Chapter 5

Application of Saponin-Containing Plants in Foods and Cosmetics

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Additional information is available at the end of the chapter

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1. Introduction

Saponins are a class of natural products which are structurally constructed of aglycone (triterpene or steroid) and sugars (hexose and/or uronic acid). The name 'saponin' comes from soap as its containing plants agitated in water form soapy lather. Saponins are widely distributed in many plants and are relatively widespread in our foodstuffs and herbal preparations. Saponins traditionally used as a natural detergent. In addition to this physical property, plant-derived triterpenoid and steroidal saponins have historically received a number of industrial and commercial applications ranging from their use as sources of raw materials for the production of steroid hormones in the pharmaceutical industry, to their use as food additives and as ingredients in photographic emulsions, fire extinguishers and other industrial applications which take advantage of their generally non-ionic surfactant properties [1-3]. They also exhibit a variety of biological activities, and have been investigated toward the development of new natural medicines and prove the efficacy of traditional herbal medicines [4]. Other interesting biological applications for various specific saponins include their uses as anti-inflammatory [5], hypocholesterolemic [6] and immune-stimulating [7] whose properties are widely recognized and commercially utilized.

As to the application of saponins to foods and cosmetics, it is indispensable that sufficient amounts of plant resources are available, and that the content of saponins must be high. Furthermore, a plant must have a long history of human use as foodstuffs or ingredients of cosmetics, and their safety should be officially guaranteed.

The saponins of Quillaja bark and licorice root are widely utilized in the world. The *Quillaja saponaria* (Rosaceae) tree has remained of special interest, because of its bark containing 9-10

% saponins. A large amount of Quillaja saponin is utilized in photosensitized film as a surfactant. It is used also in beverages, food ingredients, shampoos, liquid detergents, toothpastes and extinguishers as an emulsifier and long-lasting foaming agent. Recently, the saponin mixture possesses the immunoadjuvant property and has pharmaceutical application as suspension stabilizer [8].

Nearly 50,000 tons of licorice roots (*Glycyrrhiza* spp., Leguminosae) are consumed on a year basis. Licorice extract and its major saponin, glycyrrhizin (yield: more than 2.5%), are used as a medicine and as a sweetener and flavor enhancer in foods and cigarettes [9].

It is known that the deterioration of cooked foods is caused mainly by yeast, and that many skin diseases are due to infection by dermatophytic fungi and yeasts. In an expansion of utilization of saponins in foods and cosmetics, we have examined antifungal and antiyeast saponins.

2. Screening of antiyeast saponins

Crude saponin fractions from several plants were subjected to an antiyeast screening test using *Candida albicans* and/or *Saccharomyces cerevisiae*. Preparation of saponin fraction for screening test was following methods. Each plant material was extracted with hot 50% of MeOH. A suspension of the MeOH-extract in H2O was chromatographed on a column of Diaion HP-20 eluting with 40%-, and MeOH. The MeOH eluate (crude saponin fraction) was subjected to the screening test.

Inhibitory activity against each yeast was determined using agar dilution method. The inhibitory activity of the samples was assessed as the minimum inhibitory concentration (MIC), the lowest concentration tested at which no growth was observed.

Table 1 shows the screening results of antiyeast activity tests of crude saponin mixtures from several plants. The saponin fraction from licorice root, quillaja bark, gypsophila root and soy bean seed showed no activity (MIC:>1000μg/ml) and that of hedera leaf, marronier seed, ginseng root, camellia seed, saponaria rhizome and tea seed showed a weak activity (MIC:500~1000μg/ml), wheras crude saponin fraction from pericarps of *Sapindus mukurossi* and the stems of Mohave yucca exhibited significant activity, the active principles of both these materials were further investigated in detail.

	C.a.	S.c.		C.u.	S.c.
Licorice root	>1000	>1000	Ginseng root	1000	1000
Quillaja bark	>1000	>1000	Camellia seed	1000	1000
Gypsophila root	>1000	>1000	Saponaria rhizome	NT	1000
Hedera leaf	1000	1000	Tea seed	500	500
Soy been seed	NT	>1000	Yucca stem	NT	250
Marronier seed	1000	1000	Sapindus pericarp	250	250

C.a: Candida albicans, S.c.: Saccharomyces cerevisiae, NT: not tested

Table 1. Antiyeast activities of crude saponin fractions (MIC μg/ml)

3. *Sapindus* pericarps

Addition of an antifungal and antiyeast ingredient to cosmetics is desirable for the protection of skin against, and prevention of, dandruff generation, dermatomycosis and cutaneous candidiasis.

