Fermented Food Products
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Foreword

The widely used fermented food products are enriched with beneficial probiotic microorganisms which provide a wide range of health benefits from better digestion to stronger immunity. Their significant role in the diet of developed, developing, and underdeveloped countries human population is commendable. The fermentation process also enhances the nutritive value of the food and minimizes the toxicity of the food material. In addition, the fermented food products also contribute to the cultural identity, local economy, and gastronomical delight.

Apart from the widely popular fermented food products, some of the traditional fermented food products have also been included in this book. Currently, there is a renewed interest in traditional fermented foods, mainly driven by the purported health benefits of fermented foods, both as vehicles of probiotic organisms and health-promoting metabolites.

The book comprises a total of 23 chapters listed under eight sections which deal with the different views of fermented food products from Global diversity to molecular tools involved. Furthermore, the book emphasizes specific ethnic fermented foods and beverages made from diverse sources viz. animal, plant and milk, etc. and used in different countries. The book caters the different geographic regions of the world with respect to the fermented food products, consumption as well as their therapeutic uses. I am sure that the readers will attain updated and recent information about different kinds of fermented food products.

I congratulate the editorial team and contributors of this book and appeal to the readers, including young researchers, scientists, and academicians to make use of this interesting book.

Myunghee Kim
Fermentation is a traditional process which is generally used to preserve the food from spoilage in the earlier days. It was primarily developed for the stabilization of perishable agricultural produce. Notwithstanding, the technology has evolved beyond food preservation into a tool for creating desirable organoleptic, nutritional and functional attributes in food products. Fermented food products still make up a significant portion of the diet in developing countries. Now a new dimensional approach leads to the enhancement of nutritional properties, inhibition of spoilage and contaminant organisms, and conversion of non-nutritive foods into nutritive ones by fermentation process. Moreover, the concept of developing therapeutic food products is appealing and growing nowadays. Apart from this, the existing reports denoted the degradation of toxic and non-nutritive factors, and this process played a pivotal role in food technology by means of fermented food products since they act as a bio-preservative by producing organic acids, antioxidants, and antimicrobial compounds.

This book is intended to provide a comprehensive overview about the different dimensions of fermented food products used in the world. These aspects include the global overview about the fermented food products such as plant-, animal-, and dairy-based fermented food products, as well as nutritive values of fermented beverages. The common fermented foods include kefir, kombucha, sauerkraut, pickles, miso, tempeh, natto, kimchi, curd, cheese, yogurt, beer, wine, vinegar, idli, dosa, porridge, and dhokla. The different chapters of this book mainly cover the traditional fermented food products of various geographical locations of world, application of molecular tools in fermented food products and their probable nutritional and therapeutic benefits. Since a lot of traditional fermentation-based food products are still not reaching to the scientific community and the population worldwide, this book is a scientific approach towards educating and spreading the awareness of such beneficial fermented foods with interesting information.

Furthermore, the recent scientific reports revealed that the exact mechanism of microorganisms is still unknown in some traditional fermented food products, hence, the book also provides the future insights for research in these traditional foods. In this book, a total of 23 chapters are placed under seven different sections, along with a special section allotted for traditional fermented food products of multifarious countries.

This book can be used as a source of information in different fields like microbiology, biotechnology, food technology, food science, food engineering, food chemistry as well as nutrition and health sciences. We the editors strongly believe that the book will be helpful to readers in all aspects including academic and research and it will certainly drive the future research in traditional fermented food products in order to reveal the precise role of microorganisms in food fermentation.

A. SANKARANARAYANAN
N. AMARESAN
D. DHANASEKARAN
About the Editors

Dr. Sankaranarayanan is associated with C.G. Bhakta Institute of Biotechnology, Uka Tarsadia University, Gujarat, India, from 2015 onwards. He has experience in the fields of Antimicrobial activity of herbal and nano particles against MDR pathogens and fermented food products. His current research focus is on microbes in fermented food products and removal of bacteria from food by dielectrophoresis. He has published six chapters in various books and 50 research articles in International and National journals of repute, has guided 4 Ph.D. and 16 M.Phil. scholars and operated five minor funded projects. From 2002 to 2015, he worked as an Assistant Professor & Head, Department of Microbiology, K.S.R. College of Arts & Science, Tiruchengode, Tamil Nadu. He has been awarded with the Indian Academy of Sciences (IASC), National Academy of Sciences (NAS), and The National Academy of Sciences (TNAS)–sponsored summer research fellowship for young teachers consecutively for three years. His name is included as a Mentor in DST-Mentors/Resource persons for summer/winter camps and other INSPIRE initiatives, Department of Science & Technology, Govt. of India, New Delhi. He is a Grant reviewer in British Society of Antimicrobial Chemotherapy (BSAC), UK. He has involved himself in the organization of various National/International seminars/symposia. He is actively involved as an Editor/Editorial board member in journals and reviewers in various International/National reputed journals and acted as an external examiner to adjudicate the Ph.D. thesis of various universities in India.

