Postharvest Storage of White Asparagus (*Asparagus officinalis* L.): Changes in Dietary Fiber (Nonstarch Polysaccharides)

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Changes occurring in the content and composition of the dietary fiber of white asparagus during storage in different conditions were studied (2 °C; 2 °C in polyethylene bags with air; 2 °C in polyethylene bags with a selected gas mixture). The neutral sugars and uronic acid composition of dietary fiber was determined by gas chromatography and by a spectrophotometric method. The modifications observed in the dietary fiber of the asparagus stored at 2 °C were more rapid and pronounced than those in polyethylene bags. The most important changes corresponded to xylose and glucose from insoluble dietary fiber and galactose from soluble dietary fiber. Statistical analysis indicated that the modifications were significantly affected by the type of storage and time.

Keywords: *Asparagus officinalis L.; nonstarch polysaccharides; storage*

INTRODUCTION

Asparagus (*Asparagus officinalis* L.) is a fleshy monocotyledon that, in the edible stem, contains a range of tissues: epidermis, sclerenchyma sheath, parenchyma, vascular bundles, and parenchyma of the pith (Waldron and Selvendran, 1990). When harvested, asparagus spears are rapidly developing, with the meristematic tip region possessing intense metabolic activity (Silva et al., 1997). This quickly causes irreversible structural and functional degeneration that affects the quality of asparagus (Haard et al., 1974; Clore et al., 1976).

Keeping quality is defined as the time a product remains acceptable, and it can be used as a general indication of the overall product quality (Tijskens and Polderdijk, 1996). The positive effect of the different systems of storage on keeping quality is based on reducing the overall rate of the metabolic processes (Brash et al., 1995).

The plant cell wall properties influence the way in which plant tissues undergo mechanical deformation and failure during mastication (Waldron et al., 1997). The major components of dietary fiber are derived from cell wall polymers, and the amount and relative proportions of these can be modified during storage (Redondo-Cuenca et al., 1997).

The aim of this work is to know the evolution of the composition of dietary fiber of white asparagus stored under different conditions. Two factors of great importance that affect the shelf life of vegetables have been considered: temperature and packaging. The nonstarch polysaccharides (NSP) form the major components of dietary fiber. These polysaccharides are constituted by neutral sugars (rhamnose, fucose, arabinose, xylose, mannose, galactose, and glucose) as well as by uronic acids. The postharvest modifications affect the NSP and therefore the proportion of each of these monomers. This work studies the changes in the dietary fiber in terms of the modifications of each monomer in both the insoluble and soluble fractions, analyzed by gas−liquid chromatography.

MATERIALS AND METHODS

Plant Material. White asparagus spears (*A. officinalis* L.) of 17−22 cm were harvested manually in Alcalá del Río (Seville, Spain) and transported to the laboratory immediately. Uniform comparable stems were washed with cold water to eliminate residues of soil and other impurities. Some samples were selected for analysis (at-harvest samples), and the remainder of the spears were divided into three lots. One of them was stored at 2 °C (storage A), and the second one was packaged in polyethylene film bags (permeability = 175 cm^3 24 h^{-1} m^{-2} bar^{-1} to O_2 and 850 cm^3 24 h^{-1} m^{-2} bar^{-1} to CO_2) at 2 °C (storage B), both in air (21% O_2, 0.1−0.3% CO_2 and 78% N_2). The third lot was stored in the same type of film and temperature but with a gas mixture that consisted of only 15% O_2, 10% CO_2, and 75% N_2 (storage C). Packaging was made in a Vapta Model EUVAC 50 vacuum chamber; once the air was evacuated by vacuum pressure, plastic bags were flushed by injection with the selected gas mixture and heat sealed. The final gas/sample ratio in all bags was ∼4:1 (v/w). In each type of storage, samples were analyzed 4, 8, 12, 17, and 21 days after harvesting. Three samples or bags were used for each storage at each sample point. Results were obtained at least in duplicate for each sample.

Preparation of Samples for Analysis. At set times samples were dried in a freeze-dryer (Telstar, S.A., Model Cryodos), at −45 °C and 25 mbar, and kept in hermetically closed bottles at −20 °C until analysis. The water content was evaluated by the mass loss of the freeze-dried material in relation to the fresh material. It was determined for aliquot parts that were freeze-dried at the same time as the samples.

