Nitrate and Nitrite Content of Market Potatoes


Ninety-nine samples of retail market potatoes from New York City, Chicago, the Washington, D.C., area, Grand Forks, N.D., and Wenatchee, Wash., were analyzed for nitrate by the nitroxylenol distillation method and nitrite by diazotization. An overall average of 120 ppm of nitrate and 0.44 ppm of nitrite was found, with $S = 64$ and 0.36, respectively. Significant differences in nitrate content existed among markets (Wenatchee highest at 139, Grand Forks lowest at 82) and area of growth (Idaho highest at 151, north central lowest at 80). A significant positive correlation ($r = 0.25$) was found for all samples between nitrate and nitrite content. Dehydrated potato flakes from eight varieties grown under four fertilization levels were analyzed. Nitrate levels (fresh weight basis) were strongly dependent upon variety; the average nitrate level for the eight varieties was significantly higher for the highest level of fertilization than other levels. No nitrite was found. The nitrate and nitrite contents of the potatoes are not considered excessive, but varietal and agronomic influences preclude direct comparison with the few literature values.

Attention has recently been directed to the nitrate and nitrite content of our food and water supplies by an awareness of increasing levels of nitrate and (potentially) nitrite in the environment. The relation of these factors to infant methemoglobinemia and to the possibility of formation of carcinogenic nitrosamines has been reviewed (Phillips, 1971; National Research Council, 1972; Wolff and Wasserman, 1972) and will not be discussed here.

Nitrates are normal constituents of plant materials; there is a considerable amount of analytical data in the literature (Achtzehn and Hawat, 1969; Ashton, 1970; Fogden and Fogden, 1969; Jackson et al., 1967; Rooma, 1971) on average values and ranges for many of our foodstuffs, including prepared infant foods. Of the common vegetables beets, celery, endive, kale, radishes, lettuce, spinach, turnips, and broccoli are usually reported to exceed 1000 ppm of nitrate (fresh basis), and infant foods containing these vegetables may be correspondingly high in nitrate.

A recent instance of relatively high levels of nitrate and nitrite in a lot of dried potatoes intended for further processing has prompted an inquiry into the nitrate and nitrite content of these samples as available to the U. S. consumer.

The relatively sparse data available in the literature on nitrate levels in potatoes are summarized in Table I. Data of Gilbert et al. (1946) are not included because the potatoes used in their work were from soils known to produce vegetables of abnormally high nitrate content. No information concerning variety or origin of the potatoes is provided in any of the work listed in Table I.

There are likewise relatively few data available on the effects of nitrogen fertilization on the nitrate content of potato tubers. Possibly the most extensive paper is that of Hlavsová et al. (1970). Three Czech potato varieties were grown under eight fertilizer treatments, replicated six times. It was concluded that the nitrate content of the tuber was dependent both on the variety and on the amount of fertilization, with the highest nitrate values resulting from the heaviest fertilization. It was also noted that nitrate levels in tubers increased more rapidly than yield. The well-known decrease in solids content with fertilization was also evident in their data.

Selected data from the Czech study are shown in Table II. The original paper also includes data on yield, solids content, nitrogen removal, and several additional fertilization levels.

A limited sampling of fresh potatoes was made by USDA personnel from retail markets in five areas of the U. S. The nitrate and nitrite content of these samples has been determined and the results are presented and discussed in this paper. In addition, a series of samples of dehydrated potato flakes was made available to us which had been processed from potatoes (eight varieties) grown in the Red River Valley at four levels of fertilization. These samples have also been analyzed for nitrate and nitrite content.

**MATERIALS AND METHODS**

**Nitrate Analysis.** Four published procedures for nitrate determination were investigated. Two, requiring preliminary reduction to nitrite followed by diazotization to produce azo dyes (Middleton, 1957; Nelson et al., 1957) were found to produce results variably lower than the two described below and were dropped from further consideration. The two procedures selected for final evaluation were the nitrate electrode and the nitroxylenol procedure.

For the electrode procedure the standard addition method was used, as described by Westcott (1971) using a Beckman nitrate electrode.

