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Analysis of Dietary Fiber Content of Common Korean Foods

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Abstract

Eighty nine common Korean foods were analyzed by the enzymatic-gravimetric method developed by Prosky *et al.* and adopted by AOAC to determine total dietary fiber (TDF) content. The average TDF content of the foods analyzed was 4.78±3.55% for cereal and grain products, 2.56±1.65% for potatoes and starches, 1.94±0.77% for sugar and sweets, 10.81±6.57% for pulse and pulse products, 9.70±5.92% for nuts and seeds, 15.38±15.76% for seasonings, and 4.98±4.35% for beverages. The foods containing the highest TDF values in the food groups were whole grain barley (17.88%) in cereals, yellow soybean (21.05%) in pulses, black sesame (21.34%) in nuts and seeds, and red pepper powder (39.37%) in seasonings except San Cho powder (52.43%). TDF content of rice, the main staple food of Korea, was 2.75% for brown rice and 0.96% for well-milled rice. The TDF value of the foods analyzed ranged from 0.12 to 23.4 times that of crude fiber reported in the Korean food composition tables. When we consider dietary fiber contents of foods and food consumption patterns together, it is recommended to consume brown rice instead of well-milled rice and increase the consumption of minor cereals and pulses to raise dietary fiber intake.

Key words : total dietary fiber, cereal, pulse

INTRODUCTION

Since Burkitt *et al.* (1,2) and Trowell (3) proposed 'fiber hypothesis', many studies (4-9) have demonstrated the health and therapeutic benefits of dietary fiber and have recommended an increase in the intake of dietary fiber. Dietary fiber is a heterogeneous mixture of polysaccharides and lignin, resistant to hydrolysis by human digestive enzymes (9,10). Thus there is no exact definition of dietary fiber nor one internationally agreed method of dietary fiber analysis.

As an interest in the role of dietary fiber in human nutrition has increased, many countries such as U.S.A., U.K., Japan and Norway have measured dietary fiber content of foods using a variety of fiber analysis methods (11-20). However, there are not enough studies to determine dietary fiber content of foods in Korea. Several investigators (21-25) measured fiber content of some vegetables by Mongeau method, Prosky method, Southgate method, or Van Soest method. Kim *et al.* (26,27) have recently analyzed twenty Korean foods including cereals, pulses, vegetables and seaweeds to determine dietary fiber content using AOAC Prosky method (28), Mongeau-Brassard method (29) and Englyst method (30). It was suggested that the determination of total dietary fiber (TDF) by AOAC method took less time and showed smaller amount of error than by Mongeau-Brassard method.

Since there were no systematic studies to measure TDF content of Korean foods, crude fiber (CF) values, not TDF, are presented in Korean food composition tables (31,32). CF analysis measures only 50 to 80% of cellulose, 10 to 50% of lignin, and about 20% of insoluble hemicellulose. Since CF value of foods was reported to be only one fifth of TDF value (33), it is impossible to use the food composition tables to estimate dietary fiber intakes in Korea. Therefore, studies to assess dietary fiber content of Korean foods using the precise and accurate method of dietary fiber analysis are clearly needed.

The purposes of the present study are to determine dietary fiber content of Korean foods and to evaluate those foods as sources of dietary fiber. TDF value of

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eighty nine common Korean foods was determined by the enzymatic-gravimetric method which was developed and modified by Prosky *et al.* (34) and adopted by AOAC in 1988 (28). The AOAC method is at present the most widely used fiber analysis method because it has shown good reproducibility (35) and is well-adapted to meet the needs of food labeiling and quality control (36). The present study would also contribute to the development of a database which could be used to estimate dietary fiber intake in Korea.

MATERIALS AND METHODS

Sample preparation

Foods in cereal and grain products, potatoes and starches, sugar and sweets, pulse and pulse products, nuts and seeds, seasonings, and beverages which contain more than 2% of CF were selected, based on the food composition tables developed by the Korea Institute for Population and Health (31) and by the Rural Nutrition Institute (32). In addition, some frequently consumed foods were chosen, based on the National Nutrition Survey Report by the Ministry of Health and Social Affairs (37) and A Study on the Development of a Model of Balanced Diet for Korea by the Korea Advanced Food Research Institute (38).