Dr. N. Amaresan is an Assistant Professor at C.G. Bhakta Institute of Biotechnology, Uka Tarsadia University, Gujarat, India. He is basically a microbiologist, and has obtained his Ph.D. degree on endophytic PGP bacteria from Bharathidasan University, Tamil Nadu. Dr. Amaresan has over 13 years of experience in teaching & research and made several original and novel discoveries, especially in various allied fields of microbiology mainly plant-microbe interactions, bioremediation, plant pathology and others. For his original discoveries on agriculturally important microorganisms, he has been awarded young scientist awards by the Association of Microbiologists of India and National Academy of Biological Sciences. He has also been awarded visiting scientist fellowship from the National Academy of India to learn advanced techniques. He has handled two institute-funded and four externally funded projects from DST, GEMI, DBT, and so on. He has published more than 50 research articles and books of national and international reputation. He has also deposited over 350 bacterial 16S rDNA and fungal ITS rDNA sequences in the GenBank (NCBI, EMBL & DDBJ) and also has preserved over 150 microbial germplasm in various culture collection centers of India.
Dr. Dharumadurai Dhanasekaran is an Assistant Professor at the Department of Microbiology, School of Life Sciences, Bharathidasan University, Tiruchirappalli, India. He has experience in the fields of actinobacteriology, mycology, and phycology. His current research focus is on actinobacteria, microalgae, fungi, and mushroom for animal and human health improvement. He has been awarded UGC-Raman Post-Doctoral Fellowship and worked in the Department of Molecular, Cellular and Biomedical Sciences, University of New Hampshire, Durham, USA. He has qualified the Tamil Nadu State Eligibility Test (SET) for Lectureship in Life Science. He has deposited around 103 nucleotide sequences in GenBank, 5 bioactive compounds in Pubchem, published 101 research and review articles including one paper in Nature Group Journal Scientific Report and 19 Book chapters. He has h-index of 20 with total citations of 1364 as per Google Scholar. He has edited six books on Antimicrobial compounds: Synthetic and Natural compounds, Microbial control of Vector borne Diseases, CRC Press, Taylor & Francis Group, New York, Fungicides for Plant and Animal Diseases, Actinobacteria: Basics and Biotechnological applications, Algae-Organisms for Imminent Biotechnology, Microbial Biofilms – Importance and Applications under In-tech open access publisher, Eastern Europe. He has guided 10 Ph.D. candidates and organized several national level symposia, conference and workshop programs. He received major research projects from the Department of Biotechnology, the University Grants Commission, the Indian Council for Medical research, and the International Foundation for Science, Sweden. He is member in American Society for Microbiology, North American Mycology Association, Mycological Society of India, National Academy of Biological Sciences and member in editorial boards in National, International Journals, Doctoral committee member, Board of study member in Microbiology and Reviewer in the scientific Journals and research grants. As per the reports of Indian Journal of Experimental Biology, 51, 2013, Dr. Dharmadurai Dhanasekaran is rated in the second position among the top five institutions in the field of Actinobacteria research in India.
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Section 1

Overview
Diversity of Global Fermented Food Products:
An Overview

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1 Introduction

Fermentation is a process that transforms any substrate into food products with the aid of microorganisms such as bacteria, fungi, and yeast; enhances the quality of food materials, that is, flavor, taste, and palatability (Azokpota 2015); extends shelf life, preservation, aroma, and nutrient profile (Giraffa 2004; Katz 2012); inhibits the growth of unwanted microbes; and removes antinutritional properties. The word fermentation is derived from the Latin word *fermentare*, which means ‘to leaven’. During the fermentation process, production of various organic acids, carbon dioxide, antimicrobial peptides, and bacteriocins suppresses the growth of spoilage microorganisms and the process acts as a natural preservative. The traditional practices are followed at a small-scale level in houses (curd, a fermented dairy product) and at a large-scale level in industries (soy sauce, a grain-based product) in defined environmental conditions.

Fermented food is an integral part of the human diet throughout the world. The consumption of fermented food products either as a part of the diet or as a complete diet depends on the food habits of individuals. Production of fermented food may vary based on the cultures used, raw material availability, taste preferences of consumers/particular regions, and the technology used. According to a report, more than 5000 fermented food products are consumed by humans throughout the world (Ray et al. 2016). Although the production process may vary, all fermented food products are prepared such that they are acceptable by consumers. Moreover, in some fermented products, especially alcoholic beverages, the extended storage enhances their value than the freshly prepared one. Still some folklore practices of fermented food products are unable to reach the vicinity of scientific communities, and they are followed only by a particular hub of people at a particular time. Further, a recent research report insisted on the need of re-discovering and updating the positive aspects of fermented food products, especially the less concentrated plant-based fermented food products (Lavefve et al. 2019).

A variety of substrates are used in the production of fermented food products, including cereals, grains, leaves, milk, vegetables, fish, and meat, as substrates by solid-state fermentation (SSF) and submerged fermentation (SmF) processes mediated through bacteria, fungi, and yeast.

Fermented food products ensure that food is available to everyone. The reason behind this is most of the food materials available in nature are easily perishable in their raw condition, and there is a high possibility of their deterioration by spoilage microbes. Hence, enhanced quality, extended shelf life, and edibility of fermented food ensure that food is available throughout the year (Rolle and Satin 2002; Patra et al. 2016; Adewumi 2018) (Figure 1.1).
Limited the growth of spoilaging organisms

**FIGURE 1.1** Different beneficial perceptions of fermented food products.

**TABLE 1.1**
Diversified substrates used for fermented food products

<table>
<thead>
<tr>
<th>S. no.</th>
<th>Name of the substrate</th>
<th>Country used</th>
<th>Names of the fermented food</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cereal grains</td>
<td>Africa, Ghana, Tanzania, India, Sri Lanka, Nepal</td>
<td>Doklu, Kenkey, Togwa, Dosa and idli</td>
</tr>
<tr>
<td>2.</td>
<td>Legume</td>
<td>Japan, India, Indonesia</td>
<td>Natto, Kinema, Tempe</td>
</tr>
<tr>
<td>3.</td>
<td>Roots and tubers</td>
<td>West Africa, Brazil</td>
<td>Lafun, Taruba</td>
</tr>
<tr>
<td>4.</td>
<td>Fruits and vegetables</td>
<td>Korea, Nepal, Mexico, Taiwan</td>
<td>Kimchi, Khalpi, Pulque, Suan-tsai</td>
</tr>
<tr>
<td>5.</td>
<td>Bamboo shoots</td>
<td>Taiwan, India (Northeast)</td>
<td>Jiang-sun, Soidon</td>
</tr>
<tr>
<td>6.</td>
<td>Milk and dairy products</td>
<td>China, Russia, Turkey, India</td>
<td>Kurut, Koumiss, Aryan, Shrikhand</td>
</tr>
<tr>
<td>7.</td>
<td>Meat and sea foods</td>
<td>Portugal, Turkey, Thailand, Ethiopia, India</td>
<td>Alheira, Sucuk, Nham, Wakalim, Jamma</td>
</tr>
</tbody>
</table>

*Continued*
Another noteworthy point is that the availability of diversified substrates, including cereal grains, pulses, roots and tubers, fruits and vegetables, edible bamboo shoots, milk and dairy products, meat and sea foods, tea leaves, cocoa, sugar cane, and oil palm sap, is the reason for the availability of a variety of fermented products in the world (Table 1.1).

