

## ***Fungi in Fermented Foods***

Fermented foods are defined as ***foods or beverages produced through controlled microbial growth, and the conversion of food components through enzymatic action***. In recent years, fermented foods have undergone a surge in popularity, mainly due to their proposed health benefits. Examples of some of the common fermented foods are kefir, kombucha, sauerkraut, tempeh, natto, miso, kimchi, sourdough bread etc).

Fermented foods are important to human health due to the potential probiotic effect of their constituent microorganisms, the fermentation-derived production of bioactive peptides, biogenic amines, and conversion of phenolic compounds to biologically active compounds, as well as the reduction of anti-nutrients. The most widely investigated fermented food is **kefir**.

The popularity of fermented foods and beverages is due to their enhanced **shelf-life, safety, functionality, sensory, and nutritional properties**. The latter includes the presence of **bioactive molecules, vitamins**, and other constituents with increased availability due to the process of fermentation. Many fermented foods also contain **live microorganisms** that may improve gastrointestinal health and provide other health benefits, including lowering the risk of type two diabetes and cardiovascular diseases.

The number of organisms in fermented foods can vary significantly, depending on how products were manufactured and processed, as well as conditions and duration of storage. Most commonly consumed fermented foods include cultured dairy products, cheese, fermented sausage, fermented vegetables, soy-fermented foods, and fermented cereal products.

Fermentation has long been used to preserve and enhance the shelf-life, flavor, texture, and functional properties of food (Hutkins, 2018). More recently, the consumption of fermented foods containing live microorganisms has emerged as an important dietary strategy for improving human health (Marco et al., 2017).

In general, lactic acid bacteria (LAB) from several genera, including ***Lactobacillus*, *Streptococcus*, and *Leuconostoc*** are

predominant in fermented foods, but other bacteria as well as **yeast** and fungi also contribute to food fermentations.

Fermented foods have unique functional properties imparting some health benefits to consumers due to presence of functional microorganisms, which possess probiotics properties, antimicrobial, antioxidant, peptide production, etc. Health benefits of some global fermented foods are synthesis of nutrients, prevention of cardiovascular disease, prevention of cancer, gastrointestinal disorders, allergic reactions, diabetes, among others. The present paper is aimed to review the information on some functional properties of the microorganisms associated with fermented foods and beverages, and their health-promoting benefits to consumers.

Several genera with **hundreds of species of yeasts** have been isolated from fermented foods, alcoholic beverages and non-food mixed amyolytic starters which mostly include ***Candida*, *Debaryomyces*, *Geotrichum*, *Hansenula*, *Kluyveromyces*, *Pichia*, *Rhodotorula*, *Saccharomyces*, *Saccharomycopsis*, *Schizosaccharomyces*, *Torulopsis*, *Wickerhamomyces***, and ***Zygosaccharomyces***. Species of ***Actinomucor*, *Amylomyces*, *Aspergillus*, *Monascus*, *Mucor*, *Neurospora*, *Penicillium*, *Rhizopus***, and ***Ustilago*** are reported for many fermented foods, Asian non-food amyolytic starters, and alcoholic beverages.

Functional properties of microorganisms in fermented foods include probiotics properties, antimicrobial properties, antioxidant, peptide production, fibrinolytic activity, poly-glutamic acid, degradation of antinutritive compounds, etc. which may be important criteria for selection of starter culture(s) to be used in the manufacture of functional foods. Some genera and species of microorganisms are used as commercial starters in food fermentation, and some of products are commercialized and marketed globally as functional foods, health foods, therapeutic foods and nutraceuticals foods. The present paper is aimed to review the information on some functional properties of the microorganisms associated with fermented foods and beverages, and their health-promoting benefits to consumers.

Some Fungi used as commercial starters in food fermentation (amended and compiled from references: [Mogensen et al., 2002](#); [Bernardeau et al., 2006](#); [Bourdichon et al., 2012](#); [Thapa and Tamang, 2015](#)).

Group	Genera/species	Product/application(s)
Yeasts	<i>S. bayanus</i>	<i>Kefir</i> fermentation; juice and wine fermentation
	<i>S. cerevisiae</i>	Beer, bread, invertase (food additive)
	<i>S. cerevisiae</i> subsp. <i>boulardii</i>	Used as probiotic culture
	<i>S. florentius</i>	<i>Kefir</i> fermentation
	<i>S. pastorianus</i>	Beer
	<i>S. sake</i>	<i>Sake</i> fermentation
	<i>S. unisporus</i>	<i>Kefir</i> fermentation
	<i>Schizosaccharomyces pombe</i>	Wine
	<i>Zygosaccharomyces rouxii</i>	Soy sauce
Filamentous moulds	<i>Aspergillus flavus</i>	$\alpha$ -amylases (food additive)
	<i>A. niger</i>	Beverages; industrial production of citric acid; amyloglucosidases, pectinase, cellulase, glucose oxidase, protease (food additives)
	<i>A. oryzae</i> , <i>A. sojae</i>	Soy sauce, beverages; $\alpha$ -amylases, amyloglucosidase, lipase (food additives)
	<i>Penicillium camemberti</i>	White mold cheeses (camembert type)
	<i>P. notatum</i>	Glucose oxidases (food additive)
	<i>P. roqueforti</i>	Blue mold cheeses
	<i>Rhizopus oligosporus</i>	<i>Tempe</i> fermentation
	<i>R. oryzae</i>	Soy sauce, <i>koji</i>