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THE CHEMICAL COMPOSITION AND NUTRITIVE VALUE OF POTATO

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1. Introduction

Roots and tubers rank next in importance to cereals as source of energy in the diets of people in several countries, notably Ireland, West Germany, France, Brazil and Africa.[1] Among the roots and tubers, potato (*Solanum tuberosum*) ranks high in its nutritive value and popularity as an article of food.[2] The importance of roots and tubers as staple food lies in the fact that they yield about 2-3 times as much calories per acre as common cereals and can be cultivated both as a kitchen garden crop and on a field scale.[3] The possibilities of increasing the production and consumption of potato and other roots and tubers in India to make up the cereal deficit have been indicated by some workers.[4]

2. Production and Consumption

Data regarding the total annual production of potato in certain countries are given in Table I. It is evident that U.S S R. is the single largest producer while Poland ranks second Other important producers are France, Germany and U. S. A. Data regarding the per caput availability of potato and other starchy roots in some countries are given in Table II. The countries consuming large amounts of potato and other tubers are Ireland, Germany, Poland, France, Brazil, Peru, United Kingdom, Canada, New Zealand

Table I *Production* of Potato in different countries during 1961–62*

Country	Production (in thousand metric tons)
Europe	
France	14,331
Germany (Federal Republic)	21,504
Ireland	2,145
Italy	3,932
Poland	45,203
United kingdom	6,358
U.S.S.R.	84,310
North & Central America	
Canada	1,997
U.S.A.	13,317
South America	
Argentina	1,184
Brazil	1,081
Peru	1,244
Asia	
India	2,767
Japan	3,848
Pakistan	484
Turkey	1,410
Africa	
Algeria	119
South Africa	327
U.A.R.	392
Oceania	
Australia	534
New Zealand	230

*FAO (1962) Production Year Book Vol. 16.

Table II *Per caput* production of potato and other starchy roots*

Country	Year	Supply/Caput (kg/year)
Europe		
France	1959/60	109
Germany (Federal Republic)	1960/61	128
Ireland	1961	140
Italy	1961/62	55
United Kingdom	1961/62	81
North and Central America		
Canada	1961/62	69
U.S.A.	1961	47
South America		
Argentina	1960	76
Brazil	1960	123
Peru	1960	137
Far East		
India	1960/61	11
Japan	1960	68
Pakistan	1960/61	4
Africa and Near East		
South Africa	1959/60	21
Turkey	1959/60	38
U.A.R.	1960/61	13
Oceania		
Australia	1960/61	40
New Zealand	1961	61

*FAO (1962) Production Year Book vol. 16.

and Japan. It is of interest to note that the annual per caput availability of roots and tubers in India is only 11 kg. as compared with 68kg. in Japan and 140 kg. in Ireland.

3. Chemical Composition

The chemical composition of raw potato flour as compared with that of certain cereals and roots is given in Table III. It is of interest to note that potato flour compares favourably with cereals and millets in its content of proteins, essential minerals and vitamins. It contains 2-3 times as much of protein and other nutrients as white sweet potato and tapioca flours. The chemical composition of different varieties of potato grown in various countries has been summarized by Lampitt and Goldenberg,[5] Burton,[6] Chatfield[2] Roy Choudhuri *et al*[6a], and Talburt and Smith[7], The chemical composition varies with respect to variety, area of growth, cultural practices, maturity at harvest, subsequent storage history etc. Further the methods of analysis used by different workers have varied to some extent, the whole potato being analysed by some and peeled potato by others.[9]

4. Nitrogenous Constituents

The total nitrogen content of potato may range from 1-2% of dry weight.