The purpose of this chapter is to introduce the various fermented food products and their diversity, including household fermented food products, countries where they are used and their health benefits. It is interesting to note at this juncture that although several books, reviews (Hesseltine and Wang 1986; Reddy et al. 1986; Nout and Rombouts 1990; Sanni 1993) and reports/monographs are available on indigenous food products, still the role of microbes in the production of few of the indigenous fermented food products is not yet revealed (Beuchat 1983, 1987; Reddy et al. 1986). Hence, researchers/scientists involved in the research based on fermented food products should reveal the role of organisms involved in the formation of fermented food products and list out various health aspects that one may gain by consuming them. There are chances that the fermented food products have some indigenous features that are beneficial for human health, and it is a bounden duty of researchers/scientists to report about this to the world.

### 2 Food Fermentation—Definition and Types

Fermentation is a basic and traditional practice followed everywhere in the world from a household scale to industrial level. Fermented foods are gifts to humankind by nature, and the reactions are mediated by microbes.

Fermented food is defined as the metabolic conversion of raw substrate into food with improved quality, and the reaction is mediated by microorganisms. In another view, it is a metabolic process in which carbohydrates/associated compounds are oxidized with the release of energy in the absence of electron acceptors.

Fermented food is also defined as a process that utilizes the microbial metabolic activity for the stabilization and transformation of food materials (Terefe 2016) fit for consumption with enhanced values of the product.

It is a metabolic-oriented microbial process that enhances the shelf life of the product, its aroma, flavor, and texture, and inhibits the unwanted microbes and removes toxicity from the...
food and makes it ready for consumption. Katz (2012) stated that ‘the fermented food products are the transformation of food by microbial mediated enzymes.’

SSF and SmF processes are carried out in fermented food industries in the presence as well as in the absence of oxygen. SSF process includes mushroom, bread, cocoa, tempeh (Erkmen and Bozoglu 2016), taruba (Ramos et al. 2015), and gari (Chisti 2014), whereas submerged fermentation (SmF) process includes pickling vegetables, yogurt, beer, wine (Erkmen and Bozoglu 2016), busa (Blandino et al. 2003) fufu, lafun, and agbelima (Oyewole 2001; Coulin et al. 2006).

### 3 Global Diversity of Various Fermented Food Products

Fermentation is one of the traditional and ancient processes, in which the metabolic activities of microbial organisms (Terefe 2016; Wilburn and Ryan 2017) enhance the value of the food products (Nout 2014). By the end of the fermentation, antimicrobial metabolites, production of bacteriocins, and synthesis of organic acids inhibit the food-borne pathogens (Kim et al. 2016) and enhance the organoleptic characteristics of food, thereby increasing its health benefits and shelf life (Heperkan 2013; Hwang et al. 2017). Basically, fermented food is an integral part of everyday diets of humans around the world and plays an important role in various traditional practices (Ansorena and Astiasarán 2016; Narzary et al. 2016; Kanwar and Keshani 2016) (Table 1.2).

Basically, a wide variety of fermented foods is available and used by all kinds of people invariably, especially those living in marginalized and vulnerable societal platforms (Montet et al. 2006). Some of the fermented food products play an important role in the traditional rituals of a particular community. Fermented milk products play an important role in the human diet throughout their life (Adolfsson et al. 2004). Lactic acid bacteria (LAB) play a predominant role in the production of fermented food products. LAB generate acidic environment, which inhibits the spoilage and disease-causing organisms by producing bacteriocins substances (Widyastuti and Febrisiantosa 2014). Also, the presence of vitamins, calcium, potassium, magnesium, and zinc in milk and milk-based fermented products is a noteworthy point. The presence of vitamins varies according to the fermented dairy products (Dönmez et al. 2014).

Fermented cereal-based foods basically lack essential amino acids and other basic nutritive compounds. A simple and alternate way mediated through fermentation is to increase the nutritive value of cereals (Ozdemir et al. 2007), especially some amino acids, vitamins of group B (Blandino et al. 2003), antioxidants (Đoršević et al. 2010), and free amino acids, and to reduce the nonnutritive compounds, such as polyphenols, phytates, and tannins (Şanlier et al. 2017).

Fermented milk and milk-based products are part of the human diet throughout their life. Thus, needless to reveal the importance of dairy and dairy-based fermented food products (Adolfsson et al. 2004) on human health. LAB play a vital role in the production of various milk and milk-based fermented products (Zukiewicz-Sobczak et al. 2014), in enhancement of their nutritional properties (Jeong et al. 2016), and also in improving their shelf life (Widyastuti and Febrisiantosa 2014). LAB enhance the value of fermented milk and milk-based products, providing an acidic environment by the conversion of lactose into lactic acid, which inhibits both the spoilage and pathogenic microbes (Widyastuti and Febrisiantosa 2014). Cheese is a prominent fermented dairy product rich in calcium and vitamin B contents (Ansorena and Astiasarán 2016). According to a recent report, the breakdown of casein and the formation of bioactive compounds are responsible for the biological activities (López-Expósito et al. 2017). A probiotic coagulated fermented dairy product yoghurt has enhanced vitamin B series with calcium, magnesium, potassium, and zinc ions (Wang et al. 2013). Microbes, especially LAB, play a vital role in the aroma and taste of fermented dairy products, especially koumiss. Koumiss is a slightly alcoholic fermented beverage with sour taste and alcoholic flavor (Lv and Wang 2009; Zhang and Zhang 2012; Choi 2016), which is due to the lactic acid and alcohol fermentation. The last product in
<table>
<thead>
<tr>
<th>Sources</th>
<th>Substrates</th>
<th>Product</th>
<th>Nature</th>
<th>Organisms involved</th>
<th>Country</th>
<th>Health benefits/nutrition</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize, Sorghum</td>
<td></td>
<td>Busa Beverage</td>
<td></td>
<td><em>S. cerevisiae</em>, <em>L. plantarum</em>, <em>L. casei</em>, <em>L. Brevis</em></td>
<td>Kenya, East Africa</td>
<td>Sour taste; sugar and protein</td>
<td>Odunfa and Oyewole 1997</td>
</tr>
<tr>
<td>Wheat</td>
<td>Injera</td>
<td>Bread-like product, slightly acidic</td>
<td></td>
<td><em>L. plantarum</em>, <em>S. cerevisiae</em></td>
<td>Ethiopia</td>
<td>Iron, potassium, vitamin A and K</td>
<td>Olasupo <em>et al.</em> 2010</td>
</tr>
<tr>
<td>Sorghum</td>
<td>Hussuwa</td>
<td>Cooked dough</td>
<td></td>
<td><em>L. fermentarum</em>,</td>
<td>Sudan</td>
<td>Antioxidant, antidiabetic, and antiobesity</td>
<td>Yousif <em>et al.</em> 2010</td>
</tr>
<tr>
<td>Wheat flour</td>
<td>Jalebi</td>
<td>Sweet, crispy, soft in nature, chewy; ghee fried</td>
<td></td>
<td><em>L. fermentarum</em>, <em>L. lactis</em>, <em>S. cerevisiae</em></td>
<td>India, Pakistan, Nepal</td>
<td>Lactose and protein with fat</td>
<td>Batra and Millner 1976, Asgar and Chauhan 2019</td>
</tr>
<tr>
<td>Sorghum, wheat, and millet</td>
<td>Kunu-zi</td>
<td>Slightly acidic, viscous</td>
<td></td>
<td><em>Corynebacterium</em> sp., <em>Fusarium</em> sp. <em>S. cerevisiae</em></td>
<td>Nigeria</td>
<td>Nonalcoholic</td>
<td>Oguntoyinbo <em>et al.</em> 2011</td>
</tr>
<tr>
<td>Maize</td>
<td>Poto-poto slurry</td>
<td>Slurry</td>
<td></td>
<td><em>L. plantarum</em>, <em>L. acidophilus</em>, <em>Bacillus</em> sp. <em>Enterococcus</em> sp.</td>
<td>Congo</td>
<td>Multivitamins and minerals</td>
<td>Abriouel <em>et al.</em> 2006</td>
</tr>
</tbody>
</table>

