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Dietary Fibre in Raw and Cooked Potatoes

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ABSTRACT

The content of dietary fibre (DF) in raw and cooked potatoes was determined.

Cooking resulted in a higher content of insoluble DF due to more material determined as cellulose and non-cellulosic glucose in cooked than in raw potatoes, while the level of soluble DF was less affected. The higher content of material determined as cellulose and non-cellulosic glucose probably reflected the presence of retrograded starch.

Cooked potatoes showed approximately the same content of DF whether before or after cooking, boiled in water or steam boiled.

For insoluble DF, gravimetry and gas–liquid chromatography/colorimetry gave the same amounts. For soluble DF, the latter method gave lower results.

INTRODUCTION

The general interest in dietary fibre (DF) has led to a series of investigations of the DF content of various plant foods.

The DF content of potatoes, as compared with that of other commonly used vegetables, is rather low, calculated on a dry weight basis (Theander & Åman, 1979; Englyst, 1981; Reistad, 1983). However, on a fresh weight basis the DF contents of the two groups are not widely different, due to a lower water content in potatoes (Theander & Åman, 1979; Reistad, 1983).

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Potatoes are eaten almost daily in many countries, thereby giving a steady contribution to the DF of the diet.

As potatoes are almost exclusively used in the cooked state, it was of interest to evaluate the influence of cooking on the content and composition of DF. This has previously been investigated by other groups (Theander & Åman, 1979; Englyst *et al.*, 1982; Varo *et al.*, 1983). However, these investigations gave little information on cooking conditions, treatment before and after cooking, etc. The aim of our investigation was to determine the influence of such factors on DF and thereby be able to calculate the content and composition of DF in potatoes as served in most Norwegian households.

MATERIALS AND METHODS

Preparation of samples

Potatoes (variety Beate), 25 kg, were collected at Gartnerhallen A/L, the major Norwegian potato and vegetable distributor, and used without further storage.

The size of potato used was between 70 and 90 g. They were carefully scrubbed with a soft brush in water in order to remove the dirt without breaking the skin and dried on filter paper. Cooking of peeled, as well as unpeeled, potatoes, was carried out as recommended by home economic teachers in order to obtain a good end product. The potatoes were either steam boiled or boiled in just enough water to cover them. Salt was not added. Trial runs to determine cooking time were carried out to avoid damaging the potatoes in the actual cooking, which was carried out in triplicate. Each sample was handled separately past the milling step. Equal weights of the three sample batches were thoroughly mixed prior to moisture and DF determinations.

In the boiling procedure, the preweighed sample (approximately 0·5 kg) was put in boiling water or on a perforated stand above the boiling water level. At the end of the cooking period the water was discarded and the sample left in the cooking pan without a lid for 3 min to evaporate the cooking water adhering to the potatoes. The total sample was then transferred to a flat dish for 15 min to allow some cooling to achieve a stable weight. If cooked with peel, this was removed and the sample reweighed. All samples were then diced (approximately 3 mm^3), frozen at

– 25 °C freeze-dried and milled in a grain mill (Casella & Co., London) fitted with a 0·5 mm screen.

The milled material was stored in small, tightly capped glass jars in desiccators above blue silica gel.

Determination of DF

DF was determined according to the method of Asp *et al.* (1983). In addition, the samples were subjected to analysis by a combination of this method and that of Englyst (1981). The procedure of Asp *et al.* (1983) was carried out past the filtration step for both soluble and insoluble DF and the residues in the filter crucibles were dried at 40 °C at reduced pressure (< 10 mm Hg). The residues were hydrolysed according to the technique of Englyst (1981)—soluble DF in 2M trifluoroacetic acid for 1 h at 120 °C and insoluble DF in 0·5M H_2SO_4 at 100 °C for 2·5 h. The neutral, non-cellulosic monosaccharides in the hydrolysates were determined by gas–liquid chromatography, uronic acids and cellulosic glucose by colorimetry (Englyst, 1981), with minor modifications (Reistad, 1983).

Determination of moisture content

Moisture content in the freeze-dried material was determined by drying at 60 °C at reduced pressure (< 10 mm Hg) to constant weight.

