	Russia	2009
K. rhizophila NBRC 103217	Biotechnology	Protein expression system that uses *K. rhizophila* as a host, for expression of in non-aqueous environments	US20120142050 A1	United States	2009
K. palustris FSDN-A	Environmental	Strain application in wastewater denitrogenation treatment processes and is especially suitable for the treatment of wastewater containing nitrogen oxides and organic pollutants	CN103103141B	China	2011
Kocuria sp. 4B	Biotechnology	Manufacture of polymer containing cystathionine using the strain *Kocuria* spp. 4B as a producer	WO2012133823 A1	Japan	2011
K. rosea	Environmental	*K. rosea* with humus reduction activity and with resistance to salts and alkalis	CN102618463B	China	2012
Kocuria sp. VKM Ac-2624D	Environmental	Strain capable of quickly discarding oil and derivatives (diesel, engine oil, hydraulic oil, gas condensate)	RU2560279C1	Russia	2014
K. marina	Clinical; Foods	Extract of bacterial origin with potential for use in the generation of polymeric structures with bioactive surfaces, capable of inhibiting the formation of microbial biofilms	WO2019126902 A1	Chile	2017

Source: Google Patents (https://patents.google.com/advanced), *K*= *Kocuria*

Food flavors are generally produced by decomposition of free amino acids and inhibiting the oxidation of unsaturated free fatty acids, participating proteases and lipases [29,31,32]. *Staphylococcus* and *Kocuria* spp. Contribute to rancidity prevention by the production of catalase and superoxide dismutase as natural antioxidants [30,32]. Table 2 summarizes these bacterial enzymatic activities and their respective properties during the maturation processes.

In addition to enzymes described in Table 2, *Kocuria* strains can produce other enzymes and compounds in food maturation. Feng et al. [33] described detection and characterization of an alkaline serine protease (SF1) produced by *K. kristinae* F7 strain. The authors reported that this enzyme included a great potential use in soy fermented foods, accelerating the maturation processes [33].

Researchers from the same group investigated action of the KP3 protease produced by *K. rosea* KDF3 strain on maturation of sufu, a traditional Chinese food prepared with soy curd, generally in cubes. The protease KP3 was able to decrease maturation time of sufu over 30 days, which could help expedite industrial production of the food [34].

Callejon et al. [35] characterized an amine oxidase produced by *K. varians* strain LTH 1540 isolated from artisanal fermented sausages. The authors suggested that the enzyme might include uses in beverage and fermented food industries since one of the biggest problems in manufacture of these foods is the presence of biogenic amines such as cadaverine and putrescine. These substances are associated with poor sanitary conditions of grapes, remaining in wines and causing economic losses. The *K. varians* LTH 1540 strain could degrade up to 30% of putrescine from an initial concentration of 40 mg l^{-1} in wine samples after seven days of incubation. At this time, however, no viable *K. varians* cells could be recovered from wines [35].

Table 2. Enzymes produced by Gram-positive cocci in fermentation processes of foods and their respective activities

Bacterial enzymes	Performance in food maturation
Proteases	Flavor and texture development
Nitrato-reductase	Staining formation
Lipases	Flavor development
Catalases	Decomposition of peroxides Staining stabilization Rancidity prevention
Superoxide desmutase	Antioxidant activity

Adapted from [30] and [32].

However, it is noteworthy that production of unwanted proteases and lipases in certain food matrices can become a technological problem. Reports have been published on the isolation of *K. varians* and *K. kristinae* in raw milks with strains exhibiting proteolytic and lipolytic activities. Evidences are available on possible applicability of the technological properties of foods, especially interaction of

Kocuria spp. with other microorganisms that can yield technological benefits when are cocultivated. In 2007, Tremonte et al. investigated interactions between isolates of *K. varians* and *Staphylococcus xylosus* from fermented meat products. They found that the *Staphylococcus xylosus* isolates included high stimulatory effects on proteolytic activity of *K. varians* K4 [11]. Centeno et al. [6] reported that use of a mixed culture of *K. varians* and *Yarrowia lipolytica* in prematuration stage of *Tetilla* cheeses (popular in Galicia, Spain) improved formation of volatiles such as acids, greases, esters and sulfur compounds and thereby improved the flavor [6]. These interactions need highlights since inhibitory activities against pathogenic or undesirable bacteria are generally reported in literatures, majorly through the production of antimicrobial substances such as bacteriocins and other compounds. However, a few reports refer to activities that stimulate interactions in foods, involving *Kocuria* spp.

