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Editorial

Lactic Acid Fermentation as a Strategy for Nutritional Enhancement

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Lactic acid fermentation has been employed for centuries, primarily as a method for preservation of excess foodstuff and secondarily as a means to obtain flavorful food. Nowadays, nutritional enhancement, either through the removal of anti-nutritional factors or the production of nutritive compounds, has been added to the aforementioned benefits.

Research was initially focused on the identification of the dominating microbiota, their dynamics during fermentation and storage of the final product as well as the fate of pathogenic bacteria that may be present in the raw materials. The importance of the biotransformations occurring during fermentation and their effect on the nutritional value of the final product was soon highlighted and therefore extensively studied.

The outcome of fermentation depends upon the interplay between a number of biotic and abiotic factors. From a nutritional perspective, the parameters that define the nutritional value of the final product are the nutritional value of the raw materials, the capacity of the microorganisms that drive the fermentation and the parameters of the processing that may be required for effective transport and storage.

A number of health benefits, such as prevention of hypertension, lowering of serum LDL-cholesterol values, hypertriacylglycerolaemia, insulin resistance etc. have been correlated with the consumption of lactic acid fermented products [1]. Their attribution to specific substances, procedures or microbial consortia has been the epicenter of intensive study. Currently, research is focused on the properties of the microbiota that dominates fermentation, which are almost exclusively strain-specific. More accurately, their probiotic potential as well as the production of enzymes and secondary metabolites that may have a direct impact on the nutritional value of the final product have been extensively considered.

Maintenance of a healthy intestinal microbiota through the probiotic concept has been widely assessed. A microbial culture may be considered as potentially probiotic when it fulfills a series of criteria that are continuously updated and refer to their safety, functional and technological properties [2]. The latter refers to attributes required for specific production processes. Regarding safety, absence of potential virulence factors should be verified and the interactions with the native GIT microbiota and the host should be carefully assessed. The functional properties refer to the ability to survive the extreme conditions of the GIT and furthermore colonize it and persist. In addition, antagonistic activity against invasive Gram-negative pathogenic bacteria should be exhibited along with a series of assets beneficial to the host. The latter may include anti-diabetic, anti-tumor, pro-inflammatory and cholesterol-lowering potential, prevention and treatment of diarrhea, atopic dermatitis, bacterial vaginosis, irritable bowel syndrome, inflammatory bowel disease, constipation etc. Recent advances in the field of molecular biology have allowed prediction of all these functions to take place through omic approaches instead of *in vitro* testing. Evaluation of the probiotic potential through genetic determinants may increase throughput but may provide with both false positive and negative results originating from suboptimal PCR conditions or compromised transcription and/or translation potential. Worldwide, probiotic delivery takes place almost exclusively through dairy products mostly due to their commercial significance. Several other products have also been considered for that purpose, including fermented meat products, fruits and vegetables. The latter may also be considered an important vehicle but only at regional level, where these products have met commercial significance. However, considering the additional nutritional benefits that are presented below, an increase in their consumption is reasonable to occur.

The enzymes that may affect the nutritional value of the final product and are currently the subject of active research include proteases, phytase as well as enzymes involved in the degradation of phenolic compounds. Proteolysis is particularly important for the generation of bioactive peptides and the decomposition of toxic ones. The former has been mainly studied in the case of milk and meat products whereas the latter is particularly important for the hydrolysis of the 31-43 fragment of A-gliadin in wheat flour, which is toxic to celiac patients [3]. Phytic acid is an important antinutritional factor of legumes, cereals and nuts as it may strongly chelate bivalent cations. Degradation by microbial phytases has been reported to increase bivalent cation bioavailability [4]. The degradation of phenolic compounds present in fruits and vegetables, mainly by *Lb. plantarum* strains, has been extensively assessed. These properties are strain-dependent and result in the production of antioxidant compounds (e.g. hydroxytyrosol) as well as flavoring agents (e.g. 4-vinyl phenol). However, in the majority of the studies, the changes in the antioxidant activity during fermentation is assessed and thus only a few enzymes (e.g. tannase, p-coumaric acid decarboxylase) have been genetically and biochemically characterized [5,6].

The secondary metabolites that have drawn specific attention are vitamins of the B-complex, γ-aminobutyric acid (GABA) as well as biogenic amines. Production of vitamins belonging to the B complex and GABA are not considered as common properties among lactic acid bacteria. However, their production by several strains belonging to *Lactobacillus* spp., *Lactococcus* spp., *Leuconostoc* spp., *Pediococcus* spp., *Enterococcus* spp. and *Streptococcus* spp. has been reported. Furthermore, *in vitro* and *in situ* optimization procedures have been performed in some cases. Regarding B vitamins, research is mainly focused on the production of riboflavin, folate and cobalamin due to their significance for human health and well-being. A wealth of literature is currently available on the enrichment primary of dairy and secondary of cereal products, as a result of application of producer strains. Although this approach seems promising, the producer strains should also possess technological traits that enable their use in specific products. In addition, the loci involved in their biosynthesis have been characterized and thus screening through -omic technologies has been enabled [7]. Cereal proteins are considered as suitable substrate for the production of GABA. Thus, several studies have assessed the *in situ* production and stability during production of cereal products, mainly sourdough bread. As in the previous case, the genes encoding for the pyridocal-5'-phosphate-dependent glutamate decarboxylase that catalyzes L-glutamate decarboxylation as well as the one encoding for the glutamate/gamma-amino butyrate antiporter that is necessary for GABA export have been characterized facilitating screening procedures at DNA level [8]. Occurrence of biogenic amines in every type of fermented food has been reported. In some cases, such as in wine and possibly lactic acid fermented fruits and vegetables, their presence has been attributed to agricultural practices. However, microbial decarboxylase activity is considered as the primary reason for their accumulation. Strains belonging to *Lactobacillus* spp., *Lactococcus* spp., *Leuconostoc* spp., *Enterococcus* spp., Staphylococcus spp. as well as enterobacteria have been reported to possess high decarboxylase activity. Currently, some of the factors contributing to their accumulation have been understood leading to the adoption of prevention strategies; however, there is a significant lack of integrated studies [9].

The great potential of lactic acid fermentation as a nutritional enhancement strategy has been adequately exhibited and attributed principally to strain-dependent properties of the microbiota that drive this process. However, further research is necessary since most of the respective biochemical pathways remain largely understudied. In addition, more *in vivo* studies are required in order to verify these positive effects on human health and well-being.

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