Table III. *Chemical composition of potato as compared with that of certain other roots and cereals* (values per 100g)

Foodstuffs	Moisture (g)	Protein (N x 6.25) (g)	Fat (g)	Calcium (mg)	Iron (mg)	Vitamin A value (i u.)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Ascorbic acid (mg)	Calorific value	Reference No.
Potato, Raw	78	1.7	0.1	7	0.6	0	0.08	0.03	1.2	10	70	6
,, flour	7	8.5	0.4	30	3.0	0	0.21	0.10	5.0	20	349	6
Sweet potato, white (raw)	69	1.2	0.3	20	0.8	0	0.08	0.04	0.7	24	124	91
,, ,, flour	7	3.6	0.9	60	2.4	0	0.24	0.12	2.1	—	372	91
Tapioca, raw (*Manihot utilissima*)	62	0.9	0.2	12	0.5	0	0.04	0.02	0.4	27	109	6
,, flour	14	1.5	0.6	25	1.0	0	0.08	0.04	1.0	0	338	6
Kaffir corn (*Sorghum vulgare*)	11	10.1	3.3	39	4.2	200	0.41	0.15	4.0	0	343	6
Maize, yellow (*Zea mays*)	12	9.5	4.3	7	2.3	450	0.45	0.11	2.0	0	356	6
Ragi (*Eleusine coracana*)	11	6.5	1.7	350	4.0	100	0.35	0.05	1.5	0	332	6
Rice milled, raw	13	6.7	0.7	10	0.9	0	0.08	0.03	1.6	0	360	6
Pearl millet (*Pennesetum typhoideum*)	11	11.7	4.7	28	4.0	200	0.33	0.15	2.1	0	348	6
Wheat, medium, whole	12	12.2	2.3	36	4.0	0	0.41	0.10	4.6	0	334	6

About 90% of N is soluble in the usual aqueous protein solvents, the insoluble N being associated with the skin and outer cortex

4.1 *Protein*: About one third to one half of the total nitrogen is present as protein.[8] The proportions of proteins is higher in immature than in mature tubers. The main protein is a globulin known as *tuberin*. This was found to contain 14 8% N and 1.1% S and 1.8% minerals.[9]

4.2 *Non-protein nitrogenous (NPN) constituents* : The bulk of the NPN is present as free amino acids.[3] Asparagine and glutamine are present in approximately equal amounts and together account for one half of the NPN. Besides the common amino acids, the following unusual amino acids have been found to be present. γ-amino butyric acid, α - amino butyric acid, β—alanine and methionine sulphoxide.[10 12] Besides, free amino acids, peptides and peptones are also present.[8] Other nitrogenous constituents reported to be present are choline, trigonellin, adenine, hypoxanthine and allantoin.[13]

4.3 *Amino acid composition* : Data[14,15] regarding the amino acid composition of tuberin and non-protein nitrogenous fraction are given in Table IV and data regarding the amino acid composition of the whole nitrogenous constituents of some varieties of potato[14,16 19] in Table V. The results indicate that potato is a good source of all essential amino acids except the sulphur amino acids.

Table IV *Essential amino acid composition†(g/16gN) of whole nitrogenous constituents, tuberin and non-protein nitrogenous consituents of white potato (var. King Edward)*

Amino acid	whole potato	Tuberin	Non-protein nitrogen
Arginine	4.4	6.0	2.6
Histidine	1.7	2.2	1.1
Lysine	5.0	7.7	1.9
Tryptophan	0.8	1.6	—
Phenylalanine	5.4	6.6	4.1
Cystine	1.7	2.1	1.2
Methionine	1.6	2.3	0.8
Threonine	3.7	5.9	1.1
Valine	4.8	6.1	3·3

†Reference No. 14 and 15.

5. Carbohydrates

The carbohydrates of potato consist mainly of starch. Small amounts of other polysaccharides eg. hemicellulose, cellulose, pectin and sugars have been reported to be present. [2,7]

5.1 *Starch* : It is present in the form of granules which are ellipsoidal in shape, about 60-100 microns in size on the average. They are larger than the average starch granules of cereal grains The two main components of starch i. e. amylose and amylopectin are present in the ratio of 1 : 3 Phosphorus has been shown to be chemically combined in the starch.[20] The viscosity of gels prepared from potato

