



ELSEVIER

Food Chemistry 65 (1999) 175–181

Food  
Chemistry

## Characterisation of peach dietary fibre concentrate as a food ingredient

Nuria Grigelmo-Miguel<sup>a</sup>, Shela Gorinstein<sup>b</sup>, Olga Martín-Belloso<sup>a,\*</sup>

<sup>a</sup>Food Technology Department, UTPV-CeRTA, University of Lleida, Rovira Roure 177, 25198 Lleida, Spain

<sup>b</sup>The Hebrew University of Jerusalem, School of Pharmacy, P.O. Box 12065, Jerusalem, 91120, Israel

Received 21 April 1998; received in revised form and accepted 3 August 1998

### Abstract

Insoluble and soluble dietary fibre (DF) fractions of peach DF concentrate, obtained by an enzymatic-chemical method, were analysed for neutral sugars, uronic acids and Klason lignin. Proximate composition, energy value, colour and water- and oil-holding capacities were also determined. Total DF constituted 31–36% dry matter (DM) of the concentrate and insoluble DF was its major fraction (20–24% DM). The high proportion of soluble fraction (11–12% DM) in the peach DF concentrate, in comparison with cereal brans, was noticeable. Insoluble and total dietary fibre contents significantly decreased throughout the harvest time of the original fresh fruit. Results suggested that peach DF concentrate may be not only an excellent DF source but an ingredient in the food industry because it showed a high affinity for water (9.12–12.09 g water/g fibre) and low energy (3.723–3.494 kcal/g). However, the use of this material could affect the colour and pH of the final product. © 1999 Elsevier Science Ltd.. All rights reserved.

### 1. Introduction

The dietary fibre (DF) concept includes some substances, which are present in plants and resist the action of human digestive enzymes. The principal DF sources are cell wall components (cellulose, hemicellulose, lignin and pectic substances) and non-structural components (gums and mucilages) as well as industrial additives (modified cellulose, modified pectin, commercial gums and algae polysaccharides) (Johnson, 1990). Clearly, the composition and behaviour of the DF depend on the age, specie, and anatomical characteristics of the plant material (Kay, 1982).

High-fibre diets are associated with the prevention and treatment of some diseases such as constipation, diverticular disease, colonic cancer, coronary heart disease and diabetes (Mendeloff, 1987; Tinker, Schneeman, Davis, Gallaher & Waggoner, 1991; Anderson, Smith & Guftason, 1994; Cassidy, Bingham & Cummings, 1994). Although numerous health organisations suggest increasing the consumption of DF, with specific recommendations of 30–45 g per day (Bonfield, 1985; Spiller, 1986; Eastwood, 1987; Schweizer & Würsch, 1991),

people in developed countries currently only eat about 11–12 g per day (Saura-Calixto, 1993).

DF may be divided into two parts when it is dispersed in water: a soluble and an insoluble fraction (Periago, Ros, López, Martínez & Rincón, 1993). Each fraction has different physiological effects (Schneeman, 1987). The insoluble part is related to both water absorption and intestinal regulation, whereas the soluble fraction is associated with the reduction of cholesterol in blood and the diminution in the intestinal absorption of glucose (Periago, Ros, López, Martínez & Rincón, 1993). In terms of health benefits, both kinds of fibre complement each other and a 70–50% insoluble and 30–50% soluble DF is considered a well balanced proportion (Schneeman, 1987).

DF from cereal brans is a typical ingredient in high DF food products, but the presence of soluble DF in cereals is quite low (Table 1). This is not the case with fruits where the ratio between soluble and insoluble DF fractions is more balanced (Saura-Calixto, 1993). Thus, in the high-dietary-fibre food products development field, there is growing interest in finding fruit DF sources.

The objective of this work was to determine the content of insoluble and soluble DF fractions in peach DF concentrate as well as the constituents of each one of these fractions. The proximate composition and the

\* Corresponding author. Tel.: +349 73 702593/702521; fax: +349 73 702596/238264; e-mail: Qmartin@tecal.udl.es.

