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Antibacterial Activity of Sweetpotato (*Ipomoea batatas* L.) Fiber on Food Hygienic Bacteria

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The antibacterial activity of sweetpotato fiber against pathogenic *Escherichia coli* (O157:H7), *Salmonella typhimurium, Staphylococcus aureus,* and *Saccharomyces cerevisiae* was investigated using microcalorimetry. The fiber enzymatically prepared from three varieties of sweetpotato storage roots (Koganesengan, Shiroyutaka, and Kyushu No. 124) exhibited bacteriostatic activity against pathogenic *E. coli, S. typhimurium,* and *S. aureus;* however, commercial fiber (Satsumaimo fiber) after citric acid fermentation of sweetpotato starch waste did not exhibit antibacterial activity against these bacteria. All sweetpotato fiber, including Satsumaimo fiber, used in this experiment exhibited no antibacterial activity against *S. cerevisiae.* Chitin exhibited no activity against pathogenic *E. coli;* however, clear activity of pectin, calcium alginate, and Kyushu No. 124 was observed, in that order. The yield of boiled-water extract from enzymatically prepared fiber was three times greater than that from Satsumaimo fiber. Chemical analysis of the boiled-water-soluble fraction suggested that its main component is pectin. The acid sugar content of sweetpotato fiber was much higher than that of Satsumaimo fiber. The boiled-water-insoluble fraction exhibited bacteriostatic activities, but the boiled-water-soluble fraction did not. Bacteriostatic activity of sweetpotato fiber was suggested to be due to the synergistic effect of cellulose, hemicellulose, and pectin of the fiber.

Key words: sweetpotato; bacteriostatic activity; fiber; food hygienic bacteria

Sweetpotato is important in solving global issues related to food, energy, natural resources, and the environment in the 21st century.[1)] In recent years, the release of new varieties of sweetpotato have enabled KONARC to develop new uses of this plant. New products (e.g., juice, powder, and brewed drinks) made from flesh-colored sweetpotato have been made practicable.[2)] Disposition of shochu waste, starch waste, and strained lees from juice production is a critical problem from the

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viewpoint of environmental protection. Starch waste of sweetpotato has been used in citric acid fermentation. However, utilization of this waste in fermentation is difficult, due to the importing of low-cost foreign-made citric acid. Therefore, the development of new uses of starch waste is needed.

The intake of dietary fiber is low among Japanese people. The Japanese government recommends a daily intake of 25 g per day of dietary fiber; however, the actual daily intake per person was 15.2 g in 2008. Dietary fiber is recommended to protect against colon cancer and heart disease in Western countries, and to relieve constipation in Japan. Substantial epidemiological and physiological studies have confirmed that dietary fiber helps prevent diverticulosis, cardiovascular disease, colon cancer, and diabetes.[3] Dietary fiber removes such health-risk factors as artificial food color,[4] aluminum,[5] and mutagens[6, 7] by adsorbing these factors from the body, and improves the flora of intestinal bacteria.[8] Our study also revealed that dietary fiber enzymatically prepared from several varieties of sweetpotato storage roots enhanced two types of Bifidobacterium, and the functional activity varied with varietal differences among sweetpotatoes.[9] Furthermore, dietary fiber has been actively used to decrease caloric intake and to improve food quality. Therefore, the demand for dietary fiber is expected to increase in the future. Studies on dietary fiber have been conducted for soybean, rice bran, wheat bran, corn skin, and vegetables; however, none have focused on sweetpotato.[10]

The growth control of food hygienic bacteria is important from the viewpoint of agricultural production. Adding antibiotics or antibacterial substances to food and feed is useful for food preservation and improvement of livestock growth. However, overuse of antibiotics and antibacterial substances results in the development of antibiotic-resistant bacteria.[11] Regulation of food hygienic bacteria using sweetpotato dietary fiber may be beneficial for both preventing food poisoning and for improving health.

