

Dietary fiber content and composition of fruits in Taiwan

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Forty-one fresh fruits frequently consumed in the Taiwan area were analysed for their dietary fiber content by an enzymatic-gravimetric method. Total dietary fiber (TDF) of these fruits ranged from 0.2 g (per 100 g edible weight) in grapes to 8.6 g in eggfruit. In citrus fruit, the proportion of soluble fiber in TDF was more than 50%. However, in some fruits like guavas and waxapple, soluble fiber took less than 30% of TDF. Soluble fiber in almost all fruit was comprised of a large amount of uronic acids, while the composition of insoluble non-cellulose polysaccharides (INCP) varied a great deal. Mangos and pummelos of different varieties were different in their sugar composition of INCP. Insoluble non-cellulose polysaccharides of a crisp type of persimmon had more arabinose and galactose, but those of soft persimmon contained mainly xylose. These results show that different types of fruit are distinct in their composition and hence, the properties of their dietary fiber. These data are useful for dietary assessments in Taiwan and South-East Asia.

Keywords: dietary fiber, fruit, soluble fiber, insoluble fiber.

Introduction

Dietary fiber has been a subject of attentive research since the term was coined by Burkitt and Trowell in the early 1970s.¹ Findings of the beneficial effect of a high fiber diet continued to be reported.² High fiber intake has been shown to be inversely associated with the risk of coronary heart disease^{2–4} and colorectal cancer.^{5,6} However, fiber from different food sources did not exert the same beneficial health properties,^{2–7} which may be due to differences in the compositions of the food sources. The composition of dietary fiber of 53 commonly consumed vegetables in Taiwan was reported previously.⁸ The results showed a wide variation in the contents of fiber components among vegetables. In the past two decades, the amount of fruit available per capita in Taiwan has almost doubled due both to increases in domestic production and to importation.⁹ According to a dietary survey, fruit was the second contributor of fiber next to vegetables in the diets of people in Taiwan;¹⁰ therefore, dietary fiber values of fruit are essential in estimating the total fiber intake in the Taiwan area. In this report, the fiber content and composition of 41 fruits grown locally were listed. The sugar composition of both soluble fiber and insoluble non-cellulose polysaccharides were also presented. This paper, and the previous one on vegetables,⁸ provide basic information for evaluating the dietary effects of fiber intake in Taiwan.

Methods

All fruits were purchased from local markets in Taiwan. For each item, three samples were obtained from different markets and the data presented is the average value. According to local consuming habits, fruit samples were hulled, peeled or seeded. The edible portion was either sliced or homogenized, freeze-dried and milled to particles of between 0.60 and 0.25 mm in size. Dietary fiber was determined by a modified procedure from the enzymatic-gravimetric method¹¹ as detailed in a previous report.⁸ Quadruplicate samples

(0.5000 g each) were first extracted with methanol and ether to remove pigments.¹² The extracted residue was treated consecutively with α -amylase, protease and amyloglucosidase.¹³ The weight of undigested residue after subtracting the weight of protein and ash was quantified as total dietary fiber (TDF).

The TDF precipitate was dissolved in hot water to extract soluble dietary fiber (SDF). The residual insoluble part was then separated into insoluble non-cellulose polysaccharides (INCP), cellulose and lignin by acid treatments.¹⁴ The sugar compositions of SDF and INCP were determined by gas chromatography in the form of alditol acetate.¹⁵ Uronic acid in SDF and INCP was determined by a colorimetric method.¹⁶

Results

The contents of total dietary fiber of 41 fruits are shown in Table 1. Because most fruits contained a high amount of water, the fiber contents of all fruits were less than 10% of the edible weight. Grape (peeled) had the least amount of fiber (0.2%). Eggfruit, with less moisture, contained the highest amount of TDF (8.6%). When TDF was calculated as the percentage of dry matter, it ranged from 48.3% in white guava to 1.2% in grape (Table 2).

