DISTRIBUTION OF MINERAL CONSTITUENTS AND DRY MATTER IN THE POTATO TUBER[1]

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INTRODUCTION

This study was undertaken as part of an investigation on chemical and physical factors which might influence the processing quality of potatoes, in particular, the texture of French fries. Poor texture is encountered at times from unknown causes. It was felt that some effect of mineral content on composition, such as the well-known depression of starch content by chloride, might be responsible.

Published information on various constituents relates mainly to the tuber as a whole or to the peeled tuber. Summaries indicating the ranges of mineral element concentrations normally present are given by Lampitt and Goldenberg (6), Talburt and Smith (9), and Brautlecht and Getchell (2). In this regard, geographical location has probably more pronounced effects on composition than have varietal differences (6).

The distribution of mineral constituents within the tuber has received little attention. Glynne and Jackson (4) reported on variation in nitrogen content in different sectors of the tuber, Hughes and Swain (5) studied iron and phosphorus gradients, and Macklon and De Kock (7) investigated the distribution of potassium, calcium, iron, and phosphorus.

MATERIALS AND METHODS

Twelve lots of Netted Gem (Russet Burbank) tubers, 1965 crop, were examined. Four lots were obtained from Alberta, three from Manitoba, and five from New Brunswick .The first seven are designated West and the rest as East.

Seventeen sub-samples were prepared from each lot of 20 tubers in the following manner. A lengthwise central slice, $^3/_{16}$ inch thick, was cut from the well-washed and superficially dried tuber, in such a way as to include a minimum number of eyes. The slice was placed on a ground glass plate mounted over a fluorescent light and scored part way through crosswise so as to mark it into quarters.

Using a scalpel, a section 1 mm thick was cut from the outside of the slice, thus including the periderm and cortex (section A). Section B was then cut off along the vascular ring, which was easily visible. Where an eye had been included the cut followed the ring to the edge of the slice. A third cut divided the remainder of the storage parenchyma roughly into halves and the outer portion was designated section C. Finally, the pith, fairly well delineated as a water-soaked area, was cut away from the remaining portion of parenchyma (section D) to yield pith sample (section E).

Sections A, B, C and D were broken into quarters on the scored

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marks and the quarters of each section were number 1, 2, 3 and 4 from stem to bud end. Section E was retained whole as a single sample. There were thus 17 sub-samples per slice. As each separation was made the piece was dropped into liquid nitrogen. When all the sub-sections of one lot had been accumulated they were weighed rapidly, then freeze-dried and ground for analysis.

Analyses were made for potassium, magnesium, calcium, sodium, iron, manganese, zinc, and copper by atomic absorption spectrometry. Phosphorus was determined by the method of Parks and Dunn (8), nitrogen by the Kjeldahl method (1), and chlorine by titration (3).

Results and Discussion

The results of the analyses are too numerous to list completely in the form of two-way tables (sections x quarters). In Table 1 are given the mean values of quarters, averaging over sections, and in Table 2 the mean values of sections, averaging over quarters.

In Table 1 a number of statistically significant over-all trends from stem to bud end (1 to 4) were evident and are indicated in the table as linear (L) or quadratic (Q). The trends for potassium and phosphorus were in agreement with those reported by Macklon and De Kock (7). Hughes and Swain (5) noted the same trend for phosphorus. When because of interaction (sections x quarters), the sections were considered separately, many significant trends were evident. However, it was felt that the general picture was better indicated by the over-all trends reported for these cases in Table 1. It will be noted that in both Eastern and Western samples a progressive decrease in nitrogen and dry matter was indicated, in agreement with the findings of Glynne and Jackson (4).

Table 2 lists, along with the means, standard errors for comparison among sections A, B, C and D. Standard errors are given separately for the means of the E sections, because they are based on fewer samples than the means for the other sections. There were significant differences for several elements when E was compared with the arithmetic mean of the rest of the tuber sections. The main differences of interest were that the pith E was lower than this mean, and actually lower than any of the means of separate sections, in manganese, zinc, copper, and dry matter, and higher in chlorine.

Not statistically significant, but of interest, were overall declines in concentration from outer to inner secions in magnesium, iron, manganese, zinc, and copper. There was a pronounced fall followed by a rise in potassium and chlorine. The two outer sections had the highest calcium and phosphorus contents. Nitrogen content fell from A to B, rose slightly, then fell in the E layer, much the same picture as found by Glynne and Jackson (4). Dry matter content rose from A to B, then declined to E, as was also noted by these authors.