The nitroxylenol method of Lipp and Döberg (1964) was employed in which 3,4-dimethylphenol is nitrated and the nitroxylenol is separated by distillation. The procedure as used is as follows. Pipet a 1.0-ml sample or standard into an iodine flask, add 0.1 g of 3,4-dimethylphenol and 10 ml of concentrated sulfuric acid, stopper the flask, and warm for 2 min. Add 30 ml of distilled water, cool in cold tap water, hold 30 min, and transfer the entire reaction mixture with washings to a micro-Kjeldahl steam distillation apparatus. Collect the distillate in a 25-ml volumetric flask containing 3 ml of 5% sodium hydroxide. Distill to just below the mark and make to volume with distilled water. The absorbance at 430 nm is determined with a Beckman B spectrophotometer.

**Nitrite Analysis.** Two diazotization methods were investigated. One, using $\alpha$-naphthol and sulfanilic acid, forms with nitrite a yellow dye [orange I (Middleton, 1957)]. The other, using 1-naphthylamine and sulfanilic acid, forms a red azo dye (Nelson et al., 1954). Since both methods gave essentially the same results in preliminary work 1-naphthylamine was selected since the reagents are commercially available in premixed measured quantities. Further, the red dye differs more from the natural yellow color of the potato juice. The procedure is as follows. Four milliliters of potato juice or standard is pipetted into a 25-ml cylinder, 21 ml of distilled water is added, and the contents of a NitriVer (Hach Chemical Co., Ames, Iowa) powder pillow is added. A light red color develops and,
RESULTS AND DISCUSSION

Accuracy and Precision of Methods. The nitrate electrode and the nitroxylenol method were each applied to ten replicate potato juice samples with a standard deviation of 5.02 and 3.12 ppm of nitrate, respectively. Recovery of added nitrate for 76 samples was 91.5% for the nitrate electrode and 106.5% for the chemical method for 37 determinations. Standard deviation for nitrate in ten replications was 0.012 ppm, with 84.3% recovery of added nitrate.

To obtain a measure of the precision of the extraction and analysis, five tubers from one sample were quartered lengthwise and four samples were made containing one quarter from each. Results by the nitroxylenol method were 77.9, 83.0, 86.6, and 88.5 ppm, S = 4.66.

Variability within individual 10-lb lots of potatoes was examined. Five samples of five tubers were taken at random from each of three lots of potatoes. Single lengthwise quarters from each of the five potatoes were combined and analyzed for nitrate (nitroxylenol) and nitrite. Results appear in Table III. It is evident that individual variation in nitrate and nitrite content among tubers requires that a more elaborate sampling scheme be employed to obtain results truly representative of a large lot of potatoes.

All tuber samples were analyzed for nitrate by both the electrode method and the nitroxylenol method, and all results are expressed as parts of nitrate per million of potato juice. The average values found by each method, corrected for recovery of added nitrate as given above, are seen in Table IV. Analysis of variance was calculated for the uncorrected results and also for the corrected values. Table IV shows the F ratio values associated with methods and materials for the uncorrected data and also for the "corrected" data. In both cases, the difference due to methods

<p>| Table I. Nitrate Content of Potatoes |</p>
<table>
<thead>
<tr>
<th>No. of samples</th>
<th>Avg. ppm NO₃</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>77</td>
<td>40-106</td>
</tr>
<tr>
<td>1</td>
<td>63</td>
<td>Wilson (1949)</td>
</tr>
<tr>
<td>5</td>
<td>104</td>
<td>34-143</td>
</tr>
<tr>
<td>7</td>
<td>40</td>
<td>Achtzehn and Hawat (1969)</td>
</tr>
<tr>
<td>19</td>
<td>130</td>
<td>Hlavsova et al. (1969)</td>
</tr>
<tr>
<td>52</td>
<td>77.21</td>
<td>Subbotin et al. (1970)</td>
</tr>
<tr>
<td>15</td>
<td>17.6</td>
<td>Rooma (1971)</td>
</tr>
</tbody>
</table>

<p>| Table II. Effect of Fertilization on Nitrate Content of Potatoes |</p>
<table>
<thead>
<tr>
<th>Fertilization, kg/ha</th>
<th>Nitrate content in variety, mg/kg fresh wt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manure</td>
<td>N</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>250</td>
<td>0</td>
</tr>
<tr>
<td>250</td>
<td>0</td>
</tr>
<tr>
<td>250</td>
<td>80</td>
</tr>
<tr>
<td>250</td>
<td>120</td>
</tr>
</tbody>
</table>