Significant antiyeast activity was observed for the crude saponin fraction from the pericarps of *Sapindus mukurossi* (Sapindaceae), a tall tree that grows abundantly in China and Japan. Pericaps of this plant have been used as a natural detergent, and are utilized as foaming-stabilizing agents in chemical fire extinguishers in Japan. The pericarps have also been used as an antitussive, anti-inflammatory and anthelmintic agent as well as for treatment of dermatomycosis. In Japan, the pericarps is called "enmei-hi", which means "life prolonging pericarps", and in China, it has been called "wu-huan-zi", which means "non-illness fruit".

4. Antifungal and antiyeast oleanane-saponins of *Sapindus* pericarps

The percarps were extracted with hot 90% MeOH. A suspension of the MeOH-extract in H_2O was chromatographed on a column of highly porous polymer (Diaion H-20) eluting with H_2O and 50%- and 85%-MeOH, successively. 85%-MeOH eluate gave a saponin-mixture (mono- and bis-desmosides, SP-mix). Hederagenin (1) was obtained from SP-mix by usual acid hydrolysis. Saponins 2-7 were isolated from SP-mix, such as monodesmosides: saponin A (2), sapindoside B (3), saponin C (4), sapindoside A (5), mukurozi-saponin E1 (6) etc. and bisdesmosides: mukurozi-saponin Y1 (7) etc. [10]. The structures of these saponins are shown in Figure 1.

Antidermatophytic activities of these saponins are shown in Table 2. All the monodesmosides exhibited strong growth inhibition. It is noteworthy that activity of sapindoside A is almost as strong as that of griseofulvin, the well-known antidermatophytic antibiotic. Griseofulvin does not show inhibitory activity against a pathogenic yeast, *Candida albicans*, while these monodesmosides ehhibited significant inhibition. The bisdesmosides, mukurozi-saponin Y1 showed no activity.

It was found that while purified monodesmosides of pericarps are sparingly soluble in water, their solubility was greatly increased in the presence of bisdesmosides [10]. These phenomena are important for the biological activities of the pericarps.

5. Structure-antifungal activity relationship

Figure 1 showed antidermatophytic activity against *Tricophyton rubrum* was investigated for a variety of oleanane saponins. Saponins 8-10 were separated from roots of *Anemone rivularis* [11]. Saponins 11-13 were isolated from bupleurum roots [12], and saponins 14 and 15 were prepared from 11 and 12, respectively by the reference [13]. Saponin 16 was isolated from

roots of *Kalopanax septemlobus* [14]. Saponin 17-20 were isolated from brans of *Chenopodium quinoa* [15, 16], and saponin 21 from rhizome of *Thladiantha hookeri* var. *pentadactyla* [17], derivative 1 (22) was prepared from 21, and derivative 2 (23) from 22 [16].

It was disclosed that for growth inhibition, the presence of free 28-COOH, 23-OH and 3-*O*-glycosyl groups is essential (Figure 2). A sugar moiety was prerequisite for the antifungal activity of oleanane saponin. All the bisdesmosides of hederagein, such as kalopanaxsaponin B (16), the 28-COOH of which is glycosylated, showed no activity. Mono- and bisdesmosides of oleanolic acid, such as saponin CP4 (8), which lack a 23-OH, also showed no growth inhibition. Saikosaponins, the active principles of *Bupleurum* radix, lack a 28-COOH, exhibiting no activity. Thalandioside H1 (21), a bisdesmoside which was isolated from *Thandiantha hookeri* var. *pentaphyla* in yield of 10% without any chromatography (Nie et al., 1989), showed no activity, while a monodesmoside of hederagein derived from this bisdesmoside, exhibited activity. Activity was also obserbed for hederagenin-3-*O*-α-L-arabinoside (24) which was prepared from 17 [18].

	Trichophyton mentagrophytes	***T. rubrum***	***Epidermophyton floccosum***	***Sabouraudites canis***	***Candida albicans***
SP-mix	25	25	25	12.5	50
2. saponin A	6.25	6.25	6.25	3.13	12.5
3. sapindoside B	6.25	6.25	3.13	3.13	12.5
4. saponin C	6.25	6.25	6.25	3.13	25
5. sapindoside A	3.13	1.56	3.13	1.56	12.5
6. mukurozi-saponin E1	6.25	6.25	6.25	3.13	12.5
7. Mukurozi-saponin Y1	>100	>100	>100	>100	>100
1. Hederagenin	>100	>100	>100	>100	>100
griseofulvin*	3.13	1.56	0.78	1.56	>100
* positive control					

Table 2. Antimicrobial activities of saponins and saponin mixture (**SP-mix**) against dermatophytes (**MIC**:μg/ml)

6. Antimicrobial activity of the saponin fraction of *Sapindus* pericarps

For commercial utilization as ingredient in cosmetics, the saponin fraction was prepared as follows. The methanolic extract was subjected to chromatography on Diaion HP-20. After removal of other water-soluble constituents by elution with water and then 50% of MeOH, the saponin fraction was obtained by elution with 80% MeOH.

