



HAL
open science

Lactobacillus use for plant fermentation: new ways for plantbased product valorization

Vincent Phalip, Morgan Le Rouzic, Pauline Bruniaux, Cyril Ravenschot, François Krier, Rozenn Ravallec, Benoît Cudennec, François Coutte

► **To cite this version:**

Vincent Phalip, Morgan Le Rouzic, Pauline Bruniaux, Cyril Ravenschot, François Krier, et al.. Lactobacillus use for plant fermentation: new ways for plantbased product valorization. Lactobacillus - A Multifunctional Genus, 2021, 978-1-80355-445-7. hal-04548721

HAL Id: hal-04548721

<https://hal.univ-lille.fr/hal-04548721v1>

Submitted on 16 Apr 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Lactobacillus use for plant fermentation: new ways for plant-based product valorization

Morgan Le Rouzic^{1,2*}, Pauline Bruniaux^{1,3*}, Cyril Raveschot³, François Krier¹, Vincent Phalip¹, Rozenn Ravallec¹, Benoit Cudennec¹, François Coutte¹

¹ Université de Lille, UMRt BioEcoAgro 1158-INRAE, Institut Charles Viollette, F-59000 Lille, France

² Eurabiotech, 70 rue du Docteur Yersin, F-59210 Loos, France

³ VF-Bioscience, 70 rue du Docteur Yersin, F-59210 Loos, France

*Both authors have contributed equally to this work

Corresponding authors: francois.coutte@univ-lille.fr

Abstract

Today plant production increases, but most industrial processes generate a lot of waste and by-products for which, in the actual context, it is a priority to re-cycle or valorize. One of the cheapest ways of valorization is fermentation, especially lactic fermentation by *Lactobacillus* species, which produces lactic acid and other molecules of industrial interest such as bioactive compounds like anthocyanin, organic acid, peptides or phenol, widely found in plant matrix mostly in cereals, grass, fruits and vegetables. Bioactive compounds can exert health benefits like antioxidant, anti-inflammatory, antimicrobial or probiotic activities. Moreover, lactic fermentation can improve existing products and lead to new applications in food, livestock feeding, and biotechnology as lactic acid, proteins or silage production. This chapter reviews the use of *Lactobacillus* strains in the fermentation process of many plant bioresources or plant by-products through their different bioactivities, active molecules, and applications.

Keywords: *Lactobacillus* genera, lactic acid fermentation, by-product valorization, bioactivities, health benefits.

1. Introduction

The world's population of 7.6 billion people continues to grow, forecasted to reach 8.3 billion in 2025 and nearly 10 billion by 2050 [1]. Concomitantly, the Earth's resources are depleting. Depending on the different scenarios, global food demand is expected to increase by 40% to 68% by 2050 [2]. Among food resources, plants are at the center of particular interests, with the global production of plant-based products constantly increasing while at the same time producing significant waste. In this context, it's a priority to re-cycle or revalue those by-products [1].



The main objectives of using plant by-products is to revalorize wastes, to reduce pollution and to limit resource depletion. Fermentation represents one of the least polluting methods. Plants by-products fermentation contribute to sustainable development, in fact, this type of valorization intervenes in some goals of the United Nations 2030 Agenda, including the third objective: good health and well-being and the twelfth objective: the responsible consumption and production. Consumption of fermented plant by-products therefore allows responsible consumption. Fermentation of plant by-product leads to bioactivities linked to human health like antioxidant, anti-inflammatory, or antimicrobial activities which are involved in good health and well-being [3]. Plant-based foods are sources of numerous bioactive compounds such as fibers, vitamins, minerals or phenolic compounds. These nutrients are required for organism survival and growth [4]. In many countries, certain plants' health benefits and traditional use have been recognized for decades [5]. Since industries exploit plant-based foods, many agro-industrial by-products that still contain valuable compounds are generated. Many companies are now seeking to re-cycle wastes from their fruit and vegetable activities to address environmental and economic issues. For example, cereal waste reached about 40 000 to 45 000 tons per year in Europe [6]. By-products are mostly used for livestock feeding or methanization but have great potential to generate food or dietary supplements for human use [6,7]. Another example concerns the waste from the citrus industry, which amounts to 50 million tons per year and represents the most important waste from fruits exploitation. The by-products management represents a real problem of food waste and raise major issues [8] Consequently, in recent years, there is an increasing interest in plant by-products valorization.

In China dating back 9000 years, humans empirically exploited the fermentation process for numerous applications [9]. Studied since the 19th century, lactic acid fermentation has been an essential process for food processing and preservation for many millennia [10]. Humans took advantage of it for their food, notably by developing bread, beer, wine, cheese or vinegar. Then, fermentation using lactic acid bacteria has been largely studied to improve plants' nutritional and functional properties. Due to their richness in nutrients, water and natural ferments, plants such as fruits and vegetables represent an optimal substrate for *Lactobacillus* [11]. Lactic acid bacteria constitute a diverse group of Gram-positive, catalase-negative bacteria producing lactic acid as the main end-product. Numerous lactic acid bacteria-fermented food products are obtained with organisms belonging to *Lactobacillus* genera [12]. With more than 200 species of *Lactobacillus* bacteria [11], this genus is certainly the main and most diverse lactic acid bacteria group. A study published in 2020 re-evaluated the genetic relatedness and phylogeny of *Lactobacillus* species. Based on a polyphasic approach such as whole genome comparison, core genome phylogeny, physiological criteria and ecology of the organisms, the genus *Lactobacillus* was reclassified into 25 genera (2 pre-existing genus and 23 new genera). This work showed the wide and extensive diversity of the *Lactobacillaceae* family [13]. *Lactobacillus* species are commonly used in fermented food. Depending on the species, their enzymatic activities including amylase, lactate dehydrogenase, peptidase, proteinase, α - and β -glucosidases, decarboxylase, lactate dehydrogenase, peptidase, phenolic acid decarboxylase, phenol reductase, proteinase or tannase, are very useful in food fermentation [14]. These enzymes can degrade the plant cell wall matrix, leading to the liberation of many bioactive compounds, which can be modified structurally or not by the action of other enzymes in the bacteria.



Today, several ecological and economic issues are at the heart of the research surrounding lactic fermentation. The optimization of yield, cost and energy consumption, as well as the valorization of plant-derived products represent challenges for the industry [15]. To meet this demand, the use of new substrates and the genetic engineering of fermentation strains are studied as they represent potential solutions [11]. Moreover, it is now known that lactic fermentation increases the content of bioactive compounds. Indeed, this fermentation process is well known to strengthen the immune and antioxidant (AO) effect of medicinal plants by increasing the bioavailability of active compounds, but also by the production (or the bioconversion) of plant metabolites into new bioactive molecules [16]. To increase the bioactivities and organoleptic characteristics of fermented products, *Lactobacillus* converts the metabolizable molecules thanks to their enzymes, in particular *L. plantarum*, which is one of the most used *Lactobacillus* as a fermentation starter. This degradation increases molecules' bioavailability and improves their absorption [17]. A fermentation starter is usually a consortium of bacteria that helps the fermentation process to start. Today, the use of starter cultures in food fermentation is one of the necessary ingredients for good production. In addition, LAB used as starter in food industry provide safe product with good nutritional and organoleptic qualities. LAB are used as starter for many products, including fruit, vegetables and cereal products [18]. As illustrated in figure 1, the production of biomolecules by lactic fermentation of plant by-products can induce other bio-activities. This chapter refers to antioxidant (AO), anti-inflammatory (AI), antimicrobial prebiotic activities and others. These can be used in human food and beverage, livestock feeding, or biotechnology mainly to produce lactic acid. Those activities and applications will be detailed in this chapter.

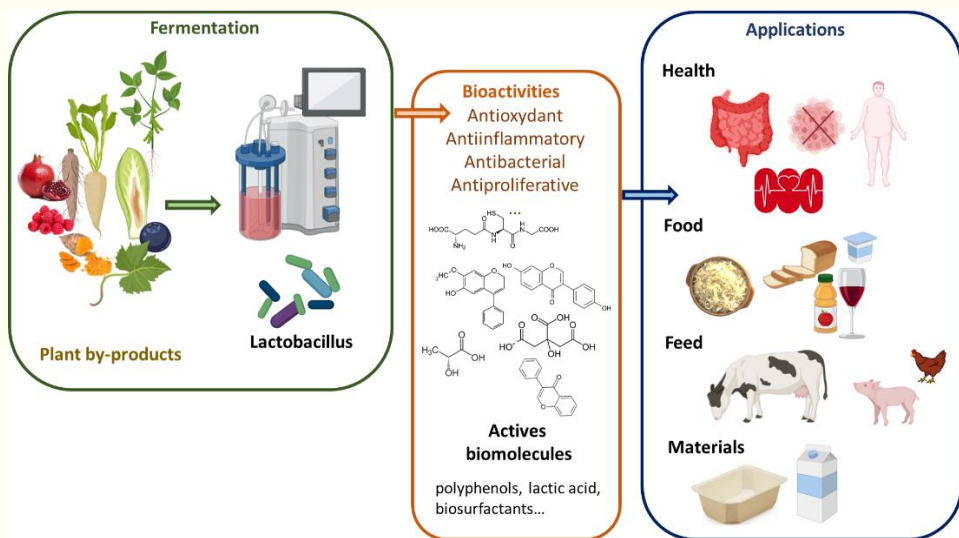


Figure 1: Summary of the biomolecules, bioactivities generated by the fermentation by *Lactobacillus* strains of plant products or by-products and their application domains.

