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The Potato as a Healthy Food in Modern Ireland

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SUMMARY

The status of potatoes in the diet in pre-Famine times, and in the early and late 1900s is discussed. Consumer trends in the 1990s have been towards processed potato products and the boiled potato has become less popular. More effort, therefore, should be focused on improving the convenience aspects of raw potatoes in order to reverse this trend.

Boiling, steaming, microwaving and baking are the best cooking options and in these forms potatoes are low-fat, and are an excellent source of energy, complex carbohydrate, thiamine, and vitamin C. They also supply protein, dietary fibre, minerals and other nutrients in smaller quantities. Garnishing with fat-spreads and/or cooking in oil greatly increases fat content. Vitamin C is one of the 'ACE' vitamins and its anti-oxidant function is being increasingly recognised. Careful cooking is needed to conserve vitamin C, and the warm-holding of potatoes should be avoided.

Recent findings indicate little difference in the composition and nutritive value of organically produced vs conventionally grown potatoes. The level of toxicants, both inherent and added is very low for Irish potatoes.

Finally, an intake of 2 to 3 boiled potatoes (lightly garnished) per person per day is advocated on a population basis.

INTRODUCTION

The potato was introduced into Ireland in the sixteenth century and Ireland is now synonymous with the potato largely due to the Famine in the last century. The potato has always been considered a healthy food and was the mainstay of the diet in parts of rural Ireland in pre-Famine times. However, there has been a huge decline in consumption from

the massive adult intake of 5-6 kg per person per day (by labourers and small holders) at that time (1), to about 0.4 kg per person per day (2) in the 1990s. Ireland still remains at the top of the European league for potato consumption and the acreage of potatoes in 1998 was 15.8 kha with a yield of about 470 ktonnes (3). Traditionally potatoes were consumed in Ireland as boiled with skins on, and while some are still consumed this way, there has been a swing towards French fries and crisps, and more recently towards a range of convenience potato products. This paper assesses the status of the potato as a healthy food in modern Ireland against a background of (i) decreased consumption, (ii) the move away from the boiled potato, (iii) increased intensity of production, (iv) the introduction of new cultivars and storage techniques, and (v) the availability of better techniques for assessing the nutritive content and properties of foods. Brief data and information on potatoes from pre-Famine times and from 1918 are cited, and are compared with modern values.

PRE-FAMINE

The reliance on the potato is evident in the late 17th century *Political Anatomy of Ireland,* which notes the dominant position of the potato in the diet of the Irish (4):

"....their food is bread and cakes; whereof a peny serves a week for each; potatoes from August till May.... As for flesh they seldom eat it".

Doyle (5) studied the nutritional adequacy of the Irishman's diet in 1840 (Table 1) and

Table 1: Nutritional adequacy of the Irishman's diet in 1840

	10 lbs of potatoes + 1 pint whole milk	Approximate daily requirements for an adult
Energy (MJ)	16.4	12.8
Protein (g)	64	70
Calcium (g)	2.6	0.6
Iron (mg)	21.7	8.4
Vitamin D units	900	300
Vitamin C (mg)	318	60

Source: Doyle, 1975 (5)

the data show that 10 lbs of potatoes plus one pint of whole milk per day gave more than the daily requirements for energy, calcium, iron, and vitamins D and C, and almost the requirement for protein, i.e. the diet was good. Data for the composition of boiled potatoes (Table 3) indicate that they are rich in energy and complex carbohydrate (starch) and are a significant source of vitamin C, i.e. an average helping of boiled potatoes supplies about half the daily requirement of vitamin C. The quality of potato protein is good (almost as good as egg) but the content is small at about 1.4%, as is the dietary fibre content (Table 3). However, multiplying the left had column in Table 3 by 50 approximates the intake of energy and nutrients in pre-Famine times, and in this context the intakes of protein, and especially dietary fibre, are very good. These data show that potatoes and milk, when consumed in volume, are an 'all round' nutritious low-fat diet which would satisfy most of the requirements in today's dietary guidelines. However, such a diet would not be tolerated by today's sophisticated consumers because of its blandness and monotony.

1918 STUDY

Johnson (6) evaluated 67 potato cultivars in a landmark study published in 1918 entitled "*The Industrial and Nutritive Value of the Potato in Ireland*". The mean dry matter values (Table 2) were relatively similar to those of today's modern cultivars (3) as were starch contents. Johnson showed the link between tuber density and dry matter content, and between dry matter and flouriness (i.e. high dry matter is associated with flouriness).