Table V. *Essential amino acid composition of some varieties of potato*

Amino acid	European†		American**	Indian††			Literature values*		
				Great Scot	President	Upto-date	Average	Maximum	Minimum
Arginine	7.1	4.4	5.0	5.38	4.57	5.21	4.93	5.74	4.32
Histidine	1.2	1.7	1.5	1.38	1.52	1.43	1.44	1.70	1.20
Lysine	3.7	5.0	5.5	6.25	6.21	5.94	5.33	6.70	4.67
Methionine	2.5	1.6	1.5	1.40	2.84	1.24	1.25	1.66	0.61
Cystine	0.6	1.7	—	0.61	0.84	0.73	0.96	1.70	0.58
Phenylalanine	3.7	5.4	4.7	4.20	4.42	4.41	4.42	5.41	3.09
Threonine	2.5	3.7	3.4	3.43	4.78	2.60	3.94	4.67	3.44
Tryptophan	1.0	0.8	1.0	0.95	1.10	0.96	1.07	1.77	0.68
Leucine	4.6	—	4.8	5.92	5.84	5.63	5.98	5.63	4.29
Isoleucine	5.9	—	4.3	4.36	4.52	4.24	4 38	5.29	3.62
Valine	4.3	4.8	5.8	4.53	5.20	4.84	5 34	6.05	4.74

Reference numbers † 14, 15 & 16
** 17
†† 18
* 19

starch seems to be closely correlated with phosphorus content of starch.[21] It has been found that there is a close correlation among specific gravity, total solids and starch content.[2] The high starch content of potatoes has made the manufacture of starch economically feasible, especially in Europe.

5.2 *Non-starch polysaccharides:* The non-starch polysaccharides comprise about 4% of the total solids and consist of the cell wall and intercellular cementing substance.[2,5] They may broadly be grouped as follows : (a) celluloses (b) pectic substances (c) hemicelluloses and (d) other polysaccharides. Cellulose is present in the supporting membrane of the cell wall and constitutes some 10-20% of the non-starch polysaccharides of the potato. The content of pectic substances has been reported to range from 0.7-1.5%[22]. Hemicelluloses constitute about 1% of the total solids.[23] In addition, small amounts of oligosaccharides are also present.[24]

5.3 *Sugars*: Reducing sugars and sucrose have been reported to occur in small amounts in fresh potato tuber. Burton[25] found in fresh tubers, a total content of 0.96% of which 0.76% was in the form of reducing sugars. Gooding and Hubbard[26] reported the presence of 1.27 % reducing sugars and 0.55% sucrose. The sugar content of potato varies to a considerable extent depending on the maturity and period and temperature of storage.[22,7]

6. Minerals

The mineral content of potato has been determined by a large number of workers.[6,27] The results are summarised in Table VI. Potato is a rich source of potassium (568 mg/100g). It is a poor source of sodium (about 6.5 mg/100 g) and calcium (7.7 mg/100g). It is a good source of phosphorus (about 40.3mg/100g) of which about 20% is in the form of phytate phosphorus.[25] Fair amounts of magnesium, iron and copper and traces of zinc, flourine and iodine are present in potato.[5]

Table VI. *The mineral content of potato* (mg/100g)*

Mineral	Fresh basis†	Dry basis
Calcium	7.7	32.3
Phosphorus	40.3	169.3
Sodium	6.5	27.3
Potassium	568	2386
Magnesium	24.2	101.6
Chlorine	78.5	329.7
Iron	0.75	3.15
Copper	0.15	0.63

*Ref. No. 27 † Moisture 75.8%

7. Vitamins

A large amount of work has been carried out by different workers on the vitamin content of potato[28,29] As is to be expected, the great majority of papers deal with vitamin C, since potato is an important source of this vitamin for human nutrition. The vitamin content of potato is given in Table VII.

Table VII. *Vitamin content of raw potato*

Vitamin	(Values/100g)
Ascorbic acid * (mg)	10
Thiamine * (mg)	0.08
Riboflavin * (mg)	0.03
Nicotinic acid * (mg)	1.2
Pyridoxine † (mg)	0.22
Pantothenic acid † (mg)	0.4
Folic acid † (μg)	6.8
Choline† (mg)	29
Inositol † (mg)	29

* Ref. 6 † Ref. 31.