2. Bioactivities resulting from the fermentation of plant products or by-products by *Lactobacillus* genera

2.1. Antioxidant activity

Many *Lactobacillus* enzymes can generate compounds with strong AO activity from plant by-products. For example, β -galactosidase releases isoflavone and oleuropein aglycone while tannases generate propylgallate [16]. Glycosylated polyphenols such as tannins, lignans, isoflavones, flavonols, and anthocyanins are widespread in plant products. Absorption in the intestine depends mainly on their degree of glycosylation. Some strains of *Lactobacillus*, such as *L. plantarum* possess glycosidases that are crucial for the absorption of glycosylated polyphenols and, thus, the resulting AO activity [19]. In most cases, the AO activity is studied with conventional biochemical antioxidant tests such as 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS), hydroxyl or alkyl radical scavenging activities, the ferric-reducing antioxidant power (FRAP), superoxide dismutase (SOD) -like activity, β -carotene bleaching and oxygen radical absorbance capacity (ORAC). In addition to biochemical *in vitro* tests, other studies investigated the antioxidant capacity of fermented products with *in vitro* cell-based assays. In reference [16] demonstrated that the fermentation of *L. plantarum* increased the AO properties of a kiwi extract. They correlated this result with the increased protocatechic and chlorogenic acid amounts in the fermented products, less represented in the starting extract [20]. The production of gallic acid was also observed with the fermentation of red chicory leaves by *L. plantarum* et *L. hilgardi* thanks to tannases [21]. Moreover, co-fermentation by *L. gassieri* and *Bifidobacterium animalis* allowed the release of caffeic acid and conjugated chlorogenic acid after fermentation of sunflower seeds by the action of cinnamoyl esterase. Tannins are also the product of biomass fermentation by *Lactobacillus*. Tannases hydrolyze the ester bond, and gallate decarboxylase converts gallic acid to pyrogallol; thus, *Lactobacillus* generates gallic acid, glucose and pyrogallol [22].

Several studies have illustrated the fermentation of plants as Indian chilli pepper, grape pomace, dandelion beverage and cereal-based plant beverages by *Lactobacillus spp.*, allowing the obtention of polyphenol compounds (caffeic acid, succinate, pyruvate, pyroglutamate) with AO capacity [23–25]. In [26] they evidenced that rice bran and wheat bran fermented with *L. plantarum* possessed AO capacity thanks to their hydroxyl and oxygen radical scavenging activities. Furthermore, purified fractions exerted reactive oxygen species (ROS) scavenging activity in HUVEC cells and decreased the senescence of the cultured cells, also conferring to the fermented fractions an antiaging activity. These activities were attributed to the acids and ketones [26]. Co-cultivation of *L. johnsonii* and *Bacillus coagulans* was undertaken in [27] to yield an soybean meal with enhanced AO properties. Interestingly, co-cultivation induced a significant increase in total phenolic content [27]. Fruits are also an excellent matrix for fermentation thanks to their high levels of dietary fiber, sugars, vitamins, minerals and phenols. Furthermore, lactic fermentation preserves and improves food safety, the nutritional value and preserves the organoleptic quality. Especially, when plants are fermented by endophyte *Lactobacillus*, it allows preservation of color, firmness, AO activity, growth's fermentation starters and inhibits pathogens in mediums. Numerous studies have been conducted on the lactic fermentation of berries and red fruits rich in polyphenols. *L. casei* was studied for the fermentation of blueberry pulp [28]. In another example studied in [29], the mulberry juice fermented in co-culture by three different strains (*L. plantarum*, *L. acidophilus* and *L. paracasei*) showed a higher AO capacity [29].



In reference [30] they investigated the fermentation of cherry silverberry fruits (*Elaeagnus multiflora* Thunb.) fermented by pure cultures of *L. plantarum* KCTC 33131 and *L. casei* KCTC 13086 alone or in mixed culture [30]. In reference [31] they studied the fermentation by *L. plantarum* FNC 0027 of Jamaican cherry (*Muntingia calabura* Linn.), which induce the production of phenolic compounds and the inhibition of diabetic-related enzymes (α -glucosidase, α -amylase and amyloglucosidase). They evidenced that gallic acid, 5,7 dihydroxyflavone and dihydrokaempferol were produced [31].

Valorization of argan press cake were also carried-out by lactic acid fermentation using a specifically isolated strain of *L. plantarum* Argan-L1. Argan press cake is a waste from oil production containing polyphenols and saponins. The authors demonstrated that the saccharose from argan press cake was easily converted to lactic acid during the fermentation process. Moreover, the fermented extract presented an enhanced AO capacity, but the total phenolic compound was slightly decreased [32].

L. plantarum KCCM 11613P isolated from Kimchi allowed the production of ginsenosides after fermentation of Korean red ginseng (*Panax ginseng*)[33]. In reference [34] evidenced that fermented soymilk products showed a better AO capacity associated with increased isoflavone aglycone contents. Moreover, the fermented extracts inhibited the DNA oxidation induced by the Fenton reagent [34]. All these studies show the interest in using *Lactobacillus* to increase the antioxidant properties of fermented products. Moreover, this antioxidant activity is often associated with the anti-inflammatory activity of some extracts. The fermentation of other vegetable matrices can induce an antioxidant activity of the products, as shown in the Table 1.

2.2. Anti-inflammatory activity

Vegetables, fruits and plants (tomato, cucumber, pear, apple, mandarin, parsley, carrot, celery, onion, burdock, kale, spinach, aloe vera, civet, grape, jujube, cabbage, and perilla) fermented by *L. plantarum* offer interesting AI molecules [35]. These molecules include organic acids (OA) such as lactic acid, 3-phennyl-lactate, indole-3-lactate, β -hydroxybutyrate, gamma-aminobutyric acid (GABA) and glycerol. When studying the AI capacity (and the AO capacity) of these compounds, the parameters studied are nitric oxide (NO), IL-6 (interleukins) and tumor-necrosis factor-alpha (TNF-alpha) levels and the DPPH test on RAW cells [36]. Another study showed the AI properties of fermented plant extract (*Artemisia capillaris*) in RAW 264.7 cells, which stimulated NO and IL-10 secretion without cytotoxic effects [37]. Thus, the fermentation of *Aronia melanocarpa* extract by *L. plantarum* was investigated to produce GABA, polyphenol and flavonoid compounds. The fermented extract was evidenced to exert AI effects inhibiting the production of proinflammatory cytokines in RAW 264.7 cells and modulating the immune response in mice [38]. Furthermore, several molecules derived from the fermentation of red fruit juices have been studied for their AI effects. For example, anthocyanins from these products are believed to produce the TNF-alpha and proinflammatory cytokines [23].

Fermented Asian products were highly investigated for their AI properties. Thus, a specific strain of *L. plantarum* is implicated in the fermentation of the traditional Korean fermented vegetable food, the kimchi. It secreted exopolysaccharides able to protect against rotavirus-induced diarrhea [39]. Turmeric, another plant from Asia was also the subject of numerous studies for its AI properties and particularly after fermentation. The development of turmeric extracts with potential health applications, particularly for inflammation, is increased.



The production of curcuminoid molecules, such as curcumin was enhanced by the fermentation of turmeric (*Curcuma longa*) by *L. johnsonii*. The turmeric extracts showed AI and antiallergic effects in atopic dermatitis mice and induced a decrease in serum immunoglobulin E and proinflammatory cytokines in lipopolysaccharide-induced inflammation (LPS) [40]. Supplementation of turmeric extract fermented by *L. rhamnosus* (GG-ATCC 53103) and *Bifidobacterium animalis* (BB12) strains, have allowed the maintenance of gut microbiota's bacterial growth in case of inflammation. It also reduced the inflammatory state by limiting the production of proinflammatory cytokines IL-8 [41]. Another study showed that the fermentation of turmeric by *L. fermentum* have increased the curcumin yield by 9.76%. The AI activity was demonstrated in RAW 264.7 cells by modifying the nitrite level, the expression of TNF-alpha and TLR-4 and the activation of the JNK pathway. These phenolic compounds also showed a protective effect against TLR-4 receptor cascade activation, TNF-alpha and nitric oxide production. In addition, the extract limited the proinflammatory response and low-grade oxidative stress induced by LPS [42].

2.3. Antimicrobial activity

The molecules produced during the fermentation of plant biomasses by *Lactobacillus* can also present antimicrobial activities. The production of antimicrobial molecules by *Lactobacillus* has already been described, including lactobrevin and lactobacillin [43]. For example, in [44] an interesting concept of valorization of okara's by solid state fermentation was presented with a co-culture of the yeast *Yarrowia lipolytica* and *Lactobacillus casei*. Okara's is an oleaginous by-product of plant milk production. The authors used fermentation to generate molecules with antimicrobial activity (up to 33% reduction of *Bacillus subtilis* development and a modest effect on *Aspergillus niger*) [44].

In reference [45], a metabolic study on *Allium tuberosum* to produce a food additive with antimicrobial activity against pathogens poultry was conducted. Endophytic *Lactobacillus* have been isolated from Chinese chives. Among those *Lactobacillus* strains, *L. plantarum* can produce flavonols exerting antimicrobial activity [45]. In [46], fermentation of quinoa by the strain *L. plantarum* CDL 778 leads to a higher production of antifungal compounds was shown. It was also observed that during the fermentation of sweet lemon juice (*Citrus limetta*), the antimicrobial activity against *Escherichia coli* and *Salmonella Typhimurium* was increased. These activities were correlated with the increase of lactic acid content and the decrease of citric acid, total phenolic compounds and sugars contents [47]. Moreover, fermentation of the red sorghum cereal allows the conversion of flavanones into eriodyctiol and naringenin, which displayed an interesting antimicrobial activity [22].

2.4. Prebiotic activity

Several studies showed that fermented fruits and vegetables harbor prebiotic effects. Compounds produced by fermentation from plants, induce a modification of the intestinal microbiota. These fermented extracts offer great prospects. Studies highlighted their health potential for humans but also animals. Indeed, two fermented extracts obtained from algae and chicory, plantain, alfalfa and broad leaf dock, presented prebiotic and AO effects. This study was conducted on weaned lambs, and the results showed an improvement of their resistance to infection and their survival, for both extracts. Similar studies showed these same effects for thyme and rosemary [48]. In reference [49], the prebiotic potential was determined and the AI effect of chicory root and pulp compared to inulin, as a positive control, on the intestinal



barrier on IPEC-J2 cells. Those tests were realized with five fermented by-products (chicory roots, chicory and citrus pulp, rye bran and soybean bark) by different *Lactobacillus* spp. An increase of *Lactobacillus* spp. Was observed for all substrates except for chicory roots. The latter was very fermentable and produced a butyrate ratio similar to inulin, while chicory pulp had a higher ratio than inulin. For acetate, chicory and citrus pulp, soybean bark had a higher ratio than inulin. Those short-chain fatty acids (SCFA) derived from dietary fiber fermentation contribute to maintain intestinal health. Rye bran caused an important stimulation on *Bifidobacterium* spp. Growth. Rye bran and soybean bark have a positive effect on the intestinal microbiota. Fermented chicory roots and pulp promote up-regulation of tiny junction genes and maintain the integrity of the intestinal barrier. Finally, fermented chicory pulp inhibited proinflammatory cytokines such as TNF-alpha and triggered the metabolic pathway that inhibits inflammatory cytokine production. [49].