This paper describes the antibacterial activity of dietary fiber enzymatically prepared from three varieties of sweetpotato for a new use of starch waste. Antibacterial activity is usually measured in the sample-solubilized condition in culture broth. The calorimetric method was adopted for the present experiments because sweetpotato fiber and commercial dietary fiber are insoluble in culture broth. The calorimetric method is used to measure bacterial growth, regardless of the sample's state.[12] To the best of our knowledge, the antibacterial activity of dietary fiber from sweetpotato roots has not been reported prior to this study.

Materials and Methods

Chemicals and bacteria. Pectin originating from citrus and calcium alginate were obtained from Wako Pure Chemical Industries, Ltd. (Kyoto, Japan). Chitin was a product of Kanto Chemical Co., Inc. (Tokyo, Japan). Commercial sweetpotato fiber (Satsumaimo fiber) is a lee after citric acid fermentation of starch waste and is a product of Kyushukako Co., Ltd. (Kagoshima, Japan).

This fiber was freeze-dried and ground for the experiments. *Salmonella typhimurium* IFO 12529, pathogenic *Escherichia coli* (0157:H7), *Staphylococcus aureus* IFO 3060, and *Saccharomyces cerevisiae* lFO 0304 were supplied by the Institute for Fermentation (IFO), Osaka, Japan.

Sweetpotato materials and preparation of dietary fiber. Three varieties of sweetpotato (Koganesengan, Shiroyutaka, and Kyushu No. 124) were cultivated in 1996 under the same conditions in an experiment field of KONARC at Miyakonojo (Japan). Koganesengan and Shiroyutaka have been used for starch production. Kyuhsu No. 124 is a new line with a high content of starch.

For this study, dietary fiber was prepared with reference to the reports of Noda *et al.*[13] First, roughly 1 kg of sweetpotato storage root was washed, dice-cut, and homogenized with distilled water using a mixer. The homogenate was then re-ground using a masquerader and put through a 200-mesh sieve. The resultant starch waste was dehydrated and dried for 24 hr at 50°C. Crude starch fiber was suspended in 1 L of deionized water, and the suspension was adjusted to pH 6.3. To this suspension, 0.1 ml (300U) of α-amylase solution (Speedase HS, Nagase BioChemical Co., Kyoto, Japan) was added, and digestion was carried out for 30 min at 95°C. The suspension was cooled at 60°C; then 0.1 ml (700U) of glucoamylase solution (NeoXL128, Nagase BioChemical Co., Kyoto, Japan) was added, and the reaction was held for 6 hr at 60°C. Starch-removed fiber was collected through a 300-mesh sieve and washed thoroughly with deionized water. The resultant fiber was freeze-dried and powdered with a mill.

Fractionation of cell wall materials. Fiber components were fractionated according to the method of Shibuya and Iwasaki.[14] Fiber (1.5 g) was treated with 300 ml of 0.25% ammonium oxalate solution at 90°C for 3 hr. The mixture was filtered with a G-3 glass filter and washed with 100 ml of 0.25% ammonium oxalate solution. The combined filtrate was next dialyzed against deionized water and freeze-dried to obtain the pectin fraction; the residue was washed successively with deionized water, methanol, and acetone (each 50 ml) and air-dried. This residue was then treated with 100 ml of 4 M potassium hydroxide solution containing 0.1% sodium tetrahydroborate, incubated at room temperature for 24 hr, and filtered. The alkaline extract was neutralized with acetic acid, dialyzed against deionized water, and freeze-dried to yield a hemicellulose fraction. The residue was again washed with deionized water, methanol, and acetone (each 50 ml), and then air-dried to yield a cellulose fraction.

