Date received: July 1994

Dietary fibre content and composition of vegetables in Taiwan area

Su-Chien Chang, Meei-Shyuan Lee, Ching-Hui Li, Mou-Liang Chen

Department of Biochemistry and Department of Public Health, National Defense Medical Center, Taiwan*

Fifty-three fresh vegetables frequently consumed in the Taiwan area were analysed for their dietary fibre content by an enzymatic-gravimetric method. Of these vegetables, the total dietary fibre ranged from 0.7g (per 100g edible weight) in large cucumbers to 13.2g in lima beans. Further fractionation of total dietary fibre has shown that the majority of vegetables contain more insoluble fibre than soluble fibre with the exception of sponge gourds, burdocks and carrots. Soluble fibre in most vegetables contain mostly uronic acids while the insoluble noncellulose polysaccharides (INCP) fraction is composed mainly of xylose and galactose. Mushrooms are unique in that both their soluble fibre and INCP fractions consist mainly of glucose. These results of dietary fibre content and composition of vegetables are useful for dietary assessments in Taiwan and the Southeast Asian area.

Introduction

Dietary fibre, as first coined by Burkitt and Trowell[1], is a group of nondigestible components of plant structure, including nonstarch polysaccharides and lignin. Each component is distinguished by its sugar residues and the linkages among them[2]. High fibre intake has been shown to be protective against some diseases[3,4]. Evidence has also shown that fibres of different compositions may exert different physiological effects[5]. Foods with a higher proportion of soluble fibre have a more profound effect in lowering serum cholesterol[6-8], while insoluble fibres tend to accelerate intestinal transit[5]. Therefore, information about the distribution of dietary fibre is useful in evaluating the health benefits of fibre-rich foods.

Owing to subtropical location and horticultural development, many kinds of vegetable species are able to grow in Taiwan and are frequently consumed. In the estimations from the food balance sheets[9], vegetables provided about 35% of all dietary fibre available to people in Taiwan[10]. A household dietary survey yielded a total of 57 items of fresh vegetables commonly eaten in the Taiwan area[11]. Thus, data on the fibre composition of vegetables are of great value in conducting dietary assessments in the area. The most frequently consumed vegetables were included in this study to provide fibre data for these foods.

Our laboratory had previously used the detergent method[12] to assay the fibre content of some vegetables in the Taiwan area[13]. However, the enzymatic method has currently become more widely adopted in estimating food fibre content[14,15]. Thus, in this present investigation, the enzymatic gravimetric method was applied to analyse the dietary fibre content of 53 common vegetables of the Taiwan area. In addition, the distribution of each fraction of total dietary fibre and sugar composition of soluble and insoluble fibre were also determined.

Methods

All vegetables were purchased from local markets in Taiwan. To take into account the different varieties of each vegetable, three samples of each item were obtained from different markets and the data presented is the average value. Edible portions of vegetables were sliced, freeze-dried and milled by a Wiley mill fitted with a 30 mesh sieve. All milled particles were passed through a 0.60mm mesh and retained in a 0.25mm mesh.

Dietary fibre was determined by a modified procedure of the enzymatic- gravimetric method. Samples in quadruplicate (0.5000g each) were extracted with methanol and ether in order to remove fat and pigments as described by Chen and Anderson[16]. The extracted residue was then suspended in 0.08M phosphate buffer and gelatinised with heat- stable α- amylase (Sigma Co., MO, USA) and followed by digestion with protease and amyloglucosidase[15]. For items with higher starch content, like legumes, DMSO (dimethylsulfoxide) was added to help the dispersion of starch[17]. After enzyme digestion, 4 volumes of ethanol were added to precipitate the fibre. The precipitated fibre was harvested by centrifugation (1500xg, 10min) instead of filtration[17]. The precipitate was washed twice with 80% methanol and once with acetone. In every washing the supernatant was siphoned off after centrifugation (1500xg, 10min). The washed precipitate was then dried to a constant weight. Total dietary fibre (TDF) content was determined by the weight of precipitate after subtracting the protein and ash content.

The TDF precipitate was then extracted twice using hot water in a boiling water bath[18]. The soluble fibre in the supernatant was removed after centrifugation and then dried. Aliquots were then hydrolysed with 1M H_2SO_4 and assayed for sugar and uronic acid. The insoluble residue was also dried and weighed. The amount of soluble fibre (SDF) was then calculated as the loss in weight after water extraction and corrected for protein and ash content.