Table 1  
Dietary fibre content of some cereal derivatives (% dry matter)

Origin of fibre	Total dietary fibre	Insoluble dietary fibre	Soluble dietary fibre	Reference
Corn bran	87.87	87.47	0.40	(Prosky, Asp, Schweizer, DeVries & Furda, 1988)
Wheat bran	44.46	41.59	2.87	(Prosky, Asp, Schweizer, DeVries & Furda, 1988)
Oat bran	10.24	7.07	3.17	(Mañas, 1992)
Barley bagasse	43.11	41.42	1.69	(Mollá, Esteban, Valiente & López-Andreu, 1994)
Wheat bran	44.0	41.1	2.9	(Grigelmo-Miguel & Martín-Belloso, 1997)
Oat bran	23.8	20.2	3.6	(Grigelmo-Miguel & Martín-Belloso, 1997)

main physical properties (pH, acidity, apparent density, energy, colour and water- and oil-holding capacities) were also studied. In addition, the evolution of these DF properties during the harvesting time of the original fruit was also evaluated.

## 2. Materials and methods

### 2.1. Materials

The DF concentrates from peach (*Prunus persica*) var. Sudanell picked at three different harvests (August, September and October) were supplied in dehydrated form by the factory Indulérica, S.A. (Alguaire, Lleida, Spain). Those peach DF concentrates were the result of drying the washed peach bagasse, which remained after peach juice extraction, according to factory protocol (Sorribas, 1993). Upon arrival in our laboratory, the peach DF concentrates were ground to 30 mesh with a centrifugal mill (Cyclotec 1093, Tecator, Höganäs, Sweden) prior to chemical and physical determinations.

The ripeness indices (RI), defined as the soluble solids/acidity ratio of the original peaches, were: 20–25 in those picked in August, 18–25 in those from September and, 17–24 in the peaches from October.

### 2.2. Methods

#### 2.2.1. Fibre analysis

The method was based on the enzymatic removal of protein from the material and the separation into soluble and insoluble fractions by centrifugation (Fig. 1). The experimental procedure followed (Mañas, 1992) was a modification of the AOAC method (Prosky, Asp, Schweizer, DeVries & Furda, 1988). The entire treatment was carried out in a centrifugation tube, avoiding any possible sample loss. Samples were enzymatically digested under the same conditions as used in the AOAC official method (Prosky, Asp, Schweizer, DeVries & Furda, 1988). Given that the samples did not contain starch,  $\alpha$ -amylase and amyloglucosidase treatments were not necessary. After performing the protease treatment, insoluble DF residue was obtained through a centrifugation step. Supernatant and water washes were collected in the same tube for further isolation of the

soluble DF fraction, which was dialysed using a continuous water-renovation system. The system consisted of a 30 l methacrylate dialysis chamber linked to a pre-chamber, with a thermostat, and an evacuation system. Tap water was propelled with a peristaltic pump to the bottom of the pre-chamber, where it was heated to 25°C, overflowing then into the dialysis chamber. Water flow was 7 l/h. Soluble DF fractions were introduced into dialysis tubing (12 000–14 000 MWCO, Dialysis Tubing Visking 9–36/32 mm, Medicell International, London, UK) and placed into the dialysis chamber. An additional device that created an elliptical movement, attached to a speed control system, achieved continuous agitation of the dialysis bags. Neutral sugars and uronic acids in the soluble DF fraction were quantified by spectrophotometric procedures (Southgate, 1976; Scott, 1979, respectively).

The insoluble DF residue was chemically hydrolysed with sulphuric acid (12 M, 30°C, 1 h; 1 M, 100°C, 90 min) and the subsequent residue quantified gravimetrically as Klason Lignin. Neutral sugars and uronic acids in the supernatant were quantified in the same manner as in the soluble DF fraction.