Measurement of antibacterial activity. The bacteria was cultured in trypto-soya broth (Nissui Pharmaceutical Co., Ltd., Tokyo, Japan) for a fixed time at 37°C, and the yeast was cultured in potato dextrose broth (Difco Laboratories, Detroit, MI, USA) for a fixed time at 30°C. A fixed amount of fiber sample was weighed into a culture bottle with 10ml of culture broth and autoclaved. After 0.1 ml bacteria suspension precultured in each broth was added, the growth of bacteria was measured automatically with a microbial calorimeter (Bio Thermo Analyzer, TMC-8308, Nippon Medi-

cal & Chemical Instruments Co., Ltd., Osaka, Japan). A 0.1 ml suspension of preincubated *S. aureus, S. typhimurium,* and *S. cerevisiae* was then added to the culture bottle without dilution. Pathogenic *E. coli* suspension was used with 1 x 10^6 times dilution.

Preparation of boiled-water-soluble and -insoluble fraction. For antibacterial activity of boiled-water-soluble and -insoluble fraction from Kyushu No. 124 fiber, the fiber (0.5 g) was boiled in 10 ml of deionized water for 10 min. The suspension was centrifuged at 39,000 x g for 10 min, and the supernatant and precipitate were separated. The resultant precipitate was boiled again under the same conditions, and the suspension was re-centrifuged under the same conditions as described above. The combined supernatant and precipitate were lyophilized, weighed, and examined for antimicrobial activity.

Determination of the sugar content and analysis of the sugar components of the boiled-water-soluble fraction. Sugar content was determined by the phenol-sulfuric acid method and the carbazole method. Sugar components were analyzed using a HPLC (Model L-6200, Hitachi Co., Tokyo, Japan) with a fluorescence monitor (Model F-1050, Hitachi Co., Tokyo, Japan). The samples for HPLC analysis of sugar components were prepared by hydrolysis with 70% sulfuric acid. Sugar components were separated on a 4.6 mm x 25 cm Shim-pack ISA-07/S2504 column (Shimadzu Co., Kyoto, Japan).

Results and Discussion

Yield of sweetpotato fiber

Three varieties of sweetpotato fiber (Koganesengan, Shiroyutaka, and Kyushu No. 124) were prepared from storage roots by treatment of α-amylase and glucoamylase (Table 1). The yield of fiber per kilogram of storage root was 20.7 g (2.1%) from Shiroyutaka 20.4 g (2.0%) from Koganesengan, and 18.2 g (1.8%) from Kyushu No. 124. The yield of fiber from Kyushu No. 124 was approximately 10% lower than that of the other two varieties. These values relatively agreed with those of the indigestible food fiber reported in the *Standard Tables of Food Composition in Japan* (4th edition). The mean dietary fiber (fresh weight basis) of four cooked American cultivars was

Table 1. Yield of sweetpotato fiber from Shiroyutaka, Koganesengan, and Kyusyu No. 124

Variety	Weight of material (g)	Yield of freeze-dried fiber (g)	Yield (g/kg root)
Shiroyutaka	1,088	22.5	20.7
Koganesengan	1,090	22.2	20.4
Kyushu No. 124	1,259	22.9	18.2

comparable at 3.6%.[15] The dietary fiber content of South Pacific sweetpotato roots ranges from 0.46% to 2.93% on a fresh weight basis.[16] Further dietary fiber content from sweetpotato varies with harvest time.[13] It is difficult to compare the values for dietary fiber of sweetpotato determined by various groups of researchers, as they used different methods of analysis and did not include the same components in their determinations.

