한국농화학회지 제 41 권 제 1 호(1998)
Agricultural Chemistry and Biotechnology
Vol. 41, No. 1, pp. 104~109(1998)

Growth-inhibitory Responses of Human Intestinal Bacteria to Extracts from Indian and African Plants

Young-Joon Ahn*, Suck-Joon Park, Don-Ha Choi[1], Hyung-Chan Cho[2] and I. G. Hiremath[3]

[1]*Division of Applied Biology and Chemistry, College of Agriculture and Life Sciences, Seoul National University, Suwon 441-744, Republic of Korea, Forestry Research Institute, Seoul 130-010, Republic of Korea,*
[2]*Department of Life Resource Science, Woosuk University, Samrye, Wanju, Jeonbuk 565-800, Republic of Korea,*
[3]*University of Agricultural Sciences, Dharwad, Krishi Nagar, Dharwad 580 005, Karnataka, India*

Abstract : Methanol extracts from 84 Indian plant samples (50 species in 31 families) and 27 African plant samples (20 species in 12 families) *in vitro* were tested for their growth-inhibitory activities against *Bifidobacterium bifidum, Bifidobacterium longum, Lactobacillus acidophilus, Clostridium perfringens*, and *Escherichia coli*, using a paper disc agar diffusion method under O_2-free conditions. The responses varied with bacterial strain, plant species and plant part. Extracts from *Cymbopogon citratus* whole plants, *Ocimum basilicum* whole plant, *Madhuca indica* flowers, and *Aegle marmelos* leaves among Indian plant samples moderately or strongly inhibited the growth of *Cl. perfringens* whereas moderate growth-inhibitory activity against *E. coli* was obtained from extract of Indian *O. basilicum* whole plants. These plant extracts did not affect the growth of the lactic acid forming bacteria tested. These results may be an indication of at least one of the pharmacological actions of these tropical plants.(Received November 3, 1997; accepted November 21, 1997)

Introduction

Approximately 400 kinds of microorganisms are resident in the human intestinal tract as a highly complex ecosystem with considerable species diversity. They not only participate in normal physiological functions, but significantly also contribute to the genesis of various disease states by biotransforming a variety of ingested or endogenously formed compounds to useful or harmful derivatives. Accordingly, these biotransformations may influence drug efficacy, toxicity, carcinogenesis and aging.[1,2]

Differences in the intestinal bacteria between patients and healthy subjects, and between younger and elderly subjects have been observed. The normal gastrointestinal microbiota is found to be predominantly composed of lactic acid bacteria which seem to play a large role in metabolism, host defense against infection, aging and immunopotentiation.[1,2] On the other hand, the microbiota of cancer patients[3,4] and patients with Alzheimer's disease[6] are composed of a high concentration of clostridia and eubacteria with few lactic acid bacteria. It has also been reported that elderly subjects harbour fewer bifidobacteria but larger numbers of clostridia than younger subjects.[6] Accordingly, any disturbance of the microbiota may cause a variety of diseases of abnormal physiological states.

Recently, much interest has been focused on plant-drived bifidus factors which promote the growth of beneficial bacteria and plant-derived growth inhibitors against harmful bacteria such as *Clostridium perfringens* and *Escherichia coli* because plants virtually are the richest source of bioactive organic chemicals.[7,8] We already reported growth responses of human intestinal bacteria to various oriental medicinal plant extracts.[9-13] However, the effects of tropical plant extracts on growth of intestinal bacteria remain unknown in spite of their excellent pharmacological action.[14-16]

In the laboratory study described herein, we assessed the growth-inhibitory responses of human intestinal bacteria to methanol extracts of tropical plant species collected from India and Niger (West Africa).

Materials and Methods

Bacterial strains and culture conditions

The intestinal bacterial strains used in this study were as follows; *Bifidobacterium bifidum* ATCC 29521, *Bifidobacterium longum* ATCC 15707, *Lactobacillus acidophilus*

Key words : intestinal bacteria, indian plants, african plants, tropical plants, growth inhibition
*Corresponding author

JCM 315, *Clostridium perfringens* ATCC 13124, and *Escherichia coli* ATCC 11775. Stock cultures of 5 strains were routinely stored on Eggerth-Gagnon Liver Extract-Field slant[17] at -80°C and were subcultured on Eggerth-Gagnon (EG) agar (Eiken Chemical, Japan) when required, and were incubated anaerobically at 37°C for 2 d in an anaerobic chamber (Coy Lab., USA) in an atmosphere of 5% H_2 + 15% CO_2 + 80% N_2.

