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Food Safety as well as Security can be Threatened by Climate Change

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Opinion

Climate change is universally recognized as a current crisis, threatening worldwide food security due to decreased crops yields and failed harvest following extreme events. The quality of crop products is affected by global warming as well as yields; however, little attention is paid to the risks related to the different composition of edible vegetables that happens as a consequence of the physiological adaptation of plants to changing climate. One main consequence of climate change is drought, and a widespread adaptive mechanisms of tolerance to drought stress in plants is the osmotic adjustment: newly synthesized osmotically active compounds, named osmolytes, are accumulated in plant cells with the role of osmoprotection and osmoregulation [1]. Decreasing the osmotic potential allows plants to maintain osmotic balance and water potential, supporting the water influx and preserving the turgor-depending processes, such as stomatal opening, photosynthesis, cells enlarging and growth; moreover, osmoprotection hinders the oxidative stress induced by drought and sustains ion homeostasis [1,2]. Vitality and survival of plants capable of osmolytes accumulation are higher where water availability is limited [3]. Osmolytes can be inorganic molecules, such as K+, but more frequently they are organic compatible solutes, such as monosaccharides (fructose, glucose) disaccharides (sucrose, trehalose) oligosaccharides (raffinose), polysaccharides (fructans), polyols (sorbitol, mannitol, inositol, glycerol) and other compounds such as proline, glycine-betaine, proline-betaine, inositol derivatives, choline O -sulfate, dimethyl sulfonium propironate [2,4]. These compounds are not directly harmful for the human health; however, some concern could rise in some instances, for example, when fermented foods are produced from vegetables.

Fermented vegetables are present worldwide in the human diet. Olives, sauerkraut and pickled cucumbers are widespread almost all over the world; kimchi, produced from cabbage and other vegetables and fruits such as sweet potato, eggplant, dropwort, radish, leaf mustard, turnip, lettuce, red pepper, garlic, chilli etc, is a basic component of the Asian diet, in particular in South Korea where it is the traditional dish; several foods and food components are obtained from the fermentation of soybeans; and other traditional fermented vegetable can be found in specific countries [5,6]. Fermented foods are considered beneficial to health: they can contribute to boost the immune system, to prevent cancer and to reduce the blood cholesterol; moreover, in certain cases they are carriers of microorganisms acting as probiotics. Fermentation implies acidification, that associated to high salt concentration improves the shelf life of the products. The main players of these kind of fermentations are typically lactic acid bacteria (LAB). Usually, LABs became dominant more or less rapidly due to their attitude to produce lactic acid, that drops the pH to value at which other microorganisms are inhibited; among them, for instance, Enterobacteriaceae, that are always present during the early phases, but disappear at the end of natural fermentations. However, it is not uncommon the spoilage of naturally fermented food by undesirable microorganisms. Microbial populations naturally present in the vegetables and in the environment can differently develop during fermentation, and their prevalence is mainly conditioned by the vegetable composition: for instance, the overall microbial growth in olives is usually lower when compared to cabbage, because of the presence of phenols at higher concentrations; other factors, such as salt concentration in brines, temperature and oxygen availability, can also affect growth and dominance of specific microbial populations [5]. Then, the chemical composition of vegetables is one main factor that can affect the balance among the different microbial populations during fermentation; in particular, certain sugars and polyols can act as selective energy an carbon sources. Recently, an uncommon growth of Enterobacteriaceae and molds was observed, associated to a rising pH, during late phases of olives fermentation [7].

The row olives were characterized by a high mannitol content, that was about 25% of the total sugars and sugar alcohols. Several spoiling microorganisms present in olive brines, that usually don't grow in these kind of fermentations, could be helped by the presence of mannitol, becoming more competitive because of their ability to use mannitol as energy and carbon source: among them, Enterobacteriaceae (i.e., *Klebsiella, Serratia, Proteus, Escherichia coli*) and molds (i.e. *Fusarium* spp.), but also other bacteria including *Staphylococcus aureus*. Likewise, also potentially harmful microorganisms can appear in fermented foods due to changing composition of row matrix. In the olive tree, mannitol is the main osmolyte accumulated in response to drought stress [8]; therefore, climate change could increase the frequency of high mannitol content in olives, modifying the equilibrium among microbial populations in favor of mannitol-catabolizing microorganisms. Recently, several reports of anomalous olive fermentations, with no growth of LABs, high growth of yeasts, and presence of *S. aureus*, have been reported (personal communications): this should be more taken into account in evaluating risks and consequences related to climate change, as these are signals for possible food safety risks. Mannitol can also favor the growth of mycotoxin-producing molds such as *Penicillium* spp. and *Aspergillus* spp [9].

In addition, also other osmolytes can selectively promote the growth of certain microorganisms. Proline can contribute to pathogenesis and can be used as nitrogen, carbon and energy source by bacterial and protozoa pathogens such as *Helicobacter pylori, Escherichia coli, Salmonella typhimurium, Staphylococcus aureus, Mycobacterium tuberculosis, Chlostridium difficile, Cryptococcus neoformans, Trypanosoma* spp., *Leishmania* spp. and *Ehrlichia chaffeensis* [10]. *E. coli* can also grow on trehalose [11]. *Pseudomonas aeruginosa* can use glycine-betaine as osmoprotectant and as the sole source of energy and carbon [12]. Moreover, osmolyte-rich edible vegetables could play a role in food safety not only for fermented foods, but also by exerting a selective pressure directly on gut microbiota, favoring the prevalence of specific microorganisms; this should deserve more attention, as it is very timely the awareness of the importance of gut microbiota composition on the human health [13, 14, 15]. In addition to this, it should be taken into account that also other potentially harmful secondary metabolites accumulate as a consequence of climatic stress in plants, such as alkaloids, cyanogenic glycosides, or polyamines [1, 16, 17]. All these aspects should be furtherly investigated and also considered when planning practices for "land challenges" [18].

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