Antibacterial activity of sweetpotato fiber against bacteria and yeast

The antibacterial activity of sweetpotato fiber, including Satsumaimo fiber, against pathogenic *E. coli, S. typhimurium, S. aureus,* and *S. cerevisiae* was examined using a microbial calorimeter (Fig. 1). Each sample was added to the broth at a final concentration of 5%, and 0.5 ml of distilled water for the dietary fiber in the control culture bottle. Pathogenic *E. coli* in the trypto-soya broth grew much faster than non-pathogenic *E. coli* (data not shown). Therefore, the preincubated suspension of this bacterium with dilution was used for this study (Fig. 1). The growth of pathogenic *E. coli* without the addition of fiber indicated a peak of power at 11 hr after the start of cultivation (Fig. 1A). Adding Satsumaimo fiber produced the same growth peak as the control. The growth peak was observed at 12 hr with the addition of Shiroyutaka fiber, at 13 hr with the addition of Koganesengan fiber, and at 14 hr with the addition of Kyushu No. 124 fiber. Adding fiber thus effectively delayed the growth of pathogenic *E. coli.* Against *S. typhimurium,* control and Satsumaimo fiber exhibited a growth peak at 16 hr after the start of cultivation. However, the growth peak occurred at 22 hr with the addition of Kyushu No. 124 fiber, at 23 hr with the addition of Shiroyutaka

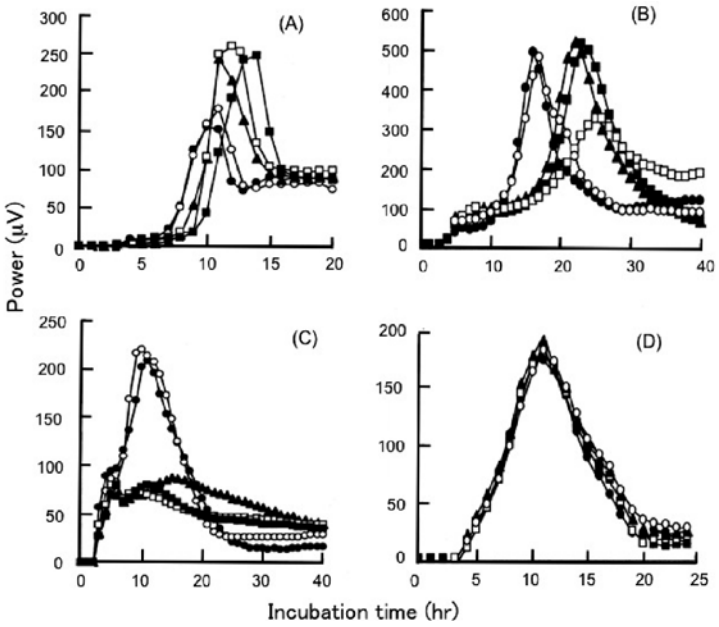

Fig. 1. Effect of sweetpotato fiber on bacterial growth

(A), pathogenic *E. coli*; (B), *S. typhimurium*; (C), *S. aureus*; (D), *S. cerevisiae*; ●, control; ○, Satsumaimo fiber; □, Koganesengan; ■, Kyushu No. 124; ▲, Shiroyutaka.

fiber, and at 26 hr with the addition of Koganesengan fiber. The strength of bacteriostatic activity was in order Koganesengan, Shiroyutaka, and Kyushu No. 124 (Fig. 1B). Against *S. aureus,* the growth peak of the control and Satsumaimo fiber was observed at 11 hr after the start of cultivation (Fig. 1C). No sharp growth in the bottles with Koganesengan, Shiroyutaka, or Kyushu No. 124 fiber were observed, suggesting that the dietary fiber prepared from sweetpotato roots effectively depressed the growth of *S. aureus*. Satsumaimo fiber and sweetpotato fibers had no effect on the growth of *S. cerevisiae* (Fig. 1D). These data suggest the existence of bacteriostatic components in sweetpotato fiber.

Effect of additional Kyushu No. 124 fiber on the growth of pathogenic E. coli.

Fiber of Kyushu No. 124 was added at 0, 0.1 g, 0.2 g, 0.3 g, and 0.5 g per l0 ml of the culture broth. The control and the culture broth with 0.1 g of fiber exhibited the same growth peak. The growth of pathogenic *E. coli* was delayed with increased addition of the fiber (data not shown).