Plant materials and sample preparation

Eighty-four Indian plant samples (50 plant species in 31 families) consisting of leaf (29), stem (24), root (1), flower (1), fruit (3), seed (5), seed oil (1), oilcake (1) and whole plant (19) were collected during March-April and August-September in India (Table 1). Twenty-seven African plant samples (20 plant species in 12 families) composed of leaf (9), stem (6), fruit (1) and whole plant (11) were collected during October in Niger, West Africa (Table 2). The plant materials were dried in shade, finely powdered using a blender and then were extracted twice with methanol at room temperature and filtered (Toyo filter No. 2). The combined filtrate was concentrated *in vacuo* at 35°C. The yield of each sample extraction is shown in Tables 1 and 2.

Table 1. Indian plants tested

Plant species	Family name	Part collected	Yield (%)
Adhatoda vasica	Acanthaceae	leaf	28
		stem	27
Agave americana	Agavaceae	whole	5
Achyranthes aspera	Amaranthaceae	whole	15
		stem	13
Annona squamosa	Annonaceae	seed	13
Nerium indicum	Apocynaceae	root	15
		stem	21
		leaf	14
Thevetia peruviana		leaf	20
Acorus calamus	Araceae	whole	20
Calotropis gigantea	Asclepiadaceae	leaf	23
Eupatorium odoratum	Asteraceae	whole	11
Eupatorium triplinerve		whole	18
Parthenium hysterophorus		whole	19
Bignonia anguiscati	Bignoniaceae	leaf	24
		stem	20
Opuntia elatior	Cactaceae	leaf	9
Cassia auriculata	Caesalpiniaceae	leaf	13
		stem	17
Cassia tora		whole	28
Cannabis sativa	Cannabinaceae	whole	22
Artemisia maritima	Compositae	whole	11
Acanthospermum hispidum		whole	9
Cuscuta reflexa	Convolvulaceae	whole	6
Thuja occidentalis	Cupressaceae	leaf	22
		stem	13
Acalypha indica	Equphorbiaceae	leaf	23
Ricinus communis	Euphorbiaceae	leaf	22
Jatropha integerrima		whole	15
Cymbopogon citratus	Gramineae	whole	19
Ocimum americanum	Labiatae	leaf	21
		whole	15
		seed	14
		stem	13
Ocimum basilicum		whole	19
Ocimum sanctum		whole	15
Azadirachta indica	Meliaceae	leaf	26
		seed	17
		stem	23
Melia azedarach		leaf	21
		seed	17
		stem	24
Swietenia mahagoni		leaf	19
		fruit	20
Acacia ferruginea	Mimosaceae	leaf	18
		stem	17
Prosopis chinensis		leaf	21
		strem	22
Ficus elastica	Moraceae	leaf	13
		stem	16
Bougainvillea spectabilis	Nyctaginaceae	leaf	24
		stem	24
Arachis hypogaea	Papilionaceae	whole	23
Pongamia pinnata		leaf	15
		seed	20
		stem	11
Sesbania grandiflora		leaf	22
		stem	22
Ziziphus mauritiana	Rhamnaceae	leaf	23
Aegle marmelos	Rutaceae	fruit	19
		leaf	25
		stem	24
Murraya koenigii		leaf	25
		stem	28
Bassia latifolia	Sapotaceae	leaf	15
Madhuca indica		flower	25
		oilcake	12
		leaf	15
		oil	26
		seed	23
		stem	15
Veronica anagallis	Scrophulariaceae	stem	20
Datura metel var. *alba*	Solanaceae	fruit	20
		leaf	26
		seed	23
		stem	25
Strychnos nux-vomica	Strychnaceae	leaf	19
Clerodendrum inerme	Verbenaceae	whole	26
Lantana camara		leaf	19
Lantana camara aculeata		stem	16
Stachytarpheta indica		whole	22
Vitex negundo		leaf	23
		stem	25

