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ORIGINAL RESEARCH

Sampling of Potatoes to Determine Representative Values for Nutrient Content in a National Food Composition Table

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To update the Norwegian Food Composition Table (FCT), representative samples of 10 potato varieties — all domestically grown, were selected according to production and market statistics. The major varieties grown in different parts of the country were analysed separately, whereas less important potato varieties or analytes of less importance were analysed from one or more composite sample(s). A sample normally contained subsamples from five growers in the area. Potatoes to be stored for consumption during winter were sampled at harvest and after 4–6 months of storage. Of the 34 nutrients that were analysed, vitamin C is presented as an example of how the FCT values were derived from the analytical results. The content of vitamin C varied between 7 and 20 mg/100 g edible potato when analysed at different times during the year. The FCT-value of storage potatoes was set to 16 mg at harvest time. The different varieties and growing conditions may partly explain the apparent differences from other Nordic FCT-values, but "artificial" deviations due to different sampling and analytical methods may also be present.

Key Words: potato; sampling; calculation of weighted nutrient content; vitamin C.

INTRODUCTION

A high consumption of vegetables and fruits is important for prevention of cancer, heart diseases and several other conditions related to health (World Cancer Research Fund, 1997; Law and Morris, 1998; Gaziano *et al*., 1995). According to Norkost a dietary survey in 1993–1994 among a nationally representative sample of 3144 Norwegian men and women 16–79 years old (Johansson and Andersen, 1998), the average intake of fresh fruits and vegetables including potatoes, was 376 g per day. Potatoes and vegetables each accounted for 35% of the total intake and fruits 30%. As the total intake of these foods is much less than desirable, the National Council on Nutrition and Physical Activity has initiated several projects to increase their consumption.

During 1992–1995 an analytical study of the nutritional composition of domestically grown potatoes, vegetables, fruits and berries was carried out in order to update the data in the Norwegian Food Composition Table (FCT). The table values for these foods had not been thoroughly revised since the first edition was published in 1960 (Landsforeningen for kosthold og helse, 1960). Thus, a change in plant varieties over time and focus on a larger range of nutrients were the major reasons for this study.

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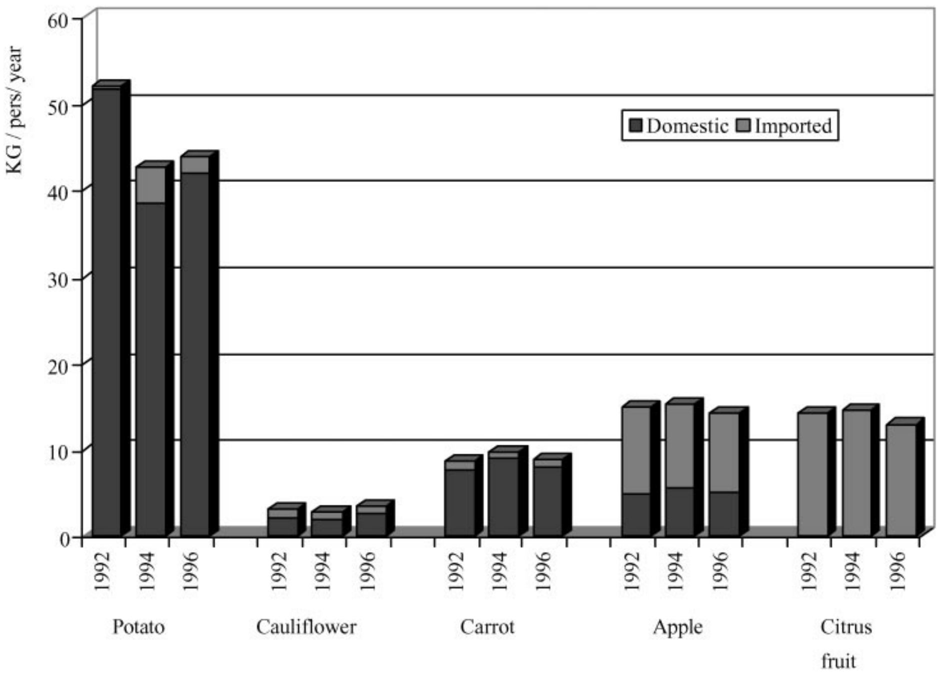

FIGURE 1. Available supply of domestically grown and imported potatoes and some commonly used vegetables and fruits for human consumption.