2.5. Other bioactivities related to medicine

Numerous bioactivities could result from the lactic fermentation of plant by-products. In reference [50], they associated the AO activity with potential hypoglycemic effects of *Diospyros lotus* fruit fermented by *L. plantarum* and *Microbacterium flavum*. They observed an inhibition of the α -glucosidase activity *in vitro*. In addition, the authors showed that catechinic, tannic, and ellagic acid levels were enhanced during fermentation [50]. In the same way, several studies were interested in the capacity of *Lactobacillus* fermented products to exert a positive effect in the prevention of obesity and associated metabolic diseases. In [51], cabbage-apple juice fermented by *L. plantarum* exerted anti-obesity and hypolipidemic effects *in vivo* in high fat diet-fed rats was highlighted [51].

Moreover, soy fermented products by *Lactobacillus* spp. Have interesting biomolecule contents and present anti-tumoral effects. Indeed, these fermented soybean extracts could inhibit, *in vitro*, the growth of several cancerous cell models: fibrosarcoma and adenocarcinoma of the breast. It also reduces the risk of breast cancer, significantly influencing survival, apoptosis and tumor inhibition rates in mice. Clinical studies were also conducted to investigate the effects of fermented soybean extract on chemotherapy-induced immunosuppression. Results showed that the populations of immune cells with activity against tumor cells, the natural killer cells, are significantly increased [23]. Using cell-based experiments, other works investigated putative other health effects associated with AO activity. Indeed, the authors showed promising antiproliferative and apoptotic effects of the extracts on the HeLa cancer cell line. In another study, authors have shown that the fermented blueberries by *L. plantarum* displayed anticancer activities. Their results suggest that polyphenols, in high concentrations in blueberries, were metabolized during fermentation into active phenols such as catechol [52].

3. Applications

3.1. Food products

Product of the lactic fermentation, bread has been, for a longtime, an important foodstuff of the diet of many cultures. The bread fermentation process was often optimized and revisited to better meet the needs of consumers or to face economic and social issues. The fermentation of wheat leaven by *L. plantarum* allows the conversion of ferulic acid into vinyl guaiacol, ethyl guaiacol and dihydro ferulic acid. This conversion allows the improvement of the final bread product quality [22].



Corn flour is another example of bread raw material, and its application in the bakery illustrates the potential of lactic fermentation. In addition to different wheat bread ingredients, maize milling improves the nutritional profile after being fermented by *L. plantarum* T6B10 and *Weissella Bonfuse BAN8*. Indeed, an increase in amino acids (AA) and proteins contents, AO activity, and lipase and phytic acid inhibition have been observed. It leads to increase dietary fiber, digestibility, and it improves the texture, taste and nutritional value of bread [53]. The same outcome was observed with the fermentation of brans from hull-less barley, emmer and pigmented wheat varieties with the same *Lactobacillus* in the same conditions [54]. Another study highlighted wheat flour substitute to make bread, a sourdough obtained from fermented djulis (*Chenopodium formosanum*) by *L. casei*. The produced bread contained higher levels of total phenolic and flavonoid compounds and increased hardness and chewiness compared to classical bread. The addition of djulis sourdough also extended the shelf life by approximately two days [55].

A process to valorize semolina pasta with hemp flour, chickpea grains and milling by-products by fermenting them with *L. plantarum* and *L. rossiae* was proposed [56]. However, it is necessary to note that enzymatic pre-treatment of the substrates must be carried out beforehand. This could affect the economic viability of the process. In a laboratory scale, they obtained extensive protein degradation and consequently digestibility, reduction of 50% of tannins concentration and also of phytic acid concentration [56]. *L. plantarum*, which has high proteolytic activities, was used for the fermentation of quinoa instead of wheat. Quinoa is an interesting cereal for celiac patients because it is gluten-free. The study revealed that quinoa is more easily fermented by this lactic acid bacteria than wheat. Those high proteolytic activities of the strain were highlighted by the increase of the total peptides and free AA contents from quinoa slurries compared to wheat slurries [46]. In reference [54], the potential use of oat extract resulting from cereal processing and displaying high protein content as yoghurt alternatives was questioned. Fermentation of this by-product with *L. delbrüchii* subsp. *Bulgaricus* and *Streptococcus thermophilus* followed by starch gelatinization by heating generated two kinds of gels with interesting rheological and organoleptic properties. Authors placed their studies in the context of plant-based products substituting dairy ones for health and environmental reasons. They discussed the consumer acceptance of such products but claimed that sensory descriptors like soft, sweet and smooth are highlighted by the sensory panel [57]. Another example of food products fermentation value is the fermentation of olive by *L. plantarum*. Kachouri et al. have shown that the phenolic content of olive oil increases after fermentation by this strain [58]. Other studies have shown that the fermentation of the common Spanish table olive improves preservation and the taste. Indeed, *L. plantarum* ferments olive brine, leading to a reduction in the oleuropein content of the olives [59–63]. In addition, wastewater from olive production, which is another olive co-product, has been exploited in [64]. When fermented by *L. plantarum*, the content of phenolic compounds becomes more interesting. The antioxidant activity was tested by DPPH and ABTS assay. This co-product has a 50% higher antioxidant activity after fermentation by *L. plantarum*. [64].

In order to innovate in the food market, research is being conducted into the development of plant beverages rich in active compounds and with health benefits for consumers. Functional plant beverages fermented by *Lactobacillus* are widely studied. Water extracts of plants such as soy, pea, coconut or rice represent non-dairy milk alternatives. Lactic fermentation of these beverages could improve protein content, solubility and AA's availability. Some *Lactobacillus* strains are also responsible for vitamins biosynthesis during fermentation (vitamin K, vitamin B). Anti-nutrient compounds such as phytates are hydrolyzed during fermentation by some phytase-producing strains, which improve the digestibility and mineral content of the final product [65]. However, optimizing flavors and nutritional quality remains



a challenge today because the latter are often criticized for their low nutritional quality and bland taste caused by their short shelf life. A color change has been observed by Do and Fan in fermented fruit or carrot juices by *Lactobacillus* strains, indicating that carotenoids are modified in cis carotenoid isomers responsible for color change during fermentation by *Lactobacillus* [66]. Rheological studies have also been performed. Indeed, in [67], the effects of different *Lactobacillus* species on volatile and nonvolatile flavor compounds in juices fermentation were studied. The main objective of this research was to clear the marker metabolites generated by different species of *Lactobacillus* strains, which contribute to the flavor and reveal the roles of diverse species of *Lactobacillus* in the formation of flavor compounds. The main markers were 2,3-butanedione, hexenal, acetic acid, formic acid as volatile compounds and lactic acid, malic acid, citric acid as nonvolatile compounds [67].

In another application for the beverage sector, one of the main ideas is to provide fermented products with prebiotic effects from a different matrix of vegetable juice as raw material. Consumers' demand for non-dairy prebiotic foods is constantly increasing due to drawbacks related to dairy foods such as allergy, lactose intolerance, as well as lifestyle change or religious beliefs. In that context, the reference [55] presents a development of a functional drink based on soy and quinoa (*Chenopodium quinoa Willd*) obtained by fermentation by *Lactobacillus casei* LC-1. This drink presents a prebiotic effect stimulating the gut microbiota and reducing the following bacterial populations: *Clostridium spp*, *Bacteroides spp*, *Enterobacteria* and *Enterococcus spp* [68]. Cabbage juice and fresh cabbage, fermented by *Lactobacillus*, are also being studied for the development of probiotic products. Mixed with other vegetables (carrots, onion, cucumber), white and red cabbage fermented with *L. plantarum*, *L. casei*, *L. acidophilus* or *L. delbrueckii* have a good fermentation profile and a potential as a functional probiotic drink as demonstrated by Hyunah et al. [69–72]. Dunkley and Hekmat evaluated the sensory properties and worked to assess the growth and viability of *L. rhamnosus* GR-1 in carrot juice, carrot apple juice, carrot orange juice and carrot beet juice over 72 h of fermentation and 30 days of refrigerated storage at 4°C. The conclusion was that carrot, carrot apple, carrot orange and carrot beet juice fermented with *L. rhamnosus* GR-1 proved to be a satisfactory alternative to dairy-based prebiotic products. All juices achieved viable counts greater than the required minimum counts to be classified as prebiotic. Sensory evaluation results also indicated a market potential for prebiotic vegetable juice. Developing prebiotic vegetable juice using *L. rhamnosus* GR-1 as a probiotic agent will give consumers a viable non-dairy alternative which can provide many health benefits [73]. Co or triculture can be used to improve activities as bergamot juice has been fermented by 3 *Lactobacillus* (*L. plantarum* 107 subsp *plantarum* PTCC 1896, *L. plantarum* AF1, *L. plantarum* LP3) in tri culture. This combination allowed a higher AO activity. Bergamot juice fermented could also be used as a functional drink [74].

Other by-products are re-cycled, especially in the brewery sector. A study aimed to produce a beverage rich in polyphenol from brewers' spent grain. Fermentation by *L. plantarum* ATCC 8014 was realized, followed by tests on phenolic compound content and AO activity. Phenol content and AO have increased during fermentation. The beverage was more concentrated in phenol compounds than before the fermentation, and its bioactive compounds were more stable [75]. More recently, coffee cherry pulp has been used in infusion to obtain an AO drink called cascara. To improve the AO activity of this beverage, it has been fermented by endophytic *L. casei* [76]. A turmeric-based functional drink was also obtained by co-fermentation with *Enterococcus faecium*, *Lactococcus lactis* subsp. *lacti* and *L. plantarum*. The measurement of the AO capacity was done by titration of total phenolic compounds, and the prebiotic effect was also highlighted by *in vitro* and *in vivo* tests.



