PROTEIN, NONPROTEIN, AND TOTAL NITROGEN IN SEEDLINGS OF POTATOES[1]

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ABSTRACT

Analyses for secific gravity, total solids, total nitrogen, protein nitrogen, and nonprotein nitrogen are reported for 73 seedling samples grown in Maine, and for 10 selections grown in Idaho. The interactions between the various constituents, as indicated by regression analysis, are discussed. These samples indicate a potential for breeding a variety of potato with a higher than average protein content, but further work is necessary to determine the inheritance pattern. This work is in progress.

RESUMEN

Se reportan análisis para investigar gravedad específica, sólidos totales, nitrógeno de proteinas y nitrógeno de otros compuestos no proteínicos de 73 muestras de brotes crecidos en Maine y de 10 selecciones crecidas en Idaho. Se discuten las interacciones entre los varios constituyentes, como están indicadas por el análisis de regresión. Estas muestras indican un potencial de producir una variedad de papa con un contenido de proteina más alto que él promedio pero se necesita trabajo adicional para determinar el modo de herencia. Este trabajo está en progreso.

While the potato has long been known as a nutritious food, the carbohydrate to protein ratio is relatively high. Hartwell (7) reported that the potato, as the only source of protein in the diet, was not adequate to meet the needs of the rat unless consumed in large quantities. Kon and Klein (10) quoted the work of Hindhede (8) to show that the potato can serve as the sole source of nitrogen for humans. These authors then confirmed Hindherde by showing that a man and woman were maintained in good health, on such a diet, for 167 days. To obtain the 5.7 and 3.8 g, respectively, of nitrogen that they consumed daily (sufficient for nitrogen equilibrium), they ate an average of 1680 g (3.7 lb.) and 1120 g (2.5 lb.) of potatoes, respectively. If the protein content of the potato was considerably higher, in relation to the starch content, it could provide a significant protein intake even at reduced consumption levels and, thus, be an improved food not only in the United States but in less developed areas.

It has also been shown that, unlike many foodstuffs, the nonprotein nitrogen of the white potato has considerable nutritional value, since it consists largely of free amino acids, a factor which compliments the potato protein nutritionally (2).

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Based upon these and other reports, an investigation has been undertaken into the possibilities of breeding a potato variety of much greater protein content than is presently available. The consequences of this increase, in addition to improved nutritional value, could, of course, be many and varied. Growing, storage, cooking, processing, flavor and texture qualities may be altered, and the direction of these changes cannot be predicted. It is, therefore, necessary to proceed with the breeding steps and determine the ultimate results experimentally.

It is a generally accepted concept that the level of soil fertility and nutrient availability affect the protein content of a specific potato variety. Early workers were not convinced that a potato variety could transmit desirable characteristics to its progeny. Grabner (6) reported that several potato selections, having the same parents, differed much in starch content. Modern techniques in genetics, statistics, and analytical procedures have shown that there are varietal differences in potato protein content. Sengbusch (14), in rating potato varieties, set his standard of value as the amount of protein produced, in relation to starch, per unit of land surface. Also Novak (13) reported that potatoes from Holland contained a high percentage of protein while those from Denmark had a low protein content. He discussed the possibility of developing new varieties of potatoes with higher protein content.

Therefore, with the ready availability of many experimental potato selections, it was thought that a survey of these for total nitrogen, protein nitrogen and nonprotein nitrogen, as well as the calculated ratio of protein nitrogen to nonprotein nitrogen, would indicate the rage of values with which the geneticist could work. In addition, the possibility of one or more potato selections with an interestingly high protein content, which might be transmitted to its progeny, was of interest. This paper is a report of the analyses of 83 selections.

Materials and Methods

The two sources of the potato samples were as follows: (a) A series of 73 breeding samples propagated, under the supervision of one of us (R. V. A.), at the Maine Experiment Station, Presque Isle, Maine; and (b) a series of 10 parents and selections furnished by Dr. Joseph J. Pavek of the USDA Agricultural Research Service stationed at the Idaho Branch Experiment Station, Aberdeen, Idaho.

The Maine samples consisted of about 5 lb. each of 73 seedling samples. These were all grown in the same plot, thereby eliminating as much as possible any variables due to growing conditions. Immediately after harvest these samples were shipped from Maine to the Campbell Institute for Agricultural Research, Riverton, New Jersey, where they were stored at 42 F (5.55 C) and 85% relative humidity. About 15 samples at a time were transported to the Laboratory in Philadelphia for analysis.

The Idaho samples were a general cross section of selections with a bias toward those high in specific gravity. Eight of these, in yield trials, had a mean specific gravity of 1.100 and included the high solids Lenape variety. These samples were analyzed immediately upon reception at the Laboratory and are reported according to their pedigree numbers, followed by an asterisk to differentiate them from the Maine samples.

All of the samples were analyzed in the same manner, and duplicates of each were used in the analysis. Each sample (ca. 5 lb.) was graded in two equal rows starting with the largest and ending with the smallest tubers. Each row (ca. 1200 to 1400 g.) was separately treated as a duplicate sample. The potatoes were thoroughly scrubbed to remove all foreign matter and the specific gravity was determined by weighing in air and in water by the method of Murphy and Govern (12). The total solids figure, as indicated by specific gravity, was used to determine the moisture content of each sample for extraction purposes. Sufficient absolute ethanol was added to the tubers, in a large Waring Blender,[4] to bring the alcohol content to 70% w/w, considering the original moisture content, as described by Talley et al. (17).