Foods were purchased locally from LG supermarket and open markets in Changwon from 1994 through 1995. Foods containing more than 5% fat were defatted with petroleum ether before milling. The wet samples were freeze-dried before milling. The samples were ground by a mill (Samsung Co., Korea) to 40 mesh and stored in capped jars in a desiccator until analysis was carried out.

Dietary fiber analysis

TDF content of eighty nine foods was analyzed by AOAC Prosky method (28). Four 1-g samples of each material were weighed out into beakers. 50ml of pH 6.0 phosphate buffer and 0.1ml of α-amylase (Sigma Chemical Co., St. Louis, MO, USA) were added to each beaker. The beakers were incubated for 15min in a boiling water bath and cooled to room temperature. 0.1ml of protease and 0.3ml of amyloglucosidase (Sigma Chemical Co., St. Louis, MO, USA) were added. The beakers were incubated in a 60°C shaking water bath for 30min after 0.275N NaOH and 0.325N HCl were added in turn. Four volumes of 95% ethanol were added to each beaker and the solution was set overnight at room temperature to precipitate dietary fiber. Each enzyme digest was filtered through fritted crucible containing dried Celite (Sigma Chemical Co., St. Louis, MO, USA) while suction was applied. The residues were washed with 78% ethanol and acetone successively. The crucibles containing the residues were dried in 105°C oven, cooled in a desiccator and weighed. The residues from two samples were anlayzed for protein by Kjeldahl method (39) using 6.25 as protein factor except where nitrogen content in the protein sample is shown by Sin (40) and AOAC (41). The residues from the other two samples were ashed for 5 hr at 525°C, cooled in a desiccator, and weighed. The TDF is weight of the residue less weight of the protein and ash. Blanks were run through the entire procedure along with samples to measure any contributions from reagents to residue weight. The TDF value was expressed as a percentage of dry and wet weight of the food.

RESULTS AND DISCUSSION

TDF content of eighty nine common Korean foods based on dry and wet weight is shown in Tables 1~8. The amount of dietary fiber of the twenty nine foods in cereal and grain products based on wet weight ranged from 0.67% in Ka Rae Ddok to 17.88% in whole grain barley (Table 1). The mean ($\pm$SD) TDF content of cereal and grain products was 4.78$\pm$3.55%. TDF content of rice, the staple cereal of Korea, was 2.75% for brown rice and 0.96% for well-milled rice. Thus, it is suggested that consumption of brown rice instead of well-milled rice should be encouraged to increase intake of dietary fiber. The concentration of TDF of well-milled rice from the present study was similar to that reported by Kim *et al.* (1.02%) (26) and slightly higher than that reported by Nishimune *et al.* (0.72-%) (14). Kim *et al.* (26) used the same modified Prosky method as used in this study, but the original Prosky method (42) was used by Nishimune *et al.* (14). The modified method has shown to be an improved

method compared with the original method (34) and was adopted officially by AOAC (28) in 1988.

Foods with a high amount of TDF among minor cereals were whole grain barley, whole grain wheat (10.48%), milled barley (9.93%), milled foxtail millet (4.80%), milled sorghum (4.74%), whole grain buckwheat (4.62%), and milled Job's tears (3.93%). TDF content of wheat flour (3.67%) was similar to that reported by Schakel *et al.* (3.60%) (17) and higher than that by Nishimune *et al.* (2.44%) (14). The variations appeared to be due to differences in samples used for analysis.

Among grain products analyzed, popcorn (10.18 %) and parched barley powder (7.39%) were good sources of dietary fiber. TDF value of popcorn was similar to that reported by Nishimune *et al.* (9.71%) (14) and that by Schakel *et al.* (11.00%) (17). TDF content of whole wheat bread (8.64%) was about three times higher than white bread (3.01%). Dry wheat noodles had 2.16% TDF and Ra Myŏn contained 3.60%. Although Ka Rae Ddŏk, stick shaped rice cake contained only 0.67% TDF, Shi Ru Ddŏk contained 3.36 % since small red bean powder was added.