Kombucha is a sweet infusion of green tea leaves usually fermented with Kombu, a fungus. One study shows that replacing Kombu with *L. casei* and *L. plantarum*, which are derived from kefir, enhances the glucuronic acid production, leading to greater antimicrobial and antioxidant activities [77]. Another study showed that a mixture of LAB from kefir and kombucha (*L. casei*, *L. plantarum*, *L. acidophilus*, *L. casei* and *L. plantarum*) increases the glucuronic acid concentration, antimicrobial and antioxidant activities and allows the use of Kombucha as a health drink [78]. Hou et al. have demonstrated the link between antimicrobial activities of kombucha with polyphenols and LAB, especially against *Escherichia coli*, *Salmonella tify*, *Vibrio cholerae*, and *Shigella dysenteriae* [79]. Green tea used in Kombucha may have activity when it's fermented by *L. plantarum*. Indeed, fermented extract derived from *Camellia sinensis* is able to mitigate ethanol-induced liver damage. *In vitro* and *in vivo* tests on hepatic cells (HepG2,) and murin model exposed to fermented green tea extract, show after exposure of ethanol a better viability and an increase of hepatic alcohol dehydrogenase [80].

3.2. Livestock feeding

The products of the fermentation of plants by *Lactobacillus* strains can be used in many fields ranging from livestock feeding, such as ruminant by decreasing gas production [81]. *Lactobacillus* strains can also be used for silage preparation. Silages are grass or other green fodders compacted and stored in airtight conditions, typically in a silo, to be used as livestock feeding in the winter. Many studies focus on using *Lactobacillus* strains to improve the quality of the silage. In reference [82], the effect of *L. brevis* and *L. parafarraginis* used as inoculants and microbial communities of corn stover silage was studied. After 20 days, the 2 *Lactobacillus* strains were predominant and a reduction in lactic acid content coupled with an increase in acetic acid and 1,2-propanediol contents was observed. An improvement of the silage quality and a reproducibility ensiling process were observed [82]. Recently in [83], the effect of *L. plantarum* addition on the nutritive value of dwarf elephant grass (*Pennisetum purpureum* cv Mott) silage was presented. The aim was to examine the effects of different *L. plantarum* addition on the physical quality, pH, and nutritional value (dry matter, organic matter, crude protein, crude fiber). After incubation, a good quality of silage (fresh and acidic odor, good texture and no fungi) and a pH around 4 was observed. *L. plantarum* addition accelerates ensilage fermentation [83]. In [84], an increase in silage quality thanks to the addition of waste molasses to *L. plantarum* MTD1 was observed. In the same context, the addition of cellulase was studied to evaluate the effects on the chemical composition, bacterial communities, stability of mixed silage made with high-moisture amaranth and rice straw fermented by *L. plantarum*.

Cellulases increased the abundance of *Lactobacillus* bacteria and reduced the abundance of other lactic acid bacteria. It decreased pH, acetic acid content, ammonia nitrogen content and increased lactic acid concentration after 7 days of ensiling [85]. In conclusion, the silage treated with both *Lactobacillus* bacteria and cellulase showed the best silage quality. Optimizing the digestibility of feeds and thus increasing their nutritional value is a challenge for the livestock feeding industry. In another study, the fermentation product of an extract of ginger and turmeric mixture by *Lactobacillus* spp. was supplemented to chickens. Biological analyses of AO enzymes and analysis of gut microbiota and lymphoid organs, showed a prebiotic effect, AO effect and improvement of resistance to bacterial infections [86].



3.3. Lactic acid production from plant biomass

The use of low-cost by-products is of primary interest since it allows the production costs to be lowered compared to the use of complex culture media made with pure and refined products. Consequently, many by-products have been tested in the last few years, in association with screening of the best microbial strains, the best fermentation process and the best conditions to make them work together [87]. Lactic acid is one of the most widely used organic acids for a long time in various industries, such as the food, cosmetics, pharmaceutical, and textile industries, and flavor, conservation, AO and antimicrobial activity [88]. In the last decade, it has also become an essential platform molecule in the biomaterials sector to produce polylactic acid (PLA), a bio-based polymer. This new interest has led to an explosion in worldwide demand. One of the characteristics of polylactic acid, is its thermal resistance, a critical parameter for manufacturing thermoformed materials (packaging, film, etc.). *Lactobacillus* have been traditionally used for lactic acid production [89,90]. When using large-scale fermentation bioprocesses, the biomass feedstock must be carefully selected as it accounts for almost half of the production costs of biopolymers [89]. To address this production cost issue, scientists and industrials have focused on lignocellulosic biomass as a fermentation substrate for lactic acid production. Nevertheless, to be easily usable, saccharification pre-treatments are necessary to break down cellulose into fermentable carbohydrates. Moreover, *Lactobacillus* are classified as either homofermentative or heterofermentative. *L. delbrueckii* is a homofermentative strain commonly used for the production of lactic acid [91]. Homofermentative strains of *Lactobacillus* cannot use pentose carbohydrates from hemicellulose, but heterofermentative ones, such as *L. brevis* can use these carbohydrates by taking the phosphoketolase pathway [90].

In reference [89], the fermentation of 11 different carbohydrates from seaweed or plant biomass as a carbon source to produce L-lactic acid with seven different *Lactobacillus* species was investigated. Comparative analysis of the expected yield of lactic acid production revealed that seaweeds allowed production rates comparable to lignocellulosic biomasses [89]. In another study, beet molasse was used to produce lactic acid using *L. delbrueckii* IFO 3202 during batch and continuous fermentation, dilution rate of 0.5 h^{-1} was determined as the best one and allows to reach a maximum productivity of $11 \text{ g L}^{-1} \text{ h}^{-1}$. Authors demonstrated the importance of medium supplementation by yeast extract, as *Lactobacilli* are tedious microorganisms that require many substrates and substances to grow [92]. Nevertheless, it is estimated that the addition of yeast extract can contribute up to 30% of the cost of producing lactic acid [93]. Zhang & Vadlani have studied the production of D-lactic acid by a homofermentative strain, *L. delbrueckii* ATCC 9649, through a sequential hydrolysis and fermentation process (SHF) and a simultaneous saccharification and fermentation process (SSF). In this work, first, the saccharification of pulp and corn stover was done, and then carbohydrates generated from hydrolysis were used by *L. delbrueckii* and converted to D-lactic acid with high purity (99.8 %). The authors highlighted that the SHF process compared to the SSF process, avoids substrate inhibition and increases the productivity and the yield of D-lactic acid [91]. Same researchers' team have then engineered a strain of *L. plantarum*, introducing gene encoding isomerase and xylulokinase, for the overproduction of D-lactic acid from corn stover and soybean meal extract. In this work, authors have optimized the culture medium through response surface methodology using saccharified corn stover as carbon source and soybean meal extract as a nitrogen source to substitute YE in the medium to produce high purity of D-lactic acid (99%). A maximum productivity of $0.82 \text{ g L}^{-1} \text{ h}^{-1}$ of D-lactic acid was obtained in the optimized medium, 10% higher than with YE as the main nitrogen source [90].



Saccharification and fermentation could be performed at the same time (simultaneous saccharification and fermentation) and was used for instance by Tu et al for LA production. With *L. plantarum*, they obtained up to 65.6 g/L of lactic acid with a conversion of cellulose of 69% [94]. By using inulin from chicory, in [95] they obtained a best performance by simultaneous saccharification and fermentation to produce D-lactic acid with *L. bulgaricus*. In their process, they obtained a molecule optically pure (99.9%) which could be interesting for further chemical processes. The productivity is also high with 123 gL⁻¹ starting from 120 gL⁻¹ of inulin treated by inulinase. The enzymatic treatment yielded inulin used instead of glucose in MRS medium for fermentation [94,95].

In another example, the lactic acid production from fermented orange peels was evaluated by ion-exchange chromatography. The solid fermentations are in mono or co-culture, with *L. casei* 2246, *L. plantarum* 285 and *L. paracasei* 4186. This study showed that fermentation allows higher lactic acid production with the monoculture *L. casei* 2246 and the co-culture *L. casei* 2246 with *L. plantarum* 285. Glucose could also be converted to lactic acid by symbiotic relationship between different lactic acid bacteria. *L. helveticus* is an AA producing strain (alanine, serine, aspartate, glutamate, aromatic AA and histidine), whereas *L. delbrueckii* is a lactic acid-producing strain but produces little of these AAs necessary for its growth. Thus, this co-fermentation optimized the lactic acid yield [88]. Before industrialization of such a process, scale-up has to be demonstrated and down-stream processes (purification) to be implemented and considered. However, another technology could also be used for lactic acid production by microorganisms. Indeed, solid-state fermentation was used with cassava bagasse as substrate and *L. delbrueckii* as microorganism [87,96].

3.4. Other applications of active ingredients produced from fermented plant extracts

Another biotechnology application is the production of proteins, peptides, or AA like GABA. Indeed, plant by-products are sources of different proteins which could be hydrolyzed during fermentation by *Lactobacillus* species. These microorganisms, especially *L. plantarum*, have developed a proteolytic system to fulfil their nitrogen requirement. The proteolytic activities and protein hydrolysis patterns differ widely from one strain to another. The resulting peptides displayed different biological functions such as angiotensin-converting enzyme inhibition, mineral binding, antidiabetic, satiating, immunomodulating, opioid, AO or antimicrobial activities [12]. The strain *L. plantarum* LP-9 of was used to co-produce GABA and lactic acid from agro-residues such as wheat bran, rice bran, corn bran. Results were compared to the use of cassava (starchy food crop), and production yields were significant and comparable to this control condition [97]. Co-fermentation of Ginseng root and leaf extract always by a *L. plantarum* EJ2014 and *B. subtilis*, showed also a production of GABA [98]. The fermentation of Kimchi by *L. brevis* BJ20 allows the conversion of glutamic acid into GABA. This process is particularly interesting because GABA has an AO activity demonstrated during the study of DPPH scavenging, superoxide scavenging and xanthine oxidase inhibition tests [99]. Biotechnology also allows production of cosmetic or pharmaceutical products or surfactants. Biosurfactants production was investigated using *L. paracasei* on enzymatically hydrolyzed vineyard pruning waste. This study presented the complete process for this waste valorization using acid hydrolysis, delignification and enzymatic hydrolysis steps. Authors have demonstrated the impact of the carbon source extraction process on the biosurfactant composition produced by the strain *L. paracasei* A20 [100].