Many of the old data had also been borrowed from FCTs in other countries. For domestically grown foods this may not be appropriate as growing conditions, including climate, soil, use of fertilizers, etc., and selection of varieties may vary considerably, even within the Nordic countries.

In Norway, only 3% of the land is used for agricultural purposes. Per capita statistics for 1992, 1994 and 1996 show that almost the entire supply of potatoes is grown domestically, whereas the imported proportion varies considerably between different types of vegetables and fruits (Fig. 1). Approximately 30% of the total supply of vegetables available for human consumption in Norway and 75% of the total supply of fruits and berries are currently being imported.

To obtain nationally representative values for potatoes, it was necessary not only to sample the major varieties that were grown in Norway but climatic differences in the various regions of the country also had to be accounted for. This paper presents the sampling plan and describes how the table values for vitamin C were determined from the analytical results taking into consideration available statistics.

MATERIALS AND METHODS

Potato Varieties and Geographic Regions

According to the Potato Marketing Board in Norway (1994), three main varieties are grown for human consumption during the summer months, two are harvested and used during autumn and three main varieties are cultivated as storage potatoes, these may be kept until the next spring or early summer. Table 1 shows the distribution of

TABLE 1

Distribution of potato varieties in Norway[1]

Potato varieties	Area (%)
Main summer varieties (3)	7
Main autumn varieties (2)	13
Main storage varieties (3)	52
Other varieties for consumption as fresh potatoes	8
Varieties used only in the production of chips, etc.	20

[1] Potato Marketing Board (1994).

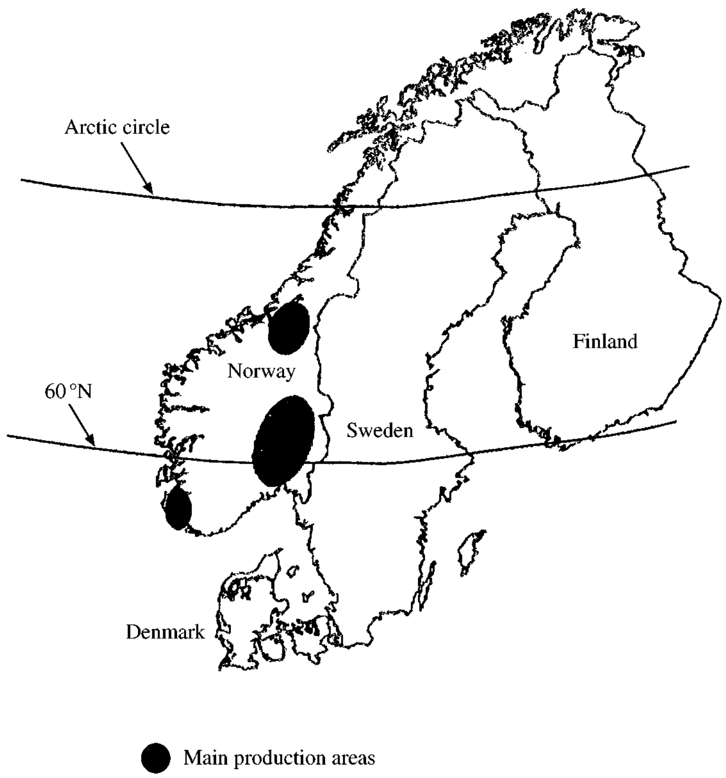

FIGURE 2. Main areas for growing potatoes in Norway.

the seasonal varieties for consumption as fresh potatoes and the proportion of potatoes used for manufacturing potato chips and other processed products. As no production statistic is available for potatoes, the quantities are based on area shares.

The main farming areas for cultivating potatoes in Norway are indicated in Figure 2. Some of the potato varieties are only grown in certain areas of the country. This is mostly due to varying climatic conditions. Farmers in the southeastern part of Norway produce 73% of the potatoes used for fresh consumption. The southwest and central parts of Norway contribute most of the remaining amount of potatoes

TABLE 2

Distribution of main potato varieties by harvesting season and farming region

Potato variety	Norway (%)[1]	Farming region: South east (%)[2]	South west (%)	Central (%)	North (%)
Main summer varieties					
Rutt	3	61	8	10	0.3
Ostara	2	49	21	21	0.3
Snøgg	2	69	13	6	0.9
Main autumn varieties					
Laila	8	76	6	13	0.1
Troll	4	18	18	21	35
Main storage varieties					
Beate	34	91	3	3	0.1
Pimpernell	14	45	9	35	5.5
Kerrs Pink	4	72	19	6	0.1

[1] Percent of all potato varieties grown in Norway.
[2] Percent of each potato variety by region.
All percentages represent production area shares, Potato Marketing Board in Norway (1994).