Dietary Fiber Analysis. Dietary fiber was obtained according to the Prosky et al. method (1988), which is based on the enzymatic removal of starch and protein from material and

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Table 1. Moisture Content of Samples in Different Storages[a]

days	storage A	storage B	storage C
0	92.47 ± 0.54[a]	92.47 ± 0.54[a]	92.47 ± 0.54[a]
4	91.52 ± 0.46[b]	92.45 ± 0.25[a]	92.61 ± 0.25[a]
8	90.11 ± 0.33[c]	92.40 ± 0.45[a]	92.24 ± 0.33[a]
12	88.35 ± 0.12[d]	90.89 ± 0.02[b]	92.25 ± 0.50[a]
17	86.93 ± 0.08[e]	90.51 ± 0.28[b]	91.06 ± 0.25[b]
21	86.70 ± 0.57[e]	91.67 ± 0.35[b]	91.34 ± 0.04[b]
signif	***	***	***

[a] Significance levels of ANOVA: ***, $p < 0.001$. Duncan's test ($p < 0.05$): values with different superscripts differ significantly.

the separation into insoluble dietary fiber (IDF) and soluble dietary fiber (SDF) by filtration.

Hydrolysis. IDF and SDF were hydrolyzed according to the procedure of Englyst et al. (1992): 12 M H_2SO_4 (35 °C/1 h) to disperse cellulose and hydrolysis with 2 M H_2SO_4 (100 °C/2 h).

Neutral Sugar Composition. Neutral sugars from both IDF and SDF were reduced with sodium borohydride in 6 M ammonium hydroxide solution (200 mg/1 mL) and acetylated with acetic anhydride with *N*-methylimidazole as a catalyst. Alditol acetates were analyzed by gas−liquid chromatography using allose as the internal standard (Englyst et al., 1992). A Perkin-Elmer Autosystem GC chromatograph with a flame ionization detector was used, with injector and detector temperatures of 275 °C, an oven temperature of 235 °C, carrier gas (nitrogen) at 22 psi, and a 007 cyanopropyl methyl silica capillary column (30 m long, 0.25 mm i.d., and 0.25 μm film thickness).

Uronic Acid Content. Uronic acid contents of IDF and SDF were determined colorimetrically with 3,5-dimethylphenol according to the method of Scott (1979), using D-galacturonic acid as the standard.

Statistical Analysis. The data from each type of storage were statistically analyzed by one-way analysis of variance. Duncan's multiple-range test was applied to establish differences between storage date means. Two-way analysis of variance was employed to determine significant interaction between time and storage.

RESULTS AND DISCUSSION

The water content of the samples subjected to the three types of storage changed in different manners (Table 1). In the asparagus kept at 2 °C (storage A) progressive moisture losses were observed ($p < 0.001$). This produced a marked desiccation of the product, which was shown by a shriveled appearance. Water loss is presumably through evaporation and to a lesser extent through the metabolism of food reserves (Waldron and Selvendran, 1990). Loss of moisture, with consequent wilting and shriveling, is one of the obvious ways in which freshness of fruits and vegetables is lost. Because fruits and vegetables are 80−95% water, they are susceptible to moisture loss whenever the relative humidity is <80−95%. Moisture losses of 3−6% are usually enough to cause marked deterioration of quality for many kinds of produce. Consequently, it is important to reduce such moisture losses (Day, 1993). The storages in polyethylene bags (storages B and C) reduced the susceptibility to drying of the samples. Although there were small but significant losses of moisture ($p < 0.001$), these occurred later than in storage A.

The aim of this work was the study of the modifications of cell wall polysaccharides of white asparagus stored in different conditions. The most important modifications of asparagus during storage are located in the cell wall, and for this reason the monomeric composition of polysaccharides, expressed as dietary fiber, was analyzed. In the present work, the Prosky et al. method (1988) was used, which allows the separation of IDF and SDF. The IDF is constituted mainly by cellulose and hemicellulosic polysaccharides and the SDF by pectic polysaccharides. The results obtained for the studied samples are expressed in grams per 100 g of dry matter (Tables 2−7).

White asparagus at harvest point (day 0) presented a high content of dietary fiber, with more than two-thirds being IDF and the rest SDF. In the IDF, neutral sugars predominated compared with uronic acids in the SDF.