The saponin fraction showed moderate antibacterial activity against Gram-positive bacteria, while no activity was obserbed against Gram-negative bacteria (Table 3).

A summarized in Table 4, the saponin fraction exhibited growth inhibition against food deteriorating yeasts, *Pichia nakazawae*, *Debaryomyces hansenii* and *Hansenula anomala*, as well as against *Malassezia furfur* which is associated with dandruff generation. The activity of sapo-

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nin fraction against common fungi was not so strong, while it exhibited remarkable growth-inhibitory effects against the following dermatophytic fungi and pathogenic yeast, *Tricophyton rubrum*, *T. mentagrophytes*, *Sabouraudites canis*, and *Epidermophyton floccosum* (which are known as dermatophytic fungi) and against *Candida albicans*, a pathogenic yeast which causes cutaneous candidiasis.

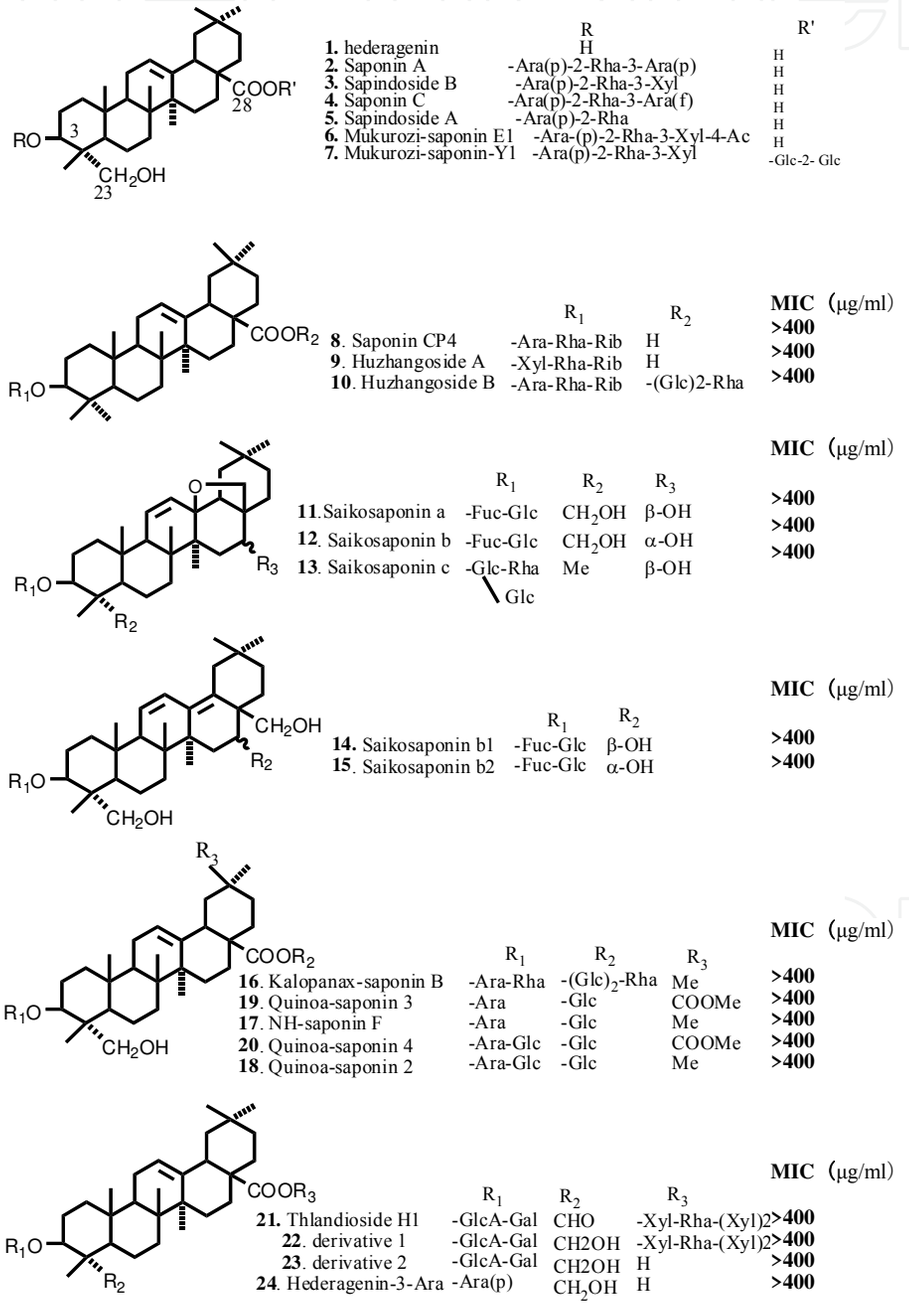

Figure 1. Structure and antifungal activities of saponins on *Tricophyton rubrum*