<p>| Table III. Variability of Nitrate and Nitrite Content among Five Samples of Three Lots of Tubers |</p>
<table>
<thead>
<tr>
<th>Sample</th>
<th>Nitrate, ppm</th>
<th>Nitrite, ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>1</td>
<td>237</td>
<td>56</td>
</tr>
<tr>
<td>2</td>
<td>269</td>
<td>82</td>
</tr>
<tr>
<td>3</td>
<td>187</td>
<td>59</td>
</tr>
<tr>
<td>4</td>
<td>172</td>
<td>72</td>
</tr>
<tr>
<td>5</td>
<td>177</td>
<td>91</td>
</tr>
<tr>
<td>Mean</td>
<td>207.2</td>
<td>72.0</td>
</tr>
<tr>
<td>CV (%)</td>
<td>43.4</td>
<td>10.6</td>
</tr>
<tr>
<td>CV (%)</td>
<td>24.0</td>
<td>14.7</td>
</tr>
</tbody>
</table>

| Table IV. Comparison of Nitrate Electrode and the Nitroxylenol Method |
|----------------|--------------|--------------|
| Mean values | Uncorrected, ppm | Corrected, ppm |
| Nitrate electrode | 140.4 | 155.5 |
| Nitroxylenol | 127.6 | 119.6 |

<table>
<thead>
<tr>
<th>Analysis of variance</th>
<th>DF</th>
<th>Uncorrected, F</th>
<th>Corrected, F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variance associated with</td>
<td>Methods</td>
<td>1</td>
<td>1.29</td>
</tr>
<tr>
<td>Materials</td>
<td>97</td>
<td>35.95</td>
<td>29.63</td>
</tr>
<tr>
<td>Error</td>
<td>97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole Set</td>
<td>195</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| All F ratios significant at the 1% level. |
solved factors are present which influence the accuracy of values for 99 potato samples, grouped by location of
five times that due to sample differences and hence unre-
ly used in the past and because the colored material that were selected for reporting because it has been more wide-
One or both methods. Data from the chemical method
Table VI. Nitrate Content of Potatoes from Different Areas

<table>
<thead>
<tr>
<th>Market Origin</th>
<th>Variety</th>
<th>Nitrate, ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washington, D. C.</td>
<td>'Round White'</td>
<td>362</td>
</tr>
<tr>
<td>Washington, D. C.</td>
<td>'Round White'</td>
<td>332</td>
</tr>
<tr>
<td>New York</td>
<td>New Jersey</td>
<td>247</td>
</tr>
<tr>
<td>New York</td>
<td>239</td>
<td></td>
</tr>
<tr>
<td>Wenatchee</td>
<td>238</td>
<td></td>
</tr>
<tr>
<td>Wenatchee</td>
<td>236</td>
<td></td>
</tr>
<tr>
<td>New York</td>
<td>Idaho Russet Burbank</td>
<td>228</td>
</tr>
<tr>
<td>Wenatchee</td>
<td>228</td>
<td></td>
</tr>
<tr>
<td>Washington</td>
<td>Long Island 'Round White'</td>
<td>222</td>
</tr>
<tr>
<td>Washington New Jersey 'Round White'</td>
<td>212</td>
<td></td>
</tr>
</tbody>
</table>

Grand Forks N. Dakota Red Pontiac 7
Grand Forks N. Dakota Red Pontiac 8
Grand Forks Minnesota Red Pontiac 12
Grand Forks Minnesota Red Pontiac 14
Chicago Minnesota 26
Washington Maine 'Round White' 28
New York Maine 31
New York Long Island 44
Grand Forks Minnesota Kennebec 47
Chicago Wisconsin Russet Burbank 49