The IDF comprised mainly glucose, xylose, and galactose, with lesser amounts of uronic acids, arabinose, mannose, rhamnose, and fucose. In the SDF uronic acids, galactose and arabinose predominated, with the other monomers being less so (rhamnose, mannose, glucose, and xylose). The composition of the dietary fiber of white asparagus indicated the presence of cellulose, xylans, and galactans in the IDF and of galacturonans and arabinogalactans in the SDF.

Storage A, at 2 °C, produced modifications in the proportion of the monomers that constitute the dietary fiber of white asparagus. In the IDF (Table 2) xylose and glucose were most affected. Both of them showed important increments ($p < 0.001$) up to day 8 and then stabilized. In the case of xylose the increase was almost 100% of the initial value. Waldron and Selvendran (1990) point out increases in xylans and cellulose in accordance with the increased secondary thickening and associated toughening that occurs in asparagus during storage. Selvendran and Robertson (1994) state that xylose, the main constituent of hemicelluloses, increases during maturation. Uronic acids (Table 3) also showed increases, between days 4 and 12, then stabilized and exhibited a marked decrease in the last days ($p < 0.001$). As a consequence of the increases of xylose and glucose, increases in the NSP also occurred ($p < 0.001$).

With respect to the SDF (Table 2) the changes that occurred in arabinose and galactose ($p < 0.001$) stand out. Arabinose showed marked losses between days 4 and 8 and then stabilized. In the case of galactose there were important losses up to day 12. Uronic acids, as also the NSP (Table 3), decreased from the begining ($p < 0.001$). Selvendran and MacDougall (1995) indicate that a marked change produced in vegetable cell walls during storage is the loss of galactose from the pectic polysaccharides. It is likely that the galactose lost during storage originates from pectic rhamnogalacturonans, which have side chains containing (1−4)-galactosyl and (1−5)-linked arabinosyl residues (Waldron and Selvendran, 1990).

Asparagus kept in polyethylene bags with air (storage B) underwent losses in arabinose, galactose, and glucose and increases in mannose of the IDF ($p < 0.001$) (Table 4). Uronic acids of this fraction (Table 5) suffered losses between days 8 and 12 ($p < 0.001$). The decreases in the monomers caused the NSP corresponding to this fraction of the dietary fiber to be lower at the end of the experiment ($p < 0.001$). With respect to the SDF, the arabinose and mannose suffered losses in the final days ($p < 0.001$) (Table 4) and also the uronic acids and the NSP ($p < 0.001$) (Table 5).

With the samples stored in polyethylene bags and the selected gas mixture (storage C) it was observed for the IDF (Table 6) that the arabinose shows a gradual

Table 2. Storage A: Evolution of Neutral Sugar Composition of Dietary Fiber (Expressed as Grams per 100 g of Dry Matter)[a]