Table 2: Data for 67 potato cultivars

Test	Mean	SD[1]	Range
Starch (%)	16.1	3.06	11.7-22.0
Dry matter (%)	22.8	2.73	17.8-28.8
Density (SG)[2]	1.09	0.012	1.069-1.117

Source: Johnson (1918) (6)

[1]Standard deviation
[2]Specific gravity

He showed considerable foresight in extolling the benefits of starch in the diet, and his comments and those of Funk on vitamins proved unerringly accurate and were as follows:

"Increasing importance is being attached by physiologists to the part played in the diet by certain obscure bodies present in extremely small quantities, called vitamines. These accessory factors in growth and nutrition are known to be essential for the maintenance of health, and are usually present in sufficient quantity in a normal mixed diet. Their absence leads to deficiency diseases, such as rickets and scurvy. Funk showed that a potato soup, owing to its vitamines, will cure a "deficient". Though the potato vitamines have not been localised or isolated, it is, judging from analogy, extremely probable that they occur in the outer layer of the cortex, just beneath the skin. Thick peeling and subsequent long standing in water before cooking are effective ways of removing the vitamines, and thus reducing enormously the food value of the potato. Cooking in their jackets by steaming or roasting, and subsequent thin peeling, are effective means of conserving the vitamines.

CURRENT RESEARCH

This and subsequent sections deal with the status of the potato as a healthy food in the 1990s and beyond. The 1990s have brought changes in the acreages of cultivars being grown (Kerr's Pink, Rooster and Record were the top three in 1998) in Ireland, increased potato imports, higher yields/intensity, more cold storage, a continuing swing to the consumption of processed potato products, and changing consumer attitudes towards potatoes.

Consumer aspects

A recent consumer survey (7) carried out by the Market Research Bureau of Ireland on behalf of An Bord Glas used a stratified random sample of 1000 people. Some of the main findings relating to 'fresh' potatoes (i.e. as distinct from crisps or 'French fries) were as follows:

- consumers require quality, safety and flavour
- 92% said part of traditional Ireland
- 76% said part of dinner in the evening
- 60% ate potatoes at least once per day
- 43% considered potatoes very nourishing
- 13% said convenient to prepare
- 9% said imaginative/creative/fun cooking
- 7% said part of a modern lifestyle

These and other comments suggest that overall, 'fresh' potatoes do not have a popular image in modern Ireland. This agrees with the findings of Kolasa (8) who said "*how far do we have to go to convince you the potato is a vegetable*". A 1988 survey in the USA indicated that 93% of consumers knew that potatoes are low in calories and 71% knew they are nutritious,. These figures contrast with those for 1973 which were 68 and 56% respectively. This shift was attributed to the promotional activities of the US National Potato Board. However, reports from numerous US studies show a persistence to the belief that potatoes and starch are fattening. Kolasa concludes that the potato plays its role in human nutrition only to the extent that it is consumed.

The above data emphasise the need for promoting convenience for the consumer. More attention should be focused, therefore, on selling clean potatoes, on selling pre-prepared uncooked potatoes, and on cooking by microwaving (takes 6-7 minutes).

Boiled potato composition

Boiled potato composition is given in Table 3 together with the recommended daily amounts for some of the nutrients. Multiplying the left hand column (Table 3) by 50 approximates the nutrient intake per person per day of those consuming 5 kg of potatoes daily in pre-Famine times. A multiplier of 3 to 4 would be used for today's consumer.

Table 3: Boiled potato composition (per 100 g)

		RDA[1]
Energy (MJ)	0.34	10.9
Water (g)	80.5	-
Starch (g)	19.3	-
Protein (g)	1.4	54
Dietary fibre (g)	1.0	25
Sugar (g)	0.4	-
Fat (g)	0.1	<35% of energy
Vitamin C (mg)	7	60
Thiamine (mg)	0.08	1.09
Folic acid (μg)	10	300

[1]Recommended daily amount (adult male)

On this basis boiled potatoes are an excellent source of energy, complex carbohydrate (starch), vitamin C and thiamine. They are very low in fat but this 'positive' is often offset by high-fat cooking methods (see below). The energy value of potatoes relates closely to the dry matter content which is mostly comprised of starch. Hence a low dry matter (19%) cultivar such as Cara will have about 70% of the energy content of a high dry matter (27%) cultivar such as Golden Wonder.

Complex carbohydrate

Current dietary advice is for a high intake (close to 50% of energy intake) of complex carbohydrate (starch), and in this regard the potato is an excellent source. Complex carbohydrate is medium/high in energy but the starch is 'packaged' in cells, the rate of energy release is relatively slow, and so complex carbohydrate is not fattening, i.e. the energy tends to be used as it is released rather than being stored in the body. Boiled potatoes have a low energy density (2.7 kJ/g) in common with apples (2.3), porridge (2.6), bananas (3.6), white rice (4.9), and many other foods, and contrasts with higher energy density foods such as French fries (10.7), and white bread (10.6), and with very energy-dense foods such as popcorn (21.3), potato crisps (22.7) and peanuts (26.3 kJ/g).

