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Review Article

COSMECEUTICAL IMPORTANCE OF FERMENTED PLANT EXTRACTS: A SHORT REVIEW

BHAGAVATHI SUNDARAM SIVAMARUTHI, CHAIYAVAT CHAIYASUT, PERIYANAINA KESIKA*

Innovation Center for Holistic Health, Nutraceuticals, and Cosmeceuticals, Faculty of Pharmacy, Chiang Mai University, Chiang Mai 50200, Thailand
Email: p.kesika@gmail.com

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ABSTRACT

Personal care products, especially cosmetics, are regularly used all over the world. The used cosmetics are discharged continuously into the environment that affects the ecosystem and human well-being. The chemical and synthetic active compounds in the cosmetics cause some severe allergies and unwanted side effects to the customers. Currently, many customers are aware of the product composition, and they are stringent in product selection. So, cosmetic producers are keen to search for an alternative, and natural active principles for the development and improvisation of the cosmetic products to attain many customers. Phytochemicals are known for several pharmacological and cosmeceutical applications. Fermentation process improved the quality of the active phytochemicals and also facilitates the easy absorption of them by human system. Recently, several research groups are working on the cosmeceutical importance of fermented plant extracts (FPE), particularly on anti-ageing, anti-wrinkle, and whitening property of FPE. The current manuscript is presenting a brief on cosmeceutical importance of FPE.

Keywords: Fermented plant extracts, Cosmetics, Phytochemicals, Anti-aging, Anti-wrinkle

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INTRODUCTION

Fermented foods (FF), fermented plant beverages (FPB), and its extracts represent an essential role in the cultural development and foodscape of humans. The types and preparation of FF are fluctuating based on the origin of the food. The ethnobotanical survey, functional importance, and making process of traditional fermented plant foods of Northern Europe, Eastern Europe, Korea, India, and Namibia have been reported recently [1-5]. FPB and fermented plant extracts (FPE) are rich sources of antioxidants, vitamins, minerals, polyphenols, proteins, fibres, and probiotics. Therefore, FPB has been reported for several health benefits [6-8]. The improvement of phytochemical content and bioactivities of FPB depends on the fermenting microbes and fermentation conditions. It has already been reported that the enhancement of phyto-content and formation of desired micronutrients like L-glutamic and γ-aminobutyric acids in fermented plants are obtained with specific starter cultures [9-12].

Cosmetics are stable mixtures of one or more active compounds with additives and some preservatives, which offers the enhancement of the physical appearance of the users. Cosmetics usage and cosmetic industries are increasing in the modern world. The cosmetic industries are keen on the development of new products or improvement of existing products with innovative active principles. Recently, dynamic tenets from natural resources are eminent among the company as well as consumers. Terrestrial and marine resources are the commonly-searched source of active compounds and are reported for several cosmetic applications like anti-ageing, anti-wrinkle, skin whitening, and natural dyes [13]. In another hand, the release of cosmetic debris, and cosmetic discharges in the domestic sewage leads to serious concern about human health. Some cosmetic constituents like parabens and triclosan are considered as severe environmental pollutants [14]. Effective and safe alternatives for the development of future cosmetics is necessary. The food-based bioactive principles may provide a possible way to advance the cosmetic research and its market. Recently, scientific reports are revealing the potential of FPB and FPE in cosmetic fields.

We have searched the literature in Scopus, PubMed, Google Scholar using the keywords "Fermented Plant" and "Cosmetics". There was no year based restriction in selecting the publications. The literature that deals with the use of fermented plant juices and its extract for the cosmetic purposes were selected for the preparation of the current manuscript. The present study provides an overview of reported cosmeceutical importance of FPE in brief.

Cosmeceutical Importance of FPE

The aqueous extract of *Fructus arctii* was fermented with *Grifola frondosa* HB0071 (FFAE), and also β-glucosidase content, 5-lipoxygenase inhibitory and antioxidant activities were analyzed. FFAE treated UV-A exposed human dermal fibroblasts show reduced expression of matrix metalloproteinase-1 (MMP-1), and the suppression was dose-dependent. The collagen biosynthetic activity was also stimulated by FFAE. The results suggested that FFAE can be a strong cosmetic candidate [15].