7.1 *Thiamine* : Fixsen and Roscoe[28] give values ranging from 90-130μg/100g, while the values cited by Booher *et al*,[29] range from 48-186 μg per 100g.

7.2 *Riboflavin* : Fixsen and Roscoe[28a]. cite values ranging from 7.5-60μg and 10-55μg per 100g respectively.

7.3 *Nicotinic acid* : In reviews of literature by Bacharach [30] and McVicar and Berryman[31] values of 1-2mg and 0.4-2.0 mg per 100g. have been reported.

7.4 *Other B-vitamins* : In a recent review of the literature Harding and Crooks[32] report values of 0.22 mg pyridoxine, 0.4 mg. pantothenic acid, 6.8μg folic acid, 29 mg. choline and 29mg inositol, per 100g of potato.

7.5 *Ascorbic acid*: Potato is a good source of ascorbic acid but the ascorbic acid content varies widely and is influenced by the variety, degree of maturity, cultural practices and storage. Barker[33] showed that ascorbic acid content varied with the storage and maturity. Livak and Morse[34] estimated the reduced ascorbic acid and dehydro ascorbic acid contents of potatoes obtained from local supermarket twice a month from the end of October to April. Range of values were 3-17 mg for reduced ascorbic acid and 9 to 13 mg for dehydro-ascorbic acid.

8. Enzymes

A considerable amount of literature is available about the enzyme systems present in potato.[2,5] The most important enzymes are polyphenol oxidase, and tyrosinase and phosphorylase. A large number of other enzymes are also present as in other plant tissues. Both polyphenol oxidase and tyrosinase are involved in the oxidation of catechol derivatives and tyrosine respectively to dark pigments and are responsible for the darkening of the cut surface of potato. The other enzymes present, take part in the various metabolic processes which are constantly taking place in living plant tissues, like the potato tuber.

9. Polyphenols and Pigments

The phenolic compounds of potato are, at least in part, responsible for certain discolouration in raw and processed potato.[2,5] Chemically they may be grouped as follows (1) polyphenols (2) monohydric phenols, (3) tannins, (4) anthocyanins and flavones and (5) coumarins. Clagett and Tottingham[35] found that peeled potato contains about 3 to 7 mg of catechol per 100g. Nash and Smith[36] reported that normal potato contained 56 mg of total phenols per 100g. Tyrosine, the major monohydric phenolic compound has been reported to be present to the extent of 0.1-0.3% on dry weight basis[37]. Two coumarins have claimed to be partly responsible for the discolouration of cooked potato. The coumarin derivatives known as scopoletin and esculetin have been detected in potato.[38,39] Paper chromatographic studies[40] have revealed the presence of several polyphenols. The total alcohol soluble polyphenols are present to the extent of 0.5% on the dry weight basis. Flavones have also been reported to be present.[41] The green colour which appears in the area immediately between the skin of a potato tuber exposed to visible light over a period of several days has been shown to be due to the formation of chlorophyll.[42]

10. Acids

Robertson and Smith[43] reported that the pH of the potato tubers varied from one part to another in the same tuber and also with the degree of maturity and period of storage, thus indicating that acidity also will vary correspondingly. Curl and Nelson[44] reported the presence of citric, isocitric, malic and oxalic acids in potato. Other investigators have confirmed the presence of citric and malic acids.[45,46]