Table VIII. Nitrate Content of Market Potatoes

<table>
<thead>
<tr>
<th>Market</th>
<th>No. of samples</th>
<th>Range, ppm</th>
<th>Mean, ppm</th>
<th>$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washington, D. C.</td>
<td>24</td>
<td>0-1.71</td>
<td>0.56 a</td>
<td>0.54</td>
</tr>
<tr>
<td>Chicago, Ill.</td>
<td>15</td>
<td>0-1.12</td>
<td>0.54 ab</td>
<td>0.28</td>
</tr>
<tr>
<td>Grand Forks, N. D.</td>
<td>18</td>
<td>0-1.31</td>
<td>0.48 ab</td>
<td>0.37</td>
</tr>
<tr>
<td>Wenatchee, Wash.</td>
<td>14</td>
<td>0.06-0.61</td>
<td>0.35 c</td>
<td>0.22</td>
</tr>
<tr>
<td>New York, N. Y.</td>
<td>28</td>
<td>0-0.89</td>
<td>0.26 c</td>
<td>0.26</td>
</tr>
<tr>
<td>All samples</td>
<td>99</td>
<td>0-1.71</td>
<td>0.44</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Table V. Nitrate Content of Market Potatoes

<table>
<thead>
<tr>
<th>No. of samples</th>
<th>Range</th>
<th>Mean, ppm</th>
<th>$</th>
</tr>
</thead>
<tbody>
<tr>
<td>All samples</td>
<td>99</td>
<td>7-362</td>
<td>120</td>
</tr>
<tr>
<td>By location of market</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wenatchee, Wash.</td>
<td>14</td>
<td>52-238</td>
<td>139 a</td>
</tr>
<tr>
<td>Washington, D. C.</td>
<td>24</td>
<td>28-362</td>
<td>137 ab</td>
</tr>
<tr>
<td>New York, N. Y.</td>
<td>28</td>
<td>31-247</td>
<td>127 abc</td>
</tr>
<tr>
<td>Chicago, Ill.</td>
<td>15</td>
<td>26-188</td>
<td>105 d</td>
</tr>
<tr>
<td>Grand Forks, N. D.</td>
<td>18</td>
<td>7-161</td>
<td>82 e</td>
</tr>
<tr>
<td>By variety</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russet Burbank</td>
<td>37</td>
<td>49-228</td>
<td>127</td>
</tr>
<tr>
<td>Red Bliss</td>
<td>4</td>
<td>60-186</td>
<td>118</td>
</tr>
<tr>
<td>Norland</td>
<td>4</td>
<td>76-98</td>
<td>85</td>
</tr>
<tr>
<td>Red Pontiac</td>
<td>8</td>
<td>7-159</td>
<td>61</td>
</tr>
<tr>
<td>Norgold Russet</td>
<td>2</td>
<td>146-156</td>
<td>152</td>
</tr>
<tr>
<td>Kennebec</td>
<td>2</td>
<td>47-64</td>
<td>55</td>
</tr>
<tr>
<td>By location of origin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maine</td>
<td>19</td>
<td>31-362</td>
<td>112</td>
</tr>
<tr>
<td>Long Island</td>
<td>12</td>
<td>44-222</td>
<td>114</td>
</tr>
<tr>
<td>Florida</td>
<td>4</td>
<td>60-186</td>
<td>113</td>
</tr>
<tr>
<td>Idaho</td>
<td>15</td>
<td>61-227</td>
<td>151</td>
</tr>
<tr>
<td>New Jersey</td>
<td>4</td>
<td>114-246</td>
<td>195</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>2</td>
<td>114-187</td>
<td>150</td>
</tr>
<tr>
<td>New York</td>
<td>2</td>
<td>94-111</td>
<td>102</td>
</tr>
<tr>
<td>Minnesota</td>
<td>11</td>
<td>12-98</td>
<td>62</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>9</td>
<td>49-158</td>
<td>117</td>
</tr>
<tr>
<td>North Dakota</td>
<td>5</td>
<td>7-94</td>
<td>54</td>
</tr>
</tbody>
</table>

a Means followed by the same letter are not significantly different. For probability levels see text. b Actually purchased in Beltsville, College Park, and Berwyn Heights, Md. c As stated on bag label.