Microbiological assay

For bioassay of growth-inhibitory responses against test

Table 2. African plants tested

Plant species	Family name	Part collected	Yield (%)
Amaranthus viridis	Amaranthaceae	whole	27
Blepharis linarifolia		whole	20
Celosia trigyna		whole	32
Calotropis gigantea	Asclepiadaceae	leaf	25
Cassia mimosoides	Caesalpinaceae	leaf	22
Cassia occidentalis		whole	25
Cassia tora		whole	29
Boscia senagalensis	Capparidaceae	leaf	29
		stem	19
Clome viscosa		whole	22
Combretum glutinotum	Combretaceae	leaf	20
		stem	19
Combretum micronthum		whole	26
Guiera senagalensis		leaf	26
		seed	19
Piloitigma vetilicolin		whole	27
Ipomoea asarifolia	Convolvulaceae	whole	26
Azadirachta indica	Meliaceae	leaf	26
Prosopis chinensis	Mimosaceae	fruit	20
		leaf	21
		stem	23
Bougainvillea spectabilis	Nyctaginaceae	leaf	24
		seed	22
Boirerio radiata	Rubiaceae	whole	19
Waltheria indica	Sterculiaceae	whole	29
Balanites aegyptiaca	Zygophyllaceae	leaf	21
		stem	19

intestinal bacteria, the paper disc agar diffusion method was used.[10] The most important factor in primary screening for bioactive substances may be the starting concentration. We already reported that 10-20 mg/disc of plant extract did not cause any problem such as solubility and detection of its minor active components.[10,13] A sample (10 mg) dissolved in methanol was applied by Drummond glass microcapillary to a paper disc (Advantec 8-mm diameter and 1-mm thick, Toyo Roshi). After evaporation, the paper discs were placed on EG agar surface inoculated with each strain. They were incubated at 37°C for 2 d in an atmosphere of 5% H_2 + 15% CO_2 + 80% N_2. Control discs received methanol. All tests of inhibition were performed in triplicate.

The growth responses of test samples were determined by comparison with those of controls. The inhibitory responses were classified as previously described; strong response +++, zone diameter >20 mm; moderate ++, zone diameter 16-20 mm; weak +, zone diameter 10-15 mm; and no response · , zone diameter <10 mm.[10,13]

Results

Growth-inhibitory activity of intestinal bacteria to extracts from Indian plant samples is shown in Table 3. In a test with *Bif. bifidum* which is predominant in the intestines of infants, extracts from *Prosopis chinensis* leaves strongly inhibited the growth of this bacteria (+++). With *Bif. longum* which is dominant bacteria in the intestines of adults, moderate growth inhibitory activity (++) was obtained in extracts from *Ocimum sanctum* whole plants, *Aegle marmelos* fruits, and leaves and stems of *P. chinensis*. For *Lact. acidophilus*, extracts from *Arachis hypogaea* whole plants, *Azadirachta indica* stems, and *P. chinensis* leaves strongly inhibited the growth of this bacteria (+++) whereas moderate inhibitory-responses (++) were produced from extracts of *Clerodendrum inerme* whole plants, *O. sanctum* whole plants, and *Sesbania grandiflora* stems.

The growth inhibition to harmful bacteria such as *Cl. perfringens* and *E. coli* also varied with plant species and part sampled (Table 3). Extracts from *A. marmelos* leaves and *Madhuca indica* flowers showed strong inhibitory activity

Table 3. Growth-inhibitory activity of intestinal bacteria to extracts of Indian plants

Plant name[a]		Bacterial strain[b]				
		Bif. bifidum	*Bif. longum*	*Lact. acidophilus*	*Cl. perfringens*	*E. coli*
A. indica	L	·[c]	·	·	+	·
A. hypogaea	Wp	·	·	+++	·	·
A. indica	St	·	·	+++	·	·
C. inerme	Wp	·	·	++	·	·
C. citratus	Wp	·	·	·	++	·
D. metel	L	+	·	·	·	·
E. odoratum	Wp	·	·	·	+	·
E. triplinerve	Wp	·	·	·	+	·
N. indicum	L	·	+	·	·	·
N. indicum	R	·	+	·	·	·
O. americanum	St	·	·	·	+	·
O. americanum	Se	·	·	·	+	·
O. basilicum	Wp	·	·	·	++	++
O. sanctum	Wp	·	++	++	++	·
P. pinnata	L	·	+	·	·	·
P. chinensis	L	+++	·	+++	++	·
R. communis	L	·	+	·	+	·
T. occidentalis	L	·	+	·	·	·
V. anagallis	St	·	+	·	·	·
A. ferruginea	L	·	+	·	·	·
A. marmelos	L	·	·	·	+++	·
A. marmelos	St	·	+	·	+	·
S. grandiflora	L	·	·	+	·	·
S. grandiflora	St	·	+	++	·	·
S. indica	Wp	·	+	·	·	·
A. aspera	Wp	·	·	+	·	·
A. hispidum	Wp	·	·	+	+	·
M. indica	Fl	·	·	·	+++	·
A. marmelos	Fr	·	++	·	+	·