11. Solanine:

A number of workers have reported the presence of toxic glycoside alkaloid in potatoes.[2,7] Solanine is composed of one molecule each of the alkaloid solanidine and the sugars dextrose, galactose and rhamnose. The results of analysis of the solanine content of various parts of potato reported by Lampitt and his co-workers[47] were as follows: whole tuber, 7.5 mg; peeled potato 1.2 mg; peel, 15 mg per 100 g. of the material. It is evident that peeling potatoes will remove a considerable part of the solanine present in the tubers. Solanine content has been reported to increase in potato as a result of injury. McKee[48] found solanine content of injured potatoes to increase progressively as follows—21, 108 and 120 mg. per 100 g fresh tissue on the second, fourth and sixth day after injury. It is usually accepted that although solanine is poisonous to man, there is little danger of untoward effects at concentrations below 20 mg per 100 g. There appears to have been only one important outbreak of solanine poisoning[49] in the United Kingdom, in Glasgow in 1917. There was one death among 61 persons affected; the solanine content of the potatoes eaten by the victim was 41 mg per 100g. Wilson[50] reported poisoning of 4 adults in one family. The potatoes had been baked without peeling, and the batch from which they came contained 50 mg. solanine per 100g. Vomiting, abdominal pain, and diarrhoea began about 8 hours after the potatoes had been eaten The highest concentration of solanine is in the skin and immediately under it. One member of the family removed the skin before eating the potatoes showed no symptoms of poisoning. The two who ate one potato each were mildly affected, one who had two potatoes moderately, and one who had three very severely.

12. Effect of Storage on Chemical Composition

Cold storage of potatoes prevents excessive loss of moisture, development of rots and sprouts and loss of vitamin C. The chemical changes occurring during storage of potato are briefly described below.

12.1 Specific gravity: The specific gravity is an important index of the suitability of potato for different types of commercial processing.[5] For example high specific gravity potatoes are preferred for potato chips, French fries and de-hydration. On the other hand, potatoes of low specific gravity are preferred for canning because they slough or fall apart less during processing than potatoes of high specific gravity. Heinze *et al.*,[51] reported that potatoes stored at relative humidity of 83-84% at 40° and 55°F increased in specific gravity. When stored at relative humidity of 90% and temperatures of 40 and 50°F respectively, the specific gravity remained more or less constant.

Sugar content: Potatoes with high sugar content yield chips of light brown colour. The sugar content of potatoes stored below 50°F increases during storage.[2,7] Appleman[52] and Wright *et al*[53]., have made a detailed study of the effect of storage temperature on the sugar content of potato. The results have shown that in potatoes stored at 40-50°F, sugar content rapidly increases to about 3% on fresh weight basis and the starch content decreases When the same potatoes are stored again at a higher temperature of 70°F for six weeks, the sugar content rapidly decreases and the starch content returns to almost the original level as a result of resynthesis from the sugars.[54]

12.2 Nitrogenous constituents: The crude protein (N x 6.25) content of potato ranges approximately from 1.5% to 2.5% on fresh weight basis. This consists of proteins, peptides, amides and free amino acids. Appleman and Miller[55] observed very little change in the nitrogenous constituents of mature potato stored at 20°C. Immature potato, however, showed a decrease in true protein nitrogen accompanied by a marked increase in free amino acid nitrogen and some increase in amide-N. Stuart and Appleman[56] found that the protein nitrogen of tubers stored at 35.6°F was slightly less than that at room temperature. There were practically no differences in the free amino acid nitrogen and amide nitrogen of potatoes stored at these two temperatures.

12.3 Ascorbic acid: Several workers[57-59] have reported a marked loss of ascorbic acid in potato during storage. Zilva and Barker[59] found that the initial ascorbic acid content of 30 mg/100g fell to about 12-15mg/100g. after storage at 50°F for about 6 months. Olliver[57] found slower rates of loss at 32°F than at 50°F or at room temperature. but some other workers[60,61] reported the loss of ascorbic acid to be more rapid at 32°F than at 50°F.

13. Effect of Cooking and Processing on Chemical Composition

The methods commonly employed in preparing potato for human consumption are boiling in water, steaming, baking, deep fat frying and canning. Large quantities of potato are dehydrated and stored in the dehydrated form. The losses of vitamins occurring during cooking and processing have been reviewed by some workers [2,5,62] The results are briefly discussed below. The chemical composition[63] of cooked, baked, canned and fried potatoes is given in Table VIII.