days	rhamnose	fucose	arabinose	xylose	mannose	galactose	glucose
				Insoluble Dietary Fiber			
0	0.31 ± 0.04^{b}	0.10 ± 0.02	1.03 ± 0.03	2.62 ± 0.07^{c}	0.41 ± 0.01^{d}	2.35 ± 0.05^{b}	7.50 ± 0.20^{c}
4	0.31 ± 0.01^{b}	0.12 ± 0.02	1.06 ± 0.09	3.87 ± 0.07^{b}	0.44 ± 0.02^{cd}	2.37 ± 0.07^{b}	8.47 ± 0.74^{b}
8	0.34 ± 0.04^{ab}	0.12 ± 0.02	1.19 ± 0.11	4.93 ± 0.09^{a}	0.49 ± 0.04^{ab}	2.82 ± 0.25^{a}	10.00 ± 0.48^{a}
12	0.37 ± 0.01^{a}	0.12 ± 0.02	1.24 ± 0.18	5.01 ± 0.19^{a}	0.52 ± 0.01^{a}	2.91 ± 0.28^{a}	10.49 ± 0.26^{a}
17	0.35 ± 0.01^{a}	0.12 ± 0.01	1.25 ± 0.25	5.11 ± 0.10^{a}	0.48 ± 0.02^{bc}	2.93 ± 0.08^{a}	10.70 ± 0.61^{a}
21	0.32 ± 0.01^{b}	0.13 ± 0.01	1.17 ± 0.07	5.14 ± 0.57^{a}	0.47 ± 0.02^{bc}	2.51 ± 0.03^{b}	10.14 ± 0.28^{a}
signif	*	ns	ns	***	***	***	***
				Soluble Dietary Fiber			
0	0.23 ± 0.01^{b}		0.62 ± 0.03^{a}	0.03 ± 0.01^{b}	0.19 ± 0.01^{c}	1.43 ± 0.04^{a}	0.07 ± 0.01
4	0.24 ± 0.01^{b}		0.56 ± 0.14^{a}	0.03 ± 0.01^{b}	0.19 ± 0.01^{c}	1.26 ± 0.05^{b}	0.07 ± 0.01
8	0.25 ± 0.04^{b}		0.38 ± 0.04^{b}	0.03 ± 0.01^{b}	0.20 ± 0.02^{bc}	1.13 ± 0.08^{c}	0.07 ± 0.01
12	0.25 ± 0.03^{b}		0.37 ± 0.01^{b}	0.03 ± 0.01^{b}	0.21 ± 0.01^{ab}	0.96 ± 0.04^{d}	0.07 ± 0.01
17	0.29 ± 0.02^{a}		0.39 ± 0.01^{b}	0.04 ± 0.01^{a}	0.22 ± 0.01^{a}	0.95 ± 0.12^{d}	0.07 ± 0.01
21	0.32 ± 0.01^{a}		0.46 ± 0.02^{b}	0.03 ± 0.01^{b}	0.20 ± 0.01^{c}	0.93 ± 0.03^{d}	0.07 ± 0.01
signif	***		***	**	***	***	ns

[a] Significance levels of ANOVA: ***, $p < 0.001$; **, $p < 0.01$; *, $p < 0.05$; ns, nonsignificative. Duncan's test ($p < 0.05$): values with different superscripts differ significantly.

Table 3. Storage A: Neutral Sugars, Uronic Acids, and NSP Content of Dietary Fiber (Expressed as Grams per 100 g of Dry Matter)[a]

	insoluble dietary fiber			soluble dietary fiber			
days	neutral sugars	uronic acids	NSP[b]	neutral sugars	uronic acids	NSP[b]	total NSP[b]
0	14.33 ± 0.23^{c}	1.33 ± 0.12^{c}	15.66 ± 0.18^{e}	2.56 ± 0.06^{a}	3.46 ± 0.04^{a}	6.03 ± 0.10^{a}	21.68 ± 0.18^{d}
4	16.65 ± 0.79^{b}	1.33 ± 0.08^{c}	17.97 ± 0.75^{d}	2.34 ± 0.16^{b}	3.01 ± 0.18^{ab}	5.36 ± 0.29^{b}	23.33 ± 0.91^{c}
8	19.88 ± 0.99^{a}	1.73 ± 0.08^{b}	21.61 ± 1.03^{bc}	2.07 ± 0.03^{c}	2.57 ± 0.51^{b}	4.64 ± 0.50^{c}	26.25 ± 0.63^{b}
12	20.66 ± 0.58^{a}	2.14 ± 0.10^{a}	22.80 ± 0.67^{ab}	1.90 ± 0.06^{d}	3.23 ± 0.45^{a}	5.12 ± 0.41^{bc}	27.92 ± 0.76^{a}
17	20.94 ± 0.94^{a}	2.12 ± 0.11^{a}	23.06 ± 1.02^{a}	1.96 ± 0.14^{cd}	3.09 ± 0.47^{ab}	5.05 ± 0.44^{bc}	28.10 ± 1.05^{a}
21	19.8 ± 0.83^{a}	1.25 ± 0.10^{c}	21.11 ± 0.92^{c}	1.99 ± 0.06^{cd}	2.03 ± 0.14^{c}	4.02 ± 0.19^{d}	25.13 ± 0.74^{b}
signif	***	***	***	***	***	***	***

[a] Significance levels of ANOVA: ***, $p < 0.001$. Duncan's test ($p < 0.05$): values with different superscripts differ significantly. [b] NSP, nonstarch polysaccharides.