[a]Plant species showing activity are presented.
[b]Exposed to 10 mg/disc.
[c]Strong response +++, zone diameter >20 mm; moderate ++, zone diameter 16-20 mm; weak +, zone diameter 10-15 mm; no response · , zone diameter <10 mm.

Table 4. Growth-inhibitory activity of intestinal bacteria to extracts of African plants

Plant name[a]		Bacterial strain[b]				
		Bif. bifidum	*Bif. longum*	*Lact. acidophilus*	*Cl. perfringens*	*E. coli*
C. mimosoides	L	·[c]	+	·	·	·
G. senagalensis	L	·	+	·	·	·
G. senagalensis	S	·	+	·	·	·
B. radiata	Wp	·	+	·	·	·
A. viridis	Wp	·	+	·	·	·
C. tora	Wp	·	++	·	·	·
P. chinensis	L	+++	++	+++	++	+
P. chinensis	St	·	+		+	·

[a]Plant species showing activity are presented.
[b]Exposed to 10 mg/disc.
[c]For explanation, see Table 3.

against *Cl. perfringens* whereas moderate activity (++) was obtained in extracts from whole plants of *Cymbopogon citratus, Ocimum basilicum* and *O. sanctum*, and *P. chinensis* leaves. In a test with *E. coli*, extracts from *O. basilicum* whole plants only revealed moderate growth-inhibitory activity (++).

Table 4 revealed the growth-inhibitory activity of African plant samples against intestinal bacteria tested. Similar growth responses with the Indian samples were observed from the African samples. Like Indian *P. chinensis* leaves, extract of the African species revealed also strong and moderate growth-inhibition against the lactic acid bacteria and *Cl. perfringens*, respectively. Extract of *Cassia tora* whole plants exhibited moderate growth inhibition to *Bif. longum*. The other plant samples showed little or no activity against the bacteria used.

Discussion

In the laboratory study with the human intestinal bacteria, growth-inhibitory responses of extracts from 84 Indian and 27 African plant samples varied with plant species, plant part and bacterial strain. However, there were no differences in growth responses to extracts of same species between India- and Africa-collected plants. Because plants virtually constitute a rich source of bioactive organic chemicals[7,8] and native herbal practices are replaced by modern medical practices,[18] in recent years much concern has been focused on plant materials for potentially useful products or lead compounds for synthetic compounds at various medicinal fields. It has been acknowledged that tropical plants have various pharmacological actions. The details along with economic importance of majority of Indian plants are provided by Umrao *et al.*[15] and Schmelzer.[16]

Among beneficial bacteria, bifidobacteria have a close relation with the human health. Their proposed physiological effects pertain to improvement of intestinal microbiota by preventing colonization of pathogens, amelioration of diarrhea or constipation,[19] nutrition production such as vitimins and essential amino acids, improvement of lactose tolerance of milk products,[1] decrease in serum cholesterol levels, immunity activation, and antitumorigenic activity.[20,21] Bifidobacteria growth-promoting factors, usually called bifidus factor, have therefore been extensively studied since György *et al.*[22] suggested their existence in human milk. Extracts of some Oriental medicinal plants such as *Panax ginseng*[10,12] and *Thea chinensis*[9,23] were found to have selective growth-promoting activity against only lactic acid bacteria.

Clostridia have harmful effects on human health such as sudden death, toxicity, mutagenesis, carcinogensis, or aging. They act by biotransforming a variety of ingested or endogenously formed compounds to harmful products like *N*-nitroso compounds or aromatic steroids within the gastrointestine. Because *Cl. perfringens* produces a variety of toxic enzymes such as phospholipase and collagenase disintegrating plasma membrane of host, and toxins which increase permeability of blood vessel of intestine and cause enteritis and colitis, and stimulate aging and tumor genesis of human,[24] much intestest has been focused on selective plant-derived growth inhibitors against *Cl. perfringens* in intestine, based upon the fact that plant-derived materials seem to be less toxic to human.