Table 2 also presents the contents of individual component of dietary fiber. The composition varied widely among fruits. In the citrus group, for example lemons, oranges and pummelos, SDF contributed more than 50% of total fiber. There were also fruits in which cellulose comprised about 40% of dietary fiber, for example yellow pear, eggfruit, and papaya. Persimmons had a particularly high percentage of lignin, which was almost half of total dietary fiber.

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The composition of constituent sugars and uronic acid of SDF is shown in Table 3. In almost all fruits, SDF was composed mainly of uronic acid. Arabinose and galactose were the next abundant sugars in most items. However, banana, grape, and pineapple had more mannose in their SDF. Compared with SDF, the composition of INCP was more inconsistent (Table 4). Some fruits contained more xylose, such as guavas, pears, and pineapple. Some, such as carambola, longan, and lychee, had high arabinose in the INCP part. Persimmons of different treatments were very different in their composition of INCP, as the crisp type had more arabinose and galactose but the soft type was high in xylose.

Some fruit of different varieties such as guavas and mangos are similar in TDF content, although this is not so for the plum group (Table 1). The green variety of plum had higher contents of all fiber components than did the other two vari-

eties. However, their SDF and INCP compositions are all alike.

Discussion

The fruits assayed in this paper were limited to those produced in the Taiwan area given that the imported varieties could be referred to in food composition data of their place of origin.

There are few data on fruit fiber from other countries with which the present results could be compared. The TDF values of some fruits¹⁷⁻¹⁹ analyzed by the enzymatic-gravimetric method are listed in Table 5. These values vary within a reasonable range as some variation would be expected due to difference in variety or ripening condition of samples. Pineapple in our study was assayed without removing the core, which may account for the higher dietary fiber value.

Table 1. Dietary fiber content of fruits in Taiwan

Food item		Total dietary fiber (% of edible weight)
English name	Scientific name	
Apple, green	<i>Malus pumila</i>	4.2
Apple, red (peeled)	<i>Malus pumila</i>	1.0
Banana	<i>Musa sapientum</i>	2.0
Carambola	<i>Averrhoa carambola</i>	1.8
Eggfruit	<i>Lucuma nervosa</i>	8.6
Grape, purple (peeled)	<i>Vitis vinifera</i>	0.2
Guava, Thai	<i>Psidium guajava</i>	4.9
Guava, white	<i>Psidium guajava</i>	5.3
Indian jujube	<i>Zizyphus mauritiana</i>	2.7
Kumquat	<i>Fortunella</i> spp.	5.7
Lemon	<i>Citrus limon</i>	2.7
Longan	<i>Euphoria longana</i>	5.9
Loquat	<i>Eriobotrya japonica</i>	2.1
Lychee	<i>Nephelium litchi</i>	2.5
Mango, native	<i>Mangifera indica</i>	1.2
Mango, Irwen	<i>Mangifera indica</i>	1.4
Melon, cantaloupe	<i>Cucumis melo</i>	0.7
Melon, green	<i>Cucumis melo</i>	0.6
Melon, yellow	<i>Cucumis melo</i>	1.5
Orange, ponkan	<i>Citrus reticulata</i>	3.6
Orange, sweet	<i>Citrus sinensis</i>	5.4
Orange, tankan	<i>Citrus tankan</i>	4.1
Papaya	<i>Carica papaya</i>	2.7
Peach	<i>Prunus persica</i>	3.9
Pear, brown (peeled)	<i>Pyrus pyrifolia</i>	3.2
Pear, yellow	<i>Pyrus</i> spp.	5.2
Persimmon, crisp type	<i>Diospyros kaki</i>	4.3
Persimmon, soft type	<i>Diospyros kaki</i>	5.2
Pineapple	<i>Ananas comosus</i>	1.6
Prune (Mei), green	<i>Prunus mume</i>	2.3
Plum, oriental	<i>Prunus salicina</i>	—
green		4.0
red		1.7
yellow		1.6
Pummelo, red	<i>Citrus grandis</i>	2.3
Pummelo, white	<i>Citrus grandis</i>	2.7
Pummelo, Wentan	<i>Citrus grandis</i>	2.7
Strawberry	<i>Fragaria ananassa</i>	1.7
Tomato, small	<i>Lycopersicon esculentum</i>	2.4
Watermelon, red	<i>Citrullus vulgaris</i>	1.4
Watermelon, yellow	<i>Citrullus vulgaris</i>	0.8
Waxapple	<i>Syzygium javanicum</i>	1.4