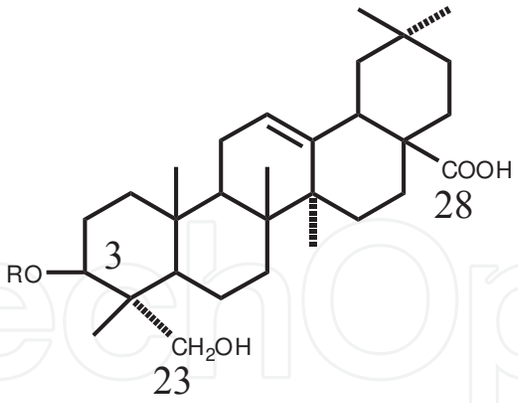

Figure 2. Structure-antimicrobial activity relationship of oleanane-type saponin analogues

Gram-positive, MIC:μg/ml		**Gram-negative, MIC:μg/ml**	
Staphylococcus			
aureus IID 671	400	*Escherichia coli* HUT 215	>400
epidermidis IID 866	400	*Pseudomonas aeruginosa* JCM 2776	>400
Streptococcus mutans IFO 13955	400	*Alcaligenes faecalis* IFO 13111	>400
Bacillus subtilis IFO 3007	400	*Proteus vulgaris* IFO 3851	>400

Table 3. Antibacterial activity of saponin mixture (SP-mix)

Yeast, **MIC:μg/ml**			
Saccharomyces cerevisiae IFO 0203	100	*Candida utilis* IFO 0396	100
Pichia nakazawae HUT 1688	50	*Hansenula anomala* HUT 7083	50
Malassezia furfur IFO 0656	200	*Debaryomyces hansenii* IFO 0018	>400
Fungi, **MIC:μg/ml**			
Aspergillus niger IFO 4343	>400	*Rhizopus nigricans* IFO 4731	>400
Mucor pusillus HUT 1185	100	*Penicillium citrinum* IFO 4631	>400

Table 4. Antiyeast and antifungal activity of saponin Mixture (**SP-mix**)

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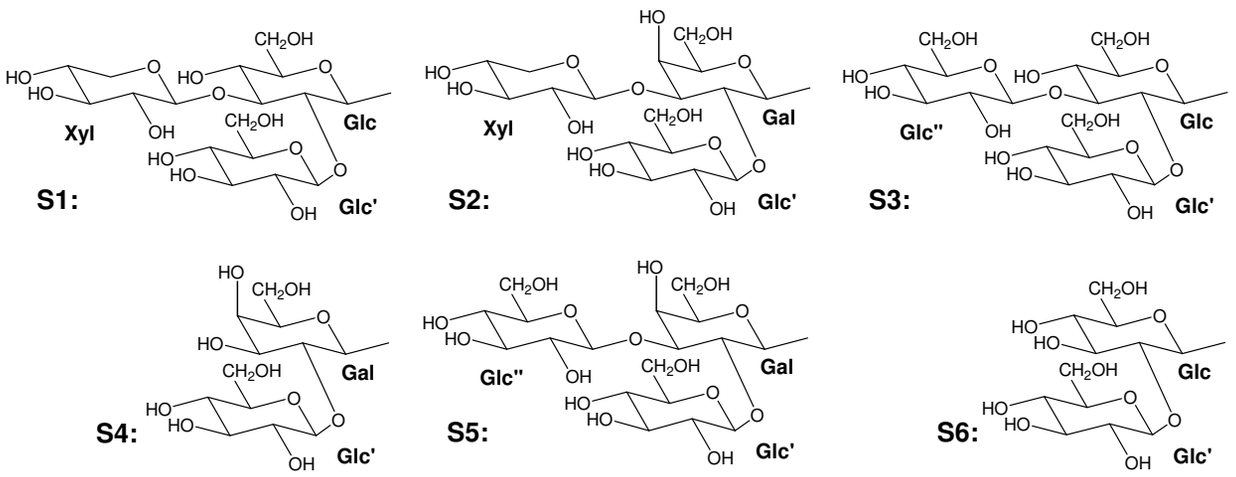