*(Continued)*
<table>
<thead>
<tr>
<th>Sources</th>
<th>Substrates</th>
<th>Product</th>
<th>Nature</th>
<th>Organisms involved</th>
<th>Country</th>
<th>Health benefits/nutrition</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>Puto</td>
<td>Steam based</td>
<td>highly viscous</td>
<td><em>Leuconostoc mesenteroides</em></td>
<td>Philippines</td>
<td>Carbohydrate rich with sodium and potassium</td>
<td>Steinkraus 2004</td>
</tr>
<tr>
<td>Rye, wheat</td>
<td>Sourdough</td>
<td>Slightly acidic</td>
<td><em>Lb. casei, Lb. delbrueckii, Lb. Plantarum</em></td>
<td>Australia, America, Europe</td>
<td></td>
<td>High protein, essential amino acids, and fiber</td>
<td>Pontonio and Rizzello 2019</td>
</tr>
<tr>
<td>Maize, Sorghum, Millet</td>
<td>Uji</td>
<td>Sour, acidic</td>
<td><em>L. plantarum, Leuconostoc mesenteroides</em></td>
<td>Uganda, Kenya</td>
<td></td>
<td>Starch and dietary fiber</td>
<td>Odunfa and Oyewole 1997</td>
</tr>
<tr>
<td>Maize</td>
<td>Champu</td>
<td>Beverage</td>
<td><em>S. cerevisiae</em></td>
<td>Colombia</td>
<td></td>
<td>Vitamins, minerals, dietary fiber, antioxidant</td>
<td>Osorio-Cadavid <em>et al.</em> 2008</td>
</tr>
<tr>
<td>Milk</td>
<td>Cow milk/buffalo milk</td>
<td>Cheese</td>
<td>Solid, soft</td>
<td><em>Lc. lactis, Lb. casei, Leuconostoc spp.</em> <em>Peni. Roqueforti</em></td>
<td>Throughout Universe</td>
<td>Protein, total fat, cholesterol, sodium, potassium, and calcium</td>
<td>Quigley <em>et al.</em> 2011</td>
</tr>
<tr>
<td>Cow milk</td>
<td>Amasi</td>
<td>Sour taste, acidic, thick fluid</td>
<td><em>Enterococcus sp. Leuconostoc sp.</em></td>
<td>Zimbabwe, South Africa</td>
<td></td>
<td>Antiinflammatory, boost the immune system, and reduce inflammation</td>
<td>Osvik <em>et al.</em> 2013</td>
</tr>
<tr>
<td>Cow/buffalo milk</td>
<td>Dahi</td>
<td>Gelly with whey</td>
<td><em>Lact. lactis, Strep. cremoris, Candida sp.</em></td>
<td>India, Nepal, Sri Lanka, Bangladesh, Pakistan</td>
<td></td>
<td>Boost the immune system, lower cholesterol, promote digestion</td>
<td>Patil <em>et al.</em> 2010</td>
</tr>
<tr>
<td>Sheep, goat, cow</td>
<td>Kefir</td>
<td>Fermented milk, alcoholic</td>
<td><em>Lb. brevis, Lb. bulgaricus, S. cerevisiae</em></td>
<td>Russia</td>
<td></td>
<td>Improved digestion, hypocholesterolemic effect, antiinflammatory, antioxidant</td>
<td>Bernardreau <em>et al.</em> 2006; Rosa <em>et al.</em> 2017</td>
</tr>
<tr>
<td>Animal milk</td>
<td>Yogurt</td>
<td>Acidic, viscous, curd like gel</td>
<td><em>Strep. thermophilus, Lb. acidophilus, Bifidobacterium sp.</em></td>
<td>America, Australia, Europe</td>
<td></td>
<td>Maintain bone health, rich with calcium, vitamins, and minerals; conjugated linoleic acids</td>
<td>Angelakis <em>et al.</em> 2011</td>
</tr>
<tr>
<td>Cow milk</td>
<td>Viili</td>
<td>Dense liquid, sweet</td>
<td><em>Lb. lactis, Leuc. Mesenteroides</em></td>
<td>Finland</td>
<td></td>
<td>Antioxidant, anti inflammation, immuno modulation, anticancer</td>
<td>Kahala <em>et al.</em> 2008</td>
</tr>
<tr>
<td>Cow milk</td>
<td>Doogh/Ayran/Tan</td>
<td>Diluted yoghurt</td>
<td><em>Lb. acidophilus</em></td>
<td>Turkey, Iran, Jordan, Armenia, Kazakhstan</td>
<td></td>
<td>Rich with calcium, minerals, and vitamins</td>
<td>Yildiz, 2010</td>
</tr>
</tbody>
</table>