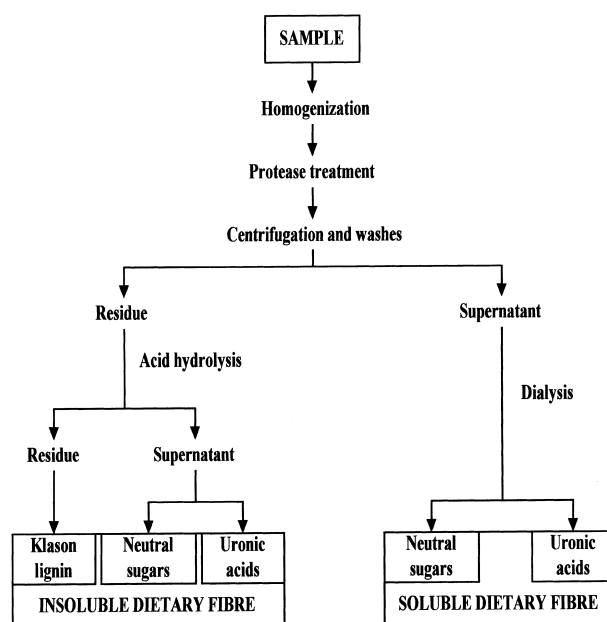


Fig. 1. Dietary fibre analysis procedure.

### 2.2.2. Complementary analysis

**Proximate composition:** Peach DF protein, ash, fat and moisture determination were carried out by standard procedures (AOAC, 1984).

**Water (WHC) and oil (OHC) holding capacities:** The WHC and OHC of the peach DF concentrates were determined at 25°C by centrifugation according to the Chevalier method (Chevalier, 1993).

**pH and acidity:** The pH was determined potentiometrically with a pH-meter using 10% (w/v) peach DF solutions. The acidity of these solutions was determined by titration with NaOH (0.1 N) to pH 8.10, and the results were expressed as g citric acid/100 ml sample.

**Colour:** The CieLab co-ordinates ( $L^*$ ,  $a^*$ ,  $b^*$ ) of the peach DF concentrates were directly read in a glass cuvette with a spectrophotocolorimetre MiniScan MS/Y-2500 (HunterLab, Reston, VA, USA), calibrated with a white tile ( $L^* = 94.0$ ,  $a^* = -1.1$ ,  $b^* = 0.6$ ), at 60° with a D-65 illuminant source.

**Apparent density:** This was determined as the weight divided by the volume of the peach DF concentrate (Larrauri, Rodríguez, Fernández, & Borroto, 1994).

**Energy value:** The gross energy value was determined by combustion with the aid of an adiabatic bomb calorimeter (Autobomb, Gallenkamp, UK).

### 2.2.3. Statistical analysis

Three measurements were taken on each analysis, and the results were expressed as the mean of those values  $\pm$  standard deviation. Analysis of variance procedure (Statgraphics 6.0, Statgraphics STSC, Rockville, MD, USA, 1992) was performed at  $p = 0.05$  to study the variation among the different harvest times. The Least Significant Difference (LSD) test was employed to determine differences among results.

## 3. Results and discussion

### 3.1. Dietary fibre content

Total DF constituted 30.7–36.1% DM of the peach DF concentrate (Table 2). The insoluble DF was the major fraction in the product, but the high presence of soluble fraction (11–12% DM) in comparison with cereal DF was noticeable (Table 1). The soluble fraction

represented 34% of the total DF content of the product. This fact placed peach DF concentrates among the richest fruit and vegetable processing by-products (Table 3).

Peach DF concentrate showed an insoluble/soluble DF ratio of 66/34, which is according to Saura-Calixto's recommendation (Saura-Calixto, 1993). Consequently, the ingestion of peach DF may have beneficial physiological effects due to both insoluble and soluble fractions, whereas other DF, such as those from cucumber skin, pineapple peel, grape pomace and, more so, from cereals, may result in a very much lower effect, in some cases imperceptible, of the properties associated with the soluble DF fraction (Tables 1 and 3). Nevertheless, the benefits of peach DF concentrates need to be tested in physiological studies.

Neutral sugars, principally formed by cellulose and hemicelluloses, and uronic acids made up of pectic substances were present in both the soluble and insoluble fractions of peach DF concentrate. They constituted 43% and 37% of the total DF, respectively. The high proportions of these substances indicated that the peach DF may have the typical physiological properties attributed to cellulose, hemicelluloses and pectins (Perigo, Ros, López, Martínez & Rincón, 1993).