Table 1: Other studies that complement the *in vitro* examples cited in this chapter

By-product used	<i>Lactobacillus spp.</i>	FP	Product generated	Bio-activity	Remark	Reference
Apple juice	<i>L. plantarum</i>	LF	PC	AO		[101]
Apple juice	<i>Saccharomyces cerevisiae</i> , then <i>L. plantarum</i>	LF	PC, OA	AO		[102]
Margosa (<i>Momordica charantia</i> L.)	<i>L. plantarum</i> NCU116	LF	SCFA LA PC	AO	Juice's sterilization exerted adverse effects	[103]
Porcelain plant (<i>Graptopetalum paraguayense</i> E. Walther)	<i>L. plantarum</i> BCRC 10357	LF	PC	AO	Assayed during the maturity of the leaves	[104]
Milled wheat	<i>L. plantarum</i> + <i>Streptococcus thermophilus</i>	LF Co	PC	AO, AM, PB	Anti-burning properties	[105]
Apple by-products	<i>L. plantarum</i>	LF	PC	AO, barrier integrity	Caco-2	[106]
Mango	<i>L. plantarum</i> + <i>Saccharomyces cerevisiae</i>	SB Co	Mango slurry, PC	AO		[107]
Liquorice root	<i>L. plantarum</i>	SB F	PC	AO		[108]
Jussara pulp (<i>Euterpe edulis</i>)	<i>Lactobacillus</i> and <i>Bifidobacterium</i>	LF Co	OA: protocatechic acid	AO	Conversion of anthocyanins	[109]
Acerola	<i>L. acidophilus</i> + <i>Bifidobacterium longum</i>	BF	beverage	PB	↗resistance of PB to gastrointestinal digestion	[110]
Cauliflower & white beans mix	<i>L. plantarum</i> 299	SB F	Riboflavin, Folate, Vitamin B12, AA		Nutritional value	[111]
Wheat germ	<i>L. plantarum</i> + <i>L. rossiae</i>	LF	Bread rich in PC, phytases	AO	☒ anti-nutritional factor, ☑ protein digestibility	[112]
Date juice	<i>L. casei</i> subsp. <i>rhamnosus</i>	LF	LA		Nitrogen source optimisation	[113]
Date juice	<i>L. sp.</i> KCP01	LF	LA		Medium optimisation	[114]
Solid carob	<i>L. rhamnosus</i>	BF	LA	Many diseases	Immobilization in alginate beads	[115]
Banana, papaya, pineapple, orange	<i>L. plantarum</i>	BF	LA		Best LA's production for banana et pineapple	[116]

Anti-inflammatory (AI), antimicrobial (AM), AO (AO), batch fermentation (BF), co-culture (Co), exopolysaccharides (EPS), fermentation process (FP), interleukins (IL), immune-modulatory (IM), lactic acid (LA), liquid fermentation (LF), nitric oxide (NO), organic acids (OA), probiotic effect (PB), phenolic compounds (PC), solid batch fermentation (SBF), short chain fatty acid (SCFA), solid fermentation (SF).

4. Limitations and future challenges

Faced with ecological and societal problems such as pollution, global warming and overpopulation, crop yields are increasingly challenging to sustain. Moreover, while demand is increasing in developed countries, poor populations struggle to feed themselves, and there is much undernutrition in these countries. This is why the food and agriculture industry have to find solutions to provide for the needs of all. Among these, a better use of plant resources and a better exploitation of their by-products appear to be two solutions of interest. In addition, consumers are looking for more natural products with health benefits and industrials are looking for economically viable bio-based solutions. Fruit and vegetable wastes and by-products from cereals are potential for revalorization because of their quantity and richness in nutrients and bacterial strains suitable for lactic fermentation.



When lactic acid bacteria ferment the nutrients that compose them, the functional and nutritional properties increase, representing significant opportunities for the agri-food, biotechnology, medical, nutraceutical and cosmetic industries. As it was presented in this chapter, the fermentation of plant products by *Lactobacillus* allows the production of numerous bioactive molecules for the development of many applications. Nevertheless, to meet the demand, lactic acid fermentation by *Lactobacillus* requires optimization. Firstly, the use of plant by-products requires a crucial design of the fermentation process depending on the raw material (solid, liquid, semi-liquid fermentations). This design could lead to the development and the emergence of new processes which should be able to meet the industrial viability, economic yields and consumer's needs. Consequently, an important work is still needed on these processes to increase the commercialization of new bio-based products from plant by-products. In another hand, *Lactobacillus* strains are fastidious bacteria in their nutritional requirements and are not necessary well metabolically adapted for their growth from any substrates, and the use of GMOs is a very limiting criteria for many applications (food, cosmetics, etc.). The growth parameters and enzymatic activities of *Lactobacillus* strains have an important impact on the applications and particularly when the fermentation substrate is complex. Therefore, it is necessary to work on the culture conditions and metabolic adaptation of these strains to maximize the enzymatic activities and the production rates of the molecules of interest. Consequently, many constraints exist, such as the lack of scientific data and hindsight, the control of the culture conditions and the separation and purification processes to recover the bioactive compounds. More efforts are urgently needed to overcome these problems. Nevertheless, one of the advantages of production with *Lactobacillus* is its ability to produce several types of molecules simultaneously, typically lactic acid and other molecules (derived or transformed from the substrate), which makes the fermentation process industrially interesting. Such multi-products strategies have to be promoted in the near future up to industrial scale.

5. Conclusion

Lactic acid fermentation is an ancestral process performed by numerous bacterial strains. Fermentation conditions, substrates and potential additives represent challenges and constraints for yield optimization, process' stabilization and standardization. Indeed, lactic fermentation by *Lactobacillus* allows the production of many molecules of interest. When these bacteria ferment plant products, they induce biochemical conversions and the production of phenolic compounds, organic acids and vitamins thanks to their enzymatic activities. This review highlights the different applications related to the production of these compounds. The latter possess bioactivities such as AO, AI, prebiotic, antimicrobial, and many others. Moreover, they represent a growing interest for the food industry for their capacity to increase the nutritional value but also for their use as preservative and modifier of organoleptic properties. The various studies reviewed here are looking for alternatives to meet consumer's demand for environmental and societal issues. To reduce production costs and the carbon footprint of the process, genetic engineering and the revalorization of plant by-products appear as interesting avenues of research to improve the yield of compounds of interest. However, many scientific data are still missing for the mastery of fermentation by *Lactobacillus*. More studies are necessary to identify the biochemical reactions and metabolism of *Lactobacillus* involved in producing bioactive compounds. Furthermore, studies need to be conducted to investigate further the mechanisms involved in the bioactivities of interest.



Acronyms and Abbreviations

AA: Amino acids
 ABTS : Acide 2,2'-azino-bis(3-éthylbenzothiazoline-6-sulphonique)
 AI: Anti inflammatoire
 AM: Anti-microbienne
 AO: Antioxydant
 BF: Batch fermentation
 Co: Co-culture
 DNA: Deoxyribonucleic acid
 DPPH : 2,2-DiPhenyl-1-PicrylHydrazyl
 EPS : Exopolysaccharides
 FP: Fermentation process
 FRAP : Ferric reducing antioxydant power
 GABA : Gamma-aminobutyric acid
 IL-6, IL-10: Interleukins
 IM: Immuno-modulatory
 LA: Lactic acid
 LF: Liquid fermentation
 LPS : Lipopolysaccharide
 NO: Nitric oxide
 OA: Organic acids
 ORAC : Oxygen Radical Absorbance Capacity
 PC : Phenolic compounds
 PB: Prebiotic effect
 ROS : Reactive oxygen species
 SBF : Solid batch fermentation
 SF: Solid fermentation
 SFCA: Short chain fatty acid
 TNF-alpha: Tumor-necrosis factor-alpha

Acknowledgements

The authors would like to thank the financial support for the Charles Viollette Industrial Chair provided by the Lille European Metropolis (MEL) and the Isite of the University of Lille.

References

1. Lugtenberg BJJ, Malfanova N, Kamilova F, Berg G. Plant Growth Promotion by Microbes. de Bruijn FJ, éditeur. *Molecular Microbial Ecology of the Rhizosphere*. 18 mars 2013;559-73.
2. Hérault B. La demande alimentaire en 2050 : chiffres, incertitudes et marges de manœuvre. Ministère de l'Agriculture, de l'Alimentation, de la Pêche, de la Ruralité et de l'Aménagement du territoire; 2011 févr. Report No.: 27.
3. Department of Economic and Social Affairs, Sustainable Development. THE 17 GOALS | Sustainable Development [Internet]. Organisation des Nations Unies. [cité 6 févr 2022]. Disponible sur: <https://sdgs.un.org/fr/goals>
4. Septembre-Malaterre A, Remize F, Poucheret P. Fruits and vegetables, as a source of nutritional compounds and phytochemicals: Changes in bioactive compounds during lactic fermentation. *Food Research International*. févr 2018;104:86-99.
5. Dogan K, Tornuk F. Improvement of bioavailability of bioactive compounds of medicinal herbs by drying and fermentation with *Lactobacillus plantarum*. *Functional Foods in Health and Disease*. 31 déc 2019;9(12):735-48.
6. Ravindran R, Jaiswal AK. Exploitation of Food Industry Waste for High-Value Products. *Trends in Biotechnology*. janv 2016;34(1):58-69.
7. Görgüç A, Gençdağ E, Yılmaz FM. Bioactive peptides derived from plant origin by-products: Biological activities and techno-functional utilizations in food developments – A review. *Food Research International*. 1 oct 2020;136:109504.
8. Bustamante D, Tortajada M, Ramón D, Rojas A. Production of D-Lactic Acid by the Fermentation of Orange Peel Waste Hydrolysate by Lactic Acid Bacteria. *Fermentation*. mars 2020;6(1):1.