Table 2. Dietary fiber composition of fruits in Taiwan

Food item	TDF	SDF	INCP	Cellulose	Lignin
(% of dry weight)					
Apple, green	22.1	8.9	5.8	5.4	2.0
Apple, red	8.4	3.1	1.4	3.1	0.8
Banana	7.4	4.2	1.6	0.7	1.5
Carambola	19.3	7.4	5.3	5.0	1.6
Eggfruit	27.6	8.2	4.7	10.7	3.9
Grape, purple	1.2	0.4	0.7	0.2	0.3
Guava, Thai	37.2	10.1	12.9	9.2	5.0
Guava, white	48.3	11.6	16.7	15.7	4.3
Indian jujube	23.0	8.4	7.9	2.9	3.8
Kumquat	34.0	19.4	6.6	5.6	2.5
Lemon	28.7	16.4	6.2	5.3	0.9
Longan	19.3	9.3	3.1	6.1	0.8
Loquat	16.8	8.4	3.5	3.4	1.8
Lychee	14.1	8.2	3.7	1.0	1.7
Mango, native	6.6	3.1	1.7	1.6	0.9
Mango, Irwen	10.0	3.9	3.0	1.4	1.9
Melon, cantaloupe	7.9	3.7	2.0	2.3	0.2
Melon, green skin	6.8	5.0	1.7	0.2	0.0
Melon, yellow skin	19.3	7.6	2.9	6.6	2.0
Orange, ponkan	25.7	15.4	5.1	3.3	2.0
Orange, sweet	38.7	21.7	7.7	6.9	2.8
Orange, tankan	32.5	18.6	6.7	4.4	3.3
Papaya	35.2	15.0	4.9	13.9	1.5
Peach	26.3	13.9	7.0	4.5	3.8
Pear, brown	27.9	9.5	8.3	6.7	3.6
Pear, yellow	46.9	12.2	12.8	19.0	3.1
Persimmon, crisp type	23.7	6.2	4.4	1.5	11.6
Persimmon, soft type	30.6	8.4	6.0	2.1	14.8
Pineapple	14.0	3.0	6.8	2.8	1.6
Plum, oriental					
green	37.0	17.3	8.7	7.0	4.1
red	13.9	8.5	2.5	1.3	1.6
yellow	13.8	8.2	3.2	1.6	0.9
Prune, green	25.6	12.7	5.5	5.1	2.2
Pummelo, red	25.1	15.5	5.2	0.6	3.8
Pummelo, white	21.8	11.2	5.2	1.2	4.3
Pummelo, Wentan	25.3	13.8	6.2	3.5	1.8
Strawberry	16.3	9.4	2.9	1.5	2.4
Tomato, small	29.1	12.3	5.8	5.0	5.1
Watermelon, red	17.2	8.9	3.9	2.5	3.1
Watermelon, yellow	10.9	5.1	3.1	1.6	1.0
Waxapple	20.1	5.0	7.3	4.6	3.3

TDF, total dietary fiber; SDF, soluble dietary fiber; INCP, insoluble non-cellulose polysaccharides.