The DF concentrate obtained from peaches picked in August was the highest in total ( $36.1 \pm 0.5\%$  DM), insoluble ( $23.8 \pm 0.4\%$  DM) and soluble ( $12.3 \pm 0.1\%$  DM) DF. Both the total DF and the insoluble fraction decreased throughout the harvest time (Table 2). This evolution was due to the fact that Klason lignin and neutral sugars included in the insoluble DF fraction, diminished during harvest time (Table 2). The peaches picked in August were riper than at the other harvest times and they showed the greatest Klason lignin ( $7.4 \pm 0.2\%$  DM) and neutral sugars ( $15.2 \pm 0.4\%$  DM) contents (Table 2). That corroborated the observations of Kay (1982), who reported that the ripening of the plant cell is associated with a change in fibre composition in favour of increasing proportions of cellulose and lignin.

### 3.2. Proximate composition

The moisture of DF concentrates depends primarily on the intensity of the pulp dehydration during the processing of DF concentrates. Indulérica, S.A. kept

Table 2  
Composition of peach dietary fibre concentrates (% dry matter)

Harvest time	Total dietary fibre	Insoluble dietary fibre				Soluble dietary fibre		
		Klason lignin	Neutral sugars	Uronic acids	Total	Neutral sugars	Uronic acids	Total
August	$36.1 \pm 0.5^a$	$7.4 \pm 0.2^a$	$12.7 \pm 0.4^a$	$3.7 \pm 0.2^a$	$23.8 \pm 0.4^a$	$2.54 \pm 0.08^a$	$9.8 \pm 0.2^a$	$12.3 \pm 0.1^a$
September	$32.7 \pm 0.9^b$	$6.4 \pm 0.2^b$	$12.0 \pm 0.2^b$	$3.6 \pm 0.2^a$	$22.0 \pm 0.3^b$	$2.42 \pm 0.04^a$	$8.3 \pm 0.5^b$	$10.7 \pm 0.6^b$
October	$30.7 \pm 0.8^c$	$5.7 \pm 0.1^c$	$10.7 \pm 0.6^c$	$3.5 \pm 0.2^a$	$20.0 \pm 0.5^c$	$2.48 \pm 0.09^a$	$8.3 \pm 0.2^b$	$10.8 \pm 0.3^b$

Means within a column with different letters are significantly different at  $p \geq 0.05$ .

Table 3  
Soluble dietary fibre (DF) proportion in the total DF content of some agricultural by-products

Agricultural by-product	Soluble dietary fibre (%)	Reference
Carob pods	16.8	(Saura-Calixto, 1988)
Cider wastes	21.6	(Goñi, Torre & Saura-Calixto, 1989)
White grape pomace	12.0	(Saura-Calixto, Goñi, Mañas & Abia, 1991)
Red grape pomace	6.8	(Saura-Calixto, Goñi, Mañas & Abia, 1991)
Cucumber pulp	19.8	(Rodríguez, Redondo & Villaneuva, 1992)
Cucumber skin	8.3	(Rodríguez, Redondo & Villaneuva, 1992)
Citric husk	30.0	(Larrauri, Rodríguez, Fernández, & Borroto, 1994)
Pineapple peel	3.5	(Larrauri, Rodríguez, Fernández, & Borroto, 1994)
Grape pomace	6.8	(Valiente, Arrigoni, Esteban & Amado, 1995)
Apple DF	23.0	(Grigelmo-Miguel & Martín-Belloso, 1997)
Pear DF	39.1	(Grigelmo-Miguel & Martín-Belloso, 1997)
Orange DF	36.0	(Grigelmo-Miguel & Martín-Belloso, 1997)
Peach DF	27.1	(Grigelmo-Miguel & Martín-Belloso, 1997)
Artichoke DF	24.3	(Grigelmo-Miguel & Martín-Belloso, 1997)
Asparagus DF	21.2	(Grigelmo-Miguel & Martín-Belloso, 1997)

the moisture of all the peach DF concentrates under 10% to avoid the growth of micro-organisms.

The main components of DF concentrate were carbohydrates. The fat content was low because most peach lipids are in the pit (approximately 50% of weight) (Primo, 1979) and this was separated in the juice processing. The protein content of peach DF concentrate was also low and it was the only component, among those studied, which decreased throughout the peach harvest time (Table 4). The mineral content of peach DF concentrate remained between 2.8% and 3.0% DM.

