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Review

Recent research process of fermented plant extract: A review

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ABSTRACT

Background: Fermented plant extract (FPE) is a plant functional food which originates from Japan. FPEs use various plants as materials, and they are fermented by various microorganisms to make a beverage or other physical forms. With plenty of nutrients and active substance, FPE provides many health benefits.
Scope and approach: In this review, we present a brief summary of the recent research progresses in traditional and modern FPE products, including microorganisms used, manufacturing technology, bioactive substances and health benefits.
Key findings and conclusions: FPE has many benefits to human, not only to health but also to industry, and other aspects. The development prospects of FPE products has great potential.
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1. Introduction

Fermented plant extract (FPE) is a kind of plant functional food very popular in China, Japan and some other Asian place. Various plants including cereals, legumes, fresh fruits and vegetables, edible fungi (although not plant), medicinal and edible traditional medicine can be the materials to produce FPE. FPEs are fermented by various microorganisms, such as yeast, lactic acid bacteria(LAB), and acetic acid bacteria(Blandino, Al-Aseeri, Pandiella, Cantero, & Webb, 2003), to make a beverage, or other physical forms. Traditional products like pickles, bean paste, natto, miso, etc., may also be viewed as FPE products, but usually they are fermented spontaneously (some are not now produced in an industrial scale(Aloys & Angeline, 2009; Erten, Tanguler, & Canbaş, 2008)), while most of the modern ones are inoculated artificially. FPE is different from other fermented products like wine, vinegar and yoghourt. One reason is that there is no alcohol or only a very small amount of it(Altay, Karbancıoglu-Güler, Daskaya-Dikmen, & Heperkan, 2013). Another is that it only uses plants and edible fungi as materials. There are more kinds of microorganisms in FPE is also a reason, for there is only one main kind of microorganism in wine(yeast), vinegar(acetic acid bacteria) and yoghourt(LAB), while in FPEs there can be two or more. The flavor and taste are also different.

Sometimes FPE is called plant ferment or plant enzyme. In Chinese as well as Japanese the word "酵素" (Jiaosu) has two meanings, fermentation and enzyme. For this reason, many FPE manufacturers in China and Japan claim that their products can supplement enzymes for human body. It is a misleading statement. Enzymes essentially are proteins, and most of them are decomposed in human body, resulting in no identifiable help to the improvement of the corresponding human endogenous enzymes, neither in content nor in activity, though it has been proved that the intake of some enzymes, superoxide dismutase (SOD) for example, does work in an unknown way(Edeas, Peltier, Claise, Khalfoun, & Lindenbaum, 1996; Regnault, Soursac, Roch-Arveiller, Postaire, & Hazebroucq, 1996). However, FPEs contain abundant enzymes, vitamins, minerals and secondary metabolites, which do benefit human health(Arici & Daglioglu, 2002; Marsh, Hill, Ross, & Cotter, 2014; Ray & Sivakumar, 2009; Yilmaz-Ersan & Turan, 2012).

With plenty of nutrients and active substance, FPE provides a variety of health benefits, such as cleaning up the gut, anti-inflammatory effect, detoxification, anti-bacterial, hemostasis, etc.(Altay et al., 2013; Arici & Daglioglu, 2002; Erten et al., 2008; Ray & Sivakumar, 2009), with a wide range of applications. In this review, we present a summary of the recent research progresses of traditional and modern FPE products, including their microorganisms used, manufacturing technology, bioactive substances and

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health benefits.

2. Microorganisms

By fermentation microorganisms can benefit human in many aspects. A brief summary of the commonly used probiotics is presented in Table 1. The main benefits of using microorganisms in FPE are follows(Urbonaviciene, Viskelis, & Bartkiene, 2015):

1) Extend shelf life: produce metabolites such as organic acid, ethanol, bacteriocins, etc. to inhibit the growth of harmful bacteria.
2) Improve food safety by inhibiting pathogens or by decomposing toxic compounds.
3) Improve nutritional value by production of metabolites like proteins, essential amino acids, essential fatty acids and vitamins.
4) Enhance organoleptic food quality by producing desirable acids and aromatic compounds.

