OBSERVATIONS

ON THE

FARINACEOUS PRODUCTS

OF VARIOUS KINDS

OF THE

POTATOE.

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The vegetable kingdom is so abundantly supplied with starch-bearing plants, that some account of them would form an interesting subject of inquiry, but the limits within which I have restricted myself will prevent me from doing so, and I shall, therefore, confine these observations, with a trifling exception, to an investigation into the farinaceous properties of one which is now so peculiarly adapted, both by habitude and cultivation to this country, that it has become one of the most useful, and important additions to our food.

The following quotation (Dickson's Vegetable Kingdom) is so appropriate, that it will serve as an introduction, better than any farther remarks of my own :—

"The potatoe is not only the source of the purest starch of all, but has many interesting points connected with its history and habitudes. No plant has contributed more to banish those famines which formerly were of frequent occurrence in Europe, and all the dire train of suffering and disease consequent upon them. Yet did it, in many instances, require royal edicts to induce some nations to cultivate what is now regarded as one of the prime blessings of Providence, from nearly one end of the earth to the other; the potatoe being raised from Hammerfest, in Lapland, latitude 71. north, through all Europe, the plains of India, in China, Japan, the South Sea Islands, New Holland, even to New Zealand. What renders it so peculiarly valuable is, that in the seasons when the corn crop fails, that of potatoes is generally more abundant, thus furnishing a substitute for the other, which proves defective from atmospheric considerations, which have little influence over the potatoe, placed as it

is under ground, and secure from extremes of temperature."

The quantity of starch in the potatoe is most abundant in the winter months, but varies when grown in different soils, or climates, and by the manures employed. This is also observed in the cereal plants, the wheat grown in Sicily and the Crimea, possessing more gluten than that produced in more northern latitudes; yet, by the use of manure, by better cultivation, and by their untiring energy in tillage, the residents in our less favoured regions, far surpass the inhabitants of more genial climes in the productiveness of their crops.

The gluten of the potatoe, from the nitrogen it contains, renders the tuber of more value as an esculent, while the farinaceous productions of the tropics, although destitute of it, are as equally adapted to their use, as the more stimulating diet required for the sustenance of man in colder climates.

Starch-bearing plants are, therefore, abundant in those regions. In the Indian Archipelago, the palm-like trees yielding sago, *Sagus Rum-*

phii, *Cycas Circinalis*, and *Phœnix Farinifera*, and in South America, the fan palm *Mauritia Flexuosa*, with many others. The Sagus Rumphii, one of the smallest palm trees which seldom exceeds thirty feet in height, has yielded in its fifteenth year, 600 lbs. of sago. Captain Sir Edward Belcher, in his "Narrative of a Voyage Round the World," recently published, states, that the sago tree, which at Amboina, Bouro, Ceram, and adjacent Islands grows most luxuriantly, and attains a large size, eighteen inches in diameter, is calculated to subsist a family for one month, or even six weeks. Mr. Crawford, (Ind. Archip.) expresses himself in similar terms.

The quantity of starch and gluten also vary in the same kind of potatoe. When the tuber is fresh gathered, it is more abundant than when stored up for use. The starch diminishes in spring, when germination commences, being converted into sugar, in order to afford the bud that nutriment which it afterwards derives when more fully grown, from the soil by the agency of its roots, and from the air by its leaves, as they become developed.

The following experiments were made when the tuber was fresh from the field:

		Starch.	Gluten and Fibre.	Water.
Leigh's Blacks, Sweep, or Black Pink Eyes,	per cent. fresh	17.3	8.4	74.3
Ditto.....	stored	16.0	7.7	76.3
Red Champion, ...	fresh	17.5	7.0	75.5
Ditto.....	stored	15.6	6.6	77.8
Radical, ...	fresh	15.4	6.6	78.0
Ditto.....	stored	15.0	7.2	77.8

Dr. Playfair (Lect. Roy. Ag. Soc.) gives the following as contained in 100 lbs. of the fresh root :

Organic Matter 27 lbs. Ashes. 1 lb. Water 72 lbs.