As a result of the low proportion of high-energy components in peach DF concentrate, the energy value of this product was also low and diminished with the amount of protein (Table 4). These results suggested that the product could be used as an ingredient in low fat food products.

### 3.3. Water and oil holding capacities

Peach DF concentrate presented a great WHC in comparison with other agricultural by-products (Tables 5 and 6). The peach DF from October had the highest value and those from August and September showed a similar WHC between the two. The high WHC of peach DF concentrate suggested that this material could be used as a functional ingredient to avoid syneresis and to modify the viscosity and texture of formulated products in addition to reducing calories by the total or partial substitution of high-energy ingredients.

Table 4  
Proximate composition of peach dietary fibre concentrate

Harvest time	Carbohydrate (%)	Fat (%)	Protein (%)	Ash (%)	Gross energy (kcal/g)
August	83.64 ± 0.03 <sup>a</sup>	1.478 ± 0.003 <sup>a</sup>	6.29 ± 0.07 <sup>a</sup>	3.0 ± 0.1 <sup>a</sup>	3.723 ± 0.009 <sup>a</sup>
September	83.27 ± 0.33 <sup>a</sup>	1.485 ± 0.004 <sup>b</sup>	5.73 ± 0.04 <sup>b</sup>	2.8 ± 0.2 <sup>b</sup>	3.667 ± 0.003 <sup>b</sup>
October	84.90 ± 0.31 <sup>b</sup>	1.477 ± 0.002 <sup>a</sup>	5.44 ± 0.12 <sup>c</sup>	2.9 ± 0.1 <sup>ab</sup>	3.494 ± 0.001 <sup>c</sup>

Means within a column with different letters are significantly different at  $p \geq 0.05$ .

OHC is another functional property of some ingredients used in formulated food. Ingredients with a high OHC allowed the stabilisation of high fat food products and emulsions (Kuntz, 1994). Peach DF concentrate showed a higher OHC than 1 g oil/g fibre with no evolution throughout the harvest time of the original fruit (Table 5). Not much information was found about the OHC of DF from other agricultural by-products, but the results obtained in the present study were similar to those found by Chevalier (1993) in pea fibre and by Femenia, Lefebvre, Thebaudin, Robertson and Bourgeois (1997) in cauliflower fibre.

### 3.4. pH and acidity

The pH values of the 10% peach DF concentrate solutions remained below 4.0 (Table 5). The DF concentrate from peaches harvested in October showed the lowest pH and the highest acidity because the fruit was picked less ripe than those harvested in August and September were.

### 3.5. Apparent density

The apparent density of peach DF concentrate ranged between 525 and 627 g/l with no evolution throughout the harvest time (Table 5). This property depends on the structural characteristics of each material, the particle size and their distribution (Larrauri, Rodríguez, Fernández, & Borroto, 1994). The results

Table 5  
Physicochemical properties of peach dietary fibre (DF) concentrate

Harvest time	WHC (g water/g fibre)	OHC (g oil/g fibre)	pH <sup>1</sup>	Acidity <sup>1</sup> (g acid citric/100 ml)	Apparent density (g/l)	L*	H*
August	9.2 ± 0.2 <sup>a</sup>	1.02 ± 0.05 <sup>a</sup>	3.93 ± 0.03 <sup>a</sup>	0.165 ± 0.002 <sup>a</sup>	627 ± 4 <sup>a</sup>	72.30 ± 0.08 <sup>a</sup>	1.311 ± 0.001 <sup>a</sup>
September	9.3 ± 0.1 <sup>a</sup>	1.11 ± 0.03 <sup>b</sup>	3.91 ± 0.02 <sup>a</sup>	0.164 ± 0.002 <sup>a</sup>	525 ± 5 <sup>b</sup>	70.23 ± 0.05 <sup>b</sup>	1.288 ± 0.001 <sup>b</sup>
October	12.1 ± 0.2 <sup>b</sup>	1.09 ± 0.04 <sup>ab</sup>	3.85 ± 0.02 <sup>b</sup>	0.178 ± 0.001 <sup>b</sup>	594 ± 9 <sup>c</sup>	64.00 ± 0.06 <sup>c</sup>	1.255 ± 0.002 <sup>c</sup>

Means within a column with different letters are significantly different at  $p \geq 0.05$ .