From this potato-alcohol slurry, the following aliquots (by weight) were taken in duplicate and analyzed by the indicated method.

1. Samples for direct total solids determinations: Aliquots were placed in weighed aluminum moisture dishes, covered and weighed immediately. Ethanol and water were removed by heating in a mechanical convection oven at 60 C for 3 hrs., followed by 2 hrs. at 130 C. The per cent solids was calculated from the residue weight.

2. Samples for total nitrogen by microkjeldahl. Aliquots were pipetted into weighted microkjeldahl flasks, capped, and weighed immediately. Sulfuric acid (1 ml., conc.) was added and the flasks recapped. These samples were held for subsequent analysis in the usual manner.

3. Samples for protein nitrogen determination. These analyses were carried out by using a modified method of White (18). About 8 in. of nitrogen-free, cellulose dialyzer tubing, with an inflated diameter of 0.25 in.. was tightly knotted twice at one end. The tubing was pre-opened, by sliding a section of ⅛ in. OD teflon tubing into the open end, and then placed in a corked, numbered test tube. The tare weight of the entire assembly was recorded.

A sampling syringe was made as follows: The tip of an 8 in. section of ⅛ in. OD teflon tubing was drawn to about one-half its diameter. The opposite end was spread into a flange. This flange was then fitted with a small rubber bulb. The syringe was used to withdraw extract aliquots from the potato slurry and to transfer it to the dialyzer tube with facility. A reasonable headspace was left in the bag when sealed by means of two firm knots. By replacing the filled dialyzer bag into the corked test tube immediately, accurate net weights could be recorded even if alcohol diffusion and evaporation had begun.

The potato slurry was dialyzed against running tap water which, during the winter months when this work was carried out, remained sufficiently cold (10 to 15 C) to discourage the growth of organisms in the samples. A 20 hr. dialysis was sufficient to remove the free amino acids, amides, and low molecular weight peptides. After the dialysis period, the bags were rinsed with distilled water and carefully opened in the area of the headspace. They were inverted and dropped into kjeldahl flasks which, after addition of 1 ml. of conc. H_2SO_4, were immediately capped.

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[4]Mention of company or trade names does not imply endorsement by the Department of Agriculture over others not named.

Kjeldahl analysis of the cellulose tubing and sample resulted in the protein nitrogen content of the sample. The difference between the protein and total nitrogen values was considered as the nonprotein nitrogen fraction.

4. Samples of the slurry, equivalent to 50 g fresh weight of potato, were withdrawn and held in the cold in the event that additional analytical samples were required.

Linear regression curves, used to study the data, were calculated and plotted with the aid of the IBM 1130 computer. The procedure used for calculation of these curves was based on least squares fitting (4).

The equation used in the calculation of the 95% confidence limits for the linear regression data, was taken from Draper and Smith (3). These limits were also calculated and plotted by means of the IBM 1130 computer. Standard error of the mean was calculated by means of the equation:

$$SE = \sqrt{\frac{\Sigma(Y - Y\ calc.)^2}{n\ (n-2)}}$$

Results and Discussion

Table 1 presents the analytical data for the 83 samples, arranged according to decreasing total nitrogen content. The analyses include total nitrogen, protein nitrogen, and nonprotein nitrogen on both a fresh and a dry basis. In addition, the calculated values for percentage of protein nitrogen and of nonprotein nitrogen in the total nitrogen fraction and the protein nitrogen to nonprotein nitrogen ratios are given.

Many years of study of the chemical composition of potatoes have revealed that an increase in the dry matter of the tuber is accompanied by a comparable increase in the starch content. This has led to the prevailing opinion that the non-starch solids are relatively constant over a wide range of total solids variation. Burton (1) has reported this constant to be about 6%. Many tables in the literature corroborate this value (5, 9, 11).

Recently, Houghland (9) discussed the relationship of specific gravity, dry matter and starch content and showed that, in potatoes having 13.3% total solids, about 56.5% of this dry matter consisted of starch. At a total solids content of 32.2%, however, he showed the starch content to be 79.0% of the dry matter. On a fresh basis, this would mean there was an increase of only 1% in the non-starch fraction of the tuber, and an increase of 18.9% in the solids or an average of 0.0529% non-starch for each 1% increase in total solids between these two extremes.

Since the total nitrogen content of tubers ranges from 1.4-2.8% of the dry weight (16) and the protein nitrogen content rarely exceeds 50% of this value, any efforts to increase the protein content of potatoes by merely breeding for an increase in dry matter content would show little promise of success.