13.1 Boiling in water or steaming: Whole potatoes are commonly cooked in water and the skin is peeled off after boiling; sometimes peeled potatoes are boiled in water. The losses of vitamins (due to leaching into water). from peeled potatoes will naturally be greater than from the whole potatoes. Chick[64] found in whole potato cooked in boiling water for 30 minutes, the retention of thiamine

Table VIII. *Chemical composition of cooked, fried, baked and canned samples of different varieties of potato*
(Values per 100 g)

Constituent	Raw			Cooked			Fried			Canned			Baked		
	P	GS	UD	P	GS	UD	P	GS	UD	P	GS	UD	P.	GS	UD
Moisture (g)	77.1	77.4	75.6	77.8	77.5	76.0	4.2	5.6	3.6	79.8	79.2	78.6	69.8	70.1	70.5
Protein (Nx6.25) (g)	1.8	2.3	1.8	1.7	2 3	1.8	3.4	4.1	3.7	1.5	1 9	1.4	2.3	2.9	2.1
Fat (Ether extractives) (g)	0 1	0.1	0.1	0 1	0.1	0.1	52.8	54.6	45.8	0.1	0.1	0.1	0,1	0.1	0.1
Ash (g)	1.0	0.9	1.0	1.0	0.8	0.9	1.8	1.7	2.0	1.9	1.6	1.8	1.3	1.0	1.2
Calcium (mg)	6.6	6.5	6.2	6.5	6.8	6.3	12.5	11.5	12.6	8.7	8.4	8.8	8.6	7.2	7.4
Phosphorus (mg)	37.0	37.4	33.7	35.8	41.5	31.6	69.8	66.0	69.4	36.8	38.2	34.8	48.2	42.5	40.4
Iron (mg)	1.7	1.4	1 3	1.7	1 5	1.2	3.2	2.4	2.7	1.8	1.4	1.4	2.2	1.5	1.6
Vitamin C (mg)	14.7	14.3	14.9	11.4	10.6	11.7	13.9	10.4	15.3	4.9	4.3	4.7	8.6	8.3	8.9

P = President GS = Great Scot UD = Upto Date as 75% and ascorbic acid 68%. Oser *et al.*,[65] reported that the retentions of different vitamins in cooked potatoes were as follows : thiamine 70%, riboflavin 55%, niacin 74% and ascorbic acid 88%. Gleim *et al.*[65] reported that the retention of different vitamins in potatoes steamed for 53 minutes and they were as follows :- thiamine 48% riboflavin 72%, niacin 72%, and ascorbic acid 88%.

13.2 *Baking* : Spiers *et al*.,[67] reported that the baked potatoes retained 96% of the ascorbic acid while samples of boiled potatoes retained 100%. The retention of thiamine in baked potato has been reported to vary from 55 to 80%[68-70] Streightoff *et al*[71] observed a loss of 28% ascorbic acid and very little loss of thiamine, riboflavin and niacin in baked potato Roy chouduri *et al.*[63] reported a loss of 50-56% of ascorbic acid as a result of baking.

13.3 Canning : Olliver[72] reported losses of ascorbic acid varying from 25-52% in canned potatoes while Zilva and Morris[73] reported a loss of about 25%. Hanning and Mudambi[74] found that the thiamine and ascorbic acid contents of canned potatoes were about the same as those of the fluid, indicating a loss of about 50% if the fluid were to be discarded. They found considerable variation in the thiamine (from 0.23 to 0.61μg/g) and in the ascorbic acid (from 4.4 to 26.8 mg/100g) contents of different samples tested by them. Roy Choudhuri *et al.*,[63] reported a loss of about 65-70% of ascorbic acid in canned potatoes

13.4 Frying : Levy[68] noted a loss of 55 to 80% of ascorbic acid in fried potatoes. Richardson *etal.*,[75] and Roy Choudhuri *etal.*,[63] reported losses of 57% and 50-59% respectively in ascorbic acid as a result of frying.