<sup>1</sup> Results in a 10% DF suspension.

Table 6  
Water holding capacity (WHC) of some agricultural by-products (g water/g fibre)

Agricultural by-products	WHC	Reference
Apple processing wastes	11.7	(Adams, Evans, Oakenfull & Sidhu, 1986)
Orange processing wastes	16.2	(Adams, Evans, Oakenfull & Sidhu, 1986)
Wheat bran	6.6	(Adams, Evans, Oakenfull & Sidhu, 1986)
Wheat bran	10.0	(Cadden, 1987)
Oat bran	5.5	(Cadden, 1987)
Seedless grapefruit	9.7	(Goñi, Torre & Saura-Calixto, 1989)
Citrus husk	3.6	(Larrauri, Rodríguez, Fernández, & Borroto, 1994)
Pineapple peel	3.5	(Larrauri, Rodríguez, Fernández, & Borroto, 1994)
Apple DF	6.3	(Grigelmo-Miguel & Martín-Belloso, 1997)
Pear DF	6.8	(Grigelmo-Miguel & Martín-Belloso, 1997)
Orange DF	12.4	(Grigelmo-Miguel & Martín-Belloso, 1997)
Peach DF	12.6	(Grigelmo-Miguel & Martín-Belloso, 1997)
Artichoke DF	13.2	(Grigelmo-Miguel & Martín-Belloso, 1997)
Asparagus DF	11.2	(Grigelmo-Miguel & Martín-Belloso, 1997)

obtained were similar to those found in grapefruit husks (Fernández, Borroto, Larrauri & Sevillano, 1993), citric husk and pineapple peel (Larrauri, Rodríguez, Fernández, & Borroto, 1994).

### 3.6. Colour

The peach DF concentrate was mildly orange and, consequently, the incorporation of the product within a food system may affect the colour. The lightness and tone (Table 5) of peach DF concentrate decreased with more advanced harvesting, while the  $a^*$  and  $b^*$  values increased (Fig. 2). Therefore, the October DF concentrate was the darkest and brownest. The colour of concentrates is influenced by many factors, such as variety and maturity of the fruit, but especially, by the drying process of the pulp. During pulp dehydration, it reaches high temperatures which cause enzymatic and non-enzymatic browning (Maillard reactions) which darken the product (Clotet, Erruz & Valero, 1994; Monsalve-González, Barbosa-Cánovas, McEvily & Iyengar, 1994).

## 4. Conclusions

Peach DF concentrate turned out to be an adequate source of DF because it was high in total DF (31–36% DM) and the product showed a greater proportion of

soluble fraction than cereals and other DF concentrates from fruit and vegetable processing wastes. Consequently, its insoluble/soluble DF fractions ratio (66/34) was in the range reported as being the best for nutritional purposes but physiological studies must be conducted to confirm effects on health. Total DF and the insoluble fraction contents decreased throughout the harvest time.

It was demonstrated that peach DF concentrate showed suitable WHC and OHC properties and,

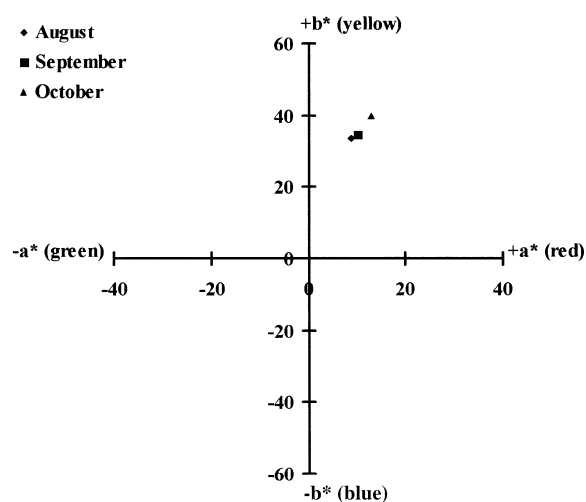


Fig. 2. Position of peach dietary fibre (DF) concentrate in  $a^*$ ,  $b^*$  CIE-Lab diagram.

because of that, the material may be used as a functional ingredient when designing new products. The peach DF from October showed the highest WHC and those from August and September showed a similar value between the two.

