Food Chemistry **17** (1985) 265–272

Dietary Fibre in Some Norwegian Plant Foods During Storage

R. Reistad, I. Andelic, M. Steen & E. S. Røgeberg

National Institute for Consumer Research, PO Box 173,
N-1324 Lysaker, Norway

&

W. Frölich

Norwegian Cereal Institute, PO Box 8116 Dep., Oslo 1, Norway

(Received: 28 January, 1985)

ABSTRACT

The dietary fibre (DF) content of some storage-strong vegetables, grown in Norway, has been determined. The vegetables were collected at harvest time and at intervals during storage, to monitor the DF content during the storage season.

Nantes, a variety of carrot, and Hygro, an onion variety, were available throughout the entire period of investigation. A slight decrease in the DF content with length of storage was observed for carrots, but not for onions.

With cabbage (Golden Acre, Toten Amager and Blue Top varieties) and rutabaga (Gry and Bangholm varieties) any particular variety was available only for a shorter period (1–4 months), with little overlap between varieties. No systematic change in DF content was observed within any variety during this period. However, differences in DF content from variety to variety within the same vegetable were found.

The observed DF variations within each vegetable, whether due to storage or to variety, were relatively slight and need not normally be taken into account when estimating the DF contents of diets containing these vegetables. Some methodological problems are discussed.

Food Chemistry 0308-8146/85/$03·30

INTRODUCTION

In Norway, most of the fresh vegetables consumed are based on products which can be grown in a cold climate and which, in addition, have good storage properties. For some products, the same variety is available to consumers throughout the storage period. For others, a particular variety is available only for a shorter period, being replaced later by other varieties. Vegetables are important contributors to the dietary fibre (DF) content of the human diet. It was therefore considered of interest to investigate whether the DF content of such products changed during storage, and whether such possible changes were substantial enough to be taken into account when estimating the DF content of diets. In this connection, we wished to investigate good quality vegetables as available to the consumer in stores, and not products grown and stored under defined conditions.

MATERIALS AND METHODS

The vegetables, all grown in Norway, were collected at intervals from July until March/May the following year at Gartnerhallen A/L, the major Norwegian vegetable distributor. On each collection date the same vegetable variety was collected from two different producers. Equal weights of these two samples were prepared for analysis together, in order to minimise possible effects of growth and handling conditions prior to delivery to the distributor. Further preparations of samples were as previously described (Reistad, 1983). The material was used without processing, freeze-dried, ground in a mortar and stored in tightly capped glass jars in desiccators at 4 °C above blue silica gel.

Moisture determinations

Removal of residual water from the freeze-dried material was carried out at 60 °C at reduced pressure (< 10 mm Hg) until constant weight.

DF determinations

DF was determined by the enzymatic gravimetric method of Asp *et al.* (1983), based on the method of Hellendoorn *et al.* (1975), here called Asp's method.

Selected samples were, in addition, analysed by the fractionation method of Englyst (1981) with minor modifications (Reistad, 1983), here called Englyst's method, to detect possible changes in the composition of DF polysaccharides between varieties or upon storage.

All analyses were carried out in duplicate.

RESULTS AND DISCUSSION

Vegetables are normally stored by the producer and channelled to the distributor only shortly before distribution to the retailer.

In this work we chose to collect the material at the distributor level. This made it possible to obtain the same product and variety from more than one producer each time material was collected, to obtain vegetables of good and even quality, as well as adequate information about the products. In addition, the vegetables would shortly be available to the consumer through retail stores.

The DF contents of the material collected are shown in Table 1. For carrot and onion, the same variety was available throughout the entire storage period, from autumn to spring, which made it possible to monitor the DF content during that period. For cabbage and rutabaga, available varieties were subject to change, any one variety being available only for a shorter period (1–4 months), with little overlap between varieties. Thus, for these vegetables, comparison within one variety for a longer period was not possible. However, this arrangement allowed us to investigate possible differences in DF content between varieties.

Table 1 shows that there was little change in total DF content of onions during storage, while a slight decrease with increasing length of storage was observed for carrots.

For cabbage and rutabaga, differences in DF contents were found between some, but not all, varieties. Of the three cabbage varieties (Golden Acre, a summer variety, Blue Top, an autumn/winter variety, and Toten Amager, a winter/spring variety), Blue Top had a slightly higher level of DF. As expected, because of relatively short observation periods, no consistent and systematic change in DF content with increasing length of storage was observed within each variety of cabbage and rutabaga.

Table 2 shows the composition of non-starch polysaccharides (NSP) of some of the samples listed in Table 1.