RESULTS AND DISCUSSION

In the present investigation, the DF contents were determined in peeled potatoes only, the peeling being carried out before or after cooking. Unpeeled potatoes contain more DF than peeled ones, but, except for a short period just after harvesting, potatoes are always peeled before consumption. It is also difficult to remove the dirt completely from raw potatoes without damaging and also removing some of the skin in the cleaning process, making the DF results on such samples of limited general value.

It is seen from Table 1 that cooking resulted in only a slight weight loss, less for potatoes cooked with skin than without. Consequently, correcting for this weight loss had little influence on the DF contents when calculated on a raw weight basis (Table 2, last column).

TABLE 1
Some Data on the Potato Material Used for Analysis

Treatment of potatoes	*Cooking time (min)*	*Dry matter (wt. %)*	*Loss upon cooking (wt. %)*	*Edible material (wt. %)*
Raw, peeled	0	21·1	—	76
Boiled in water, peeled after boiling	22	21·7	1·7	91[a]
Steam-boiled, peeled after boiling	25	22·1	1·7	91[a]
Boiled in water, peeled before boiling	20	21·7	3·6	76[b]
Steam-boiled, peeled before boiling	22	23·7	4·6	76[b]

[a] Weight loss upon cooking included.
[b] Weight loss upon cooking not included.

Table 2 also shows that the content of soluble DF was not widely different in raw and cooked potatoes. The method of cooking and the time of peeling did not seem to greatly influence the results.

This suggests that there was little leakage of soluble DF to the surrounding medium during cooking, even for potatoes cooked without skin.

The content of insoluble DF was somewhat higher in cooked than in raw potatoes. The increase seemed to reflect a higher content of cellulose and non-cellulosic glucose (Table 3) but was probably due to the presence of retrograded starch (Englyst *et al.*, 1982, 1983). Again, the method of cooking and the time of peeling did not seem to influence the results.

It is known that part of the starch of cooked potatoes is easily retrograded (Englyst *et al.*, 1982), rendering it unavailable to starch-degrading enzymes and resulting in incomplete removal of this polysaccharide upon DF analysis. Retrograded starch is probably also unavailable to the amylases of the gastrointestinal tract (Asp & Johansson, 1984) and should thus be considered part of the DF. This has been done in the present paper.

In the method of determination of non-starch polysaccharide used by us (Englyst, 1981), retrograded starch might be expected to show up partly as glucose in the insoluble non-cellulosic polysaccharide fraction after hydrolysis in 0·5M H_2SO_4 and left partly unhydrolysed and

TABLE 2
Content of Dietary Fibre (Weight %) in Raw and Cooked Potatoes, Analysed According to Asp *et al.* (1983)

Sample	*DF based on dry weight*			*DF based on weight of raw or cooked material*			*DF based on raw weight*
	Soluble	*Insoluble*	*Total*	*Soluble*	*Insoluble*	*Total*	*Total*
Raw, peeled	3·5	4·0	7·5	0·8	0·8	1·6	1·6
Boiled in water, peeled after boiling	3·3	4·9	8·2	0·7	1·1	1·8	1·7
Steam-boiled, peeled after boiling	2·8	5·1	7·9	0·6	1·1	1·7	1·7
Boiled in water, peeled before boiling	3·7	5·1	8·8	0·8	1·1	1·9	1·8
Steam-boiled, peeled before boiling	3·3	5·2	8·5	0·8	1·2	2·0	1·9

determined as cellulose after the subsequent treatment in 12M H_2SO_4. This was also found, as mentioned above. This is consistent with the work of Englyst *et al.* (1982) which showed that the resistant starch of cooked potatoes was partly hydrolysed by the conditions used for the liberation of monosaccharides from non-cellulosic polysaccharides (M H_2SO_4, 2 h, 100 °C) and left partly unhydrolysed and determined as cellulosic glucose after exposure to 12M H_2SO_4 followed by hydrolysis in M H_2SO_4.

Englyst *et al.* (1982) have also established conditions for avoiding retrogradation of starch in cooked potatoes. This required immediate analysis, or rapid freezing in a solid CO_2–methanol bath prior to storage below −25 °C. Any delay caused retrogradation.