These observations generally hold true for the 83 samples included in this study. While there were some exceptions, which will be discussed later, the curve of the regression data (Fig. 1) having an F value of 40.4 indicates, with 95% confidence, that the percentage of total nitrogen on a dry weight basis, is higher in low solids potatoes than in those of

TABLE 1.—*Analysis of breeding selections of potato tubers from Maine and Idaho.*

Samp. No.	Specific Gravity	Total Solids	Per cent fresh basis TN†	PN‡	NPN§	Per cent dry basis TN	PN	NPN	PN/TN	NPN/TN	PN/NPN
LENAPE*	1.1171	29.57	0.564	0.348	0.216	1.91	1.18	0.73	61.8	38.2	1.6
B5412-10	1.0655	18.57	0.527	0.253	0.274	2.84	1.36	1.48	47.9	52.1	0.9
NORGOLD*	1.0936	22.22	0.499	0.264	0.235	2.25	1.19	1.06	52.9	47.1	1.1
B5459-1	1.0943	22.77	0.456	0.250	0.206	2.00	1.10	0.90	55.0	45.0	1.2
B5669-4	1.0692	17.68	0.451	0.200	0.251	2.55	1.13	1.42	44.3	55.7	0.8
RUSSET B.*	1.0880	22.63	0.449	0.190	0.259	1.98	0.84	1.14	42.4	57.6	0.7
BR5968-4	1.0652	17.33	0.447	0.253	0.194	2.58	1.46	1.12	56.6	43.4	1.3
B5458-6	1.0740	21.82	0.443	0.242	0.201	2.03	1.11	0.92	54.7	45.3	1.2
B5131-2	1.0862	20.81	0.441	0.249	0.192	2.12	1.20	0.92	56.6	43.4	1.3
B5680-1	1.0772	20.22	0.437	0.242	0.195	2.16	1.20	0.96	55.6	44.4	1.3
B5281-1	1.0694	17.22	0.436	0.221	0.215	2.53	1.28	1.25	50.6	49.4	1.0
BR5948-1	1.0974	25.12	0.434	0.244	0.190	1.73	0.97	0.76	56.1	43.9	1.3
B5267-2	1.0738	18.52	0.432	0.228	0.204	2.33	1.23	1.10	52.8	47.2	1.1
B5141-6	1.1028	24.79	0.428	0.260	0.168	1.73	1.05	0.68	60.7	39.3	1.5
B5647-8	1.0655	17.80	0.426	0.226	0.200	2.39	1.27	1.12	53.1	46.9	1.1
A483-17*	1.0860	22.26	0.426	0.192	0.234	1.91	0.86	1.05	45.0	55.0	0.8
B5755-7	1.0809	21.23	0.425	0.216	0.209	2.00	1.02	0.98	51.0	49.0	1.0
A492-2*	1.1015	26.07	0.424	0.244	0.180	1.62	0.94	0.68	58.0	42.0	1.4
B5665-7	1.0792	20.26	0.417	0.252	0.165	2.06	1.24	0.82	60.2	39.8	1.5
B5691-2	1.0824	21.10	0.415	0.209	0.206	1.97	0.99	0.98	50.3	49.7	1.0
B5461-4	1.0734	18.95	0.414	0.248	0.166	2.18	1.31	0.87	60.1	39.9	1.5
B5410-26	1.0747	18.91	0.411	0.264	0.147	2.17	1.40	0.77	64.5	35.4	1.8
B5036-40	1.0709	17.94	0.410	0.224	0.186	2.29	1.25	1.04	54.6	45.4	1.2
A589-65*	1.1105	26.79	0.407	0.259	0.148	1.52	0.97	0.55	63.8	36.2	1.8
BR5941-6	1.0707	19.69	0.405	0.220	0.185	2.06	1.12	0.94	54.4	45.6	1.2
A477-8*	1.0873	22.95	0.405	0.195	0.210	1.76	0.85	0.91	48.3	51.7	0.9
B5591-1	1.0809	20.93	0.404	0.246	0.158	1.93	1.18	0.75	61.1	38.9	1.6
B5701-2	1.0676	17.64	0.402	0.191	0.211	2.28	1.08	1.20	47.4	52.6	0.9
B5286-24	1.0778	18.54	0.402	0.185	0.117	2.17	1.00	1.17	46.1	53.9	0.9
SHOSHONI*	1.0837	21.75	0.402	0.208	0.194	1.85	0.96	0.89	51.9	48.1	1.1
B5422-6	1.0716	18.12	0.400	0.196	0.204	2.21	1.08	1.13	48.9	51.1	1.0

TABLE 1.—(*continued*).