Correspondence address: Su-Chien Chang
Department of Biochemistry National Defense Medical Center
P. 0. Box 90048-501 Taipei, Taiwan, ROC
Tel: +886-2-365-5740 Fax: +886-2-368-1354

Table 1. Dietary fibre content of vegetables consumed in Taiwan area

Food item			TDF % of	TDF	SDF	INCP	C	L*
Chinese name	English name	Scientific name	edible weight		% of dry weight			
葉菜類	**Leafy vegetables**							
莧　菜	Amaranth, green	Amaranthus mangostanus	3.21	43.0	15.8	13.7	8.0	6.1
紅莧菜	Amaranth, red	Amaranthus mangostanus	3.14	39.8	9.5	17.7	11.3	2.7
芥蘭菜	Borecole	Brassica oleracea	2.64	29.8	8.9	9.1	9.2	4.1
甘　藍	Cabbage	Brassica oleracea	1.67	22.5	5.9	7.7	8.0	2.1
包心白菜	Chinese cabbage	Brassica pekinenses	1.06	24.7	9.7	6.5	5.5	3.7
茼　蒿	Garland chrysanthemum	Chrysanthemum coronarium	1.92	36.4	14.4	8.2	10.1	4.2
結球萵苣	Head lettuce	Lactuca sativa	1.34	32.5	13.3	5.9	9.0	4.5
萵仔菜	Leaf lettuce	Lactuca sativa	1.59	30.5	8.0	9.5	6.1	8.8
大芥菜	Leaf mustard	Brassica juncea	2.35	33.4	12.1	9.9	10.8	1.4
豆　苗	Pea leaves	Pisum sativum	2.81	45.1	17.7	12.9	12.6	2.4
青江菜	Pe-tsai, Chin-chian	Brassica chinensis	2.34	36.2	13.3	10.7	7.1	5.9
小白菜	Pe-tsai	Brassica rapa	1.54	34.2	11.0	10.2	6.8	7.4
油　菜	Rape	Brassica campestris	2.17	31.5	10.5	9.1	8.7	3.8
菠　菜	Spinach	Spinacia oleracea	2.48	37.2	11.9	11.7	11.4	3.2
甘薯葉	Sweet potato leaves	Ipomoea batatas	3.93	38.3	13.1	8.9	10.7	6.7
空心菜	Water convolvulus	Ipomoea aquatica	3.17	46.8	18.4	10.6	11.3	6.7
瓜類	**Gourds**							
苦　瓜	Bitter gourd	Momordica charantia	1.98	34.2	14.9	6.2	8.6	5.6
瓠　瓜	Bottle gourd	Lagenaria siceraria	1.04	24.5	11.8	6.5	5.0	1.9
大黃瓜	Cucumber, large	Cucumis sativus	0.71	17.7	6.5	5.0	6.6	0.8
小黃瓜	Cucumber, small, unpeeled	Cucumis sativus	1.04	22.0	7.7	6.1	8.9	0.2
絲　瓜	Sponge gourd	Luffa cylindrica	1.00	18.1	11.2	2.6	2.9	1.4
冬　瓜	Wax gourd	Benincasa hispida	1.13	27.5	9.6	6.7	10.0	2.5
鮮豆類	**Legumes, fresh**							
四季豆	Green bean	Phaseolus vulgaris	2.88	33.1	12.4	9.3	9.6	2.8