On the other hand, peach DF concentrate had a low energy value; therefore it may be used as an ingredient in dietetic and low-calorie products, but the incorporation of peach DF concentrate within a food system may slightly affect the colour and the pH of the final product. The October DF concentrate was the darkest and brownest and showed the lowest pH.

As a result, peach DF concentrate appeared to be a versatile ingredient that perfectly combined a natural origin, a well-balanced fibre content, great functional properties and a low energy value for use by the food industry. Nevertheless, its use will depend on microbiological safety and organoleptic properties.

### Acknowledgements

The authors thank the factory Indulérica, S.A. (Alguairé, Lleida, Spain) for providing the peach DF concentrates, and Mr. José Lorente Fernández for his assistance. The General Direction of Scientific and Technical Research of the Ministry of Education and Science in Spain supported this study.

### References

- Adams, R. G., Evans, A. J., Oakenfull, D. G., & Sidhu, G. S. (1986). Fruit processing wastes as dietary fibre supplements. *Proc. Nutr. Soc. Aust.*, *11*, 115.
- Anderson, J. W., Smith, B. M., & Guftanson, N. J. (1994). Health benefits and practical aspects of high-fiber diets. *Am. J. Clin. Nutr.*, *59* (Suppl.), S1242–S1247.
- AOAC (1984). Fruits and fruit products. *Official Methods of Analysis* (14th ed.). Washington, DC: Association of Official Analytical Chemists.
- Bonfield, C. T. (1985). Socioeconomic aspects of a fiber-deficient public diet. In G.V. Vahouny, & D. Kritchvsky (Eds.), *Dietary Fibre: Basic and Clinical Aspects* (pp. 55–67). New York: Plenum Press.
- Cadden, A. M. (1987). Comparative effects of particle size reduction on physical structure and water binding properties of several plant fibers. *J. Food Sci.*, *52* (6), 1595–1599 & 1631.
- Cassidy, A., Bingham, S. A., & Cummings, J. H. (1994). Starch intake and colorectal cancer risk: an international comparison. *Br. J. Cancer*, *69*, 937–942.
- Clotet, R., Erruz, E., & Valero, J. (1994). Brunissement non enzymatique dans un aliment complexe en fonction du temps, de l'activité de l'eau, du pH et de la température: corrélations. *Industries Alimentaires et Agricoles*, *111*, 667–670.
- Chevalier, Ir. O. (1993). Swelite, a multifunctional ingredient: applications in sauces and meat products. In *Food ingredients Europe: conference proceedings* (pp. 129–135). Maarsen, The Netherlands: Expoconsult Publishers.
- Eastwood, M. A. (1987). Dietary fiber and risk of cancer. *Nutr. Rev.*, *7*, 193.
- Femenia, A., Lefebvre, A.-C., Thebaudin, J.-Y., Robertson, J. A., & Bourgeois, C.-M. (1997). Physical and sensory properties of model foods supplemented with cauliflower fiber. *J. Food Sci.*, *62* (4), 635–639.
- Fernández, M., Borroto, B., Larrauri, J. A., & Sevillano, E. (1993). Fibra dietética de toronja: producto natural sin aditivos. *Alimentaria*, *247*, 81–83.
- Goñi, I., Torre, M., & Saura-Calixto, F. (1989). Determination of dietary fibre in cider wastes. Comparison of methods. *Food Chem.*, *33*, 151–159.
- Grigelmo-Miguel, N., & Martín-Belloso, O. (1997). A dietary fiber supplement from fruit and vegetable processing waste. In *1997 conference of food engineering (CoFE '97)*. Los Angeles, CA: American Institute of Chemical Engineers, 73G[4549].
- Johnson, I.T. (1990). Fibre sources for the food industry. *Proc. Nutr. Soc.*, *49*, 31–38.