Kocuria strains produce antimicrobial substances with potential uses in food industries. In 1996, Pridmore et al. characterized an antimicrobial substance produced by *K. varians* isolates (still cited as *Micrococcus varians*) from raw Italian salamis. This substance was called variacine and shown as a bacteriocin of the group l antibiotics with antimicrobial activities against several bacteria, including *Listeria* spp., *Staphylococcus* spp. and bacilli. The authors stated that the use of antimicrobial producing strains as cultures that initiated the fermentation process could contribute to the preservation of sausages [36]. In a later study, a spray dried fermented milk based concentrate containing 3.1 $mg.kg^{-1}$ active variacin was mixed with commercially available chocolate and vanilla desserts inoculated with a cocktail of three strains of *Bacillus cereus*. Variacine presented significant antimicrobial activities against growth of this pathogen at refrigeration abuse temperatures [37]. Kocurin produced by a marine isolate of *K. palustris* is a thiazolyl peptide with inhibitory activities against various Gram-positive bacteria, including methicillin-resistant *Staphylococcus aureus* (MRSA). Since the biochemical is an antibiotic, it may show activities against Gram-negative bacteria and fungi as well [38].

Another antimicrobial substance produced by *Kocuria* spp. has recently been described. The substance is called kocumarin and produced by a strain of *K. marina* isolated from brown seaweeds. Kocumarin is an acid (4-[(Z)-2-phenylethyl] benzoic acid) that includes potent antimicrobial activities against pathogenic bacteria such as isolates of MRSA and fungi. Furthermore, the substance includes potential clinical and food uses [9]. Bundale et al. [39] identified peptide KCR3A produced by *K. kristinae* KCR3 with antibacterial and antifungal activities. According to the authors, KCR3A included a much broader range of bioactivities than that antimicrobial substances (e.g., kocurin and variacin) produced by other species of *Kocuria* did [39]. It is noteworthy that although several bacteriocins and other antimicrobial substances include potential uses against deteriorating or pathogenic bacteria in foods, only nisin produced by *Lactococcus lactis* has been licensed as a food preservative and "generally recognized as safe" by the US Food and Drugs Administration [40].

3. Risks

3.1. Biofilm production

Biofilms can be described as accumulations of microbial cells, associated with surfaces and immersed in self-produced polymeric matrices [41,42]. In food processing plants, binding of cells to the substrate and subsequent formation of biofilms can be directly affected by the material types on contact surfaces and components of the processed foods often [43]. Production of microbial biofilms is a major problem in food industries as it involves deterioration of foods in addition to promoted transmission of pathogens associated with foodborne diseases. According to Bridier et al. [44], bacterial contamination of surfaces is one of the most relevant factors in persistence of pathogens in food-processing environments. Moreover, it is suggested to include significant effects on public health [44]. Production of biofilms by *Kocuria* spp. in environments of food production and processing has been reported in several studies. However, biofilms are mostly composed of a cocktail of microorganisms.

Interactions between species such as *Kocuria* spp., resulting in increased biofilm formation in foods and associated utensils and equipment, have frequently been described in literatures. Weber et al. [42] detected strains of *Kocuria* spp. forming biofilms in piping systems of milking machines with other dominant genera such as *Bacillus*, *Acinetobacter* and *Pseudomonas*. They suggested necessity for the improvement of machine sanitation systems [42]. Carpentier and Chassaing [45] cultivated a variety of bacterial isolates, including *K. varians*, in binary culture biofilms with *Listeria* (*L.*) *monocytogenes* in stainless steel coupons to mimic production of biofilms in food industrial equipment. Using epifluorescence microscopy, the French authors found that *L. monocytogenes* cells were grouped around the *K. varians* microcolonies and were not mixed. This revealed that presence of *K. varians* favored colonization of the surface by *L. monocytogenes*, unlike other microorganisms. They suggested that in facilities of food industries, for example, the resident microbiota might include significant effects on colonization of *L. monocytegenes* [45]. Midelet et al. [46] reported similar results while investigating binding and transfer of *L. monocytogenes* from mixed and pure biofilms. The authors found no differences between the populations of *L. monocytogenes* grown in presence of *K. varians* and those in pure culture after contact with various solid substrates simulating surfaces in meat-processing sites. They concluded that these two species might share available nutrients, consequently resulting in smaller populations at the end of their growth, compared to when they grow alone. Thus, it was more likely that *K. varians* helped colonization of *L. monocytogenes* on the substrates [46]. More recently, a Danish study showed that presence of a *K. rhizophila* isolate from food processing environments in various bacterial species resulted in synergistic biofilm formation [47].