Figure 3. Saponins from Mohave yucca

7. *Sapindus* saponin fraction as an antidermatophytic ingredient in cosmetics

It is difficult to use *Sapindu*s saponin fraction as a food ingredient without long-term toxicity test, because we have no history of this fraction or *Sapindus* extract as a foodstuff. Furthrmore, it tastes very bitter, changing the taste of foods. On the other hand, the extract has been used as a folk detergent,and is listed in the Japanese Cosmeic Ingredient Codex (JCIC), being authorized as an ingredient in cosmetics by the Ministry of Health and Welfare in Japan. We reconfirmed the safety of the saponin fraction by dermal toxicity tests. It did not show primary dermal irritant, sentitization, phototoxicity or photosensitization effects. The present study strongly suggests that the saponins of the pericarps as an ingredient in toiletries, are valuable not only as detergents, but also for the prevention of dermatomycosis, cutaneous candidiasis as well as for dandruff generation.

8. Mohave Yucca (Yucca schidigera)

Yucca species (Agavaceae), grows widely in North and Central America. Mohave yucca, *Y. schidigera*, has been used as a foodstuff and folk medicine by Native Americans as well as early California settlers to treat a variety of ailments including arthritis and inflammation [3], and is approved for use in food and beverages by the U.S. Food and Drug Administra-

tion (FDA) under Title 21 CFR 172.510, FEMA number 3121. Yucca products are currently used in a number of applications. Yucca powder and yucca extract are used as animal feed additives, as in reference [19]. Other applications include the use of the extract of this plant is now utilized as a long-lasting foaming agent in carbonated beverages, root beer, regular and low-alcohol beers, and in shampoos and foaming cosmetics. Recently, the potential of biological activities of saponins and phenolics from this plant was reviewed [20].

9. Antiyeast and antifungal spirostanoid saponins from Mohave yucca

The presence of steroidal saponins in this plant has been reported previously [21,22]. As to the saponin constituents of this plant, a monodesmoside named YS-1 is isolated and identified as in [23]. We have conducted the isolation and identification of individual saponins that had not been achieved prior to this study [24,25].

The EtOH extract of this plant was subjected to colomn chromatography on highly porous polymer, Diaion HP-20, which is styrene-divinylbenzene polymer. After successive elution with water and 60% and 80% MeOH, a saponin fraction which showed significant antiyeast activity against *Saccharomyces cerevisiae* was obtained by elution with 90% MeOH. This fraction was subjected to successive chromatography on silica gel and then octadesysilylated silica gel (ODS) and was finaly separated by HPLC on ODS to give fourteen yucca saponins 25-38.

Figure 3 shows the structure of all of these saponins and their sapogenins. The antiyeast activities of each saponin from *Y. schidigera* against six kinds of yeast, *Saccharomyces cerevisiae* (brewers yeast), *Candida albicans* (a pathogenic yeast) and *Hansenula anomala*, *Pichia nakazawae*, *Kloeckera apiculata* and *Debaryomyces hansenii* (food-deteriorating yeasts) were determined and are summarized in Table 5.

Those saponins having a branched-chain trisaccharide moiety without any oxygen functionalities at C-2 and –12 exhibited potent antiyeast activities, while saponins with 2β-hydroxyl (5,6,13, and 14) or 12-keto (4 and 12) groups showed very weak or no activity. A saponin (11) with a disaccharide moiety exhibited relatively low activities. The aglycons showed no antiyeast activity.

10. Antimicrobial activity of the saponin fraction

For the commercial utilization of Mohave yucca, the antimicrobial activity of the saponin fraction which was obtained by column chromatography of the extract on Diaion HP-20 (*vide supra*) was investigated. It showed no or only weak growth inhibition against both Gram-positive and Gram-negative bacteria (Table 6).