Dr. Kane, (Indust. Res. of Ireland) in a table from Mons. Payen, states the results of seven varieties of the potatoe, grown on soil of a similar quality, as follows :

VARIETIES.	1 cwt. Seed produced	1 Statute Acre produced	100 parts Contained Water	Starch	Gluten and Fibre
Rohan	58 cwt.	14½ tons	75.2	16.6	8.2
Large Yellow	37 „	9⅓ „	68.7	23.3	8.0
Scotch	32 „	8 „	69.8	22.0	8.2
Slow Island..	56 „	14 „	79.4	12.3	8.3
Legonzac ...	32 „	8 „	71.2	20.5	8.3
Siberian	40 „	10 „	77.8	14.0	8.2
Duvillers ...	40 „	10 „	78.3	13.6	8.1

" These results show that the quantity of starch is not largest necessarily in those varieties which yield the greatest weight of tubers. Thus an acre of large yellow potatoes which gives but 9⅓

tons of tubers, produces 2 tons 3 cwt. of starch, while the acre of Slow Island potatoes, which produces 14 tons, gives only 1 ton 15 cwt. of starch. In cultivating the plant for the purpose of extracting this material, it is therefore of the greatest importance to attend to the existence of these varieties."

The next Table was first drawn up in order to show the relative productiveness of my own crop, and it was afterwards enlarged by the addition of varieties procured from other places. The experiments were made in the months of November, December, January, and February, before any signs of germination had appeared, and while the quantity of starch was at its maximum point.

		1 cwt. seed produced	1 Stat. acre produced	100 parts Produced: Water	Starch	Gluten & Fibre
		cwt.	tons.			
In Soil of similar quality.	Leigh's Blacks ... Sweeps, or Black Pink Eyes mean of 3 analysis	10	10¼	76.3	16.0	7.7
	Red Champion mean of 3	7¾	7¾	77.1	16.2	6.7
	Radicals mean of 2 analysis	7¾	7¾	77.9	15.2	6.9
	Kidney	9	10½	74.8	18.2	7.0
	Golden Ball	9	9⅓	76.5	16.4	7.1
	Farmer	12½	12½	79.7	14.5	5.8
	Apple (Irish).....	8	8	78.1	15.3	6.6

		1 cwt. seed produced	1 Stat. acre produced	100 parts Produced: Water	Starch	Gluten & Fibre
Chat Moss Peat Soil with Marl.	Leigh's Blacks	15	15½	77.0	16.4	6.6
	Stranger or Cornwall Red.....	17	18	80.5	13.5	6.0
	Scotch Cup	15	15½	73.3	19.7	7.0
	Bread Fruit	12½	13⅓	77.8	16.4	5.8
	Pink Eye			76.7	17.3	6.0
Pink Eye (from Irlam)				79.1	15.1	5.8
Ditto do.				74.7	17.9	7.4
Ditto (Culcheth, clayey soil)				74.1	20.0	5.9
Forty-fold.....				76.6	16.4	7.0
Stranger, (New Hall)				79.7	12.0	8.3
Strawberry Potatoe from Cumberland...				74.3	18.2	7.5
Leigh's Blacks				75.6	16.9	7.5
Ditto				76.9	16.5	6.6

The potatoes were peeled in every instance, and this may be the cause why the proportion of gluten and fibre is less than in the preceding table.

In three varieties, the red colour with which the water was tinged, contained, when evaporated,

In the Radical	2.1	per cent.
Cornwall Red	2.4	,,
Irish Apple.....	4.7	,,

The last named potatoe is very red-skinned, and required extra washing to free the starch from the colour which pervaded its entire mass.

This per-centage has not been added in the table. It disappears in boiling, for the water is not tinged by it. Its taste is acrid, being perhaps that principle which renders the tuber unwholesome when raw, and to which it owes its botanical name, *solanum tuberosum*. It possesses this property in common with many of the starch-bearing plants of the tuberous kind. The Cassada, *Janipha* or *Jatropha Manihot*, called Cassava when made into flour, and from which also the tapioca is prepared, is poisonous in its raw state, the poison being said to consist in a volatile oil. The Arums also, of which the *Arum Macrorhizon*, *Arum Colocasia*, and *Caladium Acre*, are cultivated in the South Sea Islands, and are called Tarro by the natives, possess equally deleterious qualities when fresh ; but upon the application of heat, are deprived of their virulence, supplying a bland and nutritious food to the inhabitants, and are preferred by them to other kinds of food possessing similar qualities.