Recent studies have shown that carbohydrate-rich diets which result in high post-meal (postprandial) glucose and insulin responses are associated with undesirable human fat profiles, greater body fat, and the development of insulin resistance in humans. For these reasons Holt *et al* (9) carried out a major study on the insulin score of 38 foods (published in 1998). Each food was served plain as a 1000 kJ portion to separate sets (11 to 13) of persons. The insulin score for each food was calculated as the area under the 120 min insulin-response curve relative to that for bread, multiplied by 100. The results showed that the important Western staples, bread and potato were among the most

Table 4: Insulin score[1] for 1000 kJ servings

Food	Serving wt (g) [A]	Insulin score [B]	[B]/[A]
Jellybeans	88	160	1.82
Mars bar	54	122	2.26
Potatoes	368	121	0.33
White bread	94	100	1.06
Bananas	279	81	0.29
Cornflakes	170	75	0.44
Doughnuts	65	74	1.14

[1]Area under 120 - min plasma insulin response curve, relative to that for bread, multiplied by 100

insulogenic (insulin-generating) foods. In contrast, pasta, oatmeal, porridge and all-bran produced relatively low insulin responses. The insulin score for potatoes at 121 (Table 4) was relatively high compared to that for bananas, cornflakes and doughnuts. However, potatoes have a low energy density and when the insulin score (B) is related to the serving weight (A) corresponding to 1000 kJ, the ratio of B/A is the second lowest only to bananas, i.e. the high insulin score of potatoes is due to their large 'serving weight'.

Dietary fibre and resistant starch

Boiled potatoes have a low dietary fibre, content at about 1%, but the value increases for boiled/eaten with skins (2%), or baked/eaten with skins (2.5%), or consumed as French fries (3.2%). Cooked potatoes also contain resistant starch (RS), i.e. some of the starch becomes

resistant to digestion in the small intestine and behaves, physiologically as dietary fibre i.e. RS has a beneficial function *in-vivo*. The resistance to digestion results from the retrogradation of both the amylose and amylopectin fractions of starch. Retrogradation of starch dispersions is favoured by low temperatures and high concentrations. Recent tests at The National Food Centre indicate that boiled potatoes contain about 10% of resistant starch on a dry matter basis which is equivalent to about 2% as eaten (10). There was no difference in the RS content of seven cultivars tested. In addition to raising the dietary fibre content of the potatoes, RS is less calorific than ordinary starch with an energy value of 8.5 compared with 16 kJ/g. This means that boiled potatoes have a lower (by 5 to 10%) energy content, *in-vivo*, than thought previously.

Table 5: Effect of multiple cooking-cooling on the development of resistant starch (% on dry matter) in boiled potatoes

Cook-cool[1]	Storage temperature[2]	
	4°C	20°C
Once	12.8	12.1
Twice	17.5	14.1
Three times	23.2	18.2

[1]Cook for 4 min; blast cool at -30°C for 8 min
[2]All samples were stored for 24 hr before testing

Boiling followed by cooling also raises RS content (Table 5) and cooking-cooling three times gives RS values in excess of 20% (on dry matter) when stored for 24 hr at chill temperatures. This has implications for potato salad which is normally eaten cold. Reheating chilled cooked potatoes, or mash causes some of the RS to loose its resistance and become digestible again. Warm-holding mashed potatoes in an oven at 70°C for 60 min raised RS values from 2 to 5%. However, warm-holding has a negative impact on vitamin C status.

The 'ACE' vitamins

Vitamins A, C and E are collectively known as the 'ACE' vitamins because of their key importance. Provitamin A is found as carotene in carrots and other foods, vitamin C in

fruits, vegetables and potatoes, and vitamin E in vegetable oils. All three are antioxidants and act as 'free radical quenchers', or 'scavengers' in our bodies. A free radical is a group of atoms which normally exist only in combination with other atoms and is brought into independent existence by 'special conditions'. Free radicals contain an unpaired electron and are extremely reactive chemically. Free radicals can be produced from food constituents *in-vivo* or during cooking, and have been linked to cancer induction, tissue ageing, and to damage of the heart muscle. It is imperative, therefore, that they are scavenged or quenched and hence the importance of an adequate intake of the 'ACE' vitamins. Vitamin C also promotes healing and prevents scurvy, but its most important function may be that of an antioxidant.