皇帝豆	Lima bean	Phaseolus limensis	13.24	44.5	5.7	17.9	20.6	0.8
豌豆莢	Podded pea	Pisum sativum	2.54	22.6	8.0	6.7	7.3	2.1
毛　豆	Soybean, immature	Glycine max	11.88	37.3	6.8	19.2	9.5	1.9
豇　豆	Yard long bean	Vigna unguiculata	3.88	37.4	13.7	7.9	12.4	4.7
芽莖及花果類	**Stems, flowers, fruit**							
綠蘆筍	Asparagus, green	Asparagus officinalis	1.95	27.2	10.1	6.0	10.1	2.3
綠竹筍	Bamboo shoot, green	Bambusa oldhami	1.86	26.5	3.5	15.1	8.3	1.3
青　椒	Bell pepper, green	Capsicum annum	1.44	26.1	12.0	3.7	8.8	2.5
青花菜	Broccoli	Brassica oleracea var. italica	3.13	30.8	12.7	7.8	9.0	2.3
花椰菜	Cauliflower	Brassica oleracea var. botrytis	2.51	29.6	10.1	8.3	10.1	2.8
芹　菜	Celery, Chinese	Apium graveolens	2.50	44.3	17.2	9.6	11.4	7.5
茭白筍	Coba shoot	Zizania latifolia	3.01	33.7	11.6	10.8	9.9	2.9
金針花	Daylily flower	Hemerocallis disticha	3.24	27.7	11.1	7.6	8.9	0.9
茄　子	Eggplant	Solanum melongena	2.23	32.5	10.9	3.3	15.7	4.6
韭　菜	Leek, Chinese	Allium odorum	3.51	42.8	20.0	7.6	10.5	5.9
韭　黃	Leek, etiolated	Allium odorum	1.77	31.3	13.2	7.7	8.3	3.4
韭菜花	Leek flower	Allium odorum	2.46	30.0	12.7	5.3	10.8	1.4
綠豆芽	Mung bean sprout	Phaseolus radiatus	1.41	26.7	10.6	5.6	8.8	2.2
豌豆芽	Pea sprout	Pisum sativum	2.80	31.0	10.8	6.6	11.3	3.0
黃豆芽	Soybean sprout	Glycine max	3.00	34.8	9.9	6.3	18.4	1.2
菇類	**Mushrooms**							
鮮香菇	Forest mushroom	Lentinus edodes	4.03	41.2	5.4	20.1	15.2	1.1
鮮洋菇	Mushroom	Agaricus bisporus	3.61	35.4	7.3	16.9	10.8	1.7
鮮草菇	Straw mushroom	Volvariella volvacea	2.39	27.1	7.5	9.6	8.8	2.6
金針菇	Winter mushroom	Flammulina velutipes	3.79	34.2	5.5	15.8	13.2	0.5
根莖類	**Tubers & roots**							
牛　蒡	Burdock	Arctium lappa	7.55	29.2	19.0	3.7	5.7	1.3
胡蘿蔔	Carrot	Daucus carota	3.26	27.6	17.0	3.7	5.9	1.7
球莖甘藍	Kohlrabi	Brassica oleracea	1.74	22.1	8.7	5.5	7.6	1.2
蓮　藕	Lotus root	Nelumbo nucifera	2.25	11.8	2.9	3.4	5.0	1.1
洋　蔥	Onion, yellow	Allium cepa	0.96	13.0	6.4	2.6	4.1	0.7
白蘿蔔	Radish, Chinese	Raphanus sativus	1.42	24.4	10.4	5.0	8.0	1.9
荸　薺	Water chestnut	Eleocharis dulcis	1.91	9.3	0.7	3.9	5.3	0.2