Samp. No.	Specific Gravity	Total Solids	Per cent fresh basis TN†	PN‡	NPN§	Per cent dry basis TN	PN	NPN	PN/TN	NPN/TN	PN/NPN
B5052-7	1.0690	17.64	0.399	0.227	0.172	2.26	1.29	0.97	57.1	42.9	1.3
B5422-9	1.0732	18.51	0.398	0.236	0.162	2.15	1.27	0.88	59.1	40.9	1.4
B5400-8	1.0842	21.29	0.397	0.228	0.169	1.86	1.07	0.79	57.5	42.5	1.4
B5458-3	1.0918	19.60	0.396	0.206	0.190	2.02	1.05	0.97	52.0	48.0	1.1
BR5967-7	1.0908	23.59	0.395	0.264	0.131	1.67	1.12	0.55	67.1	32.9	2.0
B5647-9	1.0768	20.61	0.395	0.237	0.158	1.92	1.15	0.77	59.9	40.1	1.5
B5089-18	1.0705	18.99	0.394	0.194	0.200	2.07	1.02	1.05	49.3	50.7	1.0
BR5951-3	1.0768	20.04	0.390	0.225	0.165	1.95	1.12	0.83	57.4	42.6	1.3
B5446-4	1.0639	16.27	0.388	0.194	0.194	2.38	1.19	1.19	50.0	50.0	1.0
BR5946-9	1.0881	22.14	0.387	0.231	0.156	1.75	1.04	0.71	59.4	40.6	1.5
B5698-8	1.0684	17.37	0.385	0.187	0.198	2.22	1.08	1.14	48.6	51.4	0.9
B5613-1	1.0760	19.11	0.385	0.222	0.163	2.01	1.16	0.85	57.7	42.3	1.4
BR5965-3	1.0812	19.70	0.384	0.199	0.185	1.95	1.01	0.94	51.8	48.2	1.1
B5593-1	1.0685	17.80	0.383	0.187	0.196	2.15	1.05	1.10	48.8	51.2	1.0
B5282-13	1.0732	19.65	0.379	0.211	0.168	1.93	1.07	0.86	55.4	44.6	1.2
B5066-3	1.0697	17.82	0.378	0.208	0.170	2.12	1.17	0.95	55.2	44.8	1.2
B5298-4	1.0763	19.99	0.377	0.226	0.151	1.89	1.13	0.76	52.9	40.2	1.5
BR5960-5	1.0858	21.91	0.376	0.225	0.151	1.72	1.03	0.69	59.9	40.1	1.5
BR5957-1	1.0772	19.08	0.373	0.240	0.133	1.95	1.26	0.69	64.6	35.4	1.8
BR5940-4	1.0723	18.59	0.372	0.193	0.179	2.00	1.04	0.96	52.0	48.0	1.1
BR5954-6	1.0660	17.19	0.370	0.193	0.177	2.15	1.12	1.03	52.1	47.9	1.1
B5415-6	1.0790	20.79	0.367	0.205	0.162	1.77	0.99	0.78	55.9	44.1	1.3
A6356*	1.0881	23.40	0.364	0.183	0.181	1.56	0.78	0.78	50.0	50.0	1.0
B5236-8	1.0684	17.77	0.360	0.162	0.198	2.03	0.91	1.12	44.8	55.2	0.8
B5132-3	1.0708	19.11	0.358	0.191	0.167	1.87	1.00	0.87	53.5	46.5	1.1
B5088-7	1.0638	16.43	0.358	0.214	0.144	2.18	1.30	0.88	59.6	40.3	1.5
B5090-11	1.0690	17.63	0.357	0.186	0.171	2.02	1.06	0.96	52.5	47.5	1.1
BR5950-2	1.0769	19.05	0.355	0.177	0.178	1.86	0.93	0.93	50.0	50.0	1.0
B5676-2	1.0805	20.73	0.355	0.175	0.180	1.71	0.84	0.87	49.1	50.9	1.0
B5687-12	1.0678	19.45	0.354	0.212	0.142	1.82	1.09	0.73	59.9	40.1	1.5
B5421-3	1.0620	15.49	0.352	0.176	0.176	2.27	1.14	1.13	50.2	49.8	1.0
B5422-10	1.0731	19.64	0.350	0.216	0.134	1.78	1.10	0.68	61.8	38.2	1.6

TABLE 1.—*(continued)*.

Samp. No.	Specific Gravity	Total Solids	Per cent fresh basis TN†	PN‡	NPN§	Per cent dry basis TN	PN	NPN	PN/TN	NPN/ TN	PN/ NPN
B5299-39	1.0808	20.07	0.350	0.183	0.167	1.74	0.91	0.83	52.3	47.7	1.1
B5617-5	1.0919	22.75	0.349	0.228	0.121	1.53	1.00	0.53	65.4	34.6	1.9
B5604-1	1.0632	16.79	0.349	0.177	0.172	2.08	1.05	1.03	50.5	49.5	1.0
B5696-3	1.0656	17.30	0.346	0.149	0.197	2.00	0.86	1.14	43.0	57.0	0.8
B5000-18	1.0748	19.07	0.346	0.198	0.148	1.81	1.04	0.77	57.5	42.5	1.4
B5288-5	1.0687	16.86	0.346	0.148	0.198	2.05	0.88	1.17	42.9	57.1	0.8
B5598-2	1.0686	18.15	0.345	0.177	0.158	1.90	0.98	0.92	51.6	48.4	1.1
A6207-3*	1.0825	21.98	0.342	0.162	0.180	1.56	0.74	0.82	47.4	52.6	0.9
B5701-21	1.0786	19.74	0.341	0.178	0.163	1.73	0.90	0.83	52.0	48.0	1.1
B5736-3	1.0821	20.27	0.341	0.205	0.136	1.68	1.01	0.67	60.1	39.9	1.5
B5683-5	1.0852	20.56	0.340	0.169	0.171	1.65	0.82	0.83	49.7	50.3	1.0
B5408-2	1.0695	18.16	0.339	0.198	0.141	1.87	1.09	0.78	58.3	41.7	1.4
B5702-1	1.0702	18.67	0.338	0.155	0.183	1.81	0.83	0.98	45.9	54.1	0.8
BR5991-25	1.0827	20.54	0.335	0.220	0.115	1.63	1.07	0.56	65.6	34.4	1.9
B5287-16	1.0699	18.73	0.331	0.122	0.209	1.77	0.65	1 12	36.7	63.3	0.6
B5459-7	1.0759	18.75	0.325	0.177	0.148	1.73	0.94	0.79	54.3	45.7	1.2
BR5960-13	1.0836	22.59	0.317	0.198	0.119	1.40	0.88	0.52	62.9	37.1	1.7
BR5970-4	1.0759	18.25	0.316	0.152	0.164	1.73	0.83	0.90	48.0	52.0	0.9
B5740-2	1.0668	16.97	0.303	0.174	0.129	1.79	1.03	0.76	57.5	42.5	1.4
B5755-3	1.0707	18.65	0.299	0.139	0.160	1.60	0.75	0.85	46.9	53.1	0.9

*Indicate selections or varieties grown in Idaho.
†TN = Total nitrogen.
‡PN = Protein nitrogen.
§NPN = Non-protein nitrogen.