Persimmons were unusually high in the proportion of lignin (Table 2) they contained. Local persimmons are harvested before ripening. Fruit of the soft variety is then injected through a small hole at the base of stalk with a few drops of alkaline solution such as sodium carbonate; the fruit then turns red and soft in a couple of days. The crisp type of persimmon is then immersed in a 4% lime solution for several days and it then becomes yellowish and crisp. These processes are carried out to eliminate the astringency coming from the high amount of polyphenols such as tannins in the unripe persimmon.²⁰ The alkaline treatments cause the polymerization of polyphenols, which become less soluble and may have contributed to the high lignin content of persimmons in our results. This attribution needs to be further explored.

In the fruits assayed, uronic acid almost exclusively comprised the largest proportion of SDF (Table 3), which revealed that pectin was the major component of soluble

fiber in most fruits. This was also demonstrated in the reports of Englyst and Cummings¹⁵ and Marlett.²¹

Compared with vegetables,⁸ the sugar composition of INCP in fruits varied a great deal more (Table 4). Mangoes of two varieties were different in their sugar composition of INCP; the native type had more xylose and galactose but the Irwen variety contained more mannose and galactose. Red pummelo and white pummelo were also distinct in their INCP composition. These denoted varied properties of dietary fiber even from the same kind of fruit. Different treatments given to persimmons after harvesting resulted in them having altered sugar composition in INCP. It is not clear how such processing changes the monosaccharide distribution in these fruits.

A household dietary survey in the Taiwan area revealed 29 types of fresh fruit commonly consumed.¹⁰ The fruit intake provided 1.6 g crude fiber¹⁰ or 3.3 g total dietary fiber

Table 3. Composition of constituent sugars and uronic acid of soluble dietary fibre in fruits

Food item	Rha (%)	Ara (%)	Xyl (%)	Man (%)	Gal (%)	Glu (%)	Uronic acid (%)
Apple, green	1.5	11.1	2.2	2.9	11.0	4.2	67.1
Apple, red	1.5	6.1	1.7	5.3	6.5	3.5	75.3
Banana	0.4	2.1	1.7	17.6	5.3	10.3	62.6
Carambola	1.0	8.5	1.2	3.1	7.5	2.7	76.1
Eggfruit	1.2	6.2	1.2	4.0	9.5	2.9	75.0
Grape, purple	0.9	5.8	1.0	17.0	8.8	7.1	59.3
Guava, Thai	1.4	12.6	1.6	2.7	6.9	3.0	71.8
Guava, white	2.0	15.6	1.3	2.5	8.8	4.7	65.1
Indian jujube	2.7	8.9	2.0	2.6	7.2	5.1	71.6
Kumquat	1.4	17.0	0.8	2.4	17.6	3.3	57.5
Lemon	1.8	10.4	0.8	3.3	12.4	3.5	67.8
Longan	2.1	20.6	2.7	11.4	9.0	6.3	47.9
Loquat	1.5	17.4	2.7	5.3	5.7	3.4	64.0
Lychee	1.8	22.2	0.5	6.1	8.5	2.4	58.6
Mango, native	1.1	8.5	2.8	4.7	18.3	6.2	58.3
Mango, Irwen	1.0	10.5	1.1	2.0	16.7	5.6	63.1
Melon, cantaloupe	1.4	6.5	2.7	10.1	9.7	7.7	61.9
Melon, green skin	0.6	3.0	0.8	8.0	11.4	4.7	71.4
Melon, yellow skin	1.1	2.3	1.2	1.8	5.1	2.5	85.9
Orange, ponkan	2.1	9.2	1.6	3.2	10.6	3.1	70.1
Orange, sweet	1.3	11.9	1.1	2.8	15.2	4.9	62.7
Orange, tankan	1.6	10.1	0.4	2.4	7.9	1.5	76.1
Papaya	1.9	2.4	2.0	4.2	6.4	4.6	78.5
Peach	1.8	18.4	1.9	3.3	10.0	4.7	59.8
Pear, brown	1.5	10.7	4.8	3.6	8.0	8.8	62.6
Pear, yellow	2.5	16.9	3.9	3.2	8.2	5.2	60.1
Persimmon, crisp type	2.5	13.7	2.3	7.0	24.4	7.6	42.5
Persimmon, soft type	2.3	13.6	4.0	7.2	13.0	11.0	48.9
Pineapple	0.0	7.8	9.5	22.6	18.0	10.8	31.3
Plum, oriental							
green	1.5	8.0	0.5	2.6	34.4	3.5	49.4
red	1.4	12.3	1.0	3.9	38.8	5.3	37.3
yellow	1.5	7.1	0.7	2.0	22.3	1.3	65.1
Prune, green	1.4	6.8	1.1	2.6	10.4	3.8	74.0
Pummelo, red	2.8	19.6	1.1	5.0	9.9	4.5	57.1
Pummelo, white	1.2	15.1	1.0	3.6	7.0	3.8	68.3
Pummelo, Wentan	1.5	21.3	0.7	5.3	12.2	5.6	53.4
Strawberry	1.3	6.9	2.7	4.9	12.6	5.6	65.9
Tomato, small	2.4	5.2	2.2	4.6	9.8	3.9	71.9
Watermelon, red	0.9	4.0	8.5	6.8	8.0	4.0	67.7
Watermelon, yellow	0.9	6.5	7.4	12.0	11.2	4.8	57.2
Waxapple	1.8	7.6	1.5	6.1	8.7	3.8	70.4