The application of microorganisms in modern FPE is well known. By selecting microorganisms which are already produced commercially, it is much easier for producers to control the fermentation process and hence the product quality(Havas et al., 2014; Sharma & Mishra, 2013). The microorganisms used in modern FPE production include yeast, LAB, moulds(Wardhani, Vázquez, & Pandiella, 2010), etc. Some microorganisms fermented together will produce a better quality product, such as a better sensory quality and a higher amino acid production, so the starter cultures may include two or more main microorganisms. (*S. cerevisiae* plus *L. mesenteroides* subsp. *mesenteroides* plus *L. confusus* for boza, *L. plantarum*[bx], *L. fermentum*, and *L. paracasei* subsp. *paracasei* 2 for shalgam) (Tangüler & Erten, 2013; Zorba, Hancioglu, Genc, Karapinar, & Ova, 2003). But some others won't. For example, when soy beverage is fermented with *S. thermophilus* and *L. helveticus* together, the isoflavone level of the beverage is lower than that of the beverage fermented by *S. thermophilus* alone(C. P. Champagne, Green-Johnson, Raymond, Barrette, & Buckley, 2009; Claude P Champagne, Tompkins, Buckley, & Green-Johnson, 2010), (reduced by 9.4%) which lowers the quality of the product, so they are fermented by only one kind of microorganism.

The use of microorganisms in traditional and modern FPEs differs a lot because of different fermentation process. The use of microorganisms in the traditional FPEs is complex compared to that in modern FPEs. Firstly, the species of the microbes in traditional FPEs are much more various. For example, there are 9 kinds of lactic acid bacteria (LAB), 6 kinds of yeasts and 5 kinds of coliforms and 1 kind of mould (*Penicillium* spp.) in sobia, a traditional FPE made in Saudi Arabia(Gassem, 2002). In Champu's(from Colombia), there are 8 kinds of dominant yeasts (Osorio-Cadavid, Chaves-López, Tofalo, Paparella, & Suzzi, 2008). Secondly, the population of different kinds of microorganisms changes differently during the fermentation. For example, the population of most kinds of LAB increases in shalgam (from Turkey), but still there are 3 kinds (*Leuconostoc mesenteroides* subsp. *mesenteroides*, *Pediococcus pentosaceaceus*, and *Lactobacillus delbrueckii* subsp. *delbrueckii*) of microorganisms decreased in population during the fermentation(Tanguler & Erten, 2012a, 2012b).

When applying microorganisms in traditional FPE into commerce, isolation and identification of the microorganisms is needed. The isolation and identification methods are also listed in Table 1. The methods include conventional microbiological analyses, rRNA analysis, and other methods. Other methods are rarely used, but there are still some examples. The yeasts in chicha (from Peru) were identified as *Saccharomyces cerevisiae* by MALDI-TOF MS (Matrix Assisted Laser DesorptionIonization-Time of Flight Mass Spectrometry(Vallejo et al., 2013), while the main microorganisms in chicha are LAB and *Bacillus*(Patricia et al., 2015; Puerari, Magalhães-Guedes, & Schwan, 2015)). However, usually researchers use rRNA analysis for the identification of the probiotics

Table 1
Probiotics in fermented plant extract.

FPE products	Microorganisms	Origin	Identification method	References
Sobia	LAB, yeasts, moulds, coliforms	Nature	API systems	(Gassem, 2002)
Shalgam	LAB, mesophilic aerobic bacteria, yeasts, non-*Saccharomyces* yeasts, coliforms	Nature	API systems	(Tanguler & Erten, 2012a, 2012b)
Chicha	*S. cerevisiae*, LAB, yeasts, *Bacillus*	Nature	MALDI-TOF MS	(Vallejo et al., 2013)
Champu' s	*S. cerevisiae*	Nature	conventional microbiological analyses & PCR-RFLP of ITS1-5.8S rDNA-ITS2	(Osorio-Cadavid et al., 2008)
fermented garcinia beverage	*Hanseniaspora. sp.*	Nature	biochemical tests & 18S rRNA gene sequence	(Amit Kumar & Anu Appaiah 2014)
fermented grape	yeasts	Nature	26S rDNA and D1/D2 sequence analysis	(Shi et al., 2015)
Indian indigenous pickled vegetables	LAB	Nature	standard and molecular methods (16S rDNA	(Kumar et al., 2012)
fermented star fruit beverage	*L. plantarum* SS2	Nature	–	(22)
boza	Yeasts, LAB	Nature	Carbohydrate fermentation reactions & PCR with species-specific primers	(Botes et al., 2007; Gotcheva et al., 2000) (Svetoslav D Todorov, 2010; S. D. Todorov & Dicks, 2006) (Von Mollendorff et al., 2006)
fermented herbal mate extract	*L. acidophilus*	Industry	–	(Parada, Soccol, Soccol, Lima, & Lindner, 2012)
fermented CW beverage	LAB	Nature	–	(Prado et al., 2015)
Fermented lychee	yeasts	Industry & nature	–	(Juliana Alvarenga Alves, et al., 2010)
Fermented emmer	LAB	Industry	–	(38)

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