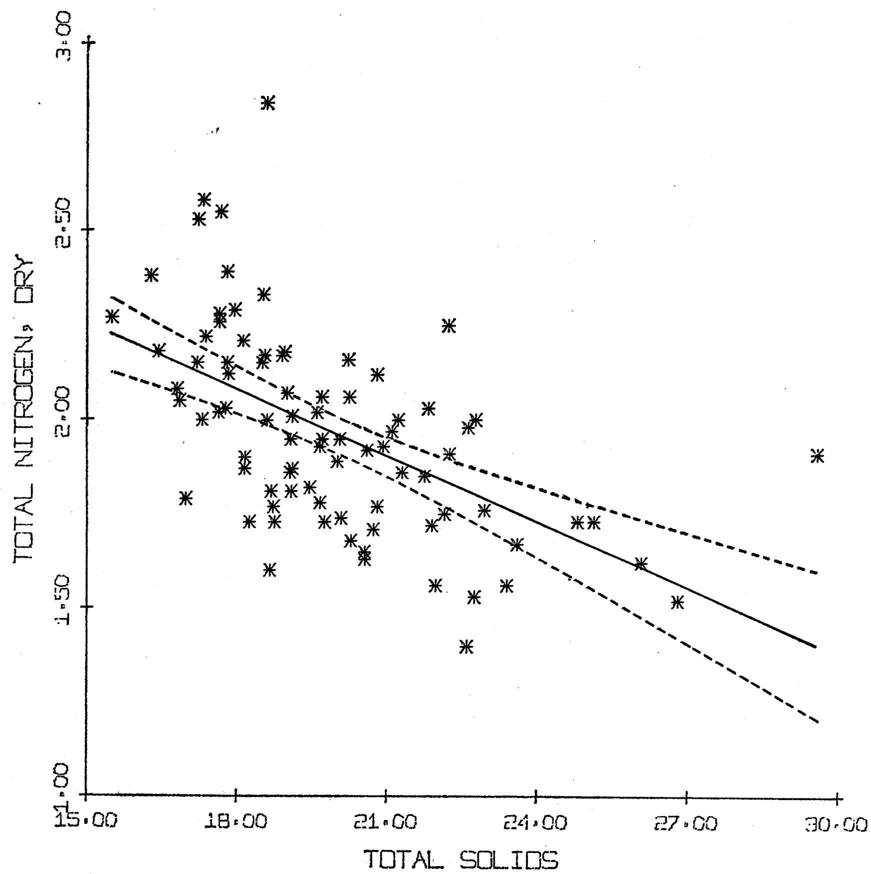

FIG. 1.—Regression of total nitrogen (moisture free basis) on total solids. $s\bar{x} = 0.007$.

high solids which could be predicted from the Houghland data (9). Even though the point scatter appears fairly wide, the narrow confidence limits about the curve indicate its reliability. Again on a dry weight basis, similar calculation for total solids vs. protein nitrogen and total solids vs. non-protein nitrogen, respectively indicate a direct correlation with the total nitrogen data. These data are also significant at the 95% level.

Observation of these three nitrogen values plotted against total solids, on a fresh weight basis, shows that there is a reversal of the slopes of the curves for total and protein nitrogen (Figs. 2 and 3). Using a greatly expanded Y axis, the slight increase in both total and protein nitrogen with a large increase in total solids can be observed. These data are also significant at the 95% level. Fig. 4 indicates little or no change in non-protein nitrogen with increasing dry matter, but the point scatter was such that the data are not significant at the 95% level.