The same group also devised a method for determining the retrograded starch by solubilising in 2M KOH, followed by enzymatic degradation and determination as glucose.

In our work, we were interested in the content of DF in cooked potatoes as they are normally served in private households. Consequently, no effort was taken to prevent starch from retrograding during a period corresponding to the time between cooking and serving. As starch retrogradation mainly takes place during the cooling period following heating, raw potato samples were expected to contain little inaccessible starch. Accordingly, the content of non-cellulosic glucose was low in this

TABLE 3

Constituents of Non-starch Polysaccharides of Raw and Cooked Potatoes, Analysed by a Combination of the Methods of Asp *et al.* (1983) and Englyst (1981). Calculated as Polymers on a Dry Weight Basis (Weight %)

Sample	*NSP*			*Cellulose*	*Ur.a.*		*Rha*		*Fuc*		*Ara*		*Xyl*		*Man*		*Gal*		*Glu*[a]	
	S	*I*	*T*		*S*	*I*	*S*	*I*	*S*	*I*	*S*	*I*	*S*	*I*	*S*	*I*	*S*	*I*	*S*	*I*
Raw, peeled	1·9	3·9	5·8	2·0	0·5	0·2	tr.	tr.	—	—	0·1	0·2	—	0·1	tr.	—	0·9	1·2	0·4	0·2
Boiled in water, peeled after boiling	2·2	4·8	7·0	2·7	0·7	—	tr.	tr.	—	—	0·1	0·1	—	0·1	tr.	tr.	1·1	0·8	0·3	1·1
Steam-boiled, peeled after boiling	2·0	5·3	7·3	2·7	0·6	—	tr.	tr.	—	—	0·1	0·2	—	0·1	tr.	tr.	1·0	1·0	0·3	1·3
Boiled in water, peeled before boiling	1·8	4·9	6·7	2·4	0·6	—	tr.	tr.	—	—	0·1	0·2	tr.	0·1	tr.	—	0·9	1·1	0·2	1·1
Steam-boiled, peeled before boiling	1·5	5·2	6·7	2·5	0·5	—	tr.	tr.	—	—	0·1	0·2	tr.	0·1	tr.	—	0·6	1·3	0·3	1·1

[a] Cellulose not included.
NSP, Non-starch polysaccharides.
S, Soluble.
I, Insoluble.
T, total.
tr., trace.
—, none detected.

Ur.a., uronic acids.
Rha, rhamnose.
Fuc, fucose.
Ara, arabinose.
Xyl, xylose.
Man, mannose.
Gal, galactose.
Glu, glucose.

material (Table 3). Table 3 also shows that, apart from cellulose and non-cellulosic glucose, which were higher in cooked than in raw potatoes, the amounts of the various other constituents of the non-starch polysaccharides were not significantly different.

However, as observed and discussed previously for other plant foods (Reistad & Frölich, 1984; Reistad *et al.*, 1985), the gravimetric method of Asp *et al.* (1983) gave higher results than the sum of neutral monosaccharides and uronic acids determined according to Englyst (1981). In the present work the difference was limited to soluble DF. Similar results were obtained in an interlaboratory study (Varo *et al.*, 1983). In this investigation soluble DF levels of potato were significantly higher when analysed according to Asp *et al.* (1983) than according to a modified Southgate–Englyst method (Laine *et al.*, 1981), while levels of insoluble DF were about the same. Raw potatoes contained less DF than cooked potatoes, reflecting, among other things, more cellulose in the latter samples.

The hybrid procedure of Asp *et al.* (1983) and Englyst (1981) described in the present paper, was also used in a previous investigation (Reistad & Frölich, 1984). It was then found that this procedure—and that of Englyst (1981)—gave approximately the same results.

From our investigation it may be concluded that, although cooked potatoes on a dry weight basis contain somewhat more DF than raw potatoes, the difference is slight when based on the weight of the product as consumed (Table 2). Also, surprisingly little difference in DF content and composition was found between potatoes peeled before and after cooking. Boiling in water and steam-boiling also gave approximately the same results.

However, our results are based on optimal cooking of whole potatoes, and a short time period between cooking and consumption. Cutting, overcooking and warmholding for longer time periods may, to a greater extent, also influence the DF content.

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