Bifidobacterium animalis mediated fermentation process increased the amino acids, sugars, proteins, peptides, and free isoflavonoids content of fermented soybean extract (FSBE) compared to fresh soybean, which may offer some cosmetological benefits like moisture, anti-ageing, emollience, and tensor action. Thus, facial mask formulation was prepared with FSBE, and the physical and physicochemical stability were assessed. The results suggested that the formulation with 5% FSBE was stable in the measured parameters like performance test, pH, apparent viscosity, and organoleptic characteristics that could be used as a safe facial mask [16].

Astragalus membranaceus var. *mongholicus* was fermented by *Bacillus subtilis* natto ATCC 7059 (FAME), and the functionality of fermented extract was studied using human epidermal keratinocytes and dermal fibroblasts (table 1). FAME had a growth-stimulating effect on keratinocytes and fibroblasts, and also significantly enhanced the production of hyaluronic acid (HA), one of the main extracellular matrix components in the skin. The expression of hyaluronan synthase 2 and 3 were upregulated by FAME in fibroblasts, and HaCaT cells in a dose-dependent manner, respectively. Even though fermentation reduced the phytochemical content, especially isoflavonoids of *A. membranaceus,* FAME activates the HA production in the studied skin cells. The results claimed that FAME has skincare properties [17].

Citrus unshiu peel aqueous extracts were fermented by *Schizophyllum commune* (S-CPE), and the fermentation facilitates the conversion of glycoside form of flavonoids into aglycones. UV-A exposed human dermal fibroblasts was treated with S-CPE and found that S-CPE reduced the expression of MMP-1 in a dose-dependent way. The UV-A mediated increase in senescence-associated β-galactosidase has been reversed up to 45% by S-CPE. The presence of hesperetin in S-CPE may be responsible for the collagen biosynthetic activity, and the study suggested that S-CPE can be a cosmetic constituent [18].

The selected eight Korean herbs (*Atractylodes macrocephala*, *Angelica gigas*, *Broussonetia kazinoki*, *Glycyrrhiza glabra*, *Lithospermum officinale*, *Morus alba*, *Poria cocos*, and *Paeonia albiflora*) mixture (2% each) were extracted with water and fermented using *Phellinus linteus.* Tyrosinase and melanogenesis suppression activity of the extract were analyzed. The results revealed that the extract has melanin and tyrosinase inhibition activity (dose-dependent manner) in 3-isobutyl-1-methylxanthine stimulated B16F0 mouse melanoma cells. The extract activates phosphatidylinositol 3-kinase/Akt/glycogen synthase kinase-3beta signalling pathway and suppresses the microphthalmia-associated transcription factor. Thereby, the extract exhibits the anti-hyperpigmentation effects [19].

Lactobacillus brevis mediated fermented red ginseng (FRG) was found to be rich in ginsenoside metabolites, flavonoids, polyphenols and uronic acid than that of the unfermented red ginseng (RG). The tyrosinase and elastase inhibitory activities were increased in FRG when compared to RG. The skin irritation and sensitization test was conducted in Hartley strain guinea pigs and found that FRG (10%) was non-irritating material and had only 20% of sensitizing property compared to RG. The study claimed that FRG had increased whitening and antiwrinkle efficacy, and reduced toxic effect than that of the RG [20]. *Alcaligenes piechaudii* CC-ESB2 mediated fermented *Rhodiola rosea* L. (AFR) and fermented *Lonicera japonica* Thunb. (AFL) showed higher antioxidant activity and total phenol content *in vitro*. The results demanded that AFR and AFL can be appropriate for food, drug, and cosmetic applications [21].

Aqueous extract of *Camellia sinensis* (black, green, and white tea extracts) (AECS) has been reported for anti-melanogenic activity. Black tea extract showed tyrosinase inhibitory effect in a dose-dependent manner, and it was attributed to reducing tyrosinase protein levels and tyrosinase activity. The results suggested that AECS could be a skin-whitening agent [22].