The following experiments were made with the view of ascertaining whether the starch was equally distributed throughout the potatoe.

		Starch.	Gluten & Fibre.
Leigh's Blacks ...	Nose, or Eye end ...	14.7	6.6
Ditto	Heel, or Root end ...	19.2	8.4
Ditto	Eye end	15.6	6.6
Ditto	Root end	17.3	6.6

It, therefore, appears that the heel, or that portion connected with the stalk, possesses a greater proportion of farina than that part where the eyes most abound; but being prevented from testing their correctness by farther investigation, I am unable to state whether this difference is of casual or of uniform result. It is, however, certain that the root end of some of the long kind (as the kidney,) is more mealy when boiled, and the opposite end more waxy. The correct explanation may be, that the root end, from its direct connexion with the stem, is first ripened.

The following proportions of starch and gluten are given by different writers.—

Dr. Playfair, in 100 parts

Albumen	Unazotized matter	Water
2.0	25.0	73.0

and Professor Johnstone, in a more definite analysis, gives

Water	Husk or Woody Fibre	Starch, Gum, and Sugar	Gluten, Albumen, and Caseine	Fatty Matter	Saline Matter
75.0	5.0	12.0	2.25	0,3	0.8 to 1.

There is a deficiency in this analysis of more than 4.0 per cent.

Boussingault obtained in 100 parts, dry material, 24.1, water, 75.9.

The quantity of starch and gluten per acre is stated by Mr. Karkeek to be, in 12½ tons or 26,880 lbs.

Gluten, Albumen, &c.	600 lbs.	Starch, Gum, Sugar & Fat	3330.	Water 20,250
	or, 2.2 per cent.		12.5	

A deficiency also occurs here of 2700 lbs., or nearly 10 per cent. of which no account is given.

Dr. Kane, in a Table collected from the best authorities, gives the quantity of actual nutritious material usually derived from a statute acre of ground as 9 tons, or 20,160 lbs., producing

	Starch and Sugar	Gluten	Oil	Total.
	3427 lbs.	604	45	4076
or,	17.0 per cent.	3.0	0.2	water 79.8

If the mean of the analysis of Payen be taken, the produce per acre will be rather more than 10½ tons, or 23,946 lbs., consisting of

	Starch	Gluten and Fibre	Total
	3537 lbs.	1652	5189
or,	17.5 per cent.	8.2	water 74.3

In the first 11 varieties in my own Table, the average produce will be nearly $11\frac{3}{4}$ tons or 24,947 lbs. The quantity of nutriment will be

	Starch	Gluten and Fibre	Total
	3252	1335	4587
or,	16.1 per cent.	6.7	water 77.2

The mean of 20 varieties will be

Starch	Gluten and Fibre	Water
16.4	6.8	76.8

According to Boussingault, the usual crop per statute acre, is $6\frac{1}{2}$ tons or 14,560 lbs. when stored, and when dry 3,509 lbs. and 142 lbs. ashes.

If the per centage previously given by Boussingault be divided in accordance with the mean of M. Payen, and of my own, it will afford a near approximation to the quantity of nutritious aliment of both, and will be,

	Starch.	Gluten, &c.	Water.
Boussingault.....	16.8	7.4	75.8
Payen	17.4	8.2	74.4
My own.....	16.4	6.8	76.8

The mean of these will afford the probable average of starch, and of gluten, allowing 5.0 per cent. for fibrous matter. Starch 16.9, Gluten 2.5, Fibre, &c. 5.0, Water 75.6.

Mr. Knight states that the quantity of starch varied from $8\frac{1}{4}$ to 20 per cent., but from the names of those potatoes which produced the smallest proportion, it is likely they had degenerated from long cultivation, and they are not taken into consideration.

The starch and the gluten of the potatoe therefore vary considerably. The lowest proportion of starch being 12.0, and the highest 23.0 per cent., while in the gluten it is from 2.0 to 3.0 per cent. It is probable that the fibrous part contains a considerable portion of nutritious aliment, as "From 2.0 to 3.0 per cent. of fecula always remains with the residual pulp, which it is impossible to obtain."

The tabular view inserted below, exhibits the difference of nutriment in some of the most important articles of food.