TABLE 3

Schedule for sampling and analysis of potatoes

Potato varieties	Year of harvesting	Time of sampling	Time of analysis
Summer	1993	13.07–2.09.1993	Jul–Sept 1993
Autumn	1993	26.07–20.10.1993	Jul–Oct 1993
Storage	1993	1.10–17.12.1993	Oct–Dec 1993
	1994	19.01–27.02.1995	Jan–Feb 1995
			May 1995

available in the Norwegian market, whereas less than 4% of the production is from northern Norway.

Sampling Plan

A sampling plan was developed to cover the main regions growing potatoes with respect to climatic conditions and the importance of each variety in the region according to area share production statistics (Table 2). For the most important varieties, samples were collected separately in each main region. Due to financial constraints the samples to be analysed were composites of subsamples collected from five different farmers within the specific geographic regions. Each subsample weighed approximately 2 kg.

In general, one composite sample was collected for each of the main varieties in each of the main regions growing potatoes. The sampling dates for the potatoes are shown in Table 3. The summer and autumn varieties were only sampled from the 1993 crop. For the most common autumn variety (Laila), two composite samples were collected in the southeastern region of Norway, as 76% of this particular variety is grown in this area. For the other autumn variety (Troll), a composite sample was collected only in the northern region. Troll is the most commonly cultivated potato variety in this part of the country.

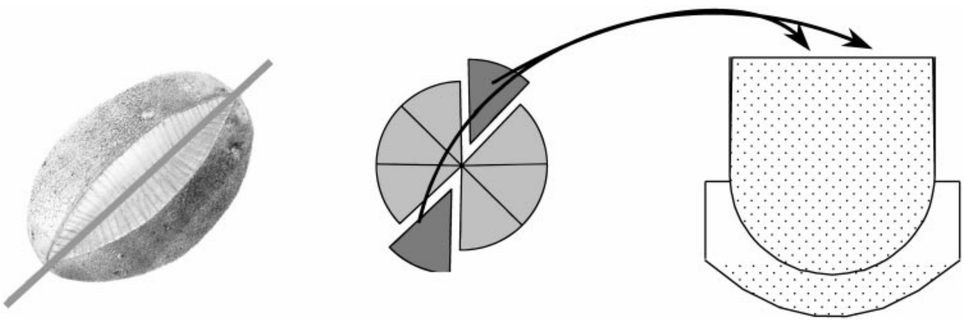

FIGURE 3. Reduction of the potato samples.

Of the three main storage varieties, one composite sample was collected from the 1993 crop in each of the three major growing areas during October, November and December. The same storage varieties and regions were also sampled from the 1994 crop during January and February 1995. At this time, the weight of the subsamples were increased to 6 kg each to account for deterioration of the potato tubers during storage and two composite samples were taken from the south eastern part of Norway. One-third of these larger samples were analysed immediately, whereas the remaining 4 kg of each subsample was stored by a wholesale dealer at $+4°C$ and normal humidity until May before analysis.

Handling of the Potato Samples

Collection and preparation of the samples was done by the Food Control Authority in Bergen. They also performed the analytical work in cooperation with the Institute of Nutrition at the Directorate of Fisheries in Bergen.

The potato tubers were washed, scrubbed and dried with a paper cloth before peeling. The composite samples were reduced by cutting each potato into eight equal-sized longitudinal sectors. Two sectors from opposite sides of each potato were used for the laboratory sample as shown in Figure 3.

The laboratory samples were homogenized in a food processor and immediately divided into test portions. Depending on what analytical parameters were to be determined, the test portions were either frozen and stored at $-80°C$ or freeze-dried. To avoid contact with air, the samples to be analysed for vitamin C were only partially homogenized before further treatment. Whenever possible, the analysis of vitamin C was performed immediately after the first homogenization step. If for practical reasons this could not be done, the analytical test samples were stored for a short period at $-80°C$.