Generally, food services are not free from the formation of biofilms, whose presence can increase risks of cross-contamination through the survival of bacteria from sanitizing agents used in daily cleaning processes. In a study in Korea, susceptibility of bacterial isolates to disinfectants from the kitchen of a cafeteria was assessed. Of the most isolated genera, *Kocuria* spp. ranked the third after *Bacillus* spp. and *Staphylococcus* spp. More than 50% of the isolates produced biofilms and assessments with sanitizers revealed the resistance of *Kocuria* isolates to sodium hypochlorite (NaClO) and hydrogen peroxide (H_2O_2). However, the isolates were more susceptible to benzalkonium chloride, citric acid and lactic acid [48]. This study demonstrated real needs of further precise hygienic practices in food-service establishments. In a study carried out by the current authors in Brazil, 31% of the *K. varians* isolates from pasteurized milks were biofilm producers. It is noteworthy that a part of the producer isolates were resistant to antibiotics, with one of them presenting multidrug resistance phenotypes [8]. Although mostly undesirable, biofilms could be beneficial when produced by fermentation-initiating cultures as their production could decrease or inhibit food colonization by pathogens or deteriorators [31,49].

3.2. Antibiotic resistance

Resistance to antimicrobial agents by bacteria isolated from foods has been a great concern for years. Gardini et al. [10], reported strains of *Staphylococcus* and *Kocuria* resistant to antibiotics (some multi-resistant) isolated from fermented sausages in Italy. Authors recommended careful use of antibiotics in animal rearing and improvement in hygienic conditions during livestock production [10]. In the last decade, effects of the food chain on transmission of antibiotic resistance have been well described. Emerging data show the prevalence of a broad spectrum of commensal bacteria carrying resistance genes in ready-to-eat foods and presence of free resistance genes in various foods. These free genes and resistant bacteria can reach human microbiota after consuming those foods, thus allowing horizontal share of these genes through gene transfer mechanisms [50-52]. No multiple studies are available on antibiotic resistance of *Kocuria* strains isolated from foods, mostly refer to clinical studies. Table 3 presents studies that cite *Kocuria* isolates from foods with antibiotic resistance.

In a French study, *Kocuria* spp. were able to grow in simultaneous presence of penicillin and oxacillin. Most isolates showed resistance to erythromycin, although *Kocuria* spp. and *Staphylococcus* spp. were generally sensitive to this antimicrobial as well as oxacillin and spiramycin; antibiotics to which, *Kocuria* spp. were resistant [53].

In a study in Poland, strains of *K. rhizophila* were characterized with a high prevalence rate in trouts, causing a 50% mortality rate in fishes. Based on molecular analyses, the bacterial isolates from trouts were similar to those isolated from food-processing environments, including those with resistance to sulfazotrim [54].

Rodriguez-Alonso et al. [55] isolated *K. varians* from artisanal cheeses made from raw milks in Spain. Of the three isolates characterized, one showed resistance to an antimicrobial, while the other two were resistant to more than five antibiotics with high resistances against furazolide and oxacillin [55]. In a Brazilian study on pasteurized milks, several isolates of *Kocuria* were identified, half of which were multidrug-resistant (MDR), majorly to clindamycin, tetracycline and penicillin [8].

4. Decreasing risks

Even with potential uses in several areas with emphasis on use in foods, *Kocuria* spp. can include risks to food safety. Omics techniques could improve the safety, needed to continuous supply of foods to consumers [56]. These techniques include a wide range of uses in food microbiology such as improvement of food safety by detecting pathogens, understanding of pathogenicity mechanisms, detection of virulence levels of bacterial strains and beneficial aspects of the industrial strains [57-59]. Genomics, proteomics, transcriptomics and metabolomics enable investigation of strain diversity naturally present in traditional foods that can be used as starter cultures by allowing rapid screening of promising strains with desirable functional characteristics and lack of negative features [31]. For example, shotgun metagenomics can differentiate taxonomic profiling of foodborne bacteria and possible antimicrobial resistance genes in foods [60]. For the safe use of *Kocuria* strains in foods, risk assessments should be carried out to predict health problems. Acccording to Codex Alimentarius Commission, risk assessments consist of hazard identification, hazard characterization, exposure assessment and risk characterization [61]. These informations can be achieved via integration of genotypic (by omics technologies) and phenotypic data in simulation tools and experimental challenge tests, targeting assessment ways to effectively control the risks [62].