Comparison of the Eastern and Western groups of samples (Table 3) showed that the Eastern potatoes had a higher iron content (5% significance level), higher manganese, zinc, and chlorine (1% significance level), and lower magnesium and calcium (5% significance level). The difference in chlorine was large, and analyses on matching soil samples showed a water-soluble chloride content of 62-80 ppm for Eastern soils and about 4 ppm for Western.

TABLE 1.—*Constituents as percent of fresh weight. Means of quarters averaging over sections.*[c]

Position in tuber	K	Mg	Ca x 10^2	Na	Fe x 10^3	Mn x 10^3	Zn x 10^3	Cu x 10^3	N	P	Cl	D.M.
East 1[b]	0.29	0.020	0.19	0.060	0.64	0.33	0.39	0.19	0.39	0.040	0.058	22.3
2	.33	.019	.14	.036	.47	.28	.36	.19	.37	.042	.055	21.3
3	.36	.019	.15	.041	.47	.26	.34	.19	.35	.043	.045	20.4
4	.37	.018	.19	.049	.47	.27	.33	.18	.34	.044	.030	19.4
S.E.[c]	.0126	.000308	.0130	.00752	.0374	.00894	.00854	.0113	.00412	.000557	.00158	.158
Trend	L (+)	L (−)[d]	Q	NS	Q	Q[d]	L (−)	NS	L (−)[d]	L (+)[d]	Q[d]	L (−)[d]
West 1	0.30	0.024	0.31	0.055	0.55	0.13	0.24	0.10	0.34	0.036	0.009	22.0
2	.31	.023	.25	.050	.42	.15	.25	.11	.34	.038	.011	21.9
3	.36	.023	.24	.050	.37	.15	.26	.12	.33	0.39	.011	21.6
4	.41	.025	.31	.038	.38	.16	.26	.13	.33	.041	.009	21.0
S.E.[c]	.00943	.000566	.0155	.00538	.0360	.00412	.0123	.00693	.00332	.000848	.000781	.149
Trend	L (+)	NS	Q	NS	L (−)[d]	L (+)[d]	NS	L (+)	L (−)[d]	L (+)	Q	L (−)[d]

[a]The analytical results for the A (skin) section are omitted for iron, manganese, zinc, and copper because of possible soil contamination. Because the other elements were present in much higher concentrations it is not considered likely that the results were seriously affected by contamination.

[b]Positions in tubers: East = New Brunswick, West = Alberta and Manitoba; 1 = stem end quarter, 4 = bud end quarter. Quarters were in turn cut into sections from skin (A) to pith area (E).

[c]Standard error for comparison of quarters. Degrees of freedom for Fe, Mn, Zn, and Cu were 48 for East, 67 for West; for other components, 64 for East, 91 for West.

[d]Significant interaction Sections (excluding E) x Quarters, — the trend is not consistent throughout the sections.

TABLE 2.—*Constituents as percent of fresh weight. Means of sections averaging over quarters.*

Position in tuber[a]	K	Mg	Ca x 10^2	Na	Fe x 10^3	Mn x 10^3	Zn x 10^3	Cu x 10^3	N	P	Cl	D.M.
East A	0.45	0.022	0.28	0.065	[b]	[b]	[b]	[b]	0.40	0.045	0.065	19.0
B	.35	.019	.21	.035	0.55	0.32	0.39	0.22	.34	.046	.031	24.2
C	.27	.019	.08	.034	.49	.29	.36	.17	.37	.039	.038	21.9
D	.28	.017	.10	.052	.49	.25	.33	.17	.35	.039	.054	18.3
E	.39	.017	.11	.048	.42	.16	.28	.15	.32	.043	.070	14.4
S.E. 1[c]	.0126	.000308	.0130	.00752	.0331	.00894	.00742	.00975	.00412	.000557	.00158	.158
S.E. 2[d]	.0254	.000624	.0261	.0150	.0648	.0155	.0148	.0195	.00825	.00111	.00316	.316
		[e]				[e]			[e]	[e]	[e]	[e]
West A	0.46	0.026	0.52	0.043	[b]	[b]	[b]	[b]	0.37	0.040	0.013	19.9
B	.37	.023	.30	.034	0.46	0.12	0.27	0.13	.29	.041	0.008	24.3
C	.28	.023	.14	.049	.41	.16	.23	.10	.33	.035	.007	22.4
D	.27	.024	.15	.061	.43	.16	.26	.12	.35	.039	.012	19.8
E	.41	.021	.17	.036	.37	.10	.21	.08	.33	.039	.020	15.7
S.E. 1	.00943	.000566	.0155	.00538	.0316	.00412	.0107	.00600	.00332	.000848	.000781	.149
S.E. 2	.0189	.00114	.0311	.0108	.0640	.00837	.0214	.0119	.00663	.00169	.00155	.397
					[e]	[e]			[e]			[e]