For carrot, the slight decrease in DF content with increasing length of storage seemed to be due to a somewhat lower level of galactose and, to a

TABLE 1

Dietary Fibre Content in Various Plant Materials Collected During Storage (Asp's Method)

Sample	*Variety*	*Date collected*	*% Dry material*	*Weight % on dry basis*			*Weight % on fresh basis*		
				Soluble	*Insoluble*	*Total*	*Soluble*	*Insoluble*	*Total*
Carrot	Nantes	July 8	10·4	9·4	17·1	26·5	1·0	1·8	2·8
	Nantes	Sept. 9	10·1	9·8	16·1	25·9	1·0	1·6	2·6
	Nantes	Nov. 11	10·8	9·1	14·6	23·7	1·0	1·6	2·6
	Nantes	Feb. 17	10·9	8·4	13·0	21·4	0·9	1·4	2·3
	Nantes	March 27	10·7	8·5	13·9	22·3	0·9	1·5	2·4
Onion	Hygro	July 29	11·1	6·4	11·3	17·7	0·7	1·3	2·0
	Hygro	Sept. 23	11·9	5·9	11·3	17·3	0·7	1·2	1·9
	Hygro	Dec. 9	11·2	5·3	10·6	15·9	0·6	1·2	1·8
	Hygro	Feb. 17	11·6	6·1	10·7	16·7	0·7	1·2	1·9
	Hygro	May 20	11·6	6·1	10·0	16·1	0·7	1·2	1·9
Cabbage	Golden Acre	July 8	6·8	6·5	17·3	23·8	0·4	1·2	1·6
	Golden Acre	July 29	8·2	5·0	17·1	22·1	0·4	1·4	1·8
	Blue Top	Sept. 23	9·4	5·4	20·8	26·2	0·5	2·0	2·5
	Blue Top	Nov. 11	9·6	6·3	20·7	27·0	0·6	2·0	2·6
	Toten Amager	Feb. 17	9·5	5·4	17·0	22·4	0·5	1·6	2·1
	Toten Amager	March 27	8·8	5·2	16·8	22·0	0·5	1·5	2·0
Rutabaga	Gry	July 8	10·5	7·1	17·6	24·7	0·8	1·9	2·7
	Gry	July 29	10·3	7·5	17·1	24·6	0·8	1·8	2·6
	Gry	Aug. 26	11·5	8·9	15·7	24·6	1·0	1·8	2·8
	Bangholm	Oct. 8	11·6	7·5	13·8	21·3	0·9	1·6	2·5
	Bangholm	Dec. 9	11·2	7·4	12·6	20·0	0·8	1·4	2·2
	Bangholm	Feb. 17	11·6	7·5	12·3	19·8	0·9	1·4	2·3

TABLE 2

Constituents of Non-Starch Polysaccharides, Calculated as Polymers (Weight %) on Dry Weight Basis (Englyst's Method)

Sample	*Variety*	*Date collected*	*Total NSP*	*Cellulose*	*Ur.a.*		*Rha*		*Fuc*		*Ara*		*Xyl*		*Man*		*Gal*		*Glu*[a]	
					S	*I*	*S*	*I*	*S*	*I*	*S*	*I*	*S*	*I*	*S*	*I*	*S*	*I*	*S*	*I*
Carrot	Nantes	Sept. 9	17·1	5·9	5·5	1·0	0·1	tr	—	—	1·0	0·7	—	0·1	—	0·1	1·4	1·2	—	0·1
	Nantes	Feb. 17	14·4	5·5	5·5	0·8	0·1	tr	—	—	0·7	0·4	—	0·1	—	0·1	0·6	0·5	—	0·1
Onion	Hygro	July 29	11·8	3·5	4·1	0·3	0·1	—	—	tr	0·2	0·1	0·1	0·2	—	tr	2·3	0·9	—	tr
	Hygro	Dec. 9	12·3	3·9	3·4	0·6	0·1	0·1	—	tr	0·2	0·2	—	0·3	—	—	1·6	1·9	—	tr
Cabbage	Golden Acre	July 8	16·3	6·4	3·4	1·4	0·1	tr	—	0·1	0·8	1·2	0·1	0·7	—	0·1	0·6	1·2	—	0·2
	Blue Top	Sept. 23	18·1	7·1	3·3	1·8	0·1	0·1	—	0·1	1·1	1·9	0·1	0·6	—	0·1	0·4	1·3	—	0·1
	Blue Top	Nov. 11	18·2	6·9	3·1	2·3	0·1	0·1	—	0·2	0·9	2·2	tr	0·7	—	0·1	0·3	1·1	—	0·2
	Toten Amager	Feb. 17	14·9	6·2	3·1	1·6	0·1	tr	—	0·1	0·8	1·3	tr	0·5	—	0·1	0·3	0·7	—	0·1
Rutabaga	Gry	Aug. 26	18·7	7·7	5·8	0·7	0·2	—	—	0·1	1·3	0·6	—	0·4	—	0·1	0·9	0·8	—	0·1
	Bangholm	Dec. 9	16·1	6·6	5·0	0·9	0·2	—	—	0·1	0·8	0·7	—	0·4	—	0·1	0·5	0·7	—	0·1

tr, Trace. —, Below detection limit. Ur.a., uronic acid (as galacturonic acid). S, Soluble. I, Insoluble. NSP, Non-starch polysaccharides.

