Food Sci. Biotechnol. Vol. 18, No. 6, pp. 1545 ~ 1547 (2009)

RESEARCH NOTE

Food Science and Biotechnology

Characterization of Insoluble Fibers Prepared from the Peel of Ripe Soft Persimmon (*Diospyros kaki* L. cv. Daebong)

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Abstract The fiber-rich fractions including enzyme treated insoluble dietary fiber, alcohol insoluble solid, and water insoluble solid were prepared from the peel of soft ripe persimmon, and to evaluate and compare the yields, proximate compositions, monosaccharide profiles, and functional properties. The results showed that uronic acid was the main sugar followed by glucose, which indicated that all insoluble fibers were mainly composed of pectic substances and cellulose. The presence of xylose and fucose indicated the occurrence of hemicellulose. All fiber-rich fractions were exhibited high yield and functional properties. Thus, the peel of ripe persimmon could be used as fiber supplements.

Keywords: persimmon peel, fiber rich fraction, insoluble dietary fiber, alcohol insoluble solid, water insoluble solid

Introduction

Health benefits of dietary fibers have led to an increased consumption of fiber-rich products. Dietary fiber plays important roles in the prevention of diabetes, obesity, atherosclerosis, heart diseases, colon cancer, and colorectal cancer (1). The consumption of insoluble fibers is beneficial to intestinal functions by enhancing intestinal peristalsis and increasing fecal bulk (2).

Insoluble dietary fibers (IDFs) are the larger fiber fraction in the peels of some fruits and vegetables, and so might produce pronounced effects on intestinal regulation and stool volume (3). Different IDFs have already been isolated from different sources such as sweet orange peel (3), passion fruit rind (4) and seed (5), and carrot (2). Persimmon peel is rich in dietary fiber and most of the total dietary fiber was IDF. Dietary supplementation with persimmon peel can lower blood glucose, plasma triglyceride, and total cholesterol levels in diabetic rats (6).

Fiber addition to foods is an alternative way to compensate for the existent deficiency in the diet. Thus, the aim of this study was to evaluate and compare the yields, proximate compositions, monosaccharide profiles, and functional properties of enzyme treated insoluble dietary fiber (IDF), alcohol insoluble solid (AIS), and water insoluble solid (WIS) fiber-rich fractions from the peel of persimmon.

Materials and Methods

Persimmon peel samples Persimmon (*Diospyros kaki* L. cv. Daebong) fruits were purchased from a local farm in South Korea and selected on the basis of skin color, uniformity, and size. The fruits were then kept to ripen at room temperature (20°C). After harvesting persimmon, it takes 3 weeks to use as a sample. The peels were removed and collected, whereas pulps were sieved to make puree. The peels were then dried at 50°C in a hot air drier (Dasol Scientific, Seoul, Korea) and ground to obtain peel powder. AIS and WIS were prepared according to the method of Chau and Huang (3). IDF was prepared using the fiber assay kit (Megazyme K-TDFR, Wicklow, Ireland).

Proximate compositions analysis Crude protein and ash content were determined by AOAC method (7).

Chemical analysis of fiber components Neutral sugars and uronic acid were determined according to the method described by Englyst and Hudson (8). Klason lignin content was obtained from the weight of residue left after hydrolysis with 72% sulfuric acid (H_2SO_4) at room temperature for 3 hr, diluted to 1 M H_2SO_4 and heated at 100°C for 2.5 hr. The insoluble residue was washed thoroughly with hot water (90°C), and then dried at 105°C for 18 hr. The residue represents Klason lignin.

Functional properties The swelling capacity (SWC) and bulk density were determined according to the method of Robertson *et al.* (9) and Onuma-Okezie and Bello (10), respectively. The water holding capacity (WHC) and oil holding capacity (OHC) were determined according to the method of Bencini (11).

Statistical analysis All measurements were performed in triplicate for each sample. Analysis of variance (ANOVA), Duncan's multiple range tests (at $p<0.05$) and regression analysis were performed by using SPSS for Windows Version 14.0 (Chicago, IL, USA).

Results and Discussion

Yields of insoluble fiber-rich fractions from the peel of ripe persimmon fruit The peels of ripe soft persimmon were rich in IDF, AIS, and WIS (46.0, 68.5, and 51.4 g/100 g, respectively) (Table 1). The yield of AIS was higher, whereas IDF was lower. The relatively higher yield of AIS

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Received August 13, 2009; Revised September 21, 2009; Accepted September 22, 2009

Table 1. Yields of the insoluble fiber-rich fractions prepared from the peel of ripe soft persimmon fruit

Dietary fiber	Extraction yield (g/100 g)
Insoluble dietary fiber (IDF)	46.0±0.62[a1)]
Alcohol insoluble solid (AIS)	68.5±0.73[c]
Water insoluble solid (WIS)	51.4±1.02[b]

[1)]All values are expressed as mean±SD of triplicate determinations; [a-c)]Values with different superscripts within the same column are significantly different among samples (p<0.05).

might be due to the alcohol precipitate such as protein and some inorganic substances (2).