13.5 Dehydration: The chemical composition of potato flour prepared from three different varieties of potato reported by Roy Choudhuri *et al.*,[63] is given in Table IX. These workers observed a heavy loss (80-90%) of thiamine as a result of sulphiting and dehydration. The thiamine content of potato flour from three varieties ranged from 0.04 to 0.06 mg/g as compared with 0.40 to 0.49 mg/g on dry basis, in the original potato used for dehydration. The loss of ascorbic acid amounted to about 40%, the ascorbic acid content of the flours ranging from 36 to 28 mg/100g. Morgan *etal.*,[76] found that the retention of different vitamins in dehydrated potato were as follows :- thiamine 60%, riboflavin 100% niacin 94% and pantothenic acid 100% Hanning and Mudambi[74] found considerable variation in the thiamine (0.04 to 2.93 mg/g) and ascorbic acid (3.3 to 24.2 mg/100g) content of different samples of dehydrated potato.

Table IX *Chemical composition of potato flour from different varieties of potato* (values per 100g)

Constituents	Great Scot	President	Uptodate
Moisture (g)	6.0	4.7	5.2
Protein (Nx6.25) (g)	9.2	7.2	7.1
Fat (ether extractives) (g)	0.4	0.3	0.4
Ash (g)	3.5	3.6	3.9
Crude fibre (g)	1.6	1.4	1.3
Carbohydrate (by diff) (g)	79.3	82.8	82.1
Reducing sugars (g)	0.8	0.8	0.9
Non-reducing sugars (g)	1.9	2.0	1.2
Starch and other carbohydrates (calculated) (g)	76.6	80.0	80.0
Calcium (mg)	28.5	25.8	25.4
Phosphorus (mg)	172.5	157.3	150.8
Iron (mg)	7.2	8.2	6.4
Thiamine (mg)	0.04	0.06	0.5
Vitamin C (mg)	36.9	37.5	38.0

14. The Nutritive Value of the Proteins of Potato

The nitrogenous constituents of potato consist of a mixture of proteins, peptides and amino acids. The essential amino acid composition of potato given in Table IV indicates that the limiting amino acids in potato proteins, as compared with egg protein are sulphur amino acids and potato is a good source of other essential amino acids. The term protein is used in this discussion for the entire nitrogenous constituents of potato. The nutritive value of potato proteins have been studied both in experiments with albino rats and with human beings. The results are briefly summarised below :

14.1 Animal experiments : McCollum[77,78] and Hartwell[79] reported that the proteins of potato did not promote good growth in rats. Mitchell[80] reported a fairly high biological value of 67 at 8% level of protein intake. Kon[81] found a biological value of 71 and a protein efficiency ratio of 2.0 for *tuberin*, the globulin of potato. Chick and Slack[82] reported that potato proteins promoted good growth and had a protein efficiency ratio of 2.0. Joseph *et al.*,[18] reported protein efficiency ratios of 0.95, 0.97 and 0.99 at 6.5% level of protein intake for three varieties of potato.

14.2 Experiments with humans: The experiments by Hindhede[83] are the best-known example on a diet consisting only of potato and margarine taken for periods of 100 days and more. The body weight was nearly maintained and positive nitrogen balances were reported when the daily intake of 'digestible nitrogen' was as low as 3-4g. corresponding to about 19-25 g protein. The subject was a man 27 years old, of body weight 70 kg who consumed 3006 calories daily and led an active life. In a carefully controlled experiment carried out by Rubner and Thomas[84] lasting for 6 days, upon a healthy man of 75 kg weight the diet consisted solely of potato; 2600g were consumed daily, with a little salt, the average daily nitrogen intake was 8.7 g. and the average daily nitrogen excretion in urine and faeces was 10.5 g showing a negative balance amounting to about 2 g. nitrogen. Other observations, however, showed equilibrium and even a positive balance. Abderhalden and his colleagues[85] reported nitrogenous equilibrium on an intake of 3.5 g N daily derived from potato whereas more than twice the amount of nitrogen was needed when it was derived from white wheat bread or rye bread. Rose and her co-workers[86] obtained a similar result with a woman subject of 50 kg weight who derived the nitrogen of her diet, 4.97 g daily from 1500 g potatoes. More recently Kon and Klein[87] reported tests on two adults, a man and a woman, who lived for 167 days in nitrogenous equilibrium and good health when consuming, respectively, an average of only 5.7 g and 3.8 g N daily, all of which was obtained from potatoes.