[a] Cellulose not included. Rha, rhamnose. Fuc, fucose. Ara, arabinose. Xyl, xylose. Man, mannose. Gal, galactose. Glu, glucose.

lesser extent, of arabinose, as revealed after approximately 5 months' storage. For onions, no significant change in the constituents of NSP was observed after the same length of storage, although there seemed to be a shift from soluble to insoluble polysaccharides.

For cabbage, the higher content of DF observed in Blue Top, compared with Golden Acre and Toten Amager, seemed to be caused by a higher level of several NSP constituents. Within Blue Top, there was no significant change in constituent monosaccharides of NSP over a period of 2 months. For rutabaga, the slightly higher DF content of Gry, a summer/autumn variety, than that of Bangholm, an autumn/winter variety, also seemed to be due to a somewhat higher level of most NSP constituents.

It is concluded that, although both variety and storage may influence the content and composition of DF in some vegetables, the changes are minor and need not normally be taken into consideration upon calculation of the DF contents of diets containing these vegetables.

It can be seen from Tables 1 and 2 that Englyst's method gave lower results than Asp's method. This was also observed earlier by Reistad & Frölich (1984). A certain degree of difference is to be expected because of the different approaches of the two methods, as briefly discussed earlier (Reistad and Frölich, 1984). This difference was most probably due to DF constituents other than NSP and possibly an underestimation by the Englyst (1981) method. Below we discuss in more detail possible causes of the differences observed. However, the conclusions of our investigation are not affected by this discussion, as any systematic irregularities will influence all samples and thus allow comparison, even though 'true' DF values are not obtained.

DF constituents other than NSP are mainly lignin, although tannins, cutin, etc., are also found in this fraction. These compounds are normally recorded as insoluble residue after treatment with 12M H_2SO_4 (Klason lignin). Englyst's method does not measure insoluble residue. In this method the sample weight is about 200 mg. With a relatively small percentage of insoluble residue, the degree of accuracy of the gravimetric determination will not be very high and the results have been omitted. They do not, however, exceed 5 % of the sample dry weight (R. Reistad, unpublished). However, Selvendran & DuPont (1984) pointed out that, in the procedure discussed, loss of acid-soluble lignin might be expected for certain plant material, resulting in an underestimation of insoluble residue.

Acid hydrolysis conditions vary somewhat from procedure to procedure. Hydrolysis and degradation always go hand in hand and the aim is maximum liberation combined with minimum degradation. In addition, correction factors are applied when appropriate. However, as monosaccharide liberation and degradation are dependent upon type of polymer, linkage, neighbouring monosaccharides, substituents, etc., 'true' correction factors may be difficult to establish. Results from standard monosaccharide mixtures exposed to the hydrolytic conditions of our method suggested little degradation. Hence, we have not corrected for possible losses due to hydrolysis, apart from the use of internal standards. Englyst (1981) corrects for a 10% loss of monosaccharides, suggesting an underestimation if correction is not applied.

In this procedure, hydrolysis in 0·5 M H_2SO_4 is carried out prior to solubilisation of cellulose in 12 M H_2SO_4. This is opposite to the sequence of these steps in most other DF procedures, including a modification of the above method (Englyst *et al.*, 1982). Initial treatment with dilute sulphuric acid may lead to incomplete dissolution and hydrolysis of certain polysaccharides (Selvendran & DuPont, 1984), thus contributing to the underestimation of NSP.

Uronic acids are determined by colorimetry (Wardi *et al.*, 1974), soluble uronic acids in unhydrolysed material and insoluble acids after hydrolysis of the corresponding DF fraction in 0·5 M H_2SO_4 at 100 °C for 2·5 h.

As pointed out by Selvendran & DuPont (1984), such a treatment may degrade some liberated uronic acids and, at the same time, be insufficient to hydrolyse other uronic acid-containing polymers, resulting in an underestimation of these constituents. Interference from hexoses complicates the picture in the method used by us. Methods less sensitive to neutral sugars might be a better alternative, if a colorimetric method is the only choice.

The importance of complete disruption of the tissue structure in the material to be analysed has been emphasized by Selvendran & DuPont (1984). They found a higher release of neutral sugars upon hydrolysis of certain DF preparations of aqueous ball-milled, than of fine-milled, samples, the former causing more complete disruption of tissue structure. Insufficient disruption may lead to incomplete removal of starch, as well as incomplete hydrolysis of polymers, the latter causing underestimation of the constituent monosaccharides of DF. No ball-milling step was included in our procedure and a complete disruption of tissue structure

has not been ensured. However, starch seemed to be completely removed (Table 2), suggesting the absence of 'pockets' inaccessible to the various reagents employed.

As more knowledge about the various DF constituents accumulates existing analytical methods will be modified to include this knowledge. It is important to keep an eye on this development and evaluate and modify our own methods accordingly.

ACKNOWLEDGEMENT

We thank The Agricultural Research Council of Norway for financial support and Gartnerhallen A/L for kind co-operation in providing material for analysis.

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