Effect of Kyushu No. 124 fiber, pectin, calcium alginate, and chitin on pathogenic E. coli growth

The bacteriostatic activity of sweetpotato fiber against food hygienic bacteria is clear (Fig. 1). Therefore, Kyushu No. 124 fiber and commercial dietary fiber, pectin, chitin, and calcium alginate were compared in pathogenic *E. coli* (Fig. 2). Each sample was added to the broth at a final concentration of 5%, and 0.5 ml of deionized water for the fiber sample was added to the control culture bottle. For the control and chitin, the same growth curve and growth peak of the bacteria were observed at 11 hr after the start of cultivation. For Kyushu No. 124, the growth peak in the fraction with fiber added was observed at 13 hr, and that in the fraction with calcium alginate added was observed at 14.5 hr. No bacteria growth in the fraction with pectin added was observed at 40 hr after cultivation, suggesting that the antibacterial activity of citrus pectin was bactericidal.

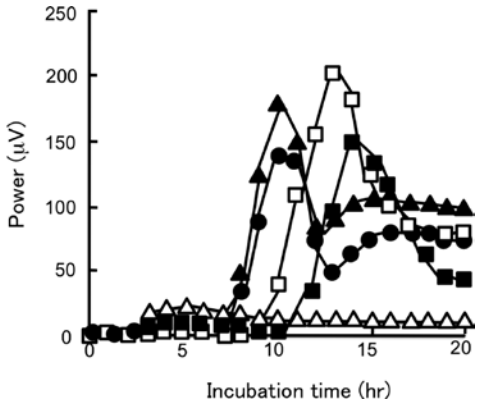

Fig. 2. Effect of commercial dietary fiber or Kyushu No. 124 fiber on pathogenic *E. coli* growth

▲, chitin; ●, control; □, Kyushu No. 124; ■, calcium alginate; △, pectin;

Content of pectin, hemicellulose, and cellulose of sweetpotato and Satsumaimo fiber

Citrus pectin exhibited strong antibacterial activity against pathogenic *E. coli* (Fig. 2). Our present data revealed a clear difference in bacteriostatic activity between Satsumaimo fiber and those enzymatically prepared from three varieties of sweetpotato storage roots (Fig. 1). Data suggest that pectin plays an important role in the antibacterial activity of sweetpotato fiber. Koganesengan, Kyushu No. 124, and Satsumaimo fiber were fractionated for pectin, hemicellulose, and cellulose content (Table 2). For Koganesengan root, pectin content was 167 mg/g fiber DW, hemicellulose content was 397 mg/g fiber DW, and cellulose content was 199 mg/g fiber DW. For Kyushu No. 124 root, pectin content was 366 mg/g fiber DW, hemicellulose content was 109 mg/g fiber DW, and cellulose content was 294 mg/g fiber DW. For Satsumaimo fiber, pectin content was 44 mg/g fiber DW, hemicellulose content was 121 mg/g fiber DW, and cellulose content was 639 mg/g fiber DW. The pectin content of Satsumaimo fiber was much less than that of Koganesengan or Kyushu No. 124 root and its main fiber component was cellulose.

Table 2. Varietal difference of pectin, hemicellulose, and cellulose contents from sweetpotato fiber

Fiber sample	Content of fiber components* (mg/g fiber DW)		
	Pectin	Hemicellulose	Cellusose
Koganesengan	167	397	199
Kyushu No. 124	366	109	294
Satsumaimo fiber	44	121	639

* Content of pectin, hemicellulose, and cellulose are the means of three experiments.