Analytical Method

The total amount of vitamin C was determined as the sum of ascorbic acid and dehydroascorbic acid by an automated fluorometric method (Roy *et al*., 1976). This is a slight modification of the AOAC method 43.056–43.062. According to this method, the final homogenization of the analytical sample should be performed in a cold diluted solution of oxalic acid and the slurry should be kept on ice in order to avoid degradation of vitamin C. Whenever the samples had been frozen, the acid solution was added while the test materials were still frozen.

Two replicates of each sample were analysed. The mean difference in vitamin C content between two replicate samples was 0.334 mg/100 g ($N = 41$).

As no reference material was available at that time, 10 replicates of a sample of strawberries were also analysed in another Norwegian laboratory using the same method. The two laboratories determined the concentration of vitamin C to be 66.8 and 65.1 mg/100 g with calculated relative standard deviations of 1.8 and 1.4%, respectively.

Calculation of Values

Analytical values of the vitamin C content were determined for each of the largest varieties of potatoes from each of the main cultivating regions. A weighted mean was calculated according to the area shares (%) according to the following two equations:

$$CV = \sum_{i=1}^{n} CV_i * AS_i(\%) \Big/ \sum_{i=1}^{n} AS_i(\%), \tag{1}$$

$$C = \sum_{j=1}^{m} CV_j * AS_j(\%) \Big/ \sum_{j=1}^{m} AS_j(\%), \tag{2}$$

where CV is the calculated concentration of vitamin C in a potato variety collected in n different regions, CV_i is the vitamin C concentration in the analysed sample(s) of the variety from region i, AS_i (%) is the area share (%) of the potato variety in the region i. C is the concentration of vitamin C calculated from m different potato varieties for use in FCT, CV_j is the calculated concentration of vitamin C in the potato variety j and AS_j is the area share (%) of the potato variety j in Norway.

All concentrations of vitamin C are given as mg/100 g edible raw potato.

RESULTS

The concentration of vitamin C in the potatoes was calculated for each variety and region according to equation (1) and the weighted country means for summer, autumn and winter potatoes respectively were calculated according to equation (2).

For example, Table 4 shows that the composite samples of the variety Pimpernell contained 13.7, 12.5 and 17.5 mg vitamin C/100 g potato, respectively, in the 1993 crop from the three main potato farming regions. As the market shares for this particular variety in the three regions were 45, 9 and 35%, the weighted mean for vitamin C in Pimpernell was calculated as 15 mg/100 g potato:

$$CV = \frac{13.7*45 + 12.5*9 + 17.5*35}{45 + 9 + 35} = 15 \text{ mg/100 g}. \tag{3}$$

The value of vitamin C to be used for storage potatoes in the 1995 edition of the Norwegian FCT (Statens Ernæringsråd and Statens Næringsmiddeltilsyn, 1995) was based on a weighted mean of the main three varieties analysed from the 1993 crop according to their overall market shares:

$$C = \frac{16*34 + 15*14 + 16*4}{34 + 14 + 4} = 16 \text{ mg/100 g}. \tag{4}$$

The potatoes that were harvested in 1994, sampled in January–February 1995 and kept under normal wholesale storage conditions retained 67% (Beate), 73% (Pimpernell) and 64% (Kerrs Pink) in May 1995 compared to their mid-winter content (Fig. 4).

TABLE 4

Concentration of vitamin C (mg/100 g raw edible potato) in different varieties of potatoes from different regions and the weighted country mean for Norway

	Farming region				Country
Potato varieties	South east	South west	Central	North	Weighted mean
Summer varieties 1993					17[1]
Rutt	15.7	20.1	11.4		16
Ostara	18.7	17.2	8.4		16
Snøgg	19.7	18.6	11.5		19
Autumn varieties 1993					13[1]
Laila	14.1				14
Troll				9.4	9
Storage varieties 1993					16[1]
Beate	15.8	15.0	18.7		16
Pimpernell	13.7	12.5	17.5		15
Kerrs Pink	16.3	15.9	15.4		16

[1] Values published in the Norwegian Food Composition Table 1995.