Proximate composition The crude protein contents of AIS, WIS, and IDF were 6.85, 6.40, and 7.95%, respectively, whereas ash contents were 1.04, 1.13, and 1.26%, respectively (Table 2). The crude protein contents of all the IDFs were higher (3.59%) but the ash content were lower (3.69%) than previously reported for persimmon peel powder (6). The lower ash content might be due to the different variety of persimmon.

Monosaccharide profiles, uronic acid, and Klason lignin content of insoluble fiber-rich fractions The monosaccharide profiles, uronic acid, and Klason lignin content of insoluble fiber-rich fractions are shown in Table 2. The total amount of monomeric sugars released from the IDF, AIS, and WIS were 10.09, 2.97, and 1.23%, respectively. The total amount of monomeric sugars of AIS and WIS were comparable to each other, whereas they were lower than that of IDF. This might be due to the presence of various amounts of non-sugar components such as protein, ash, and lignin (5). In IDF, AIS, and WIS, the percentages of different monosaccharides and uronic acid were rhamnose (7.31-12.19%), fucose (4.06-10.70%), arabinose (7.31-10.70%), xylose (2.43-10.50%), mannose (13.08-14.63%), galactose (5.69-9.71%), glucose (13.87-20.32%), and uronic acid (19.22-38.21%) of the total neutral sugars. The main components of all the IDFs were pectic substances, followed by cellulose, and hemicellulose. Garau *et al.* (12) reported similar trends for dehydrated orange skin. Klason lignin of all the IDFs ranged from 10.43-12.27% which was consistent with that reported by Larrauri *et al.* (13) for pineapple shell dietary fiber.

Functional properties The bulk density, WHC, OHC, and SWC of the fiber-rich fractions were summarized in Table 3. IDF had higher bulk density and WHC as compared to AIS and WIS. However, OHC was higher in WIS and that value was higher than those of passion fruit seed fibers (5) and some citrus by-product fibers (2).

The SWC of various insoluble fibers was consistent with those of apple pomace and citrus peel dietary fibers (14). The differences in the physicochemical properties among the various fibers and dietary fiber products might be attributed to their different chemical and physical structures as well as the different preparation methods (3).

In conclusion, the present study demonstrated that persimmon peel was rich in insoluble fiber-rich fractions which could be used as fiber supplements. Further study is needed for the physiological functions of these insoluble dietary fibers *in vitro* and *in vivo* in the future.

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Table 2. Proximate composition, monosaccharide profiles, uronic acid, and Klason lignin content of the insoluble fiber-rich fractions prepared from the peel of ripe soft persimmon fruit (%)

Dietary fiber[1)]	Protein	Ash	Klason lignin	Rhamnose	Fucose	Arabinose	Xylose	Mannose	Galactose	Glucose	Uronic acid
IDF	7.95±0.22[a2)]	1.26±0.10[c]	12.27±0.15[b]	1.23±0.01[c]	1.08±0.01[c]	1.08±0.01[c]	1.06±0.01[c]	1.32±0.01[c]	0.98±0.01[c]	1.40±0.01[c]	1.94±0.01[c]
AIS	6.85±0.39[a]	1.04±0.03[a]	10.43±0.42[a]	0.38±0.05[b]	0.26±0.05[b]	0.29±0.05[b]	0.24±0.05[b]	0.41±0.05[b]	0.20±0.05[b]	0.48±0.05[b]	0.77±0.07[b]
WIS	6.40±0.32[a]	1.13±0.06[b]	11.00±0.22[a]	0.09±0.01[a]	0.05±0.01[a]	0.09±0.01[a]	0.03±0.00[a]	0.18±0.01[a]	0.07±0.00[a]	0.25±0.01[a]	0.47±0.01[a]

[1)]IDF=insoluble dietary fiber, AIS=alcohol insoluble solid, and WIS=water insoluble solid.
[2)]All values are expressed as mean±SD of triplicate determinations; [a-c)]Values with different superscripts within the same column are significantly different among samples (p<0.05).

Table 3. Functional properties of the insoluble fiber-rich fractions prepared from the peel of ripe soft persimmon fruit

Dietary fiber	Bulk density (g/mL)	Water holding capacity (mL/g)	Oil holding capacity (mL/g)	Swelling capacity (mL/g)
Insoluble dietary fiber	0.23±0.02[c1)]	7.33±0.09[b]	3.40±0.16[a]	11.25±1.02[c]
Alcohol insoluble solid	0.15±0.00[b]	5.70±0.14[a]	3.73±0.19[ab]	7.33±0.24[b]
Water insoluble solid	0.11±0.00[a]	6.40±0.71[ab]	4.07±0.09[b]	5.33±0.24[a]

[1)]All values are expressed as mean±SD of triplicate determinations; [a-c)]Values with different superscripts within the same column are significantly different among samples (p<0.05).

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