*TDF: total dietary fibre; SDF: soluble dietary fibre; INCP: insoluble non cellulose polysaccharides; C: cellulose; L: lignin

Table 2. Composition of constituent sugars and uronic acid of SDF* in vegetables

Food Item	Rha# %	Rib %	Ara %	Xyl %	Man %	Gal %	Glu %	Uronic acid %
Leafy vegetables								
Amaranth, green	5.5	0.4	5.3	0.6	0.2	9.6	1.6	76.8
Amaranth, red	7.3	0.3	5.4	0.2	0	12.7	1.4	72.7
Borecole	3.0	0.4	8.8	0.6	0.1	7.2	0.3	79.6
Cabbage	3.9	0.2	11.4	0..9	0	10.5	0.1	72.9
Chinese cabbage	2.3	0.6	7.1	0.7	0	6.2	0.1	83.0
Garland chrysanthemum	4.9	0.5	6.9	1.2	0.2	9.3	1.1	75.8
Head lettuce	5.9	0.7	7.3	0.5	0.1	12.1	0	73.4
Leaf lettuce	2.9	1.7	8.2	1.0	0.1	11.0	4.0	71.1
Leaf mustard	4.0	0	9.9	0.3	0	11.2	0	74.6
Pea leaves	3.0	0.4	18.1	0.1	1.0	25.4	0	51.9
Pe-tsai, Chin-chian	3.4	0	7.6	1.0	0.5	9.0	3.2	75.1
Pe-tsai	5.5	0.4	7.2	1.4	0	11.6	0.5	73.3
Rape	4.9	0.5	11.1	1.4	0.1	9.3	1.5	71.2
Spinach	6.2	0.6	13.0	0.2	0.2	9.2	0.1	70.5
Sweet potato leaves	5.2	0.5	6.3	13.0	0	7.6	1.3	66.1
Water convolvulus	5.7	0.2	7.1	3.6	0.9	21.8	3.2	57.5
Gourds								
Bitter gourd	2.0	0.2	5.8	2.2	0	23.6	0	66.7
Bottle gourd	1.4	0.4	7.5	1.0	0.7	50.8	0	38.1
Cucumber, large	1.7	0.4	8.3	1.6	0	29.9	0	58.1
Cucumber, small, unpeeled	2.6	0.1	10.3	0.6	0.1	30.4	0.1	55.9
Sponge gourd	0.9	0	7.3	0.2	0	15.6	0.5	75.5
Wax gourd	1.2	0.2	2.3	0.3	0	23.1	0	72.7
Legumes, fresh								
Green Bean	2.0	0.6	8.2	1.2	1.3	16.7	3.7	66.2
Lima bean	0.6	0	17.9	7.6	10.1	5.1	12.5	46.1
Podded pea	3.0	0.3	15.7	1.4	0	23.6	2.5	54.0
Soybean, immature	2.9	0	19.7	5.3	12.4	29.7	2.8	25.8
Yard long bean	2.5	0.5	11.0	1.2	0.2	13.3	2.8	68.6
Stems, flowers, fruit								
Asparagus, green	2.9	0.3	11.3	1.9	0.3	15.2	4.2	63.9
Bamboo shoot, green	0	1.2	19.3	2.4	0	23.1	7.4	46.5
Bell Pepper, green	1.7	0.3	5.2	0.4	0	14.6	0.3	77.6
Broccoli	3.4	0.1	22.0	0.5	0	15.3	0	58.4
Cauliflower	3.1	0.2	18.6	1.0	0.1	13.5	0	63.1
Celery, Chinese	6.4	0	14.0	2.0	0	21.6	2.4	53.5
Coba shoot	0.3	2.7	14.1	4.6	0.2	12.5	36.4	29.0
Daylily flower	4.2	0	6.3	1.4	1.3	14.5	3.6	68.8
Eggplant	4.4	0.1	7.7	0.7	0	20.7	1.4	64.9
Leek, Chinese	5.3	0.3	8.5	2.6	0	25.7	0.8	56.8
Leek, etiolated	2.0	0.1	4.2	0.6	0.1	20.3	0	72.7
Leek flower	2.0	0.1	7.1	0.7	0	19.8	0	70.3
Mung bean sprout	3.2	0.3	10.5	2.2	0	24.2	1.6	58.0
Pea sprout	4.0	1.5	19.9	0.4	0.1	12.9	0.8	60.5
Soybean sprout	4.1	0.5	19.3	5.5	0	26.2	0	41.2
Mushrooms								
Forest mushroom	0	3.9	2.2	0.6	7.2	22.6	56.0	3.5
Mushroom	0	4.1	1.0	2.2	9.7	22.8	46.0	11.3
Straw mushroom	0	2.0	4.0	0	20.1	30.9	29.3	13.8
Winter mushroom	0	0	1.7	4.5	12.7	23.5	44.5	3.8
Tubers & roots								
Burdock	2.7	0.1	23.2	0.6	2.2	13.4	4.7	53.0
Carrot	3.1	0.1	17.4	0	0	35.9	3.8	39.7
Kohlrabi	5.1	0.1	15.6	0.9	0	8.8	0.6	69.1
Lotus root	0.6	0	10.3	0.4	18.2	13.8	13.1	43.7
Onion, yellow	1.4	0.1	3.6	1.9	0	51.0	0	42.0
Radish, Chinese	4.2	0.1	13.4	0.6	0	12.6	0	69.1
Water chestnut	0	0	6.3	3.5	9.5	8.3	17.5	54.8

*SDF: soluble dietary fibre; #Rha: rhamnose; Rib: ribose; Ara: arabinose; Xyl: xylose; Man: mannose; Gal: galactose; Glu: glucose

Table 3. Composition of constituent sugars and uronic acid of INCP* in vegetables