Table 4. Storage B: Evolution of Neutral Sugar Composition of Dietary Fiber (Expressed as Grams per 100 g of Dry Matter)[a]

days	rhamnose	fucose	arabinose	xylose	mannose	galactose	glucose
				Insoluble Dietary Fiber			
0	0.31 ± 0.04	0.10 ± 0.02	1.03 ± 0.03^{a}	2.62 ± 0.07^{a}	0.41 ± 0.01^{e}	2.35 ± 0.05^{a}	7.50 ± 0.20^{a}
4	0.30 ± 0.02	0.12 ± 0.03	0.98 ± 0.02^{b}	2.60 ± 0.08^{ab}	0.45 ± 0.01^{d}	2.33 ± 0.01^{a}	7.19 ± 0.19^{b}
8	0.32 ± 0.01	0.11 ± 0.02	0.98 ± 0.03^{b}	2.52 ± 0.03^{c}	0.56 ± 0.01^{b}	2.20 ± 0.11^{b}	6.92 ± 0.04^{c}
12	0.31 ± 0.04	0.10 ± 0.01	0.93 ± 0.02^{c}	2.43 ± 0.01^{d}	0.66 ± 0.05^{a}	2.18 ± 0.10^{b}	6.37 ± 0.09^{d}
17	0.31 ± 0.03	0.10 ± 0.01	0.87 ± 0.02^{d}	2.54 ± 0.03^{bc}	0.65 ± 0.02^{a}	2.08 ± 0.09^{bc}	6.98 ± 0.12^{c}
21	0.28 ± 0.02	0.10 ± 0.01	0.75 ± 0.03^{e}	2.58 ± 0.04^{abc}	0.52 ± 0.02^{c}	1.99 ± 0.06^{c}	6.92 ± 0.05^{c}
signif	ns	ns	***	***	***	***	***
				Soluble Dietary Fiber			
0	0.23 ± 0.01^{a}		0.62 ± 0.03^{b}	0.03 ± 0.01^{c}	0.19 ± 0.01^{c}	1.43 ± 0.04^{c}	0.07 ± 0.01^{c}
4	0.21 ± 0.01^{b}		0.62 ± 0.02^{b}	0.03 ± 0.01^{bc}	0.21 ± 0.02^{c}	1.44 ± 0.02^{c}	0.09 ± 0.01^{b}
8	0.20 ± 0.01^{bc}		0.62 ± 0.03^{b}	0.03 ± 0.01^{b}	0.25 ± 0.02^{b}	1.52 ± 0.05^{b}	0.11 ± 0.01^{a}
12	0.20 ± 0.01^{bc}		0.64 ± 0.02^{b}	0.05 ± 0.01^{a}	0.28 ± 0.02^{a}	1.59 ± 0.02^{a}	0.09 ± 0.01^{b}
17	0.20 ± 0.01^{c}		0.68 ± 0.03^{a}	0.06 ± 0.01^{a}	0.12 ± 0.01^{d}	1.50 ± 0.06^{b}	0.06 ± 0.01^{d}
21	0.19 ± 0.01^{c}		0.54 ± 0.02^{c}	0.06 ± 0.01^{a}	0.10 ± 0.01^{d}	1.43 ± 0.01^{c}	0.05 ± 0.01^{d}
signif	***		***	***	***	***	***

[a] Significance levels of ANOVA: ***, $p < 0.001$; ns, nonsignificative. Duncan's test ($p < 0.05$): values with different superscripts differ significantly.

decrease, which is statistically significant by day 21 ($p < 0.001$). Xylose, galactose, and glucose show a similar trend, but data are more variable. Mannose showed increases between days 8 and 12 ($p < 0.001$). Uronic acids (Table 7) decreased during the final days ($p < 0.001$), and the NSP decreased from the begining ($p < 0.001$). In the SDF (Table 6) losses of arabinose were observed from the start, but mannose, galactose, and glucose decreased at the end. Uronic acids and NSP ($p < 0.001$) (Table 7) behaved in the same way as the latter.