Table VI. Nitrate Content of Potatoes from Different Areas

<table>
<thead>
<tr>
<th>Area</th>
<th>Sample no.</th>
<th>Mean, ppm</th>
<th>$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idaho</td>
<td>15</td>
<td>151 a</td>
<td>41.2</td>
</tr>
<tr>
<td>East Central</td>
<td>20</td>
<td>133 ab</td>
<td>58.4</td>
</tr>
<tr>
<td>Maine</td>
<td>19</td>
<td>112 c</td>
<td>90.5</td>
</tr>
<tr>
<td>North Central</td>
<td>25</td>
<td>80 d</td>
<td>46.0</td>
</tr>
</tbody>
</table>

a Means followed by the same letter are not significantly different at the 1% level, except for Maine and North Central, which differ at the 5% level.

is significant at the 1% probability level; however, “cor-
recting” the values raises the variance due to methods to
five times that due to sample differences and hence unre-
solved factors are present which influence the accuracy of
one or both methods. Data from the chemical method
were selected for reporting because it has been more wide-
ly used in the past and because the colored material that
is measured is separated by distillation from the potato
extract. The data reported in this paper are treated for
the 106.5% recovery.

Nitrate Content. Table V gives the mean corrected values
for 99 potato samples, grouped by location of the
market, by the variety insofar as stated on the package,
and by geographic origin as shown on the package. Dun-
can’s Multiple Range Test (Duncan, 1955) for significance
of differences among means was applied to the data clas-
sified by location of market, since it alone included all
samples. Results are shown in the table. All indicated dif-
fferences were significant at the 1% probability level, ex-
cept those between New York City and Chicago and Chi-
cago and Grand Forks, which were significant at the 5%
level.

Although classification of the data by location of mar-
ket has no independent significance since variety prefer-
ces of consumers and proximity to growing areas control

these values, it is included here to permit its use by those
interested in area differences in nitrate ingestion.

To permit an analysis of the data according to the ori-
gin of the potatoes, results were grouped into four catego-
ories: Maine, Idaho, East Central (New York, New Jersey, Pennsylvania), and North Central (Minnesota, North Dakota, Wisconsin). As shown in Table VI, means among all areas except Idaho and the East Central differed sig-
nificantly. None of the potatoes from the Wenatchee mar-
kets were received with indication of origin, few of the
potatoes obtained in New York carried any varietal iden-
tification. The term “round white” did appear on ten
samples from the Washington area, but this is not a vari-
ety name. No statistical evaluation of varietal influence
was done because of the limited sample size.

In Table VII are listed the ten samples with the highest
nitrate content and the ten with the lowest. The wide
range of the data, implied by the relatively large standard
deviation values in Tables V and VI, is quite evident.

Nitrite Content. The nitrite content of all of the potato
samples was relatively low. None contained over 2 ppm
and only 6 of 99 fell between 1 and 2 ppm. For this reason
the data are shown in Table VIII classified only by loca-
tion of the market. Although differences between market
means are significant by Duncan’s Multiple Range Test, we
have no explanation why this is so. It is noteworthy that
the markets do not fall in the same order for nitrates
as for nitrates. Certainly none of the nitrite values of
the potatoes analyzed here are significant from the public
health standpoint.

The data were tested for correlation between nitrate
data showed that most of the potato samples obtained in gin produced a highly significant correlation for the highly significant for Chicago and Grand Forks but not for the others. Grouping the samples by state (or area) or origin from this area show this relationship. It must be noted that no data are available on the origin of the Wenatchee potatoes.

**Relation of Nitrate Content to Variety and Fertilization.** Thirty-two samples of dehydrated potato flakes were made available to us for nitrate and nitrite analysis. (The source was not the one referred to in the introductory remarks as processing material of high nitrate content.) These flakes were produced from eight varieties of potatoes grown with four levels of fertilization at the Red River Valley Potato Growers Association research farm in Grand Forks, N. D. Fertilizer levels and the results of analysis for nitrate content are shown in Table X, expressed on the fresh potato basis for comparison with other results given here. No information is available on the loss in processing, but it is noteworthy that the overall average value, 51.7 ppm of nitrate, is not far from the 59.4 average value for Minnesota–North Dakota (calculated from data in Table V), which are the lowest found in this study for any area. No nitrite was found in any sample.

An analysis of variance was carried out with the data in Table X, with the results seen in Table XI. Variance associated with variety was significant at the 1% probability level, and that for fertilization treatment at the 5% level. Duncan’s Multiple Range Test further evaluates the differences among means.

In view of the strong influence of variety and location seen in the work reported here and of fertilization level (Hlavsové et al., 1970), there is little to be gained in comparing our data with published values (Table I) which include results from six studies from several countries over a period of 64 years.