9. Wang J, Jiang L, Sun H. Early evidence for beer drinking in a 9000-year-old platform mound in southern China. *PLoS One*. 2021;16(8):e0255833.
10. Capurso L. Thirty Years of *Lactobacillus rhamnosus* GG: A Review. *Journal of Clinical Gastroenterology*. mars 2019;53(Supplement 1):S1-41.
11. Hill D, Sugrue I, Tobin C, Hill C, Stanton C, Ross RP. The *Lactobacillus casei* Group: History and Health Related Applications. *Front Microbiol*. 10 sept 2018;9:2107.
12. Raveschot C, Cudennec B, Coutte F, Flahaut C, Fremont M, Drider D, et al. Production of Bioactive Peptides by *Lactobacillus* Species: From Gene to Application. *Frontiers in Microbiology*. 2018;9:2354.
13. Zheng J, Wittouck S, Salvetti E, Franz CMAP, Harris HMB, Mattarelli P, et al. A taxonomic note on the genus *Lactobacillus*: Description of 23 novel genera, emended description of the genus *Lactobacillus* Beijerinck 1901, and union of *Lactobacillaceae* and *Leuconostocaceae*. *International Journal of Systematic and Evolutionary Microbiology*. 1 avr 2020;70(4):2782-858.
14. Muñoz R, de las Rivas B, López de Felipe F, Reverón I, Santamaría L, Esteban-Torres M, et al. Chapter 4 - Biotransformation of Phenolics by *Lactobacillus plantarum* in Fermented Foods. Frias J, Martínez-Villaluenga C, Peñas E, éditeurs. *Fermented Foods in Health and Disease Prevention*. 1 janv 2017;63-83.
15. Carpinelli Macedo JV, de Barros Ranke FF, Escaramboni B, Campioni TS, Fernández Núñez EG, de Oliva Neto P. Cost-effective lactic acid production by fermentation of agro-industrial residues. *Biocatalysis and Agricultural Biotechnology*. août 2020;27:101706.
16. Hur SJ, Lee SY, Kim Y-C, Choi I, Kim G-B. Effect of fermentation on the antioxidant activity in plant-based foods. *Food Chemistry*. 1 oct 2014;160:346-56.
17. Ruiz Rodríguez LG, Zamora Gasga VM, Pescuma M, Van Nieuwenhove C, Mozzi F, Sánchez Burgos JA. Fruits and fruit by-products as sources of bioactive compounds. Benefits and trends of lactic acid fermentation in the development of novel fruit-based functional beverages. *Food Research International*. 1 févr 2021;140:109854.
18. Bintsis T, Department of Agricultural Technology, TEI of West Macedonia, 53100 Florina, Greece. Lactic acid bacteria as starter cultures: An update in their metabolism and genetics. *AIMS Microbiology*. 2018;4(4):665-84.
19. Landete JM, Rodriguez H, De Las Rivas B, Munoz R. High-Added-Value Antioxidants Obtained from the Degradation of Wine Phenolics by *Lactobacillus plantarum*. *Journal of Food Protection*. 1 nov 2007;70(11):2670-5.
20. Zhou Y, Wang R, Zhang Y, Yang Y, Sun X, Zhang Q, et al. Biotransformation of phenolics and metabolites and the change in antioxidant activity in kiwifruit induced by *Lactobacillus plantarum* fermentation. *Journal of the Science of Food and Agriculture*. 2020;100(8):3283-90.
21. Kagkli DM, Corich V, Bovo B, Lante A, Giacomini A. Antiradical and antimicrobial properties of fermented red chicory (*Cichorium intybus* L.) by-products. *Ann Microbiol*. déc 2016;66(4):1377-86.
22. Leonard W, Zhang P, Ying D, Adhikari B, Fang Z. Fermentation transforms the phenolic profiles and bioactivities of plant-based foods. *Biotechnology Advances*. juill 2021;49:107763.
23. Feng Y, Zhang M, Mujumdar AS, Gao Z. Turmeric Extract: Potential Use as a Prebiotic and Anti-Inflammatory Compound? *Trends in Food Science & Technology*. 1 juill 2017;65:40-8.
24. Pianpumepong P, Anal AK, Doungchawee G, Noomhorm A. Study on enhanced absorption of phenolic compounds of *Lactobacillus*-fermented turmeric (*Curcuma longa* Linn.) beverages in rats. *International Journal of Food Science & Technology*. 2012;47(11):2380-7.
25. Singhal B, Pundhir A, Maurya A. In vitro evaluation of functional attributes of LABs for the development of turmeric based probiotic beverage. 2016;4:33.
26. Wang M, Lei M, Samina N, Chen L, Liu C, Yin T, et al. Impact of *Lactobacillus plantarum* 423 fermentation on the antioxidant activity and flavor properties of rice bran and wheat bran. *Food Chemistry*. 15 nov 2020;330:127156.
27. Mukherjee R, Chakraborty R, Dutta A. Comparison of optimization approaches (response surface methodology and artificial neural network-genetic algorithm) for a novel mixed culture approach in soybean meal fermentation. *J Food Process Eng*. août 2019;42(5).
28. Cheng Y, Wu T, Chu X, Tang S, Cao W, Liang F, et al. Fermented blueberry pomace with antioxidant properties improves fecal microbiota community structure and short chain fatty acids production in an in vitro mode. *LWT*. mai 2020;125:109260.
29. Kwaw E, Ma Y, Tchabo W, Apaliya MT, Wu M, Sackey AS, et al. Effect of *Lactobacillus* strains on phenolic profile, color attributes and antioxidant activities of lactic-acid-fermented mulberry juice. *Food Chemistry*. 1 juin 2018;250:148-54.
30. Lizardo RCM, Cho HD, Won YS, Seo KI. Fermentation with mono- and mixed cultures of *Lactobacillus plantarum* and *L. casei* enhances the phytochemical content and biological activities of cherry silverberry (*Elaeagnus multiflora* Thunb.) fruit. *Journal of the Science of Food and Agriculture*. 2020;100(9):3687-96.



31. Frediansyah A, Romadhoni F, Suryani, Nurhayati R, Wibowo AT. Fermentation of Jamaican Cherries Juice Using *Lactobacillus plantarum* Elevates Antioxidant Potential and Inhibitory Activity against Type II Diabetes-Related Enzymes. *Molecules*. janv 2021;26(10):2868.
32. Goto M, Kuda T, Shikano A, Charrouf Z, Yamauchi K, Yokozawa M, et al. Induction of superoxide anion radical-scavenging c. *LWT*. 1 févr 2019;100:56-61.
33. Jung J, Jang HJ, Eom SJ, Choi NS, Lee N-K, Paik H-D. Fermentation of red ginseng extract by the probiotic *Lactobacillus plantarum* KCCM 11613P: ginsenoside conversion and antioxidant effects. *Journal of Ginseng Research*. 1 janv 2019;43(1):20-6.
34. Marazza JA, Nazareno MA, de Giori GS, Garro MS. Enhancement of the antioxidant capacity of soymilk by fermentation with *Lactobacillus rhamnosus*. *Journal of Functional Foods*. 1 juill 2012;4(3):594-601.
35. Kim J, Choi K-B, Park JH, Kim KH. Metabolite profile changes and increased antioxidative and antiinflammatory activities of mixed vegetables after fermentation by *Lactobacillus plantarum*. *PLOS ONE*. 22 mai 2019;14(5):e0217180.
36. Shahbazi R, Sharifzad F, Bagheri R, Alsadi N, Yasavoli-Sharahi H, Matar C. Anti-Inflammatory and Immunomodulatory Properties of Fermented Plant Foods. *Nutrients*. mai 2021;13(5):1516.
37. Chon H, Kim G, Kim S. Comparison of Aqueous Plant Extracts before and after Fermentation with *Lactobacillus Paracasei* LS-2 on Cytokine Induction and Antioxidant Activity. *Natural Product Communications*. 1 août 2010;5(8):1934578X1000500827.
38. Ali MS, Lee E-B, Lee S-J, Lee S-P, Boby N, Suk K, et al. *Aronia melanocarpa* Extract Fermented by *Lactobacillus plantarum* E2014 Modulates Immune Response in Mice. *Antioxidants*. août 2021;10(8):1276.
39. Kim K, Lee G, Thanh HD, Kim J-H, Konkitt M, Yoon S, et al. Exopolysaccharide from *Lactobacillus plantarum* LRCC5310 offers protection against rotavirus-induced diarrhea and regulates inflammatory response. *Journal of Dairy Science*. 1 juill 2018;101(7):5702-12.
40. Kim S-B, Kang B-H, Kwon H-S, Kang J-H. Antiinflammatory and Antiallergic Activity of Fermented Turmeric by *Lactobacillus johnsonii* IDCC 9203. *Microbiology and Biotechnology Letters*. 2011;39(3):266-73.
41. Ghiamati Yazdi F, Soleimani-Zad S, van den Worm E, Folkerts G. Turmeric Extract: Potential Use as a Prebiotic and Anti-Inflammatory Compound? *Plant Foods Hum Nutr*. 1 sept 2019;74(3):293-9.
42. Yong CC, Yoon Y, Yoo HS, Oh S. Effect of *Lactobacillus* Fermentation on the Anti-Inflammatory Potential of Turmeric. *J Microbiol Biotechnol*. 28 oct 2019;29(10):1561-9.
43. Ayivi RD, Gyawali R, Krastanov A, Aljaloud SO, Worku M, Tahergorabi R, et al. Lactic Acid Bacteria: Food Safety and Human Health Applications. *Dairy*. déc 2020;1(3):202-32.
44. Cotârlet M, Stănciuc N, Bahrim GE. *Yarrowia lipolytica* and *Lactobacillus paracasei* Solid State Fermentation as a Valuable Biotechnological Tool for the Pork Lard and Okara's Biotransformation. *Microorganisms*. 22 juill 2020;8(8):1098.
45. Kothari D, Lee W-D, Jung ES, Niu K-M, Lee CH, Kim S-K. Controlled Fermentation Using Autochthonous *Lactobacillus plantarum* Improves Antimicrobial Potential of Chinese Chives against Poultry Pathogens. *Antibiotics*. juill 2020;9(7):386.
46. Dallagnol AM, Pescuma M, De Valdez GF, Rollán G. Fermentation of quinoa and wheat slurries by *Lactobacillus plantarum* CRL 778: proteolytic activity. *Appl Microbiol Biotechnol*. 1 avr 2013;97(7):3129-40.
47. Hashemi SMB, Mousavi Khaneghah A, Barba FJ, Nemati Z, Sohrabi Shokofti S, Alizadeh F. Fermented sweet lemon juice (*Citrus limetta*) using *Lactobacillus plantarum* LS5: Chemical composition, antioxidant and antibacterial activities. *Journal of Functional Foods*. 1 nov 2017;38:409-14.
48. Beck MR, Garrett K, Marshall CJ, Olejar K, Bunt CR, Maxwell TMR, et al. *Lactobacillus* fermented plant extracts provided to yearling ewes improves their lambs' antioxidant status at weaning. *Animal Feed Science and Technology*. 1 nov 2021;281:115103.
49. Uerlings J, Schroyen M, Bautil A, Courtin C, Richel A, Sureda EA, et al. In vitro prebiotic potential of agricultural by-products on intestinal fermentation, gut barrier and inflammatory status of piglets. *Br J Nutr*. 14 févr 2020;123(3):293-307.
50. Zhang Z-P, Ma J, He Y-Y, Lu J, Ren D-F. Antioxidant and hypoglycemic effects of *Diospyros lotus* fruit fermented with *Microbacterium flavum* and *Lactobacillus plantarum*. *J Biosci Bioeng*. juin 2018;125(6):682-7.
51. Park S, Son H-K, Chang H-C, Lee J-J. Effects of Cabbage-Apple Juice Fermented by *Lactobacillus plantarum* EM on Lipid Profile Improvement and Obesity Amelioration in Rats. *Nutrients*. avr 2020;12(4):1135.
52. Ryu J-Y, Kang HR, Cho SK. Changes Over the Fermentation Period in Phenolic Compounds and Antioxidant and Anticancer Activities of Blueberries Fermented by *Lactobacillus plantarum*. *Journal of Food Science*. 2019;84(8):2347-56.