When TDF content of foods was compared with CF content reported in the Korean food composition tables (31,32), the TDF content of well-milled rice and brown rice was about 2.4 and 2.1 times that of CF, respectively. The ratio of TDF to CF value in cereal and grain products was in the range of 0.51 in buckwheat to 23.40 in macaroni. These findings do not support the suggestion that TDF content of foods is about five times higher than the CF content (33). On a dry weight basis, TDF content of cereal and grain products ranged from 1.08% for glutinous rice to 20. 75% for whole grain barley.

Table 2 show TDF content of eight foods in potatoes and starches. TDF content as a percentage of wet weight ranged from 0.58 to 5.38% with an average of 2.56±1.65%. Potato chips (5.38%) and French fries (5.34%) had high level of dietary fiber among potatoes and starches. TDF content of raw potato and sweet potato was 1.25 and 2.32%, respectively. These values were very similar to the values obtained by Nishimune *et al.* (14). Taro contained 2.82% TDF. TDF content of potato and sweet potato was 2.5 and 2.9 times that of CF, repectively. TDF content of the other foods was 1.6~20.2 times higher than CF content. As a percentage of dry weight, taro contained the highest content of TDF (15.51%) and the others

Table 1. Dietary fiber content of cereal and grain products

Foods	Dietary fiber	
	Dry %	Wet %
Barley, milled	11.02	9.93
Barley, whole grain	20.75	17.88
Brown rice[1]	3.16	2.75
Buckwheat, whole grain	5.24	4.62
Foxtail millet, milled	5.44	4.80
Glutinous rice, milled	1.08	0.94
Job's tears, milled	4.39	3.93
Sorghum, milled	5.33	4.74
Well-milled rice, Japonica type	1.10	0.96
Wheat, whole grain	11.88	10.48
Wheat flour, medium	4.16	3.67
Bread, barley	8.37	5.72
Bread, corn	6.44	4.43
Bread, white	4.37	3.01
Bread, whole wheat	12.75	8.64
Buckwheat noodle, fresh	4.59	4.11
Cereals, dry, corn flakes	2.50	2.40
Cereals, dry, brown rice flakes	1.90	1.83
Cracker	1.92	1.86
Ka Rae Ddŏk[2]	1.17	0.67
Macaroni, dried	4.85	4.67
Man Dou, instant[3]	5.90	3.85
Naeng Myŏn, instant[4]	4.01	3.65
Parched barley powder	7.83	7.39
Popcorn	10.90	10.18
Ra Myŏn, instant	3.74	3.60
Shi Ru Ddŏk[5]	6.94	3.36
Wheat noodle, dried	2.50	2.16
Wheat noodle, instant[6]	2.77	2.46

[1] Unpolished rice [2] Stick shaped rice cake
[3] Ravioli [4] Cold noodle
[5] Glutinous rice cake with small red bean powder
[6] Kal Kuk Sou

Table 2. Dietary fiber content of potatoes and starches

Foods	Dietary fiber	
	Dry %	Wet %
Acron starch jelly	8.09	0.79
Mungbean starch jelly[1]	6.71	0.58
Potatoes, raw	5.72	1.25
Potatoes, French fries	8.06	5.34
Potato chips	5.61	5.38
Starch vermicelli	2.25	2.02
Sweet potatoes, raw	8.78	2.32
Taro, raw	15.51	2.82

[1] Chŏng Po Muk

contained 2.25~8.78%.