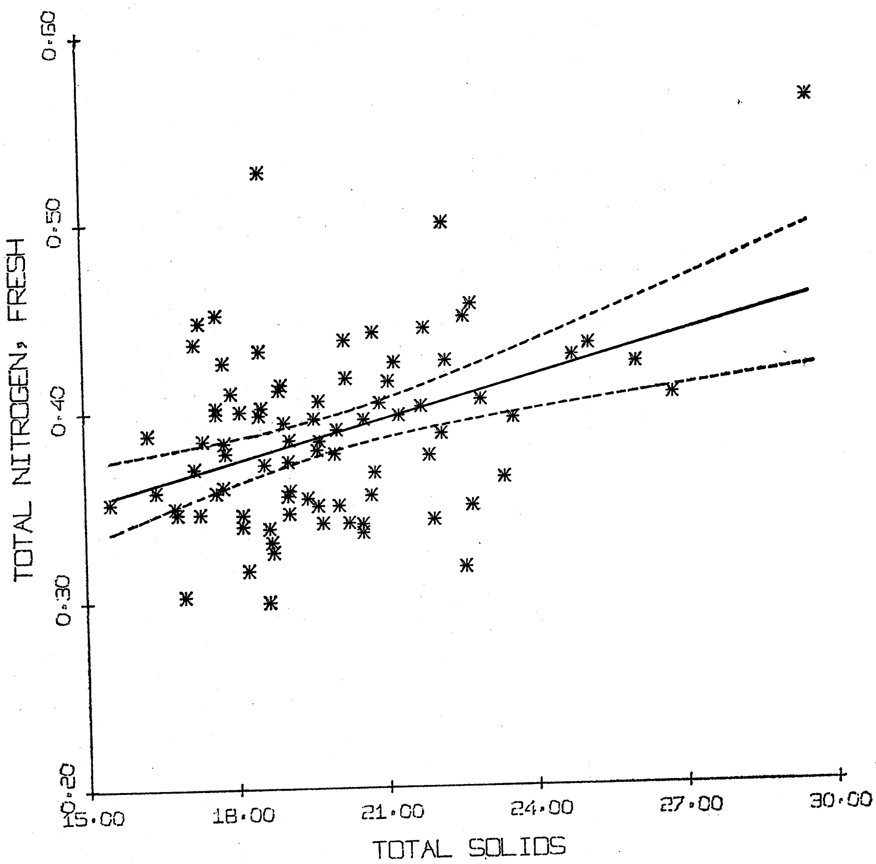

FIG. 2.—Regression of total nitrogen (fresh tuber basis) on total solids. $s\bar{x} = 0.001$.

The protein nitrogen contents were compared with the ratios of protein nitrogen to nonprotein nitrogen (Figs. 5 and 6). On both a fresh and a dry basis, an increase in protein nitrogen results in an increase in the ratio of protein to nonprotein nitrogen. This agrees with the work of Steward (15) who showed that the free amino acids serve as a source or reservoir for synthesis of protein.

Figs. 1 through 6 are the result of linear regression analysis and it is obvious, from the extremes of point scatter, that some of the potato samples produced data falling considerably higher or lower than the mean for the entire population. It was not surprising that all of the 10 potato samples from Idaho should rank in the first 20 samples with highest dry matter content, since it was this quality for which they were selected. What is surprising is the fact that the sample with the highest dry matter also contained the highest percentage of total and protein nitrogen on a fresh weight basis, and had a total and protein nitrogen content on a dry weight basis which was 30% higher than would be expected from the

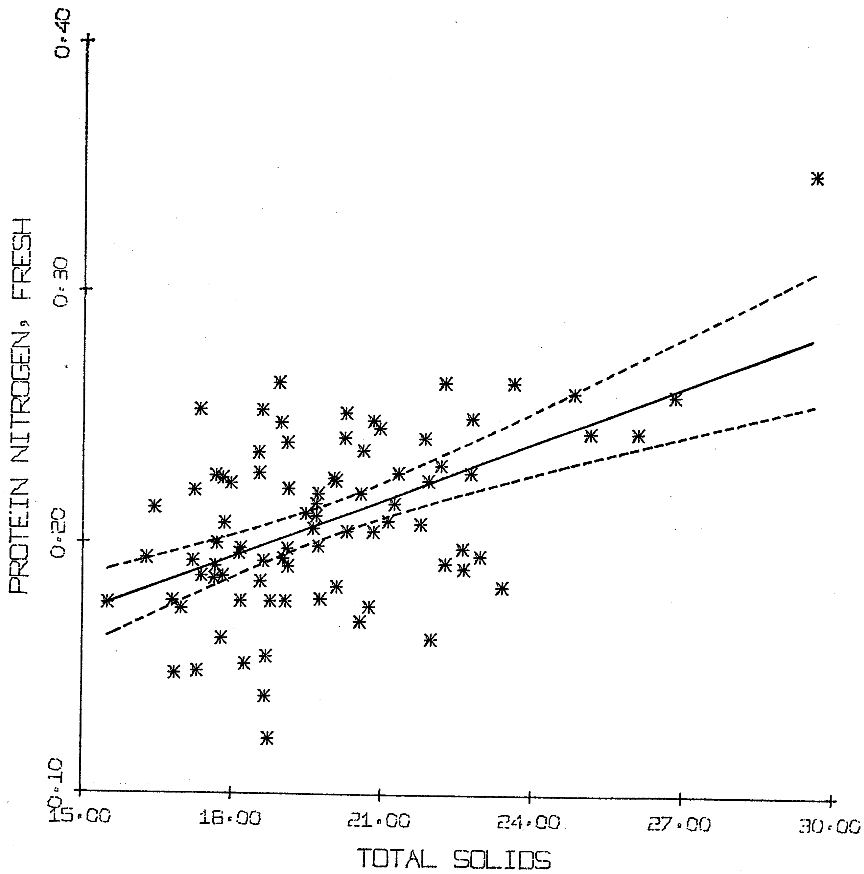

FIG. 3.—Regression of protein nitrogen (fresh tuber basis) on total solids. $s\bar{x} = 0.001$.

regression curves. This sample, interestingly enough, was the recently developed Lenape variety.

Conversely, a potato sample grown in Maine, ranking 78th in specific gravity (out of 83 samples) had, as might be expected from the data in Fig. 1, the highest percentage of total nitrogen on a dry weight basis, but ranked second only to the above-mentioned Lenape sample in total nitrogen on a fresh weight basis.