Yield and composition of boiled-water extract

In the present study, the fiber sample was autoclaved in the culture broth. Therefore, pectin solubilized from sweetpotato fiber or Satsumaimo fiber may depress bacterial growth. Pectin substance is solubilized from the fiber by steaming or boiling.[5, 17] To clarify the difference between the bacteriostatic activity of Satsumaimo fiber and sweetpotato root fiber, the freeze-dried preparation of water-boiled extracts from each sweetpotato fiber and Satsumaimo fiber was weighed (Table 3). The freeze-dried preparation from Satsumaimo fiber was 12.6 mg/g, that from Shiroyutaka fiber was 43.0 mg/g, that from Koganesengan fiber was 42.0 mg/g, and that from Kyushu No. 124 fiber was 36.0 mg/g. The yields of freeze-dried extract from Shiroyutaka, Koganesengan, and Kyushu No. 124 of sweetpotato storage roots was three times higher than that of Satsumaimo fiber. The percentage of boiled-water extract from Shiroyutaka was 0.89, that from Koganesengan was 0.86, and that from Kyushu No. 124 was 0.66. The content and composition of pectin in sweetpotato vary with cultivar, but it is at least 1% of fresh weight.[15]

Table 3. Yield and percentage of freeze-dried preparation from boiled-water extract of sweetpotato fiber

Fibers	Yield* (mg/g fiber)	Concentration (%)
Satsumaimo fiber	12.6	-
Shiroyutaka	43.0	0.89
Koganesengan	42.0	0.86
Kyushu No. 124	36.0	0.66

* Content of pectin, hemicellulose, and cellulose are the means of three experiments.

Table 4 indicates the sugar content and neutral sugar composition of boiled-water extracts from three varieties of sweetpotato and Satsumaimo fiber. The content of neutral sugar was presented as one of glucose, and that of acidic sugar was presented as one of galacturonic acid. The neutral sugar content per 100 mg of extract from Satsumaimo fiber was 91.6 mg, that from Shiroyutaka was 92.0 mg, that from Koganesengan was 67.3 mg, and that from Kyushu No. 124 fiber was 68.8 mg. The acidic sugar content per 100 mg of extract from Satsumaimo fiber was 5.3 mg, that from Shiroyutaka was 13.0 mg, that from Koganesengan was 20.5 mg, and that from Kyushu No. 124 was 22.2 mg. The acidic sugar content of extract from Koganesengan and from Kyushu No. 124 was four times higher than that from Satsumaimo fiber, and 1.6 to 1.7 times higher than that from Shiroyutaka. Rhamnose and galactose were not detected in the boiled-water extract from Satsumaimo fiber.

Table 4. Sugar content and composition of freeze-dried preparation from boiled-water extract of sweetpotato fiber

fibers	Sugar contents (mg/100mg)*		Nutritional sugar contents (mg/100 mg)						
	Glc	Gal.A	Rha	Man	Ara	Gal	Xyl	Glc	Total
Satsumaimo fiber	91.6	5.3	ND**	ND**	9.9	ND**	62.0	21.1	93.0
Shiroyutaka	92.0	13.0	0.13	ND**	22.1	14.8	7.1	30.0	74.1
Koganesengan	67.3	20.5	0.79	ND**	31.4	28.3	8.5	6.0	75.0
Kyushu No. 124	68.8	22.2	0.58	ND**	37.1	34.2	8.1	3.0	82.9

Abbreviation of sugar: Glc, glucose; Gal.A, galacturonic acid; Rha, Rhamnose; Man, mannose ; Ara, arabinose; Gal, galactose; Xyl, xylose.
*Sugar contents were expressed as glucose and galacturonic acid.
**ND, not detected

Comparison of bacteriostatic activity between boiled-water-soluble and –insoluble fraction from Kyushu No. 124 fiber