Food Item	Rha# %	Fuc %	Ara %	Xyl %	Man %	Gal %	Glu %	Uronic acid %
Leafy vegetables								
Amaranth, green	8.5	1.5	7.5	23.7	3.2	14.0	6.6	34.6
Amaranth, red	6.7	1.7	6.9	19.5	1.9	22.1	4.0	37.1
Borecole	2.1	4.2	10.8	36.0	2.1	22.9	3.5	18.5
Cabbage	3.2	2.2	12.3	22.6	1.9	20.4	7.0	30.4
Chinese cabbage	2.3	4.0	11.5	35.5	0.9	20.2	7.9	17.6
Garland chrysanthemum	3.0	1.8	6.0	36.5	2.0	14.7	16.4	19.5
Head lettuce	3.9	2.1	6.6	30.6	2.3	14.9	8.3	31.2
Leaf lettuce	2.1	2.4	6.9	33.9	2.6	19.6	6.6	26.0
Leaf mustard	1.8	2.0	8.3	31.9	3.0	19.2	8.5	25.3
Pea leaves	3.8	2.0	22.4	20.6	3.2	21.6	6.1	20.2
Pe-tsai, Chin-chian	3.3	3.6	7.4	36.8	3.8	18.2	7.2	19.8
Pe-tsai	2.4	3.6	8.0	32.9	1.1	22.1	6.4	22.7
Rape	3.0	3.4	8.8	39.0	2.7	15.2	7.1	21.0
Spinach	7.4	1.6	18.2	27.0	0.5	16.3	5.8	23.1
Sweet potato leaves	4.0	0	12.6	33.4	5.5	14.2	7.8	22.5
Water convolvulus	3.8	0	12.1	34.2	3.8	19.0	6.5	20.5
Gourds								
Bitter gourd	0	5.9	5.5	30.7	2.5	38.2	7.9	9.3
Bottle gourd	0.3	2.2	2.9	24.2	1.2	51.3	2.9	14.9
Cucumber, large	0.3	2.4	4.5	26.8	3.9	37.2	11.2	13.8
Cucumber, small, unpeeled	0.7	1.6	7.7	28.0	4.3	32.5	10.2	15.0
Sponge gourd	0.6	0.8	11.7	17.1	0.1	35.8	19.6	14.3
Wax gourd	0.7	0	22.0	28.3	3.6	23.8	29.5	12.2
Legumes, fresh								
Green Bean	2.8	2.3	17.8	18.5	1.4	33.7	7.0	16.6
Lima bean	1.3	0.9	29.2	31.2	1.6	4.7	15.8	15.3
Podded pea	3.1	2.2	17.9	33.4	0	23.1	7.3	12.9
Soybean, immature	2.5	2.4	20.7	9.2	6.4	35.9	0	22.9
Yard long bean	4.0	2.1	16.7	31.3	4.0	14.0	11.2	16.7
Stems, flowers, fruit								
Asparagus, green	1.8	2.1	10.7	48.3	4.3	13.7	6.1	13.0
Bamboo shoot, green	1.3	0	20.7	40.8	0.2	8.0	23.2	5.8
Bell Pepper, green	1.0	0.1	13.7	32.2	2.3	29.3	11.2	10.1
Broccoli	2.5	2.7	20.5	23.1	2.3	25.4	7.0	16.5
Cauliflower	2.7	31	19.3	20.8	2.4	24.1	6.6	21.0
Celery, Chinese	3.2	1.6	8.1	38.1	0.2	19.8	6.8	21.7
Coba shoot	0.1	0	22.8	32.3	0.6	8.6	29.3	6.3
Daylily flower	1.1	2.0	2.8	19.9	15.3	31.9	10.7	16.3
Eggplant	2.2	0	11.6	28.1	2.3	35.1	7.7	13.0
Leek, Chinese	1.9	2.8	7.8	36.2	3.8	26.2	6.9	14.4
Leek, etiolated	1.6	2.0	3.8	25.6	0.5	53.8	0	12.6
Leek flower	1.7	3.1	7.8	54.1	5.1	12.2	5.7	10.4
Mung bean sprout	1.8	2.7	12.4	27.3	0.4	35.3	9.9	10.2
Pea sprout	1.5	1.2	16.4	47.7	0.7	12.8	5.4	14.3
Soybean sprout	1.8	1.3	23.9	25.2	0.7	25.1	6.3	15.6
Mushrooms								
Forest mushroom	0	0.4	0.4	3.1	6.6	1.7	81.6	6.3
Mushroom	0	0	0.6	1.6	0.9	1.0	81.3	14.5
Straw mushroom	0	0	0.1	2.7	6.7	3.4	74.7	12.4
Winter mushroom	0	0.9	0.1	7.4	8.9	0	78.8	3.1
Tubers & roots								
Burdock	1.1	0.4	18.7	46.4	0.7	10.9	2.8	19.1
Carrot	2.8	0	14.2	12.8	0.4	35.7	7.6	26.4
Kohlrabi	4.6	3.2	13.6	33.6	0.3	18.1	6.7	19.8
Lotus root	3.5	0	12.5	7.1	3.0	39.7	5.2	29.0
Onion, yellow	0.6	2.5	4.8	20.9	0.3	60.1	2.1	8.8
Radish, Chinese	3.2	2.1	13.9	23.4	1.4	22.3	8.3	25.5
Water chestnut	0	0	14.8	40.9	3.2	31.8	0	9.3