**TABLE 1.2** (Cont.)

Fermented Food Products
<table>
<thead>
<tr>
<th>Food Product</th>
<th>Origin</th>
<th>Description</th>
<th>Nutritional Benefits</th>
<th>Authors and Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow milk/ buffalo milk</td>
<td>Borhani</td>
<td>Diluted Yoghurt</td>
<td>Rich with calcium, minerals, and vitamins</td>
<td>Nahidul-Islam et al. 2018</td>
</tr>
<tr>
<td>Goat milk</td>
<td>Rubing milk cake</td>
<td>Acidic</td>
<td>Contains lactose and galactose</td>
<td>Liu et al. 2018</td>
</tr>
<tr>
<td>Cow milk</td>
<td>Rob</td>
<td>Beverage</td>
<td>Antioxidant, reduce blood pressure, and lower the cholesterol</td>
<td>Abdelgadir et al. 2001</td>
</tr>
<tr>
<td>Vegetables</td>
<td>Red onion</td>
<td>Hom-dong Fermented onion</td>
<td>Organosulfurs, phenolics, flavonoids, saponins, and sapogenins</td>
<td>Phithakpol et al. 1995</td>
</tr>
<tr>
<td>Cabbage, pepper, ginger</td>
<td>Kimchi</td>
<td>Acidic, slightly sour</td>
<td>Antiinflammatory, immune system promotion, and cholesterol reduction</td>
<td>Jung et al. 2011; Hongu et al. 2017</td>
</tr>
<tr>
<td>Turnip</td>
<td>Sunki</td>
<td>Acidic, sour</td>
<td>Carbohydrate, protein, and dietary fiber</td>
<td>Watanabe et al. 2009; Endo et al. 2008</td>
</tr>
<tr>
<td>Mustard leaves</td>
<td>Burong mustasa Dakguadong</td>
<td>Salty</td>
<td>Dietary fiber, vitamins, and minerals</td>
<td>Larcia et al. 2011; Di Cagno et al. 2013; Panghal et al. 2018</td>
</tr>
<tr>
<td>Mustard/beet</td>
<td>Dua-muoi/Dua chua/ Dua cu cai (beet)</td>
<td>Salt and sugar</td>
<td>Dietary fiber, vitamins, potassium, and calcium</td>
<td>Nguyen et al. 2013; La Anh 2015</td>
</tr>
<tr>
<td>Egg plant</td>
<td>Ca muoi</td>
<td>Salt and sugar</td>
<td>Dietary fiber, vitamin, folate, and copper</td>
<td>La Anh 2015</td>
</tr>
<tr>
<td>Coconut press cake</td>
<td>Tempe bongkrek*</td>
<td>Soft and solid form; slightly salty</td>
<td>Protein, fiber, water-soluble vitamin</td>
<td>Shah and Singhal 2017</td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>Sources</th>
<th>Substrates</th>
<th>Product</th>
<th>Nature</th>
<th>Organisms involved</th>
<th>Country</th>
<th>Health benefits/nutrition</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrot and beetroot</td>
<td>Kanji</td>
<td>Salty drink</td>
<td>Lactic acid bacteria</td>
<td>India</td>
<td>Carbohydrate, protein, sugars; Indigestion and liver disorder</td>
<td>Lamba et al. 2019</td>
<td></td>
</tr>
<tr>
<td>Mixed vegetables</td>
<td>Yan-cai</td>
<td>Salty</td>
<td><em>Lactobacillus, Leucobacter</em></td>
<td>China</td>
<td>Contains lactic acid and acetic acid</td>
<td>Liu et al. 2018</td>
<td></td>
</tr>
<tr>
<td>Pak-sian</td>
<td>Pak-sian-dong</td>
<td>Salt and sugar</td>
<td><em>Lb. brevis, Lb. plantarum</em></td>
<td>Thailand</td>
<td>Carbohydrate and sugar</td>
<td>Tanasupawat and Komagata 1995</td>
<td></td>
</tr>
<tr>
<td>Cauliflower/cucumber/cabbage/celey</td>
<td>Torshi/Tursu</td>
<td>Salty</td>
<td><em>Lb. plantarum</em></td>
<td>Turkey, Bulgaria, Croatia, Serbia</td>
<td>Carbohydrate, iron, sodium, magnesium, manganese, and potassium</td>
<td>Cetin 2011</td>
<td></td>
</tr>
<tr>
<td><em>Ensete ventricosum</em></td>
<td>Kocho</td>
<td>Soft and solid form</td>
<td><em>Bacillus larvae, Leuconostoc mesenteroides, Streptococcus faecalis, Lactobacillus sp, Clostridium sp.</em></td>
<td>Africa</td>
<td>Carbohydrate, protein, and fiber</td>
<td>Gashe 1987; Yirmaga 2013</td>
<td></td>
</tr>
<tr>
<td>Tea leaves</td>
<td>Kombucha</td>
<td>Slightly sweet, acidic, and refreshing beverage</td>
<td><em>Komagataeibacter xylinum, Acetobacter xylinoides, Gluconobacter oxydans, Gluconacetobacter hansenii, Oenococcus oeni, Komagataeibacter europaeus, Lactobacillus sp, Saccharomyces sp., Schizosaccharomyces pombe, Zygosaccharomyces kombuchensis Torulaspora delbrueckii, Brettanomyces sp.</em></td>
<td>China, Japan, Russia, Europe, France, Germany, North Africa, Switzerland</td>
<td>Neurodegenerative disease prevention, blood pressure reduction, antioxidant activity, hypoglycemic effect, detoxification activity, and anticancer properties</td>
<td>Villarreal-Soto et al. 2019; Sinir et al. 2019</td>
<td></td>
</tr>
<tr>
<td>Legume</td>
<td>Locust bean</td>
<td>Dawadawa</td>
<td>Alkaline, sticky</td>
<td><em>B. licheniformis, B. subtilis, B. amyloliquefaciens</em></td>
<td>Nigeria, Ghana</td>
<td>Protein and crude fiber</td>
<td>Meerak et al. 2008</td>
</tr>
<tr>
<td>Bengal gram</td>
<td>Dhokla</td>
<td>Soft, steamy, and spongy</td>
<td><em>Ent. faecalis, Lb. Fermenti</em></td>
<td>India</td>
<td>Protein, dietary fiber, carbohydrate</td>
<td>Blandino et al. 2003</td>
<td></td>
</tr>
<tr>
<td>Soybean, red pepper</td>
<td>Gochujang</td>
<td>Solid cake form</td>
<td><em>B. licheniformis, B. subtilis, B. amyloliquefaciens</em></td>
<td>Korea</td>
<td>Carbohydrate and dietary fiber</td>
<td>Shin and Jeong 2015</td>
<td></td>
</tr>
<tr>
<td>Soybean</td>
<td>Tempeh</td>
<td>Solid cake form</td>
<td><em>Rhizopus; Lactic acid bacteria and yeast</em></td>
<td>Indonesia, Japan</td>
<td>Protein, carbohydrates and dietary fiber</td>
<td>Efrwati Suwanto et al. 2013</td>
<td></td>
</tr>
<tr>
<td>Soybean</td>
<td>Shuidouchi</td>
<td>Salty</td>
<td><em>Bacillus sp, Bacteroides sp and Lactobacillus sp.</em></td>
<td>China</td>
<td>Proteins, vitamins, and minerals</td>
<td>Chen et al. 2018</td>
<td></td>
</tr>
<tr>
<td>Root crop</td>
<td>Cassava</td>
<td>Chikwangue</td>
<td>Staple</td>
<td>Bacillus sp, Lactobacillus sp, Corynebacterium sp.</td>
<td>Africa, Zaire</td>
<td>Phytic acid, zinc, calcium, and iron</td>
<td>Odunfa and Oye-wole 1997</td>
</tr>
<tr>
<td>-----------</td>
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<td>-------------------------------------------------</td>