			In 100 parts	
			Starch	Gluten
Wheat	(French)	according to Proust ...	74.5	12.8
Do.	(Bavarian)	..... Vogel ...	68.0	24.0
Do.	(Winter)	..... Davy ...	77.0	19.0
Do.	(Spring)	..... Do.	70.0	24.0
Do.	(Sicilian)	..... Do.	75.0	21.0
Do.	(Barbary)	..... Do.	74.0	23.0
Spelt		..... Vogel ...	74.0	22.0
Barley		..... Davy ...	79.0	6.0
Rye		..... Do.	61.0	5.0
Oats		..... Do.	59.0	6.0
Rice	(Carolina)	..... Vogel ...	85.07	3.60
Maize		..... Bizio ...	80.92	0.0

The chemical proportions, by Boussingault, are in 100 parts, of

	Carbon	Hydrogen	Oxygen	Nitrogen	Ashes
Wheat	46.1 ...	5.8 ...	43.4 ...	2.3 ...	2.4
Potatoes	44.0 ...	5.8 ...	44.7 ...	1.5 ...	4.0

Professor Johnstone has a similar analysis, and Dr. Playfair states the following in

	Gluten, from Flour	Caseine, from Peas	Albumen, from Eggs	Ox Blood	Ox Flesh
	BOUSSINGAULT.	SCHERER.	JONES.	PLAYFAIR.	PLAYFAIR.
Carbon	54.2	54.138	55.000	54.35	54.12
Hydrogen	7.5	7.156	7.037	7.50	7.89
Nitrogen	13.9	15.672	15.920	15.76	15.67
Oxygen	24.4	23.034	22.007	22.39	22.32

While Mr. Rigg, (Experimental Researches) gives

	In lean Beef.	The solid fat part of Beef.	Wheat, Seeds, Husks, and Kernel, as carried from the field.
Carbon	14.4	66.95	36.9
Hydrogen ...	8.6	10.06	7.2
Oxygen	72.1	50.44	53.2
Nitrogen ...	4.5	not determinable	1.1
Ashes	0.4	0.15	1.6

Potatoe Starch and Gum

	contains	contains
Carbon	44.250	42.682
Hydrogen	6.674	6.374
Nitrogen	——	——
Oxygen	49.076	50.944

The chemical analyses of the proximate principles of the starch-bearing plants, are, according to Dickson, "mere combinations of water and carbon, (hydro-carbonates or hydrates of carbon,) or compounds of carbon with oxygen and hydrogen in the proportions in which they form water, and consist in 100 parts, of

	Water	Carbon
Gum (pure Gum Arabic) ...	58.6	41.0
Sugar (pure crystallized) ...	57.15	42.85
Starch	56.00	44.00
Lignin	50.00	50.00

"These are so many mutually convertible products, of which Gum may be looked upon as the

basis." Decandalle remarks, that, "while gum itself may be considered the nutrient principle of vegetation, diffused freely through the structure of the plant, and constantly in action, starch is apparently the same substance stored up in such a manner as not to be readily soluble in the circulating fluids," thus forming a reservoir of nutritious matter, which is to be consumed, like the fat of animals (which it clearly resembles in structure) in supporting the plant at particular periods. (Carpenter and Prout.)

The identity of lignin with starch and gum may also be stated. "Lignin may be converted into a substance resembling gum, by admixture with strong sulphuric acid, and on boiling the liquid for some time, the gum disappears, and a saccharine principle is generated." (Carp. Phys.) "Both starch and wood can, by different artificial processes, be converted either into sugar or into vinegar." (Prout, Bridg. Treat.) Starch is also converted into sugar during the progress of germination. Hempen cloth may be converted into sugar by the action of sulphuric acid, its chief constituent being lignin.

The constitution of the inorganic portion of

the ashes of wheat and potatoes, is, according to Boussingault, in 100 parts.

	Wheat	Potatoes.
Phosphoric Acid.....	47.0	11.3
Sulphuric Acid	1.0	7.1
Carbonic Acid.....	——	13.4
Chlorine	traces	2.7
Lime	2.9	1.8
Magnesia	15.9	5.4
Potash.....	29.5	51.5
Soda	traces	traces
Silica	1.3	5.6
Alumina, &c.	——	0.5
Moisture and loss	2.4	9.0

The silica in wheat-straw amounts to 67.6 per cent.