Rha, rhamnose; Ara, arabinose; Xyl, xylose; Man, mannose; Gal, galactose; Glu, glucose.

Table 4. Composition of constituent sugars and uronic acid of INCP in fruits

Food item	Rha (%)	Fuc (%)	Ara (%)	Xyl (%)	Man (%)	Gal (%)	Glu (%)	Uronic acid (%)
Apple, green	1.7	3.1	20.8	20.0	6.4	26.9	5.8	15.3
Apple, red	1.9	3.2	23.3	26.9	2.9	13.1	5.5	23.1
Banana	0.0	0.0	19.4	15.6	22.3	15.4	10.6	16.7
Carambola	1.3	1.6	39.8	11.3	9.3	19.7	4.7	12.3
Eggfruit	1.8	1.7	15.5	16.5	8.5	36.7	8.1	11.2
Grape, purple	0.0	0.0	5.4	18.6	36.1	9.2	7.6	21.5
Guava, Thai	1.6	1.8	14.8	53.1	2.7	11.9	3.1	11.1
Guava, white	1.3	1.3	13.7	55.1	3.7	10.9	3.1	10.8
Indian jujube	3.3	2.4	23.5	17.0	6.6	21.0	5.0	21.2
Kumquat	2.8	0.8	20.0	18.0	5.6	28.7	4.3	19.8
Lemon	1.4	1.6	18.2	17.1	6.7	37.4	2.6	15.0
Longan	1.5	1.8	39.9	19.1	4.6	13.3	4.6	15.2
Loquat	1.6	1.0	33.6	23.3	7.3	10.2	3.6	18.6
Lychee	0.0	0.0	45.3	9.1	13.3	8.9	5.1	18.4
Mango, native	0.8	3.1	12.9	24.7	11.7	30.5	6.5	9.8
Mango, Irwen	0.9	0.7	11.0	15.0	33.6	23.2	6.1	9.5
Melon, cantaloupe	0.3	2.6	6.5	30.2	14.2	19.8	10.2	16.1
Melon, green skin	1.4	2.4	6.2	23.9	23.5	23.9	7.2	11.4
Melon, yellow skin	1.4	3.1	3.9	31.5	15.5	19.9	10.9	13.8
Orange, ponkan	0.8	1.7	14.7	20.8	9.5	29.0	3.3	20.1
Orange, sweet	1.9	0.4	17.5	12.7	8.8	25.4	2.7	30.5
Orange, tankan	0.6	1.5	20.7	15.8	6.1	26.3	2.1	26.9
Papaya	1.3	3.4	3.0	30.3	10.7	13.6	11.4	26.3
Peach	1.7	2.7	34.0	19.4	7.4	24.9	3.8	6.0
Pear, brown	1.2	2.0	17.7	41.6	3.0	15.0	4.7	14.9
Pear, yellow	1.9	1.6	19.0	45.5	3.0	12.4	1.5	15.0
Persimmon, crisp type	1.5	0.0	20.9	12.7	13.9	38.1	5.3	7.6
Persimmon, soft type	0.0	0.7	4.5	66.3	8.2	7.6	2.5	10.2
Pineapple	0.6	0.6	21.8	44.4	1.9	16.8	3.9	10.0
Plum, oriental								
green	1.1	1.5	15.8	14.1	6.6	44.1	5.5	11.1
red	0.0	2.2	16.3	15.8	16.8	33.7	7.6	7.6
yellow	1.2	1.8	24.6	12.0	15.0	37.2	1.2	6.9
Prune, green	0.0	3.8	6.9	32.3	22.0	20.0	6.8	8.2
Pummelo, red	1.1	1.2	17.0	25.0	11.2	18.1	6.8	19.6
Pummelo, white	1.8	1.8	38.1	13.6	6.3	14.4	5.1	18.9
Pummelo, Wentan	1.9	1.7	31.7	14.7	6.4	26.0	4.2	13.4
Strawberry	1.6	2.3	10.3	30.9	8.6	20.8	6.6	18.7
Tomato, small	1.8	0.0	12.5	17.4	21.3	19.7	6.9	20.5
Watermelon, red	1.6	3.0	13.0	28.4	9.9	21.9	5.2	17.0
Watermelon, yellow	2.1	3.6	12.9	22.5	9.2	19.0	5.8	24.8
Waxapple	2.9	2.5	35.4	18.3	3.9	17.0	4.8	15.2