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<td>--------------------------</td>
</tr>
<tr>
<td></td>
<td>Cassava</td>
<td>Tape</td>
<td>Sweet</td>
<td>Streptococcus sp, Rhizopus sp.</td>
<td>Indonesia</td>
<td>Rich with calcium, magnesium</td>
<td>Ohba et al. 1989</td>
</tr>
<tr>
<td>Meat</td>
<td>Pork/ostrich</td>
<td>Salami</td>
<td>Spicy and salty</td>
<td>Staphylococcus xylosus/Micrococcus/ Lactobacillus sake, Lactobacillus curvatus</td>
<td>Europe</td>
<td>Carbohydrate, saturated fat, mono saturated, and poly unsaturated fat</td>
<td>Aquilanti et al. 2016; Bohme et al. 1996</td>
</tr>
<tr>
<td></td>
<td>Beef/mutton</td>
<td>Sucuk/ Soudjouk</td>
<td>Spicy and salty</td>
<td>Lactic acid bacteria/Staphylococcus sp. Micrococcus sp.</td>
<td>Turkey</td>
<td>Low cholesterol, high level of poly unsaturated fatty acid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pork/beef</td>
<td>Alheira</td>
<td>Dry/semi-dry sausage</td>
<td>Lb. plantarum, Lb. paraplantarum, Lb. brevis, Lb. sakei</td>
<td>Portugal</td>
<td>Carbohydrates, minerals, less fat, and cholesterol</td>
<td>Campos et al. 2013</td>
</tr>
<tr>
<td></td>
<td>Pork</td>
<td>Sa-um</td>
<td>Semi-dry, gummy</td>
<td>Firmicutes, Proteobacteria, Bacteroidetes, C. butyricum, C. citroniae, C. methylpentosum, C. perfringens, C. saccharogumia C. tetani</td>
<td>India (North eastern)</td>
<td>Carbohydrate, protein, and lipids</td>
<td>De Mandal et al. 2018</td>
</tr>
<tr>
<td>Fish</td>
<td>Fish</td>
<td>Ngari/Shidal</td>
<td>Slightly acidic and salt free</td>
<td>Lb. plantarum, Lb. pobuziihi, Lb. coryniformis, B. subtilis Staphylococcus carnosus</td>
<td>India (North eastern)</td>
<td>Antioxidant, DPPH radical scavenging activity, calcium, potassium, magnesium, sodium</td>
<td>Majumdar et al. 2015; Muzaddadi and Basu, 2012</td>
</tr>
<tr>
<td></td>
<td>Fish</td>
<td>Hentak</td>
<td>Slightly acidic and salt free</td>
<td>Micrococcus sp. Staphylococcus sp., and lactic acid bacteria</td>
<td>India (North eastern)</td>
<td>Antioxidant, DPPH radical scavenging activity, calcium, potassium, magnesium, and sodium</td>
<td>Majumdar et al. 2015.</td>
</tr>
<tr>
<td></td>
<td>Fish and shrimp</td>
<td>Prahok (fish), Kapi (shrimp) and toek tray (fish)</td>
<td>Paste form/ sauce; salty</td>
<td>Bacillus sp, Clostridium sp, Staphylococcus sp, and Tetragenococcus sp.</td>
<td>Cambodia</td>
<td>Amino acid, crude fat, total nitrogen</td>
<td>Chuon et al. 2013</td>
</tr>
<tr>
<td>Sources</td>
<td>Substrates</td>
<td>Product</td>
<td>Nature</td>
<td>Organisms involved</td>
<td>Country</td>
<td>Health benefits/nutrition</td>
<td>Reference</td>
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<tr>
<td>--------------------</td>
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<td>--------------------</td>
<td>------------------------------------------------------------------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Fish/shrimp/oyster</td>
<td>Bagoong</td>
<td>Paste/salty</td>
<td>Bacillus, Micrococcus, and Staphylococcus</td>
<td>Philippines</td>
<td>Good appetizer and seasoning agent</td>
<td>Smague 1994</td>
<td></td>
</tr>
<tr>
<td>Fish</td>
<td>Dang-pui-thu</td>
<td>B. subtilis, Staphylococcus simulans, Streptomyces sp.</td>
<td>India (Northeastern)</td>
<td>Protein rich, amino acids, fat, and minerals</td>
<td>Singh et al. 2014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish</td>
<td>Nuocmam, patis, mampla</td>
<td>Liquid form; Sauce</td>
<td>Facultative anaerobic bacteria</td>
<td>Philippines</td>
<td>Rich with proteins and amino acids, fat and total nitrogen</td>
<td>Smague 1994</td>
<td></td>
</tr>
<tr>
<td>Fruits</td>
<td>Breadfruit</td>
<td>Poipoi</td>
<td>Lactic acid bacteria</td>
<td>Tahiti</td>
<td>Rich with starch and a good energy source</td>
<td>Aalbersberg et al. 1988; Jones et al. 2011</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Red grape</td>
<td>Hardaliye</td>
<td>Lb. plantarum</td>
<td>Turkey</td>
<td>Antioxidant property</td>
<td>Kilic et al. 2016; Coskun and Tirpanci Sivri, 2013</td>
<td></td>
</tr>
<tr>
<td>Grape</td>
<td>Wine</td>
<td>Alcoholic beverage</td>
<td>S. cerevisiae</td>
<td>Throughout the World</td>
<td>Antioxidant, boost immunity, and increase bone density</td>
<td>German and Walzem 2000</td>
<td></td>
</tr>
<tr>
<td>Olive</td>
<td>Olive oil</td>
<td>Oil</td>
<td>Lb. plantarum, Lb. brevis, Lb. pentosus, Lb. mesenteroides</td>
<td>Spain, Italy</td>
<td>Carbohydrate, sugar, protein, and dietary fiber</td>
<td>Sherahi et al. 2018</td>
<td></td>
</tr>
<tr>
<td>Durian</td>
<td>Tempoyak</td>
<td>Condiment/ingredient for cooking</td>
<td>Lb. plantarum</td>
<td>Malaysia</td>
<td>Carbohydrate, protein and dietary fiber</td>
<td>Amiza et al. 2006</td>
<td></td>
</tr>
<tr>
<td>Cummingcordia</td>
<td>Pobuzihi</td>
<td>Cake/granular form</td>
<td>Lb. pobuziiii, Enterococcus casseliflavus, and Weissella cibaria</td>
<td>Taiwan</td>
<td>Rich with carbohydrates</td>
<td>Chen et al. 2013b; Swain et al. 2014</td>
<td></td>
</tr>
<tr>
<td>Peaches</td>
<td>Yan-taozh</td>
<td>Salty and sweet</td>
<td>Leuconostoc mesenteroides,</td>
<td>China and Taiwan</td>
<td>Protein, dietary fiber, and vitamin C</td>
<td>Chen et al. 2013a</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous items</td>
<td>Coconut water</td>
<td>Nata de coco</td>
<td>Acetobacter xylinum</td>
<td>Philippines and Japan</td>
<td>Thickening and gelling agent; used for food packaging</td>
<td>Verschuren et al. 2000</td>
<td></td>
</tr>
<tr>
<td>Honey</td>
<td>Tej/Kuri</td>
<td>Sweet, effervescent</td>
<td>S. cerevisiae, Kluyveromyces bulgaricus</td>
<td>Ethiopia, Eritrea/Cameroon</td>
<td>Organic acids, esters, alcohol, volatile fatty acids, carbonyl compounds, and volatile phenols</td>
<td>Johannes et al. 2013</td>
<td></td>
</tr>
</tbody>
</table>