When the three types of storage were compared, the most marked changes corresponded to storage A, especially in xylose and glucose from IDF and in galactose from SDF. The asparagus packaged in polyethylene bags (storages B and C) showed small decreases in xylose and glucose from IDF as opposed to the marked increase in storage A. Arabinose from SDF in storage B suffered small decreases at the end, whereas it had important losses in storage A. Comparison of the two assays in polyethylene bags (storages B and C) shows that for the IDF the behaviors of arabinose and galactose were similar but the loss of glucose was greater in storage C, as it was also for the uronic acids. In the SDF, storage C resulted in greater losses of arabinose and galactose. It was also significant that the losses shown

Table 5. Storage B: Neutral Sugars, Uronic Acids, and NSP Content of Dietary Fiber (Expressed as Grams per 100 g of Dry Matter)[a]

	insoluble dietary fiber			soluble dietary fiber			
days	neutral sugars	uronic acids	NSP[b]	neutral sugars	uronic acids	NSP[b]	total NSP[b]
0	14.33 ± 0.23[a]	1.33 ± 0.12[a]	15.66 ± 0.18[a]	2.56 ± 0.06[c]	3.46 ± 0.04[a]	6.03 ± 0.10[a]	21.68 ± 0.18[a]
4	13.97 ± 0.21[b]	1.41 ± 0.09[a]	15.38 ± 0.27[a]	2.59 ± 0.01[c]	3.23 ± 0.34[a]	5.82 ± 0.33[a]	21.20 ± 0.18[a]
8	13.61 ± 0.06[c]	1.55 ± 0.05[a]	15.16 ± 0.10[a]	2.72 ± 0.04[b]	3.35 ± 0.05[a]	6.07 ± 0.05[a]	21.22 ± 0.09[a]
12	12.98 ± 0.13[d]	1.20 ± 0.08[b]	14.18 ± 0.20[c]	2.85 ± 0.08[a]	3.26 ± 0.06[a]	6.11 ± 0.13[a]	20.28 ± 0.22[b]
17	13.52 ± 0.12[c]	1.11 ± 0.12[b]	14.63 ± 0.19[b]	2.61 ± 0.07[c]	2.83 ± 0.11[b]	5.44 ± 0.10[b]	20.06 ± 0.24[b]
21	13.13 ± 0.11[d]	1.05 ± 0.13[b]	14.18 ± 0.21[c]	2.37 ± 0.02[d]	2.26 ± 0.28[c]	4.63 ± 0.30[c]	18.80 ± 0.18[c]
signif	***	***	***	***	***	***	***

[a] Significance levels of ANOVA: ***, $p < 0.001$. Duncan's test ($p < 0.05$): values with different superscripts differ significantly. [b] NSP, nonstarch polysaccharides.

Table 6. Storage C: Evolution of Neutral Sugar Composition of Dietary Fiber (Expressed as Grams per 100 g of Dry Matter)[a]

days	rhamnose	fucose	arabinose	xylose	mannose	galactose	glucose
			Insoluble Dietary Fiber				
0	0.31 ± 0.04	0.10 ± 0.02[b]	1.03 ± 0.03[a]	2.62 ± 0.07[b]	0.41 ± 0.01[b]	2.35 ± 0.05[a]	7.50 ± 0.20[a]
4	0.34 ± 0.02	0.13 ± 0.01[a]	1.01 ± 0.06[a]	2.50 ± 0.19[b]	0.42 ± 0.01[b]	2.32 ± 0.06[ab]	6.41 ± 0.14[b]
8	0.32 ± 0.05	0.13 ± 0.01[a]	0.99 ± 0.04[a]	2.38 ± 0.08[bc]	0.43 ± 0.02[b]	2.29 ± 0.07[ab]	6.33 ± 0.07[b]
12	0.35 ± 0.02	0.13 ± 0.01[a]	0.97 ± 0.09[a]	2.56 ± 0.19[b]	0.49 ± 0.02[a]	2.28 ± 0.03[ab]	6.48 ± 0.20[b]
17	0.31 ± 0.04	0.11 ± 0.01[ab]	0.96 ± 0.07[a]	3.14 ± 0.05[a]	0.50 ± 0.06[a]	2.25 ± 0.05[b]	6.46 ± 0.14[b]
21	0.29 ± 0.03	0.11 ± 0.02[ab]	0.71 ± 0.03[b]	2.23 ± 0.25[c]	0.52 ± 0.02[a]	2.01 ± 0.03[c]	5.71 ± 0.35[c]
signif	ns	*	***	***	***	***	***
			Soluble Dietary Fiber				
0	0.23 ± 0.01[a]		0.62 ± 0.03[a]	0.03 ± 0.01[c]	0.19 ± 0.01[b]	1.43 ± 0.04[b]	0.07 ± 0.01[bc]
4	0.20 ± 0.01[b]		0.63 ± 0.03[a]	0.04 ± 0.01[b]	0.19 ± 0.01[b]	1.45 ± 0.05[b]	0.07 ± 0.01[bc]
8	0.20 ± 0.01[b]		0.54 ± 0.01[b]	0.05 ± 0.01[a]	0.20 ± 0.01[b]	1.56 ± 0.03[a]	0.10 ± 0.02[a]
12	0.19 ± 0.01[b]		0.52 ± 0.01[bc]	0.05 ± 0.01[a]	0.24 ± 0.01[a]	1.49 ± 0.04[ab]	0.08 ± 0.01[b]
17	0.19 ± 0.01[b]		0.50 ± 0.01[c]	0.05 ± 0.01[a]	0.15 ± 0.02[c]	1.43 ± 0.10[b]	0.06 ± 0.01[c]
21	0.16 ± 0.02[c]		0.46 ± 0.02[d]	0.05 ± 0.01[a]	0.11 ± 0.01[d]	1.25 ± 0.03[c]	0.06 ± 0.01[c]
signif	***		***	***	***	***	***