In our *in vitro* study, extracts from *C. citratus* whole plants, *O. basilicum* whole plants, *M. indica* flowers, and *A. marmelos* leaves strongly inhibited the growth of *Cl. perfringens*. These plant extracts did not affect the growth of the lactic acid bacteria tested. Similar results were reported for oriental medicinal plants[9-13] and leguminous seeds.[25] For example, extracts from *Panax ginseng, Thea chinensis, Pueraria thumbergiana, Astragalus membranaceus, Eucommia ulmoides, Coptis japonica*, and *Akebia quinata* strongly inhibited growth of *Cl. perfringens* without affecting the growth of *Bif. adolescentis*. However, it would be most desirable to both inhibit the growth of potential pathogens and/or increase the numbers of bifidobacteria in the human gut. Selective growth promoters for bifidobacteria or inhibitors for harmful bacteria are especially important for human health, because intake of these materials may normalise disturbed physiological functions which result in the prevention of diseases caused by pathogens in the gastrointestinal tract. Previous *in vivo* investigations have proved that intake of ginseng extract or green tea extract affected favorably the faecal microbiota and biochemical aspects of feces,[12,23] suggesting an indication of at least one of their pharmacological actions.

Based upon our data and these earlier findings, daily intake of bioactive tropical plant-derived materials with selectivity might be expected to alter the growth and composition of the microbial community and modulate the genesis of potentially harmful products such as carcinogenic *N*-nitroso compounds or aromatic steroids within the intestinal tract, thus protecting from a variety of diseases and helping to maintain optimal human health.

Acknowledgements

This work was supported by the Ministry of Agriculture and Forestry through the R & D Promotion Center for Agriculture, Forestry and Fishery, and the Korea Science and Engineering Foundation (KOSEF) through the Research Center for New Bio-Materials in Agriculture at Seoul National University to YJA.