53. Pontonio E, Dingo C, Gobbetti M, Rizzello CG. Maize Milling By-Products: From Food Wastes to Functional Ingredients Through Lactic Acid Bacteria Fermentation. *Front Microbiol.* 19 mars 2019;10:561.
54. Pontonio E, Dingo C, Di Cagno R, Blandino M, Gobbetti M, Rizzello CG. Brans from hull-less barley, emmer and pigmented wheat varieties: From by-products to bread nutritional improvers using selected lactic acid bacteria and xylanase. *International Journal of Food Microbiology.* janv 2020;313:108384.
55. Chen H-Y, Hsieh C-W, Chen P-C, Lin S-P, Lin Y-F, Cheng K-C. Development and Optimization of Djulis Sourdough Bread Fermented by Lactic Acid Bacteria for Antioxidant Capacity. *Molecules.* 17 sept 2021;26(18):5658.
56. Schettino R, Pontonio E, Rizzello CG. Use of Fermented Hemp, Chickpea and Milling By-Products to Improve the Nutritional Value of Semolina Pasta. *Foods.* 22 nov 2019;8(12):604.
57. Brückner-Gühmann M, Banovic M, Drusch S. Towards an increased plant protein intake: Rheological properties, sensory perception and consumer acceptability of lactic acid fermented, oat-based gels. *Food Hydrocolloids.* nov 2019;96:201-8.
58. Kachouri F, Hamdi M. Use *Lactobacillus plantarum* in olive oil process and improvement of phenolic compounds content. *Journal of Food Engineering.* déc 2006;77(3):746-52.
59. Ruiz-Barba J L, Brenes-Balbuena M, Jiménez-Díaz R, García-García P, Garrido-Fernández A. Inhibition of *Lactobacillus plantarum* by polyphenols extracted from two different kinds of olive brine. *Journal of Applied Bacteriology.* 1993;74(1):15-9.
60. Leal-Sánchez MV, Ruiz-Barba JL, Sánchez AH, Rejano L, Jiménez-Díaz R, Garrido A. Fermentation profile and optimization of green olive fermentation using *Lactobacillus plantarum* LPCO10 as a starter culture. *Food Microbiology.* août 2003;20(4):421-30.
61. Landete JM, Curiel JA, Rodríguez H, de las Rivas B, Muñoz R. Study of the inhibitory activity of phenolic compounds found in olive products and their degradation by *Lactobacillus plantarum* strains. *Food Chemistry.* mars 2008;107(1):320-6.
62. Ciafardini G, Marsilio V, Lanza B, Pozzi N. Hydrolysis of Oleuropein by *Lactobacillus plantarum* Strains Associated with Olive Fermentation. *Appl Environ Microbiol.* nov 1994;60(11):4142-7.
63. Ruiz-Barba JL, Cathcart DP, Warner PJ, Jiménez-Díaz R. Use of *Lactobacillus plantarum* LPCO10, a Bacteriocin Producer, as a Starter Culture in Spanish-Style Green Olive Fermentations. *Appl Environ Microbiol.* juin 1994;60(6):2059-64.
64. Kachouri F, Setti K, Ksontini H, Mechmeche M, Hamdi M. Improvement of antioxidant activity of olive mill wastewater phenolic compounds by *Lactobacillus plantarum* fermentation. *Desalination and Water Treatment.* 1 déc 2016;57(56):27125-37.
65. Tangyu M, Muller J, Bolten CJ, Wittmann C. Fermentation of plant-based milk alternatives for improved flavour and nutritional value. *Appl Microbiol Biotechnol.* déc 2019;103(23-24):9263-75.
66. Do TTV, Fan L. Probiotic Viability, Qualitative Characteristics, and Sensory Acceptability of Vegetable Juice Mixture Fermented with *Lactobacillus* Strains. *Food and Nutrition Sciences.* 19 avr 2019;10(04):412.
67. Cui S, Zhao N, Lu W, Zhao F, Zheng S, Wang W, et al. Effect of different *Lactobacillus* species on volatile and nonvolatile flavor compounds in juices fermentation. *Food Science & Nutrition.* 2019;7(7):2214-23.
68. Bianchi F, Rossi EA, Gomes RG, Sivieri K. Potentially synbiotic fermented beverage with aqueous extracts of quinoa (*Chenopodium quinoa* Willd) and soy. *Food Sci Technol Int.* sept 2015;21(6):403-15.
69. Yoon KY, Woodams EE, Hang YD. Production of probiotic cabbage juice by lactic acid bacteria. *Bioresource Technology.* août 2006;97(12):1427-30.
70. Lavinia BC, Manea I, Bratu MG, Avram D, Nicolescu CL. Evaluation of the cabbage and cucumber juices as substrate for *Lactobacillus acidophilus* LA-5. *Romanian Biotechnological Letters.* 2012;17(4):12.
71. Karovičová J, Drdák M, Greif G, Hybenová E. The choice of strains of *Lactobacillus* species for the lactic acid fermentation of vegetable juices. *European Food Research and Technology.* 3 nov 1999;210(1):53-6.
72. Jang H, Kim M. Characteristics of Vegetable Juice Fermented with *Lactobacillus plantarum* MKHA15 and *Leuconostoc mesenteroides* MKSR. *Journal of the Korean Dietetic Association.* 2 nov 2019;25(4):281-94.
73. Dunkley KE, Hekmat S. Development of probiotic vegetable juice using *Lactobacillus Rhamnosus* GR-1. *Nutrition & Food Science.* 1 janv 2020;50(5):955-68.
74. Hashemi SMB, Jafarpour D. Fermentation of bergamot juice with *Lactobacillus plantarum* strains in pure and mixed fermentations: Chemical composition, antioxidant activity and sensorial properties. *LWT.* 1 sept 2020;131:109803.