[a]Positions in tubers: East = New Brunswick; West = Alberta and Manitoba; A = skin section, E = pith section. Sections (except for E) were in turn cut into quarters, 1 = stem end, 4 = bud end.

[b]The analytical results for the A (skin) sections are omitted for iron, manganese, zinc, and copper because of possible soil contamination. Because the other elements are present in much higher concentrations it is not considered likely that the results were seriously affected by contamination.

[c]Standard error for comparisons of A, B, C and D. Degrees of freedom for Fe, Mn, Zn, and Cu were 48 for East, 67 West; for other components, 64 for East, 91 for West.

[d]Standard error for E. Degrees of freedom as in note [b].

[e]Significant interaction Sections (excluding E) x Quarters.

TABLE 3.—*Constituents as percent of fresh weight : Means for eastern and western regions averaging over farms and positions within potato.*[a]

	K	Mg	Ca	Na	Fe	Mn	Zn	Cu	N	P	Cl	D.M.
East[b]												
Mean	.34	.019	.0016	.047	.00055	.00028	.00035	.00018	.362	.042	.048	20.49
S.E.[c]	.0145	.00151	.000338	.00523	.0000401	.0000312 (4 d.f.)	.0000218	.0000241	.00969	.00358	.00386	.464
West[b]												
Mean	.35	.024	.0027	.046	.00043	.00014	.00025	.00011	.337	.039	.011	21.27
S.E.	.0122	.00128	.000286	.00443	.0000339	.0000065 (6 d.f.)	.0000185	.0000204	.00818	.00302	.00326	.392
Difference E-W												
Mean	—.01	—.005*[d]	—.0011*	.001	.00012*	.00014**	.00010**	.00007	.025	.003	.037**	1.28
S.E.	.0189	.00198	.000443	.00686	.0000525	.0000329 (4 d.f.)	.0000286	.0000316	.0127	.00463	.00506	.608

[a]Positions within tuber : tubers were cut into quarters, 1 = stem end, 4 = bud end, then further into sections from skin to pith.
[b]East = New Brunswick, West = Alberta and Manitoba.
[c]All standard errors based on 10 d.f. except for manganese.
[d] * significant at 5% level.
** significant at 1% level.

In the year in which this work was done there were no marked differences in French fry texture, as evaluated by taste panels, and consequently the differences in composition reported here do not seem to be directly involved in texture differences.

Summary

Statistically significant differences were found in the distribution of several constituents in the potato tuber. Some of the main differences were as follows: potassium and phosphorus increased from stem to bud end; the pith area, as compared with the remainder of the tuber, had a lower content of manganese, zinc, copper, and dry matter, and a higher content of chlorine. There were indications of a decrease in dry matter and nitrogen from stem to bud end.

A set of Netted Gem samples from New Brunswick had higher iron, manganese, zinc, and chlorine, and lower magnesium and calcium than a similar set of samples from Alberta and Manitoba.

Resumen

Se encontraron estadisticamente importantes diferencias en la distribución de varios constituentes en el tubérculos de la papa. Algunas de las diferencias más importantes fueron: potasio y fósforo incrementaron desde el tallo hasta la extremidad del brote; el área de la médula, comparada al resto del tubérculo, contenía menos manganeso, zinc, cobre y materia seca, y más cloro. Hubo indicaciones de una disminución de materia seca y de nitrógeno desde el tallo hasta la extremidad del brote.

Un grupo de muestras de Netted Gem de New Brunswick tuvo más hierro, manganeso, zinc, y cloro y menos magnesio y calcio que un grupo similar de muestras de Alberta y Manitoba.

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