*INCP: insoluble non cellulose polysaccharides; #Rha: rhamnose; Fuc: fucose; Ara: arabinose; Xyl: xylose; Man: mannose; Gal: galactose; Glu: glucose

The water-extracted residue was further treated with 1M H_2SO_4 to separate insoluble non cellulose polysaccharides (INCP) from the rest of the insoluble fibre[18]. Again, the difference in weight after this acid extraction was taken as the amount of INCP. The acid-soluble supernatant was also saved for sugar and uronic acid assay. The remaining residue was then incubated with 12M H_2SO_4 to hydrolyse the cellulose. The unhydrolysed residue was weighed and ashed at 500° C. The reduction in weight after a 12M sulphuric acid treatment was taken to be cellulose and the loss during incineration was taken as lignin.

Sugar composition was determined by gas chromatography after the conversion to alditol acetate[17]. A 3% SP2330 packed column (Supelco Co., PA, USA) was used with both the injection and detection temperature of 250° C. The column temperature was programmed from 195° C to 225° C at 2° C/ min. Uronic acid was determined by a colorimetric method[19].

Results

The contents of total dietary fibre of 53 vegetables are shown in Table 1. On a wet weight basis, TDF varies from 0.71% in large cucumbers to 13.24 % in lima beans. The values in each group of vegetables also vary. However, as percentage of dry weight, more consistent values of TDF are seen in each group except the tubers and roots group. In leafy vegetables, those consumed with the stem, such as water convolvulus and amaranth, have a higher fibre content than those without stems such as cabbages. Lima beans and immature soybeans contain less water than most other vegetables (70% vs. 90%), so the TDF of these two legumes is especially high on a wet weight basis.

Table 1 also shows the percentage, on a dry weight basis, of SDF, INCP, cellulose and lignin in vegetables. Generally, SDF level is less than the insoluble fibre levels (INCP + cellulose + lignin) in most vegetables with the exception of sponge gourds, burdocks and carrots. Water chestnuts had the least proportion of soluble fibre (8%). When dietary fibre was calculated as the sum of SDF, INCP, cellulose and lignin, the recovery ranged from 99.8% to 110.1% of the TDF values shown in Table 1.

Sugar and uronic acid composition of SDF are shown in Table 2. In most cases, uronic acid contributes the largest part of SDF. Mushrooms, however, are very different in their sugar composition of SDF with glucose and galactose as the two major constituents. Table 3 shows sugar and uronic acid composition of INCP. In most vegetables, arabinose, xylose and galactose are the predominant sugars in INCP. But the composition of INCP in mushrooms is also different in that glucose is the major constituent.

Discussion

In this paper, no intention was taken to cover all the varieties of each vegetable produced in Taiwan. However, since seasonal produces are rapidly and well distributed around the island, the samples collected are considered widely available.

The reason for using centrifugation instead of filtration in the separation of total dietary fibre is for easier collection of fibre for further fractionation. To examine the possible discrepancies in the results from filtration and centrifugation, several samples were assayed by both methods. On average, TDF from centrifugation was about 8% less than that from filtration. A standard reference material (SRM 1548, National Institute of Standards & Technology, USA) was also tested using the centrifugation procedure and measured 4.01% as TDF, which is higher than the certified value of 3.69%.

To determine the reproducibility of our assay procedure, seven vegetables from different groups were repeatedly measured for their TDF content. The coefficients of variation (CV) of four measurements are as follows: sweet potato leaves, 2.3%; large cucumbers, 7.0%; green beans, 11.4%; mushrooms, 1.8%; radishes, 4.5%; broccoli, 5.8%; mung bean sprouts, 5.1%. It seems the CV values all lie within a reasonable range.

When the TDF values in this present paper are compared with the data of neutral detergent fibre (NDF) from our previous report[13], all TDF values are higher than the NDF values of the same item of vegetable. This has been expected since the NDF method likely loses most of the soluble parts of the dietary fibre[20].

Table 4 gives the comparison of some TDF values from the present study with data from mainland China[21] and the USA[22]. Some variation is expected due to differences in species, growing conditions, age of harvesting of samples and the analytical methods.