I shall now make some remarks upon that portion of M. Payen's table, which has reference to the productiveness of the potatoe.

It is stated, that 1 cwt. of seed of the Rohan variety produced 58 cwt., and that the others varied to 32 cwt., according to the quality planted. It would therefore, only require 5 cwt. or 560 lbs. of seed per acre, in every instance, to produce the crops mentioned in the table.

This amount is so small when compared with the quantity used in general by the farmers in this neighbourhood, that I have inserted a similar column, comprising the results obtained last year from eleven varieties. In the 1st or Leigh's Blacks, 1 cwt. of seed yielded 10 cwt., and it required 2240 lbs. to produce $10\frac{1}{4}$ tons, and nearly the same result was obtained in the other varieties. As my own sets were planted more closely than is the custom of farmers, if 17 cwt. or 1904 lbs. be taken it may afford an estimate of the average quantity of seed employed by them in a statute acre.

An intelligent farmer has informed me, that in a very favourable season, 14 cwt. or 1568 lbs. of seed produced $11\frac{1}{4}$ tons; or 1 cwt. of seed yielded 16 cwt. Another farmer states, that the crop obtained by him, during an average of several years, was 12 tons, from $22\frac{1}{2}$ cwt., or 2520 lbs. of seed; or, 1 cwt. of seed produced 11 cwt.

Mr. Wakefield estimates that in nine agricultural districts in Ireland, the average crop of potatoes, per statute acre, from 1404 lbs. of seed, (about $12\frac{1}{2}$ cwt.) is 13669 lbs. of produce, or rather more than $6\frac{1}{2}$ tons. This gives 1 cwt. of seed to 10 cwt. nearly.

These results exhibit a very different estimate of the quantity of seed required in this country, with that mentioned before, unless some mistake may have occurred in the reduction of French weights to the English.

The remarks subsequently made by Dr. Kane coincide with the results obtained in my own table. The kidney potatoe produced 10½ tons, which yielded above 1 ton 18 cwt. of starch, while the crop of Strangers was 18 tons, which only produced a little more than 2 tons 8 cwt. of starch.

Starch is obtained from the potatoe by a simple process, which has been extensively circulated by Sir John Sinclair and others. Manufactories are established in France and in Scotland for its production, and many families in the latter country, and in the north of Ireland prepare it in small quantities for domestic use, while in this country it has been neglected or unnoticed. The root of white briony will also produce starch by a similar process.

When potatoe starch and arrowroot are examined by the microscope, a difference is percep-

tible. They are both spheroidal, but the former is longer and more irregular than the latter. Each particle is invested by a membrane, which renders it insoluble in cold water, but which bursts during boiling, or at a temperature of 160 degrees, Fahr. when the substance termed *amidin*, which is soluble in water, is liberated.

In conclusion, I shall briefly relate some of the most important uses to which the potatoe and its starch are peculiarly adapted.

Mr. Jacob, in his Reports, states that in the eastern part of Prussia, potatoes are applied to many useful purposes. They are cultivated to a great extent, and by converting them into starch and treacle, that land is made to yield a profit which might otherwise have produced a loss. Sugar did not answer so well, "but the treacle," says Mr. Jacob, "appeared to me as sweet as any from the tropics, the only perceptible difference between them was, that it had less consistence."

"The starch (Dr. Kane) is not the only material extracted from potatoes, and extensively available in the arts. The potatoe itself, reduced

to flour, is at present extensively employed on the Continent, in the preparation of a very wholesome quality of bread, and the starch itself is consumed in making confectionary, jellies, sago, tapioca, in thickening paper, and in a variety of uses, by which such quantities of it are employed as to render its manufacture a really important and extensive department of industry."

"The most remarkable of all the applications of potatoe starch is, however, one to which the excise laws of this country would probably present invincible impediments. It is the preparation of sugar, and of spirits. Under the influence of certain chemical agents, simple, yet peculiar in their action, and to which it would not be my province here to refer in detail, starch is converted into sugar, and this sugar, by fermentation, yields spirit. On the Continent the manufacture of sugar from corn is almost abandoned. Potatoe spirit is almost universally used, and in flavour, it so resembles brandy, that it is well known that a large quantity of the French brandy brought into London, is potatoe spirit from Hamburgh, coloured with burned sugar."