The solvent (50% ethanol, 95% ethanol, 50% ethyl acetate, and water) extracts of *Prunus persica* (L.) Batsch, *Paeonia suffruticosa* Andr., and *Asparagus cochinchinensis* (Loureiro) Merrill. were subjected to *Bifidobacterium bifidum* mediated fermentation. The fermented extracts were assessed for cytotoxicity, phytochemical content, free radical scavenging property, and tyrosinase inhibition activity. The results showed that all the extracts were nontoxic, and 50% ethanol extract exhibits improved tyrosinase inhibition activities than other solvent extracts. Finally, the study suggested that 50% ethanol extract of fermented *A. cochinchinensis* was the most significant skin-whitening candidate with superior antioxidant credibility [23].

The protein-rich, inexpensive, and pretreated (fermentation and germination) cowpea protein was studied for the emulsifying property. The results proved that germinated cowpea protein could produce stable emulsions compared to fermented cowpea protein [24].

Saccharomyces cerevisiae mediated fermented black ginseng (FBG) has been reported for the anti-wrinkle activity in cultured human fibroblasts (HS68) and proved that FBG was noncytotoxic. FBG treatment increased the expression of type I procollagen and tissue inhibitor of metalloproteinase-2 and reduced the expression of MMP-1, MMP-2, and MMP-9 in HS68 cells [25]. *Lactobacillus rhamnosus* GG mediated fermented *Codonopsis lanceolata* extract (FCLE) was assayed for cytotoxicity, tyrosinase, and α-glucosidase inhibition properties. The results suggested that FCLE exhibits a lower cytotoxic effect on CCD986sk cells than non-fermented counterpart and inhibits tyrosinase and α-glucosidase activity [26]. Kim *et al.* [26] appealed that FCLE may be used in skin-whitening cosmetic formulations.

Sirilun *et al.* [27] reported the cosmeceutical application of fermented clove, black galingale, betel, noni, green tea, and mangosteen juices containing 0.1-3.0% of peppermint oil. The mouthwash (MW) formulations were prepared, and the appearance, stability, and anti-microbial properties were analyzed. The results suggested that MW solution that contains fermented plant juices and 0.2% of peppermint oil exhibited high stability and effective anti-microbial potential with enhanced aroma and flavor [27].

Table 1: Cosmeceutical properties of fermented plant extracts

Study material	Microbes involved	Study type	Results	Key findings	Ref.
Fermented *Fructus arctii* extract (FFAE)	*Grifola frondosa* HB0071	*In vitro* (Human dermal fibroblasts)	FFAE exhibited 5-lipoxygenase inhibitory and antioxidant activities. FFAE inhibit the expression of matrix metalloproteinase (MMP-1) in UV-A treated human fibroblasts (HDF) in a dose-dependent manner.	Cosmetic applications	[15]
Fermented soybean extract (FSBE)	*Bifidobacterium animalis*	*In vitro*	Formulations were assessed for the stability at various physical conditions	Facial mask formulation containing 5% FSBE was stable in organoleptic characteristics.	[16]
Fermented *Astragalus membranaceus* var. *mongholicus* extract (FAME)	*Bacillus subtilis* natto	*In vitro* (Human epidermal keratinocytes and dermal fibroblasts)	Hyaluronic acid production was stimulated by FAME in human epidermal keratinocytes and dermal fibroblasts. The expression of hyaluronan synthase 2 and 3 was increased after FAME exposure.	Skincare	[17]
Aqueous extract of fermented *Citrus unshiu* peel extract (S-CPE)	*Schizophyllum commune*	*In vitro* (Human dermal fibroblasts; HDFs)	MMP-1 expression was inhibited, and level of senescence-associated β-galactosidase was decreased in S-CPE treated UV-A exposed HDFs. Hesperetin of S-CPE induces the collagen biosynthesis in fibroblasts.	S-CPE have UV-A induced anti-photoaging property	[18]
Aqueous extract of fermented eight herbs	*Phellinus linteus*	*In vitro* (B16F0 mouse melanoma Cells)	Dose-dependent melanin and tyrosinase inhibition activity were observed in 3-isobutyl-1-methylxanthine treated B16F0 mouse melanoma cells. The extract activates phosphatidylinositol 3-kinase/Akt/glycogen synthase kinase-3beta signalling pathway and suppresses the microphthalmia-associated transcription factor.	Anti-hyperpigmentation activity	[19]
Fermenting red ginseng	*Lactobacillus brevis*	*In vitro*, and *in vivo*	Fermentation process increased the ginsenoside metabolites in ginseng. The efficacy of whitening	Whitening, and antiwrinkle activity	[20]