The amount of TDF of five foods in sugar, syrups and sweets ranged from 1.25% for grape jam to 3.51 % for chocolate on a wet weight basis (Table 3). The average TDF content was 1.94±0.77%. TDF content of strawberry jam from this study (1.40%) and by Southgate (1.12%) (19) agreed closely. TDF content of orange marmalade (2.24%) was much higher than that reported by Southgate (0.71%) (19). Difficulty with removal of sugar components from the sample during enzyme digestion could account for this difference. TDF content of grape jam was 12.5 times higher than CF content. The CF content of chocolate was reported to be 0% (32). The ratio of TDF to CF content of apple jam and strawberry jam was 2.2 and 2.3, respectively. As a percentage of dry weight, chocolate contained the highest amount of TDF (3.57%) and the others had 1.61~2.89%.

TDF content of thirteen foods in pulse and pulse products based on wet weight varied from 1.04 to 21.05%, with an average of 10.81±6.57% (Table 4). Yellow soybean and black soybean are rich fiber sources. The TDF values of yellow soybean (21.05%) and black soybean (20.42%) from the present study and those by Kim *et al.* (26) agreed closely. Other beans including kidney bean (18.56%), mungbean (17.49 %), small red bean, red (16.68%), green peas (9.81%), small red bean, gray (7.78%) and cowpeas (7.40%) also contained high levels of TDF.

Among pulse products, food with the highest amount of TDF was curd residue (8.03%), which can also be recommended as a good source of fiber. TDF value of soybean sprouts (3.28%) was similar to that reported by Schakel *et al.* (3.70%) (17) but much higher than that obtained by Nishimune *et al.* (1.56%) (14). TDF value of soybean curd (2.27%) was much higher than that reported by Nishimune *et al.* (0.62 %) (14) and by Schakel *et al.* (1.20%) (17). The variations could be due to differences in the samples analyzed. The ratio of TDF to CF content of pulse and pulse products varied from 1.2 to 7.6. On a dry weight basis, dietary fiber values were in the range of 8.40% for cowpeas to 65.76% for soybean curd residue.

As a percentage of wet weight, TDF content of thirteen foods in nuts and seeds ranged from 1.69 to 21. 34%; the average content was 9.70±5.92% (Table 5). TDF value of black seasame, white sesame, toasted and ground sesame and powdered perilla seeds were 21.34, 19.54, 17.93 and 5.43%, respectively. Thus, various kinds of sesame can be recommended as good sources of dietary fiber. TDF content of white sesame was slightly higher than that reported by Nishimune *et al.* (15.37%) (14), and much higher than that

Table 3. Dietary fiber content of sugar, syrups and sweets

Foods	Dietary fiber	
	Dry %	Wet %
Chocolate	3.57	3.51
Jam, apple	1.78	1.31
Jam, grape	1.61	1.25
Jam, strawberry	1.90	1.40
Marmalade, orange	2.89	2.24

Table 4. Dietary fiber content of pulse and pulse products

Foods	Dietary fiber	
	Dry %	Wet %
Bam Gwa Ja[1]	8.43	6.77
Black soybean, dried	23.24	20.42
Cowpeas, dried	8.40	7.40
Green peas, raw	23.78	9.81
Kidney bean, dried	20.91	18.56
Mungbean, dried	20.72	17.49
Soybean curd	15.70	2.27
Soybean curd residue	65.76	8.03
Soybean sprout, raw	31.69	3.28
Small red bean, gray	9.16	7.78
Small red bean, red, dried	19.16	16.68
Uncur soybean curd	13.28	1.04
Yellow soybean, dried	23.25	21.05

1) Cake made from small red bean, gray

Table 5. Dietary fiber content of nuts and seeds

Foods	Dietary fiber	
	Dry %	Wet %
Acron, raw	23.70	13.06
Chestnuts, raw	12.60	5.06
Gingko nuts, raw	3.76	1.69
Peanuts, roasted	8.63	7.74
Peanut butter	6.29	6.28
Perilla seeds, powdered	6.60	5.43
Pine nuts, dried	3.03	2.86
Sesame, black, dried	22.19	21.34
Sesame, toasted and ground	19.26	17.93
Sesame, white, roasted	21.01	19.54
Sunflower seeds	8.88	8.45
Sweet almond, dried	10.97	10.63
Walnuts, dried	6.31	6.04

by Schakel *et al.* (9.13%) (17). These discrepancies could be due to sample differences and incomplete removal of fat of the sample in this study. TDF values of roasted peanuts (7.74%) and peanut butter (6.28%) were similar to the values from other studies (14,17). The ratio of TDF to CF content ranged from 1.8 to 6.7. On a dry weight basis, nuts and seeds had 3.03 to 23.70% TDF.