15. The Overall Nutritive Value of Cooked Potato and Potato Flour

The data presented in Table III show that potato on dry basis compares favourably with rice in its chemical composition. Like rice, potato flour is also deficient in calcium, but unlike rice it has a low phytate phosphorus content. In a study carried out during the whole life span of the albino rat, Bharucha and McCay[88] found that calcium salt in the form of gypsum supported the growth of animals at a level of 0.3% calcium if 69% of the diet consisted of potato flour. However, the animals did not thrive so well if the flour was replaced by whole wheat flour, unless the calcium in the diet was increased to 0.6%. The superiority of potato flour over whole wheat flour in promoting better calcium utilisation is due to the low phytate phosphorus content of the former[88]. Roy Choudhuri *et al*[89] studied the overall nutritive value of a poor Indian diet containing cooked potato or potato flour instead of rice using albino rats. The results are given in Tabl X. They found the average weekly growth rate on potato diets based on three varieties of potato (1.5 to 2.7 g) was low as compared with a growth rate of 6.6 g on poor rice diet. Supplementation of the potato diets with calcium phosphate brought about an increase in the growth rate (3.3 – 6.6 g) as compared with that

Table X *Effect of partial or complete replacement of rice in a poor rice diet by potato on the overall nutritive value of diet as judged by the growth of albino rats* (Values are mean of 8 females in each group; Duration of the experiment 8 weeks)

Diet	Daily food Intake (g) (dry wt. basis)	Mean weekly gain in weight (g)	
Rice diet *	7.1	5.1	±0.33 (42d.f.)
25% potato diet	6.8	4.0	
50% potato diet	6.8	4.2	
Potato diet	6.5	0.4	
Rice diet + Ca (0.2%)	7.4	9 1	±0.33 (42d.f.)
25% potato diet + Ca(0.2%)	7.0	10.2	
50% potato diet + Ca(0.2%)	7.0	8.4	
Potato diet + Ca(0.2%)	6.9	2.6	

* The diet contained the following ingredients (g/100g) : rice, 78.5 ; red gram dhal (*cajanus cajan*), 5.0; non-leafy vegetables (Brinjal (*solanum melongena*) and potato), 8.2; Leafy vegetables (*Amaranthus gangeticus*), 2.1; skim milk powder, 0.9; common salt 0.3 and groundnut oil, 5.0

(9.1 g) observed with calcium supplemented rice diet. In a second experiment these workers made the interesting observation that when rice in a poor rice diet (supplemented with calcium) was replaced to the extent of 25% or 50% by potato the growth rate of rats on the two diets (10.1 and 8.4 g respectively) was nearly the same as that (9.1 g) observed on the calcium supplemented rice diet. The results indicate that potato flour fortified with calcium can be used as a partial substitute for rice without affecting adversely the overall nutritive value of the diets.

16. Conclusion

It may be concluded from the data presented in this review that potato on dry basis compares well with common cereals in its nutritive value and can be used as a partial substitute for cereals. Since potato proteins are richer in lysine than cereal proteins, the former can make up the lysine deficiency in the latter. Further potato contains only small amounts of phytate phosphorus which is present in large amounts in cereals. In view of this potato promotes better utilization of calcium and phosphorus than cereals. It has been reported that the natives of Trista da Cunha who consume a diet of potato and milk are free from dental caries [90] Potato possesses another important advantage over cereals in being a good source of vitamin C. As pointed out earlier, the per caput consumption of potato in Ireland and many European countries is quite high as compared with India. In view of the fact that potato yields about 2.3 times as much calories as common cereals and can also be grown as a kitchen garden crop, it will be advantageous to increase the production and consumption of potato in densely populated countries like India.

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