* Consumed within 1–2 days; not consumed if it is yellow in color. Indonesian Government outlawed the production; however still in use by poor

Lb. — Lactobacillus
our list, kefir, is rich in vitamins and minerals. It is an acid-fermented drink, which is mildly alcoholic, creamy, and sour in taste (Prado et al. 2015; Rai et al. 2017).

A variety of products are available as fermented vegetables, with a special mention of kimchi (Korea) and sauerkraut (China), consumed throughout the world. Kimchi was one among the five healthiest foods in the world ranked by food magazine (2008), and thus grabbed worldwide attention (Hong et al., 2016a, 2016b; Kim et al. 2017). Sauerkraut, a cabbage-based fermented vegetable product, is being used in China for many years. Basically, vitamins, minerals, phosphorous, and phenolic compounds present in sauerkraut yield a lot of health benefits, and the health benefit level enhances after fermentation (Xiong et al. 2014).

In comparison with the fermented vegetable products, the fermented fruit products are less. However, they also have rich nutritional and health benefits. The pulp of durian fruit is used as a substrate in making salted fermented fruit product, namely tempoyak in Malaysia (Leisner et al. 2001). Sweet cherry (Prunus avium L.) is one among the widely used fermented food products in Italy, the United States, Iran, and Turkey.

Fermented legumes (Todorov and Holzapfel 2014) and root crops are also consumed throughout the world. After fermentation, beneficial features such as nutrient values are enhanced, while unfavorable features are diminished in legume-based fermented food products (Frias et al. 2017). Legume-based fermented food products are used in the form of soup, paste, and sticky material. In the fermentation process of legume-based products, especially soybean, both bacteria and filamentous fungi are involved (Meerak et al. 2007; Dajanta et al. 2009; Tamang 2010). Regarding root crops, cassava is the traditional and widely used staple food.

Fermented meat-based products are also one among the important food products (Kumar et al. 2017). The features of the meat products may enhance during fermentation because of the physicochemical, biochemical, and microbiological changes by key organisms involved in their production. Owing to the increasing awareness of safe and healthy fermented food products, inclusion of probiotic cultures has added a lot of benefits to fermented meat products (Neffe-Skocińska et al. 2016). LAB and micrococci used in the production of Turkish-based meat product ‘sucuk’ enhance its taste, soft texture, and color (Kaban and Kaya 2008).

Owing to quick perishability of fresh fish, the concept of fermentation is very popular in fermented fish products. Besides this benefit, the enriched nutritional value, aroma, and taste add flying colors to the fermented fish products (Özyurt et al. 2016; Adjou et al. 2017).

Fermented beverages are an integral part of the human diet and attract the attention of consumers because of the presence of various nutritive values present in them (Baschali et al. 2017). This explains the wide consumption of alcoholic beverages at this juncture, especially wine and beer. A special mention over here is Boza juice widely used in Turkey, which is prepared from a variety of cereals and is used during winter and autumn seasons. Shalgam juice, also from Turkey, is prepared from Bulgur flour, with black carrots as a base material along with salt (Üçok and Tosun, 2012). Both bacteria and fungi play an important role in its preparation (Erten et al. 2008). In general, in the fermented drinks, the low pH and other unfavorable features reduce the growth of spoilage and other unwanted bacterial populations. Furthermore, various vitamins, proteins, amino acids, and minerals are produced during the fermentation process (Colak et al. 2012).

Miscellaneous fermented foods, such as kanji prepared from rice and carrot, palm wine from palm sap, and Tej from sugar cane, also play a pivotal role in human diet and health.