On a wet weight basis, there was a wide range of TDF content among eleven foods in seasonings from 0.77 to 52.43% (Table 6). The average TDF content of seasonings (15.38±15.76%) was the highest among the food groups analyzed in the present study. Food with the highest content of dietary fiber among seasonings was San Cho powder (52.43%). Red pepper powder, a frequently consumed seasoning in Korea, had a high level of TDF (39.37%). Black pepper (24.58%) and fermented soybean powder (20.93%) also contained high levels of dietary fiber. The TDF value of black pepper was very similar to that obtained by Schakel *et al.* (24.76%) (17). Soybean paste and fermented red pepper soybean paste, commonly consumed seasonings, contained 3.10 and 4.05% TDF, respectively.

TDF content of black pepper and mustard powder was about 4.2 and 2.8 times that of CF, respectively. TDF values of fermented soybean paste and black fermented wheat paste were about 83% of CF values. The CF content of curry powder was reported to be 0% (32). The ratio of TDF to CF content of the other foods ranged from 1.2 to 2.3. On a dry weight basis, TDF value varied from 3.00% in black fermented wheat paste to 54.69% in San Cho powder.

TDF content of seven foods in beverages based on wet weight ranged from 1.30 to 14.81%; the average TDF content of beverages was 4.98±4.35% (Table 7). Instant coffee powder contained the highest amount of TDF among beverages (14.81%). This value closely agreed with that obtained by Nishimune *et al.* (14.18 %) (14), but was slightly lower than that by Southgate (16.41%) (19). Powdered Job' s tears tea (8.47%) and sweetened cocoa powder (5.20%) also had high levels of TDF. The TDF content of coffee powder was 87% of CF content. TDF value of the other foods in beverages ranged from 12 to 14% of CF value. TDF of beverages as a percentage of dry weight varied from 1.44% for powdered boxthorn tea to 16. 22% for instant coffee powder.

Table 8 showes TDF content in micellaneous foods. On a wet weight basis, TDF content of white ginseng powder and yeast was 14.56 and 11.05%, respectively. Thus, they could be considerd foods with high levels of fiber, however they are consumed in restricted amounts. TDF content of yeast was slightly lower than the value obtained by Schakel *et al.* (16.25 %) (17). Yogurt contained 0.14% TDF. TDF value of yeast was about 15.8 times that of CF. On a dry weight basis, yeast and white ginseng powder contanied

Table 6. Dietary fiber content of seasonings

Foods	Dietary fiber	
	Dry %	Wet %
Black pepper powder	27.84	24.58
Brown gravy	3.63	0.77
Curry powder, instant	6.60	6.15
Fermented red pepper soybean paste	8.20	4.05
Fermented soybean powder	22.04	20.93
Fermented wheat paste, black	3.00	1.52
Mustard powder, instant	13.66	13.96
Red pepper powder	44.37	39.37
Sam Jang[1]	5.02	2.29
San Cho powder	54.69	52.43
Soybean paste	6.20	3.10

[1]Soybean paste mixed with fermented red pepper soybean paste and garlic

Table 7. Dietary fiber content of beverages

Foods	Dietary fiber	
	Dry %	Wet %
Boxthorn tea, powder, instant	1.44	1.30
Cocoa, sweetened and powdered (Nesquik)	5.27	5.20
Coffee, dry powder, instant	16.22	14.81
Du Ch'ung tea, powder, instant	2.09	1.88
Ginger tea, powder, instant	1.69	1.55
Job's tears tea, powder, instant	8.83	8.47
O Mi Ja tea, powder, instant	1.88	1.68

Table 8. Dietary fiber content of miscellaneous foods

Foods	Dietary fiber	
	Dry %	Wet %
Ginseng powder, white	16.43	14.56
Yeast, fresh	33.52	11.05
Yogurt	0.61	0.14

33.52% and 16.43% of TDF, respectively.