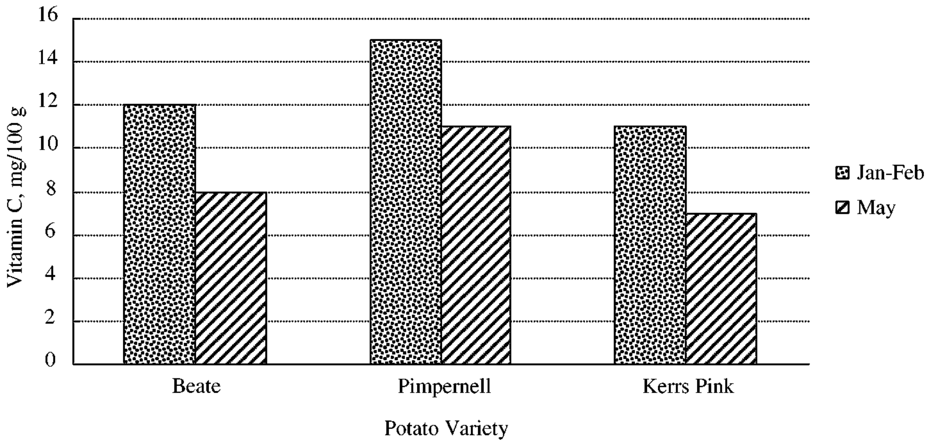

FIGURE 4. Concentration of vitamin C in storage varieties harvested in 1994 and kept under normal storage conditions until analysis in January–February and May next year.

DISCUSSION

In this study, we found that the content of vitamin C in major Norwegian potato varieties varied between 7 and 20 mg/100 g raw edible potatoes. The highest values were found in two of the summer varieties grown in southern Norway and the lowest values were found in two of the winter varieties that were kept under normal storage conditions until May the following year.

The large variation for the summer varieties (8.4–20.1 mg/100 g) compared to the storage varieties close to harvest time (12.5–18.7 mg/100 g) is due to the lower concentration of vitamin C in the summer potatoes that were grown in the central region. Differences in weather conditions (i.e., temperature and rain) between the central and southern regions during the growing period cannot explain this result.

The only variety from northern Norway that was analysed had a rather low concentration of vitamin C (9.4 mg/100 g). This variety was not sampled and analysed from the other regions due to smaller market shares.

Only a small fraction of the consumers in Norway eat home-grown potatoes. Since, the majority do not know the growing area or pay much attention to the potato variety they eat, weighted mean values were presented in the 1995 edition of the Norwegian FCT (Statens Ernæringsråd and Statens Næringsmiddeltilsyn, 1995) for summer, autumn and storage potatoes, respectively.

The table value of 16 mg/100 g raw storage potatoes does not take into account the decrease in vitamin C content over time. The present study included too few sampling points during the storage period to estimate how the decrease progressed after harvesting. More information is also needed on the market shares for the specific potato varieties during the winter and spring months. Thus, it should be noted that the published content of 16 mg vitamin C/100 g raw edible potato is only representative for the content of vitamin C at sampling time, and that this value may be somewhat higher than an estimated average for the whole period.

Compared to the earlier value of 10 mg/100 g in the Norwegian FCT for storage potatoes (Landsforeningen for kosthold og helse, 1960), the new value has increased by 60%. However, both values are within the range of values published in current editions of FCTs in the other Nordic countries, i.e., the Swedish and Finnish tables show 11 mg, whereas the Danish table shows 27 mg/100 g of potatoes (Livsmedelsverket, 1996; Rastas *et al*., 1997; Møller, 1996). Different varieties and growing conditions may partly explain the differences between the countries, but "artificial" deviations due to different sampling and analytical methods may also be present. This kind of information is generally not included in the printed tables. Even though the latest editions of the Danish and the Norwegian FCTs provide references to each nutrient value for each food, many of the cited references are not available for the common user.

According to the Norkost study, the average intake of fresh potatoes was 120 g per day among adults, and this food alone supplied 18% of the dietary vitamin C intake before estimated cooking losses were deducted (Johansson *et al*., 1997). When the old Norwegian table value for vitamin C in potatoes had been applied or the Swedish or Finnish value had been borrowed, the average intake had been 6–7% lower, while a table value borrowed from the Danish table had resulted in a 13% higher intake.

CONCLUSION

Good estimates of the nutritional content of major foods in the diet are essential in the study of many diet–health relationships, as well as for many other purposes (Deharveng *et al*., 1999). This study has demonstrated the need for proper sampling and calculation of weighted means for nutritionally important foods. Behind the seemingly exact figures in FCTs there may or may not be large and costly projects addressing factors that are known to have an impact on the result. To include a reference for each table value that points to the published description of how the values were determined might improve the users' awareness of the data quality.

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