References

1. Hentges, D. J. (1983) "Human Intestinal Microflora in Health and Disease". Academic Press, New York.
2. Mitsuoka, T. (1984) "A Color Atlas of Anaerobic Bacteria". Shobunsha, Tokyo.
3. Finegold, S. M., D. J. Flora, H. R. Attebery and V. L. Sutter (1975) Fecal bacteriology of colonic polyp patients and control patients. *Cancer Res.* **35**, 3407-3417.
4. Mastromarino, A., B. S. Reddy and E. L. Wynder (1978) Fecal profiles of anaerobic microflora of large bowel cancer patients and patients with nonhereditary large bowel polyps. *Cancer Res.* **38**, 4458-4462.
5. Fujisawa, T., M. Kuno, T. Kokubu, R. Hirata, K. Sasaki, Y. Fujisawa, K. Nakamura and T. Mitsuoka (1992) Effects of apple and corn fiber supplemented with bifidobacteria and fructooligosaccharides preparation (A & C) on the fecal microflora and fecal properties in patients with dementia senilis. *Bifidus* **5**, 173-176.
6. Gorbach, S. L., L. Nahas, P. I. Lerner and L. Weinstein (1967) Studies of intestinal microflora. I. Effects of diet, age, and periodic sampling on numbers of fecal microorganisms in man. *Gastroenterol.* **53**, 845-855.
7. Namba, T. (1986) "Colored Illustrations of Wakan-Yaku (the Crude Drugs in Japan, China and the Neighbouring Countries)". Hoikusha, Osaka.
8. Harborne, J. B. (1993) "Introduction to Ecological Biochemistry", 4th Ed., Academic Press, London.
9. Ahn, Y. J., T. Kawamura, M. Kim, T. Yamamoto and T. Mitsuoka (1991) Tea polyphenols: selective growth inhibitors of *Clostridium* spp. *Agric. Biol. Chem.* **55**, 1425-1426.
10. Ahn, Y. J., M. Kim, T. Yamamoto, T. Fujusawa and T. Mitsuoka (1990a) Selective growth responses of human intestinal bacteria to *Araliaceae* extracts. *Microbial Ecology in Health and Disease* **3**, 223-229.
11. Ahn, Y. J., J. H. Kwon, S. H. Chae, J. H. Park and J. Y. Yoo (1994) Growth-inhibitory responses of human intestinal bacteria to extracts of oriental medicinal plants. *Microbial Ecology in Health and Disease* **7**, 257-261.
12. Ahn, Y. J., M. Kim, T. Kawamura, T. Yamamoto, T. Fujisawa and T. Mitsuoka (1990b) Effects of *Panax ginseng* extract on growth responses of human intestinal bacteria and bacterial metabolism. *Korean J. Ginseng Sci.* **14**, 253-264.
13. Ahn, Y. J., S. Sakanaka, M. Kim, T. Kawamura, T. Fujisawa and T. Mitsuoka (1990c) Effect of green tea extract on growth of intestinal bacteria. *Microbial Ecology in Health and Disease* **3**, 335-338.
14. Kinghorn, A. D. and M. F. Balandrin (1993) "Human Medicinal Agents from Plants". ACS Symp. Ser. 489, Amer. Chem. Soc., Washington DC.
15. Umrao, S., A. M. Wadhwani and B. M. Tohri (1990) "Dictionary of Economic Plants in India". New Delhi: ICAR.
16. Schmelzer, G. H. (1991) "Apercue des Mauvaises Herbes dans le Sahel". Neger, DFPU BP Nilamey.
17. Mitsuoka, T., T. Sega and S. Yamamoto (1965) Eine verbesserte Methodik der Qualitativen und Quantitativen Analyse der Darmflora von Menschen und Tieren. *Zbl. Bakteriol. Hyg. I. Abt* **195**, 455-469.
18. John, W. R. (1989) "Natural Poducts of Woody Plants". Springer-Verlag.
19. Sissons, J. W. (1989) Potential of probiotic organisms to prevent diarrhoea and promote digestion infarm animals-a review. *J. Sci. Food Agric.* **49**, 1-13.
20. Hoover, D. G. (1993) Bifidobacteria: activity and potential benefits. *Food Technol.* **47**, 120-124.
21. Ishibashi, N. and S. Shimamura (1993) Bifidobacteria: research and development in Japan. *Food Technol.* **47**, 126-135.
22. György, P., R. F. Norris and C. S. Rose (1954) Bifidus factor. I. A variant of *Lactobacillus bifidus* repuiring a special growth factor. *Arch. Biochem. Biophys.* **48**, 193-201.
23. Okubo, T., N. Ishihara, A, Oura, M. Serit, M. Kim, T. Yamamoto and T. Mitsuoka (1992) *In vivo* effects of tea polyphenol intake on human intestial microflora and metabolism. *Biosci. Biotechnol. Biochem.* **56**, 588-599.
24. Stark, P. L. and A. Lee (1982) Clostridia isolated from the feces of infants during the first year of life. *J. Pediatr.* **199**, 362-368.
25. Lee, H. S. and Y. J. Ahn (1997) Growth responses of lactic acid bacteria to leguminous seed extracts. *Agric. Chem. Biotechnol.* **40**, 167-171.

인도산 및 아프리카산 식물체 추출물의 장내세균에 대한 생육억제 반응

안용준* · 박석준 · 최돈하[1] · 조형찬[2] · I. G. Hiremath[3](서울대학교 농업생명과학대학 응용생물화학부 및 농업생물 신소재연구센터, [1]우석대학교, [2]임업연구원, [3]*University of Agricultural Sciences Karnataka India*)

초 록 : 31과 50종 인도산 식물체 84 시료와 12과 20종 아프리카산 식물체 27 시료의 메탄올 조추출물의 5종 장내세균(*Bifidobacterium bifidum, Bifidobacterium longum, Lactobacillus acidophilus, Clostridium perfringens, Escherichia coli*)에 대한 생육억제활성을 *in vitro* 혐기조건하에서 여지확산법으로 검정한 결과 억제활성은 공시 세균과 식물체의 종류 및 부위에 따라 달리 나타났다. 인도산 식물체 시료중, *Cymbopogon citratus* 전부위, *Ocimum basilicum* 전부위, *Madhuca indica* 꽃 및 *Aegle marmelos* 잎 추출물이 *Cl. perfringens*에 대하여 강한 생육저해활성을 나타낸 반면, *O. basilicum* 전부위 추출물은 *E. coli*에 대하여 중간정도의 생육저해활성을 보였다. 그러나, 이들 식물체들은 공시 유산균의 생육에는 영향을 미치지 않았다. 이러한 결과로 부터 이들 열대식물들의 약리학적인 작용을 일부 설명할 수 있을 것으로 사료된다.

찾는말 : 장내세균, 인도 식물, 아프리카 식물, 열대식물, 생육저해

*연락저자