- Kay, R. M. (1982). Dietary fiber. *J. Lipid Res.*, *23*, 221–242.
- Kuntz, L. A. (1994). Fiber: from frustration to functionality. *Food Product Design*, *2*, 91–108.
- Larrauri, J. A., Rodríguez, J. L., Fernández, M., & Borroto, B. (1994). Note. Dietary fiber obtained from citrus husk and pineapple peel. *Rev. Esp. Cienc. Tecnol. Aliment.*, *34* (1), 102–107.
- Mañas, E. (1992). Análisis de fibra alimentaria. Fuentes de error en los métodos actuales y propuesta de nueva metodología. Sc. D. Thesis. University of Alcalá de Henares, Madrid, Spain.
- Mendeloff, A. I. (1987). Dietary fiber and gastrointestinal disease. *Am. J. Clin. Nutr.*, *45*, 1267–1270.
- Mollá, E., Esteban, R. M., Valiente, C., & López-Andreu, F. J. (1994). Contenido de fibra alimentaria en los subproductos procedentes de la industria cervecera y de la industria de cítricos. *Alimentaria*, *251*, 61–64.
- Monsalve-González, A., Barbosa-Cánovas, G. V., McEvily, A. J., & Iyengar, R. (1994). Inhibition of enzymatic browning in apple products by 4-hexylresorcinol. *Food Technol.*, *4*, 110–118.
- Periago, M. J., Ros, G., López, G., Martínez, M.C., & Rincón, F. (1993). Componentes de la fibra dietética y sus efectos fisiológicos. *Rev. Esp. Cienc. Tecnol. Aliment.*, *33* (3), 229–246.
- Primo, E. (1979). *Química Agrícola*. Madrid, Spain: Ed Alhambra.
- Prosby, L., Asp, N.-G., Schweizer, T. F., DeVries, J. W., & Furda, I. (1988). Determination of insoluble, soluble, and total dietary fiber in foods and food products: interlaboratory study. *J. Assoc. Off. Anal. Chem.*, *71* (5), 1017–1023.
- Rodríguez, Ma. D., Redondo, A., & Villanueva, Ma. J. (1992). Study of dietary fibre content in cucumber by gravimetric and spectrophotometric methods. *Food Chem.*, *43*, 295–298.
- Saura-Calixto, F. (1988). Effect of condensed tannins in the analysis of dietary fiber in carob pods. *J. Food Sci.*, *53* (6), 1769–1771.
- Saura-Calixto, F. (1993). Fibra dietética de manzana: hacia nuevos tipos de fibras de alta calidad. *Alimentaria*, *242*, 57–61.
- Saura-Calixto, F., Goñi, I., Mañas, E., & Abia, R. (1991). Klason lignin, condensed tannins and resistant protein as dietary fibre constituents: determination in grape pomace. *Food Chem.*, *39*, 229–309.
- Scott, R. W. (1979). Colorimetric determination of hexuronic acids in plant materials. *Anal. Chem.*, *51* (7), 936–941.
- Schneeman, B. O. (1987). Soluble vs. insoluble fiber-different physiological responses. *Food Technol.*, *41* (2), 81–82.
- Schweizer, T. F., & Wüsch, P. (1991). The physiological and nutritional importance of dietary fibre. *Experientia*, *47*, 181–186.
- Sorribas, M. (1993). Process to obtain dietary fiber from food industry by-products. ES Patent, 2.033.565-A.
- Southgate, D. A. T. (1976). *Determination of Food Carbohydrates*. London: Applied Science Publishers.
- Spiller, G. A. (1986). Suggestions for a basis on which to determine a desirable intake of dietary fiber. In: G. A. Spiller (Ed.), *CRC Handbook of Dietary Fiber in Human Nutrition* (pp. 281–283). Florida: CRC Press.

Tinker, L. F., Schneeman, B.O., Davis, P. A., Gallaher, D. D., & Waggoner, C. R. (1991). Consumption of prunes as a source of dietary fiber in men with mild hypercholesterolemia. *Am. J. Clin. Nutr.*, 53, 1259–1265.

Valiente, C., Arrigoni, E., Esteban, R. M., & Amado, R. (1995). Grape pomace as a potential food fiber. *J. Food Sci.*, 60 (4), 818–820.