If one accepts the von Scheele relationship between starch and total solids, the starch content of these samples can be calculated for comparative purposes. If one assumes that: (a) the caloric content is mainly due to starch and nitrogenous compounds (the fat content being extremely low); (b) the variation in the amino compound composition between samples is limited; and (c) the caloric values for starch and protein (in potatoes) are approximately the same (4.0 and 3.5 respectively) — then the ratio of starch to protein should give a useful index figure for each of these samples. It is interesting that sample BR5960-13 has a ratio of

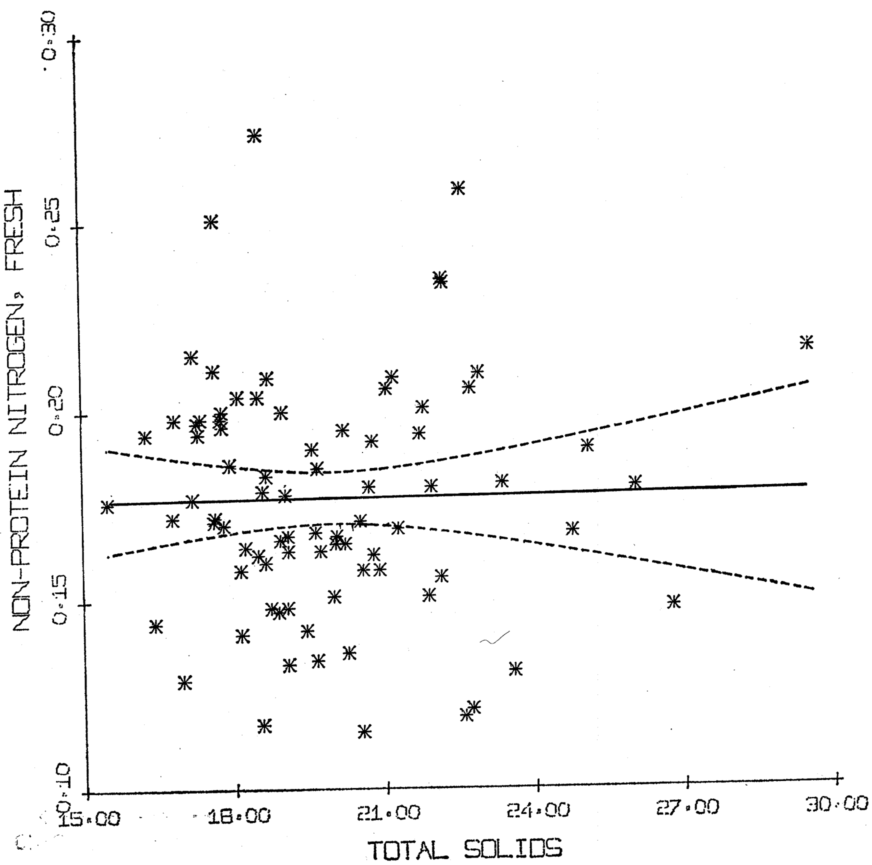

FIG. 4.—Regression of nonprotein nitrogen (fresh tuber basis) on total solids. $s\bar{x}$ = 0.001.

8.2 as compared to a ratio of 3.8 for B5412-10. These are the extremes shown by the 83 samples.

Table 2 lists the representative protein contents of various foodstuffs. A comparable figure for the percentage of total energy represented by the protein of these two potato samples (% TN(100) × 6.25/(%TN × 6.25 + % starch) is 11.0 and 20.8, respectively. The lowest energy percentage of 11.0 (the highest starch to protein ratio) of these 83 samples equals the average value for potatoes given in the table, while the highest energy percentage of 20.8 (lowest ratio) equals two-thirds of the values for lean fish and for soybean seed. The low ratio sample is the one from Maine discussed earlier. The Lenape sample, also discussed previously, had a relatively high ratio of 7.3 and an energy percentage of 13.6. Since a low ratio, or a high energy percentage, indicates a high protein content relative to the starch present, the aim of any breeding experiments should be toward a low ratio and, when combined with a relatively high total solids, a nutritious and productive variety should result.