Table 3. Antibiotic resistance patterns of *Kocuria* isolates from foods

Isolates	Source	Country	Observed resistances	Presence of MDR isolates	References
K. kristinae (n=3)	Fermented sausage	Italy	COL(n=3), MET (n=1), OXA (n=1), PIP (n=3), SUL (n=3), TET (n=1)	Yes	[10]
Kocuria spp.(not defined)	Pasteurized milk	France	ERI (n=6), OXA (n=1), PEN (n=1), SPI (n=3),	ND	[53]
Micrococcaceae (n 5) [*K. varians* (n=3); *M. luteus* (n=2)]	Raw milk cheese	Spain	AMP (n=3), CEF (n=2), OXA (n=4), PEN (n=2)	Yes	[55]
K. rhizophila (n=2)	Rainbow trout	Poland	SUL (n=2)	No	[54]
K. rhizophila (n=1)	Virgin olive oil	Italy	CIP (n=1)	No	[14]
K. varians (n=8)	Pasteurized milk	Brazil	CLI (n=5), CLO (n=3), NOR (n=1), PEN (n=4), TET (n=4)	Yes	[8]

Legend: MDR, multidrug resistant; n, number of isolates; ND, not determined; AMP, ampicillin; CEF, cephalothin; CLI, clindamycin; CIP, ciprofloxacin; CLO, chloramphenicol; COL, colistin sulfate; ERI, erythromycin; MET, methicillin; NOR, norfloxcin; OXA, oxacillin; PEN, penicillin; PIP, piperidic acid; SPI, spiramycin; SUL, sulfonamide; TET, tetracycline. *K*= *Kocuria*

5. Conclusions

Presence of *Kocuria* spp. in foods, especially in dairy products, has increasingly been reported. However, isolation of these species can be underestimated in food industries or in clinics, owing to their structural and biochemical similarities with other Gram-positive cocci that are general targets for the quantification techniques. Biotechnological uses of this bacterial group are questioned due to their varieties. Thus, further studies are needed to approve their industrial uses to produce products with added values. Production of pigments, enzymes and antimicrobial substances describes *Kocuria* as a promising genus, highlighting its desirable enzymatic activities in foods. Despite interesting aspects of biotechnological uses, concerns are addressed about the use of these bacteria. Examples of these concerns include bacterial pathogenic potency and their ability to produce biofilms, which can result in deterioration of products and food production-linked industrial problems. Furthermore, increased risks of transmission of pathogens via biofilms aggravate concerns about the use of these microorganisms. With increasing concerns about increased number of drug-resistant bacteria, it must be clear that *Kocuria* spp. can exhibit resistance to several antimicrobials. However the genus is generally considered as a commensal one, members within this genus can transfer genes to pathogenic species in food matrices.

6. Conflict of Interest

The authors declare no conflict of interest.

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گونه‌های *کوکاریا* در مواد غذایی: کاربردهای زیست فناورانه و مخاطرات و ایمنی مواد غذایی

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چکیده

سابقه و هدف: باکتری‌های جنس *کوکاریا* که در محیط‌های زیست یافت می شوند به‌تازگی جداسازی آنها از مواد غذایی به خاطر استفاده از پروتوکل های شناسایی دقیق تر با استفاده از روش‌های مولکولی و ابزاری رو به افزایش بوده است. این مقاله مروری به توصیف خواص ریست فناوری و جنبه‌های مرتبط با غذای این باکتری‌ها، که ارتباط نزدیک با موارد بالینی دارند، می‌پردازد.

یافته‌ها و نتیجه‌گیری: گونه‌های *کوکاریا* قادرند انواع آنزیم‌ها را تولید کنند و امکان استفاده از آنها در فرایندهای تیمار محیط زیستی، بالینی و تولید ترکیبات ضدمیکروبی وجود دارد. علاوه براین، این باکتری‌ها فعالیت مطلوب آنزیمی در مواد غذایی مانند تولید پروتئازها و کاتالازها را از خود نشان داده اند. وجود اثر متقابل مفید با سایر میکرارگانیسم‌ها بر افزایش تولید آنزیم‌ها و ترکیبات فرار در مواد غذایی گزارش شده‌است. با این‌حال، نگرانی‌هایی درباره این باکتری‌ها وجود دارد، شامل تولید زی‌لایه[1]، که مشکلات ایمنی و فناوری را به‌وجود می‌آورد. مقاومت باکتریایی به ترکیبات ضدمیکروبی از دیگر مشکلات است زیرا انواع جداشده این جنس اغلب به ترکیبات ضدمیکروبی مقاوم یا چندمقاومتی[2] می باشند، که خطر انتقال ژن به میکروب‌های بیماریزای مواد غذایی را افزایش می‌دهد.

. **تعارض منافع:** نویسندگان اعلام می‌کنند که هیچ نوع تعارض منافعی مرتبط با انتشار این مقاله ندارند.

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- گونه‌های *کوکاریا*
- کوکسی گرم مثبت
- امکان زیست فناوری
- زی‌لایه
- مقاومت ضدمیکروبی

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[1] biofilm
[2] multi-resistant