		(Hartley strain guinea pigs)	and antiwrinkle was improved, and skin irritation was reduced.		
Fermented *Rhodiola rosea* L. (AFR) and *Lonicera japonica* Thunb. (AFL)	*Alcaligenes piechaudii* CC-ESB2	*In vitro*	Antioxidant capacity was also increased after fermentation.	Cosmetic applications	[21]
Aqueous extract of *Camellia sinensis* (AECS)	-	*In vitro* (Melan-A cells)	AECS inhibit the melanin accumulation and synthesis, and tyrosinase activity.	Anti-melanogenic	[22]
Fermented walnut, Moutan Cortex Radicis, and asparagus root extracts	*Bifidobacterium bifidum*	*In vitro* (Skin fibroblast cells, and murine melanoma cells)	Fermented herb extract showed high tyrosinase inhibition activity than that of non-fermented counterparts. The extracts were noncytotoxic.	Skin-whitening agent	[23]
Naturally fermented cowpea, and germinated cowpea	Natural	*In vitro*	The germinated cowpea produced stable emulsions better than that of fermented cowpea.	Emulsifying properties	[24]
Fermented black ginseng (FBG)	*Saccharomyces cerevisiae*	*In vitro* (Human fibroblasts HS68)	Type I procollagen and tissue inhibitor of metalloproteinase-2 expressions were increased. MMP-1, MMP-2 and MMP-9 expression was reduced by FBG	Anti-wrinkle	[25]
Fermented *Codonopsis lanceolata* extract (FCLE)	*Lactobacillus rhamnosus* GG	*In vitro* (CCD986sk cells)	FCLE inhibits the tyrosinase and α-glucosidase activities and exhibits higher biological activity than that of non-fermented *C. lanceolata.*	Skin-whitening agent	[26]
Fermented clove, black galingale, betel, noni, green tea, and mangosteen juice	*Lactobacillus plantarum*	*In vitro*	Fermented plant-herbal juices with 0.2% of peppermint were found as an organoleptically optimum formula for mouthwash. Mouthwash formula with black galingale was stable formulation with antimicrobial activity.	Mouthwash solution	[27]

CONCLUSION AND FUTURE PROSPECTUS

The cosmetic world is often changing their cosmetic formulations to improve the products' quality and acquire new customers. The use of cosmetics is growing among the Asian countries, and people are more aware of their product selection and to know about the ingredients of the products to secure them from toxic chemicals. So cosmetic companies and researchers are in an urge to screen the natural products for the possible cosmetic applications. It is known that fermentation process might improve the phytochemical content and its effective absorption. Thus, fermented natural extracts, especially non-animal based plant extracts, are mostly studied. Even though several scientific reports on the cosmeceutical importance of fermented plant extracts are available, the reported clinical studies and human trails do not sufficiently support the stated beneficial effects. Further detailed study on the molecular mechanism of cosmeceutical properties of fermented plant extracts is required. FPE may be the possible hope for the sustainable development of cosmetic products with consumers' and environmental protection.

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AUTHORS CONTRIBUTIONS

Periyanaina Kesika and Bhagavathi Sundaram Sivamaruthi contributed to conception and design, acquisition, manuscript preparation, and critical revision of the manuscript. Chaiyavat Chaiyasut involved in the review and finalization of the manuscript. All the authors agree with the content of the manuscript.

CONFLICTS OF INTERESTS

All authors declared that there is no conflict of interest.

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