Figure 3 plots the effects of boiled-water-soluble and -insoluble fractions separated from Kyushu No. 124, the mixture of both fractions, and native (non-boiled) fiber against pathogenic *E.*

coli. The added amount of each fraction to the culture bottle was equivalent to native fiber of Kyushu No. 124. With the addition of the boiled-water-soluble fraction and the control, the growth peak was observed at 10.5 hr. The addition of the boiled-water-insoluble fraction indicated that the power peak occurred at 11.5 hr. With the addition of the mixture of both fractions, the power peak was observed at 12.5 hr and that of the native fiber at 14.5 hr. These results indicate that the boiled-water-soluble fraction rarely had an antibacterial effect against pathogenic *E. coli,* and that the main components of the activity existed in the boiled-water-insoluble fraction. The boiled-water-insoluble fraction exhibited stronger bacteriostatic activity than the control and the boiled-water-soluble fraction. However, the bacteriostatic activity of the boiled-water-insoluble fraction did not reach the level of activity of the mixture of both fractions. Furthermore, the mixture of both fractions was comparable to that of the native Kyushu No. 124 fiber. Consequently, these data suggested that the active component was mainly present in the boiled-water-insoluble fraction, but the non-active boiled-water-soluble fraction was necessary to effectively suppress pathogenic *E. coli* growth.

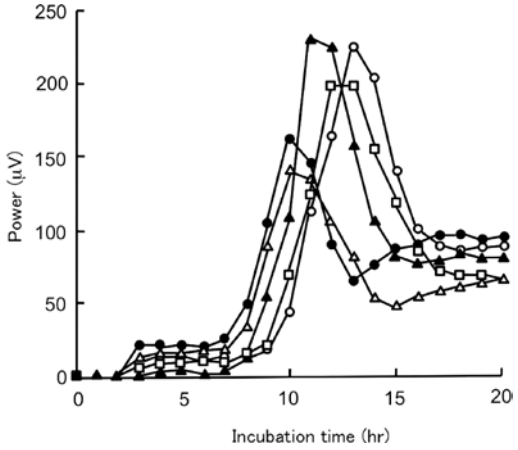

Fig. 3. Effect of boiled-water-soluble and -insoluble fraction from Kyushu No. 124 fiber on pathogenic *E. coli* growth

●, control; △, boiled-water-soluble fraction; ▲, boiled-water-insoluble fraction; □, mixture of both fractions; ○, native (non-boiled) fiber.

This study investigated the effects of the sweetpotato fiber on the growth of several kinds of food hygienic bacteria and yeast using the calorimetric method. Dietary fiber from sweetpotato bacteriostatically depressed the growth of food hygienic bacteria (Fig. 1). Kyushu No. 124 fiber dose-dependently delayed the growth of pathogenic *E. coli* (data not shown). Data indicate that a calorimetric method is useful for evaluating antibacterial activity with a culture-broth-insoluble sample. The calorimetric method is also useful for quantitatively evaluating the efficacy of antifungal agents.[18)]

An explicit difference was observed between the bacteriostatic activity of Satsumaimo fiber and that of fiber enzymatically prepared from three varieties of sweetpotato storage roots (Fig. 1).

Presently, Koganesengan and Shiroyutaka have been processed mainly as materials of starch production. Therefore, Satsumaimo fiber arises from the starch waste of both varieties. The difference between the bacteriostatic activity of enzymatically prepared fiber and that of Satsumaimo fiber is presumed to depend on the decomposition of bacteriostatic components of the fiber during citric acid fermentation. The component that decreased in the lees during citric acid fermentation was assumed to be pectin. This hypothesis is also supported by the decrease in boiled-water-soluble fraction content and acid sugar one in the boiled-water extracts of Satsumaimo fiber (Tables 3 and 4).