75. Gupta S, Jaiswal AK, Abu-Ghannam N. Optimization of fermentation conditions for the utilization of brewing waste to develop a nutraceutical rich liquid product. *Industrial Crops and Products*. janv 2013;44:272-82.
76. Oktaviani L, Astuti DI, Rosmiati M, Abduh MY. Fermentation of coffee pulp using indigenous lactic acid bacteria with simultaneous aeration to produce cascara with a high antioxidant activity. *Heliyon*. juill 2020;6(7):e04462.
77. Nguyen NK, Dong NTN, Nguyen HT, Le PH. Lactic acid bacteria: promising supplements for enhancing the biological activities of kombucha. *SpringerPlus*. déc 2015;4(1):91.
78. Nguyen NK, Dong NTN, Le PH, Nguyen HT. Evaluation of the Glucuronic Acid Production and Other Biological Activities of Fermented Sweeten-Black Tea by Kombucha Layer and the Co-Culture with Different *Lactobacillus* Sp. Strains. *International Journal Of Modern Engineering Research*. mai 2014;4(5):12-7.
79. Hou J, Luo R, Ni H, Li K, Mgomi FC, Fan L, et al. Antimicrobial potential of kombucha against foodborne pathogens: A review. *qas*. 30 août 2021;13(3):53-61.
80. Park JH, Kim Y, Kim SH. Green Tea Extract (*Camellia sinensis*) Fermented by *Lactobacillus fermentum* Attenuates Alcohol-Induced Liver Damage. *Bioscience, Biotechnology, and Biochemistry*. 23 déc 2012;76(12):2294-300.
81. Cherdthong A, Suntara C, Khota W. *Lactobacillus casei* TH14 and additives could modulate the quality, gas kinetics and the in vitro digestibility of ensilaged rice straw. *J Anim Physiol Anim Nutr*. nov 2020;104(6):1690-703.
82. Xu Z, He H, Zhang S, Kong J. Effects of inoculants *Lactobacillus brevis* and *Lactobacillus parafarraginis* on the fermentation characteristics and microbial communities of corn stover silage. *Sci Rep*. déc 2017;7(1):13614.
83. Irsyammawati A, Mashudi, Ndaru PH. The Effect of *Lactobacillus plantarum* Addition and Fermentation Periods on Nutritive Value Dwarf Elephant Grass (*Pennisetum purpureum* cv Mott) Silage. *IOP Conf Ser: Earth Environ Sci*. juin 2020;478:012049.
84. Zhao J, Dong Z, Li J, Chen L, Bai Y, Jia Y, et al. Evaluation of *Lactobacillus plantarum* MTD1 and waste molasses as fermentation modifier to increase silage quality and reduce ruminal greenhouse gas emissions of rice straw. *Science of The Total Environment*. 20 oct 2019;688:143-52.
85. Mu L, Xie Z, Hu L, Chen G, Zhang Z. *Lactobacillus plantarum* and molasses alter dynamic chemical composition, microbial community, and aerobic stability of mixed (amaranth and rice straw) silage. *J Sci Food Agric*. sept 2021;101(12):5225-35.
86. Risdianto D, Suthama N, Suprijatna E, Sunarso S. Inclusion effect of ginger and turmeric mixture combined with *Lactobacillus* spp. isolated from rumen fluid of cattle on health status and growth of broiler. *J Indonesian Trop Anim Agric*. 28 déc 2019;44(4):423.
87. Dedenaro G, Costa S, Rugiero I, Pedrini P, Tamburini E. Valorization of Agri-Food Waste via Fermentation: Production of l-lactic Acid as a Building Block for the Synthesis of Biopolymers. *Applied Sciences*. 24 nov 2016;6(12):379.
88. Ricci A, Diaz AB, Caro I, Bernini V, Galaverna G, Lazzi C, et al. Orange peels: from by-product to resource through lactic acid fermentation. *J Sci Food Agric*. déc 2019;99(15):6761-7.
89. Hwang HJ, Lee SY, Kim SM, Lee SB. Fermentation of seaweed sugars by *Lactobacillus* species and the potential of seaweed as a biomass feedstock. *Biotechnol Bioproc E*. 1 déc 2011;16(6):1231-9.
90. Zhang Y, Vadlani PV, Kumar A, Hardwidge PR, Govind R, Tanaka T, et al. Enhanced D-lactic acid production from renewable resources using engineered *Lactobacillus plantarum*. *Appl Microbiol Biotechnol*. janv 2016;100(1):279-88.
91. Zhang Y, Vadlani PV. d-Lactic acid biosynthesis from biomass-derived sugars via *Lactobacillus delbrueckii* fermentation. *Bioprocess Biosyst Eng*. 1 déc 2013;36(12):1897-904.
92. Göksungur Y, Güvenç U. Batch and Continuous Production of Lactic Acid from Beet Molasses by *Lactobacillus delbrueckii* IFO 3202. *Journal of Chemical Technology & Biotechnology*. 1997;69(4):399-404.
93. Li Z, Ding S, Li Z, Tan T. L-lactic acid production by *Lactobacillus casei* fermentation with corn steep liquor-supplemented acid-hydrolysate of soybean meal. *Biotechnol J*. déc 2006;1(12):1453-8.
94. Tu W-L, Hsu T-C, Wang C-A, Guo G-L, Chao Y. Using Novel *Lactobacillus plantarum* to Produce Lactic Acid from Lignocellulosic Biomass in an Integrated Simultaneous Saccharification and Fermentation Process. *BioResources*. 27 mars 2019;14(2):3873-85.
95. Xu Q, Zang Y, Zhou J, Liu P, Li X, Yong Q, et al. Highly efficient production of d-lactic acid from chicory-derived inulin by *Lactobacillus bulgaricus*. *Bioprocess Biosyst Eng*. 1 nov 2016;39(11):1749-57.
96. John RP, Nampoothiri KM, Pandey A. Solid-state fermentation for l-lactic acid product. *Process Biochemistry*. avr 2006;41(4):759-63.
97. Sharma P, Sharma A, Singh J, Singh N, Singh S, Tomar GS, et al. Co-production of gamma amino butyric acid (GABA) and lactic acid using *Lactobacillus plantarum* LP-9 from agro-residues. *Environmental Technology & Innovation*. août 2021;23:101650.



98. Park J-H, Garcia CV, Lee S-P. Fortification of Poly- γ -Glutamic Acid and γ -Aminobutyric Acid in Homogenized Hydroponic Ginseng Co-Fermented by *Bacillus subtilis* HA and *Lactobacillus plantarum* EJ2014. *Prev Nutr Food Sci*. déc 2019;24(4):485-91.
99. Lee B-J, Kim J-S, Kang YM, Lim J-H, Kim Y-M, Lee M-S, et al. Antioxidant activity and γ -aminobutyric acid (GABA) content in sea tangle fermented by *Lactobacillus brevis* BJ20 isolated from traditional fermented foods. *Food Chemistry*. 1 sept 2010;122(1):271-6.
100. Vecino X, Rodríguez-López L, Gudiña EJ, Cruz JM, Moldes AB, Rodrigues LR. Vineyard pruning waste as an alternative carbon source to produce novel biosurfactants by *Lactobacillus paracasei*. *Journal of Industrial and Engineering Chemistry*. 25 nov 2017;55:40-9.
101. Li Z, Teng J, Lyu Y, Hu X, Zhao Y, Wang M. Enhanced Antioxidant Activity for Apple Juice Fermented with *Lactobacillus plantarum* ATCC14917. *Molecules*. janv 2019;24(1):51.
102. Li H, Huang J, Wang Y, Wang X, Ren Y, Yue T, et al. Study on the nutritional characteristics and antioxidant activity of dealcoholized sequentially fermented apple juice with *Saccharomyces cerevisiae* and *Lactobacillus plantarum* fermentation. *Food Chemistry*. nov 2021;363:130351.
103. Gao H, Wen J-J, Hu J-L, Nie Q-X, Chen H-H, Nie S-P, et al. *Momordica charantia* juice with *Lactobacillus plantarum* fermentation: Chemical composition, antioxidant properties and aroma profile. *Food Bioscience*. 1 juin 2019;29:62-72.
104. Wu S-C, Su Y-S, Cheng H-Y. Antioxidant properties of *Lactobacillus*-fermented and non-fermented *Graptopetalum paraguayense* E. Walther at different stages of maturity. *Food Chemistry*. 1 déc 2011;129(3):804-9.
105. Reque PM, Pinilla CMB, Tinello F, Corich V, Lante A, Giacomini A, et al. Biochemical and functional properties of wheat middlings bioprocessed by lactic acid bacteria. *J Food Biochem*. juill 2020;44(7).
106. Tlais AZA, Da Ros A, Filannino P, Vincentini O, Gobbetti M, Di Cagno R. Biotechnological recycling of apple by-products: A reservoir model to produce a dietary supplement fortified with biogenic phenolic compounds. *Food Chemistry*. janv 2021;336:127616.
107. Jin X, Chen W, Chen H, Chen W, Zhong Q. Combination of *Lactobacillus plantarum* and *Saccharomyces cerevisiae* DV10 as Starter Culture to Produce Mango Slurry: Microbiological, Chemical Parameters and Antioxidant Activity. *Molecules*. janv 2019;24(23):4349.
108. Mousavi ZE, Mousavi M. The effect of fermentation by *Lactobacillus plantarum* on the physicochemical and functional properties of liquorice root extract. *LWT*. 1 mai 2019;105:164-8.
109. Braga ARC, Mesquita LM de S, Martins PLG, Habu S, de Rosso VV. *Lactobacillus* fermentation of jussara pulp leads to the enzymatic conversion of anthocyanins increasing antioxidant activity. *Journal of Food Composition and Analysis*. 1 juin 2018;69:162-70.
110. Vieira ADS, Battistini C, Bedani R, Saad SM. Acerola by-product may improve the in vitro gastrointestinal resistance of probiotic strains in a plant-based fermented beverage. *LWT*. avr 2021;141:110858.
111. Thompson HO, Önnig G, Holmgren K, Strandler HS, Hultberg M. Fermentation of Cauliflower and White Beans with *Lactobacillus plantarum* – Impact on Levels of Riboflavin, Folate, Vitamin B12, and Amino Acid Composition. *Plant Foods Hum Nutr*. juin 2020;75(2):236-42.
112. Rizzello CG, Nionelli L, Coda R, De Angelis M, Gobbetti M. Effect of sourdough fermentation on stabilisation, and chemical and nutritional characteristics of wheat germ. *Food Chemistry*. 1 avr 2010;119(3):1079-89.
113. Nancib A, Nancib N, Meziane-Cherif D, Boubendir A, Fick M, Boudrant J. Joint effect of nitrogen sources and B vitamin supplementation of date juice on lactic acid production by *Lactobacillus casei* subsp. *rhamnosus*. *Bioresource Technology*. 1 janv 2005;96(1):63-7.
114. Chauhan K, Trivedi U, Patel KC. Statistical screening of medium components by Plackett–Burman design for lactic acid production by *Lactobacillus* sp. KCP01 using date juice. *Bioresource Technology*. 1 janv 2007;98(1):98-103.
115. Bahry H, Abdalla R, Pons A, Taha S, Vial C. Optimization of lactic acid production using immobilized *Lactobacillus Rhamnosus* and carob pod waste from the Lebanese food industry. *Journal of Biotechnology*. 20 déc 2019;306:81-8.
116. Ngouénam JR, Momo Kenfack CH, Foko Kouam EM, Kaktcham PM, Maharjan R, Ngoufack FZ. Lactic acid production ability of *Lactobacillus* sp. from four tropical fruits using their by-products as carbon source. *Heliyon*. mai 2021;7(5):e07079.