	S.c.[a]	C.a.[b]	H.a.[c]	P.a.[d]	K.a.[e]	D.h.[f]
25	3.13	6.25	3.13	3.13	12.5	6.25
26	12.5	12.5	3.13	3.13	>100	>100
27	12.5	12.5	6.25	3.13	>100	>100
28	>100	>100	>100	>100	>100	>100
29	100	100	>100	100	>100	>100
30	>100	>100	>100	>100	>100	>100
31	6.25	50	3.13	3.13	>100	6.25
32	25	>100	3.13	3.13	>100	50
33	6.25	>100	3.13	12.5	>100	6.25
34	12.5	25	3.13	6.25	50	6.25
35	12.5	12.5	6.25	3.13	>100	>100
36	100	>100	100	>100	>100	>100
37	100	>100	>100	>100	>100	100
38	>100	>100	>100	100	>100	>100

[a] *Saccharomyces cerevisiae,* [b] *Candid albicans,* [c] *Hansenula anomala,* [d] *Pichia nakazawae,* [e] *Kloeckera apiculata,* [f] *Debaryomyces hansenii*

Table 5. Antiyeast activity of *Yucca schidigera* saponins

Gram-positive bacteria, MIC (µg/ml)			
Staphylococcus		*Bacillus circulans* IFO 3329	>1,000
aureus IID 671	1,000	*Lactobacillus*	
aureus IFO 3060	1,000	*plantarum* IFO 3070	>1,000
epidermidis IID 866	>1,000	*rhamnosus* IFO 12521	>1,000
Bacillus		*Enterococcus faecalis* IFO 3971	>1,000
subtilis IFO 3007	1,000	*Streptococcus mutans* IFO 13955	>1,000
licheniformis IFO 12200	1,000		
Gram-negative bacteria, MIC (µg/ml)			
Escherichia coli HUT 215	>1,000	*Pseudomonas*	
Alcaligenes faecalis IFO 13111	1,000	*aeruginosa* JCM 2776	>1,000
Proteus vulgaris IFO 3851	1,000	*fluorescens* JCM 2779	>1,000
Klebsiella pneumoniae IFO14940	1,000		

Table 6. Antibacterial acrivity of yucca saponin fraction

Yeast, MIC (μg/ml)			
Saccharomyces		*Kloeckera apiculata* IFO 154	62.5
cerevisiae IMO 293	62.5	*Debaryomyces*	
cerevisiae HUT 2075	31.3	*hanenii* IFO 18	31.3
cerevisiae JCM 2223	62.5	*hanenii* IFO 27	62.5
Hansenulla sp.	31.3	*hanenii* IFO 47	31.3
anomala HUT 7083	31.3	*hanenii* IFO 7011	125
Cryptococcus sp.	31.3	*Zygosacharomyces*	
laurentii IFO 609	125	*rouxii* IFO 845	31.3
Pichia		*rouxii* IFO 1130	31.3
nalazawae HUT 1688	31.3	*Candida famata* IFO 664	31.3
carsonii IFO 946	31.3		
Fungi, MIC (μg/ml)			
Aspergillus		*Aspergillus*	
niger IFO 4343	>1,000	*awamoi* HUT 2014	>1,000
oryzae HUT 2065	>1,000	*awamoi* HUT 2015	>1,000
oryzae HUT 2175	125	*Mucor pusillus* HUT 1185	15.6
oryzae HUT 2188	>1,000	*Rhizopus*	
oryzae HUT 2192	>1,000	*formosaensis* IFO 4756	>1,000
sydowii HUT 4097	>1,000	*nigricans* IFO 4731	>1,000
		Penicillium expansum IFO 5453	>1,000
Dermatophytic yeast and fungi, MIC (μg/ml)			
Tricophyton		*Sabouraudites canis* IFO 7863	31.3
rubrum IFO 5807	15.6	*Epidermophyton floccosum* IFO 9045	31.3
mentagrophytes IFO 5809	31.3	*Candida albicans* TIMM 0134	62.5

* food deteriorating yeast ** film-forming yeast in soy sauce

Table 7. Antiyeast and antifungal acrivity of yucca saponin fraction

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The antiyeast and antifungal activities are summarized in Table 7. The saponin fraction exhibited potent antiyeast activity. Infection of boiled rice such as "sushi" and "musubi" with *Hansenula anomala* and *Kloeckera apiculata* results in odor smelling like an organic solvent. Infection of cooked beans and processed fish meat with *Candida famata* and *Pichia carsonii* causes oders smelling like kerosene. *Pichia nakazawae, Debaryomyces hansenii* and *Zygosaccharomyces rouxii* are film-forming yeasts, damaging "soy sauce" and "miso", oriental fermented seasonings. The saponin fraction exhibited strong growth inhibition against these food-deteriorating yeasts.