4 Health Benefits

World Health Organization (WHO) and Food and Agriculture Organization (FAO) have recommended the consumption of healthy fresh foods prepared from fruits and vegetables to prevent various diseases (Endrizzi et al. 2009). By consuming fermented food products, various ailments
are prevented, and further during the fermentation process, these food products enhance various health-associated components. The harboring of microbiota in fermented food (Marco et al. 2017) is the main reason behind its benefits. Of course, the beneficial microbiota and trending probiotic bacteria reach the lower intestinal tract of human through the fermented food material; however, how long can these fermented food microbes overcome with the gut flora of human is still unclear and needs more attention in future research aspects (Derrien and van Hylckama Vlieg 2015), although the microbiota enhance the nutritive, commercial value and yield lots of benefits to human health.

In fermented food products, probiotic bacteria play a pivotal role. However, the exact mechanism of probiotic bacteria is yet to be revealed (Terpou et al. 2018). Because of biogenic effects, various primary metabolites are produced during the fermentation process. Fermented food stuffs may induce natural immunity, immunomodulatory activity, and enhance the value of final products. Probiotic bacteria can act as a prominent candidate to especially provide health benefits. Probiotic bacteria-based fermented foods act against allergy, cancer, pathogenic microbes and are rich in antioxidant properties (Caggianiello et al. 2016; Khalil et al. 2018).

Dairy and dairy-based products are an integral part of the human diet throughout the world for many years. Per capita milk consumption globally averages 214 liters per year (FAO 2006). It has been reported that (FAO 2013; Agyei et al. 2019) milk contains numerous nutrients from proteins to minerals, such as calcium, magnesium, and selenium. Nutritive value of fermented dairy products depends on various factors, such as age of animal, health, feed, and seasonal variation (Laben 1963; Bansal et al. 2003; Walker et al. 2004; Jenkins and McGuire 2006). LAB, because of their proteolytic activity, release the amino acid from the fermented dairy products (Pessione and Cirrincione 2016), which is highly required for human metabolism. Conjugate linoleic acids (CLAs) and sphingolipids fight against cancer, and CLA especially found in cheese helps to reduce obesity. Reports reveal that koumiss was used to treat tuberculosis, ulcers, and hepatitis in Mongolia (Wu et al. 2009). Owing to lot of beneficial features, including antifungal activity against A. flavus (Gamba et al. 2016), focus has increased toward kefir in recent years (Leite et al. 2013; Nielsen et al. 2014; Rosa et al. 2017).

In some fermented products, the microbes involved in the fermentation process produce bacteriocins and prevent the growth of spoilage and pathogenic organisms. Hence, they indirectly play a role in health benefits and help in anticancer activity, fighting with cholesterol and intestinal infections, accelerating the immune response, and providing high vitamins and minerals in olive fermentation. In this, it is reported that the abundance of oleic acid has a fruitful control effect on different types of cancer such as prostate, breast, and colon (Sales-Campos et al. 2013; Peres et al. 2017). The presence of COX-inhibitor has the capacity to fight against neurodegenerative disorders (Peres et al. 2017). Miso, a soybean-based fermented product, protects the consumer from radiation, stroke, hypertension, and some types of cancer (Ohuchi et al. 2005; Watanabe et al. 2006; Watanabe 2013). Cardiovascular disease and hypertension are prevented by the secretion of nattokinase enzyme, which is produced by Bacillus subtilis natto in the fermented soybean product ‘Natto’ (Park et al. 2012; Hitosugi et al. 2015; Şanlier et al. 2017). Fermented brown rice reduces DNA damage because of oxidative stress (Kong et al. 2015), and it is considered as a functional food product because of its various beneficial features (Kataoka et al. 2008; Ilowefah et al. 2015; Onuma et al. 2015). Boza, a traditional cereal-based nonalcoholic beverage, is rich in minerals; hence, it is a nourishing drink containing angiotensin-converting enzyme inhibitory peptides (Kancabaş and Karakaya, 2013). Shalgam juice is believed to control colon cancer.

In tubers and root-based food substances, such as cassava, potatoes, cocoyam, and yam, the main carbohydrate sources are hydrolyzed by LAB during the fermentation process and lead to lactic acid, which creates an acidic environment. Thus, the other pathogenic microbes and organisms responsible for food-borne illnesses were avoided similar to how naturally protected fermented food benefited the health of consumers (Giraffa 2004). Ogi, a cereal-based fermented food, is considered as the best infant food in West Africa (Odugbemi et al. 1991) because of its...
efficient inhibition activity over *S. typhi* and *S. paratyphi*. Likewise, ‘DogiK’ is used as a medicine to control infant diarrhea in Nigeria (Olukoya *et al.* 1994).

Microbes involved in the production of fermented food products not only provide health benefits but also secrete a lot of metabolites, which enhance the organoleptic characteristics of fermented food products (Akissoe *et al.* 2015; Blanco *et al.* 2016). Recent research on antibacterial (Bhattacharya *et al.* 2016, 2018; Sknepnek *et al.* 2018), antifungal, (Mahmoudi *et al.* 2016) antiviral (Fu *et al.* 2015), and antioxidant properties (Sun *et al.* 2015; Gamboa-Gomez *et al.* 2016, 2017) of plant-based fermented beverage ‘Kombucha’ states that the antioxidant property is mediated by microbial metabolism of tea polyphenols (Chakravorty *et al.* 2016). This report has been confirmed by performing both in vitro (Gamboa-Gomez *et al.* 2017; Vazquez-Cabral *et al.* 2017; Sknepnek *et al.* 2018) and in vivo (Belfassoued *et al.* 2015; Gamboa-Gomez *et al.* 2017; Salafzoon *et al.* 2017; Pakravan *et al.* 2017) tests.

A recent report revealed that the beneficial activity (Xie *et al.* 2018; Berretta *et al.* 2018) of coffee beans was due to the presence of polyphenols and melanoidins (Godos *et al.* 2014; Lopez-Barrera *et al.* 2016).

### 5 Conclusion

Microbes are involved in the production of fermented food products, which render numerous health benefits to humans. The results of the report are encouraging and anchor the beneficial activities of fermented food. Interestingly, recent research is based on in vivo studies using animals and cell lines. In the near future, the course of research may be anchored and focused toward in vivo studies, especially the competition between fermented microbes and human gut microbiota and concentration toward traditionally fermented food products produced by various innovative scientifically unrevealed methods. These approaches may lead to several beneficial scientific outcomes for humankind.

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