On a wet weight basis, seasonings ranked the highest in TDF content, followed in decreasing order by pulse and pulse products, nuts and seeds, beverages, cereal and grain products, potatoes and starches, and sugar and sweets. The TDF values from the present study were comparable with those reported by other investigators (14,17,19,26). On a dry weight basis, pulse and pulse products ranked the highest in TDF content, followed in decreasing order by seasonings, nuts and seeds, potatoes and starches, cereal and grain products, beverages, and sugar and sweets.

Although seasonings contained the highest mean content of TDF on a wet weight basis among the food groups analyzed, the levels of consumption of seasonings are relatively low compared with other foods. Since rice is the main staple food in Korea, it is recommended to increase consumption of brown rice over well-milled rice to increase dietary fiber intake. An increase in consumption of pulses, such as yellow soybean, black soybean, kidney bean, mungbean and small red bean is also encouraged to raise fiber intake. Seeds such as black sesame, white sesame, and toasted and ground sesame are also considered rich sources of dietary fiber.

The TDF value of the foods analyzed was about 0.12 to 23.40 times that of CF reported in the Korean food composition tables (31,32). Thus, it is impossible to estimate dietary fiber intakes based on these food composition tables. Therefore, we suggest that the Korean food tables should include TDF values. Marlett and Navis (43) suggested that accuracy of AOAC Prosky method mainly depends on the accurate measurement of blank and protein values. Englyst *et al.* (11) pointed out that the AOAC procedure could overestimate TDF values since this method includes a small amount of starch that is resistant to enzymatic hydrolysis in the measurement of TDF. The resistant starch mainly consists of retrograded amylose formed during food processing. They suggested that a single source of food would yield a range of TDF values, depending on the method of cooking, cooling, freezing, and other treatments used in food preparation and storage. Therefore, it is necessary to establish a standardized and well-validated method of fiber analysis which is accurate, precise, and yet prompt.

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한국인 상용식품의 식이섬유 함량 분석

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요 약

본 연구에서는 89종의 한국인 상용식품의 총 식이섬유 함량을 AOAC Prosky법으로 측정하였다. 각 식품군의 평균 총 식이섬유 함량을 습량기준으로 구해 보면 곡류 및 그 제품은 4.78±3.55%, 감자 및 전분류는 2.56±1.65%, 당류 및 그 제품은 1.94±0.77%, 두류 및 그 제품은 10.81±6.57%, 종실류 및 그 제품은 9.70±5.92%, 조미료류는 15.38±15.76%, 그리고 음료류는 4.98±4.35%를 함유하고 있었다. 식품별로 보면 곡류 중에서 통보리의 총 식이섬유량이 17.88%로 가장 높았으며, 백미는 0.96%, 현미는 2.75%, 보리쌀은 9.93%이었다. 두류 중에서는 대두, 노란콩과 검정콩이 각각 21.05와 20.42%로 가장 높았으며, 종실류 중에서는 검정깨가 21.34%로 가장 높았다. 조미료류 중에서는 산초가루가 52.43%, 고추가루가 39.37%로 총 식이섬유량이 높았으며, 음료류 중에서는 인스탄트 커피가루가 14.81%로 가장 높았다. 상용식품들의 총 식이섬유 분석치와 식품성분표의 조섬유량을 비교해 본 결과 총 식이섬유 분석치는 조섬유량의 0.12~23.4배 정도되는 넓은 범위를 보였다. 분석된 식품의 총 식이섬유 함량과 우리국민의 식습관을 고려해 보면, 백미 대신 현미를 섭취하고 잡곡의 혼용, 그리고 두류 및 그 가공품의 섭취를 권장하는 것이 식이섬유 섭취를 증가시킬 수 있는 방안이 될 수 있을 것으로 사료된다.