Table 4. Comparisons of dietary fibre values of selected vegetables from Taiwan, mainland China and USA

Vegetable	Total dietary fibre (g/100g edible portion)		
	Taiwan[a]	China[b]	USA[c]
Cabbage	1.7	2.3	1.7
Cauliflower	2.5	3.2	2.3
Carrot	3.3	3.3	2.5
Chinese celery	2.5	2.3	NA
Green pepper	1.4	NA	1.7
Onion, yellow	1.0	NA	1.7
Wax gourd	1.1	1.6	NA

a: data from present study; b: data from Wang et al.[21]; c: data from Marlett[22]; NA: not analysed

According to the household dietary survey in Taiwan (1986-1988)[23], the intake of vegetables per capita was 314g, which supplied about 4.7g of dietary fibre based on TDF values from this study. If adopting the recommended fibre intake of 20-35g per day for Americans[24], people in Taiwan need to increase consumption of complex carbohydrates and vegetables to assure adequate fibre intake.

The majority of vegetables analysed contained more insoluble fibre than soluble fibre. This result is in agreement with data from other reports[21,22]. However, for sponge gourd and carrot, higher proportion of soluble fraction than insoluble fraction was found. Similar results were also shown in Wang et al's paper[21]. In contrast, Marlett reported a much higher percentage of insoluble fibre (92% of TDF) than soluble fibre in the carrot

sample[22]. This discrepancy can be partly explained by the different species of carrots grown in Asia and the USA.

In this study, the cellulose fraction was not analysed for its sugar composition since it consists mainly of glucose. In most vegetables, uronic acid occupied a large proportion of soluble fibre which reveals that pectin is the predominant component of soluble fibre in those items. Galactose and arabinose are the most abundant neutral sugars in most of the vegetables analysed. This is also demonstrated in the reports of Englyst and Cummings[17] and Marlett[22].

Among the vegetables analysed, mushrooms are especially noteworthy for their very distinct composition of SDF and INCP. In both fractions of mushrooms, there was more glucose than any other constituent, which indicates that the major component of soluble fibre in mushrooms is not pectin. Marlett[22] has also reported that the glucose residue took up 55% of all neutral sugars and there was only a trace amount of pectin found in the mushrooms. Kurasawa et al. assayed 26 kinds of mushrooms in Japan and reported an average of 39% (dry weight basis) of dietary fibre in those mushrooms[25]. But there was no data on the sugar composition of these mushrooms available. Since varieties of mushrooms are widely cultivated and are increasingly consumed nowadays in Taiwan, the physical and chemical properties of their dietary fibre is an area worth further investigation. These results of dietary fibre content and composition of vegetables can be applied to basic nutrition research and clinical nutrition in the Taiwan and Southeast Asian area.

Acknowledgement

The authors wish to thank Kuo-Yu Chang, Yichih Ma and Chuan Yu for their technical assistance. This work was supported by a grant (DOH80-71) from Department of Health, The Executive Yuan, Republic of China.

Dietary fibre content and composition of vegetables in Taiwan Area

Su-Chien Chang, Meei-Shyuan Lee, Ching-Hui Li, Mou-Liang Chen

Asia Pacific Journal of Clinical Nutrition (1995) Volume 4, Number 2: 204-210

台灣地區蔬菜的膳食纖維含量及組成

摘 要

本研究分析台灣地區經常食用的53種蔬菜食品之膳食纖維質。分析總膳食纖維質是採用酵素分解法，總膳食纖維質所含的各類纖維質(可溶性纖維、不可溶性非纖維素多醣、纖維素及木質素)亦加以定量。可溶性纖維(SDF)及不可溶性非纖維素多醣(INCP)再分別分析其單糖及糖醛酸的含量比例。分析的蔬菜包括葉菜類16項、瓜類6項、新鮮豆類5項、芽菜及花果類15項、菇類4項、及根莖類7項。所分析的蔬菜樣本含總膳食纖維質從0.71%〔佔可食量比例〕至13.24%不等。大部份蔬菜的不可溶性纖維含量比例多於可溶性纖維，但絲瓜、牛蒡及胡蘿蔔則含較多的可溶性纖維質。多數蔬菜的可溶性纖維組成中以糖醛酸含量最多，不可溶性非纖維素多醣則以木糖及半乳糖含量較高。但菇類的膳食纖維組成比較特殊，其可溶性纖維及不可溶性多醣都含多量的葡萄糖。這些常用蔬菜之膳食纖維質含量及成分資料，可供台灣或東南亞地區基礎營養研究或營養評估之參考。