[a] Significance levels of ANOVA: ***, $p < 0.001$; *, $p < 0.05$; ns, nonsignificative. Duncan's test ($p < 0.05$): values with different superscripts differ significantly.

Table 7. Storage C: Neutral Sugars, Uronic Acids, and NSP Content of Dietary Fiber (Expressed as Grams per 100 g of Dry Matter)[a]

	insoluble dietary fiber			soluble dietary fiber			
days	neutral sugars	uronic acids	NSP[b]	neutral sugars	uronic acids	NSP[b]	total NSP[b]
0	14.33 ± 0.23[a]	1.33 ± 0.12[b]	15.66 ± 0.18[a]	2.56 ± 0.06[a]	3.46 ± 0.04[a]	6.03 ± 0.10[a]	21.6 8 ± 0.18[a]
4	13.12 ± 0.22[cd]	1.38 ± 0.06[b]	14.50 ± 0.18[c]	2.58 ± 0.04[a]	2.98 ± 0.08[bc]	5.56 ± 0.05[b]	20.06 ± 0.18[d]
8	12.88 ± 0.19[d]	1.61 ± 0.02[a]	14.49 ± 0.18[c]	2.65 ± 0.04[a]	3.29 ± 0.26[ab]	5.94 ± 0.27[a]	20.42 ± 0.27[c]
12	13.25 ± 0.31[c]	1.44 ± 0.05[b]	14.69 ± 0.26[cb]	2.56 ± 0.04[a]	3.49 ± 0.35[a]	6.05 ± 0.32[a]	20.74 ± 0.10[b]
17	13.73 ± 0.12[b]	1.13 ± 0.08[c]	14.86 ± 0.14[b]	2.38 ± 0.08[b]	2.76 ± 0.10[c]	5.14 ± 0.06[c]	20.00 ± 0.15[d]
21	11.57 ± 0.15[e]	0.79 ± 0.07[d]	12.36 ± 0.12[d]	2.09 ± 0.07[c]	2.23 ± 0.28[d]	4.32 ± 0.35[d]	16.68 ± 0.24[e]
signif	***	***	***	***	***	***	***

[a] Significance levels of ANOVA: ***, $p < 0.001$. Duncan's test ($p < 0.05$): values with different superscripts differ significantly. [b] NSP, nonstarch polysaccharides.

Table 8. Two-Way Variance Analysis

	insoluble dietary fiber		soluble dietary fiber		total dietary fiber	
	F value	*p* value	*F* value	*p* value	*F* value	*p* value
storage (S)	1069.61	<0.001	37.35	<0.001	991.11	<0.001
time (T)	41.11	<0.001	59.62	<0.001	64.31	<0.001
S × T	67.47	<0.001	5.01	<0.001	67.10	<0.001

by the monomers of the SDF in the packaged samples (storages B and C) occurred principally in the final days.

Two-way analysis of variance (Table 8) indicated that the variations of the monomers (neutral sugars and uronic acids) of polysaccharides which form insoluble, soluble, and total dietary fiber were due to both factors (storage and time). The interaction of both factors was significant ($p < 0.001$), and therefore the behaviors of the components in each storage were different.

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