Rha, rhamnose; Fuc, fucose; Ara, arabinose; Xyl, xylose; Man, mannose; Gal, galactose; Glu, glucose.

Table 5. Total dietary fiber values of selected fruits of different areas

Fruit	Total dietary fibre (% dry weight)			
	Taiwan ^a	Japan ^b	Mexico ^c	Italy ^d
Apple, peeled	8.4	11.9	#	12.8
Banana	7.4	7.0	5.6	6.7
Strawberry	16.3	18.2	23.0	23.3
Pineapple	14.0*	6.4	8.0	5.9

^a Data from present results; ^b data from Nishimune *et al.*¹⁷; ^c data from Rosado *et al.*¹⁸; ^d data from Lintas and Cappelloni¹⁹; #, value not reported; *, samples were not cored.

based on the TDF values of this report. Given that the contribution of fruit to the fiber content of local diet was only second to vegetables,¹⁰ and that fruit consumption in recent years has largely increased according to the food supply status,⁹ these data of dietary fiber content and composition of fruit would be useful in basic and clinical nutrition research in Taiwan and South-East Asia.

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臺灣地區水果的膳食纖維含量及組成

摘要

本研究分析臺灣地區生產的 41 種水果之膳食纖維質。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。分析的水果包括柑橘類、瓜果類及荔枝、龍眼、枇杷、蓮霧等區域性水果。所分析的水果樣本總膳食纖維質含量不一，最低為 0.2%（葡萄），最高為 8.6%（蛋黃果）。柑橘及柚子等類水果的可溶性纖維佔總膳食纖維含量 50% 以上，番石榴、蓮霧等的可溶性纖維則小於 30%。多數水果的 SDF 中以糖醛酸含量最多，但 INCP 的單醣組成則變異較大。同類水果但不同品種如白柚與紅柚等的 INCP 組成也不相似，軟柿及脆柿因處理方法不同也具不同 INCP 組成。這些常用水果之膳食纖維質含量及成份資料，可供臺灣或東南亞地區基礎營養研究或營養評估之參考。

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