**ACKNOWLEDGMENT**
The authors appreciate the cooperation of members of the Market Quality Division, Agricultural Research Service, in collecting samples of market potatoes, of Jack D. Westover, Pillsbury Co., Minneapolis, for the samples of potato flakes, and of the technical assistance of Robert Mink.

**LITERATURE CITED**


Received for review April 16, 1973. Accepted July 30, 1973. Mention of proprietary products is for identification only and does not imply endorsement by the U. S. Department of Agriculture over others of a similar nature not named.

### Table IX. Correlation of Nitrate and Nitrite Content of Market Potatoes

<table>
<thead>
<tr>
<th>Grouping</th>
<th>No. of samples</th>
<th>r</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>All samples</td>
<td>99</td>
<td>0.255</td>
<td>6.78*</td>
</tr>
<tr>
<td>By market</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washington</td>
<td>24</td>
<td>0.042</td>
<td>0.040</td>
</tr>
<tr>
<td>New York</td>
<td>28</td>
<td>0.293</td>
<td>2.45</td>
</tr>
<tr>
<td>Chicago</td>
<td>15</td>
<td>0.688</td>
<td>11.69**</td>
</tr>
<tr>
<td>Grand Forks</td>
<td>18</td>
<td>0.897</td>
<td>66.10**</td>
</tr>
<tr>
<td>Wenatchee</td>
<td>14</td>
<td>0.495</td>
<td>3.89</td>
</tr>
<tr>
<td>By origin</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Maine</td>
<td>19</td>
<td>0.065</td>
<td>0.074</td>
</tr>
<tr>
<td>Idaho</td>
<td>15</td>
<td>0.284</td>
<td>1.14</td>
</tr>
<tr>
<td>North Central*</td>
<td>25</td>
<td>0.895</td>
<td>93.01**</td>
</tr>
<tr>
<td>East Central†</td>
<td>20</td>
<td>0.106</td>
<td>0.21</td>
</tr>
</tbody>
</table>

* Significance: no asterisk, above 5% probability level; *, 5% level; **, 1% level. * North Dakota, Minnesota, Wisconsin. † Pennsylvania, New York (including Long Island), New Jersey.

### Table X. Effect of Variety and Fertilization on Nitrate Content of Dehydrated Potatoes

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>81.9</td>
<td>82.8</td>
<td>98.0</td>
<td>85.6</td>
</tr>
<tr>
<td>P</td>
<td>57.8</td>
<td>67.6</td>
<td>58.9</td>
<td>70.8</td>
</tr>
<tr>
<td>K</td>
<td>55.5</td>
<td>44.9</td>
<td>62.1</td>
<td>87.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variety</th>
<th>Nitrate content, ppm fresh basis</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norgold</td>
<td>81.9</td>
<td>85.6</td>
</tr>
<tr>
<td>Norland</td>
<td>67.8</td>
<td>70.8</td>
</tr>
<tr>
<td>Pontiac</td>
<td>51.5</td>
<td>56.9</td>
</tr>
<tr>
<td>Norchip</td>
<td>55.5</td>
<td>59.1</td>
</tr>
<tr>
<td>La Chipper</td>
<td>75.5</td>
<td>75.9</td>
</tr>
<tr>
<td>Kennebec</td>
<td>52.8</td>
<td>56.1</td>
</tr>
<tr>
<td>Norchic</td>
<td>43.0</td>
<td>42.7</td>
</tr>
<tr>
<td>ND 7196</td>
<td>37.2</td>
<td>51.7</td>
</tr>
<tr>
<td>Average</td>
<td>58.1 A</td>
<td>57.1 A</td>
</tr>
</tbody>
</table>

* Means followed by the same letter are not significantly different from each other at the 5% level.

### Table XI. Analysis of Variance of Data from Table X

<table>
<thead>
<tr>
<th>Variance associated with</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety</td>
<td>7</td>
<td>3585.532</td>
<td>512.23</td>
<td>5.31**</td>
</tr>
<tr>
<td>Treatment</td>
<td>3</td>
<td>1175.023</td>
<td>391.67</td>
<td>4.06*</td>
</tr>
<tr>
<td>Error</td>
<td>21</td>
<td>2026.649</td>
<td>96.51</td>
<td></td>
</tr>
<tr>
<td>Whole set</td>
<td>31</td>
<td>6787.305</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Asterisks indicate significance; *, 5% level; **, 1% level.