Pectin is a high molecular acidic polysaccharide that is formed by α-1,4 binding of D-galacturonic acids, and a complex sugar containing neutral sugars (e.g., galactose, arabinose, xylose, and rhamnose) other than galacturonic acid. Among the root crops, sweetpotato cell wall materials have the highest amount of pectin and galacturonic acid.[19] Yokotsuka *et al.* reported that reduced pectin in wine effectively depressed the growth of harmful bacteria by the synergistic effect with ethanol on fermentation.[20] Analysis of sugar components in the boiled-water-soluble fraction suggests that the boiled-water extract is pectin (Table 4). Their reports and our data (Tables 3 and 4) suggest that pectin in the boiled-water-soluble fraction depresses the growth of food hygienic bacteria. Contrary to our expectations, the boiled-water-soluble fraction from Kyushu No. 124 fiber rarely affected the growth of pathogenic *E. coli* (Fig. 3). Undegraded pectin has no bacteriostatic activity, while pectin hydrolyzated with treatment of a pectinase or sulfuric acid exhibited clear bacteriostatic activity against bacteria other than lactic acid bacteria, and weak activity or non-activity against yeasts and fungi.[21] The pectin component in the boiled-water-soluble fraction may not be reduced. Presently, we do not have any data to analyze the characteristic of citrus pectin in further detail. The boiled-water-insoluble fraction is bacteriostatic, while the soluble fraction is not (Fig. 3), suggesting that a bacteriostatic component is present mainly in the boiled-water-insoluble fraction. Yokotsuka *et al.* reported the participation of neutral sugars for bacteriostatic activity.[20] Therefore, it is possible that unknown components in the boiled-water-insoluble fraction are involved in the bacteriostatic activity of sweetpotato fiber. Further investigation will be necessary to clarify the bacteriostatic activity of neutral sugar in sweetpotato fiber.

In addition to food processing, the use of fiber in wound therapy has been considered. Suzuki *et al.* indicated that Satsumaimo fiber has favorable properties for healing wounds; since it contains a large amount of exudates, the fiber has excellent absorptive ability for serum and good adhesive ability for a number of proteins.[22] Present data indicate that fiber enzymatically prepared from three varieties of sweetpotato roots effectively depressed the growth of the suppurative microorganism *S. aureus*; however, Satsumaimo fiber did not (Fig. 1). This result suggests that Satsumaimo fiber absorbs serum proteins but cannot suppress the growth of *S. aureus*. In other words, the fiber enzymatically prepared from sweetpotato roots heals a wound more effectively than Satsumaimo fiber.

The total dietary fiber content of sweetpotato roots is similar to that of other roots and tubers, and is much higher than that of such foods as cooked rice.[23] Furthermore, sweetpotato has a well-

balanced content of soluble and insoluble fiber, with a ratio of 1:1 (excluding lignin).[23-25] Cholesterol-binding capacity has been reported for 28 fiber samples from a variety of commonly consumed tropical fruits and vegetables including sweetpotato, and sweetpotato fiber was found to be by far the most effective cholesterol binder.[26] Epidemiological, neuropathological, and biochemical studies suggest a possible link between the neurotoxicity of aluminum and the pathogenesis of Alzheimer's disease. Kawahara *et al.* indicated that aluminum induced conformational changes in β-amyloid protein and enhanced its aggregation *in vitro*.[27] Takeyama *et al.* demonstrated that dietary fiber effectively adsorbed aluminum.[5]

The gelling properties of sweetpotato pectin are similar to those of apple pectin.[28] There is a potential for extracting pectin from the peel and trim wastes, and starch waste of sweetpotato processing factories. Sweetpotato plants used for food are a moderately good source of dietary fiber, being made up of soluble and insoluble fiber, which could promote such physiological effects as reduced fecal transit time and reduced blood cholesterol levels. In addition, livestock that consumed feeds with added antibiotics or were bred in a clean environment are well-grown, indicating the involvement of the intestinal micro flora.[29] Food fiber improves the flora of intestinal bacteria.[8] These reports and our present data suggest the potential of sweetpotato fiber as livestock feed.

In conclusion, our present results indicate that sweetpotato dietary fiber effectively depresses food hygienic bacteria. Furthermore, sweetpotato dietary fiber possesses several chemopreventive properties, including the adsorption of harmful components and the growth enhancement of Bifidobacterium.[9] Sweetpotato starch waste has potential not only for maintaining and enhancing health, but also for preventing food poisoning.

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