Raw potatoes contain 8 to 30 mg/100g of vitamin C depending on the age and storage period. Tests at The National Food Centre in 1992/93 (11) indicated that the vitamin C content of raw maincrop potatoes remained relatively constant at 8 to 10 mg/100g over an 8-month storage period. This contrasted with values of 18 to 28 mg/100 g for early crop samples. The current commercial practice of bulk-storing potatoes at 2 to 3°C should help to conserve vitamin C. Cultivar also influenced the content with mean raw potato values of 6.7 (Pentland Dell), 7.0 (Record), 8.2 (Cara and Maris Piper), 8.3 (Golden Wonder), 10.3 (Rooster) and 10.6 mg/100 g (Kerr's pink) (12).

Cooking, and the presence of oxygen reduce the vitamin C content of potatoes. Losses of circa 35% have been reported during boiling (13) due to the heat and leaching (vitamin C is highly water soluble) with a further loss of about 20% during warm-holding at 60°C for 1 hour. Holding cooked mashed potato in chill storage at 3°C for 4 days reduced the vitamin C content from 13 to 4 mg/100 g (14). These data show the importance of rapid cooking followed by immediate consumption, and point to microwaving peeled or skin-on raw potatoes as a method for retaining vitamin C (i.e. short time; virtually no leaching) and increasing convenience. Microwave cooking gave at least double the retention of vitamin C than conventional boiling or steaming (15)

Effects of cooking/garnishing

The effects of cooking on vitamin C content have been described above, but of equal importance is the effect of cooking method and garnishing on the fat content of cooked potatoes. Current dietary advice advocates that the percentage energy from fat in the total diet should be less than 35%. In this regard boiled potatoes have an excellent status with only 1% of energy from fat (Table 6). Adding butter, sour cream, roasting or baking greatly

Table 6: Effect of method of cooking on the fat status and energy density of potatoes (based on 200 g)

	Fat status (% energy from fat)	Energy density (kJ/g)
Boiled	1	3.40
Mashed (+ butter 12 g, + milk 53 ml)	38	4.54
Baked	1	4.46
Baked + skins	1	3.61
Baked + skins + sour cream (10 g)	11	3.87
Roast	28	6.67
French fries	39	10.75

increase fat content (Table 6) and result in a much more energy-dense food. Boiling, baking and microwaving are the recommended cooking methods while a low-fat vinaigrette with herbs serves as an excellent garnish. Recipes for potato dishes are available from An Bord Glas, and also in a book written by Donnelly (16).

Organic potatoes

A recent (1998) study and review (17) on the yield, vitamin C and mineral contents of organically and conventionally grown potatoes indicates little difference between the two systems. There were no statistically significant differences in yield and vitamin C contents. However, phosphorus, magnesium and sodium content was higher in organically grown tubers, with manganese level higher in conventionally grown samples.

Toxicants

Toxicants are considered in this paper as those occurring naturally in the potato (inherent toxicants), and those that are applied, such as agrochemicals. The main inherent toxicants are glycoalkaloids and it is generally accepted that potatoes containing more than 200 mg of glycoalkaloids per kg of fresh weight should not be consumed. Solanine is one of the main glycoalkaloids and light promotes its development. Therefore, raw potatoes should be stored in the dark, or in light-imperiable sacks or consumer packs.

Ciéslik and Praznik (18) found that the glycoalkaloid content of potatoes varied with stage of maturity with values of 36, 54, 78 and 13 mg/kg for potatoes harvested and tested 60, 70, 80 and 111 days (fully mature) after planting, respectively. The values for mature potatoes were very low and well below the advocated maximum of 200 mg/kg. Storage of potatoes for 24 weeks at 4°C gave a higher glycolalkaloid value (61 mg/kg) compared to storing at 10°C (16 mg/kg).

In the case of agrochemcials, levels of the sprout inhibitor tecnazine and of nitrate in raw potatoes were very low. Of 44 samples tested for tecnazine in 1994 to 1996 by the Irish Department of Agriculture and Food, 37 had no detectable residue, while seven samples had residues which were well below the maximum residue limit. This result was expected as the use of bulk cold stores for potatoes has greatly reduced the need for sprout inhibitors.

Nitrate levels in cooked potatoes were also low with values of about 8 mg/kg (12) for Irish potatoes tested in 1992/93. These values are well below the 'often-quoted' maximum figure of 300 mg/kg fresh weight for vegetables

Conclusions

- Convenience for the consumer should be improved by providing clean raw potatoes and/or ready-prepared raw potatoes
- The potato has excellent nutritional properties and a consumption of 2 to 3 boiled potatoes per person per day is advocated on a population basis

- Cook by boiling, steaming, baking or microwaving and garnish with low-fat dressings
- Consume quickly after cooking and do not warm-hold

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