References

1. Burkitt DP, Trowell H. Refined carbohydrate foods and disease: Implications of dietary fibre. London: Academic Press, 1975.
2. Theander O. Chemistry of dietary fibre components. Scand J Gastroenterol 1987; 129 [suppl]: 21-28.
3. Harris PJ, Ferguson LR. Dietary fibre: its composition and role in protection against colorectal cancer. Mutat Res 1993; 290: 97-110.
4. Khaw K-T, Barrett-Connor E. Dietary fiber and reduced ischemic heart disease mortality rates in men and women: a 12-year prospective study. Am J Epidemiol 1987; 126: 1093-1102.
5. Kritchevsky D. Dietary fiber. Ann Rev Nutr 1988; 8: 301-328.
6. Schneeman BO, Lefevre M. Effects of fiber on plasma lipoprotein composition. In: Vahouny GV, Kritchevsky D, eds. Dietary fiber, basic and clinical aspects. New York: Plenum Press, 1986: 309-321.
7. Anderson JW, Gilinsky NH, Deakins DA, Smith SF, O'Neal DS, Dillon DW, Oeltgen PR. Lipid responses of hypercholesterolemic men to oat-bran and wheat-bran intake. Am J Clin Nutr 1991; 54: 678-683.
8. Ripsin CM, Keenan JM, Jacobs DR, Elmer PJ, Welch RP, Van Horn L, Liu K, Turnbull WH, Thye WH, Kestin M. Oat products and lipid lowering. A meta-analysis. JAMA 1992; 267: 3317-3325.
9. Council of Agriculture, Executive Yuan, ROC. Taiwan food balance sheets, 1950-1984.
10. Chen M-L, Chang S-C, Chang W-K. Time trend of dietary fat and fiber consumption and mortality of neoplasms in Taiwan- colon-rectum and mammary cancer. J Chin Nutr Soc(ROC) 1988; 13:1-10.
11. Pan W-H, You S-L, Hsu C-P, Chou J, Huang P-C. Major food contributors of various nutrients consumed by Chinese populations in Taiwan, 1980-1981(1): calorie, protein, carbohydrate, fat, fatty acids, cholesterol and crude fiber. J Chin Nutr Soc(ROC) 1991; 16: 1-19.
12. Robertson JB, Van Soest PJ. The detergent system of analysis and its application to human foods. In: James WPT, Theander O, eds. The analysis of dietary fiber in food. New York: Marcel Dekker, 1981: 123-158.
13. Chen M-L, Chang S-C, Guoo J-Y. Fiber contents of some Chinese vegetables and their in vitro binding capacity of bile acids. Nutr Rep Int 1982; 26: 1053-1059.
14. Prosky L, Asp N-G, Furda I, DeVries JW, Schweizer TF, Harland BF. Determination of total dietary fiber in foods, food products, and total diets: interlaboratory study. J Assoc Off Anal Chem 1984; 67: 1044-1052.
15. Prosky L, Asp N-G, Schweizer TF, DeVries JW, Furda I. Determination of insoluble, soluble, and total dietary fiber in foods and food products: interlaboratory study. J Assoc Off Anal Chem 1988; 71: 1017-1023.
16. Chen Lin W-J, Anderson JW. Soluble and insoluble plant fiber in selected cereals and vegetables. Am J Clin Nutr 1981; 34: 1077-1082.
17. Englyst HN, Cummings JH. Improved method for measurement of dietary fiber as non-starch polysaccharides in plant foods. J Assoc Off Anal Chem 1988; 71: 808-814.
18. Anderson JW, Bridges SR. Dietary fiber content of selected foods. Am J Clin Nutr 1988;.47: 440-447.
19. Blumenkrantz N, Asboe-Hansen G. New method for quantitative determination of uronic acids. Anal Biochem 1973; 54: 484-489.
20. Neilson MJ, Marlett JA. A comparison between detergent and nondetergent analyses of dietary fiber in human food stuffs, using high performance liquid chromatography to measure neutral sugar composition. J Agri Food Chem 1983; 31: 1342-1347.
21. Wang G, Robertson J, Parpia B, Chen J, Campbell TC. Dietary fiber composition of selected foods in the People's Republic of China. J Food Comp Anal 1991; 4: 293-303.
22. Marlett JA. Content and composition of dietary fiber in 117 frequently consumed foods. J Am Diet Assoc 1992; 92: 175-186.
23. Lee N-Y, Chu Y-C, Chang C-P, Shieh M-J, Kao M-D. Dietary survey in Taiwan area, 1986-1988. J Chin Nutr Soc(ROC) 1991; 16: 39-60.
24. Healthy people 2000: National health promotion and disease prevention objectives. Washington, DC: US Dept of Health and Human Services, Public Health Service, 1990.
25. Kurasawa S-I, Sugahara T, Hayashi J. Studies of dietary fibre of mushrooms and edible wild plants. Nutr Rep Int 1982; 26: 167-173.