The saponin fraction showed less activity against common fungi, while it significantly inhibited the growth of dermatophytic yeast and fungi.

Potassium sorbate has been utilized in foods as a preservative. Its antiyeast activity depends upon pH. Between pH 5.0 – 3.0, potassium sorbate completely inhibited the growth of yeast at the concentration of 0.05%, while at less acidic pH (near neutral), the activity decreased remarkably. In contrast to this, such pH dependence was not observed for the yucca saponin fraction. In the range of pH 6.3 – 3.0, it entirely inhibited the growth of yeasts at the concentration of 0.03%.

11. Effects of several culture conditions against antimicrobial activity of yucca extract

The inhibitory effects of yucca extract on the growth of the yeasts isolated from ume-zuke, a salted Japanese apricot fruit product were investigated with (2% or 5%) or without sodium chloride (Table 8). From the results of MICs of yucca extract without sodium chloride, the genera *Debaryomyces, Kloeckera, Pichia, Saccharomyces* and *Zygosaccharomyces* are sensitive to yucca extract, while the genera *Cryptococcus, Rhodotorula* and *Sporobolomyces* are tolerate to yucca extract. For the difference between these yeasts, latter yeast belong anamorphic basidiomycetous genera.

The inhibitory effect was enhanced and showed a broad antiyeast spectrum when yucca extract was used in combination with sodium chloride.

Table 9 shows the effects of several cultural conditions against antiyeast activity of yucca extract. The antiyeast activity of yucca extract was strengthened under the condition of chemical and physical conditions, low pH, alcohol, heating and high OP. While the high-polymer substances, such as polysaccharides and protein reduced antiyeast activity of yucca extract. It is interested that antiyeast activity of yucca extract was inhibited by free unsaturated fatty acids, palmitoleic acid, oleic acid and linoleic acid. On the other hand, saturated fatty acids, palmitic acid and stearic acid and oils composed of unsaturated fatty acids, olive oil, soybean oil and egg lecithin had no effect on the antiyeast activity of yucca extract.

Yeast	MIC (µg/ml)			Yeast	MIC (µg/ml)		
	NaCl				NaCl		
	0%	2%	5%		0%	2%	5%
Candida				***Pichia***			
C. albicans 221	1000	500	250	*P.anomala* 201	500	250	250
C. guilliermondii 212	>2000	1000	500	*P.anomala* 202	250	250	250
C. guilliermondii 213	>2000	2000	500	*P.anomala* 203	250	125	125
C. guilliermondii 222	1000	500	250	*P.anomala* 204	500	250	250
C. guilliermondii 224	1000	250	250	*P.anomala* 206	250	125	125
C. guilliermondii 227	>2000	>2000	2000	*P.anomala* 211	500	250	250
C. krusei 222	>2000	>2000	1000	*P.anomala* 216	500	250	125
C. lipolytica 223	62.5	62.5	62.5	*P.anomala* 219	500	250	250
C. parapsilosis 224	1000	500	500	*P.anomala* 223	500	250	250
C. tropicalis 225	>2000	>2000	1000	*P.anomala* 256	500	250	250
C. valida 226	1000	500	125	*P.anomala* 260	250	250	250
C. versatilis 228	500	250	250	*P.anomala* 261	500	250	250
C. zeylanoides 229	250	250	125	*P.anomala* 262	500	250	250
Cryptococcus				*P.anomala* 265	500	250	250
C. neoformans 231	>2000	>2000	1000	*P. farinosa* 207	250	250	125
Debaryomyces				***Rhodotorula***			
D.hansenii 201	1000	125	62.5	*R. rubra* 233	>2000	1000	500
D.hansenii 206	1000	1000	2000	***Saccharomyces***			
D.hansenii 214	1000	1000	1000	*S. cerevisiae* 203	500	250	62.5
D.hansenii 215	1000	1000	2000	*S. cerevisiae* 208	250	250	62.5
D.hansenii 220	2000	2000	>2000	*S. farmentati* 209	500	250	62.5
D.hansenii 225	1000	2000	2000	*S. fibullgera* 211	2000	1000	1000
D.hansenii 263	>2000	2000	1000	*S. servazzii* 210	2000	1000	1000
Geotrichum				***Shizosaccharomyces***			
G. candidum 218	500	125	NG	*S. pombe* 212	62.5	NG	NG
G. capitatum 219	2000	1000	NG	***Sporobolomyces***			
Hansenula				*S. albo-rubescens* 234	>2000	>2000	2000
H. saturnus 202	1000	500	250	***Torulaspora***			
Issatchenkia				*T. delbrieckii* 4188	500	125	62.5
I. orientalis 237	125	125	62.5	*T. delbrieckii* 4952	500	500	250