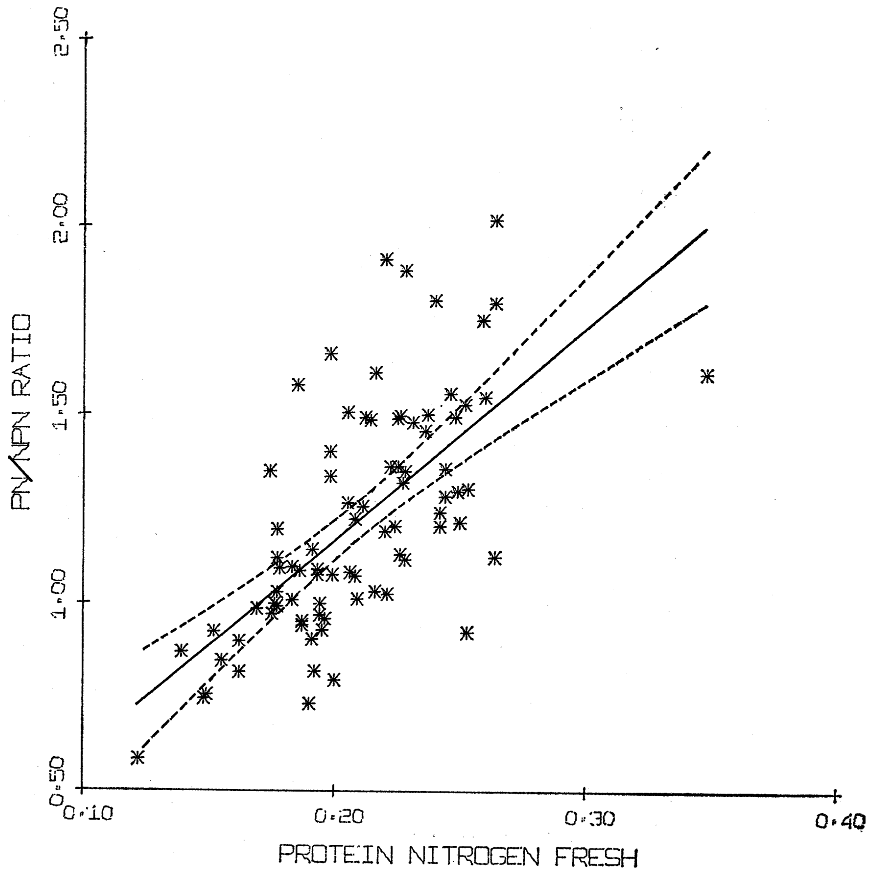

FIG. 5.—Regression of the ratio of the protein nitrogen to non-protein nitrogen on protein nitrogen on protein nitrogen (fresh tuber basis). $s\bar{x} = 0.025$.

TABLE 2.—*Representative protein contents of various major foodstuffs.*[5]

Foodstuffs	Grams per 100 grams edible portion	Percentage of total energy content of food
Cassava flour	1.5	1.8
Plantains	1.0	3.1
Irish potatoes	2.0	10.7
Milk	3.3	20.6
Wheat flour (70% extract)	10.0	11.4
Fish, lean	19.0	37.6
Soybean seed	35.0	36.6
Rice, polished	7.0	8.0
Maize meal (86% extract)	9.5	10.5

[5]Munro, H. N., An introduction to nutritional aspects of protein metabolism. In: Munro, H. N., and Allison, J. B. (eds.) Mammalian protein metabolism. Vol. II. New York, Academic Press, 1964. 642 p. Reference p. 8.

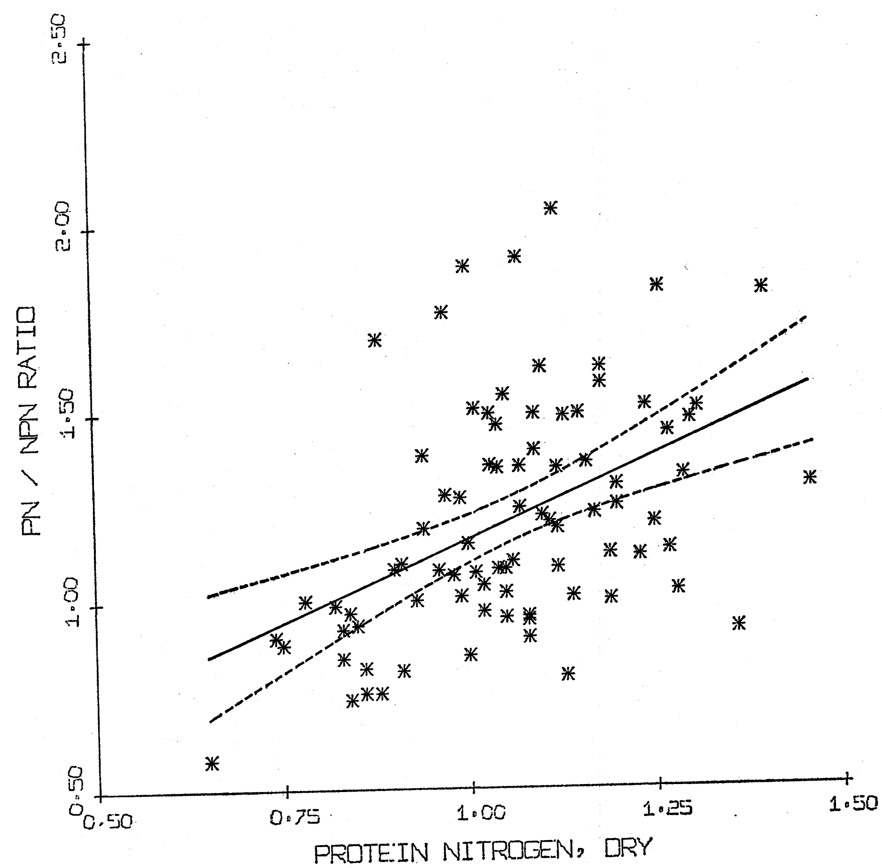

FIG. 6.—Regression of the ratio of protein nitrogen to nonprotein nitrogen on protein nitrogen (moisture free basis). sx = 0.031.

In such samples as these, and probably others, rests a potential for the development of a potato variety containing increased nitrogenous constituents, both in absolute amounts and in amounts relative to the total solids, or better, to the starch content. The goal of future work is to ascertain how these differences are transmitted to the progeny. The present work indicates that there are varietal differences, and later work must determine their inheritance pattern. The stability of the protein content in high protein selections must be tested in different environments. This must be followed by an examination of the high protein selections to determine whether the presently desirable attributes needed in cooking, processing, etc. will be retained. For these reasons, a series of experiments has been undertaken by the Crops Research Division and the Eastern Utilization Research and Development Division of the U. S. Department of Agriculture. These results will be reported at a future date.

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