Yeast	MIC (μg/ml)			Yeast	MIC (μg/ml)		
	NaCl				NaCl		
	0%	2%	5%		0%	2%	5%
Kloeckera				***Zygosaccharomyces***			
K. apiculata 203	1000	1000	500	*Z. bailii* 213	2000	250	NG
K. apiculata 208	1000	500	500	*Z. rouxii* 214	500	250	250
K. apiculata 258	1000	1000	500	*Z. rouxii* 215	250	250	250
K. apiculata 266	>2000	>2000	2000	*Z. rouxii* 216	125	125	250
K. apiculata 4631	2000	1000	62.5				
K. apiculata 12219	2000	2000	500				
K. corticis 217	1000	1000	NG				
K. corticis 236	2000	250	NG				
K. corticis 12828	500	250	NG				
K. japonica 12220	500	500	250				

NG : No growth recognized without yucca extract

Table 8. Antiyeast activity of yucca extract against 64 yeasts isolated from foods and effect of NaCl on antiyeast activity of yucca saponin fraction

	low pH	heating	alcohol	polysaccharide	protein	lipid		high OP***
USFA*	TG**							
antiyeast activity	↑[a]	↑	↑	↓	↓	↓	→	↑

*unsatulated fatty acid, **triglycerides, ***osmotic pressure

a:↑strengthen, ↓reduce, →no change

Table 9. Effects of the cultural condition against antiyeast activity of yucca extract

12. Utilization of the yucca extract as an anti-food deteriorating agents

Yucca extract is non-toxic and non-mutagenic. It is recognized as safe for human food use by U.S.FDA (listed in 21 CFR 172.510). The extract is tasteless and odourless, exerting no influence on the taste of foods. It is readily soluble in water and stable on heating. Based on the present study, commercial application of the extract for extending the shelf life of cooked foods and fermented seasonings is now under development [26].

Figure 4 shows the application of yucca extract to sponge cake. Addition of 0.2% of yucca extract to sponge cake had effective on the growth of fungi and yeasts stored in room for one week.

The application of yucca extract to strawberry jam was showed in Figure 5. The jam mixed 0.02% and 0.04% of yucca extract and stored in room for one week shows no change, whereas control jam was contaminated by fungi.

Figure 4. Application of yucca extract to sponge cake

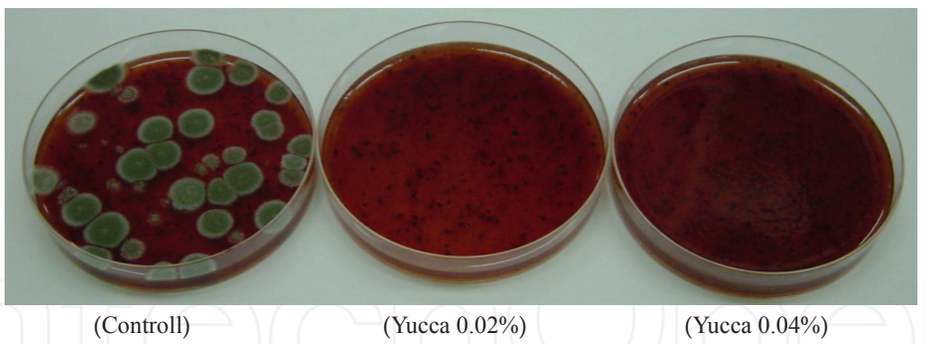

Figure 5. Application of yucca extract to strawberry jam

13. Conclusion

The microbial safety of foods and cosmetics continues to be a major concern to consumers, regulatory agencies and food industries throughout the world. Although synthetic antimicrobials are approved in many countries, the recent trend has been for use of natural preservatives, which necessitates the exploration of alternative sources of safe, effective and

acceptable natural preservatives. Many plant extracts possess antimicrobial activity against a range of bacteria, yeast and fungi, but the variations in quality and quantity of their bioactive constituents is major disadvantage to their industrial uses.

Based on the present study, mukurozi extract and yucca extract are considered to be effective for the preservation of foods and cosmetics. Both mukurozi and yucca plants have been consumed by humans for a long time. These plants also have wide application due to little pH or food component interaction.

Thus our works demonstrate that the saponin fraction from Sapindus pericarps and Mohave yucca stems can be recommended as alternative preservations for foods and cosmetics.

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